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The short-term car flow planning model in rail freight company – case study

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Abstract

With the promotion of the environmentally friendly transportation modes (the European Commission supports the freight transport operations in the rail sector), an increase in the diversification of the demand is observed. While most rail freight companies tend to apply fixed schedules, this approach is not effective turns out to be ineffective due to the need to meet the customer's specific requirements.
The purpose of this paper is to present a case study of empty wagon flow planning over a medium term horizon and to discuss the opportunities of improvement of this plans by discrete optimization. In order to increase the utilization and availability of wagons, the planning procedure with a rolling horizon has to be implemented. Unfortunately, since the plan has to be updated ca. every 4 hours, this planning approach needs effective optimization tools. Our hybrid two-stage approach is designed to be implemented in such business environment. This formulation allows us to solve real life instances even for a 7-day time horizon.

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Keywords: railway, car flow optimization, rail freight

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1. Introduction

The freight railway operator runs a number of trains in order to carry out its customer's orders. These trains need an appropriate type and number of wagons at geographically dispersed stations around Poland. Unfortunately, our experience shows that in most cases the rail freight companies operated in Poland plan their transport operation in the time horizon not longer than one day. Such a situation results from a complex optimization problem which arises in this area. In order to simplify the planning of rail cargo freights, a hierarchical approach is used. In general, the planning procedure is divided into 3 main parts:

- wagon flow planning (empty and loaded wagons),
- locomotive assignment planning,
- employee scheduling.

The operational planning procedure is initiated with the planning of the flow of wagons. While the flow of loaded wagons depends on the customer's orders, the flow of empty wagons can be used to decrease operational costs. Decision makers are aware of the relationship existing between the number of wagons used and the number of kilometers of empty wagons. The lower the number of wagons the higher the number of kilometers traveled by empty wagons. On the other hand, the lower the number of wagons, the bigger the number of problems with the wagon availability.

Similarly as in other areas of business planning, an important factor here is the uncertainty. In order to cope with varying parameters, the planning with the rolling horizon is widely used in this area. In such a situation, plans with a fixed planning horizon should be created in given intervals. This approach allows us to deal with uncertain issues, however it needs the support tools in the planning generation process (the planning procedure has to be executed at least once a day) and the system integration planning system as well as the freight execution system (optimization tools should consider as current values of parameters as possible). Our hybrid approach was designed to be used in such a business environment and is essential to plan the flow of empty wagons with a rolling horizon.

The paper is structured as follows. The description of the problem of the empty wagon flow planning is given in Section 2. In addition, this section contains a literature review and the main assumption of our proposal with a summarized contribution. In section 3 we discuss our two-stage hybrid approach in detail. Section 4 contains computational results. Finally, a summary is provided in Section 7.

2. The empty wagon flow problem

2.1. The empty wagon flow planning in practice

Rail freight transport carried out by PKP Cargo is assigned to one of two groups: block train traffic, single wagonload traffic. Block train transport orders are considered as the main ones and the plan must guarantee the maximization of the number of completed orders according to priorities. A block train traffic order is considered to be completed if the appropriate number of wagons of a given series is allocated and provided for the execution of a given order (at the right place and time). Single wagonload traffic orders may be fulfilled also as the train enhancement in block train transports (both loaded and empty). However, the train enhancement may take place only at the shunting station between 6:00 a.m. and 8:00 p.m. (ultimately, each shunting station may have different operation hours), and also if the maximum technical parameters are not exceeded (in particular, the length and gross weight of the train) and for loaded trains – if the enhanced train has a relevant low priority (priority = 3 or 4). Furthermore, the time of waiting of any train for enhancement may not exceed the limit of 4h (ultimately, a value of this parameter will vary for individual stations). A single wagonload traffic order is considered to be completed if the appropriate number of wagons of a given series is allocated and provided for the execution of a given order, and upon loading (the loading time of 8h is assumed; a target value will vary for individual orders), these wagons are assigned to one or several trains for which the departure station of the first one is the same as the order provision station, and the arrival station of the last one is the same as the destination station of the order. If the single wagonload traffic order is executed by more than one train, it is necessary to make sure that the dates of departure of