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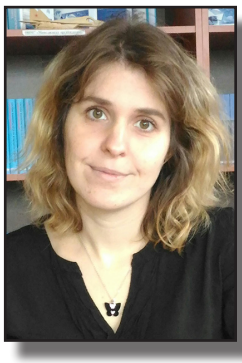
Transport System of the Republic of Sakha (Yakutia): Analysis of the State and Development Challenges



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ABSTRACT

The transport accessibility of the Arctic zone is of strategic interest for Russia from the point of view of the possibility of mineral exploration and ensuring further systemic development of this part of the national territory.

The objective of the study is to carry out a spatial analysis of the transport system of the Republic of Sakha (Yakutia), to identify its topological properties and restrictions that impede providing sufficient logistics services. Based on the method of spatial analysis, the conducted study of the state of the transport system of the Republic of Sakha (Yakutia) allowed to assess transport provision within its territory for three types of transportation: transport provision of internal regional (local) transportation, transport provision of accessibility (entry and exit) of the territory of the region, and transport provision of transit transportation across the region.

The study showed that air transport is the main mode for passenger transportation, while seasonal water and winter road transportation are the main modes of freight haulage.

The regions of Yakutia with access to traffic arteries and isolated from them have been identified. Calculations based on the Engel's coefficient allowed to proceed with a mathematical assessment of the transport system of the region, which indicates its insufficient development due to the lack of year-round transportation routes in the areas of the Far North and the Arctic zone. The transport infrastructure of this part of the region are represented by seasonal winter roads and waterways, which prevents from assessing their general year-round potential. For its assessment, it is necessary to consider seasonal availability of each individual section of the network.

Keywords: transport system, Republic of Sakha (Yakutia), airport network, water transport, Arctic zone, winter road, transport provision of the territory.

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INTRODUCTION

The Republic of Sakha (Yakutia) is not only the largest administrative territorial entity of the Russian Federation, but also the largest subnational administrative territorial entity in the world. Its total area, including the continental and insular parts, is 3,1 mln sq. km. More than 50 % of the Republic's territory is located beyond the Arctic Circle (about 1,63 million sq. km). The Arctic zone of the Republic of Sakha (Yakutia) exceeds the area of the Arctic zone of Canada [1].

According to the decree of the President of the Russian Federation[1], the land territory of the Arctic zone of the Republic of Sakha (Yakutia) includes the territories of 13 districts (ulus): Abyysky ulus, Allaikhovsky ulus, Anabarsky national (Dolgan-Evenk) ulus, Bulun ulus, Verkhnekolymsky ulus, Verkhoyansky ulus, Zhigansky national Evenk ulus, Momsky ulus, Nizhnekolymsky ulus, Oleneksky Evenk national ulus, Srednekolymsky ulus, Ust-Yansky ulus, and Even-Bytantaysky national ulus.

With such a large area, the population of the region is only 981 971 people (0,32 people per sq. km) according to Rosstat [Federal State Statistics Service] data as of January 1, 2021.The share of the urban population was 66,1 %, the share of the rural population was 33,9 %. Most of the population of Yakutia lives in the central part of the region (about 500 thousand people). The largest cities are Yakutsk, the Republic's administrative centre, Neryungri, Aldan, Lensk, Mirny, Vilyuisk, Aikhal, and Udachny. The uneven settlement is explained by the difficult natural and climatic conditions of the northern part of the region, which complicates development of the transport system and ensuring transport accessibility of all remote sparsely populated areas [2–4].

At the same time, the Republic of Sakha (Yakutia) is of great economic interest from the point of view of exploration of the richest mineral deposits. The territory of the Republic englobes 82 % of the country's diamond reserves, 17 % of gold, 61 % of uranium, 82 % of antimony, 6,2 % of iron ore, 40 % of coal, 28 % of tin and 8 % of mercury[2], as well as the reserves of rare earth elements. The diamond mining industry is widely developed, while the region is gradually developing the extraction of oil and gas resources.

