Logistics in the Arctic Region through the example of cargo transportation in Murmansk Oblast by railway transport

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Abstract. The economy of Murmansk Oblast retains its focus on raw materials. Extraction of mineral raw materials by virtue of geological and economic characteristics as well as natural and climatic features peculiar to the area will remain the dominant sector of regional economics for a long time. Extraction industry of the region is formed by extraction plants dealing with mineral raw materials, ferrous and nonferrous metal ores. The transport system plays the key role in the economy of Murmansk region. It is linked with the prevalence of industry sectors oriented toward production and distribution of considerable amounts of raw materials and metals in the region, but also with its advantageous geographical location suitable for year-round navigation and access to international maritime trade routes. Under these circumstances, each plant utilizes optimal logistical technologies of freight transportation, which provides the basis for the transportation network. Development of each plant dealing with raw mineral material extraction and processing is impossible without the development of the transport component, which in its turn requires its own development, and if realized, it will allow to increase the amount of cargo transportation in the region and will create new jobs, ensure the socio-economic development of the region. Consequently, the subject of logistics in the Arctic Region is indeed highly demanded and relevant.

1. Introduction

The development of arctic transportation system is motivated by growth potential of present cargo transportations via the Northern Sea Route (hereinafter NSR), which must be fairly considered from the viewpoint of cargo basis formation and motion vector to the destination, as three independent cargo traffic flows: international transit corridor, national arctic transportation system, providing coastal as well as export freight transportation. The first freight traffic flow of NSR is the development of transit traffic in Europe - Asia direction the shortest sea route [1]. The second one is cargo transportation for delivery and exportation from the Arctic Region of Russia (deliveries of goods to the Northern territories, offshore oil-and-gas fields), the third is export, including raw materials and energy resources (liquefied natural gas within the framework of the project Yamal LNG, iron-ore and apatite concentrates, coal from the Murmansk commercial seaport).

Among the key factors, influencing the socio-economic situation in the arctic zone of Russia, it is worth to mention complex natural and climatic conditions, selective nature of industrial and economic
development of the area, underpopulation, difficult transport accessibility, heavy reliance on supply from other regions of the country, relatively large resource intensity of production [2].

Existing export capacity of Murmansk Oblast and available transportation services create favorable conditions for extending cooperation with foreign countries.

2. General information
Murmansk Oblast is located in the northwestern region of the European part of Russia and is inherently one of the key regions of the country being a part of the Northwestern Federal District. In the south-west it borders on Republic of Karelia and in the west on Finland and in the north-west on Norway. Murmansk Oblast is one of the few regions which shares border with the countries of the European Union and NATO.

North Russian Navy is based in this region, which ensures defensive potential of Russia in the north.

Murmansk is the biggest unfrozen port inside the Arctic Circle of Russia. This is the key city providing freight transportation to the regions of the Extreme North, Arctic and abroad countries.

The area of Murmansk Oblast is 144.9 thousand square kilometers (0.85 % of the total area of Russia). The climate is arctic-temperate, maritime with the influence of warm current of the Gulf Stream’s branch [3].

3. Natural resources
In situ of the Kola Peninsula more than three dozens of raw materials are mined among which copper-nickel, iron, apatite-nepheline ores and ores of rare metals are of ultimate value. There are considerable reserves of mica, ceramic raw materials and raw materials for construction supplies, facing stones, semi-precious and ornamental stones.

Among the discovered deposits is Shtockman deposit which is world renowned.

4. Sea routes and port infrastructure of general export
Three seaports are located within the territory of the region. Two of the ports, Kandalaksha and Vitino are situated in the water area of the Kandalaksha Gulf. However, the major part of the cargo for transhipment at ports of Murmansk Oblast arrives to the regional ports and terminals located in the water area of the Kola Bay by rail transport.

Shipping company JSC «Murmansk Shipping Company» provides cargo transportation under the Russian flag.

Atomic ice-breaking fleet is based in Murmansk. Federal State Unitary Enterprise «Atomflot» of State Atomic Energy Corporation «Rosatom» serves to ensure operation and technical maintenance of atomic icebreakers and auxiliary ships. At the moment there are four functioning atomic icebreakers within the Nuclear Navy of Russia: «Yamal», «50 let Pobedy», «Taymyr» и «Vaigach». There is also the world’s only functioning transport vessel with nuclear power facility «Sevmorput». JSC «Baltic plant» carries out the construction of lead multi-purpose atomic icebreaker «Arctica» and two serial icebreakers «Sibir» and «Ural» (in service date year end 2019, 2020, 2021 accordingly) [4]. In 2018 atomic icebreakers of FSUE «Atomflot» led 331 vessels with total gross tonnage of 12.7 million tons. When compared to 2017, the capacity of led vessels increased by 5 million tons [5].

