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Scheduling algorithm of organization of wagon movement in rail network for compact transport

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ABSTRACT

Organization technology of moving of wagons in the process of operational service of rail transport plays an essential role. It is important that the wagons are moved in a compact system or in a distributed system. The article presents an algorithm for planning the movement of wagons in the compact system. Compact transportation is a form cargo transportation conducted using compact wagon trains from the station of origin to the destination station. It is pointed out as well that from the technological side diffuse movement is a more complex process due to the involvement of significant resources. When building a model of the movement of wagons in the compact system, one should pay particular attention to both the time and cost of travel. The purpose of organizing compact transportation is among others ensuring rhythmic delivery of goods, elimination of yard work on the path of train pass, using the maximum train load, acceleration of wagon rotation..

KEYWORDS: railway transport planning , compact system, wagons rotation, railway operational service

1. Introduction

In practice, the process of planning the movement of loaded and empty wagons is very complicated. When planning, one should focus on the efficient execution of the goals set. The plans should specify steps to achieve the intended purpose. Planning is the basis for all management functions. Without planning there is no good management. It is worth noting that the process of planning of transport processes is one of the most important tasks of the transport company. Proper planning ensures the ability to achieve the expected results by the carrier.

Planning the movement of trains on the railway network must be properly prepared due to the specific factors of traffic management. This is mainly due to the need to maintain safety. Users of the railway network are both passenger and freight operators. The entity, whose duty it is to take care of traffic flow is the infrastructure manager.

Meeting the needs of railway and linking all the elements together should be aimed at achieving the best possible result with the proper use of infrastructure and resources involved in the process of transport. Such a way of interaction of system components while the task is performed is called the organization of transport [1].

2. Train movement organization in literature

The basic processes that make up the process of organizing transport are planning the timetable and all activities associated with completing and passing trains. These processes cover activities starting from a demand for wagons, their consignment, dispatching and moving to the destination station. The main objective of the infrastructure manager is to prepare a reasonable timetable. Reasonable timetable on one hand is supposed to meet the needs of railway, and on the other hand, the chart of train movement required for achieving the transport for reported demand Jacyna and Gołębiowski [2,3].

Issues concerning the construction of train traffic graphs are described by many authors, Gołębiowski and Żebrak [4], Jacyna and Gołębiowski [2], Jacyna [1] Caprara et al. [5]. A major problem is the occurrence of traffic congestion on the rail network Leszczyński [6]. The importance of this issue stems from the specificity of rail transport. Problems when passing through a section of the railway network will affect the entire organization ofm movement Wolfenburg [7], Karoń, Skrzypek [8]. Other modes of transport are more resistant to this type of interference Nowosielski [9], Gajda [10] Woch [11].

Work on the construction of cyclic timetable of trains lead, among others, Luthi [12], Serafini and Ukovich [13]. In contrast, the timetables of trains in a non-cyclical formula - Carey and Lockwood [14], Corman et al. [15], Oliveira and Smith [16].

Planning for freight trains - Mu, Dessouky [17], they cover the subject of planning the freight trains moving through complex networks. Article develops an approach based on optimization of the planning of freight trains. There are two mathematical formulations of the problem of moving cars (scheduling) proposed in the article. Presented algorithms are better than the existing simple greedy heuristics and heuristic search in the immediate area.

In this regard it is important to plan additional trains on the network - Cacchiani, Caprara, Toth [18]. The problem is the planning of freight traffic on the railway network, when both passenger trains and freight trains are involved. While passenger trains have a fixed schedule, which cannot be changed, operators of freight trains place additional orders to insert new freight trains into the plan. For each freight train, the connected train operator specifies the preferred ideal schedule, which can be modified by an infrastructure manager. Overall, the goal is to introduce as much new freight trains as possible, by assigning schedules that are as close as possible to the demand requested.

Simulation models are of great importance in problems of decision support when planning the traffic on the railway network. For example Marinov, Viegas [19] used a simulation package SIMUL 8 to model a railway network. The railway network is divided into railroads, loading points, railway stations, railway terminals and railway junctions. Components of the rail network were treated as interconnected queuing systems that interact with each other. The use of simulation models to drive the movement of trains was a topic of interest for Wolfenburg [7, 20].

