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Hansen, Ingo A.

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DISCUSSION

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Ingo A. Hansen

Department Transport & Planning, Delft University of Technology, Delft, The Netherlands

Correspondence
Ingo A. Hansen, Stevinweg 1, 2628 CN Delft, The Netherlands.
Email: i.a.hansen@tudelft.nl

1 | INTRODUCTION

The proposed approach aims at simultaneously optimizing 3-D alignments and station locations for a dedicated high-speed railway link between two selected terminal stations. The optimized design of the 3-D alignment for the high-speed link builds on the recent work of the same authors on mountain railway alignment optimization (Pu et al., 2019). The problem of optimizing station locations along a railway route is new and inherently connected with the problem of railway network design and line planning. The latter problem of railway network design and line planning, however, has been neglected in the above approach and generates suboptimal solutions of the alignment design, as well as of the station locations for a (high-speed) railway route.

2 | OPTIMIZATION OF 3-D ALIGNMENTS FOR (HIGH-SPEED) RAILWAYS

3-D railway alignment designs can be optimized successfully even for complicated mountain route sections as demonstrated in Pu et al. (2019) for a given design speed. The choice of the design speed for a planned new railway link depends on many factors such as topography, settlement, transport demand and supply, construction and railway technology, railway design standards, costs, and government policy. The design speed of high-speed railway routes has grown historically in stages from 250 km/h at first via 300 km/h in the second up to 350 km/h finally.

The choice of a design speed of 350 km/h for the considered high-speed route in the province of Shandong, China, is treated by the authors without any further motivation as input given by the current railway policy and design standards in China. This route section crosses a steep mountain area on around 50% of its length and requires many expensive bridges and tunnels. The authors miss to search for a more efficient alignment design solution based on a lower design speed, for example, 250 km/h, whose estimated overall costs and net present value of the investigated high-speed route would certainly be significantly lower than the alignment solution found for the design speed of 350 km/h!

3 | OPTIMIZATION OF STATION LOCATIONS FOR DEDICATED (HIGH-SPEED) RAILWAYS

The design of station locations along a (high-speed) railway route depends on the functional design including (i) rank and position in the railway network and line,

(ii) passenger transport volume and capacity, (iii) kind, frequency, and speed of line services, (iv) length of trains, (v) number, length, width of platforms, (vi) track layout, design speed, and gradient (Hansen, 2021).

The track alignment is only one design variable of stations, while its connectivity in the overall railway line network, attractiveness for passengers from/to other stations, rural and urban accessibility determine its transport performance, operating costs, and revenues.

The problem is clearly a multi-objective one for which a Pareto front of best solutions can be expected. However, the described search method simply adds up the benefits and costs of solutions for alignment and station locations based on given unit costs input (Table 2) determined by the authors according to the official code by the Ministry of Housing and Urban-Rural Construction 2012 and a feasibility study report 2019 by the China Railway Eryuan Engineering Group for a different railway project without analyzing the impact of different values and weights for several items.

The optimization of railway station locations is closely related to the interstation distance between the stations along the railway line, which depends strongly on the desired operating speed of the trains and (mix of) lines serving the stations. The approach by Song et al. (2022) in this journal completely neglects the role of the planned railway route in the regional (high-speed) railway network and does not analyze the impact of different line services (express, all-stop) on the performance of the terminal and intermediate stations and on train operations by simply assuming that only one type of train serves all stations on the railway route and disregarding access, egress, and waiting times of the passengers at stations when computing the travel times and passenger flows.

The proposed optimization model for this dedicated high-speed link only considers two (seemingly isolated) terminal stations and does not clarify whether these are connected to other existing railway lines or are to be extended in the future. Furthermore, line planning within the broader regional (high-speed) railway network has been constrained to simple train operation by only one type of high-speed train between two given terminal stations serving one, two, or three intermediate stations along the selected railway route at the given design speed of 350 km/h. The most important design variables for transport demand (ridership) and railway transport supply (track capacity and train operation) in this corridor as a function of different railway design speed levels would need to be analyzed at first to find the most effective and efficient solution for the number and location of intermediate stations.

The impact of the chosen design speed of 350 km/h for the considered short railway route (only 90-km long) and of rather short distances between the high-speed stations on the reachable train speed and energy demand has been completely neglected by the authors. The presented model for optimized station locations has serious deficiencies with respect to the decision variables and constraints of the objective function and fails to deliver an optimized sustainable distribution of high-speed station locations. The *ex-ante*–determined design speed for such a short railway route and operation by a single type of high-speed trains stopping at all stations based on a given railway design standard in China definitively leads to suboptimal train speed profiles with quite short distances cruising at design speed or some interstation distances, where the high-speed trains cannot even reach the given design speed of 350 km/h and waste extra traction energy!

During the last two decades, the planning paradigm for railway links and lines has shifted from “first construction, then operation” to timetable-based planning and design that requires consideration and analysis of much more operation variables such as an operational program for the network, train line services, and stations. See official BAHN (2000) Development Plan for the Swiss railway network and the integration of the high-speed railway line Zurich–Berne into the existing national railway network in Switzerland on the one hand and connections to High-Speed Railway (HSR) lines in neighboring countries like Germany, France, and Italy (Montanaro, 2018), as well as Network Rail’s shift from engineering toward putting passengers first in the United

Kingdom (Turner, 2020). The approach for Integrated Railway Rapid Transit Network Design and Line Planning Problem by Canca et al. (2019) should also be considered for the planning and design of new high-speed railway lines.

4 | CONCLUSION

The optimization of railway design speed, alignment, station spacing, stop patterns, passenger travel times, cost, and revenues is much more complex than proposed in this paper. The proposed simultaneous optimization model of high-speed railway alignments and station locations is not satisfactory due to

1. A design of the railway route alignment that is predetermined by the prevailing high-speed railway planning design standard of the Chinese government. Instead, developing an innovative optimization model is necessary that can estimate the impact of different levels of (high-speed) railway design speed on the net present value of planned new railway routes.

2. The lack of a comprehensive analysis of the regional high-speed railway network including a thorough evaluation of the impact of sustainable line planning options on railway transport demand and supply that are essential input for a consistent optimization of track alignment design and choice of (intermediate) station locations on (high-speed) railway routes.

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