NATIONAL RESEARCH UNIVERSITY
HIGHER SCHOOL OF ECONOMICS

HSE Graduate School of Urbanism
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# DESIGNING A TOOL FOR MAKING TRANSPORT MODE CHOICES IN RURAL AND REMOTE AREAS: A CASE OF NEW MOSCOW

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**Abstract**

This work raises the question of mobility in rural and remote areas and the choice of transport mode for them. While notion of the mobility is being essential nowadays and more and more people do rely on the means of transport in order to get from point A to point B, some of the territories do lack the access to the transport and New Moscow is one of them. The question of the transport supply to such territories could be a challenging one for Departments of Transport, Stakeholders and decision-makers because it is hard to choose the correct mode of transport for the exact taken non-urban territory. The objective of this paper is to suggest a solution to this problem. One of the possible solutions for the mobility supply could be a demand-responsive transport system which is broadly known as a Door-To-Door service; however, it has different operation strategies today. In this work, the main method of the research is a spatial analysis, which is used in order to evaluate the current situation (supply and estimated demand) in the mobility sphere of New Moscow. The results of the analysis are used in order to make a Project Proposal – a prototype to solve the problem. The prototype itself is a program, which helps to create a route between settlements, calculate the usage, create a route and make a choice between conventional bus or demand-responsive transportation. The results of this work could be used by transport planners and governmental bodies for a first-step analysis of development possibilities for mobility services at the territory. In addition, transport activists and citizens could use this prototype for creating a demand for mobility supply via mechanism of official communication with authorities.

*Keywords*: demand-responsive transport, mobility, rural and remote areas, DRT

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**Project brief**

Modern transport systems are multifaceted and provide an extensive choice for both planners and decision-makers. Currently, there are many districts, regions, and territories that, due to certain features of their development, do not have access to transport systems or which are not enough to meet the current demand for mobility. One of the viable solutions to this problem could be a demand-responsive transportation system.

A demand-responsive transport (DRT) system can be described as a system or a service which provides mobility with the use of flexible modes and small means of transport like cars, caravans or mini-buses (Engels, 2004; Inturri, 2017; Davison, 2014; Kim, 2016). Nowadays they are not being considered as an option due to the development of high-speed means of transport and its high costs. However, there are several examples of successful systems that are working to ensure mobility for citizens. One of these examples is a city of Lincolnshire, the UK that works for more than 20 years. On the other hand, many DRT systems fail due to the economic reasons and close in one- or two-year's time.

Today the territory of countries is dispersed: while having a growth in urbanization rates, there are still numerous areas that are considered rural or remote. As an example, the European Union possesses 75% of rural/non-urban areas (Finn & Nelson, 2019). For transport planners this could be evaluated as a challenging question of mobility supply and potentially leading to using DRT as a feasible/viable solution.

The purpose of this research is to identify where it is better to provide conventional Public Transport and where – flexible solution (e.g. DRT) for mobility supply, based on the New Moscow case. In the work, it is planned to produce an analysis of the current situation in mobility in New Moscow, propose a solution for DRT with a model and a prototype. The model will include all the necessary data to start operations: economic model, fleet. A prototype will be a digital system that enables the developer or a researcher to understand which means of transport is better for the territory to make a demand for transportation.

In the first part of the project a review of the current state of transport science in the sphere of DRT will be provided. Then spatial analysis will be performed in order to understand the distribution of inhabitants, the supply of mobility, and possible mobility demand. In the final part of the work, a viable solution to the problem will be proposed.

Integrated 7 years ago, New Moscow has an average rate of supply for mobility, which is not correlating with the demand – at least 60 % of households have no access to transportation. While making some efforts in providing transportation to the Novomoskovskiy administrative district, which is close to the "old city border" and has a historically developed connection with a capital, the Troitsky administrative district is facing challenges – there are several transport routes, but a trip inside the Moscow Central Ring Road (MKAD) could take at least one hour.

The question of mobility for this area nowadays is one of the most important for the development of Moscow transportation – this territory is expected to grow dramatically. Statistics show that today there are more than 360 thousand inhabitants (235 thousand for Novomoskovskiy and 125 in Troitsky administrative districts) which is a growth in 1,5 times from 2012. The same dynamic could be seen in the housing: from 20 to 30 million square meters are located here now and more than 8 million will be built till 2021 (Kompleks gradostroitel'noy politiki i stroitel'stva goroda Moskvy (Moscow City Building Policy Committee), 2020).

With such an extensive growth of official demography and real estate, a possibility that the City will face a transport collapse in the near future exists. Nowadays New Moscow has 93 routes that are operated by state companies Mosgortrans (Moscow City Ground Transport Operator – operates Buses and Tramways), MosTransAvto (Moscow Region Bus Operator) and other private companies, which provide connection inside the area. However, citizens living in distant areas do not have access to these routes or have to make long trips to use this mobility option. One of the potential solutions to this problem is the redevelopment of the whole transportation system in New Moscow by organizing large transportation hubs that are connected to the places of settlement of citizens with the DRT system.

This system should be an essential part of the New Moscow City Transport Complex, creating a new side of (possible) MaaS network. I do propose an easy mechanism of this system – fixed routes with the possibility to change it in case of demand. In order to make this system livable, it is essential that the payment system should be connected with an existing Moscow Ticket Menu.

**Research Study**

**Introduction**

Modern mobility is a large interconnected sphere around the globe. This system includes air, cargo, personal and public transport. However, with such an extensive growth of means of mobility, we sometimes cannot manage the demand for transportation, especially in remote areas even in developed urban agglomerations.

Moscow nowadays is an example of such an agglomeration. With more than 15 million people inhabiting the city and many great numbers of the coming workforce from the region. In the year 2012, the border of Moscow city was changed – the extension to the south-west with the connection of New or so-called Grand Moscow with the space of 1480 sq km.

The territory of New Moscow possesses 21 municipalities with more than 360 thousand inhabitants. However, the existing model of transport supply with conventional routes and buses badly serves the main purpose – providing mobility to this area – because it is not the best option for such dispersed and not heterogeneously populate the territory.

Demand-responsive transport (DRT) could be a solution for providing transportation for territories, where making a route with conventional buses is not the best option from economical and other points of view. With the creation of a system that responses to the demand from end-users, it is possible to create a sustainable mean of transport for distant, rural, or other areas.

The research objective of this thesis to identify where to provide conventional Public Transport and where – flexible solution (e.g. DRT) for mobility supply, based on the New Moscow case.

To achieve the objective of this study, the following questions will be asked:

1. What is the demand-responsive transport per se?
2. What is the current situation with mobility in New Moscow?
3. What is the estimated demand for mobility in New Moscow?
4. How can the settlements be provided with mobility and by what modes?
5. Which type of demand-responsive transport is suitable for the New Moscow?

In this work, the notion of DRT will be explained, several typologies, positive and negative sides will be determined. In addition to that, the main aim of this work is to provide a new possible solution for mobility for rural areas in the example of New Moscow. In the first part of the work there is an observation of the existing literature about DRT, mentioning its different classification, approaches, etc. In the second part there is an analysis of New Moscow territory in the sphere of mobility and its supply. In the key findings there is a brief result of the work and the main proposition for the prototype.

**Literature review**

Modern transportation science gives a special role to the DRT systems around the globe. With numbers of articles and workshops, there are several ways of defining the term of DRT:

1. DRT services include such services as taxis, vehicle sharing, carpooling, and flexible transit systems. (Inturri et al., 2017).
2. DRT is:
   a. the service which is available to the general public (i.e. it is not restricted to particular groups of users according to age or disability criteria or place of employment);
   b. the service which is provided by low capacity road vehicles such as small buses, vans or taxis;
   c. the service which responds to changes in demand by either altering its route and/or its timetable;
   d. the service where the fare is charged on a per passenger and not a per-vehicle basis (Davison, Enoch, Riley, Quddus, & Wang, 2014).
3. DRT as a semi-public form of transportation that offers the carpool service of a conventional bus and the door-to-door service of taxi (Kim, Moon, & Kim, 2016).
4. DRT is a user-oriented form of passenger transport and, unlike conventional public transport, is characterized by flexible routes and/or timetables according to passenger needs, with smaller vehicles operating between pick up and drop off locations (Perera, Ho, & Hensher).
5. DRT as being a 'flexible, intermediate', transit mode which 'fills the gap' between individual taxi type services and scheduled fixed-route conventional transit (Engels & Ambrosino, 2004).

As can be seen from the above definitions, there are several approaches to the notion of DRT in the literature; however, it is possible to define it as "a system or a service which provides mobility with the use of flexible modes and small means of transport like cars, caravans or mini-buses".

The history of the notion comes from Dial-a-Ride services (DART), which were popular in the 1970s. Per se a door-to-door or Special Transport Services was a special, restricted way of moving those individuals, who had a great demand for it – elderly and disabled - from one point to another. However, not so many examples of such services survived due to the low level of profit of such systems. One of the livable examples of DART is HandyDART in Metro Vancouver which us fully subsidized by municipality.

It is crucial to understand that there are several systems of DRT. In general, they are defined by the way of providing service but they are divided by the type of work:

1. System approach:
   *a. Interchange DRT* – providing a link to the general public transport;

   b. *Network DRT* – providing support to the existing services or replacing economically inefficient routes;
   c. *Destination-Specific DRT* – a special form of providing service to a certain destination such as airports or employment zones;
   d. *Substitute DRT* – total replacement of existing public transport infrastructure, resulting in a reinvention of the whole system (Currie & Fournier, 2017).
2. Route approach:
   a. *Many-to-One Services* – where vehicles-drivers is concentrated at one of the two trip ends considerably reducing the complexity of operations;
   b. *Many-to-Few Services* – where more than a single location at one trip end, but few enough to remain manageable;
   c. *Many-to-many (Transfer)* – where vehicles-drivers can travel to or from any location, but the system may require vehicles-drivers to transfer vehicles to complete their journey;
   d. *Many-to-Many* – covering all trip origins and destinations with a direct service;
   e. *Shared Taxis* – conventional taxis accept several individuals who can use the same vehicle and it may involve route deviation (Currie & Fournier, 2017).
3. Route choice strategies:
   a. *Fully Random – FR – all vehicles drive at randomly chosen routes;*
   b. *All vehicles drive on All Flexible routes – AVAR – all vehicles drive on flexible routes;*
   c. *Each vehicle is Assigned to a Flexible Route – EVAR – each vehicle drives on a prefixed semi-flexible route* (Inturri, et al., 2017).

In addition to the system approach, there is a list of key factors identifying the success of the DRT system:

1. Keep it simple: avoid complex systems unless you are confident in the revenue;
2. Ensure DRT Operator is confident with alternative services;
3. Ensure a High Level of Marketing to the Concept because users often don’t understand how to use DRTs;
4. Raise Fares to Pay for Higher Quality Service;
5. Target Workable Catchments – under-developed areas and overly circuitous street structures should be avoided since this can increase costs (Enoch, Potter, Parkhurst, & Smith, 2004).

Davidson (2014) in his research discusses that the DRT transport solution was often chosen for rural areas where there are few passengers spread among small settlements. One of the livable examples is a system in Lincolnshire, the UK, which is many-to-many substitute DRT system, that was implemented by the government in order to provide mobility to the region where conventional public transport was too expensive.

Still, it is crucial that DRT systems are commercially unstable because it is very difficult to understand the profitability of the enterprise. As it is defined by the Workshop 4 Report – Realizing the potential benefits of DRT, the most surviving type of this system is a highly-subsidized company. High costs of implementation do spoil the sustainability of the whole idea. The statistics show that out of all DRT systems ever made, only 50% have survived (Currie & Fournier, 2017).

The system of DRT can operate using different scenarios: it could be an old-way of Dial-a-Ride or a new way of application or web-based platform that allows to an end-user to leave his or her demand for a mobility service and a dispatcher (or a program) shares the data or a prepared route to the drivers.

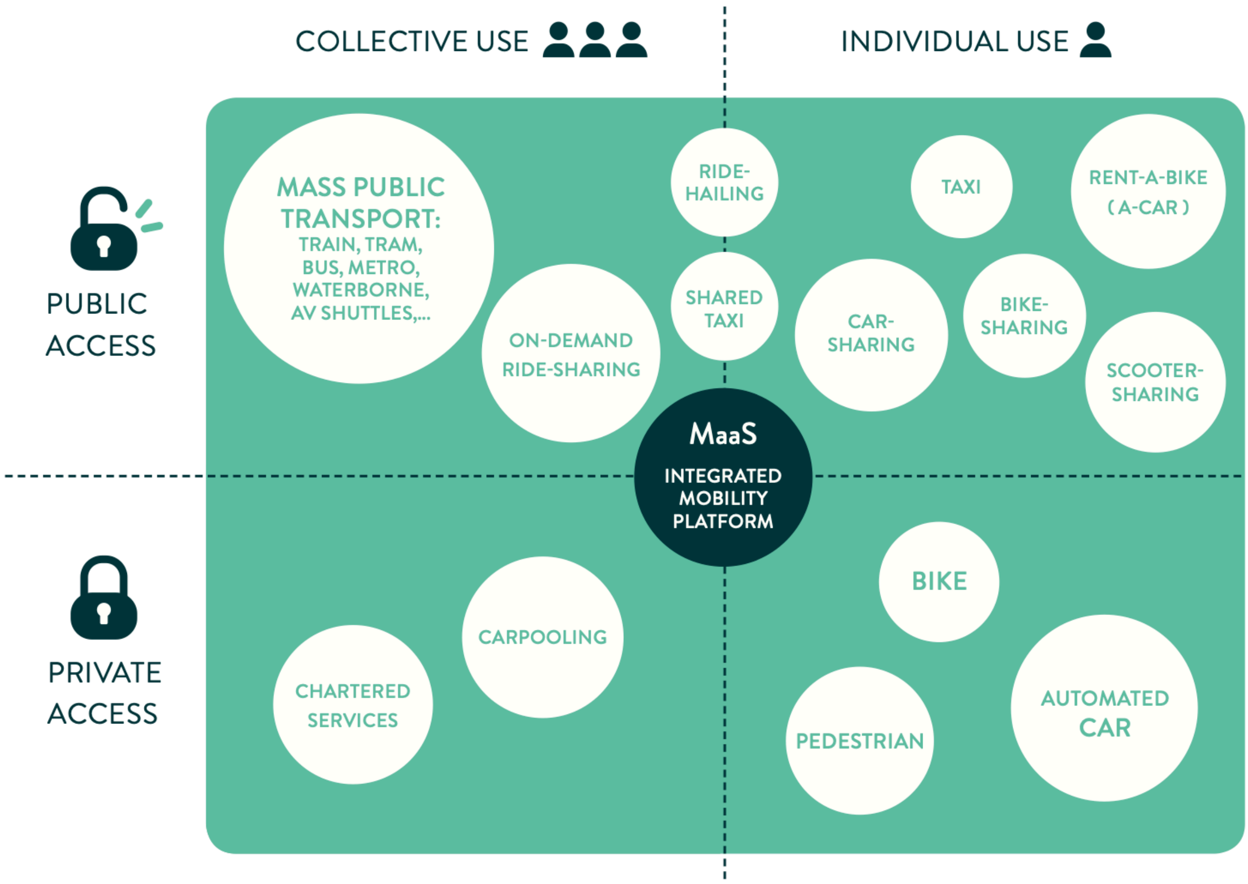



Figure 1. UITP Scheme of Public Transportation (UITP, 2019)

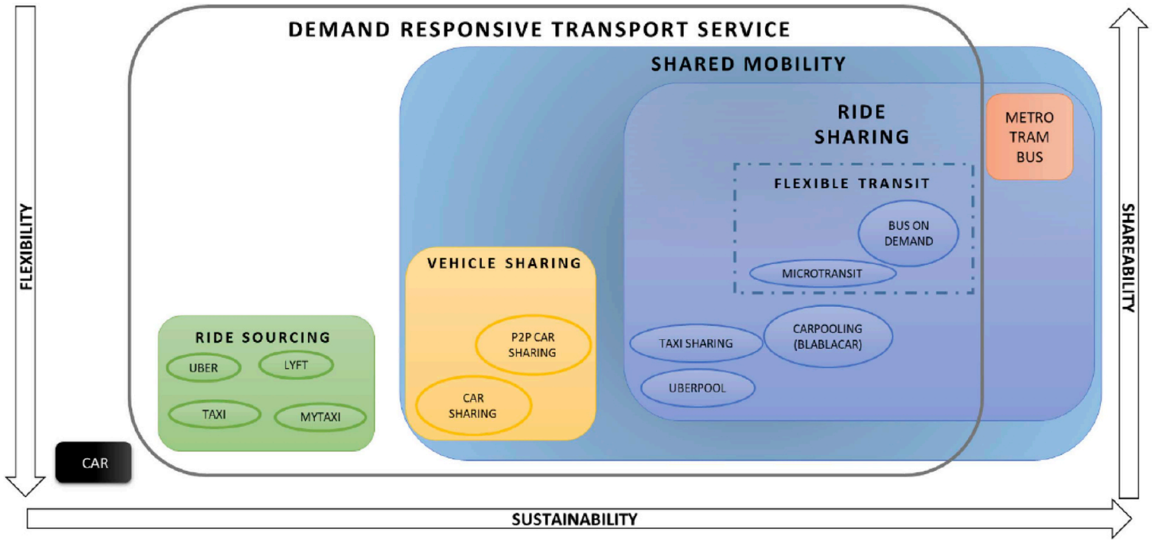



Figure 2. Classification of Demand Responsive Transport (Inturri G., 2017)

As shown in Figure 1 and Figure 2, the definition of on-demand services or flexible transit services by researchers and International Union of Public Transport (UITP) is presented. This means that they are being a part of the talk of modern research and decision-making of the sphere.

Technologically, DRT systems do need several points to be defined in order to make them work: from the dispatcher system that collects those demands for mobility, to ticketing systems and vehicles. Figure 3 represents the main parts of DRT System technology that allow it to be more responsive to the demand. As for vehicles, it is suggested to use a maximum of 2 types of vehicles in such systems, which could be small buses or mini-vans (Currie & Fournier, 2017).


Figure 3. The Demand Responsiveness of Public Transport *(Nelson, Wright, Ambrosino, & Naniopoulos, 2010)*

However, the systems of DRT face numerous challenges, that make them not a popular decision when decision-makers start making choices in the sphere of public transport organization. Currie shows that only 52% of DRT survived. It is obvious that the main challenge for them is the economy: DRTs cannot survive without subsidy from the government because they face the high-cost problem (Currie, Thredbo 16 - International Confernce Series on Competition and Ownership in Land Passenger Transport, 2019; Bruni, Guerriero, & Berladi, 2014). In developing countries DRT seeks profit, while in developed ones social objectives tend to dominate. Therefore subsidy is essential – an example of DRT system which started in 1983 was able to survive in the 1990s only because of the money from the central government (Davison, Enoch, Riley, Quddus, & Wang, 2014).

Unfortunately, governments of different countries underestimate the importance of mobility for their citizens. For example, the European Union with 75% of rural/non-urban areas focuses on the development of such a mean of transport. As the responsibility for mobility is located in different levels of governmental structure from one to another Member State of the EU, the regional framework of mobility is the most popular solution (17 out of 28 Member States). Still, Latvia is the only country that pays attention to the rural mobility question, while Estonia, Hungary and Slovenia do not have any end goals. Other countries have no policies at all. As a result, there is a “policy vacuum” in the sphere of rural mobility in the EU (Finn & Nelson, 2019).

Still, examples of successful policy-making in the sphere of DRT exist. The regulatory base in Great Britain has created numerous ways of providing such services to the public: first: being a local bus service, which is registered through Traffic Commissioners for the Bus Service Operators Grant and receives a subsidy; second: community transport organization provides services on a non-profit base; third: having a vehicle, which is registered for hiring could have designated points of pick-up (Davison, Enoch, Riley, Quddus, & Wang, 2014).

As it was mentioned above, DRT systems have several ways of interpretation. On the one hand, this fact allows individuals, governments and actors to fit in the perfect solution for their specific case and territory. On the other hand, no strict guidelines for implementing DRT systems, avoiding risks, can be found in the literature.

**Methodology**

In this work the main focus is understanding the current transportation situation in New Moscow, which will help to gain a deeper insight into the mobility needs of the residents and to determine an approximate demand in general.

In order to understand the territory, spatial distribution and the current situation in mobility, spatial analysis was performed using a dataset from the NextGIS repository, which contains all the statistics on roads, public transport, housing, etc. For this purpose, the public transport and housing layers were used.

For a better understanding of the spatial distribution of housing, a map was designed with a hexagon of 500 m in length on each side. However, there was a need to transfer the data from households into the number of inhabitants. A calculation of transport demand with the use of data on the number of inhabitants in each settlement was performed.

For the calculation of transport demand per day, a methodology by Japan International Cooperation Agency (Japan International Cooperation Agency, 2012) was used. In the methodology, a simple formula to forecast the demand with a trip rate model was proposed:

$$G^k = P * r^k$$

Where $G^k$ - the number of person trips by trip purpose,

$P$ - the quantity of population aged 5 years and more,

$r^k$ - trip rate by trip purpose.

In addition, a trip rate by trip purpose data were also mentioned in the methodology.

**Table 1. Trip Rate by Trip Purpose (Japan International Cooperation Agency, 2012)**

| Trip Purpose | Trip rate (trips per person) |
|---|---|
| To Work | 0.31 |
| To School | 0.21 |
| Business | 0.02 |
| Private | 0.10 |
| To Home | 0.63 |
| Total | 1.27 |

With the use of calculated data, it was easier to understand the demand zones for transportation in general and then to predict where to propose new modes of mobility.

