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What about train length and energy efficiency of freight trains in rescheduling models?

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Abstract

Energy efficiency and train length may be critical during rescheduling, in particular if long freight trains are considered. The first aim of this paper is to investigate how current scheduling and rescheduling models consider train length and energy efficiency. The second aim is to extend a scheduling model that considers train length and energy efficiency for drafting a rescheduling model that minimizes not only delays but also energy consumption. A small numerical example shows that this rescheduling procedure can be fast and yield to a significant reduction of energy consumption. Thus, it is worth further research. However, validation on larger instances, calibration of parameters with real operational data, and methods to speed up the procedure are still needed.

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Keywords: Energy efficiency; freight train; rail operation; rescheduling; train length.

1. Introduction

Rail freight is expected to play a major role in the European transport system. In most countries, freights share railway infrastructure with passenger services and, when disturbances (delays or disruptions) occur, passenger trains usually have higher regulatory priority in dispatching. In recent years, the interest of academia and industry in optimized rescheduling processes has increased considerably, and several strategies have been proposed. These strategies assume the aforementioned hierarchy, and most of them propose solutions for delay minimization without considering the specific operational requirements for lower priority users, such as freight trains. In fact, constraints and objectives for freight train rescheduling are usually different from the ones related to passenger trains. Freights trains scheduling and rescheduling is partly more flexible regarding route and departure/arrival times but, due to the lower priority, is also constrained by the schedules of higher prioritized trains. Thus, freight trains are forced to stop unplanned more often than passenger trains. Fig. 1 shows a conflict in simulated rail traffic: the freight train (magenta) has to stop to let the passenger train (brown) arrive at the planned stop.

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Reducing energy consumption has become a central issue for many industrial branches, and railways are no exception. Energy consumption of rail freights can be minimized by choosing energy efficient paths, schedules, and speed profiles that improve regularity, avoiding unplanned stops and minimizing acceleration phases. The Swiss Federal Railways (SBB) have recently started the roll out of ADL system (from German *Adaptive Lenkung*, adaptive train control) on their network. ADL is a driver advisory system that optimizes energy consumption for given conflict-free schedules by providing drivers with relevant speed information (Völker, 2013). Optimal speed advice is also a key element of the fully automated railway, to be considered in a long term perspective (Weidmann et al., 2015). Energy efficiency may be further improved by considering energy as cost factor within scheduling and rescheduling processes.

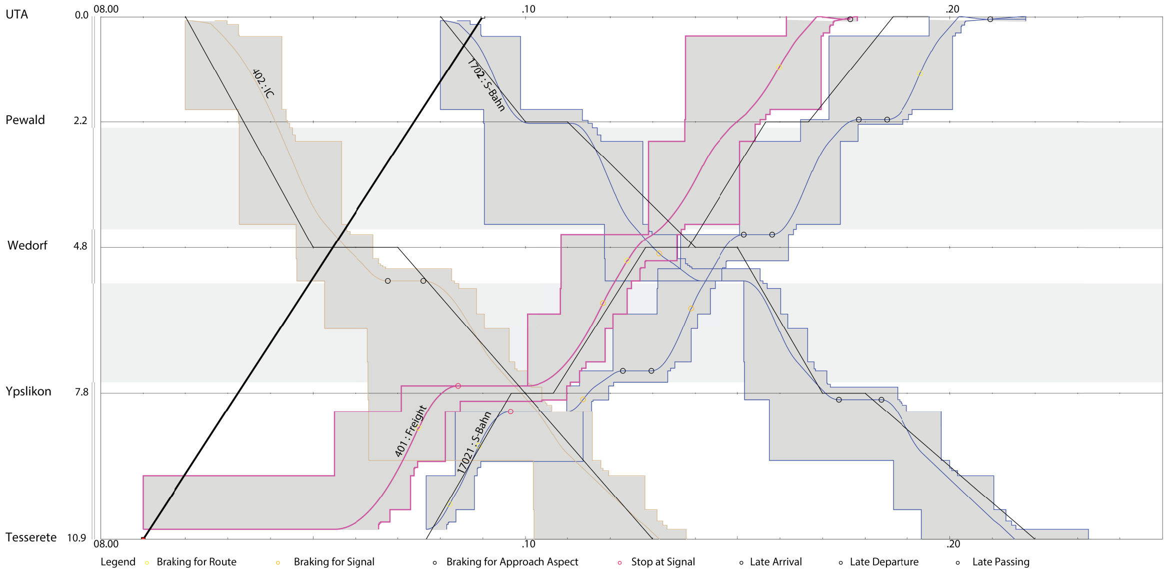

Fig. 1. Schematic representation of route conflict in mixed traffic.

Freight train length is a factor that cannot be neglected. In calculation models (Brünger and Dahlhaus, 2014), trains are often considered as mass points associated with time windows for passing each section of their path. The number of wagons of freight trains may vary from a single up to several dozens. For longer trains, the length causes the occupancy of several blocks at a time, increases the clearing time when leaving a block section and prevents crossing and overtaking in some network regions. Though, the EU showed particular attention to even longer freight trains, e.g. project Marathon (NEWOPERA Aisbl, 2014), in order to reduce costs and improve efficiency in operation. Furthermore, the variety of freight services has expanded and some services (e.g. just-in-time delivery) should have the same regulatory priority level as passenger trains.

The first aim of this paper is to evaluate scheduling and rescheduling models with respect to rail freight features in order to identify a model that considers all the specific requirements (Section 3). In particular, this work focuses on two features: (1) energy efficiency and (2) train length. The second aim is to extend a scheduling model that considers the specific requirements to rescheduling and test the plausibility on a small numerical experiment (Section 4).

2. Preliminaries

Blocks are the backbone of railway safety systems. A block allows only one single train to use a resource for a given time interval. Blocking time intervals are generally composed by several subintervals (Brünger and Dahlhaus, 2014): the time interval for clearing the first delimiting signal t_c, the time interval for seeing it t_v, the approaching time interval from the distant signal, if any, t_a, the running time interval t_b (computed at the head of the train), the clearing time interval t_o (computed at the tail), and the release time interval t_r. The components t_c, t_v and t_r do not depend on the train run and are usually assumed to be constant (Brünger and Dahlhaus, 2014). The other components depend on