3. Organizational determinants for moving wagons on the railway network

Rail transport plays an important role in the transport of goods, especially bulk commodities. In the era of market economy, both rail operators as well as those responsible for the quality of transport infrastructure must meet the demand of the market and customer expectations. Transferring cargo by rail is carried out using a variety of transport technologies. Most often it is a technology called. compact traffic or dispersed traffic. In the compact transport trains are run directly from the station of origin to the destination station. Dispersed movement is characterized by a more complex technology of transportation. Transportation is carried out on a specific railway network, consisting of the stations and railway lines. Plan of moving loaded and empty wagons is prepared on the basis of needs for transport, submitted by the buyers of transport services.

In the current market conditions, it is customers who are active participants in the transport process, submitting needs for quality and quantity of wagons, the date of origin, place of origin and destination. Unfortunately, it is not always the situation that customer requirements are adequate for the operational capacity of the carrier. Responding to the needs of customers, the carrier must balance resources to be able to meet their expectations. The carrier must prepare a process operating with full knowledge of the consequences that come with changing customer expectations. Therefore, there is a need to coordinate the reported demand for transport with the available resources in wagon stock.

In the Act on railway transport the activities that constitute the management of railway infrastructure were defined, namely [21]:

- construction and maintenance of railway infrastructure;
- operation of the train on the railway lines
- maintaining railway infrastructure in a condition for safe operation of the railway;
- sharing train paths for trains on the railway lines and the related services;
- management of real estate belonging to the railway infrastructure.

Under Regulation [22], a rail carrier should be able to obtain from the regulations published by the infrastructure manager an information about both the organizational and movement conditions.

In terms of organizational conditions this information applies e.g. to: manager contact data, the mode of communication between the carrier and the infrastructure manager, as well as the manager's internal rules, which will apply to the carrier in the preparation and functioning of a timetable. In addition, that information should take into account the means for notification of changing technical and operational parameters of railway lines, on which train paths have been allocated. This applies above all to limitations associated with construction, introduced speed limits, improper operation of railway traffic control devices, communication methods and equipment monitoring and diagnosing the rolling stock. In addition, the information may contain the terms and conditions for making changes in the timetable and rules of conduct in case of difficulties in establishing international train routes.

However, in the case of movement conditions the information relates to: detailed specification of the services provided by sharing the rail infrastructure, the requirements and conditions for rolling stock, personnel and organization of routes. This information allows the carrier to adapt the parameters of the rolling stock (wagons and locomotives) to the requirements of the infrastructure manager. Requirements for personnel are aimed to prevent accidents and contribute to the improvement of traffic safety. In addition, information on the movement conditions apply to proceedings in case of overflowing a section of infrastructure and restrictions on the use of the railway infrastructure. Information about specific technical and organizational requirements related to railway infrastructure provided by the manager is also important in this case.

The above-mentioned information allows the carrier to take into account the requirements of the infrastructure manager. The carrier builds a freight plan on the basis of the demand for transport placed by customers including the above-mentioned requirements.

4. The algorithm for moving cars in compact traffic

4.1. Assumptions for constructing the algorithm of moving loaded and empty wagons

To map the relevant parameters from the point of view of the construction of the algorithm and its use in the next stage, which is a functioning computer application, the information on the implementation of the whole process of moving wagons on the railway network is important. Each process has a beginning and an end, that is, there is an impulse to the process for starting and ending the process. The initial event is converted to an output event with the use of resources, according to the principles, rules and procedures.

It is assumed that in the beginning of the process there is cumulative demand for transportation, provided by the customer. Undoubtedly, one should take into account various types of interference of the process and the data for previously mentioned organizational and movement conditions. Fig. 1 shows schematically the elements of the model.

Because in the course of the transport process all kinds of interference may occur (e.g. stoppages of trains on the railway routes), the model assumes the ability to record these events, defined as interference. They affect the results of the calculation.

