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An assessment of railway capacity

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Abstract

In this paper, we review the main concepts and methods to perform capacity analyses, and we present an automated tool that is able to perform several capacity analyses. Capacity is extremely dependent on infrastructure, traffic, and operating parameters. Therefore, an in-depth study of the main factors that influence railway capacity is performed on several Spanish railway infrastructures. The results show how the capacity varies according to factors such as train speed, commercial stops, train heterogeneity, distance between railway signals, and timetable robustness.

Keywords: Capacity; Railway; Timetable; Train; Scheduling

1. Introduction

One consequence of the globalization of the economy and the increasing integration of the international economies is a considerable growth in the entire transport sector. During the 1990s, many countries began to suffer from congestion in certain areas and on certain routes. Nowadays, there is no doubt about the congestion of the transport situation in some countries. The problem is now beginning to threaten economic competitiveness. Greater economic development cannot take place in the current transport scenario unless ambitious measures are taken. Revitalizing the railways is one of the principal measures proposed in European transport policy. The priority is to open up markets with the deregulation of the rail transport sector as one of the principal aims. The objective is to provide railway companies with access to the railway network on equal terms; this access will be determined by infrastructure managers. This has led many railroads to reevaluate their capacity. Capital expansion is a very costly means of increasing capacity. A more cost-effective solution is to manage the existing capacity more effectively using computer-based decision support systems.

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Optimizing the use of railway infrastructure is a complex and difficult task. Therefore, numerous capacity studies must be performed in order to work out what part of extra traffic can be absorbed by the existing infrastructure and how much investment will be required for new infrastructure. The results of these studies must be rapid and precise in order to know how many route slots can be offered to railway operators and how much railway traffic can be supported by the current network. They must also provide regional and national authorities and the owners of the infrastructure with information that proves that investing in the development of the rail network is necessary and worthwhile financially.

Capacity, whose definition is a classical problem, has long been a significant issue in the railway industry. The goal of capacity analysis is to determine the maximum number of trains that would be able to operate on a given railway infrastructure, during a specific time interval, given the operational conditions. Numerous approaches and tools have been developed to address this problem; they are based on traffic patterns (Forsgren, 2003), single-track analytical models (Petersen, 1974), or algebraic approaches (Egmond, 1999). Several international companies are also working on similar computer-based systems:

- DEMIURGE (SNCF and Eurodecision, 2004) is a software program designed to assist in making rail network capacity studies. This software can evaluate a network's capacity to absorb additional traffic, to locate bottlenecks, to assist in making decisions about infrastructure investments, to optimize current and future timetables, and to calculate the residual capacity of a timetable.
- CMS (AEA Technology Rail) provides a system to plan the effective utilization of the railway capacity. It offers an easy "what-if" scenario evaluation, automatic generation of timetables, simulation of operations to predict performance and identify remedies, identification of capacity available for sale, and usage forecasts based on improved timetables. However, CMS needs to be calibrated using updated punctuality data to ensure that its predictions are valid.
- RAILCAP (Stratec) measures how much of the available capacity is used by a given operation program in a straightforward way, and it offers a very detailed analysis of bottlenecks. However, it has one major disadvantage since the modelling requires a great deal of effort. RAILCAP requires detailed descriptions of the tracks, switches, crosses, signals and speed limits.
- VIRIATO (SMA and Partner) is mainly used for adapting infrastructure to future service concepts and coordinating several operators or products that share the same infrastructure. It allows the user to determine the amount of saturation of a specified line. It compresses a given timetable, and determines the saturation rate of a line or a part of a line as a percentage. This method leads to varying results for the same line, depending on the length of the section under consideration.
- CAPRES (Lucchini and Curchod, 2001) is a model for the elaboration and saturation of timetable variants. Through the use of iterations, this model determines all available extra trainpaths, given all the constraints and interconnections between lines. A disadvantage of this model is that the traditional network and operational data have to be completed with the information about where, when and how the network capacity must be used.
- FASTTRACK II (Multimodal Applied Systems) is a computer-based train dispatching and meet-pass model that is capable of producing a feasible train dispatching plan for a user-selected corridor, given a set of proposed train schedules and a corridor's track configuration. It can be used to examine the feasibility of a set of proposed train schedules, test the impact of proposed changes in operating policies on train service, and measure both the theoretical and practical line capacity.

More information about these systems and other similar railway management systems can be found in (Barber et al., 2007).

Previous works have shown that several factors can affect capacity, and several methods have been proposed to assess it. However, since there is no commonly accepted measure of capacity, additional analytical analyses of these factors following recent recommendations of the Union of the European Railway Industries are needed. There is also a need for automatic tools that analyze different empirical methods.

In this paper, we review the main concepts and methods of assessing railway capacity, and we analyze the main factors that can affect it. In addition, we present a computer-based tool, the MOM system (Barber et al., 2006), which has been developed along the same lines as the above-mentioned tools. The MOM system is a