The development of the mineral industry requires a reliable transport infrastructure necessary for delivery of production resources (building materials, fuel, equipment), transporting specialists, and the export of mining products [5]. However, the large area of the territory, natural and climatic conditions, the presence of permafrost, terrain features, a dispersive settlement system determine the high construction cost of transport roads. According to the Government of the Republic of Sakha, in terms of transport, Yakutia is one of the most isolated and hard-to-reach regions in the world, since 90 % of its territory does not have year-round transport links[3]. When allocating the budget, priority is given to transport projects aimed at developing economically and socially justified ties, which are predominantly of interregional and country significance to the detriment of internal and local ties [6]. The peculiarities of the transport system of the Republic of Sakha (Yakutia) are: absence of alternative to the existing transport delivery schemes, consisting of several links, including seasonal routes, and limited interchangeability of modes of transport and transportation routes, which lead to increased travel time, transport monopolisation and increased costs (high tariffs) [7].

The *objective* of the study is to conduct a spatial analysis of the transport system of the Republic of Sakha (Yakutia), to identify its topological properties and constraints that impede sufficient transport provision of the territory.

RESEARCH METHODS

The study of the state of the transport system of the Republic of Sakha (Yakutia) was carried out at the first stage based on a spatial analysis of the location and topological structure of the existing networks of water, rail, and road transport. The analysis of the topological

[1] Decree of the President of the Russian Federation of May 2, 2014 No. 296 «On the land territories of the Arctic zone of the Russian Federation» (with amendments and additions introduced by the decree No. 220 of May 13, 2019). [Electronic resource]: https://www.garant.ru/products/ipo/prime/doc/70547984/. Last accessed 07.07.2021.

[2] Mining industry. Ministry of Industry and Geology of the Republic of Sakha (Yakutia) official website. [Electronic resource]: https://minprom.sakha.gov.ru/gornorudnaja-promyshlennost/gornorudnaja-promyshlennost-gorno. Last accessed 07.07.2021.

[3] The Republic of Sakha (Yakutia). Federation Council of the Federal Assembly of the Russian Federation. [Electronic resource]: http://council.gov.ru/structure/regions/SA/. Last accessed 07.07.2021.

structure of the transport network was carried out according to the methodology of S. A. Tarkhov [8; 9]. Among the main topological properties of transport networks, he singles out: spatial connectivity and isolation, mutual ranking of elements (their mutual arrangement), neighbourhood relation, cyclicity and branching of linear network elements. The assessment of the topological structure of the transport system of the Republic of Sakha (Yakutia) was based on the results of studies of imperfections in transport networks in the regions of Siberia and the Far East [7; 10].

Further, the analysis of the transport provision of the region was carried out in terms of ensuring transportation for three types of transportation: transport provision of internal regional (local) transportation, transport provision of access (entry and exit) to the territory of the region, and transport provision of transit through the territory of the region. The division of the indicator of transport provision into three components is necessary since the effective functioning of the Arctic transport system cannot be achieved without ensuring high-quality transport trunk and feeder lines [11]. The conducted analysis allowed to identify areas that have access to transport trunk lines and those which are isolated from them. Further, based on statistical data of the Ministry of Transport and Roads of the Republic of Sakha (Yakutia), it was possible to calculate indicators of the length of transport routes per 1000 sq. km of territory and per 10 000 inhabitants, the performance indicators of each mode of transport, and their respective place in the structure of passenger transportation and cargo turnover in the region.

For a mathematical assessment of the level of development of the transport system of the Republic of Sakha (Yakutia), Engel's coefficients were used considering the length of the year-round main lines of road and rail transport [12–14]. The complexity of assessing the transport provision of the Republic of Sakha (Yakutia) refers to many seasonal transportation links, which does not allow assessing their year-round potential [15–17].