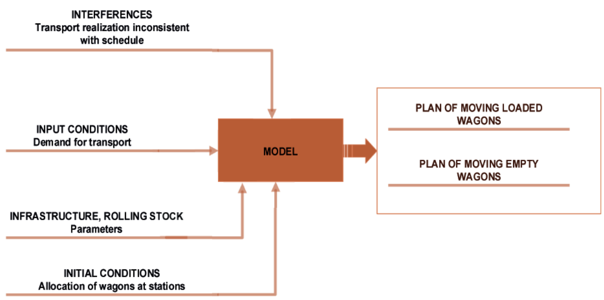

Fig. 1. Schematic diagram of the optimization of movement of loaded and empty wagons on the network [own study]

Compact transport means that the cargo is carried by a uniform wagon set from the station of origin to the destination station. With appropriate equipment of cargo loading stations for cargo sender and receiver (the appropriate length of siding track, adequate capacity of siding, etc.) the transportation starts directly from the load point of sender and arrive directly at the point of receiving by the recipient. In this case, the situation can be described as transport from one sender to one recipient.

4.2. Selected variants of transporting loaded and empty wagons in compact transport system

Transport technology plays a crucial role in the process of operational service. It is important that the wagons are moved in a compact or dispersed system.

The article considers a situation when loaded wagons are moved in a compact system technology. Empty cars can remain at the station or there may be a need to bring them in the compact system. These are the most desirable variants in terms of cost.

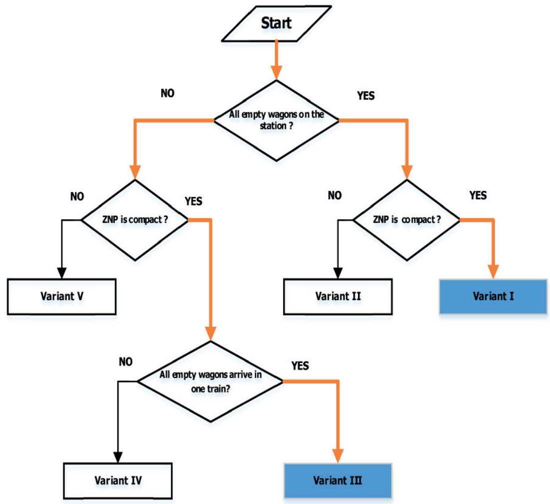

Fig. 2. Variability used for organizing transport [own study]

ZNP - the demand for loaded wagons submitted by customers

Variant I

Empty wagons are located at the station at the time when demand is submitted There is justification for freight being conducted in the compact system. A large number of loaded wagons in one transport route.

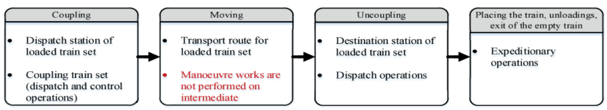

Fig. 3. Compact movement - demand covered with wagons which are empty at the station of origin [own study]

In this variant, the cost of movement of empty wagons for loading is zero. There are only the costs of moving wagons loaded in a compact train. This technology is characteristic for seaports.

Variant II

No empty wagons at the station at the time when demand is submitted There is justification for freight being conducted in the compact system and it is possible to request the empty wagons for these services in a compact system.

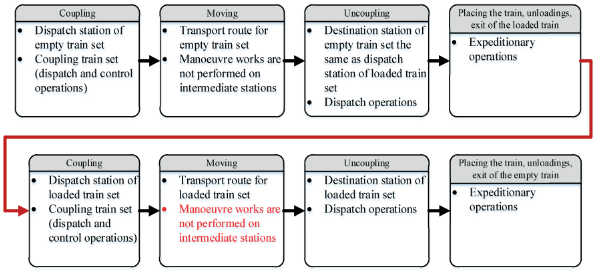

Fig. 4. Compact movement – demand covered by empty trains outside of the station of origin [own study]

That variant is the most beneficial when it comes to the total cost of providing the service, in case there is a need to provide empty wagons for the demand. The total cost consists of the costs of moving empty wagons in a compact system to be loaded plus the cost of moving loaded wagons in a compact system. This technology is characteristic for big customers reporting high demand for transport, stations in the areas where many compact trains arrive - in the area of large businesses receiving goods, e.g. power plants.

4.3. Algorithm for moving cars in a compact system

The aim of organizing the compact service is not only to ensure the rhythmic delivery of goods and the elimination of yard work on the road where the train passes, but also maximum load of trains and accelerating the rotation of wagons.

A characteristic feature of these operations is the fact that the entire service is carried out by one train, generally using one means of traction, without the need for costly jogging operations at intermediate stations. This transport system will also improve the quality, speed up delivery time, increasing the safety of shipping – it is therefore the most effective form of realization of freight, and thus the most desirable from the point of view of both the carrier and the customer. Maximizing the transport because of its characteristics is the most desirable objective in terms of operational activities.

