Transport System of Northern and Arctic Regions: Assessment and Development Problems

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Abstract. The analysis of the current state and assessment of the transport system development of the regions of the North and the Arctic was carried out. Analysis of the transport system development on the example of the regions directly bordering with the Northern Sea Route was carried out: Arkhangelsk Region, Murmansk Region, Nenets Autonomous District, Yamalo-Nenets Autonomous District, Krasnoyarsk Territory, Republic of Sakha (Yakutia), Chukotka Autonomous District, Kamchatka Territory, Magadan Region, Sakhalin Region, Primorye Territory. It is shown that the northern and arctic regions are far behind in the development of the transport industry of the subarctic countries. Primorye Territory has the best values of density of general-purpose railways and highways as well as investments in development of transport compared to other regions and is characterized by maximum level of the transport system development during the analyzed period. Of the northern regions minimal values of the transport system development have Magadan Region and Nenets Autonomous District characterized by poor development of transport communications. It is needed a further research in direction of scientific and technological substantiation of the strategic development directions of the transport system of the North and the Arctic.

1. Introduction
Transport is a strategically important area of the economy. For the Arctic territories transport system plays a key role determining the place in the system of numerous inter-regional and inter-country interactions, development of economic processes, globalization of economic activity. Problems of assessment and development of the transport system of the Northern and Arctic regions not only remain relevant to the present, but also require a transformation of approaches to solving existing problems.

Transport system in the Arctic is a national system including the Northern Sea Route, railway, river and airport communications that make up the network of international corridors: the North-West and Trans-Polar (Central) passages [1, 2].

Aim of the work is to analyze the current state and assess the development of the transport system of the Northern and Arctic regions.
2. Materials and methods

Many domestic and foreign scientific papers including technical and economic indicators of the development are devoted to the problem of analyzing the process of transport systems and communications development [3-10]. In [11] a systematic approach to assessing the properties and resource sustainability of the transport system depending on the hierarchy of organizational and functional structures is proposed at the conceptual level. An extended system of indicators of transport accessibility for the analysis of regional and local level systems is presented in [12-14]. The issues of assessment of transport and logistics infrastructure of the Russian regions are discussed in [15-20]. The methods and algorithms of intellectual analysis of the transport system organization were investigated in [21-24]. Analysis of transport, road and human potentials in the context of their interaction was considered in [25-28].

However, currently investigation of the transport system development issues in the North and Arctic has not been adequately reflected in scientific studies.

3. Results

Analysis of the transport system development on the example of the regions directly bordering with the Northern Sea Route was carried out: Arkhangelsk Region, Murmansk Region, Nenets Autonomous District, Yamalo-Nenets Autonomous District, Krasnoyarsk Territory, Republic of Sakha (Yakutia), Chukotka Autonomous District, Kamchatka Territory, Magadan Region, Sakhalin Region, Primorye Territory.

Analysis showed that for 2010-2018 the density of railways in the macroregion, except for Sakhalin Region, is not changed (table 1).

Table 1. Density of railway lines, km of lines per 10000 km² of territory (at the end of the year) [29].

| Regions                        | Years |
|--------------------------------|-------|
|                                | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  | 2018  |
| Arkhangelsk Region             | 30    | 30    | 30    | 30    | 30    | 30    | 30    | 30    | 30    |
| Murmansk Region                | 60    | 60    | 60    | 60    | 60    | 60    | 60    | 60    | 60    |
| Yamalo-Nenets Autonomous District | 6    | 6     | 6     | 6     | 6     | 6     | 6     | 6     | 6     |
| Krasnoyarsk Territory          | 9     | 9     | 9     | 9     | 9     | 9     | 9     | 9     | 9     |
| Republic of Sakha (Yakutia)    | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     |
| Primorye Territory             | 95    | 95    | 95    | 95    | 95    | 95    | 95    | 95    | 95    |
| Sakhalin Region                | 92    | 96    | 96    | 96    | 96    | 96    | 96    | 96    | 96    |
| Russian Federation             | 50    | 50    | 50    | 50    | 50    | 50    | 50    | 51    | 51    |

In the Nenets Autonomous District, Magadan Region, Kamchatka Territory the Chukotka Autonomous District there is no railway network at all. It should be noted that the northern regions of Russia are far behind the Arctic countries by the railway tracks density. For example, according to the latest official data, this indicator in Denmark is 589 km, 269 in Ireland, 242 in Sweden, 175 in Finland, 101 in Norway [30].

