Routing of freight transportation in logistics of agriculture

Iuliia Tanaino¹, Olga Yugrina¹, Larisa Zharikova¹

¹Siberian Transport University, 191 Dusi Kovalchuk st., 630049, Novosibirsk, Russia
E-mail: utanayno@gmail.com

Abstract. The development of national transport system impacts the performance of enterprises, and therefore, its viability in the market conditions. At the same time, the market is the exchange of goods and services, which is impossible without transport. Transport is a crucial component of the market infrastructure. It is essential to consolidate all the transport sectors into a multimodal transportation system, which would be convenient in terms of customer servicing, shipment time and accuracy, cargo safety, end-to-end information support, and financial relationships as well. Traditionally, the applied science deals with management of train and rail car traffic, stations, and rolling stock. In practice, carriers and cargo owners often have different priorities. The carrier needs to comply with routes and delivery time, while the customer is more concerned about shiploads, consistency in the delivery of carload shipments, and clearly scheduled delivery times. The problem of determination of ways to develop a unified transport environment facilitated by integrated multimodal transportation techniques is of a higher relevance. The purpose of this research is to identify certain stages of freight transportation, study the opportunities of applying various transportation techniques focusing on operating costs reduction, and to analyze the ways to improve routed transportation to the mutual benefit of both carriers and shippers. This work employs research methods to analyze freight transportation, and methods of mathematical modeling of the transportation process subject to introducing new techniques to minimize the number of re-classifications made on the route and reduce operating costs at unloading stations. As a result, the criteria have been identified to determine the choice of railroad transport operation activities subject to minimizing costs throughout the operating domain.

1. Introduction
In the areas of railroad transport and logistics, or when planning transportation or resources required, the transportation problem emerges and shall be solved subject to costs minimization requirements. The transportation problem in railroad operation means identifying the most appropriate operation plan. Managing the formation of rail car traffic into trains ensures reasonable train formation system with regard to the most cost-efficient rail car traffic, routes, and train formations [1, 2]. The system implies interconnected formation of all types of trains at classification yards, district stations, and freight stations, and should ensure the reliability of handling and re-classification of both train and rail car traffic at stations. A proper operation plan enables efficient freight routing and therefore reduces downtime at stations during collection and the number of rail car re-classifications at classification yards, ensures timely delivery of shipments with minimal costs [3–7].

Currently, a greater focus in the railroad business is placed on increasing the share of transit transportation and reducing the downtime of cars along the travel route, and therefore, reducing the time the rolling stock occupies the infrastructure. This is supported by freight routes [8]. Freight
Routing is a method of forming rail cars into trains that helps to reduce rail car downtime at technical stations along the route, improve the reliability and regularity of freight deliveries, accelerate the rail car turnaround, reduce the amount of re-classification at stations, save resources, ensure cargo safety during transportation [9, 10].

Routing is more efficient compared to non-routed shipments as it reduces the number of rail car re-classifications and therefore leads to operating costs reduction. The cost advantage of routed shipments is achieved when the savings from rail car route are greater than the classification costs.

The distinctive feature of the Russian railroads, due to their length, significant transportation distances, and a low density of terminals of origin or breaking-up of rail car traffic, is the intensive use of infrastructure. The public infrastructure and the single carrier enables working with minimum spare train and classification capacities of the railroad hauls and stations. In the western practice, given the density of population and short transportation distances, passenger and freight railroad traffic is separated, and railroad lines are owned by different companies. Therefore, freight transportation techniques require significantly (almost 300%) greater infrastructure (haul lines and equipped stations) than Russian railroads currently have per cargo unit. International conceptual approaches are based on the use of rigid schedules in freight transportation and circular routes for raw materials with shorter distances of shipment. At the same time, in Australia, the USA, Canada, and South Africa, the railroad lines tend to run on semi-rocky soil—for example, in Canada, the railway network is located in the south, near the US border [11–13]. In Russia, it is different: the infrastructure is built on the marshy ground and responds to increased loads in a completely different way, therefore limitations are applied for load capacity and age of rail cars. And in the United States, about 80,000 freight rail cars in operation are 41–50 years of age. The key difference between railroad operation in Russia and the US is that in Russia, freight and passenger transportation share the same railroad lines due to the country’s vast territory, which requires closer attention to traffic safety.

The motivation for this research is to improve the competitiveness of railroads through minimizing costs of railroad transportation services for both carriers and customers by reducing delivery times, applying the “just-in-time” principle, and choosing between options for transporting cargo to the destination [14, 15, 16]. The subject of the research is the transportation principles for bulk cargo, taking into account freight transportation techniques and rail transport operating costs. The purpose of the research is to develop the incentive systems for all types of routed shipments with the mutual interests of both the carrier and shippers taken into account while minimizing operating costs. This will enable a comprehensive assessment of freight transportation principles in terms of railway transport operating costs and techniques. The paper suggests an index showing operating costs reduction by avoiding re-classification at stations along the route.