The condition for its implementation is, however, knowledge of customer needs and full adjustment of available resources, mainly wagons and locomotives. So it is necessary to plan them correctly - to determine the grid of trains, meaning the number of train routes, their relations and the timing in such a way as to adjust the transport plan to the greatest possible extent to the expectations of customers. However, the planning of this type of transport is difficult for the carrier due to significant fluctuations over time in the freight volume, and the irregularity in different days of the week.

The customer placing demand for transport should give the order details in advance: the date and time of loading, station of origin, destination station, the number of wagons, a series of wagons, the customer, the type of goods. In the course of fulfilling the plan, customers also make adjustments to previous requirements.

Train maintenance during compact transport does not take place in marshalling and maneuvering stations. Compact transport is carried out with little maneuvering effort.

At the station of origin the train is prepared to leave. There are also cases of compact transport directly from the sender to the recipient's point of load. In this case, the maneuvering job is eliminated. Only work associated with the movement of the train is performed.

Compact shipments with fixed load and length of trains shall not be dispersed on the road from the station of origin to the unloading station. Upon arrival to the destination station and being examined technically and commercially processed, the train is placed in whole or in part to the recipient's delivery-receiving tracks.

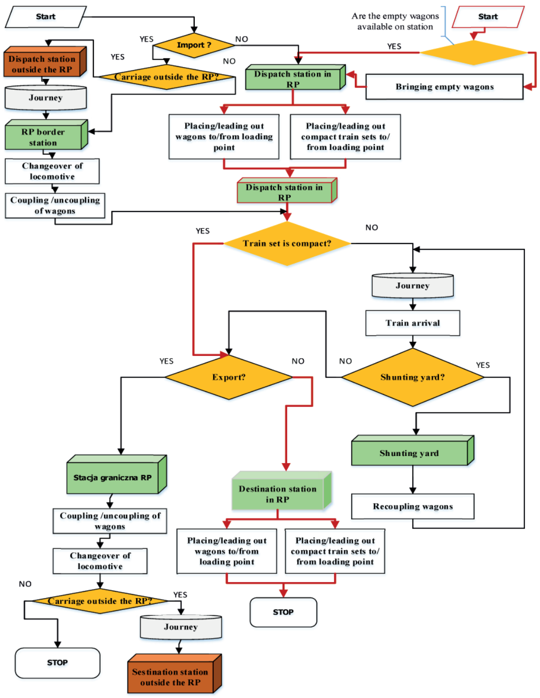

Fig. 5. Algorithm for organization of transport – compact transport [own study]

Service points maintenance is carried in accordance with the siding agreements, that determine the frequency of use as well as hours of operation. In terms of technology, maintenance of service points involves placing and taking away wagons to and from the point of delivery-receiving, which may be located in the station or customer's siding. In figure no. 5 an algorithm for organizing the compact transport has been presented. Red color highlights features of the transport process included in the algorithm of transport in domestic and compact technology. The following assumptions were made:

- stations of origin and destination on the territory of Poland,
- transportation implemented without jog on the route, given the train at the station of origin is routed to the destination station by the shortest route. The shortest way is the critical

path in terms of cost minimization. The route consists of individual sections of the infrastructure.

- in the case of trains with wagons owned by the carrier, the empty wagons are provided by the carrier.
- in the case of trains with private wagons, the owner provides the wagons.
- in the case of large and regular transport demand in one relationship wagons run in shuttle traffic (without separation) in one route (loaded in one direction and empty in the other, prepared for loading).

5. Conclusion

Transferring cargo by rail is carried out using a variety of transport technologies (compact and dispersed traffic). In the case of the demand for transport in compact technology (the need to use a large number of wagons), the movement of empty wagons in order to meet the needs of transport usually takes place in the same technology. Compact transport - both for the movement of goods and empty wagons - means that it is carried out without performing the jog on route. In the compact transport trains are run directly from the station of origin to the destination station. The compact technology is the most popular freight technology - over 80% of all transportation. This is mainly due to cost calculation and diminishing railway network. Compact technology in terms of costs definitely wins against dispersed transport.

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