

Line planning in Potsdam

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A reorganization of the line plan in Potsdam became necessary when the public transport company of Potsdam, ViP Verkehrsbetriebe Potsdam GmbH, took over six additional bus lines that were formerly operated by Havelbus Verkehrsgesellschaft mbH. The new line plan should minimize the travel time at a same cost level, and ViP emphasized the importance of a minimal number of transfers.

Line planning can be interpreted as a mathematical optimization problem by considering the public transport network as a graph and all possible lines as paths in this graph. The task is then to find a subset of lines with frequencies of operation such that a given travel demand can be routed. There are usually a set of practical requirements that has to be considered as well, e. g., a minimum cycle time for certain transportation modes or a minimum frequency requirements for each station. The main objectives are the minimization of operating costs and the minimization of travel and transfer times. Both aims are usually in conflict with each other which can be handled by a weighing parameter. Great challenges in line optimization are the integration of line planning and passenger routing and the treatment of transfers. Existing models in the literature that in-

tegrate a passenger routing in line planning either treat transfers in a rudimentary way and, hence, neglect an important aspect for the choice of the passenger routes, or they treat transfers in a too comprehensive way and cannot be solved for large scale real world problems. We developed a novel direct connection approach that allows an integrated optimization of line planning and passenger routing including accurate estimates of the number of direct travelers. The attractiveness of transfer free connections is increased by introducing a transfer penalty for each non-direct connection. In this way, a passenger routing is computed that favors direct connections. Further details can be found in [2].

Our mathematically optimized solution for the Potsdam line plan 2010 minimizes the total number of transfers by around 5 % in comparison to a "hand made" plan on the basis of experience, compare with Table 1, see also [1]. It further reduces the cost by around 4 % and the perceived travel time by around 6 %. The bottom of Figure 1 shows that the optimized solution yields more districts with a higher number of direct travelers than the "hand made" plan. ViP finally established a slightly modified version of our optimized solution, see top of Figure 1.

Table 1. *Statistics (generated with Visum) for the optimized line plan and the "hand-made" plan*

	Optimized solution	ViP-solution
average total travel time	36min 3s	36min 39s
average time in vehicle	13min 8s	14min 36s
average transfer waiting time	1min 30s	1min 29s
average start waiting time	13min 23s	12min 32s
average walking time	1min 38s	1min 37s
average perceived travel time	26min	27min 37s
total number of transfers	10595	11141
passengers with 0 transfer	37338	36851
passengers with 1 transfer	10088	10503
passengers with 2 transfers	243	306
passengers with more than 2 transfers	7	9

Further reading

- [1] R. Borndörfer, I. Friedow, and M. Karbstein. Optimierung des Linienplans 2010 in Potsdam. *Der Nahverkehr*, 30(4):34–39, 2012.
- [2] R. Borndörfer and M. Karbstein. A direct connection approach to integrated line planning and passenger routing. In D. Delling and L. Liberti, ed-

itors, *ATMOS 2012 – 12th Workshop on Algorithmic Approaches for Transportation Modeling, Optimization, and Systems*, OpenAccess Series in Informatics (OASIS), pages 47–57, Dagstuhl, Germany, 2012. Schloss Dagstuhl–Leibniz-Zentrum für Informatik. URL: <http://drops.dagstuhl.de/opus/volltexte/2012/3702>.

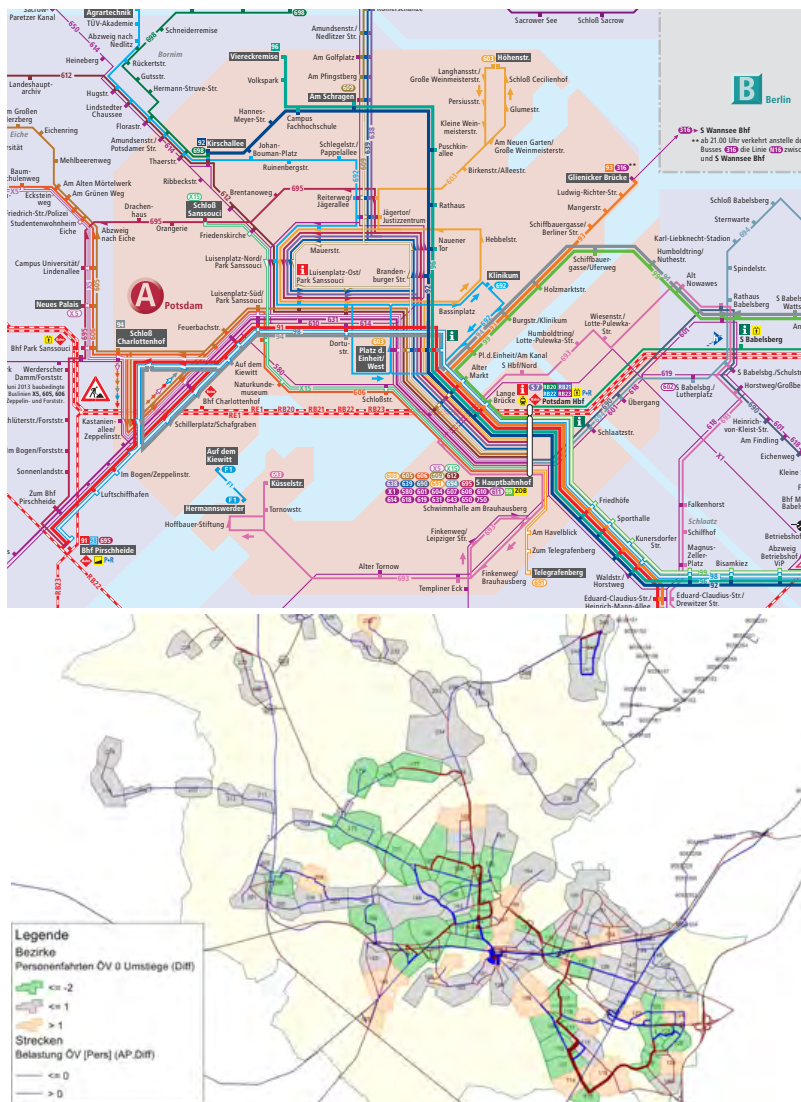


Figure 1. Top: Line plan of the inner city of Potsdam. Bottom: Potsdam and its districts. A green (red) district symbolizes more direct travelers in the optimized line plan (“hand made” plan).