After calculation of estimated mobility demand, methodology, suggested by Wright to suggest the mean of transport for the supply (Wright, 2013) was used. His main proposition is to use the ratio of passenger-km in order to predict a transportation mode. The methodology is shown in Table 2.

In order to calculate passenger-km, a simple formula of transport work parameter was used: multiply the number of estimated passengers (trips per day) by their average trip length. As there is a lack of access to the approximate trip length of each passenger, an average data from the Transport Behavior research (Muleev, 2015) was. In the research Muleev mentioned that the average trip length of minibus passengers is 14 km, while for a bus is 15,5 km. It is suggested to use an average of these two parameters, which is 14,75 km.

To calculate passenger-km per hour, the quantity of 20 hours, which is an average working time of conventional bus routes in Moscow (not including Night Buses) was used.

**Table 2. Service design recommendations for choice of vehicle,** *(Wright, 2013)*

| Passenger - km / hour | Vehicle choice |
|---|---|
| Less than 10 | Taxi |
| Between 10 and 20 | Taxi(s) or a flexible minibus (DRT) could be used - the choice will depend on availability and relative costs locally |
| Between 20 and 50 | Flexible minibus should be provided with a lower degree of route flexibility at the higher end of the range |
| Greater than 50 | Largely fixed route bus service should be provided with limited deviations |

## New Moscow Territory and Mobility analysis

*Part 1. Territorial Context*

New Moscow territory is a part of the City of Moscow, which occupies 1480 $km^2$ of territory and 21 municipalities, divided in two administrative districts (okrug's): Troitsky and Novomoskovskiy.

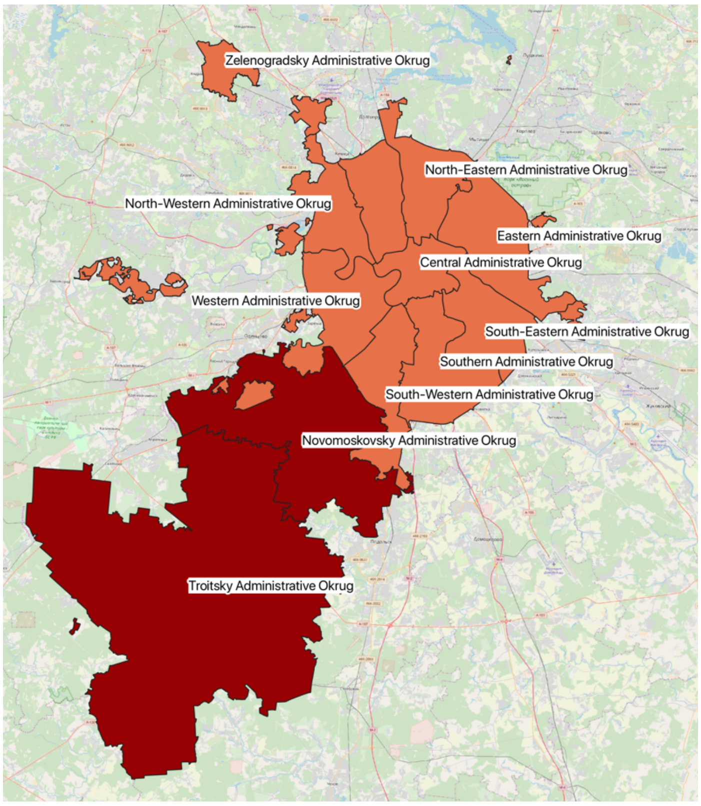



Figure 4. Map of Moscow with Troitsky and Novomoskovskiy Administrative Okrug's highlighted in red (QGIS)

This territory is populated by 360000 individuals - 235 thousand for Novomoskovskiy and 125 in Troitsky administrative districts – which represent the growth in 1,5 times from 2012. The same situation with housing – from 20 to 30 million square meters are located here now and more than 8 million will be built till 2021 (Kompleks gradostroitel'noy politiki i stroitel'stva goroda Moskvy (Moscow City Building Policy Committee), 2020).

In order to provide a broad analysis of the chosen territory, a dataset, uploaded from the NextGIS system, which includes all the data layers for GIS of Moscow such as streets, boundaries, buildings, public transport, etc, is used. All the data will be focused on the territory of New Moscow Administrative districts (Clip function in QGIS).

*Part 2. Mobility Supply evaluation*

Nowadays New Moscow has 93 routes that are operated by state companies Mosgortrans (Moscow City Ground Transport Operator – operates Buses and Tramways), MosTransAvto (Moscow Region Bus Operator) and other private companies, which provide connection inside the area. However, citizens living in a distant area do not have access to these routes or have to make long trips to this mobility option. Individuals who can get to the mobility, do spend at least one hour commuting to the old-city border (inside Moscow City Ring Road – MKAD).

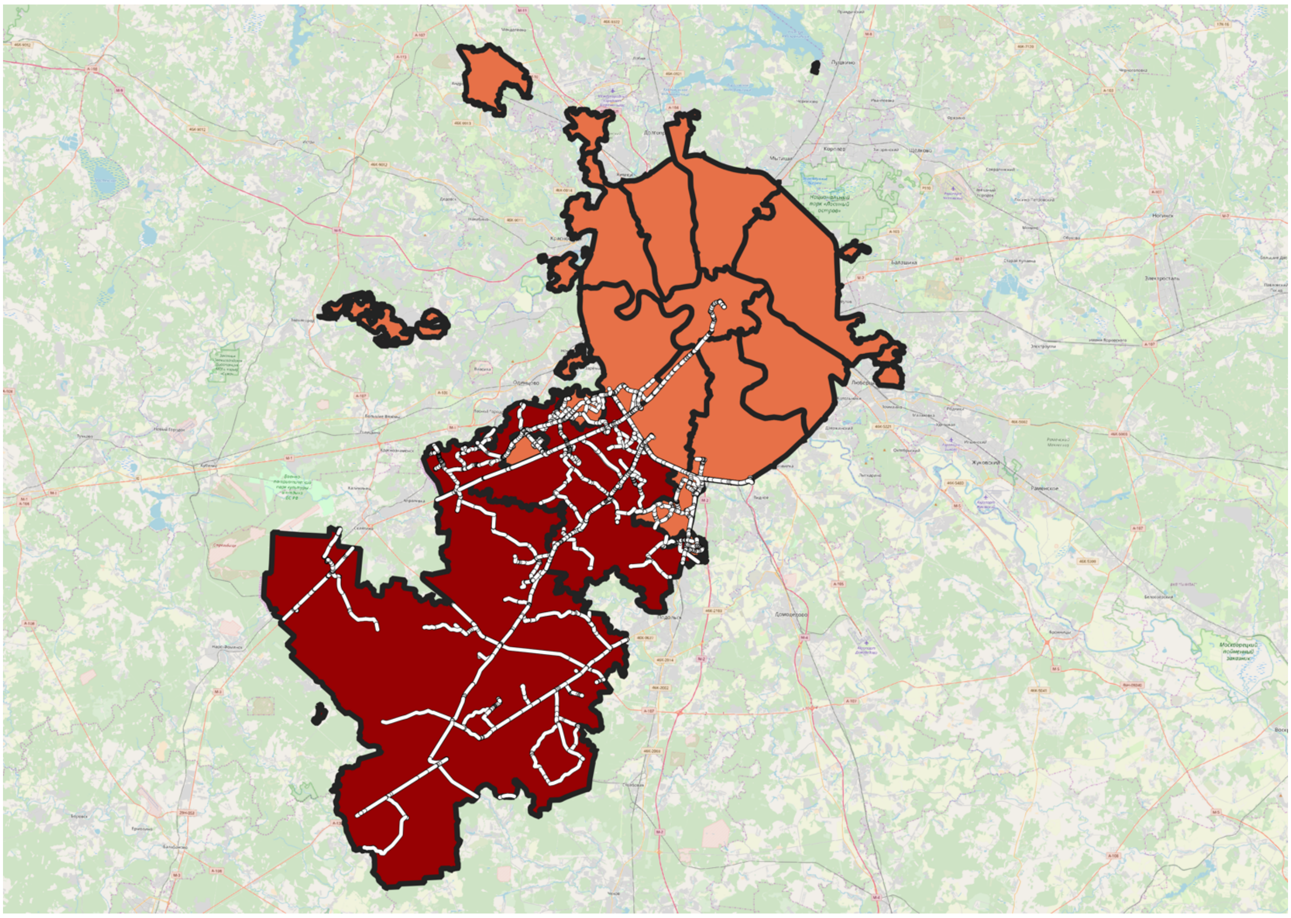


Figure 5. New Moscow Public Transport Routes Network (QGIS and NextGIS)

As shown in Figure 5, the main routes are distributed in the Novomoskovskiy district, and the main highways - Kievskoe, Kaluzhskoe and Varshavskoe – are used to provide the connection to the old Moscow. The routes get individuals mainly to the closest metro stations such as Tepliy Stan, Salarievo, Yugo-Zapadnaya. Only one route – Night 11 – provides a connection to the city center.

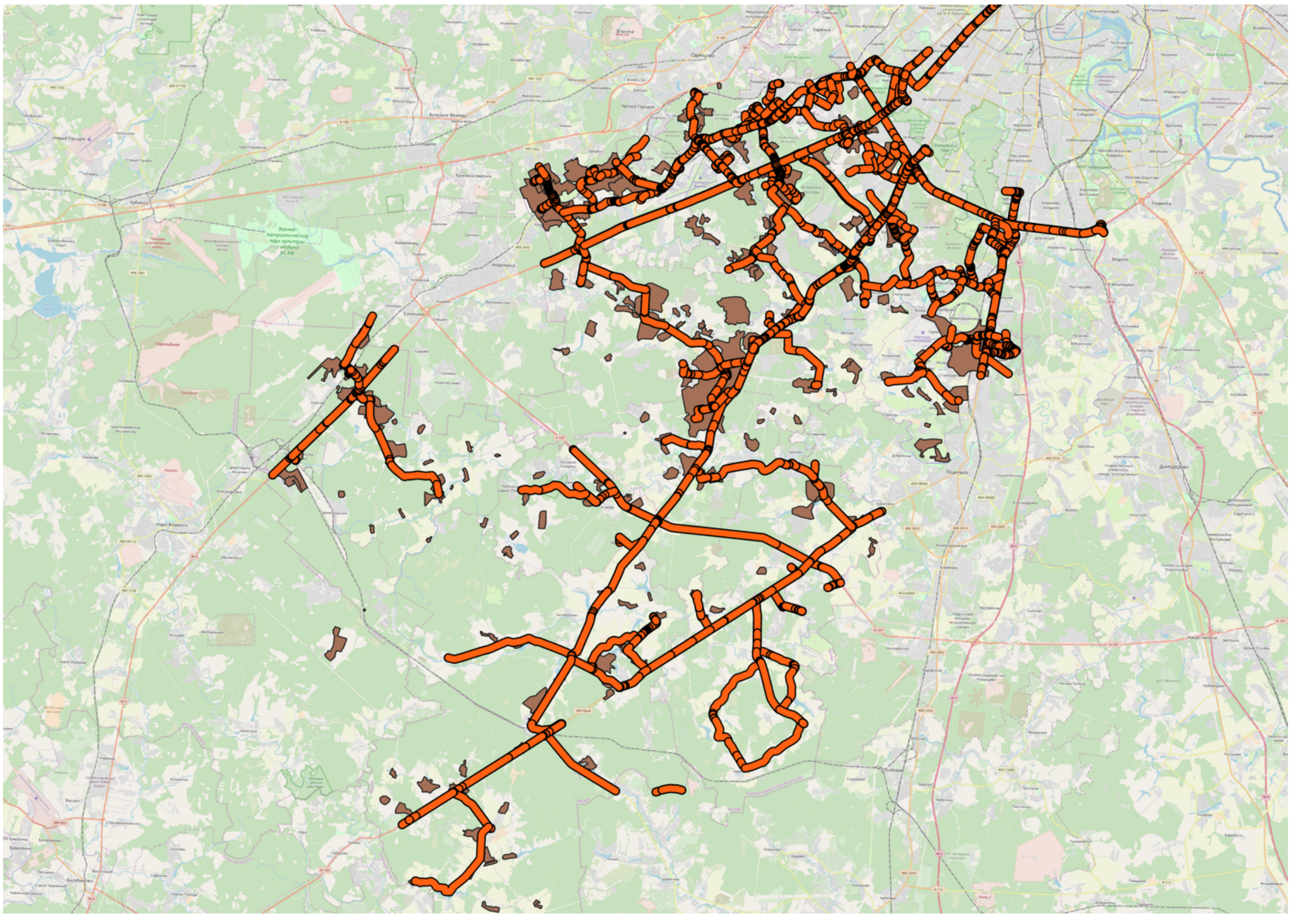


Figure 6. Map of routes and settlements (QGIS and NextGIS)

As revealed in Figure 6, several settlements do not have any connection to the public transport at all in both Administrative District – a detailed map of these settlements is shown in Figure 7. This implies that inhabitants of these territories are using other modes of transport to commute to the working places - private cars, carpooling and carsharing – which is increasing the traffic and creating congestion at the highways and in the city.

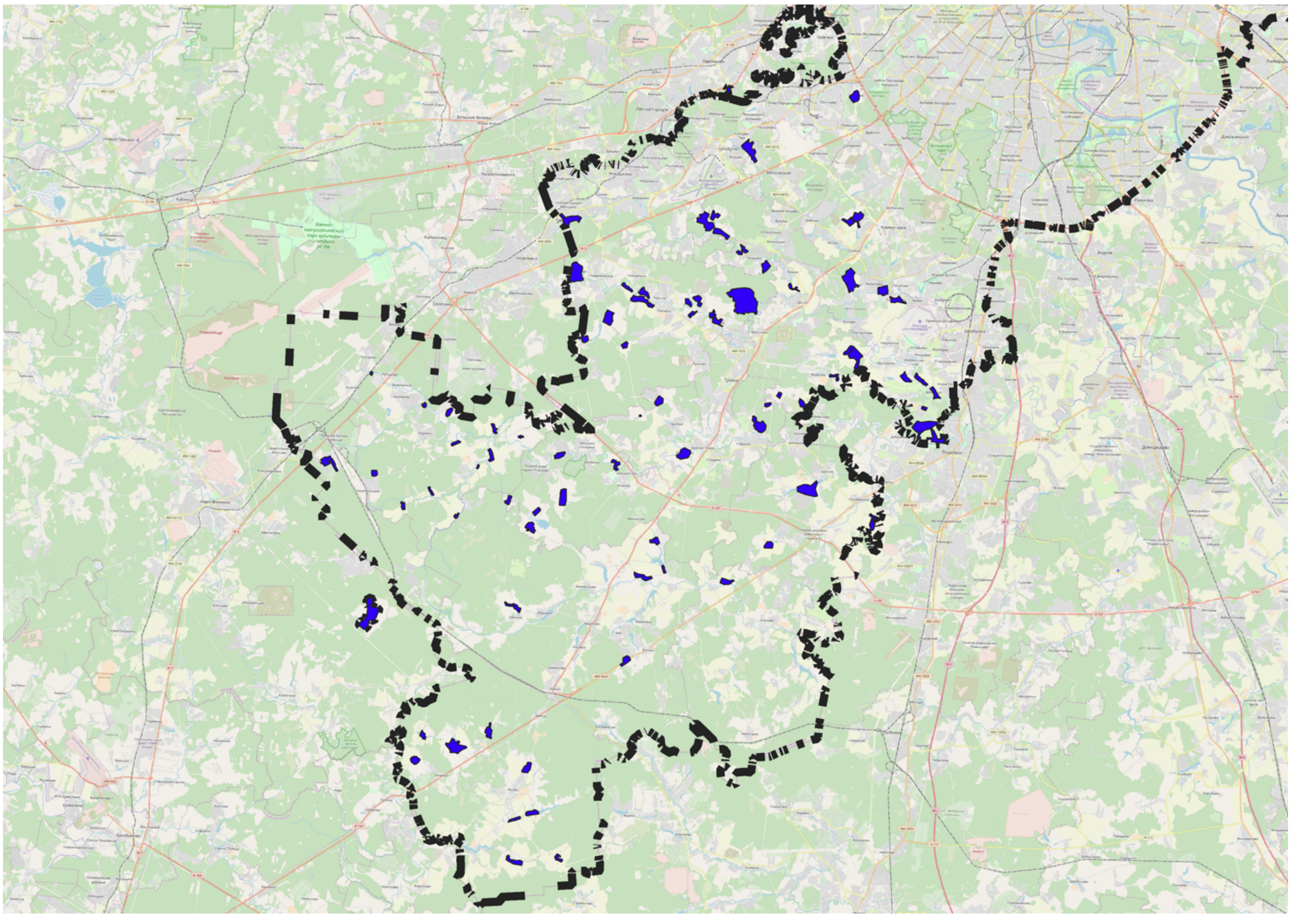


Figure 7. Map of Settlements that do not have connection with public transport (QGIS and NextGIS)

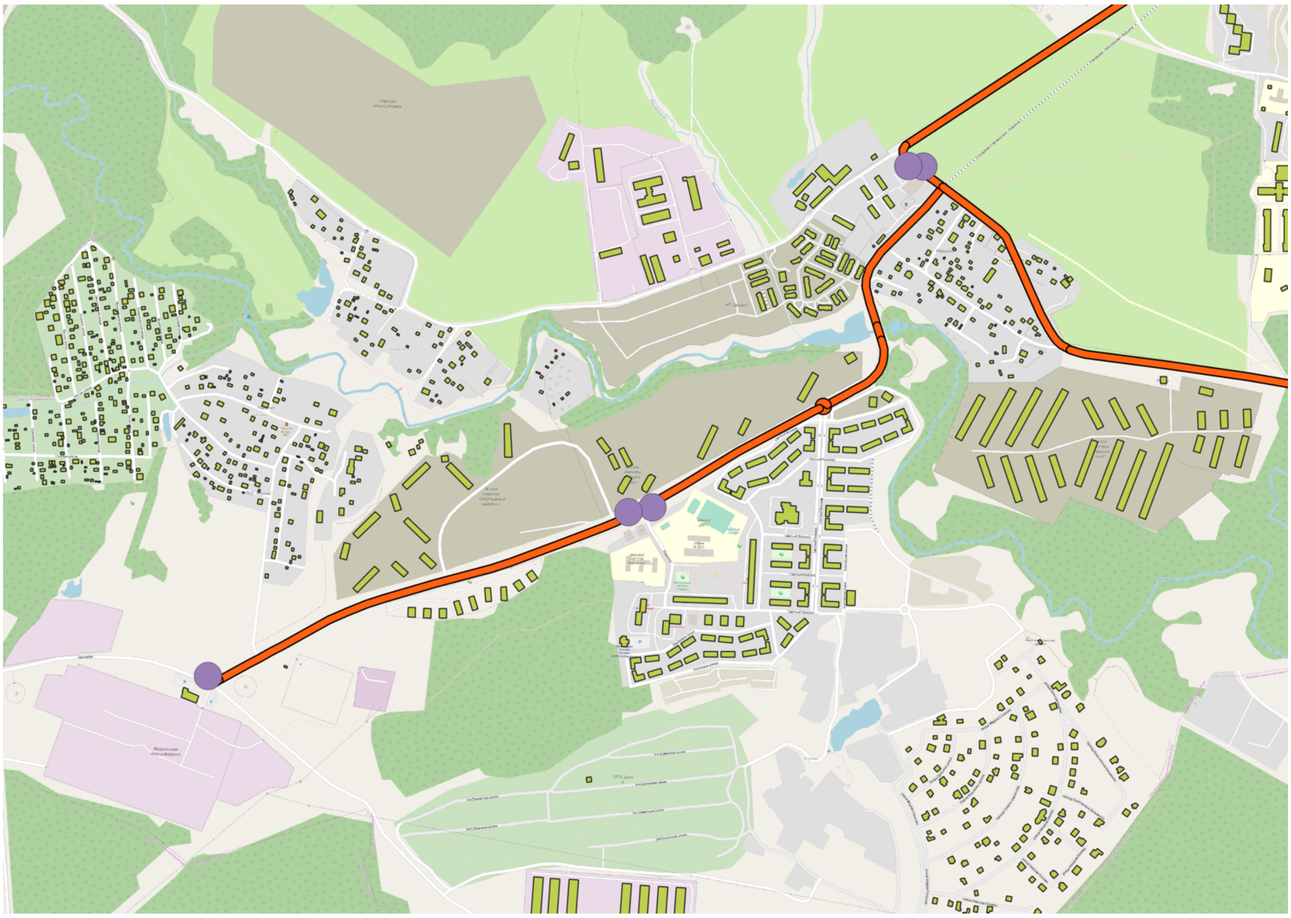


Figure 8. Village of Marino, served with public transport (QGIS and NextGIS)

Figure 9. Village of Elino, not served with public transport (QGIS and NextGIS)

**Table 3. Calculations of Mobility Data in New Moscow**

| | | |
|---|---|---|
| Total Routes | 93 | routes |
| **Part 1. Housing** | | |
| Total number of Blocks | 80494 | building |
| Blocks in public transport pedestrian accessibility area | 29581 | building |
| Blocks NOT in public transport pedestrian accessibility area | 50913 | building |
| Percentage of Blocks in public transport pedestrian accessibility area | 36,75% | |
| Percentage of Blocks NOT in public transport pedestrian accessibility area | 63,25% | |
| **Part 2. People** | | |
| Total number of Inhabitants | 360000 | people |
| Inhabitants In public transport pedestrian accessibility area | 132300 | people |
| Inhabitants NOT in public transport pedestrian accessibility area | 227700 | people |
| **Part 3. Settlements** | | |
| Total number of Villages | 197 | villages |
| Villages in public transport pedestrian accessibility area | 104 | villages |
| Villages NOT in public transport pedestrian accessibility area | 93 | villages |
| Percentage in public transport pedestrian accessibility area | 53% | |
| Percentage NOT in public transport pedestrian accessibility area | 47% | |

The data for Table 3 were collected using different functions of QGIS and Excel. For “Total Routes” all the public transport routes which were not connected with the researched territory, e.g. are operating inside the Moscow Ring Road, were manually deleted. Data for Part 1 were collected with clipping from all the buildings in Moscow with New Moscow boundaries, while “Blocks in public transport pedestrian accessibility area” was calculated with the use of 500 meters buffer, which is a normative standard for Moscow Public Transport accessibility. Calculations of Part 2 were performed with the use of proportion received after calculation of Housing in public transport pedestrian accessibility area. Calculations of Part 3 were made by clipping all the settlements, located within New Moscow boundaries with buffer form Part 1 of the Table 3.