With the lead of atomic icebreakers of «Atomflot» vessels pass through the Northern Sea Route, which is a competitive alternative to the Suez Canal for goods delivery from Europe to Asia and in the opposite direction. China is among the countries taking interest in the development and progress of the Northern Sea Route.

JSC «Murmansk commercial seaport» (JSC «MCS») is located in the ice-free water area of the Kola Bay of the Barents Sea, has year-round navigational regime of sea vessels, open access to the ocean and provides maritime traffic with ports of Western Europe, the East Coast of the USA, the Northern Sea Route, the Spitsbergen archipelago.
SUEK is one of the world’s largest coal companies and the leading coal, heat and electricity producer in Russia. SUEK holds 100% of voting shares at Murmansk Commercial Seaport [7].

Volumes of trans-shipment of cargo of ООО «Murmansk Bulk Terminal» (OOO «MBT») grew by a third in the space of two years – from 4,3 million tons in 2015 to 5,7 million tons in 2017. And this growth is still continuing. Until the construction of the terminal in Ust-Luga, Leningrad Oblast, and its launch in 2021 all the potassium that will come from Usolsk Potassium Plant will be trans-shipped in Murmansk [8].

Murmansk transport branch PJSC MMC «Norilsk Nickel» performs trans-shipment of nickel matte (intermediate product in the process of production of copper and nickel) which is produced in Transpolar branch of PJSC MMC «Norilsk Nickel» for further processing at site of JSC «Kola GMK» and also sends finished products for export. Company «Norilsk Nickel» has got its own fleet of ships and icebreaker «Dudinka» for cargo transportation.

Company «NOVATEK» took on the project «Arctic SNG 2». For its implementation OSCY Offshore Superfacility Construction Yard, «construction yard for production of SNG plants», is being built in the Kola Bay near Belokamenka village. The total area of the yard will exceed 180 hectares. The first SNG plant is planned to be sent to the Gulf of Ob in 2022. Total investments can amount to 80-90 billion rubles [9]. Project «Arctic SNG 2» involves the construction of three manufacturing stages of condensed natural gas (CNG) production with the capacity of 6,6 million tons a year, each on gravity based structures (GBS). The project is implemented on the resource base of Ustrenne deposit. As on the 1 of December 2018, the reserves of Ustrenne deposit according to the Russian classification amounted to 105 MLN million tons of liquid hydrocarbons and 1 978 Bn cubic meters of natural gas. ООО «Arctic SNG 2» holds the license for export [10].

### Table 1. Total volume of trans-shipment JSC «MCS» [6]

| Volume of trans-shipment JSC «MCS» | 2015 | 2016 | 2017 |
|-----------------------------------|------|------|------|
| (million tons)                    |      |      |      |
| Total volume of trans-shipment    | 14,66| 15,04| 15,64|
| Including coal                    | 13,64| 14,16| 14,63|
| Volume of trans-shipment of coal, %| 93,04| 94,15| 93,54|

5. **Railway transport.**

The question of construction of the railroad to Murmansk was raised on numerous occasions but wasn’t solved until the First World War. The road to the ice-free Barents Sea was absolutely necessary for delivery of weapons, medication and equipment. On the 16 of November 1916 a silver «crutch», purpose-made at one of the Petrograd plants, was nailed at the junction of two parts of the road, the southern and the northern. The following words were carved on the sides of the crutch «Murmansk railroad. Of the Great Northern Way. Milestone 618. Verst post 537 19-16». In November of 1916 there was the opening of through traffic on Murmansk line continuing down to 1,5 thousand kilometers, built in the circumstances of the First World War for 20 months. In the year of completion of the construction more than 70 thousand people worked on it. There was a special procedure that every person arriving for the construction of the railroad handed in the passport and received a tag. The last given tag had the number № 102344 on it [11].

At the present moment the Murmansk region, one of the six regions using Oktyabrskaya railroad, is a strategic part of the regional transport system. The main shippers of the Murmansk region are Kirov branch of JSC «Apatit» (production of apatite and nepheline concentrate), JSC «Kovdorskiy GOK» (production of iron-ore, apatite and baddeleyite concentrates), JSC «OLKON» (production of iron-ore concentrate), JSC «North-Western Phosphorous Company» (production of apatite concentrate), JSC «Kola GMK» (production of copper, nickel, palladium and platinum).
Kirov branch of JSC «Apatit» the world largest plant dealing with extraction and enrichment of apatite-nephelinic ores of Khibinsk deposits, carries out production of apatite and nepheline concentrates.