RESULTS. SPATIAL ANALYSIS OF THE LOCATION AND PERFORMANCE INDICATORS OF THE TRANSPORT NETWORK OF THE REPUBLIC OF SAKHA (YAKUTIA)

Historically, due to the large area of the territory, natural and climatic features, and the presence of the largest river artery in the Republic of Sakha (Yakutia), *river transport* is the cheapest and most popular. The length of the operated waterways in the Republic of Sakha (Yakutia) is 21,8 thousand km, of which 13,6 thousand km are serviced, and guaranteed depths are provided at 9,2 thousand km (Pic. 1). The water transport network of Yakutia consists of the channels of six rivers: the Lena (4440 km), Anabar (939 km), Olenek (2292 km), Yana (872 km), Indigirka (1726 km), and Kolyma (2129 km) with their tributaries, as well as of a section of the Northern Sea Route (NSR). The main waterway of the Republic is the Lena with tributaries Aldan (2273 km) and Vilyui (2650 km) [18]. The Lena is the third river in Russia in terms of basin area after the Ob and Yenisei. Besides, it is the largest river in the world that flows through permafrost area. The length of the sea coastline of Yakutia is 4,5 thousand km. The analysis showed that the Republic's river routes provide cargo delivery to 17 out of 34 districts (ulus) and the city of Yakutsk, including 11 out of 13 ulus located in the Arctic zone (except for Oleneksky and Eveno-Bytantaysky districts). Delivery of goods to the territory of the region is carried out, as a rule, from the upper river Lena after the opening of navigation. Further, the cargo is awaiting the opening of navigation at the upper reaches of the river and on the NSR. Along the NSR, cargo is delivered by river-sea vessels to the channels of the northern rivers and along them to district centres. In district centres, cargoes are deposited in warehouses and in winter they are transported by road to settlements by winter roads. Delivery of goods under this scheme takes about a year on average. The navigation period on the rivers varies from 45 to 130 days, depending on the navigation area, climatic conditions, water level, volume and quality of survey and dredging works. On the Lena, Yana, Indigirka, Kolyma rivers, navigation starts in late May – early June. On the bars of these rivers, on the Olenekskaya creek, the Olenek River and along coastal sea routes, navigation starts in late July and early August. Navigation on offshore sections is limited to 40–70 days from July 15 to October 7. The port of Tiksi is shallow and is not capable of receiving large sea vessels. The maximum allowable draft is 5,6 m; therefore, unloading is carried out in the roadstead, and due to September storms, the navigation period is reduced to 30–40 days [19]. In these conditions, there is an acute issue of deepening the water area of the seaport

Pic. 1. A schematic diagram of the network of water transport of the Republic of Sakha (Yakutia)[4].

Table 1

Length of waterways and dynamics of production indicators of water transport in the Republic of Sakha (Yakutia)*

Indicators	2013	2014	2015	2016	2017	2018	2019
Length of river waterways, thousand km	16 520	16 522	16 522	16 522	16 522	16 522	16 522
Total transported, thousand tonnes	2 757,5	2 942,3	2 709,4	2 731,8	2 745,8	2 411,8	2 798,0
Including: PJSC LORP	1 124,0	1 305,0	1 315,0	1 167,0	1 416,0	1 280,0	1 241,0
Others	1 633,5	1 637,3	1 394,4	1 564,8	1 329,8	1 131,8	1 557,0
Total cargo turnover, mln tkm	2 471,1	2 721,1	2 484,2	2 248,9	2 236,7	2 160,6	2 276,0
Passengers transported, thousand people	252,9	354,6	310,4	337,4	312,0	312,0	no data
Passenger turnover, million pkm	22,6	26,1	22,3	27,4	28,6	27,7	no data

* Compiled by the author based on the data of the Ministry of Transport and Roads of the Republic of Sakha (Yakutia).

of Tiksi, through which the region is connected with the Northern Sea Route. Without solving this problem, it is impossible to fully use the potential of the Northern Sea Route.