As presented in Table 3, 104 from 197 settlements, located in New Moscow have access to mobility: all of them are those, that are located close to the main axes of transportation and high-dense mobility system close to the Old Moscow boundary. The list of settlements is determined in Appendix 1. Figures 8 and 9 show us that not very dense village of Marino is supplied with transportation, while Elino is not. As can be seen from the calculations in Appendix 1, while most of the settlements are in the zone of mobility, approximately 26% of the population is somehow are supplied with mobility. Appendix 2 includes a list of settlements, which have no access to public transportation at all.

The data about routes validations for the year 2018 is included in Appendix 3. On average each route carries 2537 passengers daily or in total 144535 (for 57 routes managed by Mosgortrans) which is somehow correlating with the data from Table 3 on inhabitants living in public pedestrian accessibility area. However, this is not a full picture because the other 36 routes are served by Mostransavto and private companies and the data is not accessible.

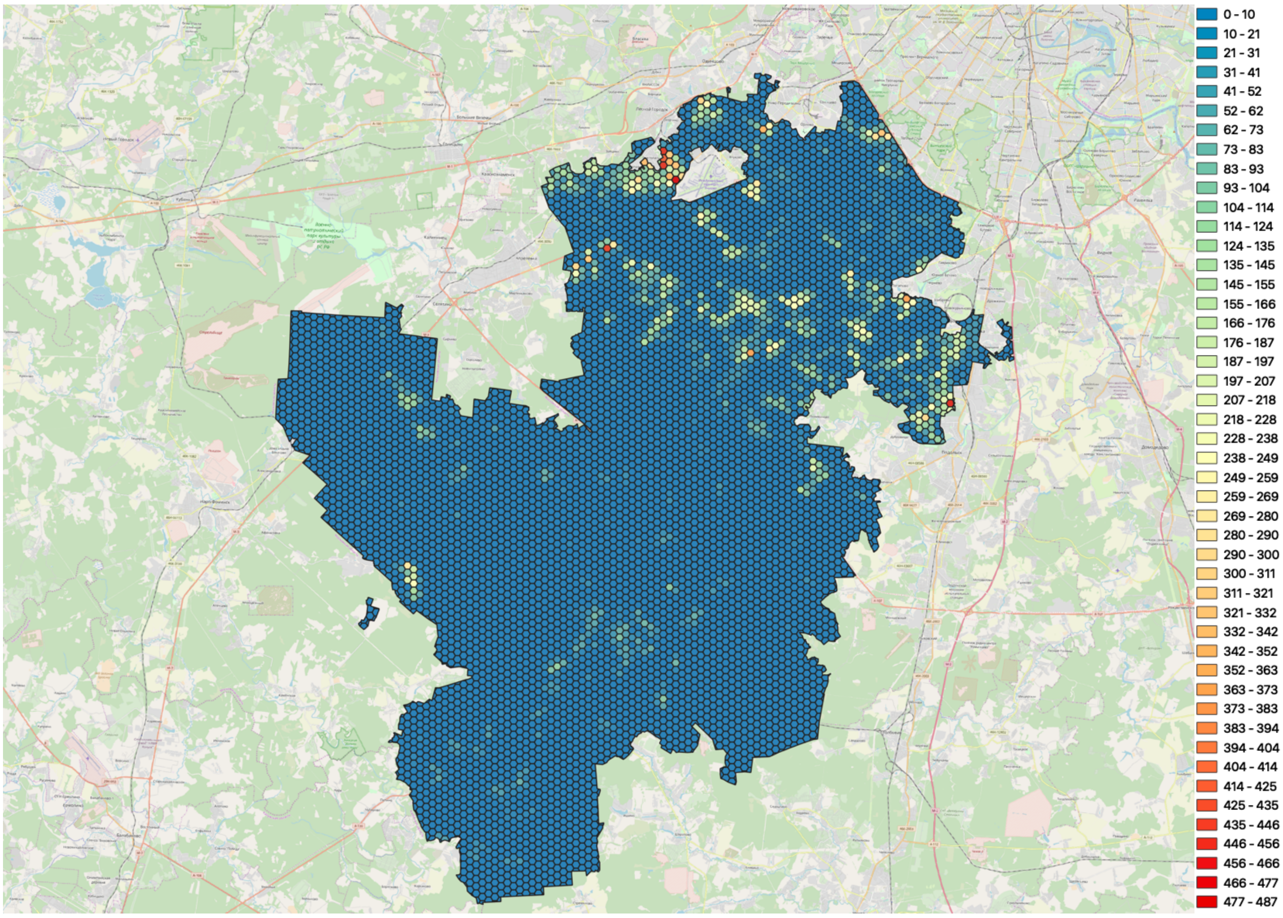



Figure 10. Hexagonal map of housing in New Moscow (QGIS and NextGIS)

Figure 10 gives us a better understanding of the distribution of population on the researched territory: the main zones of living are located closer to the Old Moscow border.

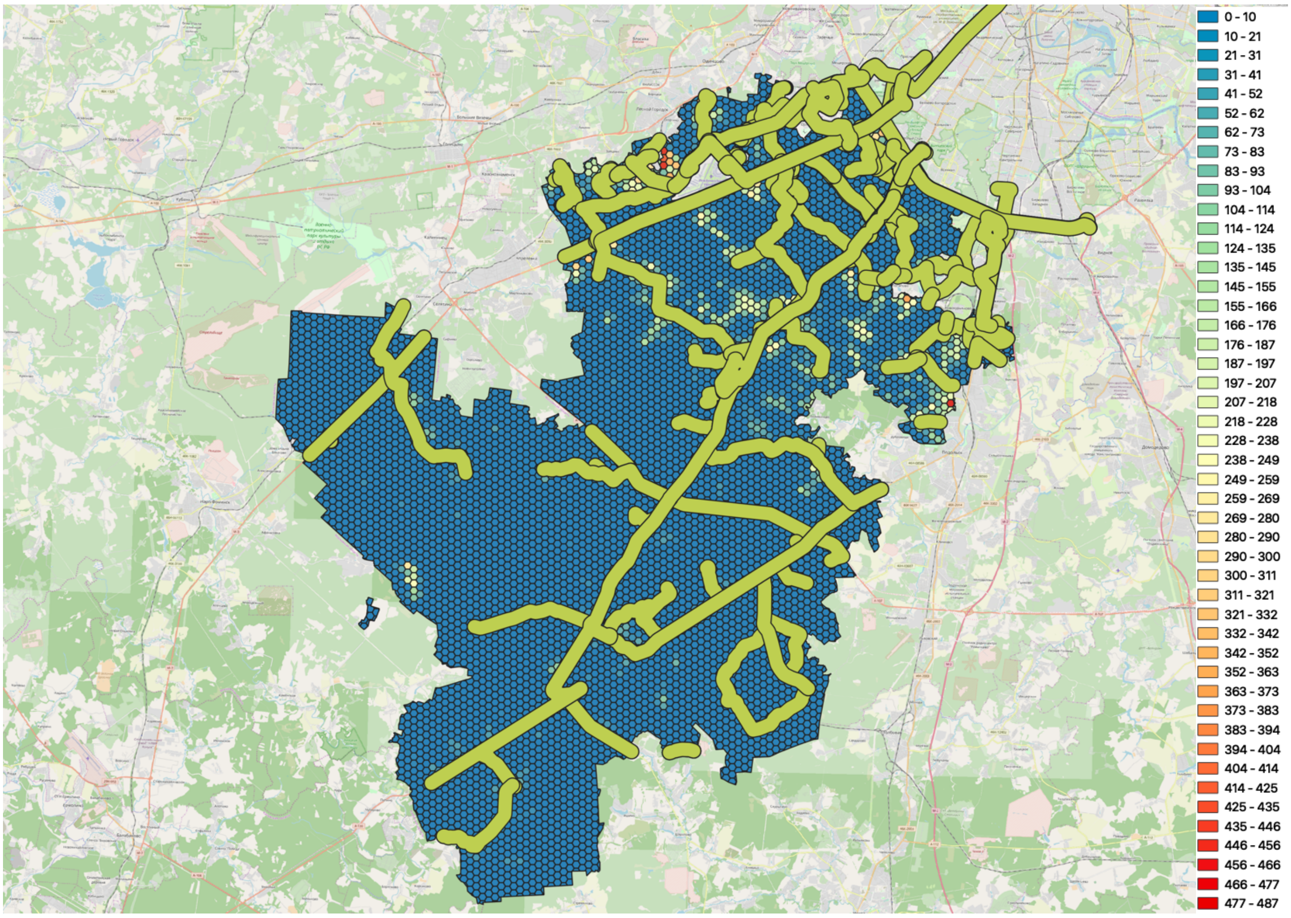


Figure 11. Hexagonal map of housing with Public Transport Access Area (QGIS and NextGIS)

Figure 11 allows us to see which parts of the New Moscow territory lack access to public transport.

The discussion above demonstrates clearly that the mobility question in New Moscow is a challenged one: while connecting almost a half of settlements to the city with several routes, operated by Mosgortrans, Mostransavto and private companies, other half lacks any connection with the Old Moscow. There are several territories that have no access to mobility, which could be considered as a mistake in planning, that should be corrected in the future.

*Part 3. Mobility demand prediction*

In order to understand the demand in the settlements that have no access to the public transport the calculation with the use of the methodology described before was performed. The total number of trips will be enough to understand the current state of demand at the territory. The results of the calculation are shown in Figure 12.

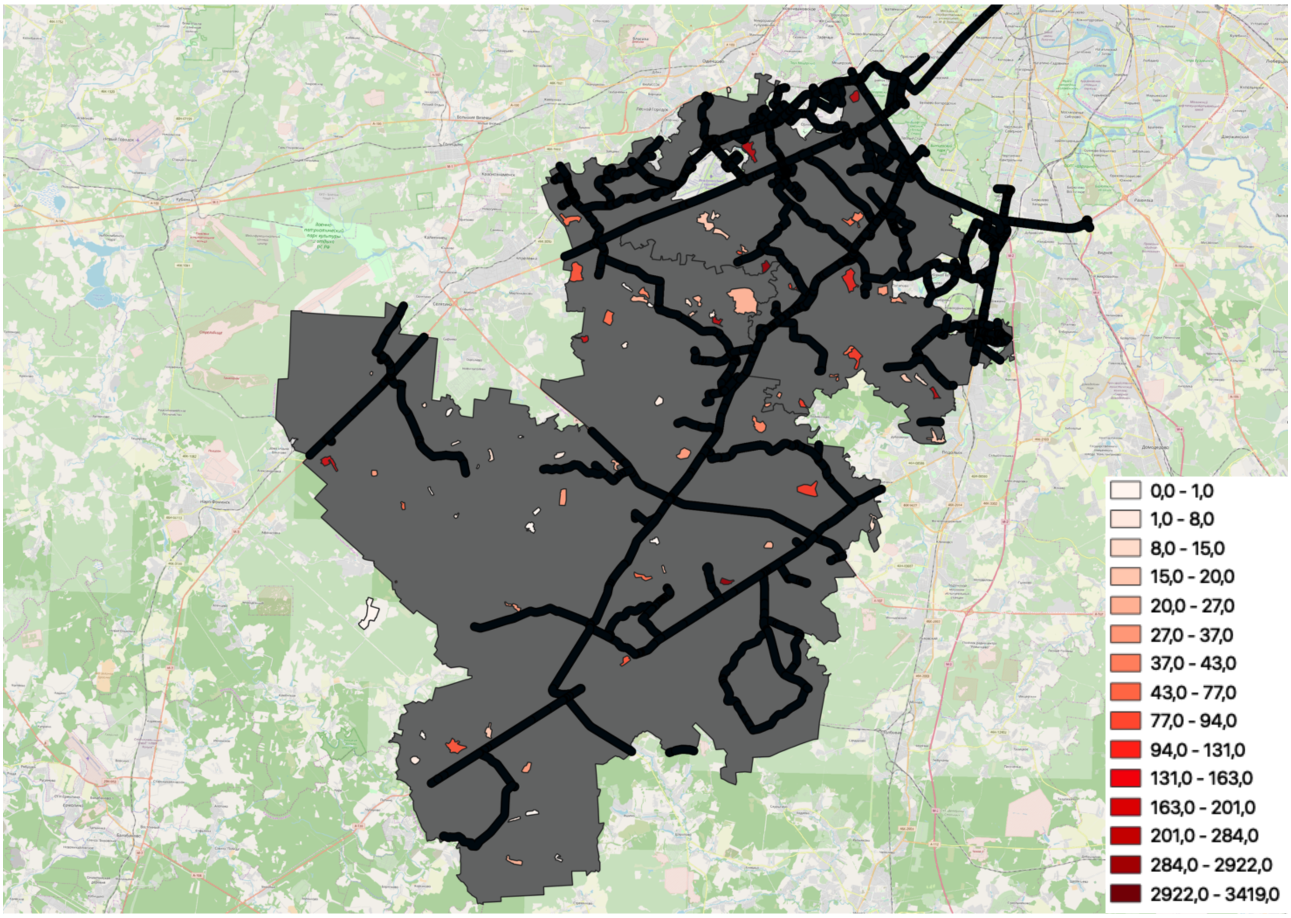



Figure 12. Visualization of Total Transport demand in settlements outside Public Transport Accessibility Area (QGIS and NextGIS)

As can be seen in Figure 12, there are several groups of settlements with the demand for transportation. These settlements are grouped in Figure 13.

Grouping of settlements was performed based on the close location to each other and being distant from current transportation routes. The current groups with the list of settlements and estimated transport demand are presented in Table 4.

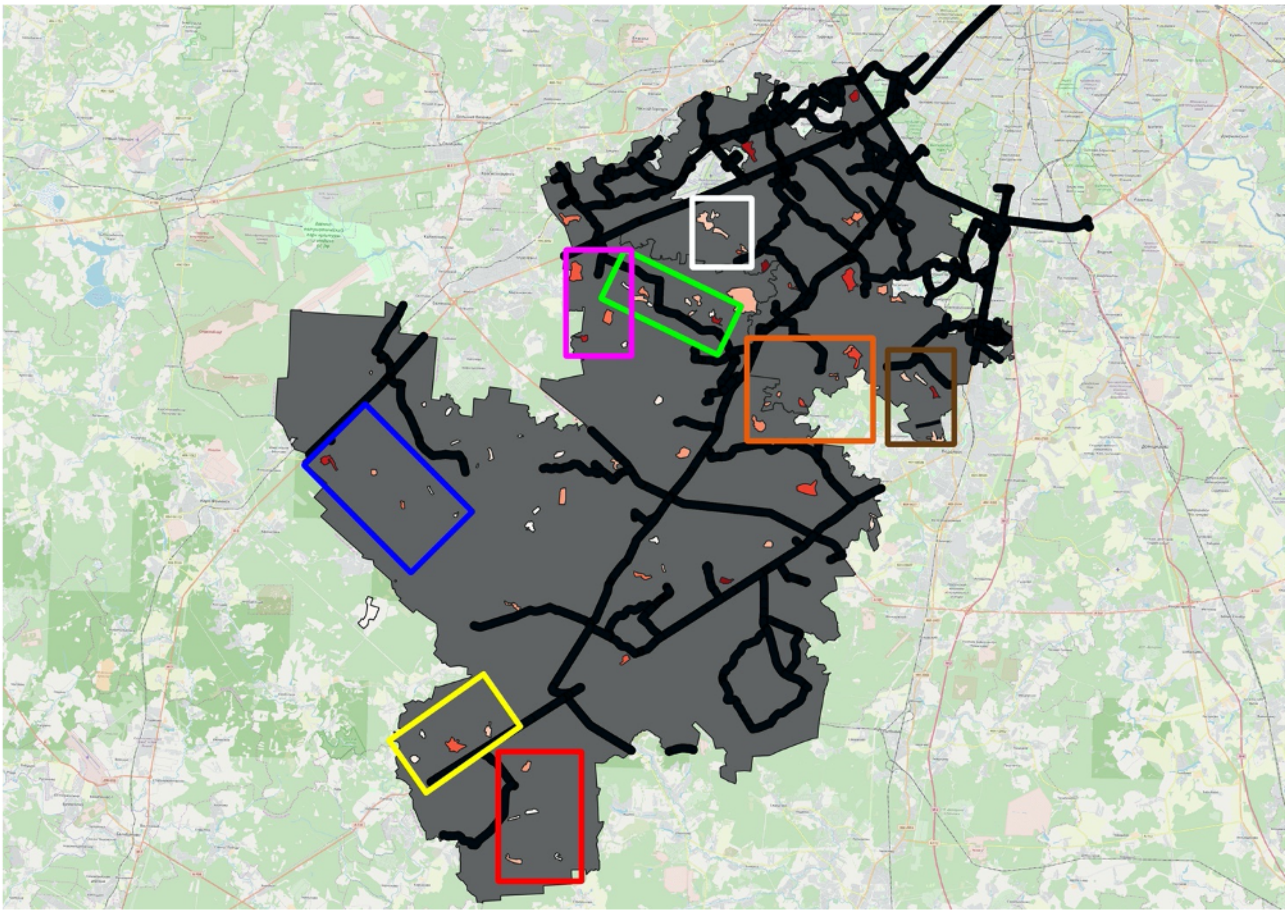


Figure 13. Grouping of Settlements

**Table 4. Grouping of Settlements**

| | Settlements | Total Trips per day, estimated |
|---|---|---|
| Group 1 | Krucha, Spas-Kuplya, Teterinki, Gornevo, Dmitrovka | 66 |
| Group 2 | Vasynino, Lopatino, Klenovka, Lykovka | 120 |
| Group 3 | Khutora Gulyaevi, Zosimova Pustin', Shelomovo, Khmyrovo | 293 |
| Group 4 | Devyatskoe, Tarasovo. Sal'kovo, Alkhimovo | 306 |
| Group 5 | Kharino, Esenino, Staroselie, Serednevo. Burtsevo, Golenishevo | 3094 |
| Group 6 | Konushkovo, Gorchakovo, Zhukovka, Fominskoe, Klokovo, Uvarovo. Gubtsevo, Khatminki, Roznovo, Pyatovskoe | 415 |
| Group 7 | Kuvekino, Vlasyevo, Evseevo, Raevo, Novinki, Pyxchevo, Kiselevka | 461 |
| Group 8 | Nastasino, Elizarovo, Kamenka | 342 |

As shown in Table 5, there is a group with a high number of estimated trips – more than 3000, and groups with less than 500 estimated trips. With the use of methodology, described by Wright it is possible to suggest a mode of transport for each group of settlements. In order to understand the length of the route, a method of the shortest route between settlements to the nearest existing public transport route is used.

**Table 5. Calculations for Suggested Mode of Transport**

| | Total Trips per day, estimated | Length of Route, km | Passenger-km per day | Passenger-km per hour | Mode of transport by Wright |
|---|---|---|---|---|---|
| Group 1 | 66 | 38 | 973,5 | 49 | DRT |
| Group 2 | 120 | 20 | 1770 | 89 | Bus |
| Group 3 | 293 | 35 | 4321,75 | 216 | Bus |
| Group 4 | 306 | 20 | 4513,5 | 226 | Bus |
| Group 5 | 3094 | 14 | 45636,5 | 2282 | Bus |
| Group 6 | 415 | 33 | 6121,25 | 306 | Bus |
| Group 7 | 461 | 31 | 6799,75 | 340 | Bus |
| Group 8 | 342 | 24 | 5044,5 | 252 | Bus |

Table 5 provides the results that there is only one zone – group 1 - that should be provided with DRT, while others have enough demand (by Wright) in order to start a conventional bus route.

The discussion above clearly demonstrates that the territory of New Moscow possesses a large number of settlements – some of them do have access to the mobility, some – do not have this possibility. Spatial analysis was used to identify the isolated areas of the mobility, calculate the trip demand and choose transport solution for each case.

*Part 4. DRT System proposal for New Moscow*

Considering the results of the discussion above, a proposal of the DRT system will be based on the requirements and definitions made by Currie (2017) and Inturri G. (2017) mentioned in the literature review.

As far as there are several routes of conventional public transport of Moscow in the area, there is no need to provide a DRT service to connect it to the Old Moscow, that is why the system will be an Interchange DRT. While connecting different settlements with conventional routes, they will be a many-to-many DRT with EVAR system because there is always a chance of new demand at the taken time by an end-user from a point which has not been served with the route. Finally, this is an Interchange many-to-many EVAR DRT system.