2. Research Methods

To determine the efficiency of car traffic handling for various types of shipments, we analyzed technical car operations during delivery with routed and carload shipments (using the freight operations research method). In accordance with railroad operation techniques, the transportation process was outlined including its steps and time expenditures. Differences were found in operating costs and time expenditures for different types of shipments, efficiency of car traffic handling was determined, the cost effectiveness of routed transportation for the carrier was determined, and the procedure for creating incentives for shippers was analyzed. The paper considers the possibility of applying an incentive system for shippers when setting up routed shipments while taking into account the carrier's interests.

There are significant differences between non-routed and routed railroad transportation. Rail car traffic concentration makes routed consignments more effective (they cannot be isolated in terms of forming trains at classification yards and district stations). Routed trains formation begins with working with freight traffic (from their origin to breaking-up).

The setting up and running of routed trains include the following main steps [8]:
- routing setup,
- running of loaded routed trains;
- breaking-up of the routing;
- running of empty trains (for circular routings).
Routing setup includes loading and making up a route, i.e. the sequence of operations from the time
the cars arrive at a station for freight operations until the departure of the made-up route.
Routing setup involves a sequence of basic operations:
- cars arrival;
- breaking-up of the train (uncoupling of blocks and individual cars);
- supply of rail cars to the points of freight operations;
- freight operations (loading);
- removing rail cars from the points of freight operations and forwarding them to the route make-up
  point;
- route make-up;
- route departure.
At this stage, to compare various technical procedures for routed and non-routed shipments, for
each railroad routing complex, sets of operations are compared to cover feasible classification options
for non-routed and routed shipments (Figure 1).

![Diagram](Image)

**Figure 1.** The sequences of operations for routed and non-routed shipments.
When comparing operations for routed and non-routed trains, some differences can be identified in the processes of routing setup or car-load shipping from the origin station but some similarities are also present.

If the car remains at the station from its arrival to the beginning of loading, the only difference between the sets of operations with routed and non-routed trains is the stage of car accumulation for unloading. The car loading time on private tracks also varies.

While the loading time on private tracks for routed trains consists of the time spent on supplying cars for loading, loading, car weighing, shunting for accumulation, accumulation, make-up, car inspection, and return cars to the station, the non-routed loading time consists of the time supplying of cars for loading, loading, car weighing, and returning cars to the station.

The rail car downtime from the end of loading until departure differs for routed and non-routed trains by the time of accumulating cars for train dispatch.

Further, with routed trains, rail cars do not wait to be removed (twait.rem.) due to the fact that they are formed and dispatched on schedules.

Thus, it is only possible to determine the actual difference between the times spent at the dispatching station for routed and non-routed shipments knowing the operation procedure of a given station.

Running of loaded routes and empty circular routes is the process of moving the made-up routed train from the point of make-up to the point of breaking-up, i.e. operations from the point of departure of the route till its arrival at the point of breaking-up or unloading (loading).

Running of routes includes the following basic steps [8]:
- traveling across sections;
- operations at technical stations (maintenance of trains, change of locomotives and locomotive crews, change the train weight or length).

Routing accelerates handling of the car traffic by avoiding intermediate re-classifications at technical stations along the route. For non-routed shipments, the number of re-classifications along the travel line and the downtime per classification yard are different for every car and depend on the travel route and destination capacity.

Breaking-up of the routing includes breaking-up the routed train and unloading it, i.e. the operations from arrival at the breaking-up or unloading point to the removal of the empty cars.

Breaking-up of the routing includes a sequence of basic operations [8]:
- car arrival cars at the breaking-up station;
- breaking-up of the routed train or uncoupling of the first block;
- car transfer to the point of freight operations or traveling of the remaining route blocks to the destination points;
- freight operations;
- car removal/transfer to the station.

Figure 2 shows the operation set at the stage of breaking-up of the routing, including possible options for train breakup for non-routed and routed arrivals.
Figure 2. The sequence of operations for routed and non-routed arrivals.

For every station, shipper, and cargo type, the set of operations has different process times for routed and non-routed shipments. Depending on local conditions, the routed train can be unloaded as a single train, or broken up at the connecting station or on private tracks. This is particularly relevant for bulk unloading stations, including port stations. The routed train may be transferred to the unloading point as a single train without adding more cars on private tracks. It is, therefore, possible to avoid car operations on public tracks at the destination station, which enables efficient use of its infrastructure by reducing the rail car downtime on it.

During bulk loading or unloading at freight stations, the operations of reception and commission of rail cars by shipper’s or consignee’s employees can be performed simultaneously, which is achieved by traveling through the station tracks without locomotive change on private tracks.

The above suggests that the difference in time spent at the destination station of the rail car is calculated individually for stations and enterprises adjacent to a given station.

To make a final decision on the possibility and economic feasibility of making up a routed shipment, the financial aspect has to be considered [17]. The legislation currently provides discounts on freight charges for shippers in case of routed shipments. And, despite that technically it is profitable for the carrier to make up train-load routings, in most cases, the size of the discount exceeds the carrier’s and infrastructure owner’s savings. Their cost advantage results from avoiding re-classification of the car traffic at technical stations and costs associated with these operations [18]. It is worth pointing out that the operating costs associated with the number of stations where re-classification is avoided are not directly determined by the transportation distance. Therefore, the carrier’s cost savings depending on the traffic capacity are not always proportional to transportation distance.