Table 2. Production results of core products [12]

| Production volume by category | 4 quarter 2018 (thousand tons) | 4 quarter 2017 | Difference 2018 | 2018 | 2017 | Difference |
|-------------------------------|---------------------------------|----------------|-----------------|------|------|------------|
| Production of JSC «Apatit»    |                                 |                |                 |      |      |            |
| Apatite                       | 2 552,7                         | 2 379,2        | 7,3%            | 10 067,0 | 9 540,4 | 5,5%       |
| Concentrate                   | 254,3                           | 261,8          | -2,9%           | 986,0 | 998,1 | -1,2%      |

Transport production is cargo and passenger transportation. Modern patterns of transportation have become incredibly more complicated and interdependent. Today Logistics as a science is the management of cargo and informational and financial flows in terms of their optimization and costs minimization.

For Russia with its vast territory the role of transportation sector of production has a strategic impact on its economical growth and qualitative transition of the economy to innovation-based development. The efficiency of other manufacturing sectors and, consequently, economic well-being of the country depend on the efficiency of transport.

The economic situation of Russia is determined by economic situations of each of its regions. The search for new, bold, innovative methods of trans-shipment, loading, transportation and unloading of cargo, the research of existing global experience, monitoring of global world trends are advancements in the direction of more effective logistics, resulting in reduction of transport cost component in the price of a product, possibility to upscale the results of innovative technologies throughout the country, as well as their patenting and export abroad in the shape of technologies.

Demchenko I.I. writes about the relevancy of coal transportation in his thesis «Scientific justification and development of the system of mechanic means for ensuring quality of coal products». In the thesis the author examines open transportation, trans-shipment from one transportation vehicle to another and storage of coal, which lead to annual losses up to 7% of mined coal, as well as severe pollution of near-by territory and air basin. He explains that during railway transportation the losses of fine size coal due to expulsion by air drafts in transportation for 500 kilometers amount to 0,5–0,6 tons calculated per one carriage. It is equivalent to 1% of transported coal. Nationwide about 3-5 million tons of coal are lost in railroad transportation per annum. Unloading of frozen coal from a gondola-car poses another problem – breakage of gondola-cars. The author suggests valid and developed designs of specialized containers, meeting the requirements of diverse customer groups and allowing to implement containerized way of transportation, provide quality maintenance and integrity of produced coal products. [13].

In his report called «Containers for bulk» V.A. Pogodin writes that scientific findings and advanced praxis allow to maintain that the radical way of preservation of qualitative and quantitative cargo characteristics and their ecological safety is package transportation of many types of bulk cargo from the shipper to the receiver (door-to-door) or to the lower hold of the vessel in specialized containers. Globalization of world economy and trade turned container transportation system into transport industry. Containerization has taken over not only general cargo, but also bulk cargo. He examines the radical solution of the problem of unloading bulk cargo from containers to the hold of the vessel, provided by rival companies RAM Spreaders and Container Rotation Systems. The specialists have mechanized the operation of emptying bulk cargo rotating the container around its longitudinal axis. He demonstrates the «patented» system of container treatment for railroad purposes called Rotainer.
CC, which permits the use of standard carriages with the interval between the ISO containers for two containers. He explains why the method of container bulk transportation (with unloading into the hold of the vessel with a rotating spreader) has not been widely used in Russia for transportation on railroads of public use. The main reason is thought to be the lack of special containers which have undergone tests and were certified by standards of the Register and Russian Railways. According to the norms, a standard ISO container can’t be used for unloading with repeated rotation on upper fittings because of non-standardized impacts on the fittings and the whole construction of the container [14].

The company Container Rotation Systems offers containers for coal certified for 360 or 180 degrees rotation, which has smooth walls for smooth unloading and minimization of dust, gross weight 38 400 kg, tare weight 3 680 kg [15].