Besides, in the summer months, the rivers of Yakutia become shallow, which requires introduction of restraints on the draft of ships, leading to a loss of the carrying capacity of the fleet. According to the data of the Lena United River Shipping Company in 2020, during the period of shallow water in the sections of the river Yana fleet was operated with a load of only 30–50 %, and in the sections of the river Indigirka with a loading of 50 %. In 2020, the situation was aggravated by forest fires in the Lena, Vilyui, Aldan, Kolyma basins, which provoked almost zero visibility. As a result, from 5 to 12 August, a ban was imposed on navigation downstream of the Aldan River[5]. The dynamics of production indicators of water transport and the length of waterways are presented in Table 1.

Restrictions associated with river shallowing and a reduction in the commercial load of river vessels lead to a decrease in the cargo turnover of river transport.

The railway transport of Yakutia is represented by the single Amur-Yakutsk main line, connecting the Trans-Siberian and Baikal-Amur main lines with the bank of the Lena opposite Yakutsk, 10 km from the village of Nizhny Bestyakh. Its length is 767 km, Pic. 2.

The absence of a bridge across the Lena River does not allow laying a railway line to the regional capital, Yakutsk. As a result, the goods delivered by rail are transloaded to river vessels or deposited in warehouses in the village of Nizhniy Bestyakh, and in winter they are delivered to Yakutsk via an ice crossing by road. The construction of the road bridge, which began in 2021, will partially solve this problem by

[4] Delivery of goods by water transport to the territory of the Republic of Sakha (Yakutia). A-Service. Delivery of goods to hard-to-reach regions. [Electronic resource]: https://as-sib.com/uslugi/rechnyie-perevozki/lena. Last accessed 07.07.2021.

[5] Lena United River Shipping Company. Annual report on the results of work for 2020. Yakutsk, 2021, 37 p.

Pic. 2. Amur-Yakutsk railway line.
(Amur-Yakutsk railway main line. Russia 24. [Electronic resource]: https://www.youtube.com/watch?v=MFJS1sQGrHs. Last accessed 07.07.2021).

organising year-round road transportation of passengers and goods to the opposite bank of the Lena River.

The main categories of cargo delivered by rail are coal, construction materials and oil products, containerised cargo, food products, and timber. Passenger traffic is carried out daily. The length of the railway line and performance indicators are presented in Table 2.

According to the Ministry of Transport and Roads of the Republic of Sakha (Yakutia), the increase in the volume of transportation of goods by rail is associated with an increase in the volume of transportation of foodstuffs following entering into force of a single lower tariff of JSC Russian Railways within the price list 10–01 since the beginning of 2018, as well as of transportation of coal by coal mining enterprises.

Since extensive network of railway transport misses, *road transport* in the Republic of Sakha (Yakutia) is the only available land mode of transport. However, the road network is also poorly developed, has seasonal operation, and individual road sections and territorially isolated. The location of the network of federal and regional highways and of local roads, including winter roads, across the territory of the Republic of Sakha (Yakutia) is shown schematically in Pic. 3.

There are three federal highways running on the territory of the Republic. The A-360 «Lena» highway with a length of 1157 km connects the R-297 «Amur» highway and the settlement of Nizhny Bestyakh. The highway does not reach Yakutsk since there is no bridge across the river Lena. In summer, the crossing is carried out by ferry, in winter using the ice bridge (from December to April), during the period of ice drift and freezing-over by hovercraft [20]. In Nizhniy Bestyakh, the highway joins the R-504 Kolyma highway. The federal highway «Kolyma» has a length of 2032 km, connects Nizhny Bestyakh to Magadan and goes to the Pacific Ocean coast. A federal highway A-331 «Vilyui» is under construction, which will have to connect Tulun of Irkutsk region through Bratsk, Ust-Kut, Mirny, to Yakutsk. On the territory of Yakutia, there exists a section from Mirny to Yakutsk, on the territory of Irkutsk region there is a segment from Tulun to Ust-Kut, the rest of the sections are connected by winter roads. In the northern and Arctic areas of the Republic, the length of highways with year-round operation is extremely insignificant. More than 92 % of the roads of the Republic of Sakha (Yakutia) are seasonal roads (winter roads).

