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The Ideal Train Timetabling Problem

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The aim of this talk is to analyze and to improve the current planning process of the passenger railway service.

In the first part, the state-of-the-art in research is presented. Given the recent changes in legislature allowing competitors in the railway industry, the current way of planning is not sufficient anymore. The original planning is based on the accessibility/mobility concept provided by one carrier (typically government owned), whereas the competitive market consists of several carriers that are driven by the profit.

Moreover, the current practice does not define the ideal timetables and thus it is assumed that they evolve incrementally, based on historical data (train occupation, ticket sales, etc.).

We introduce a definition of an ideal timetable: An ideal timetable consists of train schedules, such that the total travel time of all the passengers travelling from their origin to their destination using one or more trains is minimized.

We assume that each passenger has his/her own ideal time at which he/she wishes to travel from his/her origin to his/her destination (ideal Origin-Destination (OD) Matrix). Thus the total travel time, for a group of passengers with the same ideal time and OD, consists of the initial waiting time at the origin (passengers can either choose train departing before their ideal time or after, if there is no train at the exact ideal time), the time spent in the train(s) and the waiting time for the next train (only after the arrival to the connection point) in order to reach the destination. The amount of transfers is not limited.

This definition, allows us to address another important issue that is not well described in the literature, and that is the connections between the trains: in the cyclic version they are typically always imposed, whereas in the non-cyclic version they are not even being commented.

In order to create such timetables, we propose to insert the Ideal Train Timetabling Problem (ITTP) that is solved for each Train Operating Company (TOC) separately, into the planning process (Figure 1). The ITTP approach incorporates the passenger demand in the planning and its aim is to minimize the passengers' total travel time (weighted by the demand). The model is formulated as a MILP.

The outcome of the ITTP is the ideal timetables (including connections between the trains, based on the demand), which then serve as an input for the traditional Train Timetabling Problem (TTP). The TTP takes into account the wishes of each TOC (the ideal timetables) and creates a global feasible timetable for the given railway network, while minimizing the changes of the TOCs' wishes.

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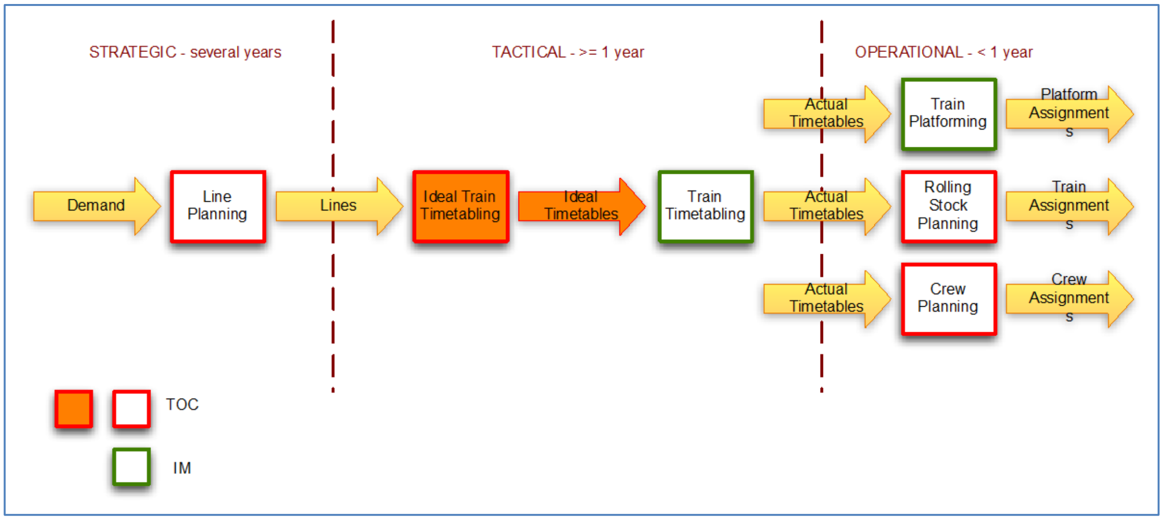

Figure 1: Updated Planning Horizon of the Passenger Railway Service

The ITTP is in line with the new market structure and it can produce both: non-cyclic and cyclic timetables.

The model is tested on the data provided by the Israel Railways (IR). The instance consists of a full demand OD Matrix of an average working day in Israel during 2008. Due to the large complexity of the model, it is solved using the Column Generation methodology.

The results are compared to the current timetables of the IR. The IR timetables are cyclic; the timetables of the ITTP approach are both cyclic and non-cyclic (run separately). At the end of the results section, we propose some manual adjustments (like scheduling extra trains on a specific lines) to achieve a better value of the objective function. This comes from the fact that the planning of the passenger railway service is sequential (due to the large complexity) and as such the global optimum cannot be reached.

The contribution of this talk is to introduce a new phase in the planning of the passenger railway service that is taking into account the passenger demand and thus not only covering the gap (missing definition of an ideal timetable), but also being consistent with a new market structure. We address the issue of the connections between the trains, i.e. the model decides if to schedule a direct train (if possible) or to connect two trains, when there is a sufficient flow of the passengers on a given OD.

Keywords: Railway Optimization, Timetabling, Demand, Ideal Timetable, Scheduled Delay