# Quantification of spillback delays
## and the influence of spillback on robustness

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## Abstract

Road users prefer reliable travel times. Travel times increase if an accident happens. This study investigates the influence of incidents on the network performance. At each link of the network an incident is simulated sequentially. Blocking of links leading traffic away from the motorway and blocking of motorways itself cause the biggest drop of network performance. Especially spillback effects are studied.
A special traffic simulator is developed in which spillback can be switched on and off. The result is that spillback must be included to get the most vulnerable link of a network. The error in estimating the performance drop made using a non-spillback simulator is the largest for incidents at motorway intersections or at links leading traffic away from the motorway. Because traffic can pass congestion if spillback is not modeled, non-spillback simulator overestimates robustness. It is for the same reason that it also overestimates the advantage of route advice.

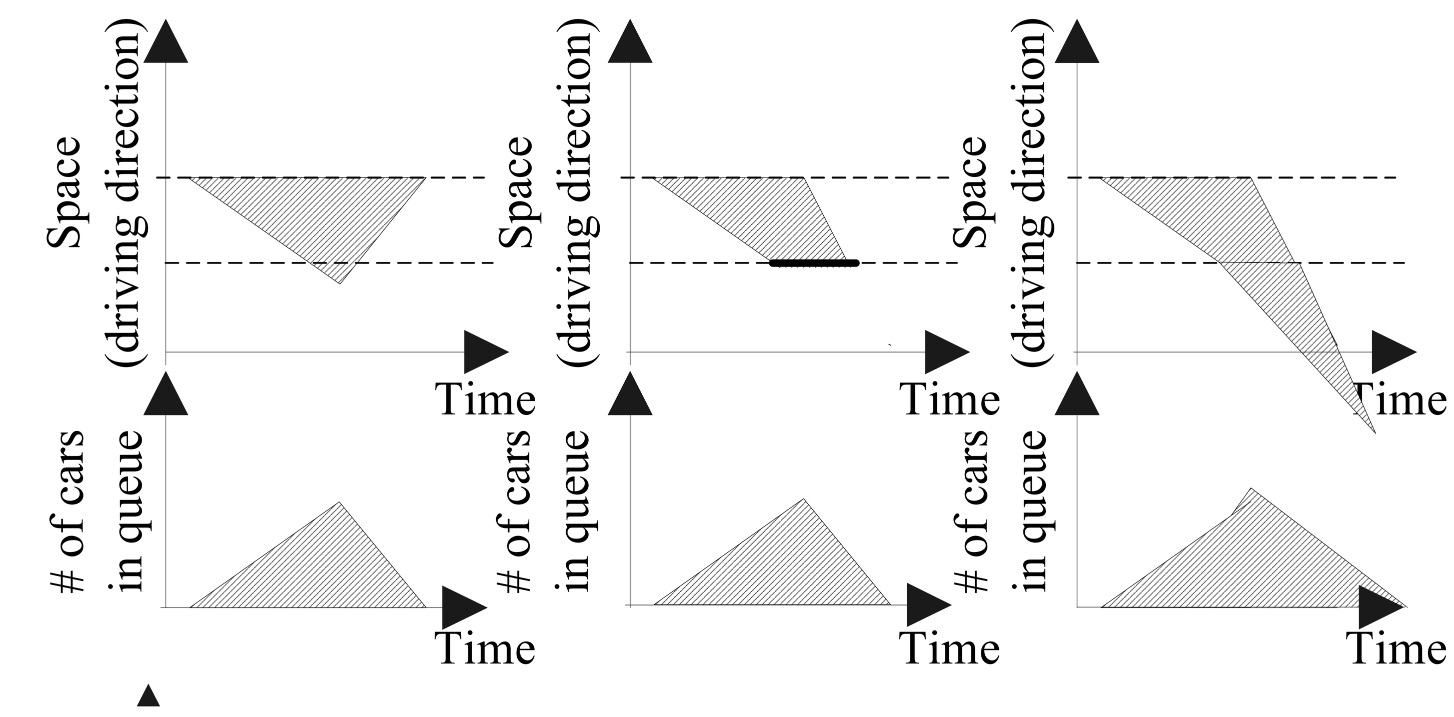


A map of the network at which the case study was carried out the Dutch city of Rotterdam, ca. 600,000 inhabitants.

## Modeling of spillback

In different macroscopic traffic models, queuing is implemented in different ways. The following three methods should be distinguished:

- Vertical queuing model
- Horizontal queuing model without spillback
- Full spillback model




Congestion patterns in a space-time (upper level) plot and the number of cars vs. time according to different models.