The length of the roads and the performance indicators of road transport in the Republic of Sakha (Yakutia) are presented in Table 3.

Cargo turnover of road transport has been showing positive dynamics from 2017 till now since this type of transportation is the only one available for settlements located far from river arteries.

The total length of the road network in the Republic is 38 998,7 km, however, more than half of the roads are seasonal and winter roads. The total length of paved roads is 12 205,9 km

Pic. 3. Location of the year-round and seasonal road network of the Republic of Sakha (Yakutia) (winter roads are marked in green, darker colour; currently not-maintained winter roads are shown with a dotted line).
(How to lay a winter road a month earlier? Round table in the Public Chamber of the Republic of Sakha (Yakutia). [Electronic resource]: https://dnevniki.ykt.ru/nikbara/1114992?mobile=true https. Last accessed 07.07.2021).

Table 2

Length and indicators of activity of railway transport in the Republic of Sakha (Yakutia)*

Indicators	2014	2015	2016	2017	2018	2019	2020
Length, km	525	525	525	525	525	525	525
Volume of cargo transportation, thousand tonnes	2 158,2	2 928,1	4 015,5	4 681,6	5 501,8	6 683,6	6 067,7
Cargo turnover, million tkm	337,2	410,1	519,8	581,7	615,8	1 047,4	1 628,4
Passengers transported, thousand people	88,8	75,6	74,9	79,6	83,6	93,1	81,7
Passenger turnover, million pkm	26,5	22,9	34,4	35,3	37,1	49,4	39,5

*Compiled by the author based on the data of the Ministry of Transport and Roads of the Republic of Sakha (Yakutia).

(31,3 %). Federal roads' length is 3 586,2 km, of which 3 313,6 km (92,4 %) are hard surfaced. Regional roads are 13 152,7 km long, of which 3 545,3 km are hard-surface roads (27,0 %). Local roads are 22 259,8 km long, of which 5 347,0 km (24,0 %)[6] have hard surface.

The period of operation of winter roads is directly related to the weather conditions and freeze-up on the rivers. On average, the working period of winter roads does not exceed four months: from the end of December to the end of April (25.12–25.04). An increase in the efficiency of their use can be achieved by increasing the accuracy of forecasting ice phenomena for all water areas of the region. One of the methods for specifying the forecast accuracy was proposed in the works of N. A. Filippova [21].

Air transport is the only one mode of transport within the transport system of the Republic of Sakha (Yakutia), capable of providing year-round transport accessibility of all districts and settlements. Airports are its main nodes of the civil aviation, interconnected by the route network of airlines and land modes of transport. On the territory of the Republic of Sakha (Yakutia), according to the Federal Air Transport Agency as of May 28, 2021, there are 31 airports[7]. 16 airports in Yakutsk and district centres will have been reconstructed till 2024[8]. The airport network of the Republic is served by four organisations: 28 airports are under the jurisdiction of the Federal State Enterprise «Airports of the North». «Airport Yakutsk» which is of federal importance, is operated by JSC «Airport Yakutsk». Talakan airport is operated by JSC «Airport Surgut», «Mirny» airport, operated by the Mirny Aviation Enterprise

[6] Government decree of the Republic of Sakha (Yakutia) No. 146 of 27.03.2010 (as amended on 17.05.2021).

[7] State register of aerodromes and heliports of civil aviation of the Russian Federation as of 28.05.2021.

[8] Tayursky, V. Runway [*Polosa razgona*]. Rossijskaya gazeta, 11.02.2021. [Electronic resource]: https://rg.ru/2021/02/11/reg-dfo/v-iakutii-nachinaetsia-massovaia-rekonstrukciia-aeroportov.html. Last accessed 07.07.2021.

