Journal of Rail Transport Planning & Management 6 (2017) 313–330

Contents lists available at ScienceDirect

Journal of Rail Transport Planning & Management

journal homepage: www.elsevier.com/locate/jrtpm

Review of planning and capacity analysis for stations with multiple platforms – Case Stuttgart 21

Ingo A. Hansen [a, b, c, *]

[a] Delft University of Technology, Stevinweg 1, 2611EH, Delft, The Netherlands
[b] Beijing Jiaotong University, Beijing, PR China
[c] Southwest Jiaotong University, Chengdu, PR China

ARTICLE INFO

Article history:
Received 24 August 2016
Accepted 20 December 2016
Available online 17 January 2017

Keywords:
Timetabling
Capacity analysis
Station
Queuing
Simulation
Operations quality

ABSTRACT

The master plan, design and capacity analysis of the future network timetable and track infrastructure of the project known as Stuttgart 21 (Germany) is reviewed with focus on the methods and results for capacity estimation of the planned through station close to the city center. The methods used and results reported for the capacity analysis of the network timetable and in particular the main through station since the first feasibility studies in 1994, complementing timetabling and operations research analysis in 1997 until the robustness analysis in the scope of the stress test simulations are described in detail in order to identify and discuss the critical issues. The shortcomings of the original approach consisting of a periodic network timetable design, queuing models for the estimation of the waiting probability and queue length for the purpose of timetabling and estimation of the operations quality respectively, as well as multiple stochastic simulations are explained and the consistency of the recent stress test simulations are examined.

Contents

* Delft University of Technology, Stevinweg 1, 2611EH, Delft, The. Netherlands.
E-mail address: i.a.hansen@tudelft.nl.

http://dx.doi.org/10.1016/j.jrtpm.2016.12.002
2210-9706/

1. Introduction

Historically, the main railway routes in big European cities (e.g. London, Paris) were mostly aligned radially and the terminal stations located in the periphery of the city center. The transfer of passengers between the different terminal tracks, stations and lines of major central stations required rather long and inconvenient walking distances between different platforms and local public transport access, egress or transfer modes in case the terminal stations were situated at different edges of the city center, like still today e.g. in Paris (Gare du Nord, Gare de l'Est, Gare de Lyon) and London (King's Cross/St. Pancras, Euston, Paddington, Victoria, Waterloo).

The existing terminal stations in a lot of big cities consist mostly of a large number of stub-end tracks, many platforms, a large-scale central hall for ticket sale, passenger processing, waiting and commercial shops, a large station square with many car parks, taxi stands, bus and tramway stops or broad stairways to/from underground metro stations apart from multi-lane access/egress roads and wide sidewalks. The terminal stations near to the city center attract/distribute generally the highest number of passengers, visitors and traffic volume in cities and become easily congested in particular at big events, season peaks and traffic disruptions. Nearby railway yards and train depots occupy a lot of scarce urban development space and generate a lot of locomotive, railcar or train-set shunting to/from arrival and departure tracks, which may cross main line tracks and reduce their capacity.

The very high level of transport demand and supply, economic and social importance of big railway stations is permanently seeking for capacity extension, which is very difficult and costly due the scarcity and extremely high value of urban space in high-density built-up city centers. The growth of population, jobs, students and visitors and of local, regional, national and international railway transport in big cities implies a continuous high pressure on the existing capacity of the railway infrastructure that stimulates the planning and development of new infrastructure and use of more efficient rolling stock, train operation and intelligent traffic management.

The further increase of fast national and interregional railway traffic led in some cities to planning and construction of new transversal or circumferential railway routes between formerly independent lines or to a replacement of former terminal stations with stub-end tracks through new stations and platforms with through tracks. Examples for the comprehensive redesign, relocation and new construction of former terminal main stations including new underground city link in Germany are Berlin, Leipzig and the planning of Stuttgart 21. The latter project for construction of a completely new through station in Stuttgart including high-speed links to the airport Stuttgart and the city of Ulm was presented to the public 1994 and approved by the government 2005 (Fig. 1). However, the project was opposed by many inhabitants and finally accepted through plebiscite 2011.

The paper is organized as follows. In the next section the main objectives of the project known as Stuttgart 21 in Germany and the issues concerning the estimation of the future railway transport volume and the design of the line network and planned new through station for long-distance high-speed trains and regional train services are highlighted. The main features of the planned line network, train services, expected additional passenger volume are described in the third section. The fourth section contains a review of the analytical and simulation methods applied and of the main results for the capacity estimation of the new high-speed route section Stuttgart - Ulm focused on the quality of train operations of the through station in Stuttgart. In the fifth section the critical issues for the estimation of the timetable, station capacity, number of platform tracks and quality of operations are discussed. Finally, conclusions about the methods applied for the design and capacity estimation of railway stations with multiple tracks are drawn and recommendations given for future research.

2. Objectives and issues

The main goal of the project Stuttgart 21 consists of the integrated (re-)novation, relocation and new construction of the railway node Stuttgart including a high-speed route to/from Ulm and a direct link to the airport Stuttgart in order to increase the number of scheduled long-distance trains/day by 75% and the number of short distance trains/day by 56% according to the operations scenario 2015 and to reduce the trip time, where possible (Eisenbahn-Bundesamt, 2005 p. 48 and 154). Furthermore, 80 ha of current railway area in the city center would be cleared for urban redevelopment (Heimerl, 1994). The existing stub-end terminal station with 16 platform tracks would be replaced by a new through station with 8 tracks and 4 platforms, while the existing depot tracks would need to be relocated to a suburban shunting yard (Fig. 2). The new through station would be called by all high-speed and regional railway lines, except the metropolitan rapid transit, called S-Bahn, lines, which will continue to operate underground the existing main station. The new to build high-speed route Stuttgart – Ulm would be connected to the new through station including a fast direct link to the airport rail station, which so far is linked only by the S-Bahn network from the western side. The dedicated S-Bahn network in Stuttgart is not shown in Fig. 2.

The project Stuttgart 21 is characterized by a number of political, environmental and technical issues:

- High-speed railway network development and environmental protection in densely-built-up metropolitan areas.
- Urban redevelopment of railway areas situated near the city center.
- Accessibility of railway stations and interconnection between high-speed, regional and urban transit lines.
- Performance of a stub-end railway station in comparison with a through station.
- Safety of large underground railway stations.