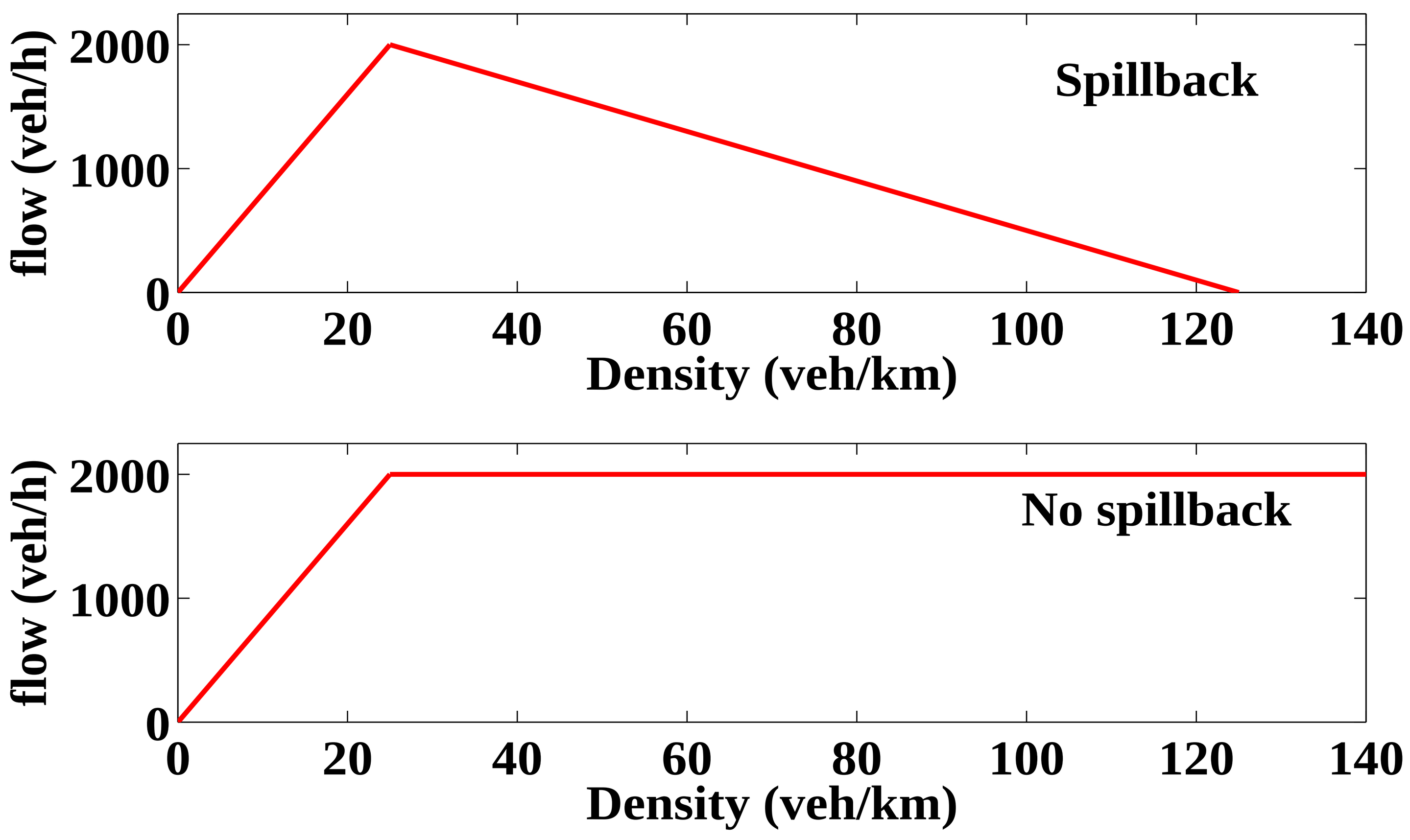
## First order model + Godunov

The flow from cell i to cell i+1 is the minimum of their demand and supply respectively:

$$\text{demand}(k) = \min\left\{\left(C / k_C\right)k, C\right\}$$

$$\text{supply}(k) = \min\left\{\left(C / \left(k_C - k_j\right)\right)\left(k - k_j\right), C\right\}$$

If spillback is not simulated, the supply of the most upstream cell of a link must be independent of the density, so the capacity C. The resulting flow-density lines are plotted aside.