Table 3

Length of highways and roads and performance indicators of motor transport in the Republic of Sakha (Yakutia)*

Indicators	2014	2015	2016	2017	2018	2019
Public roads with hard surface, km	11 367	11 714	11 766	11 900	12 047	12 205
Cargo transported, thousand tonnes	14 401,4	26 057,3	26 396,0	20 696,0	21 316,4	22 612,0
Cargo turnover, mln tkm	1 643,2	2 279,0	2 304,1	2 185,2	2 333,8	2 651,0
Passengers transported, million people	92,5	96,2	no data	96,6	94,7	no data
Passenger turnover, mln pkm	447,0	483,6	no data	475,4	456,4	no data

* Compiled by the author based on the data of the Ministry of Transport and Roads of the Republic of Sakha (Yakutia).

Table 4

Air transport performance

Indicators	2014	2015	2016	2017	2018	2019*
Cargo and mail loaded and unloaded, tonnes	31 672,46	28 253,74	32 772,26	32 361,40	27 348,40	22 575,61
Cargo turnover, million tkm	82,3	69,9	73,3	67,7	48,9	52,1
Passengers embarked and disembarked, people	1 567 655	1 624 624	1 675 180	1 757 327	1 760 858	1 849 467

* Compiled based on the data of the Ministry of Transport and Roads of the Republic of Sakha (Yakutia) for 2014–2018, data for 2019 are provided by the airport management and does not include data from Talakan airport and mail processing at Yakutsk and Mirny airports.

of PJSC ALROSA. The indicators of their activities are presented in Table 4.

The volume of cargo transportation by air in the Republic of Sakha (Yakutia) is insignificant and is formed mainly with perishable and pharmaceutical products delivered to provide remote areas. The decrease in passenger air transportation is due to the increase in fuel prices and consequently in ticket costs. On the territory of the Arctic area of the Republic, there are 14 airports (airfields) and one aviation site in the village of Nizhneyansk, which are under the jurisdiction of the Federal State Enterprise «Airports of the North». Flights to these airports are carried out from the administrative centre with a frequency of one or two flights per week. Flights on local routes are operated by AN-24 aircrafts with a capacity of 48 seats and Let L-410 Turbolet with a capacity of 19 seats with an average load of 30 to 70 %, which is economically ineffective. Therefore, airlines are reducing the frequency of flights to increase the load factor [7; 22].

Spatial location of airports and air routes in the Arctic area are shown in Pic. 4.

The calculations carried out by the author showed that in 2019 the main volume of transport work in the region fell on road transport and amounted to 2 651,0 million tkm (40 %), the cargo turnover of river transport decreased and amounted to 2 276,0 million tkm (34 %), the cargo turnover of railway transport increased and amounted to 1 628,4 million tkm (25 %), the cargo turnover of air transport amounted to 52,1 million tkm (less than 1 %). The changes took place in connection with the increased role of railway transport due to reception of some cargo flows on Ust-Kut–Nizhny Bestyakh section redirected from water transport. Road transport is most demanded when organising passenger suburban transportation, and air transport is most used for intercity intraregional traffic.

Table 5 shows the calculation of indicators of transport development of the territory of the Republic of Sakha (Yakutia), however, these indicators do not take into account the constraints of seasonal availability of water transport. The length of winter roads was not considered in the calculation of the indicators.

The Republic of Sakha (Yakutia) has an extremely low density of hard surface roads since they are absent in the northern part of the region. The length of the railway is also very small in relation to the total area of the region. As a result, the Engel's coefficient in Republic is only about 0,01. For comparison, the average value of the Engel's coefficient for the Far Eastern Federal District of the Russian Federation is 0,37, and for the Siberian Federal District it is of 0,53, but these calculations do not consider seasonality of the waterways used. In general, for the Russian Federation, the Engel's coefficient is 0,6. If, when calculating the Engel's coefficient for the Republic of Sakha (Yakutia), we consider the length of waterways and winter roads without taking into account their seasonal use, then its

Pic. 4. A schematic diagram of the airport network of the Republic of Sakha (Yakutia) and the operating route network of regular air transportation in the Arctic area. Compiled by the author based on the analysis of flight schedules of Polar Airlines and Yakutia Airlines.