It is suggested to use existing automobiles such as Mercedes-Benz Sprinter (18 seats).

Figure 14. Mercedes-Benz Sprinter. Moscow Transport Livery *(RIAMO, 2016)*

One of the possible economic benefits of the system for the Moscow Transport System could be the growth of users on the routes from and to New Moscow because new territories and settlements will be connected. The promotion of mobility could also lead to the growth of inhabitants, which could also lead to a benefit for the economy in prospective.

**Key Findings**

DRT systems could be described in several ways, which depend on their locations, type of service, etc. However, it is possible to define it as "a system or a service which provides mobility with the use of flexible modes and small means of transport like cars, caravans or mini-buses". With several approaches to organizing this mode of mobility, it is possible to fit it to any rural or remote area, which has a demand for transportation.

As a result of the territory analysis, New Moscow territory has a demand for the DRT. This territory possesses a big number of settlements which now are the parts of the City Tissue. While being a part of it, some of its settlements are not connected to the core part by any means of public transport.

The number of routes and carried passengers showed us that current capacities are not enough to carry the individuals, who live in this territory: 93 lines of official Moscow Ground Transport operator Mosgortrans, Mostransavto and private operators are not enough to cover the New Moscow. This network provides only a half of the inhabitants with an approachable opportunity of mobility, while other inhabitants are using other modes like unofficial and sometimes dangerous minibuses, carsharing, carpooling and taxis. However, this is a part of the Capital and it is of high importance for the Moscow Government to provide the mobility to these settlements, in order to give individuals a possibility of connection with and within the City.

The methodology, used in the research, provided a data of the mobility demand on the territory. As a result of a spatial analysis, eight groups of settlements with low level of supply and a high level of demand were determined. With the use of methodology on mode prediction by Wright, a mode of transport for each case was suggested. Only one group could be provided with DRT, while other groups could be supplied with conventional buses.

The main limitation of the research was the lack of data. However, with the help of Center for Moscow Traffic Organization, it was possible to obtain the data on validations, which is used in the spatial analysis. In addition, the problem of no public gathered data on Moscow Region Ground Transport carrier lead to the longtime of verification of routes with the use of open sources. The lack of data on population in the NextGIS also lead to the several steps of data collection and verification.

The significance of the study is in raising the question of the mobility supply in the New Moscow territory, which nowadays is not an often-raised problem by the decision-makers. The analysis provided the accurate data on current situation, which could be used as a basis for round of meeting and steps to the solution of the problem.

The results of the analysis will be used in the prototype use in order to determine routes and find the best option for this territory - bus or DRT – and will help us to verify the solution, proposed by Wright. In case the DRT option will be a solution, it is recommended to use the ideas of the DRT System proposal for New Moscow.

## Project proposal

In order to solve the problem, which was addressed in the Research Study of The Thesis – understanding where to use fixed or flexible modes of mobility, in this part of the work a detailed description of the solution – digital prototype for transport mode choice – is presented.

The prototype is designed to solve the problem of research and choice of transport supply for the territory. As far as mobility is a global concept, which is up-to-date for any part of the globe, the solution, presented in this part, could be used in any part of the world. As far as the software works with open-source data, it could be used by the broad public. However, the main stakeholders or users of this software could be decision-makers, transport engineers, state representatives and active citizens.

The project deliverable is a software, compatible with private computers operating on Windows 8 or 10 and connected to the Internet.

The prototype itself proposes a simple way of research of transport supply possibilities with a choice between conventional bus routes and DRT systems. It is important to mention that all the calculation now is using the data, which is relevant for Moscow. It is possible to make changes for applying the software for other territories.

*Specifications*

1. Route data input
2. Route data calculation
3. Route options calculation

*Prototype design*

In order to address the problem correctly, there were several tryouts of the prototype. The first one provided the simple calculations of costs and revenues for bus or DRT with the use of data, entered by the user, and suggested, which mode of transport is to consider as a choice for the specific route. However, this was not a useful solution for the problem, as far as the user had to make several attempts in case, there was a need for a route system.

The second version of the prototype was developed in the way of making it easy-to-use for anyone. With the use of this version of the software, the user is able to put the points, which are necessary to connect and then to receive the result of calculations. In the end the software presents a spreadsheet with the data on park (quantity of vehicle), costs, revenue and total profit (loss) for the project with an interactive routing system. This version of the prototype is used in this project proposal.

*Prototype functionality*

As it was mentioned before, the second version is currently being used as a solution for the problem, mentioned in the Thesis. In this part the full way of prototype work will be described.

As the user opens the software, the starting screen represents the map of New Moscow, which is the case for the current project. The user is invited to locate points on the map, which it is necessary to connect with public transport modes. In this version the choice is between bus or DRT. At the moment user ends the entering of routing points, the button “OK” is pressed, the program starts the calculation of all possible routes between points and all economic parameters.

As a result of the calculation, the prototype presents the spreadsheet with an estimated number of passengers, park of vehicles for Bus route and DRT route, the cost for Bus route and DRT route, revenue for Bus route and DRT route, the total amount of money for Bus route and DRT route. The last column of the spreadsheet represents the routing options: each point on the map has its number and the program calculates routes between them. It could be route only with Bus usage, only DRT usage or both: program proposes routing, following the economic parameters of the project.

*Coding features*

In order to make a working prototype there was a choice between several coding languages: Python, JavaScript and C#. In the end, the choice of C# was made because of the easy way of creating forms. However, it is limited to the work of the system for only Windows OS.

There is no need to represent all the parts of code here. Still, we need to make clear several parts of the calculations.

Here is the code for path calculations (S. 2):

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading.Tasks;

namespace BestTransportSolver
{
public class PathInfo
{
public int[] Path;

public List<Route> Routes = new List<Route>();

public int PriceKm = 80;
public double CommercialSpeed = 33.0;
public int TicketPrice = 55;

public double RouteLength { get; set; }
```

```
public int Population { get; set; }

public double CostBus { get; set; }
public double CostDRT { get; set; }

public int BusPark { get; set; }
public int DRTPark { get; set; }

public double PAXBus { get; set; }
public double PAXDrt { get; set; }

public double TotalBus { get; set; }
public double TotalDRT { get; set; }

public double RevenueBus { get; set; }
public double RevenueDrt { get; set; }

public string Name
{
get
{
return string.Join(",", Path.Select(x => x + 1)) + " (" + WhatBest + ")";
}
}

public string WhatBest
{
get
{
return TotalBus > TotalDRT ? "BUS" : "DRT";
}
}

public PathInfo(int[] path, double routeLength, int population)
{
Path = path;
RouteLength = routeLength;
Population = population;

CalculateTotals();
}

public void CalculateTotals()
{
PAXBus = Population * 0.6;
PAXDrt = Population * 0.6;
var passengersAtPeakBus = PAXBus / 20.0 * 2;
var passengersAtPeakDRT = PAXDrt / 20.0 * 2;

BusPark = (int)Math.Ceiling((passengersAtPeakBus * ((2 * RouteLength) /
(double)CommercialSpeed)) / (18 * 60));
DRTPark = (int)Math.Ceiling((passengersAtPeakDRT * ((2 * (RouteLength + (RouteLength * 0.3)))
/ (double)CommercialSpeed)) / (18 * 60));

CostBus = BusPark * (20 / ((2 * RouteLength) / (double)CommercialSpeed)) * PriceKm * 2 *
RouteLength * 365;
```

```
CostDRT = DRTPark * (20 / ((2 * RouteLength) / (double)CommercialSpeed)) * PriceKm * 2 *
RouteLength * 365;

RevenueBus = PAXBus * (TicketPrice * 0.4) * 365;
RevenueDrt = PAXDrt * (TicketPrice * 0.4) * 365;


TotalBus = RevenueBus - CostBus;
TotalDRT = RevenueDrt - CostDRT;
}
}
```

In this code there are several parameters, which are making the whole program work and calculate all necessary parameters:

PriceKm – which is an average price for 1 km of transport work. It is a constant parameter, which is 80 (rubles) in the Moscow region.

CommercialSpeed – an average commercial speed for the chosen territory. It is a constant parameter, which is 33 (km) for New Moscow.

TicketPrice – a price for a one-way ticket. It is a constant parameter, which is 55 (rubles) for Moscow Transport.

RouteLength – a length of route in km. It is a dependent parameter. It is inserted into the calculation after route creation.

Population – a number of individuals, living around each point. It is inserted into the calculation after route creation. The number for this parameter comes from OpenStreetMap data. The program looks for a polygon, in which the point is located, and takes a “population” parameter from the polygon.

PAXBus and PAXDrt – an estimated number of passengers per day.

BusPark and DRTPark – an estimated number of vehicles.

CostBus and CostDRT – an estimated cost of starting a new route/routes in a year perspective.

RevenueBus and RevenueDRT – an estimated revenue during operations in a year perspective.

TotalBus and TotalDRT – an estimated net profit (net loss) of operations in a year perspective.

*Data collection and calculations*

As far as the calculations need data, some of the numbers are already installed into the code of calculations. However, there are two parameters, which are being calculated after the user locates the routing points on the map: Population and RouteLength.

In order to receive the necessary data, the program creates a query to the Overpass-Turbo system, which allows users to get the data from OpenStreetMap. Each point of the route is being located on the polygon which, usually, represents a specific settlement. Each settlement has a “population” parameter, which often has a data inside. However, there could be empty “population” parameters. In this case, the program receives an ID of the polygon and makes a query to the WIKI services, which could overlap this data gap and send us the necessary data. The way data is collected is represented in Figure 15.

