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Assessing the usage and level-of-service of pedestrian facilities in train stations: A Swiss case study

Flurin S. Hänseler *, Michel Bierlaire, Riccardo Scarinci

Transport and Mobility Laboratory, School of Architecture, Civil and Environmental Engineering, École Polytechnique Fédérale de Lausanne, Switzerland

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ABSTRACT

A framework for assessing the usage and level-of-service of rail access facilities is presented. It consists of two parts. A dynamic demand estimator allows to obtain time-dependent pedestrian origin–destination demand within walking facilities. Using that demand, a traffic assignment model describes the propagation of pedestrians through the station, providing an estimate of prevalent traffic conditions in terms of flow, walking times, speed and density. The corresponding level-of-service of the facilities can be directly obtained. The framework is discussed at the example of Lausanne railway station. For this train station, a rich set of data sources including travel surveys, pedestrian counts and trajectories has been collected in collaboration with the Swiss Federal Railways. Results show a good performance of the framework. To underline its practical applicability, a six-step planning guideline is presented that can be used to design and optimize rail access facilities for new or existing train stations. In the long term, the framework may also be used for crowd management, involving real-time monitoring and control of pedestrian flows.

1. Introduction

Passenger railway systems around the world are undergoing a significant growth. In the last decade, the number of transported passengers in Europe and North America has increased by about 3% annually (Puentes et al., 2013; Kasparick, 2010; Amacker, 2012), while in Asia even two-digit growth rates have been observed (Chung, 2012; LTA Singapore, 2012). Partially in response to that growth, and partially inducing it, the frequency and capacity of trains have been continuously expanded (Kallas, 2014).

In the context of that expansion, rail access facilities have largely been neglected (Schneider, 2012). Rail access facilities include pedestrian walkways, waiting areas or platforms, and in the broader sense all pedestrian infrastructures within a train station. Today, these facilities are gaining attention as pedestrian congestion is becoming a common phenomenon (Ganansia et al., 2014; Hermant, 2012), waiting space on platforms and in station halls is getting scarce (Hoogendoorn and Daamen, 2004), expectations in terms of comfort and shopping opportunities are growing (Nio, 2012), or safety regulations are violated (Buchmüller and Weidmann, 2008).

To optimize the design and operation of rail access facilities, there is a general need to better understand the usage of railway stations by pedestrians (Parkinson and Fisher, 1996). Such knowledge is essential for the adequate dimensioning of infrastructures, such as the width of an underground walkway or the area of a platform. It is also beneficial for an efficient operation of a train station. For instance, should trains with a particularly large ridership be served only by certain platforms, and should the simultaneous arrival of large trains be avoided? How long should transfer times be to allow for sufficient time

* Corresponding author.

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to reach a connecting train? Which are the optimal walking routes during normal operation and in case of extreme events? Where should sales and service points be located to attract a maximum of walk-in customers?

A way of addressing such questions is by developing a quantitative, spatio-temporal understanding of pedestrian flows. This information can then be used to tackle the mentioned problems, which are often subject to financial, operational, political and legal constraints.

In this article, we present a modeling framework that provides an estimate of pedestrian origin–destination (OD) demand and is able to assess the level-of-service (LOS) of an infrastructure. Fig. 1 provides a graphical representation of that framework, considering various data sources, a demand estimator and a traffic assignment model. These elements are discussed one by one in the subsequent sections. In the last section, they are set in a general context, enriched by practical guidelines.

Throughout this article, reference is made to the railway station of Lausanne, which we have studied together with the Swiss Federal Railways (SBB) between 2011 and 2015. Lausanne railway station is the largest node in the railway network of Western Switzerland, serving 650 arriving and departing trains on weekdays (Amacker, 2012). The station has reached capacity in the year 2010, and a doubling of passenger demand is expected by 2030. About EUR 450,000 have been invested in a pedestrian tracking system to monitor pedestrian movements on central walkways, to which this study has access. In total, EUR 1.1 billion is spent between 2010 and 2020 to enlarge the station, preparing it for future growth.

At the example of that case study, we investigate whether the proposed framework can provide an accurate understanding of the usage and level-of-service of pedestrian facilities. We thereby concentrate on walking areas, as for platforms already reliable dimensioning guidelines exist (Buchmüller and Weidmann, 2008). The analysis concentrates on the understanding of the status quo for two reasons. First, a validation can be made based on real data. Second, the predictions of demand and LOS we have made in collaboration with SBB are confidential.

2. Literature review

The following review analyzes the literature on pedestrian flows in train stations in terms of three research dimensions that are relevant for this article: Data, models and applications. For an extensive literature review, the interested reader is referred to Daamen (2004) or Hänseler (2016) instead.

2.1. Data

Various forms of data have been collected in rail access facilities. These range from density and speed measurements for the estimation of density-speed relationships (Daly et al., 1991), to recordings of train arrival and departure times for the

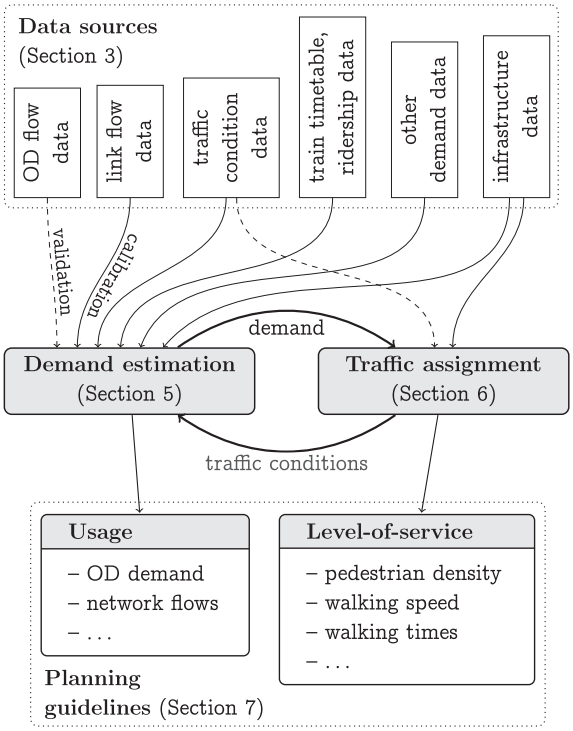

Fig. 1. Framework for estimating the usage and level-of-service of rail access facilities.