Table 5

Indicators characterizing the level of transport provision of the territory of the Republic of Sakha (Yakutia)*

Indicators	2014	2015	2016	2017	2018	2019
Density of hard surface roads per 1000 sq. km of territory, km	3,69	3,80	3,82	3,86	3,91	3,96
Density of railways per 1000 sq. km of territory, km	0,17	0,17	0,17	0,17	0,17	0,17
Density of hard surface roads per 10 000 inhabitants, km	118,79	122,06	122,20	123,40	124,58	125,57
Density of railways per 10 000 inhabitants, km	5,49	5,47	5,45	5,44	5,43	5,40
Engel's coefficient	0,01	0,01	0,01	0,01	0,01	0,01

* Calculated by the author based on the data of the Ministry of Transport and Roads of the Republic of Sakha (Yakutia).

value will be of 0,03. The complexity of considering seasonality of the use of waterways and road transport routes is associated with the different periods of operation of different sections of the network and requires a detailed mathematical analysis.

CONCLUSIONS

Spatial analysis of the transport system of the Republic of Sakha (Yakutia) has allowed to draw several conclusions.

Seasonal networks of winter roads and river routes, especially outside the southern and central parts of the region, are of predominant importance in organising cargo transportation throughout the region. Transportation by rivers and road haulage are carried out in the meridional direction and do not have sufficient connections with each other.

The main role in organising local passenger transportation between municipal districts is played by air transport, the airport network of which is poorly developed and connects only the

administrative and regional centres of the region. High tariffs for transportation reduce affordability of intraregional air transportation. The high role of air transport is an objective necessity and is confirmed by the experience of many countries [23–26].

Regarding transport provision of access (entry and exit) to the territory of the Republic of Sakha (Yakutia), one can speak of its semi-isolated position, since the northern regions have no connection between the hard-surface road network and federal highways; and railway transportation is carried out only to the Ust-Kut village and does not connect the capital of the region with the federal railway main line.

Several spatial forms of transport provision have been formed on the territory of the Republic of Sakha (Yakutia) [7; 27–29]:

• Central transport hub: the city of Yakutsk, located at the intersection of three federal highways («Lena», «Kolyma», «Vilyui»), the Berkakit–Tommot–Nizhny Bestyakh railway and Ust-Kut–Lensk–Yakutsk–Tiksi waterway along the Lena River [28], while its year-round connectivity with federal highways is hampered by the absence of a bridge across the river Lena.

• Southern transit transport hub: the city of Neryungri (Yakutsk–Aldan–Neryungri), serving Yakutsk all year round [28] with limited traffic during periods of autumn freeze-up and spring floods, with access to «Lena» federal highway and Amur-Yakutsk railway. Through it, the entrance from and the exit to the national-wide transport network is carried out [23].

• Western transport hub: the city of Mirny, which arose due to development of the diamond mining industry (Ust-Kut–Lensk–Mirny–Udachny–Olenek – Saskylakh).

• Eastern transit transport axis (Yakutsk–Khandyga–Ust-Nera) with an additionally forming haul through winter roads to the industrial Arctic areas with the destination points of Deputatsky and Zyryanka [28].

• The Arctic transport axis (Yakutsk–Tiksi and Arctic rivers), in combination with a system of winter roads, provides the Northern Delivery [seasonal delivery of goods to the northern areas], but its operation is hampered by the shallow water of the seaport of Tiksi, which limits the possibilities of servicing sea cargo vessels.

The evolution of the designated development zones of the transport system of the Republic of Sakha (Yakutia) is due to development of the resource-extracting industry in the region and does not provide year-round transport accessibility to sparsely populated northern settlements. All this impedes social and economic development of the region. In the author's opinion, development of the air transport network and expansion of the number of local air routes could be the main direction towards growing transport capacity of the Republic of Sakha (Yakutia). A more accurate mathematical assessment of the transport provision of territories requires a deep analysis of the seasonal period of use of all sections of the network and introduction of relevant data into the formula for calculating the Engel's coefficient [30].

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