```
SEARCH PLACE https://nominatim.openstreetmap.org/reverse?format=xml&lat=55.5736866419515&lon=37.2697448730469&zoom=16&addressdetails=1&extratags=1&namedetails=1&debug=0
SEARCH PLACE https://nominatim.openstreetmap.org/reverse?format=xml&lat=55.5736866419515&lon=37.2697448730469&zoom=15&addressdetails=1&extratags=1&namedetails=1&debug=0
TRY FOUND POPULATION WIKI SELECT * WHERE { wd:Q4373612 wdt:P1082 ?population}
TRY FOUND POPULATION WIKI RESULT6849
SEARCH PLACE https://nominatim.openstreetmap.org/reverse?format=xml&lat=55.5994929399703&lon=37.3504257202148&zoom=18&addressdetails=1&extratags=1&namedetails=1&debug=0
SEARCH PLACE https://nominatim.openstreetmap.org/reverse?format=xml&lat=55.5994929399703&lon=37.3504257202148&zoom=17&addressdetails=1&extratags=1&namedetails=1&debug=0
SEARCH PLACE https://nominatim.openstreetmap.org/reverse?format=xml&lat=55.5994929399703&lon=37.3504257202148&zoom=16&addressdetails=1&extratags=1&namedetails=1&debug=0
SEARCH PLACE https://nominatim.openstreetmap.org/reverse?format=xml&lat=55.5994929399703&lon=37.3504257202148&zoom=15&addressdetails=1&extratags=1&namedetails=1&debug=0
SEARCH PLACE https://nominatim.openstreetmap.org/reverse?format=xml&lat=55.5994929399703&lon=37.3504257202148&zoom=14&addressdetails=1&extratags=1&namedetails=1&debug=0
SEARCH PLACE https://nominatim.openstreetmap.org/reverse?format=xml&lat=55.5994929399703&lon=37.3504257202148&zoom=13&addressdetails=1&extratags=1&namedetails=1&debug=0
POPULATION FOUND 53417
SEARCH PLACE https://nominatim.openstreetmap.org/reverse?format=xml&lat=55.5482518196382&lon=37.3212432861328&zoom=18&addressdetails=1&extratags=1&namedetails=1&debug=0
SEARCH PLACE https://nominatim.openstreetmap.org/reverse?format=xml&lat=55.5482518196382&lon=37.3212432861328&zoom=17&addressdetails=1&extratags=1&namedetails=1&debug=0
SEARCH PLACE https://nominatim.openstreetmap.org/reverse?format=xml&lat=55.5482518196382&lon=37.3212432861328&zoom=16&addressdetails=1&extratags=1&namedetails=1&debug=0
SEARCH PLACE https://nominatim.openstreetmap.org/reverse?format=xml&lat=55.5482518196382&lon=37.3212432861328&zoom=15&addressdetails=1&extratags=1&namedetails=1&debug=0
POPULATION FOUND 2301
SEARCH PLACE https://nominatim.openstreetmap.org/reverse?format=xml&lat=55.5397051314276&lon=37.3631286621094&zoom=18&addressdetails=1&extratags=1&namedetails=1&debug=0
SEARCH PLACE https://nominatim.openstreetmap.org/reverse?format=xml&lat=55.5397051314276&lon=37.3631286621094&zoom=17&addressdetails=1&extratags=1&namedetails=1&debug=0
SEARCH PLACE https://nominatim.openstreetmap.org/reverse?format=xml&lat=55.5397051314276&lon=37.3631286621094&zoom=16&addressdetails=1&extratags=1&namedetails=1&debug=0
SEARCH PLACE https://nominatim.openstreetmap.org/reverse?format=xml&lat=55.5397051314276&lon=37.3631286621094&zoom=15&addressdetails=1&extratags=1&namedetails=1&debug=0
SEARCH PLACE https://nominatim.openstreetmap.org/reverse?format=xml&lat=55.5397051314276&lon=37.3631286621094&zoom=14&addressdetails=1&extratags=1&namedetails=1&debug=0
SEARCH PLACE https://nominatim.openstreetmap.org/reverse?format=xml&lat=55.5397051314276&lon=37.3631286621094&zoom=13&addressdetails=1&extratags=1&namedetails=1&debug=0
TRY FOUND POPULATION WIKI SELECT * WHERE { wd:Q4373598 wdt:P1082 ?population}
TRY FOUND POPULATION WIKI RESULT16901
```

Figure 15. Query for "population" data

At the same time, the program starts to calculate RouteLength, which is different for each set of options. The way the program calculates routing options and performs choice of mode is presented in Figure 16.

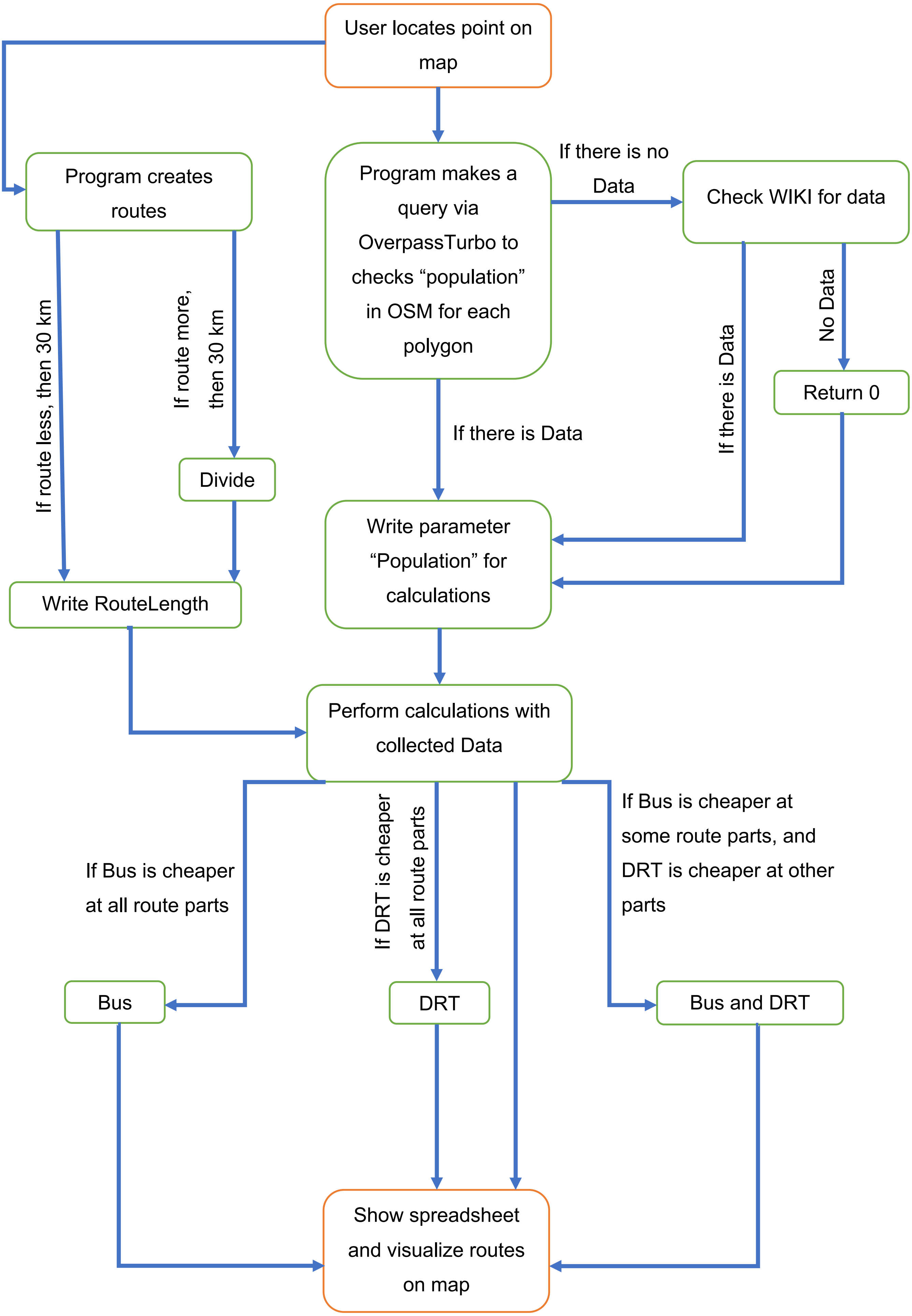
```
totalDistanceSimple=16,05
1: 1,2,3,4
     1,2    l=7,88   p=60266  bus=230404790   drt=182011192   BUS
     3,4    l=1,16   p=19202  bus=65532830    drt=50113624    BUS
2: 1,3,2,4
     1,3    l=6,94   p=9150   bus=25174050    drt=17826600    BUS
     2,4    l=1,23   p=70318  bus=270763570   drt=214298216   BUS
3: 2,1,3,4
     2,1    l=11,26  p=60266  bus=230404790   drt=182011192   BUS
     3,4    l=1,16   p=19202  bus=65532830    drt=50113624    BUS
4: 2,3,1,4
     2,3    l=8,21   p=55718  bus=212144570   drt=167403016   BUS
     1,4    l=1,23   p=23750  bus=83793050    drt=64721800    BUS
5: 3,2,1,4
     3,2    l=8,33   p=55718  bus=212144570   drt=167403016   BUS
     1,4    l=1,23   p=23750  bus=83793050    drt=64721800    BUS
6: 3,1,2,4
     3,1    l=6,94   p=9150   bus=25174050    drt=17826600    BUS
     2,4    l=1,23   p=70318  bus=270763570   drt=214298216   BUS
```

Figure 16. Route options calculation and Mode option choice

*Prototype work algorithm*

In order to create a better understanding of the program workflow, an algorithm of the prototype work is represented in Table 6.

**Table 6. Prototype algorithm**



*Prototype interface*

In order to present the data in a way, that it is possible to percept, a choice of a simple application design was made. The program features several buttons and two windows at maximum: map with all the visual data and spreadsheet with all digit data. Figure 17 represents the state of the first window after putting the points on the map: at each point there is a name of settlement and number of individuals, who live there (S.1 & S.2).

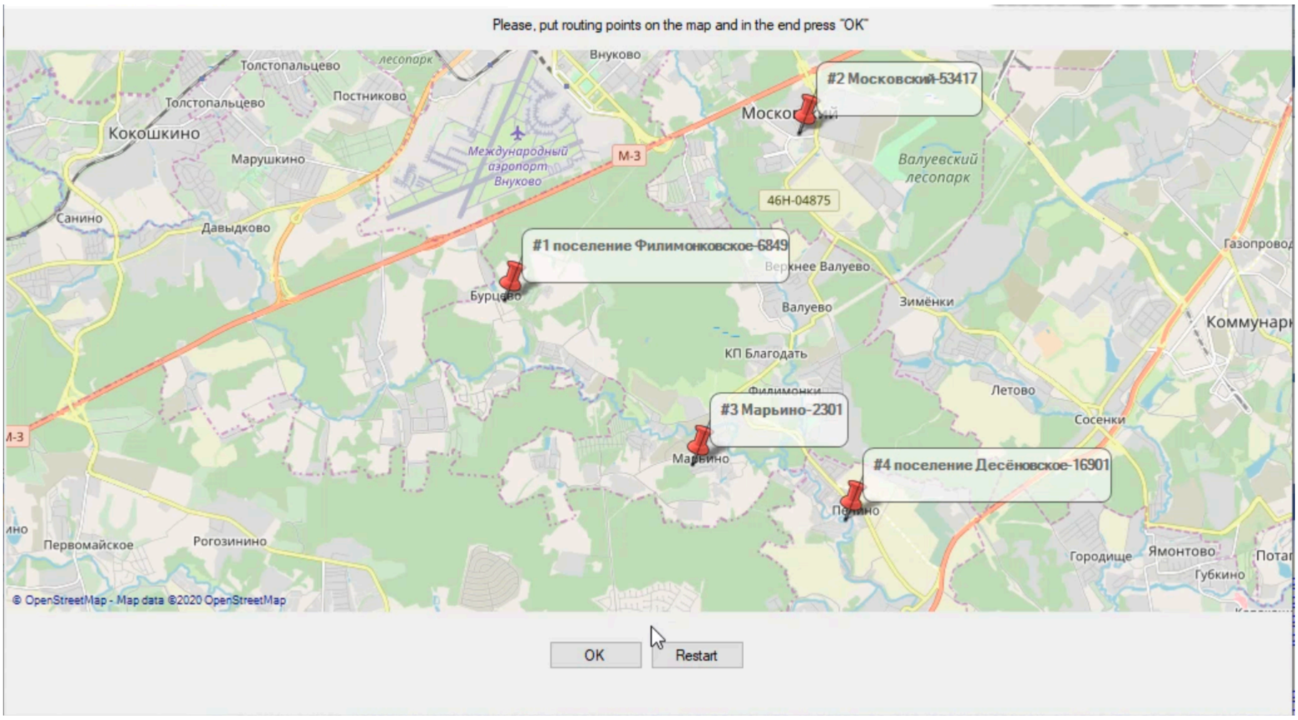



Figure 17. Prototype design. Map

After performing all the calculations (S.2), the program creates a spreadsheet, with all the data. The spreadsheet is represented in Figure 18.

As shown in Figure 18, there is a "Routing Name" column, which is an interactive part of the spreadsheet. If the user clicks on a version of the route, the routing is being shown on the map (S.3). An example of this interaction is represented in Figure 19. Figure 20 shows the maximum number of possible windows in the program: map with routing and spreadsheet at the same time.

Calculate result

| Population | RouteLength | PAXBus | PAXDrt | BusPark | DRTPark | CostBus | CostDRT | RevenueBus | RevenueDrt | TotalBus | TotalDRT | Total | Routing Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 79468 | 8,17 | 39734 | 0 | 2 | 0 | 23126400 | 0 | 319064020 | 0 | 295937620 | 0 | 295937620 | 1,3 (BUS); 2,4 (BUS) |
| 79468 | 8,17 | 39734 | 0 | 2 | 0 | 23126400 | 0 | 319064020 | 0 | 295937620 | 0 | 295937620 | 3,1 (BUS); 2,4 (BUS) |
| 79468 | 9,04 | 39734 | 0 | 2 | 0 | 23126400 | 0 | 319064020 | 0 | 295937620 | 0 | 295937620 | 1,2 (BUS); 3,4 (BUS) |
| 79468 | 9,44000000... | 39734 | 0 | 2 | 0 | 23126400 | 0 | 319064020 | 0 | 295937620 | 0 | 295937620 | 2,3 (BUS); 1,4 (BUS) |
| 79468 | 9,56 | 39734 | 0 | 2 | 0 | 23126400 | 0 | 319064020 | 0 | 295937620 | 0 | 295937620 | 3,2 (BUS); 1,4 (BUS) |
| 79468 | 12,42 | 39734 | 0 | 2 | 0 | 23126400 | 0 | 319064020 | 0 | 295937620 | 0 | 295937620 | 2,1 (BUS); 3,4 (BUS) |
| 79468 | 16,05 | 39734 | 0 | 2 | 0 | 23126400 | 0 | 319064020 | 0 | 295937620 | 0 | 295937620 | 3,1,2,4 (BUS) |
| 79468 | 16,3800000... | 39734 | 0 | 2 | 0 | 23126400 | 0 | 319064020 | 0 | 295937620 | 0 | 295937620 | 2,3,1,4 (BUS) |
| 79468 | 16,5 | 39734 | 0 | 2 | 0 | 23126400 | 0 | 319064020 | 0 | 295937620 | 0 | 295937620 | 1,3,2,4 (BUS) |
| 79468 | 17,25 | 39734 | 0 | 2 | 0 | 23126400 | 0 | 319064020 | 0 | 295937620 | 0 | 295937620 | 1,2,3,4 (BUS) |
| 79468 | 19,36 | 39734 | 0 | 2 | 0 | 23126400 | 0 | 319064020 | 0 | 295937620 | 0 | 295937620 | 2,1,3,4 (BUS) |
| 79468 | 20,82 | 39734 | 0 | 2 | 0 | 23126400 | 0 | 319064020 | 0 | 295937620 | 0 | 295937620 | 3,2,1,4 (BUS) |

OK

Figure 18. Prototype design. Spreadsheet

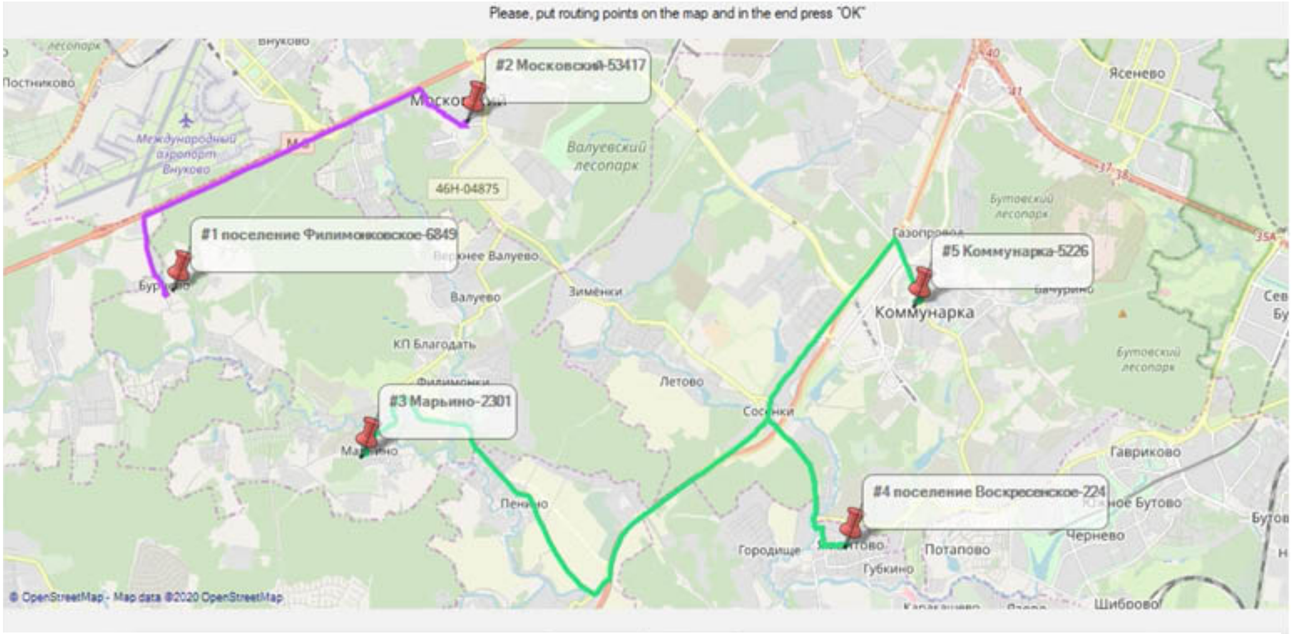
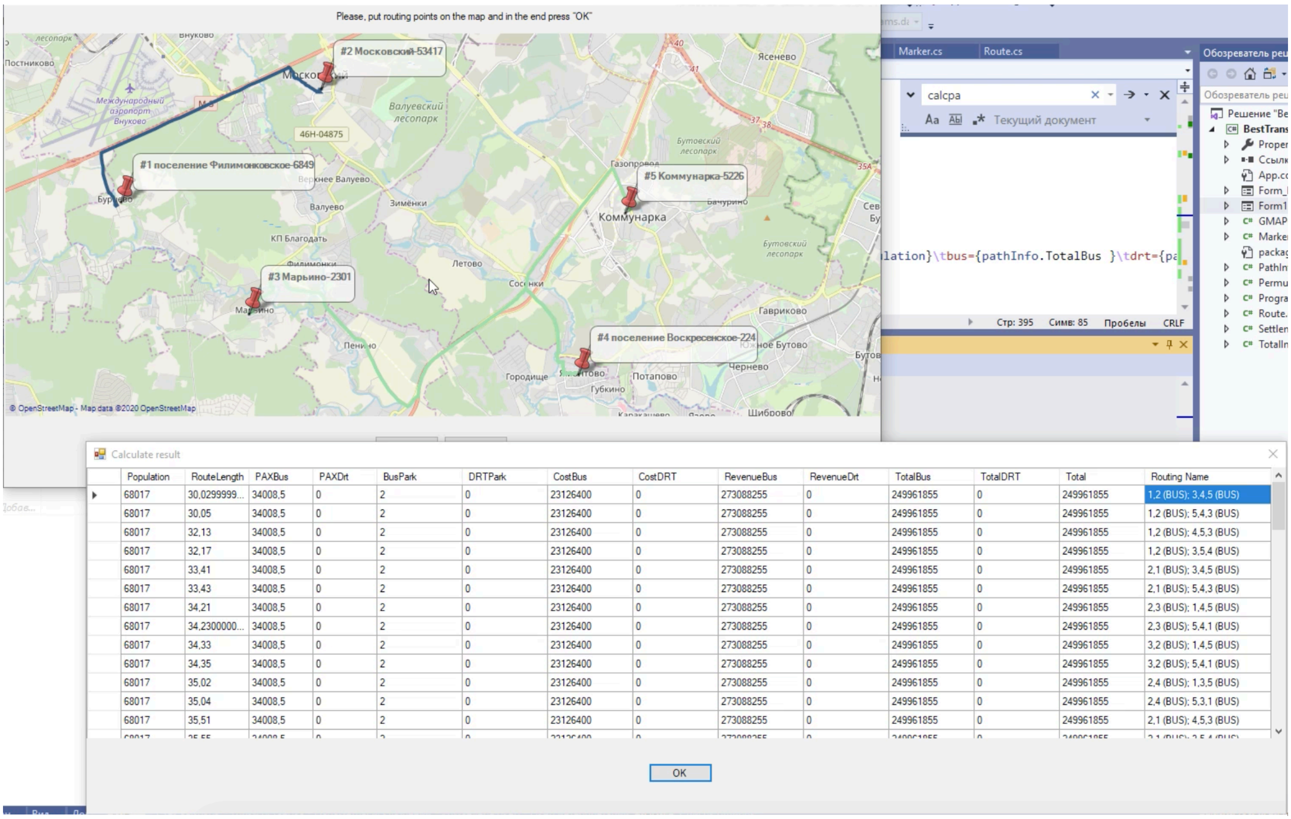



Figure 19. Prototype design. Routing map



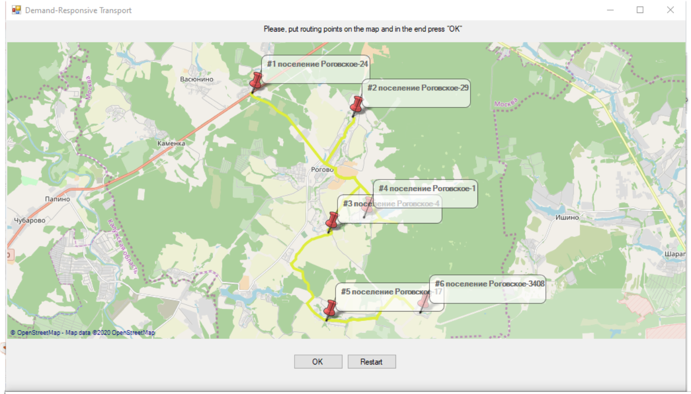

| | Population | RouteLength | PAXBus | PAXDrt | BusPark | DRTPark | CostBus | CostDRT | RevenueBus | RevenueDrt | TotalBus | TotalDRT | Total | Routing Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ▸ | 68017 | 30,0299999... | 34008,5 | 0 | 2 | 0 | 23126400 | 0 | 273088255 | 0 | 249961855 | 0 | 249961855 | 1,2 (BUS); 3,4,5 (BUS) |
| | 68017 | 30,05 | 34008,5 | 0 | 2 | 0 | 23126400 | 0 | 273088255 | 0 | 249961855 | 0 | 249961855 | 1,2 (BUS); 5,4,3 (BUS) |
| | 68017 | 32,13 | 34008,5 | 0 | 2 | 0 | 23126400 | 0 | 273088255 | 0 | 249961855 | 0 | 249961855 | 1,2 (BUS); 4,5,3 (BUS) |
| | 68017 | 32,17 | 34008,5 | 0 | 2 | 0 | 23126400 | 0 | 273088255 | 0 | 249961855 | 0 | 249961855 | 1,2 (BUS); 3,5,4 (BUS) |
| | 68017 | 33,41 | 34008,5 | 0 | 2 | 0 | 23126400 | 0 | 273088255 | 0 | 249961855 | 0 | 249961855 | 2,1 (BUS); 3,4,5 (BUS) |
| | 68017 | 33,43 | 34008,5 | 0 | 2 | 0 | 23126400 | 0 | 273088255 | 0 | 249961855 | 0 | 249961855 | 2,1 (BUS); 5,4,3 (BUS) |
| | 68017 | 34,21 | 34008,5 | 0 | 2 | 0 | 23126400 | 0 | 273088255 | 0 | 249961855 | 0 | 249961855 | 2,3 (BUS); 1,4,5 (BUS) |
| | 68017 | 34,2300000... | 34008,5 | 0 | 2 | 0 | 23126400 | 0 | 273088255 | 0 | 249961855 | 0 | 249961855 | 2,3 (BUS); 5,4,1 (BUS) |
| | 68017 | 34,33 | 34008,5 | 0 | 2 | 0 | 23126400 | 0 | 273088255 | 0 | 249961855 | 0 | 249961855 | 3,2 (BUS); 1,4,5 (BUS) |
| | 68017 | 34,35 | 34008,5 | 0 | 2 | 0 | 23126400 | 0 | 273088255 | 0 | 249961855 | 0 | 249961855 | 3,2 (BUS); 5,4,1 (BUS) |
| | 68017 | 35,02 | 34008,5 | 0 | 2 | 0 | 23126400 | 0 | 273088255 | 0 | 249961855 | 0 | 249961855 | 2,4 (BUS); 1,3,5 (BUS) |
| | 68017 | 35,04 | 34008,5 | 0 | 2 | 0 | 23126400 | 0 | 273088255 | 0 | 249961855 | 0 | 249961855 | 2,4 (BUS); 5,3,1 (BUS) |
| | 68017 | 35,51 | 34008,5 | 0 | 2 | 0 | 23126400 | 0 | 273088255 | 0 | 249961855 | 0 | 249961855 | 2,1 (BUS); 4,5,3 (BUS) |

Figure 20. Prototype design. Map and spreadsheet

*Prototype work check*

In the research part a grouping of settlements with no access to mobility was performed. This groups were used to check the way the prototype works. Here the calculations of routing and the results are provided.

Group 1: Red. Proposed mode by Wright: DRT.



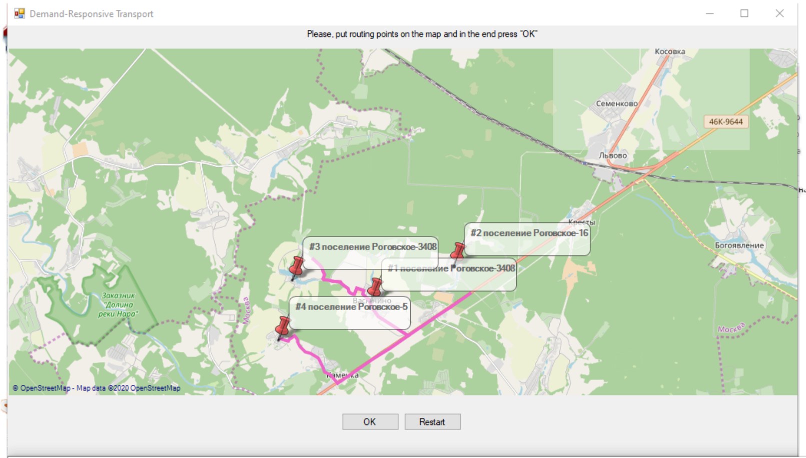

Calculate result

| | Population | RouteLength | PAXBus | PAXDrt | BusPark | DRTPark | CostBus | CostDRT | RevenueBus | RevenueDrt | TotalBus | TotalDRT | Total | Routing Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ▸ | 3483 | 27,5800000... | 0 | 2089,79999... | 0 | 1 | 0 | 19271999,99999... | 0 | 16781093,99999... | 0 | -2490906 | -2490906 | 2,1,4,3,6,5 (DRT) |
| | 3483 | 28,9799999... | 0 | 2089,79999... | 0 | 1 | 0 | 19271999,99999... | 0 | 16781093,99999... | 0 | -2490906 | -2490906 | 1,4,2,3,6,5 (DRT) |
| | 3483 | 22,49 | 0 | 2089,79999... | 0 | 1 | 0 | 19272000 | 0 | 16781093,99999... | 0 | -2490906,00000... | -2490906,00000... | 1,2,4,3,5,6 (DRT) |
| | 3483 | 22,49 | 0 | 2089,79999... | 0 | 1 | 0 | 19272000 | 0 | 16781093,99999... | 0 | -2490906,00000... | -2490906,00000... | 6,5,3,4,2,1 (DRT) |
| | 3483 | 24,13 | 0 | 2089,79999... | 0 | 1 | 0 | 19272000 | 0 | 16781093,99999... | 0 | -2490906,00000... | -2490906,00000... | 2,1,4,3,5,6 (DRT) |
| | 3483 | 24,13 | 0 | 2089,79999... | 0 | 1 | 0 | 19272000 | 0 | 16781093,99999... | 0 | -2490906,00000... | -2490906,00000... | 6,5,3,4,1,2 (DRT) |
| | 3483 | 25,5299999... | 0 | 2089,79999... | 0 | 1 | 0 | 19272000 | 0 | 16781093,99999... | 0 | -2490906,00000... | -2490906,00000... | 1,4,2,3,5,6 (DRT) |
| | 3483 | 25,63 | 0 | 2089,79999... | 0 | 1 | 0 | 19272000 | 0 | 16781093,99999... | 0 | -2490906,00000... | -2490906,00000... | 4,2,1,3,5,6 (DRT) |
| | 3483 | 25,63 | 0 | 2089,79999... | 0 | 1 | 0 | 19272000 | 0 | 16781093,99999... | 0 | -2490906,00000... | -2490906,00000... | 4,1,2,3,5,6 (DRT) |
| | 3483 | 25,6300000... | 0 | 2089,79999... | 0 | 1 | 0 | 19272000 | 0 | 16781093,99999... | 0 | -2490906,00000... | -2490906,00000... | 6,5,3,2,1,4 (DRT) |
| | 3483 | 25,6300000... | 0 | 2089,79999... | 0 | 1 | 0 | 19272000 | 0 | 16781093,99999... | 0 | -2490906,00000... | -2490906,00000... | 6,5,3,1,2,4 (DRT) |
| | 3483 | 25,9399999... | 0 | 2089,79999... | 0 | 1 | 0 | 19272000 | 0 | 16781093,99999... | 0 | -2490906,00000... | -2490906,00000... | 1,2,4,3,6,5 (DRT) |