The incentives for making up routings of all types are essential for the efficient use of railroad infrastructure and reducing the car turnaround; therefore, it is reasonable to combine it with the freight
transportation process, i.e. take into account the number of stations where re-classification is avoided along the travel route.

To that end, it is possible to apply the “car stations made available” index reflecting the reduction in railroad operating costs. The capabilities of current information systems enable taking this parameter into account at the stage of shipping paperwork before freight transportation. By setting the rate in Russian rubles (which takes into account the stations’ operating costs associated with the re-classification) ahead of time, we can calculate the operating costs reduction along the travel line of the train-load routing.

Thus, savings from setting up a given route are calculated by the following formula:

\[ S = G \times N \times n \]  

where \( N \) is the number of cars in the routed train, \( G \) is the cost of classification at the station, and \( n \) is the number of stations released from the re-classification of the rail car traffic along the route travel line.

3. Research Results

Train-load routings are profitable for all the market participants. The carrier reduces the costs of initial and final operations carried out on private tracks and receives further assurance of compliance with delivery time. For shippers, they create conditions for accelerating the product sales and reduce the need for operating assets, which, in current economic conditions, is essential for the corporate economy. For the operator company, train-load routings reduce the car turnaround and, therefore, improve its performance.

The procedure of freight transportation by routes is based on [8]:

1) concentration of freight traffic by condensing the loading of bulk cargo in individual routing consignments; scheduling of freight loading by destination by one or more shippers from one or more stations; car accumulation for a given destination on private tracks or station tracks;
2) strict compliance of the freight train classification plan when making up routings by assigning breaking-up stations and ensuring the safe handling of train-load routings or their core as a single train from origin stations to destination stations;
3) rational use of the rolling stock and facilities of public and private railroad infrastructure;
4) continuous improvement of types and methods of routed transportation.

Improving the principles of long-term freight rate regulation and the effective application of the right to flexible rate within pricing boundaries considering the mutual interests of both the carrier and shippers. To this effect, an index can be used that reflects the operating costs reduction by avoiding re-classification at stations along the route.

4. Results and Discussion

The purpose of routing is delivering cargo by a strictly scheduled time, which, in turn, reduces the additional storage costs and unwanted rail car downtime before unloading. A particularly evident example of this is the work of port stations, for which the “just-in-time” logistics principle is crucial to maintain the relevant infrastructure reserves and better regulated interaction with the port.

To ensure profitability for the participants of the transportation process, the paper suggests the “car stations made available” index. This index reflects the avoided re-classification of the car traffic at technical stations and costs, associated with those operations. Incentives for customers can be applied within the amount of cost savings per station where re-classification is avoided. By applying this rate and the “car stations made available” index, it can be calculated that the amount of charges is comparable to the savings from routed train handling.

The purpose of the effective railroad transport operation is to minimize the operating costs of transportation and to predict the cargo delivery process time to minimize the additional warehousing costs. Moreover, failures to comply with delivery time increases the carrier’s expenses due to the delayed delivery penalties.
References

[1] Osminin A 2016 Bulletin of the Joint Scientific Council of RZD OJSC 3 pp 28–40
[2] Panin V, Kolesnikova E 2011 Railroad Transport 2 pp 34–39
[3] Shatalov O 2013 Railroad Transport 8 pp 23–28
[4] Mayorov N, Kovalev K 2013 System Analysis and Logistics 9 pp 21–23
[5] Mashevet N 2006 Bulletin of Rostov State Transport University 4 24 pp 103–107
[6] Osminin A, Groshev G, Nikiforova O 2008 Railroad Transport 1 pp 62–65
[7] Kozachenko D, Vernigora R, Balanov V, Sannytsky Y, Berezovsky N, Bolvanovka T 2016 Transport Problems 11 3 pp 91–101
[8] 2018 RZD OJSC Railcar Traffic Guidelines No. 2872/p (Moscow) p 548
[9] Kuzhel A, Shapkin I, Vdovin A 2015 Railroad Transport 7 pp 14–19
[10] Syshchikov D, Tarabrin D, Gavrikov V 2018 Transport Bulletin 10 pp 41–44
[11] Cohen-Blankshtain G, Feitelson E 2011 Transportation 38 2 pp 343–361
[12] Bozejko W, Grymin R, Pempera J 2017 Proceedings of the 16th International Scientific Conference Reliability and Statistics in Transportation and Communication, RelStat pp 206–212
[13] Islam D 2014 Transport Problems 9 3 pp 43–56
[14] Yu Grina O 2015 Scientific Problems of Transport in Siberia and the Far East 4 pp 14–17
[15] Chechulina Yu 2014 Scientific Problems of Transport in Siberia and the Far East 1–2 pp 95–97
[16] Bessonenko S, Zharikova L 2015 Scientific Problems of Transport in Siberia and the Far East 4 pp 19–22
[17] Vorobyov V, Manakov A, Reger A, Tanano I 2018 MATEC Web of Conferences 216 02009
[18] Tanano I, Yu Grina O, Zharikova L 2018 MATEC Web of Conferences 216 02015