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The effect of temporary speed restrictions, analyzed by using real train traffic data

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Abstract

This paper studies the effect of temporary speed restrictions (TSR) in railways. We present a method for analyzing the effect of TSR. TSR, or slow orders, are imposed on the railway to ensure safe use of the infrastructure. We have documented that TSRs give variations in the running times for trains. The impact of the TSR is basically depending on several factors, including the difference in speed between normal and reduced speed, the length of the TSR and the length and weight of the train. We found that speed restrictions typically caused delays up to 60 seconds. A best fit analysis indicates that a TSR adds about 25 seconds plus added time depending on the length of the TSR. This corresponds relative well with theoretically expected values. The effect of TSRs is on average relatively well aligned with theoretical calculations. However, the variations are large. Our study has shown that TSRs can have negative effects on the precision of the railway system. As a part of the research, we developed a tool that identifies and evaluates the effect of TSRs on traffic.

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Keywords: Railway; Temporary speed restrictions; punctuality

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1. Introduction

The purpose of this paper is to study the effect of temporary speed restrictions (TSR) in railways. We present a method for analyzing the effect of TSRs. TSR, or slow orders, are usually imposed by railway dispatchers for sections of track that are deficient, or when there is a requirement to perform maintenance, see for example Bruzek et al. (2015); Macciotta et al. (2016). The railway groups' standard GK/RT0038 and GK/RT0075 (Railway Group Standard, 2000, 2015) defines speed restriction as "a set out principles governing the signing and advice of permissible speeds, temporary speed restrictions and emergency speed restrictions on running lines to ensure that train drivers have sufficient information to control their trains safely". Speed restrictions influence the running times of the trains. TSRs tend to disrupt timetables and can affect time-sensitive shipments, so railroads should have incentives to get them cleared as soon as safely possible. TSRs can be issued for several occasions, such as poor welding of rails, issues with settling ballast, or rail geometry defects. Violation of TSRs can cause serious accidents (McNaughton, 1977).

A reduction in speed would cause longer running time on the affected part of the line. Delays can be a consequence of a TSR, especially on single line tracks. Speed reductions should therefore be imposed carefully. On single line tracks can delays cause propagated delays on other trains. Therefore it is important that the minimum restriction should be imposed, lasting the minimum time span possible, and allowing the maximum allowable speed, while taking the need for safety and operating conditions into account (Samuel, 1961). The number of slow orders can be used to benchmark the asset management performance of a railway infrastructure manager. Which is the case in Norway, in addition to TSRs, infrastructure management is evaluated based on registrations of delay cases, related to the infrastructure, and selected other parameters.

There are a number of factors which can influence punctuality in railway traffic (Olsson & Haugland, 2004; Vuchic, 2005). Common influencing factors include capacity utilization, passenger number and behavior, weather, timetable characteristics, quality of rolling stock and infrastructure, as well as other factors internal and external to the railway system. TSRs can be included in this list. Lv et al. (2015) highlight that availability of traffic data have been exploding recently, they propose to rethink the traffic flow prediction problem based on deep architecture models with big traffic data. Chen et al. (2015) shows that traffic data refer to datasets are becoming available and provide an overview of approaches for data visualization, to support analysis of distributions and structures of datasets in order to reveal hidden patterns in the data. This paper joins this research tradition. There has been some previous research on TSRs, including Gorman (2009) and Lovett et al. (2013). Olsson and Haugland (2004) made related investigation on factors affecting punctuality, which was a point of inspiration for this articles research questions. In their research, they have used the Norwegian railway network near Oslo and on the Nordland line to analyse the effect and correlation of certain variables to punctuality. The correlation between TSR and delays was found to be weak and sometimes opposite to what is expected. Liu et al. (2009) discuss optimal driving patters on line with speed restrictions. Junfeng and Dong (2010) analysed management of temporary speed restrictions in CTCS-systems. Zhao and Wang (2012) and Yuan et al. (2013) present a model for representing temporary speed restrictions in the Chinese Train Control System-3(CTCS-3). Zhou and Mi (2013) analyse of the effect of speed restriction based on simulations. Bruzek et al. (2015) developed a model to automatically issue slow orders based on a model for rail heat prediction, they compared theoretical heat slow orders generated by the model and found good accuracy in predicting slow orders. Lovett et al. (2013) discussed descriptive degradation models, which can consider the costs of slow orders and compare the delay from slow orders to the risk of an accident.

The scientific contribution of this paper is to evaluate the effect of TSRs based on empirical data. To a certain extent, it would seem self-evident that a temporary speed restriction would cause a delay. Given that the timetable is based on a certain maximum speed on a line section, not being able to drive that fast would cause a delay. Train drivers frequently make this argument, and they obviously have a point. However, running time margins are generally added to the timetable, as described by Goverde (2005). Nominal running times are based on a maximal speed profile in normal conditions. To make a timetable realistic, planners add margins to allow for variations in rolling stock performance, individual driving patterns for drivers, variations in weather conditions and, for example temporary speed restrictions. Depending on the train operator's geographical location or country of origin, there are different magnitudes of the margins that are added in the timetable. Running time margins are typically expressed as a percentage of the nominal running time. Norwegian railways use 4% running time margins as a basis, but extra