| | 3483 | 25,9399999... | 0 | 2089,79999... | 0 | 1 | 0 | 19272000 | 0 | 16781093,99999... | 0 | -2490906,00000... | -2490906,00000... | 5,6,3,4,2,1 (DRT) |

OK

Figure 21. Prototype calculations. Group 1

Group 2: Yellow. Proposed mode by Wright: Bus.



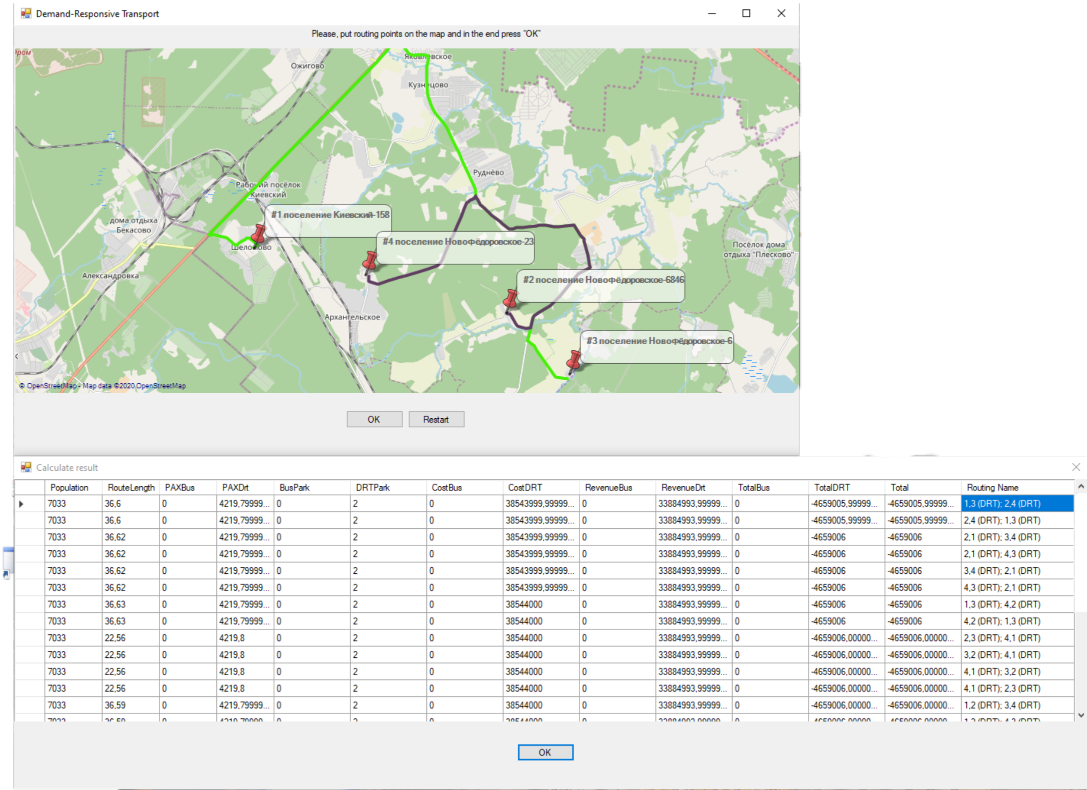

Calculate result

| | Population | RouteLength | PAXBus | PAXDrt | BusPark | DRTPark | CostBus | CostDRT | RevenueBus | RevenueDrt | TotalBus | TotalDRT | Total | Routing Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ▸ | 6837 | 15,2199999... | 0 | 4102,2 | 0 | 1 | 0 | 19271999,99999... | 0 | 32940665,99999... | 0 | 13668666 | 13668666 | 2,3,1,4 (DRT) |
| | 6837 | 15,2199999... | 0 | 4102,2 | 0 | 1 | 0 | 19271999,99999... | 0 | 32940665,99999... | 0 | 13668666 | 13668666 | 4,1,3,2 (DRT) |
| | 6837 | 18,8699999... | 0 | 4102,2 | 0 | 1 | 0 | 19271999,99999... | 0 | 32940665,99999... | 0 | 13668666 | 13668666 | 1,2,3,4 (DRT) |
| | 6837 | 18,8699999... | 0 | 4102,2 | 0 | 1 | 0 | 19271999,99999... | 0 | 32940665,99999... | 0 | 13668666 | 13668666 | 4,3,2,1 (DRT) |
| | 6837 | 19,6199999... | 0 | 4102,2 | 0 | 1 | 0 | 19271999,99999... | 0 | 32940665,99999... | 0 | 13668666 | 13668666 | 1,2,4,3 (DRT) |
| | 6837 | 19,6199999... | 0 | 4102,2 | 0 | 1 | 0 | 19271999,99999... | 0 | 32940665,99999... | 0 | 13668666 | 13668666 | 3,4,2,1 (DRT) |
| | 6837 | 19,63 | 0 | 4102,2 | 0 | 1 | 0 | 19271999,99999... | 0 | 32940665,99999... | 0 | 13668666 | 13668666 | 1,4,2,3 (DRT) |
| | 6837 | 19,63 | 0 | 4102,2 | 0 | 1 | 0 | 19271999,99999... | 0 | 32940665,99999... | 0 | 13668666 | 13668666 | 3,2,4,1 (DRT) |
| | 6837 | 13,29 | 0 | 4102,2 | 0 | 1 | 0 | 19272000 | 0 | 32940665,99999... | 0 | 13668665,99999... | 13668665,99999... | 3,1,2,4 (DRT) |
| | 6837 | 13,29 | 0 | 4102,2 | 0 | 1 | 0 | 19272000 | 0 | 32940665,99999... | 0 | 13668665,99999... | 13668665,99999... | 4,2,1,3 (DRT) |
| | 6837 | 15,8999999... | 0 | 4102,2 | 0 | 1 | 0 | 19272000 | 0 | 32940665,99999... | 0 | 13668665,99999... | 13668665,99999... | 1,3,2,4 (DRT) |
| | 6837 | 15,8999999... | 0 | 4102,2 | 0 | 1 | 0 | 19272000 | 0 | 32940665,99999... | 0 | 13668665,99999... | 13668665,99999... | 4,2,3,1 (DRT) |
| | 6837 | 15,9699999... | 0 | 4102,2 | 0 | 1 | 0 | 19272000 | 0 | 32940665,99999... | 0 | 13668665,99999... | 13668665,99999... | 2,4,1,3 (DRT) |

OK

Figure 22. Prototype calculations. Group 2

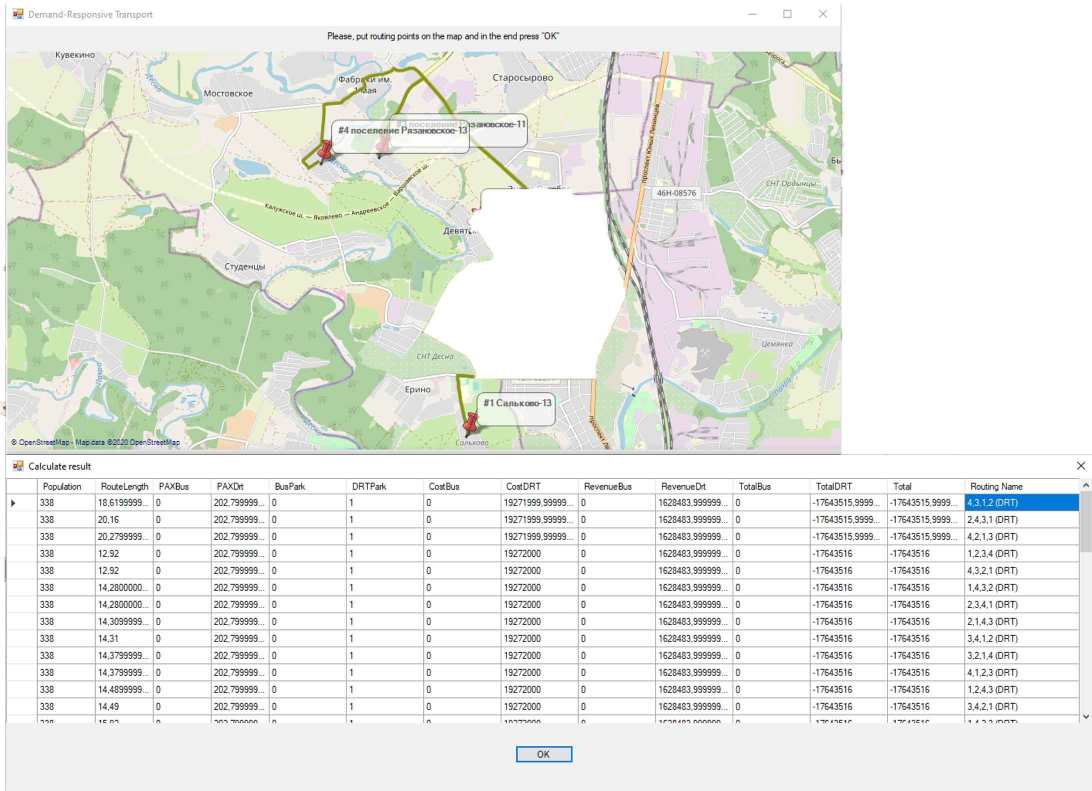
Group 3: Blue. Proposed mode by Wright: Bus.




| | Population | RouteLength | PAXBus | PAXDrt | BusPark | DRTPark | CostBus | CostDRT | RevenueBus | RevenueDrt | TotalBus | TotalDRT | Total | Routing Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ▶ | 7033 | 36,6 | 0 | 4219,79999... | 0 | 2 | 0 | 38543999,99999... | 0 | 33884993,99999... | 0 | -4659005,99999... | -4659005,99999... | 1,3 (DRT); 2,4 (DRT) |
| | 7033 | 36,6 | 0 | 4219,79999... | 0 | 2 | 0 | 38543999,99999... | 0 | 33884993,99999... | 0 | -4659005,99999... | -4659005,99999... | 2,4 (DRT); 1,3 (DRT) |
| | 7033 | 36,62 | 0 | 4219,79999... | 0 | 2 | 0 | 38543999,99999... | 0 | 33884993,99999... | 0 | -4659006 | -4659006 | 2,1 (DRT); 3,4 (DRT) |
| | 7033 | 36,62 | 0 | 4219,79999... | 0 | 2 | 0 | 38543999,99999... | 0 | 33884993,99999... | 0 | -4659006 | -4659006 | 2,1 (DRT); 4,3 (DRT) |
| | 7033 | 36,62 | 0 | 4219,79999... | 0 | 2 | 0 | 38543999,99999... | 0 | 33884993,99999... | 0 | -4659006 | -4659006 | 3,4 (DRT); 2,1 (DRT) |
| | 7033 | 36,62 | 0 | 4219,79999... | 0 | 2 | 0 | 38543999,99999... | 0 | 33884993,99999... | 0 | -4659006 | -4659006 | 4,3 (DRT); 2,1 (DRT) |
| | 7033 | 36,63 | 0 | 4219,79999... | 0 | 2 | 0 | 38544000 | 0 | 33884993,99999... | 0 | -4659006 | -4659006 | 1,3 (DRT); 4,2 (DRT) |
| | 7033 | 36,63 | 0 | 4219,79999... | 0 | 2 | 0 | 38544000 | 0 | 33884993,99999... | 0 | -4659006 | -4659006 | 4,2 (DRT); 1,3 (DRT) |
| | 7033 | 22,56 | 0 | 4219,8 | 0 | 2 | 0 | 38544000 | 0 | 33884993,99999... | 0 | -4659006,00000... | -4659006,00000... | 2,3 (DRT); 4,1 (DRT) |
| | 7033 | 22,56 | 0 | 4219,8 | 0 | 2 | 0 | 38544000 | 0 | 33884993,99999... | 0 | -4659006,00000... | -4659006,00000... | 3,2 (DRT); 4,1 (DRT) |
| | 7033 | 22,56 | 0 | 4219,8 | 0 | 2 | 0 | 38544000 | 0 | 33884993,99999... | 0 | -4659006,00000... | -4659006,00000... | 4,1 (DRT); 3,2 (DRT) |
| | 7033 | 22,56 | 0 | 4219,8 | 0 | 2 | 0 | 38544000 | 0 | 33884993,99999... | 0 | -4659006,00000... | -4659006,00000... | 4,1 (DRT); 2,3 (DRT) |
| | 7033 | 36,59 | 0 | 4219,79999... | 0 | 2 | 0 | 38544000 | 0 | 33884993,99999... | 0 | -4659006,00000... | -4659006,00000... | 1,2 (DRT); 3,4 (DRT) |

Figure 23. Prototype calculations. Group 3

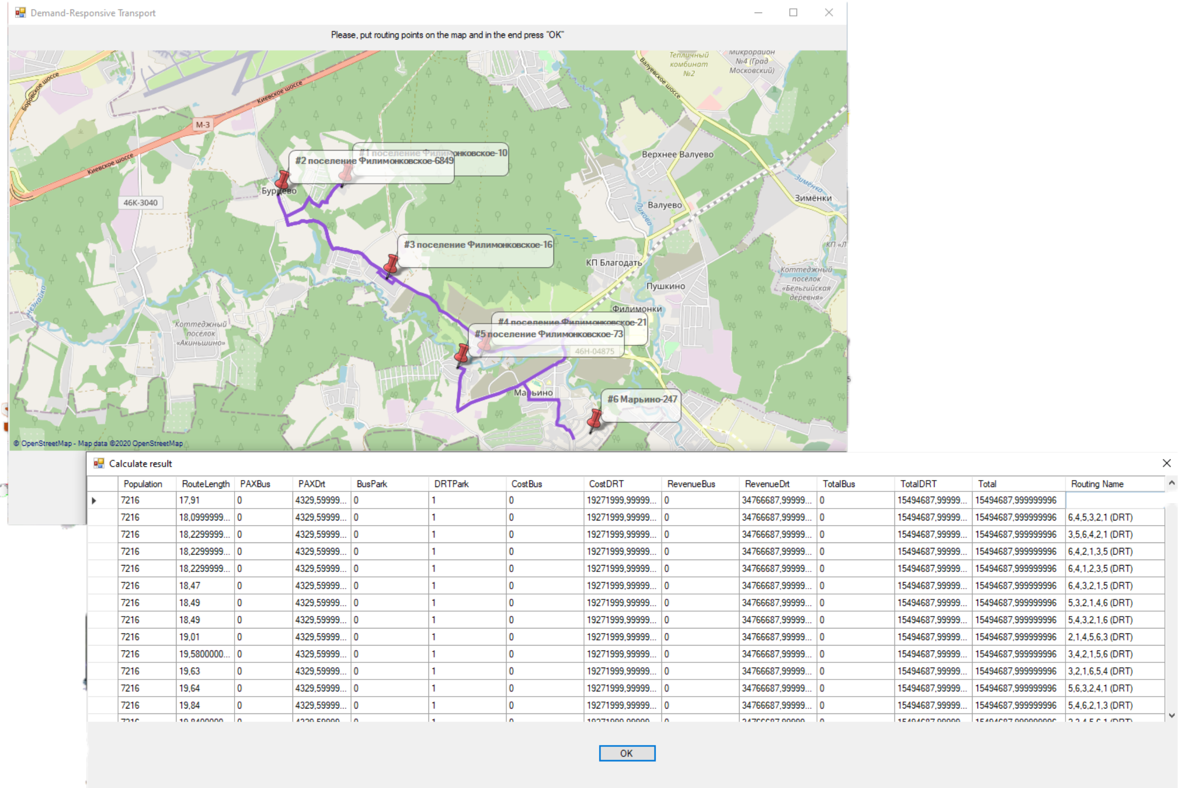
Group 4: Brown. Proposed mode by Wright: Bus.




| | Population | RouteLength | PAXBus | PAXDrt | BusPark | DRTPark | CostBus | CostDRT | RevenueBus | RevenueDrt | TotalBus | TotalDRT | Total | Routing Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ▶ | 338 | 18,6199999... | 0 | 202,799999... | 0 | 1 | 0 | 19271999,99999... | 0 | 1628483,999999... | 0 | -17643515,9999... | -17643515,9999... | 4,3,1,2 (DRT) |
| | 338 | 20,16 | 0 | 202,799999... | 0 | 1 | 0 | 19271999,99999... | 0 | 1628483,999999... | 0 | -17643515,9999... | -17643515,9999... | 2,4,3,1 (DRT) |
| | 338 | 20,2799999... | 0 | 202,799999... | 0 | 1 | 0 | 19271999,99999... | 0 | 1628483,999999... | 0 | -17643515,9999... | -17643515,9999... | 4,2,1,3 (DRT) |
| | 338 | 12,92 | 0 | 202,799999... | 0 | 1 | 0 | 19272000 | 0 | 1628483,999999... | 0 | -17643516 | -17643516 | 1,2,3,4 (DRT) |
| | 338 | 12,92 | 0 | 202,799999... | 0 | 1 | 0 | 19272000 | 0 | 1628483,999999... | 0 | -17643516 | -17643516 | 4,3,2,1 (DRT) |
| | 338 | 14,2800000... | 0 | 202,799999... | 0 | 1 | 0 | 19272000 | 0 | 1628483,999999... | 0 | -17643516 | -17643516 | 1,4,3,2 (DRT) |
| | 338 | 14,2800000... | 0 | 202,799999... | 0 | 1 | 0 | 19272000 | 0 | 1628483,999999... | 0 | -17643516 | -17643516 | 2,3,4,1 (DRT) |
| | 338 | 14,3099999... | 0 | 202,799999... | 0 | 1 | 0 | 19272000 | 0 | 1628483,999999... | 0 | -17643516 | -17643516 | 2,1,4,3 (DRT) |
| | 338 | 14,31 | 0 | 202,799999... | 0 | 1 | 0 | 19272000 | 0 | 1628483,999999... | 0 | -17643516 | -17643516 | 3,4,1,2 (DRT) |
| | 338 | 14,3799999... | 0 | 202,799999... | 0 | 1 | 0 | 19272000 | 0 | 1628483,999999... | 0 | -17643516 | -17643516 | 3,2,1,4 (DRT) |
| | 338 | 14,3799999... | 0 | 202,799999... | 0 | 1 | 0 | 19272000 | 0 | 1628483,999999... | 0 | -17643516 | -17643516 | 4,1,2,3 (DRT) |
| | 338 | 14,4899999... | 0 | 202,799999... | 0 | 1 | 0 | 19272000 | 0 | 1628483,999999... | 0 | -17643516 | -17643516 | 1,2,4,3 (DRT) |
| | 338 | 14,49 | 0 | 202,799999... | 0 | 1 | 0 | 19272000 | 0 | 1628483,999999... | 0 | -17643516 | -17643516 | 3,4,2,1 (DRT) |

Figure 24. Prototype calculations. Group 4

Group 5: White. Proposed mode by Wright: Bus.



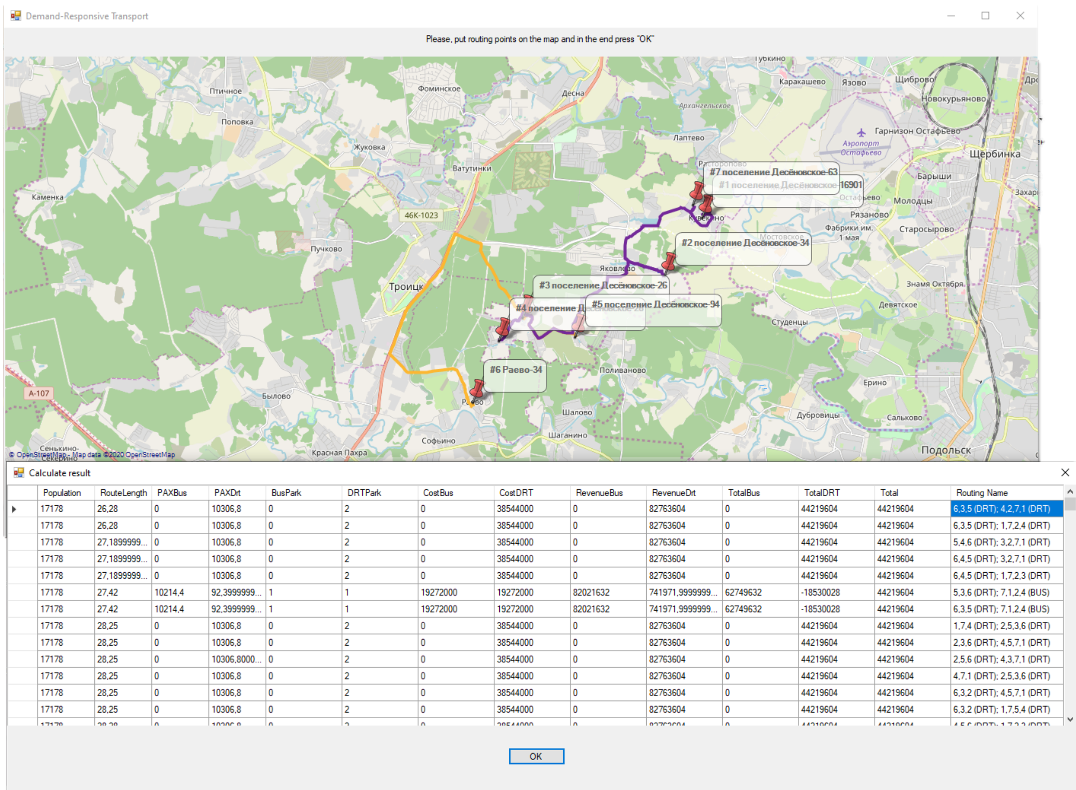

| Population | RouteLength | PAXBus | PAXDrt | BusPark | DRTPark | CostBus | CostDRT | RevenueBus | RevenueDrt | TotalBus | TotalDRT | Total | Routing Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7216 | 17,91 | 0 | 4329,59999... | 0 | 1 | 0 | 19271999,99999... | 0 | 34766687,99999... | 0 | 15494687,99999... | 15494687,999999996 | |
| 7216 | 18,0999999... | 0 | 4329,59999... | 0 | 1 | 0 | 19271999,99999... | 0 | 34766687,99999... | 0 | 15494687,99999... | 15494687,999999996 | 6,4,5,3,2,1 (DRT) |
| 7216 | 18,2299999... | 0 | 4329,59999... | 0 | 1 | 0 | 19271999,99999... | 0 | 34766687,99999... | 0 | 15494687,99999... | 15494687,999999996 | 3,5,6,4,2,1 (DRT) |
| 7216 | 18,2299999... | 0 | 4329,59999... | 0 | 1 | 0 | 19271999,99999... | 0 | 34766687,99999... | 0 | 15494687,99999... | 15494687,999999996 | 6,4,2,1,3,5 (DRT) |
| 7216 | 18,2299999... | 0 | 4329,59999... | 0 | 1 | 0 | 19271999,99999... | 0 | 34766687,99999... | 0 | 15494687,99999... | 15494687,999999996 | 6,4,1,2,3,5 (DRT) |
| 7216 | 18,47 | 0 | 4329,59999... | 0 | 1 | 0 | 19271999,99999... | 0 | 34766687,99999... | 0 | 15494687,99999... | 15494687,999999996 | 6,4,3,2,1,5 (DRT) |
| 7216 | 18,49 | 0 | 4329,59999... | 0 | 1 | 0 | 19271999,99999... | 0 | 34766687,99999... | 0 | 15494687,99999... | 15494687,999999996 | 5,3,2,1,4,6 (DRT) |
| 7216 | 18,49 | 0 | 4329,59999... | 0 | 1 | 0 | 19271999,99999... | 0 | 34766687,99999... | 0 | 15494687,99999... | 15494687,999999996 | 5,4,3,2,1,6 (DRT) |
| 7216 | 19,01 | 0 | 4329,59999... | 0 | 1 | 0 | 19271999,99999... | 0 | 34766687,99999... | 0 | 15494687,99999... | 15494687,999999996 | 2,1,4,5,6,3 (DRT) |
| 7216 | 19,5800000... | 0 | 4329,59999... | 0 | 1 | 0 | 19271999,99999... | 0 | 34766687,99999... | 0 | 15494687,99999... | 15494687,999999996 | 3,4,2,1,5,6 (DRT) |
| 7216 | 19,63 | 0 | 4329,59999... | 0 | 1 | 0 | 19271999,99999... | 0 | 34766687,99999... | 0 | 15494687,99999... | 15494687,999999996 | 3,2,1,6,5,4 (DRT) |
| 7216 | 19,64 | 0 | 4329,59999... | 0 | 1 | 0 | 19271999,99999... | 0 | 34766687,99999... | 0 | 15494687,99999... | 15494687,999999996 | 5,6,3,2,4,1 (DRT) |
| 7216 | 19,84 | 0 | 4329,59999... | 0 | 1 | 0 | 19271999,99999... | 0 | 34766687,99999... | 0 | 15494687,99999... | 15494687,999999996 | 5,4,6,2,1,3 (DRT) |

Figure 25. Prototype calculations. Group 5

Group 6: Green. Proposed mode by Wright: Bus.

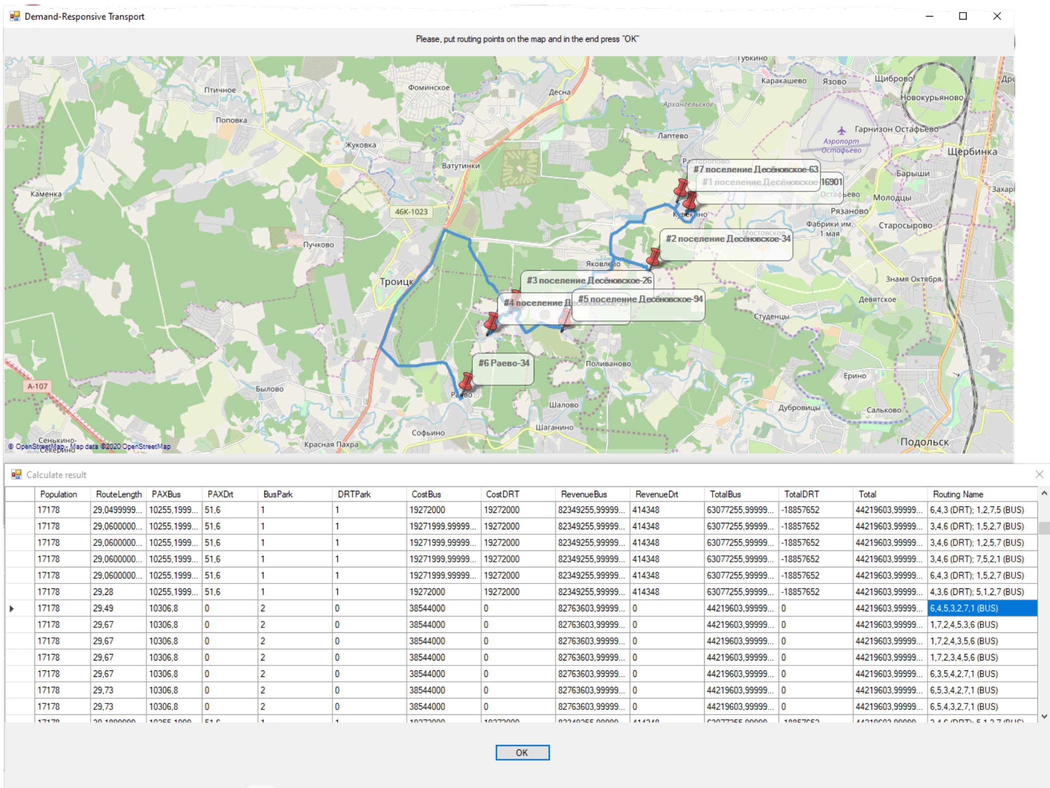
This group had too many points, the PC could not finish the calculations.

Group 7: Orange. Proposed mode by Wright: Bus.



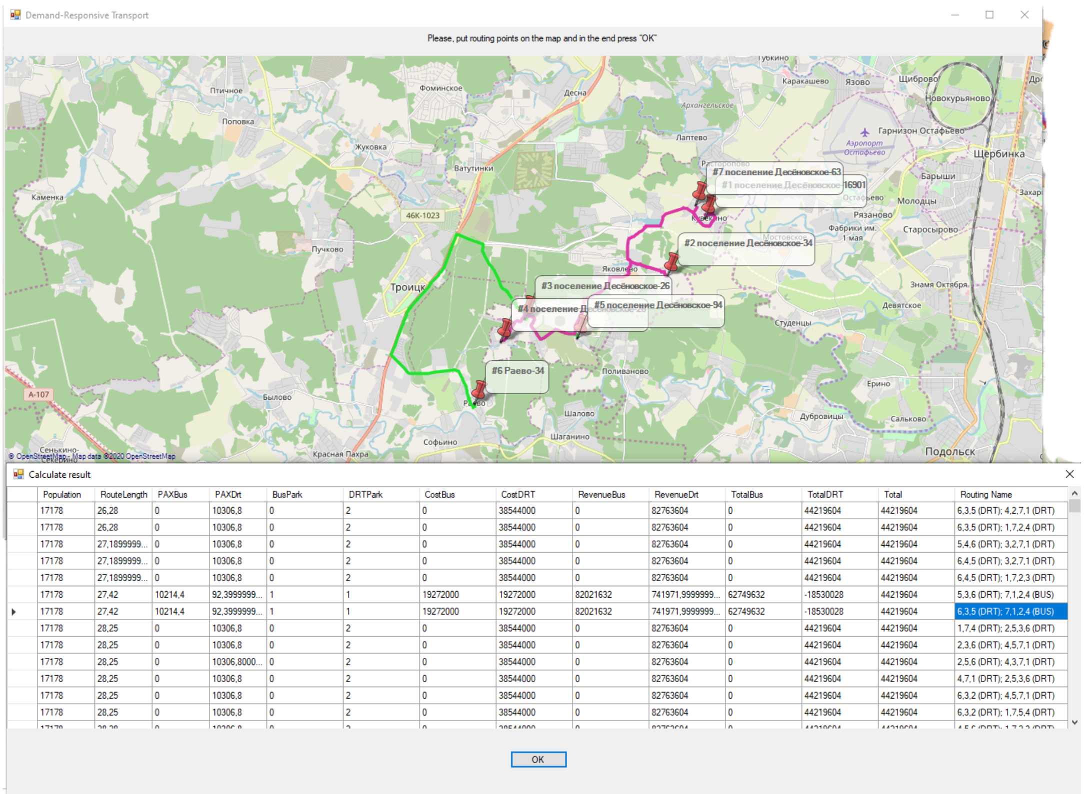

| Population | RouteLength | PAXBus | PAXDrt | BusPark | DRTPark | CostBus | CostDRT | RevenueBus | RevenueDrt | TotalBus | TotalDRT | Total | Routing Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17178 | 26,28 | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 6,3,5 (DRT); 4,2,7,1 (DRT) |
| 17178 | 26,28 | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 6,3,5 (DRT); 1,7,2,4 (DRT) |
| 17178 | 27,1899999... | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 5,4,6 (DRT); 3,2,7,1 (DRT) |
| 17178 | 27,1899999... | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 6,4,5 (DRT); 3,2,7,1 (DRT) |
| 17178 | 27,1899999... | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 6,4,5 (DRT); 1,7,2,3 (DRT) |
| 17178 | 27,42 | 10214,4 | 92,3999999... | 1 | 1 | 19272000 | 19272000 | 82021632 | 741971,9999999... | 62749632 | -18530028 | 44219604 | 5,3,6 (DRT); 7,1,2,4 (BUS) |
| 17178 | 27,42 | 10214,4 | 92,3999999... | 1 | 1 | 19272000 | 19272000 | 82021632 | 741971,9999999... | 62749632 | -18530028 | 44219604 | 6,3,5 (DRT); 7,1,2,4 (BUS) |
| 17178 | 28,25 | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 1,7,4 (DRT); 2,5,3,6 (DRT) |
| 17178 | 28,25 | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 2,3,6 (DRT); 4,5,7,1 (DRT) |
| 17178 | 28,25 | 0 | 10306,8000... | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 2,5,6 (DRT); 4,3,7,1 (DRT) |
| 17178 | 28,25 | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 4,7,1 (DRT); 2,5,3,6 (DRT) |
| 17178 | 28,25 | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 6,3,2 (DRT); 4,5,7,1 (DRT) |
| 17178 | 28,25 | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 6,3,2 (DRT); 1,7,5,4 (DRT) |

Figure 26. Prototype calculations. Group 7 - DRT Routing




| | Population | RouteLength | PAXBus | PAXDrt | BusPark | DRTPark | CostBus | CostDRT | RevenueBus | RevenueDrt | TotalBus | TotalDRT | Total | Routing Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 17178 | 29,0499999... | 10255,1999... | 51,6 | 1 | 1 | 19272000 | 19272000 | 82349255,99999... | 414348 | 63077255,99999... | -18857652 | 44219603,99999... | 6,4,3 (DRT); 1,2,7,5 (BUS) |
| | 17178 | 29,0600000... | 10255,1999... | 51,6 | 1 | 1 | 19271999,99999... | 19272000 | 82349255,99999... | 414348 | 63077255,99999... | -18857652 | 44219603,99999... | 3,4,6 (DRT); 1,5,2,7 (BUS) |
| | 17178 | 29,0600000... | 10255,1999... | 51,6 | 1 | 1 | 19271999,99999... | 19272000 | 82349255,99999... | 414348 | 63077255,99999... | -18857652 | 44219603,99999... | 3,4,6 (DRT); 1,2,5,7 (BUS) |
| | 17178 | 29,0600000... | 10255,1999... | 51,6 | 1 | 1 | 19271999,99999... | 19272000 | 82349255,99999... | 414348 | 63077255,99999... | -18857652 | 44219603,99999... | 3,4,6 (DRT); 7,5,2,1 (BUS) |