Therefore, under free market conditions the solution of scientific problem of theoretical background development, improvement of existing and creation of new designs of specialized containers for bulk transportation by railroad is of paramount importance. It is suggested to consider the process of bulk cargo transportation in specialized containers from the point of view of formation of cargo base and motion vector to the destination with emphasis on returning empty containers for loading. The decision about the type of a railway carriage or a container for cargo transportation is made by the owner of cargo, taking into consideration loading, transportation, unloading and transshipment capabilities, as well as comparison of bottom-line cost per 1 ton of transported cargo, taking into account all the expenses. In case of relatively long transportation distances of bulk cargo by rail in Russia, creation of new designs of specialized containers which, after unloading, are able to be loaded with other type of cargo and move forward in the direction of the next loading, will cut the cost of transportation per 1 ton of cargo and create competition with existing logistic schemes. For example, let us examine coal transportations from Kemerovo Oblast (Kuzbass) to Murmansk seaport and further for export which are currently carried out in gondola cars with cargo losses en route and return of some part of empty gondola cars for coal reloading. Exploitation possibility analysis of specialized containers with a lift-off cover for coal transportation on Kuzbass station – Murmansk station (and further export) route with unloading in Murmansk commercial port with container treatment system with Rotainer CC system will allow to compare both variants from the point of view of unloading speed of coal at the port, but also take into account cost of expenses per 1 ton of transportation and trans-shipment, including exception of loss of cargo in a container in comparison with the open transportation method. After unloading the empty container can be executed for loading of cargo from enterprises of Murmansk Oblast, for example, for loading apatite concentrate (Kirov branch of JSC «Apatit», JSC «Kovdorskiy GOK», JSC «North-Western Phosphorous Company»), to avoid transportation of empty containers on Murmansk station – Kuzbass coal loading station route that will lead to cost-efficiency per 1 ton of transported coal. Provision should be made for loading apatite concentrate with the aid of a reusable, soft, interoperational container for avoiding mixing the remnants of coal with apatite concentrate, such a container can be kept folded and be situated under the floor area of the container until the moment of loading. Unloading of apatite concentrate by the receiver at the station should take place in two stages, at stage one bulk of the cargo should be unloaded from two sides of the container through hatches in side-doors mechanically, with the help of detachable wheels the remnants of the cargo should be unloaded with the help of alteration of container floor shape by means of gradual lifting of the assumed longitudinal axis of the container floor just over the natural angle of repose of the cargo. The use of suggested construction with modified floor configuration will allow to unload apatite concentrate from the container without removing the container from the platform.
Figure 1. The floor of the container at the top spot of lifting of the assumed longitudinal axis

After unloadingapatite concentrate the empty container should be executed at the station for loading coal in Kemerovo Oblast.

As the result of researching problem state of coal transportation in containers, consolidation of theory and practice on this matter, it was failed to evidentiate any research on implementation of alternating coal and bulk transportation in containers with modified floor shape.

6. Development of Murmansk transport hub

In compliance with the Decree of the Government of the Russian Federation from the 20 of December 2017 N 1596 (as amended by RF Government Regulation from 03.03.2018 N 223) «Of confirmation of the governmental program of the Russian Federation «Development of transport system», the final target of the project «Integrated development of Murmansk transport hub» is creating the all-year deep water sea hub, the center for processing and refining of oil cargo, transshipment of coal and inorganic mineral fertilizers, integrated into the International Transport Corridor «North – South».

Main expected results of project implementation:
- reconstruction of existing and creation of new objects of port infrastructure (insuring cargo turnover of 70 million tons a year before 2025), railway and road-transport infrastructure, including the west coast of the Kola Bay;
- organization of regional transport-logistical system and the integration of it into the International Transport Corridor «North – South» system;
- creating the system of coordination of subjects of regional transport market at the transport hub.

Stages and execution deadlines:
Project development 2011-2018.
Construction 2014-2021.

The project is executed in the format of public-private partnership and involves construction of works of federal as well as private property.

| Table 3. The amount and sources of financing (million rubles) |
|-------------------------------------------------------------|
| Total: | 139 176,2 |
| Federal budget: | 59 753,1 |
| Non-budgetary sources: | 79 423,1 |

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Project execution is the essential and mandatory requirement for achieving assigned objectives in developing of the Arctic zone in the Russian Federation, also for increasing the capabilities for development of deposits of useful minerals at the arctic shelf, it will also enable to use transit and resource potential of Murmansk Oblast and adjacent maritime space to the maximum extent possible.

7. Conclusion
The project «Integrated development of Murmansk transport hub» is important for development of the Murmansk region and strategic for development of Russia. It will allow to considerably increase the capacity of north-west ports. At the moment, favorable external economic situation with coal for the Russian Federation, as one of the major parts of Russian energy export, is the basis for coal export expansion on the foreign markets.

The Murmansk region using October Railway has the leading role of the Murmansk Oblast transport system as the fittest for mass cargo transportation carried out day and night in any time of year and weather conditions. The significant condition for regional development is researching possibilities for decreasing transport component in the costs of cargo transportation, analysis of existing logistic schemes and search for new ones. The suggested scheme of containerized cargo transportation will allow to optimize the transport process and consequently improve efficiency of territorial business entities, that will influence solution of socio-economic problems of the Russian Arctic zone.

