Multi-Objective Stop Location Optimization Model for Minimizing Social, User, and Operator Costs in Urban Tram Systems

Transportation Research Board
103rd Annual Meeting, January 7-11, 2024
Paper nr. TRBAM-24-00238

T. de Ridder[1], J, van der Stok[2], H. Farah[1], N. van Oort[1], B. van Arem[1]
[1] Transport and Planning, TU Delft, NL [2] HTM Personenvervoer, NL

First author:

Tim de Ridder
t.ridderde@gmail.com

INTRODUCTION AND OBJECTIVE

- **Relocation of stops** can enhance the **quality of a transit system**.
- Determining optimal stop locations involves striking a balance between two competing goals of **accessibility and efficiency**.
- **Generalizability of results** from previous research is **limited** as often assumptions are made, mainly regarding transit demand.
- The objective is therefore to develop a **multi-objective optimization** model to make the trade-offs between factors influencing stop locations explicit and **enabling precise determination of optimal stop locations** across a transit system.

METHODS AND DATA

- Various cost components of all possible stop configurations in a network are determined in **preprocessing steps** and, with the use of a **solving algorithm**, the optimal network for the chosen objective can be obtained.
- The model is run in **iterations**, as shown in Figure 1, to incorporate the effects of shorter journey times on overall transit demand.
- Detailed **socio-economic data** of zones are used, alongside **Smartcard data**, to estimate **transit demand** precisely.
- **Automatic Vehicle Location data** are used to estimate the effects of stop relocation on **operations**.

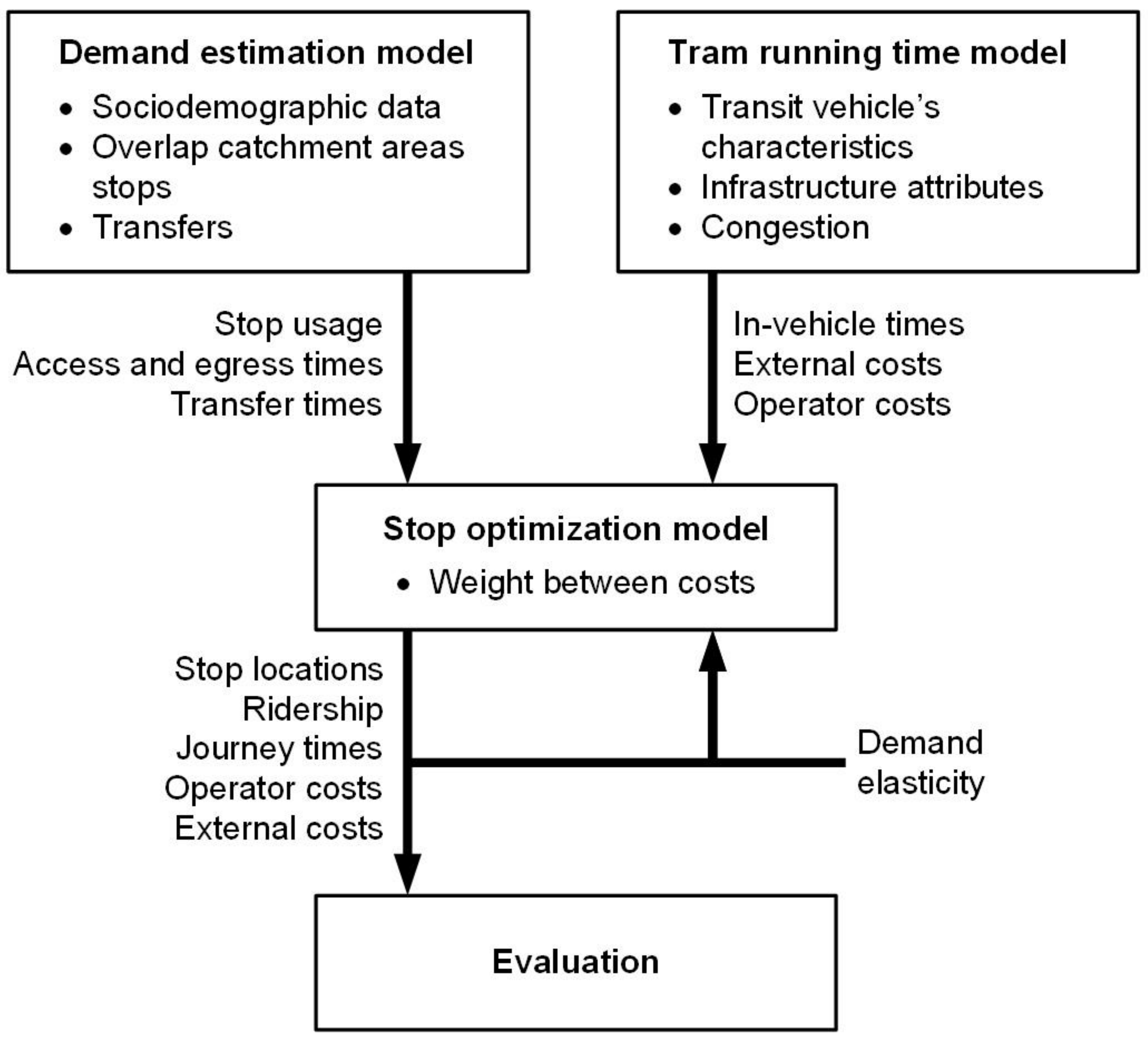

Figure 1: Outline of the models used for determining optimal stop locations.