| | 17178 | 29,0600000... | 10255,1999... | 51,6 | 1 | 1 | 19271999,99999... | 19272000 | 82349255,99999... | 414348 | 63077255,99999... | -18857652 | 44219603,99999... | 6,4,3 (DRT); 1,5,2,7 (BUS) |
| | 17178 | 29,28 | 10255,1999... | 51,6 | 1 | 1 | 19272000 | 19272000 | 82349255,99999... | 414348 | 63077255,99999... | -18857652 | 44219603,99999... | 4,3,6 (DRT); 5,1,2,7 (BUS) |
| ▸ | 17178 | 29,49 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763603,99999... | 0 | 44219603,99999... | 0 | 44219603,99999... | 6,4,5,3,2,7,1 (BUS) |
| | 17178 | 29,67 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763603,99999... | 0 | 44219603,99999... | 0 | 44219603,99999... | 1,7,2,4,5,3,6 (BUS) |
| | 17178 | 29,67 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763603,99999... | 0 | 44219603,99999... | 0 | 44219603,99999... | 1,7,2,4,3,5,6 (BUS) |
| | 17178 | 29,67 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763603,99999... | 0 | 44219603,99999... | 0 | 44219603,99999... | 1,7,2,3,4,5,6 (BUS) |
| | 17178 | 29,67 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763603,99999... | 0 | 44219603,99999... | 0 | 44219603,99999... | 6,3,5,4,2,7,1 (BUS) |
| | 17178 | 29,73 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763603,99999... | 0 | 44219603,99999... | 0 | 44219603,99999... | 6,5,3,4,2,7,1 (BUS) |
| | 17178 | 29,73 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763603,99999... | 0 | 44219603,99999... | 0 | 44219603,99999... | 6,5,4,3,2,7,1 (BUS) |

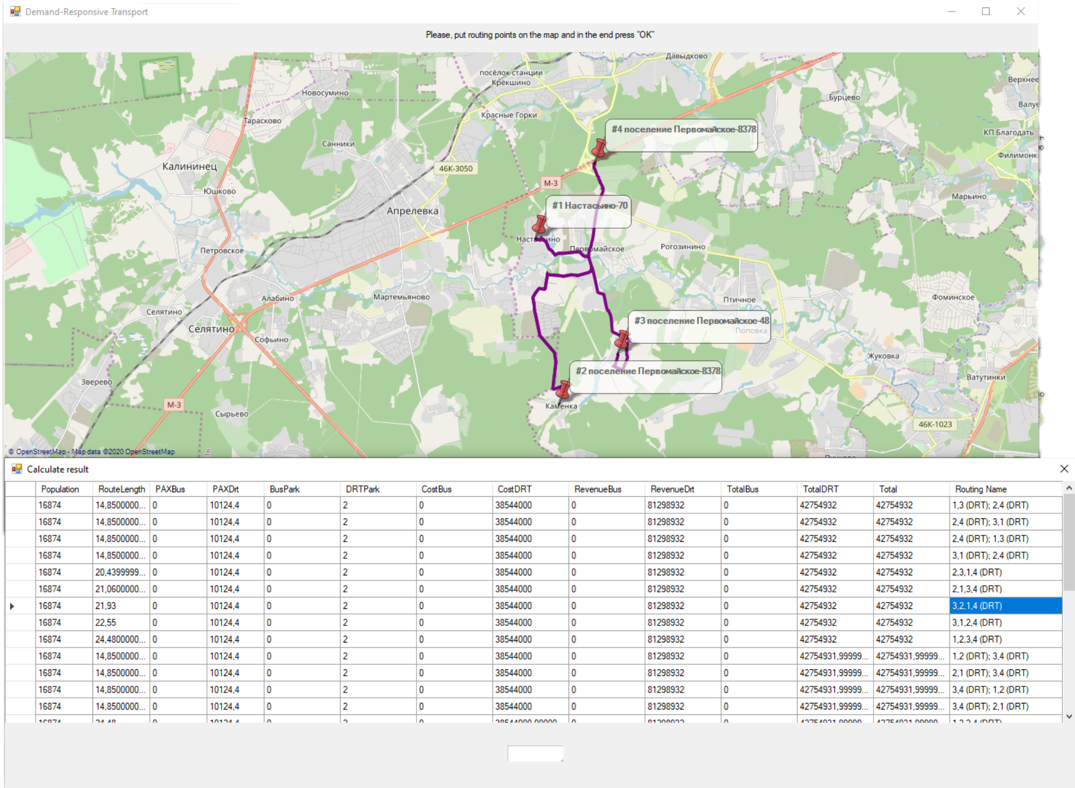
Figure 27. Prototype calculations. Group 7 - Bus Routing




| | Population | RouteLength | PAXBus | PAXDrt | BusPark | DRTPark | CostBus | CostDRT | RevenueBus | RevenueDrt | TotalBus | TotalDRT | Total | Routing Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 17178 | 26,28 | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 6,3,5 (DRT); 4,2,7,1 (DRT) |
| | 17178 | 26,28 | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 6,3,5 (DRT); 1,7,2,4 (DRT) |
| | 17178 | 27,1899999... | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 5,4,6 (DRT); 3,2,7,1 (DRT) |
| | 17178 | 27,1899999... | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 6,4,5 (DRT); 3,2,7,1 (DRT) |
| | 17178 | 27,1899999... | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 6,4,5 (DRT); 1,7,2,3 (DRT) |
| | 17178 | 27,42 | 10214,4 | 92,3999999... | 1 | 1 | 19272000 | 19272000 | 82021632 | 741971,9999999... | 62749632 | -18530028 | 44219604 | 5,3,6 (DRT); 7,1,2,4 (BUS) |
| ▸ | 17178 | 27,42 | 10214,4 | 92,3999999... | 1 | 1 | 19272000 | 19272000 | 82021632 | 741971,9999999... | 62749632 | -18530028 | 44219604 | 6,3,5 (DRT); 7,1,2,4 (BUS) |
| | 17178 | 28,25 | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 1,7,4 (DRT); 2,5,3,6 (DRT) |
| | 17178 | 28,25 | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 2,3,6 (DRT); 4,5,7,1 (DRT) |
| | 17178 | 28,25 | 0 | 10306,8000... | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 2,5,6 (DRT); 4,3,7,1 (DRT) |
| | 17178 | 28,25 | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 4,7,1 (DRT); 2,5,3,6 (DRT) |
| | 17178 | 28,25 | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 6,3,2 (DRT); 4,5,7,1 (DRT) |
| | 17178 | 28,25 | 0 | 10306,8 | 0 | 2 | 0 | 38544000 | 0 | 82763604 | 0 | 44219604 | 44219604 | 6,3,2 (DRT); 1,7,5,4 (DRT) |

Figure 28. Prototype calculations. Group 7 - DRT&Bus Routing

Group 8: Pink. Proposed mode by Wright: Bus.




| | Population | RouteLength | PAXBus | PAXDrt | BusPark | DRTPark | CostBus | CostDRT | RevenueBus | RevenueDrt | TotalBus | TotalDRT | Total | Routing Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 16874 | 14,8500000... | 0 | 10124,4 | 0 | 2 | 0 | 38544000 | 0 | 81298932 | 0 | 42754932 | 42754932 | 1,3 (DRT); 2,4 (DRT) |
| | 16874 | 14,8500000... | 0 | 10124,4 | 0 | 2 | 0 | 38544000 | 0 | 81298932 | 0 | 42754932 | 42754932 | 2,4 (DRT); 3,1 (DRT) |
| | 16874 | 14,8500000... | 0 | 10124,4 | 0 | 2 | 0 | 38544000 | 0 | 81298932 | 0 | 42754932 | 42754932 | 2,4 (DRT); 1,3 (DRT) |
| | 16874 | 14,8500000... | 0 | 10124,4 | 0 | 2 | 0 | 38544000 | 0 | 81298932 | 0 | 42754932 | 42754932 | 3,1 (DRT); 2,4 (DRT) |
| | 16874 | 20,4399999... | 0 | 10124,4 | 0 | 2 | 0 | 38544000 | 0 | 81298932 | 0 | 42754932 | 42754932 | 2,3,1,4 (DRT) |
| | 16874 | 21,0600000... | 0 | 10124,4 | 0 | 2 | 0 | 38544000 | 0 | 81298932 | 0 | 42754932 | 42754932 | 2,1,3,4 (DRT) |
| ▸ | 16874 | 21,93 | 0 | 10124,4 | 0 | 2 | 0 | 38544000 | 0 | 81298932 | 0 | 42754932 | 42754932 | 3,2,1,4 (DRT) |
| | 16874 | 22,55 | 0 | 10124,4 | 0 | 2 | 0 | 38544000 | 0 | 81298932 | 0 | 42754932 | 42754932 | 3,1,2,4 (DRT) |
| | 16874 | 24,4800000... | 0 | 10124,4 | 0 | 2 | 0 | 38544000 | 0 | 81298932 | 0 | 42754932 | 42754932 | 1,2,3,4 (DRT) |
| | 16874 | 14,8500000... | 0 | 10124,4 | 0 | 2 | 0 | 38544000 | 0 | 81298932 | 0 | 42754931,99999... | 42754931,99999... | 1,2 (DRT); 3,4 (DRT) |
| | 16874 | 14,8500000... | 0 | 10124,4 | 0 | 2 | 0 | 38544000 | 0 | 81298932 | 0 | 42754931,99999... | 42754931,99999... | 2,1 (DRT); 3,4 (DRT) |
| | 16874 | 14,8500000... | 0 | 10124,4 | 0 | 2 | 0 | 38544000 | 0 | 81298932 | 0 | 42754931,99999... | 42754931,99999... | 3,4 (DRT); 1,2 (DRT) |
| | 16874 | 14,8500000... | 0 | 10124,4 | 0 | 2 | 0 | 38544000 | 0 | 81298932 | 0 | 42754931,99999... | 42754931,99999... | 3,4 (DRT); 2,1 (DRT) |

Figure 29. Prototype calculations. Group 8

**Table 7. Comparison of results of mode choice (Wright & Prototype)**

| | Mode of transport by Wright | Mode of transport by prototype |
|---|---|---|
| Group 1 | DRT | DRT |
| Group 2 | Bus | DRT |
| Group 3 | Bus | DRT |
| Group 4 | Bus | DRT |
| Group 5 | Bus | DRT |
| Group 6 | Bus | No data |
| Group 7 | Bus | DRT / Bus / DRT&BUS |
| Group 8 | Bus | DRT |

As we can see from Table 7, the results of methodology by Wright and of prototype calculations are different in 6 cases out of 8. This could be a result of different ways of calculating of the parameters and different approaches to the question.

*Limitations*

The main part of the current prototype which is an advantage but still could be improved is data collection from OpenStreetMap service via Overpass-Turbo: while gathering data on population, it could receive no data at all for some parts of route or a false data, because of mistakes in polygons in the information source. During tests, sometimes the same data of bigger administrative entity was received instead of settlement "population" data. In order to partly solve this problem, data on the population of all settlements in New Moscow was entered into the database. However, it is crucial that the prototype is not an instrument for spatial analysis.

Furthermore, the current situation with polygons allows to user to make a connection only between settlements, because cities are perceived as one polygon in OpenStreetMap, which leads to writing population of the whole city for each point of the route. For example, if a user had an intention to make a route in Moscow between four points, the program will write 12262741 to the population four times. This may lead to miscalculations.

However, users can benefit from the prototype because of its easy-to-understand interface and possibility to adjust all the calculations to the needs of the exact territory.

*Practical implications*

The prototype and the results of the calculations could be used by transport planners and governmental bodies for a first-step analysis of development possibilities for mobility services at the territory. In addition, transport activists and citizens could use this prototype for creating a demand for mobility supply via mechanism of official communication with authorities.

*Recommendations*

In order to perform the calculation and receive accurate data, it is recommended to check data on OpenStreetMap about the chosen for research and calculations territory. As far as OpenStreetMap is an open-source platform, many users have already contributed to the development and accuracy of the map.

It is recommended for Russian State Statistical Services to provide accurate and actualized data for researchers in different forms – XLS, CSV, JSON, Shapefile, GeoJSON, etc. – in order to allow individuals to perform an accurate analysis. As an example of such service could be a website of Canadian government agency commissioned with producing statistics – Statistics Canada/Statistique Canada.

*Suggestions for future development*

As this project is a prototype, there could be several ways of development. In order to achieve accurate calculations, the code could be developed, the source of data could be changed (from OpenStreetMap to other accurate databases) and the data input function could be developed. The last part could be created as a csv-file input to the program, which reads the encoded digits and includes them into the calculations. The current design of the prototype could be developed in order to make it more user-friendly.

## Conclusions

The main objective of the study was to identify where it is better to provide conventional Public Transport and where – flexible solution (e.g. DRT) for mobility supply, based on the New Moscow case. In the text the notion of DRT was evaluated, spatial analysis with identification of mobility supply and demand was conducted with the use of GIS systems and databases.

As a result of the spatial analysis, it could be mentioned that New Moscow is undersupplied with mobility. With 93 routes, served by state transport operators and private companies, the territory is not covered with estimated level of transport service: at least half of the settlements have no access to the transportation at all. In order to provide a solution, eight groups of settlements were created and a proposal of modes of transport by Wright was made.

In order to reach the main objective of the study, a prototype was proposed. This is an application which allows user (decision-maker, transport planner or an activist) to make an easy first-step analysis of possible solution for a transport supply question for a territory. As a result, it creates a several routing options with a choice between conventional bus or DRT and calculates all the necessary economic data.

The basic choice between conventional bus routes and DRT was made on purpose: in order to provide New Moscow with a new mobility mode and Moscow City Government and Department of Transport and Road Infrastructure Development with a new possible solution for this rural and remote territory. DRT at this territory could become the option because it allows to provide small, dispersed groups of people (which are located in New Moscow) with a convenient mode of transport. City of Moscow should consider this as a possible solution for this territory, because there are no other options now for citizens.

The system of DRT in New Moscow should be developed in way, that allows to make it commercially viable. First, a system of subsidies should be created, because 90% DRT systems fail in first two years because of the lack of funds. Second, it is important to create routes, that are useful both for the City and for the citizens. Third, it is necessary to use small buses for the system because they are cheaper than the big one and all DRT systems do use this type of vehicle.

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**Appendix 1. List of Settlements within area in public transport pedestrian accessibility area and Calculation**

| Name in Russian | Name in English | Population | Total Area | Area in public transport pedestrian accessibility area | Proportion | Approximate population within public transport pedestrian accessibility area |
|---|---|---|---|---|---|---|
| Абабурово | Ababurovo | 236 | 55,56 | 6,88 | 0,12 | 29 |
| Александрово | Aleksandrovo | 67 | 46,72 | 4,01 | 0,09 | 6 |
| Анкудиново | Ankudinovo | 6 | 14,27 | 6,11 | 0,43 | 3 |
| Армейский | Armeiskii | 156 | 8,97 | 8,97 | 1,00 | 156 |
