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Adding timetable flexibility to real-time railway traffic management

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The adherence to a timetable with precise departure and arrival times becomes increasingly challenging in real-world scenarios due to the daily fluctuations in rail traffic, leading to uncertainties that complicate effective real-time traffic management. In this paper, we introduce and optimise timetable flexibility to enhance operational robustness and reduce conflicts resulting from minor train path deviations. We propose a Train Rescheduling with Flexibility (TRF) model, relying on a Mixed Integer Linear Programming (MILP) formulation. The primary objective is to minimise timetable deviation, while maximising timetable flexibility. The punctuality threshold is utilised to optimise time allowances within the real-time traffic plan, considering passenger connections and preventing early departures. A real-life case study that focuses on part of the Dutch railway characterised by complex track layouts and heterogeneous rail traffic is used to validate our model. Furthermore, we investigate the impact of predictive delays on flexibility, along with conducting sensitivity analyses on key parameters such as flexibility weight and punctuality threshold. The results of our optimisation model demonstrate its effectiveness in exploiting timetable flexibility to deal with disturbances.