Chapter 5
Discrete-Event Simulation Models for Assessing Incidents in Railway Systems

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ABSTRACT

This paper presents a discrete event simulation model developed with a commercial environment. A modular approach is adopted, which facilitates building models for different railway systems. A key feature of this simulator is that it simultaneously models train movements and passenger behavior. The simulator has been used to assess two different policies when short incidents occur. Incidents are characterized by different factors, which are analyzed for both policies. A case-study is presented based on a subsystem of the commuter train network of the province of Madrid in Spain.

INTRODUCTION

Transportation is a key activity in modern society and, more specifically, railway transportation. Many aspects are to be studied so that these systems perform effectively and efficiently. In particular, when railway systems operate, there are short incidents which may occur, and for a short duration a train may not be available, altering the rest of the system. This type of incident, which may occur relatively often, can deteriorate system performance. Simulation models can be very useful to study off-line different policies for addressing these incidents.

In this paper we present a framework for developing simulation models. A model has been developed for representing part of the commuting railway system in the province of Madrid (Spain).
In this context, only short duration incidents are evaluated, which are those where a train is stopped for some reason but passengers are not transferred to a different train. After the problem related to the incident has been solved, the trip is restored and passengers are eventually delivered to their destinations.

Long duration incidents are beyond the scope of this paper. Nevertheless, with some additional effort to extend the current simulation models, long term incidents could also be addressed. Additionally, and though we do not present it in this paper, simulation models can be used to assess schedules. Optimization models are very useful for obtaining train schedules. However, for these optimization models to be solvable in reasonable times, simplifications are to be made. Therefore simulation models, which include a higher level of detail, can be used to check whether the outcome from an optimization model is really feasible.

A wide range of simulators has been developed over time devised to assist some decision making processes in railway systems. Some of those simulators are low-detailed ones or even intended for entertainment, such as Caprino (2003). Some other simulators help manage power supply in railway systems, such as the works by Busco et al. (2003), Mellitt and Goodman (1978), Kawashima (1992), Stephan (2008). There are discrete-event simulation based simulators which are more similar to that presented in this paper. Some of them focus on the signaling system and how to control the system: Astengo (1998), Hill and Yates (1995), Gomez-Rey (2008), Maixner et al. (2004).

Other discrete event simulators are intended to manage the systems in terms of composing schedules, assessing their feasibility, etc., such as Middelkoop and Bouwman (2000), Mera (2000) Koelemeijer (2000), Hooghiemstra (1998), Galaverna (1992), Galaverna (1992) and Dorfman and Medanic (2004).

These simulators have been developed using either a low level general language, such as C++, (Mera, 2000; Galaverna, 1992; Paloucci & Pesenti, 1999), or discrete event simulation environments; this is the case for DONS-Simulator developed in Arena© (Hooghiemstra, 1998), SIMONE developed in Entreprise Dynamics© (Middelkoop & Bouwman, 2000), which were specifically created for the Dutch railway network.

Most of the simulators described in the literature have been developed modularly, which is advantageous in several ways. It yields shorter development times, it allows separating design and implementation process, and it highly easies model verification (Hooghiemstra, 1998).

The previous simulators have three main objectives. First, assessing the robustness of schedules obtained by some other means (Gronberg, 2002; Hooghiemstra, 1998; Koelemeijer, 2000; Middelkoop & Bouwman, 2000). Second, generating schedules (Dorfman & Medanic, 2004). And third, assisting the decision making process for shunting operations (Miao, 2000).

The level of detail of all these simulators is lower than the one presented in this paper, but for the case of Miao (2000).

The main weakness of all simulators found in the literature is that although they represent trains movements (tracks, signaling, etc.) they do not include passenger behavior and therefore, any detailed study on how operating policies influence passengers satisfaction cannot be properly assessed.

To the best knowledge of the authors, previous works only modeled how trains operate, in terms of speed, movements, traffic lights rules, etc. and were mainly used to check whether schedules could be feasible. In this paper we present a simulation model for studying the entire system, which includes modeling trains and passenger behavior. Representing passengers’ arrival and transportation combined with capacitated trains is a contribution which allows for a broader analysis of railway systems.

As to other approaches for addressing problems of this type, only simulators have been found in the literature. Because the high level of detail which