Northern regions, except for Primorye Territory, are far behind the average indicators of the Russian Federation by density of public highways with hard surface (table 2).

By the highway density only Primorye Territory is ahead of average Russian values. In Denmark the density of highways is 1,730 km per 1,000 km² of territory, in Ireland - 1,321, Sweden - 492, Finland - 330, Norway - 293, Canada - 121.
Table 2. Density of public highways with hard surface, km of highways per 1000 km² of the territory (at the end of the year) [29].

| Regions                              | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|--------------------------------------|------|------|------|------|------|------|------|------|------|
| Arkhangelsk Region                   | 26.0 | 27.0 | 28.0 | 29.0 | 29.0 | 29.0 | 29.0 | 29.0 | 29.0 |
| Nenets Autonomous District           | 1.1  | 1.1  | 1.2  | 1.2  | 1.2  | 1.3  | 1.4  | 1.5  |      |
| Murmansk Region                      | 19.0 | 20.0 | 23.0 | 23.0 | 23.0 | 23.0 | 23.0 | 23.0 | 23.0 |
| Yamalo-Nenets Autonomous District    | 1.8  | 1.8  | 2.4  | 2.8  | 2.8  | 2.9  | 3.0  | 3.0  | 3.1  |
| Krasnoyarsk Territory (Yakutia)      | 6.4  | 11.0 | 11.0 | 11.0 | 11.0 | 12.0 | 12.0 | 12.0 | 12.0 |
| Republic of Sakha (Yakutia)          | 2.7  | 2.7  | 3.3  | 3.6  | 3.7  | 3.8  | 3.8  | 3.9  | 3.9  |
| Kamchatka Territory                  | 3.6  | 3.6  | 3.9  | 4.0  | 4.1  | 4.2  | 4.2  | 4.4  | 4.5  |
| Primorye Territory                   | 52.0 | 51.0 | 88.0 | 89.0 | 89.0 | 93.0 | 92.0 | 90.0 | 91.0 |
| Magadan Region                       | 4.7  | 4.7  | 5.3  | 5.2  | 5.3  | 5.3  | 5.4  | 5.5  | 5.6  |
| Sakhalin Region                      | 14.0 | 14.0 | 20.0 | 21.0 | 22.0 | 23.0 | 23.0 | 25.0 | 27.0 |
| Chukotka Autonomous District         | 0.8  | 0.9  | 0.9  | 1.0  | 0.9  | 0.9  | 1.0  | 1.2  | 1.2  |
| Russian Federation                   | 39.0 | 43.0 | 54.0 | 58.0 | 60.0 | 61.0 | 62.0 | 62.0 | 63.0 |

The majority of the analyzed regions, except for Sakhalin Oblast, exceed similar indicators of the Russian Federation by the wear degree of fixed assets in transport during the period under review (table 3).

Table 3. Wear degree of fixed assets according to the transport economic activity [29].

| Regions                              | 2010 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|--------------------------------------|------|------|------|------|------|------|------|
| Arkhangelsk Region                   | 41.0 | 43.8 | 46.4 | 50.1 | 58.2 | 55.4 | 54.7 |
| Nenets Autonomous District           | 15.8 | 33.0 | 39.4 | 44.6 | 48.7 | 53.0 | 57.4 |
| Murmansk Region                      | 34.6 | 43.6 | 44.5 | 46.6 | 49.0 | 44.1 | 40.5 |
| Yamalo-Nenets Autonomous District    | 49.3 | 42.2 | 43.4 | 44.5 | 28.4 | 30.3 | 31.8 |
| Krasnoyarsk Territory (Yakutia)      | 41.1 | 44.3 | 46.3 | 49.0 | 47.1 | 38.5 | 40.5 |
| Republic of Sakha (Yakutia)          | 40.8 | 28.5 | 32.5 | 38.5 | 38.3 | 39.9 | 43.5 |
| Kamchatka Territory                  | 47.6 | 52.1 | 48.7 | 46.4 | 45.8 | 35.6 | 39.8 |
| Primorye Territory                   | 28.5 | 30.0 | 32.1 | 37.0 | 40.0 | 40.4 | 47.4 |
| Magadan Region                       | 60.6 | 55.8 | 51.9 | 56.4 | 54.1 | 48.9 | 51.1 |
| Sakhalin Region                      | 28.3 | 31.6 | 33.6 | 34.1 | 30.8 | 29.0 | 30.3 |
| Chukotka Autonomous District         | 28.2 | 36.4 | 36.1 | 40.8 | 44.3 | 43.1 | 48.4 |
| Russian Federation                   | 35.8 | 40.0 | 42.7 | 44.0 | 44.5 | 42.1 | 39.7 |