According to the Russian President’s letter by Vladimir Putin from 01.03.2018 to the Federal Assembly «The speed of technological changes rapidly increases, skyrockets. «…». Technological inferiority, dependence signify decrease of safety and economic opportunities of the country and, as the result, the loss of sovereignty» [16].

Increase in volumes of extraction of each enterprise of the Murmansk region, growth of transshipment of ports and terminals, investments in construction of new plants (OSCY in Belokamenka) lead to creating new jobs, development of the territory and increase in tax revenues for the treasury at all levels of the Russian Federation.

The research was conducted within the topic № 0226-2019-0022 IES «Scientific and applied foundations of sustainable development and modernization of maritime economic activity in the western part of the Arctic zone of the Russian Federation» by state assignment of FRC KSC RAS.

References
[1] K Kikkas and E Romashkina 2018 IOP Conf. Ser.: Earth Environ. Sci. 180 012016
[2] Agarkov S A et al 2018 Primary areas of efficiency improvement of business operations in the Arctic zone of the Russian Federation Notes of Mining Institute 230 209-216
[3] Official web portal of the Murmansk Oblast government Available from: https://gov-murman.ru/region/index.php [Accessed 24th February 2019]
[4] Ananeva E V Makarov A V 2018 Contribution of atomic icebreaker fleet in development of arctic projects MurmanskshelfInfo 2 (32) 11-17
[5] Official web portal of FSUE «Atomflot» Available from: http://www.rosatomflot.ru/press-centr/novosti-predprivativa/2019/01/31/11226-ledokoly-rosatomflota-proveli-v-2018-godu-331-sudno-obshej-vmestimostyu-127-mln-tonn/ [Accessed 24th February 2019]
[6] Dotsenko A A 2018 Report on the 8th international conference «Logistics in the Arctic» Available from: http://murmanshelf-conf.ru/archive/presentations/2018/%D0%94%D0%BE%D1%86%D0%B5%D0%BD%D0%BA%D0%BE%20%D0%90.%D0%9C%D0%9C%D0%A2%D0%9F.pdf [Accessed 24th February 2019]
[7] Official web portal of SUEK Available from: http://www.suek.com/our-business/logistics/#maly-port [Accessed 24th February 2019]
[8] Official web portal of «Rossiiskaya gazeta» Available from: https://rg.ru/2018/08/30/nechaev-perspektivnye-investproekty-pozvoliaiut-nam-ouvereno-smotret-v-badushchee.html [Accessed 24th February 2019]
[9] Official web portal of TV-channel «Arctic-TV» Available from: https://xn----7sbhwjb3brd.xn--p1ai/news/glavnye-sobytiya-dnya/megaproekt-strategicheskogo-znacheniya-v-belokamenke
[Accessed 26th February 2019]

[10] Official web portal of PAO «NOVATEK» Available from:
http://www.novatek.ru/ru/press/releases/archive/index.php?id_4=2895&afrom_4=01.01.2018&ato_4=31.12.2018 [Accessed 25th February 2019]

[11] Garkotin V P 2015 The Northern route (Kandalaksha: «Niva-Press»)

[12] Official web portal of «FosAgro» Company Available from:
https://www.phosagro.ru/investors/ir/item16765.php [Accessed 17th February 2019]

[13] Demchenko I I 2009 Scientific justification and development of mechanization system for ensuring quality of coal products Synopsis of thesis for procuring academic degree of the Doctor of Technical Sciences (Irkutsk)

[14] Pogodin V A 2017 Report on the conference «Equipment and technologies for ports: effective investments» Available from:
http://morproekt.ru/attachments/article/55/21.09.17%20%D0%9A%D0%BE%D0%BD%D1%82%D0%B5%D0%B8%CC%86%D0%BD%D0%B5%D1%80%D0%BE%D0%BC%20%D0%BF%D0%BE%20%D0%BD%D0%B0%D0%B2%D0%B0%D0%BB%D0%BE%D1%87%D0%BD%D1%8B%D0%BC.pdf [Accessed 26th February 2019]

[15] Official web portal of Container Rotation Systems Company Available from:
https://containerrotationsystems.com/coal-container---coalcontainer.html [Accessed 26th February 2019]

[16] The letter of the President Vladimir Putin from 01.03.2018 to the Federal Assembly Available from:
http://kremlin.ru/events/president/news/56957/work [Accessed 17th February 2019]