SCENARIOS

Three objectives are evaluated with the use of our optimization model:

- Minimization of **social costs** (optimal for society)
- Minimization of **user costs** (optimal for the user)
- Minimization of **operator costs** (optimal for the operator)

The social costs are the sum of the user costs, operator costs and external costs. The used objective function for this objective is:

$$Obj(\min) = C_{U_{current}} * \left(\frac{C_U}{C_{U_{current}}} - \frac{B}{B_{current}} - \frac{KM}{KM_{current}}\right) + C_O + C_E$$

RESULTS CASE STUDY THE HAGUE

- In areas where **trip distances** are short and near the end of a tram line, **stop spacing** should be denser compared to other parts of the system.
- The potential **speed** on a line section does **not affect** the optimal **stop spacing** significantly, due to long dwell times in the system.

Objective	Optimal for society	Optimal for the user	Optimal for the operator
Number of stops	-16.5%	-5.7%	-16.5%
Ridership	+0.8%	+3.5%	+1.2%
Operator costs	-8.6%	-3.2%	-8.8%
Emission costs	-13.7%	-5.9%	-14.4%

Table 1: Results case study The Hague.

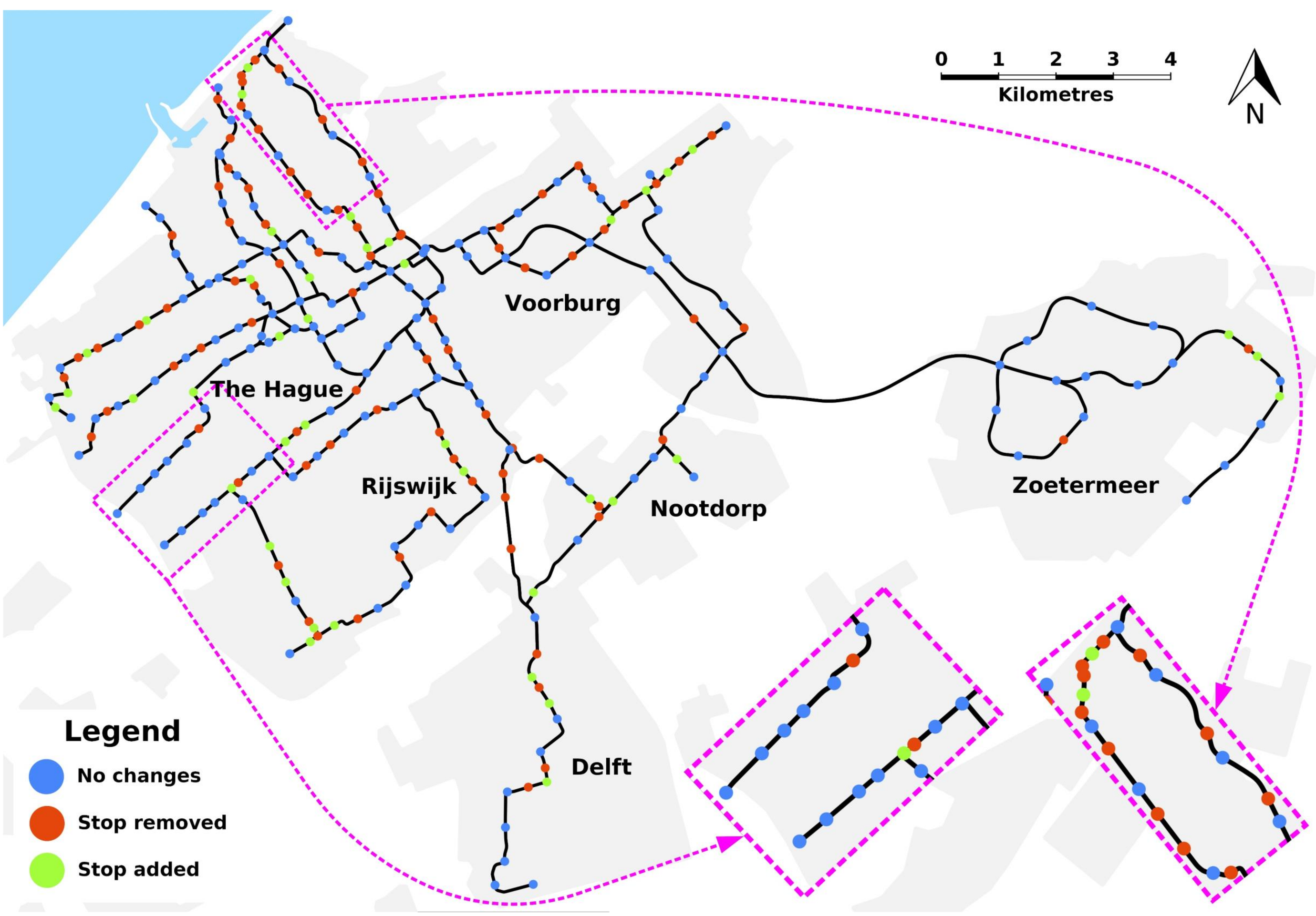

Figure 2: Stop locations when the social costs are minimized.

CONCLUSIONS

- Depending on the objective and the line segment, stops should be added, relocated or removed. The **ratio between local and through passengers** is most important for optimal stop spacing.
- The **efficiency** of a transit network can be **improved** significantly by relocating transit stops.
- **Fewer stops do not** necessarily **result in fewer passengers**. Mainly on sections with a lot of through passengers, should stops be spaced further apart. Yet, on a few occasions do additional stops lead to higher ridership.

Smart Public Transport

HTM