| Бабенки | Babenki | 105 | 39,44 | 35,19 | 0,89 | 94 |
| Белоусово | Belousovo | 24 | 55,74 | 11,62 | 0,21 | 5 |
| Богородское | Bogorodskoe | 5 | 59,50 | 10,56 | 0,18 | 1 |
| Богоявление | Bogoiavlenie | 38 | 49,89 | 1,12 | 0,02 | 1 |
| Большое Свинорье | Bolshoe Svinore | 27 | 142,31 | 78,70 | 0,55 | 15 |
| Ботаково | Botakovo | 49 | 10,72 | 10,72 | 1,00 | 49 |
| Брёхово | Brekhovo | 10 | 153,12 | 1,87 | 0,01 | 0 |
| Бунчиха | Bunchikha | 24 | 72,22 | 54,15 | 0,75 | 18 |
| Былово | Bylovo | 422 | 73,04 | 31,93 | 0,44 | 184 |
| Валуево | Valuevo | 435 | 32,58 | 22,79 | 0,70 | 304 |
| Ватутинки | Vatutinki | 11081 | 123,04 | 54,05 | 0,44 | 4868 |
| Верхнее Валуево | Verkhnee Valuevo | 53 | 59,85 | 41,72 | 0,70 | 37 |
| Власово | Vlasovo | 78 | 120,71 | 20,40 | 0,17 | 13 |
| Внуково | Vnukovo | 7815 | 83,32 | 61,95 | 0,74 | 5810 |
| Ворсино | Vorsino | 22 | 31,60 | 11,04 | 0,35 | 8 |
| Газопровод | Gazoprovod | 2443 | 61,88 | 16,30 | 0,26 | 644 |
| Голохвастово | Golokhvastovo | 43 | 20,62 | 20,62 | 1,00 | 43 |
| Десна | Desna | 22413 | 100,36 | 46,74 | 0,47 | 10437 |
| Дешино | Deshino | 59 | 33,83 | 14,69 | 0,43 | 26 |
| Дровнино | Drovnino | 25 | 30,54 | 8,36 | 0,27 | 7 |
| Зверево | Zverevo | 50 | 97,80 | 65,75 | 0,67 | 34 |
| Зимёнки | Zimenki | 97 | 13,45 | 13,11 | 0,97 | 95 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Знамя Октября | Znamia Oktiabria | 7394 | 164,70 | 44,19 | 0,27 | 1984 |
| Изварино | Izvarino | 179 | 23,68 | 5,22 | 0,22 | 39 |
| Ильино | Ilino | 47 | 19,84 | 19,44 | 0,98 | 46 |
| Ильичёвка | Ilichevka | 467 | 18,71 | 3,13 | 0,17 | 78 |
| Института Полиомиелита | Instituta Poliomielita | 248 | 13,84 | 6,79 | 0,49 | 122 |
| Каменка | Kamenka | 151 | 86,98 | 39,02 | 0,45 | 68 |
| Картмазово | Kartmazovo | 308 | 78,72 | 19,61 | 0,25 | 77 |
| Климовка | Klimovka | 2 | 13,67 | 10,67 | 0,78 | 2 |
| Кнутово | Knutovo | 10 | 32,97 | 0,34 | 0,01 | 0 |
| Кокошкино | Kokoshkino | 19045 | 338,89 | 83,13 | 0,25 | 4672 |
| Коммунарка | Kommunarka | 5226 | 243,18 | 84,74 | 0,35 | 1821 |
| Конаково | Konakovo | 20 | 20,97 | 0,10 | 0,00 | 0 |
| Красная Пахра | Krasnaia Pakhra | 2434 | 115,44 | 25,27 | 0,22 | 533 |
| Красное | Krasnoe | 95 | 45,61 | 25,78 | 0,57 | 54 |
| Крёкшино | Krekshino | 63 | 437,04 | 105,57 | 0,24 | 15 |
| Кресты | Kresty | 125 | 54,76 | 50,26 | 0,92 | 115 |
| Кузнецово | Kuznetcovo | 774 | 226,00 | 0,70 | 0,00 | 2 |
| Кузовлево | Kuzovlevo | 13 | 20,95 | 16,69 | 0,80 | 10 |
| Лапшинка | Lapshinka | 224 | 69,13 | 1,13 | 0,02 | 4 |
| Ларёво | Larevo | 77 | 22,36 | 15,54 | 0,69 | 54 |
| Летово | Letovo | 178 | 41,69 | 4,16 | 0,10 | 18 |
| Ликова | Likova | 122 | 16,21 | 11,93 | 0,74 | 90 |
| ЛМС | LMS | 5238 | 157,09 | 12,74 | 0,08 | 425 |
| Львово | Lvovo | 168 | 14,80 | 14,15 | 0,96 | 161 |
| Мамыри | Mamyri | 414 | 12,29 | 3,34 | 0,27 | 112 |
| Марушкино | Marushkino | 7082 | 272,08 | 18,87 | 0,07 | 491 |
| Марьино | Marino | 2301 | 144,98 | 20,45 | 0,14 | 325 |
| Мешково | Meshkovo | 504 | 117,61 | 1,25 | 0,01 | 5 |
| Михайловское | Mikhailovskoe | 100 | 42,15 | 23,13 | 0,55 | 55 |
| Московский | Moskovskii | 61224 | 465,38 | 98,22 | 0,21 | 12922 |
| Мосрентген | Mosrentgen | 20736 | 210,41 | 57,85 | 0,27 | 5702 |
| Мостовское | Mostovskoe | 227 | 58,85 | 27,90 | 0,47 | 108 |
| Ознобишино | Oznobishino | 298 | 88,65 | 63,47 | 0,72 | 213 |
| Остафьево | Ostafevo | 1149 | 56,42 | 0,56 | 0,01 | 11 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Пенино | Penino | 172 | 18,18 | 18,18 | 1,00 | 172 |
| Первомайское | Pervomaiskoe | 8481 | 37,07 | 13,18 | 0,36 | 3016 |
| Поповка | Popovka | 102 | 218,15 | 78,75 | 0,36 | 37 |
| Посёлок кирпичного завода | Poselok kirpichnogo zavoda | 12 | 10,20 | 0,99 | 0,10 | 1 |
| посёлок станции Крёкшино | poselok stantcii Krekshino | 196 | 79,40 | 19,56 | 0,25 | 48 |
| Постниково | Postnikovo | 157 | 55,27 | 1,38 | 0,03 | 4 |
| Птичное | Ptichnoe | 4262 | 296,72 | 81,92 | 0,28 | 1177 |
| Пучково | Puchkovo | 350 | 48,92 | 21,16 | 0,43 | 151 |
| Пыхтино | Pykhtino | 155 | 25,97 | 3,44 | 0,13 | 21 |
| рабочий посёлок Киевский | rabochii poselok Kievskii | 13714 | 99,97 | 21,21 | 0,21 | 2909 |
| Рассказовка | Rasskazovka | 408 | 53,00 | 31,13 | 0,59 | 240 |
| Рассудово | Rassudovo | 269 | 163,70 | 59,58 | 0,36 | 98 |
| Рогозинино | Rogozinino | 24 | 46,52 | 21,57 | 0,46 | 11 |
| Рождественно | Rozhdestvenn o | 2 | 42,00 | 5,25 | 0,13 | 0 |
| Руднёво | Rudnevo | 187 | 140,91 | 47,88 | 0,34 | 64 |
| Румянцево | Rumiantcevo | 673 | 51,85 | 17,92 | 0,35 | 233 |
| Саларьево | Salarevo | 369 | 58,82 | 1,36 | 0,02 | 9 |
| Свитино | Svitino | 16 | 24,64 | 24,56 | 1,00 | 16 |
| Семенково | Semenkovo | 26 | 113,25 | 7,60 | 0,07 | 2 |
| совхоза Крёкшино | sovkhoza Krekshino | 1460 | 148,97 | 51,03 | 0,34 | 500 |
| Сосенки | Sosenki | 30651 | 119,47 | 71,11 | 0,60 | 18244 |
| Страдань | Stradan | 35 | 59,07 | 38,09 | 0,64 | 23 |
| Терехово | Terekhovo | 23 | 41,45 | 10,92 | 0,26 | 6 |
| Товарищево | Tovarishchevo | 2 | 23,00 | 18,56 | 0,81 | 2 |
| Троица | Troitca | 23 | 23,58 | 0,24 | 0,01 | 0 |
| Троицк | Troitck | 61079 | 1632,25 | 197,02 | 0,12 | 7372 |
| Ульяновского лесопарка | Ulianovskogo lesoparka | 24 | 39,96 | 22,74 | 0,57 | 14 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Фабрики им. 1 мая | Fabriki im. 1 maia | 3103 | 31,64 | 4,03 | 0,13 | 395 |
| Филимонки | Filimonki | 7026 | 46,09 | 10,01 | 0,22 | 1525 |
| Черепово | CHerepovo | 50 | 15,55 | 1,53 | 0,10 | 5 |
| Чириково | CHirikovo | 25 | 15,47 | 13,27 | 0,86 | 21 |
| Ширяево | SHiriaevo | 73 | 39,22 | 4,67 | 0,12 | 9 |
| Щапово | SHCHapovo | 9572 | 197,16 | 67,19 | 0,34 | 3262 |
| Щербинка | SHCHerbinka | 53281 | 762,33 | 80,08 | 0,11 | 5597 |
| Юдановка | IUdanovka | 174 | 85,02 | 69,42 | 0,82 | 142 |
| Юрьевка | IUrevka | 23 | 45,76 | 38,57 | 0,84 | 19 |
| Яковлево | IAkovlevo | 1048 | 102,51 | 12,49 | 0,12 | 128 |
| Яковлевское | IAkovlevskoe | 4138 | 105,56 | 62,59 | 0,59 | 2454 |
| Ясенки | IAsenki | 80 | 44,14 | 43,09 | 0,98 | 78 |
| | **Sum** | **383891** | **10499,805** | **2867,93** | | **101219** |

**Appendix 2. List of Settlements without area in public transport pedestrian accessibility area and Calculation**

| **Name in Russian** | **Name in English** | **Population** |
|---|---|---|
| Акулово | Akulovo | 33 |
| Алхимово | Alkhimovo | 11 |
| Алымовка | Alymovka | 11 |
| Бакланово | Baklanovo | 51 |
| Бурцево | Burtsevo | 15 |
| Варварино | Varavrino | 25 |
| Васюнино | Vasynino | 73 |
| Власьево | Vlas'yevo | 94 |
| Говорово | Govorovo | 192 |
| Голенищево | Golenishevo | 10 |
| Голохвастово | Golohvastovo | 43 |
| Горнево | Gorneevo | 1 |
| Городище | Gorodishche | 124 |
| Горчаково | Gorchakovo | 32 |
| Губкино | Gubkino | 23 |
| Губцево | Gubtsevo | 15 |
| Девятское | Devyatskoye | 301 |
| Дмитровка | Dmitrovka | 1 |
| Долгино | Dolgino | 0 |
| Евсеево | Evseevo | 63 |
| Елизарово | Elizarovo | 48 |
| Ерино | Erino | 2692 |
| Жуковка | Zhukovka | 204 |
| Заболотье | Zabolotie | 1 |
| Зайцево | Zaytsevo | 10 |
| Зосимова Пустынь | Zosimova Pustin | 23 |
| Каменка | Kamenka | 151 |
| Каракашево | Karakashevo | 22 |
| Киселёвка | Kiselevka | 26 |
| Кленовка | Klenovka | 16 |
| Клоково | Klokovo | 20 |
| Конаково | Konakovo | 20 |
| Конюшково | Konyushkovo | 6 |
| Костишово | Kostishovo | 12 |

| | | |
|---|---|---|
| Красные Горки | Krasnie Gorki | 61 |
| Круча | Krucha | 4 |
| Кувекино | Kuvekino | 97 |
| Кукшево | Kukshevo | 4 |
| Лапшинка | Lapshinka | 224 |
| Лопатино | Lopatino | 5 |
| Лужки | Luzhki | 5 |
| Лукино | Lukino | 0 |
| Лыковка | Lykovka | 1 |
| Макарово | Makarovo | 46 |
| Малеевка | Maleevka | 1 |
| Марьино | Marino | 247 |
| Мачихино | Machikhino | 1 |
| Настасьино | Nastasiino | 70 |
| Никольское | Nikolskoe | 1 |
| Новиково | Novikovo | 10 |
| Новинки | Novinki | 34 |
| Овечкино | Ovechkino | 19 |
| Пёсье | Pesie | 94 |
| Писково | Piskovo | 103 |
| Поляны | Polyani | 4 |
| посёлок Станции Мачихино | Machihino | 50 |
| Прокшино | Prokshino | 32 |
| Пудово-Сипягино | Pudovo-Sypyagino | 1 |
| Пыхчево | Pykhchevo | 26 |
| Пятовское | Pyatovskoye | 0 |
| Рабочий посёлок № 1 | Rabochiy Poselok 1 | 8 |
| Раево | Raevo | 34 |
| Рожново | Rozhnovo | 0 |
| Сальково | Salkovo | 13 |
| Сахарово | Sakharovo | 74 |
| Середнёво | Serednevo | 16 |
| Спас-Купля | Spas-Kuplya | 29 |
| Староселье | Staroselie | 21 |
| Талызина | Talyzina | 11 |
| Тарасово | Tarasovo | 13 |
| Тетеринки | Teterinki | 17 |

| | | |
|---|---|---|
| Троица | Troitsa | 23 |
| Уварово | Uvarovo | 20 |
| Фёдоровское | Fedorovskoe | 3 |
| Филино | Filino | 15 |
| Фоминское | Fominskoye | 20 |
| Харьино | Harino | 73 |
| Хатминки | Khatminki | 10 |
| Хмырово | Hmirovo | 0 |
| Хутора Гуляевы | Hutora Gulyaevi | 6 |
| Шеломово | Shelomovo | 158 |
| Ямищево | Yamisheco | 128 |
| Ярцево | Yartsevo | 22 |
| | **Total** | 6223 |

**Appendix 3. Number of Validations of tickets at New Moscow Routes by Mosgortrans, 2018**

| Route | Annual | | | Per day |
|---|---|---|---|---|
| | Discounted | Payed | Total | |
| 863 | 1005711 | 927021 | 1932732 | 5892 |
| 858 | 970101 | 785450 | 1755551 | 5352 |
| 737 | 996855 | 748043 | 1744898 | 5320 |
| 374 | 868548 | 816775 | 1685323 | 5138 |
| 108 | 956988 | 724967 | 1681955 | 5128 |
| 767 | 887135 | 763230 | 1650365 | 5032 |
| 32 | 947124 | 672017 | 1619141 | 4936 |
| 398 | 954742 | 575813 | 1530555 | 4666 |
| 33 | 818619 | 697493 | 1516112 | 4622 |
| 848 | 839548 | 671714 | 1511262 | 4608 |
| 288 | 831268 | 650058 | 1481326 | 4516 |
| 420 | 740289 | 627098 | 1367387 | 4169 |
| 781 | 696712 | 604250 | 1300962 | 3966 |
| 895 | 620439 | 670035 | 1290474 | 3934 |
| 911 | 552521 | 674197 | 1226718 | 3740 |
| 891 | 551553 | 618476 | 1170029 | 3567 |
| 531 | 576990 | 585916 | 1162906 | 3545 |
| 753 | 637376 | 498994 | 1136370 | 3465 |
| 577 | 496905 | 575734 | 1072639 | 3270 |
| 611 | 504929 | 553276 | 1058205 | 3226 |
| 882 | 442899 | 563536 | 1006435 | 3068 |
| 433 | 561958 | 434627 | 996585 | 3038 |
| 343 | 491796 | 381058 | 872854 | 2661 |
| 707 | 472448 | 355999 | 828447 | 2526 |
| 600 | 493882 | 330635 | 824517 | 2514 |
| 876 | 482114 | 341241 | 823355 | 2510 |
| 864 | 470549 | 347985 | 818534 | 2496 |
| 272 | 378189 | 368000 | 746189 | 2275 |
| 804 | 374814 | 357098 | 731912 | 2231 |
| 1002 | 367110 | 318822 | 685932 | 2091 |
| 982 | 313848 | 367767 | 681615 | 2078 |
| 734 | 360462 | 238265 | 598727 | 1825 |
| 497 | 357110 | 230232 | 587342 | 1791 |
| 508 | 316325 | 264055 | 580380 | 1769 |

| | | | | |
|---|---|---|---|---|
| 333 | 295705 | 273102 | 568807 | 1734 |
| 750 | 327955 | 236652 | 564607 | 1721 |
| 779 | 273282 | 269854 | 543136 | 1656 |
| 249 | 271444 | 258599 | 530043 | 1616 |
| 802 | 304644 | 221490 | 526134 | 1604 |
| 512 | 269924 | 235508 | 505432 | 1541 |
| 878 | 275070 | 214971 | 490041 | 1494 |
| 881 | 274257 | 183094 | 457351 | 1394 |
| 526 | 237054 | 218244 | 455298 | 1388 |
| 819 | 233622 | 103555 | 337177 | 1028 |
| 579 | 154404 | 121530 | 275934 | 841 |
| 515 | 132116 | 125168 | 257284 | 784 |
| 874 | 164670 | 80817 | 245487 | 748 |
| 514 | 133644 | 111341 | 244985 | 747 |
| 866 | 130387 | 113888 | 244275 | 745 |
| 890 | 111311 | 105666 | 216977 | 662 |
| 889 | 137169 | 75780 | 212949 | 649 |
| 1001 | 124698 | 76055 | 200753 | 612 |
| 17 | 147429 | 48886 | 196315 | 599 |
| H11 | 78741 | 32424 | 111165 | 339 |
| 860 | 70764 | 21057 | 91821 | 280 |
| 550 | 213825 | 177573 | 391398 | 193 |
| 513 | 33270 | 29049 | 62319 | 190 |
| 305 | No Data | No Data | No Data | No Data |
| 307 | No Data | No Data | No Data | No Data |
| 308 | No Data | No Data | No Data | No Data |
| 485 | No Data | No Data | No Data | No Data |
| 554 | No Data | No Data | No Data | No Data |
| 575 | No Data | No Data | No Data | No Data |
| 30 | No Data | No Data | No Data | No Data |
| 32к | No Data | No Data | No Data | No Data |
| 1003 | No Data | No Data | No Data | No Data |
| 1038 | No Data | No Data | No Data | No Data |
| 1043 | No Data | No Data | No Data | No Data |
| 1055 | No Data | No Data | No Data | No Data |
| 707к | No Data | No Data | No Data | No Data |