For an objective analysis of the transport system development in the Arctic the integral index was calculated. The study on the basis of indicators presented in a regional context by regions of the Russian Federation [29, 31-32] for 2010-2018 was carried out:

- density of railway lines, km of lines per 10000 km² of territory;
- density of public highways with hard surface, km of highways per 1000 km<sup>2</sup> of territory;
- passenger traffic by public bus, million passengers-km;
- coefficient of fixed assets validity (reverse indicator of wear degree);
- share of investments in fixed assets of transport economic activity.

The calculation of the integral index of the transport system development (IITSD) was carried out according to the formula (1):

\[
IITSD = \frac{\sum cp}{5}
\]

(1),

where \(\sum cp\) - sum of control parameters of transport communications provision.

Control parameters were calculated according to the formula (2):

\[
CP = \frac{x_i - x_{\text{min}}}{x_{\text{max}} - x_{\text{min}}}
\]

(2),

where CP – control parameters for calculation, \(x_i\) – actual value of parameter for specific region, \(x_{\text{min}}\) – minimal value of parameter in a sample, \(x_{\text{max}}\) – maximal value of parameter in a sample.

Primorye Territory has the best values of density of general-purpose railways and highways as well as investments in development of transport compared to other regions and is characterized by maximum level of the transport system development during the analyzed period (table 4). However, the main role belongs to air and water transport. There are four airports (Vladivostok-international, Dalnorechensk, Kavalerovo, Plastun) and six seaports (Vladivostok, Nahodka, Vostochny, Zarubino, Posvet, Olga).

**Table 4. Integral index of the transport system development.**

| Regions                               | Years          |
|---------------------------------------|----------------|
|                                       | 2010 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018   |
| Arkhangelsk Region                    | 0.410 | 0.393 | 0.419 | 0.411 | 0.377 | 0.336 | 0.362  |
| Nenets Autonomous District           | 0.201 | 0.168 | 0.128 | 0.108 | 0.065 | 0.019 | 0.008  |
| Murmansk Region                      | 0.405 | 0.388 | 0.398 | 0.410 | 0.453 | 0.425 | 0.551  |
| Yamalo-Nenets Autonomous District    | 0.205 | 0.287 | 0.279 | 0.274 | 0.331 | 0.257 | 0.246  |
| Krasnoyarsk Territory                | 0.359 | 0.392 | 0.404 | 0.435 | 0.421 | 0.415 | 0.433  |
| Republic of Sakha (Yakutia)          | 0.260 | 0.402 | 0.406 | 0.367 | 0.340 | 0.362 | 0.308  |
| Kamchatka Territory                   | 0.286 | 0.266 | 0.265 | 0.235 | 0.232 | 0.228 | 0.178  |
| Primorye Territory                   | 0.777 | 0.887 | 0.851 | 0.837 | 0.734 | 0.715 | 0.671  |
| Magadan Region                       | 0.077 | 0.079 | 0.077 | 0.055 | 0.100 | 0.111 | 0.061  |
| Sakhalin Region                      | 0.486 | 0.529 | 0.487 | 0.526 | 0.502 | 0.498 | 0.568  |
| Chukotka Autonomous District         | 0.165 | 0.203 | 0.185 | 0.249 | 0.280 | 0.199 | 0.128  |

Of the northern regions minimal values of the transport system development have Magadan Region and Nenets Autonomous District characterized by poor development of transport communications. The main role in these regions, due to climatic conditions and remoteness from the center, is played by air and water transport.

4. **Conclusions**

The analysis of the transport system development showed that the northern and Arctic regions are far behind the Arctic countries by the transport industry development was carried out.
Primorye Territory has the best values of density of general-purpose railways and highways as well as investment potential compared with other regions and is characterized by maximum level of the transport system development.

Minimal values of the transport system development are typical for Magadan Region and Nenets Autonomous District.

It is needed a further research in direction of scientific and technological substantiation of the strategic development directions of the transport system of the North and the Arctic.

5. References

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