The flow-density plots for a simulation model with (upper one) or without (lower one) congestion modeled.

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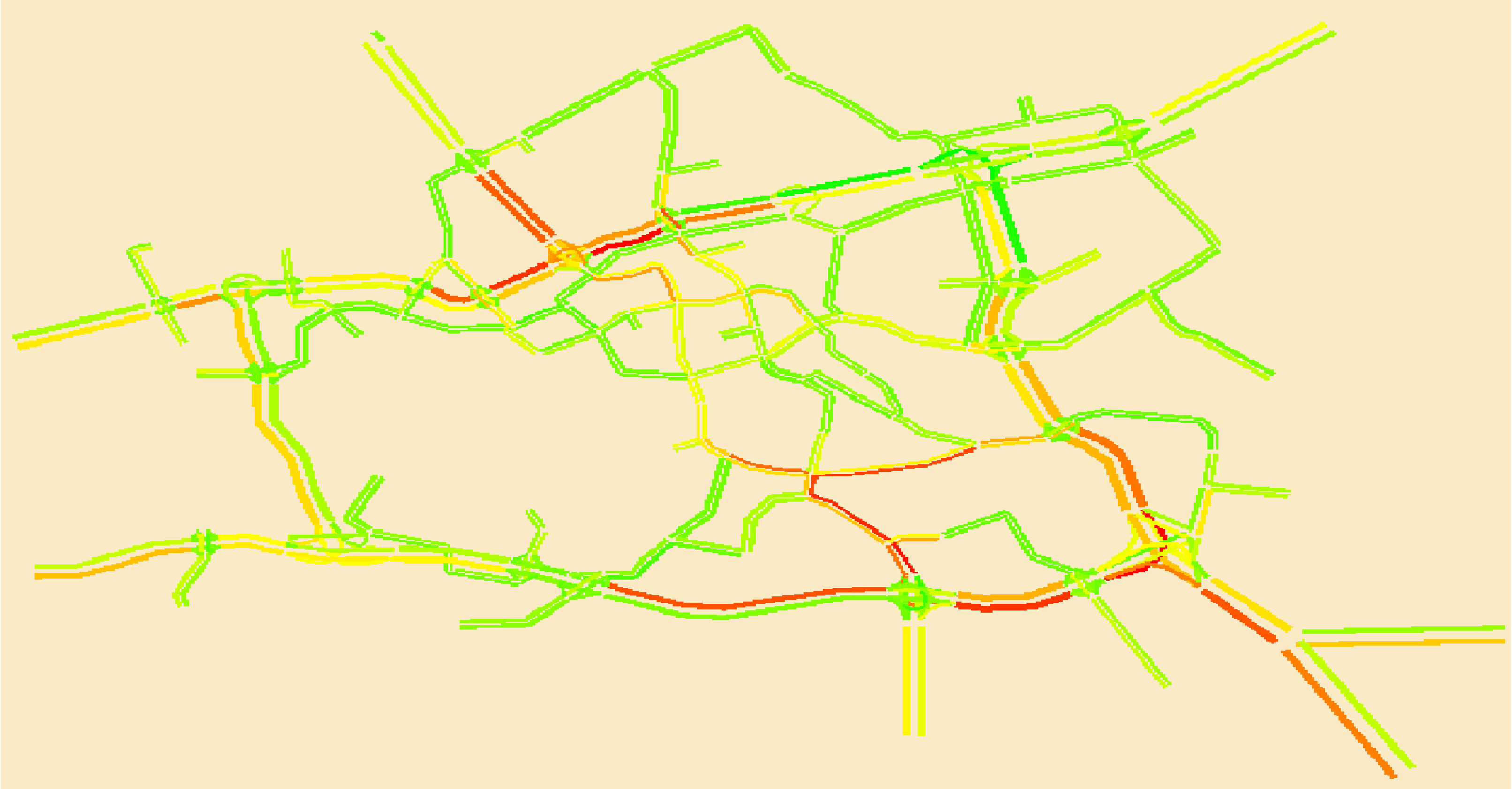


**The impact of the location of a link blocking on the network performance. A blocking of a red colored link gives the biggest reduction of the network performance.**

# Critical links

Important links for the network performance are:

- motorway links;
- links leading traffic away from the motorway.

The additional delay caused by spillback is largest if one of the following links is blocked:

- links leading traffic away from the motorway;
- motorway intersections.

For these links, the number of extra vehicles that get delayed is the highest.

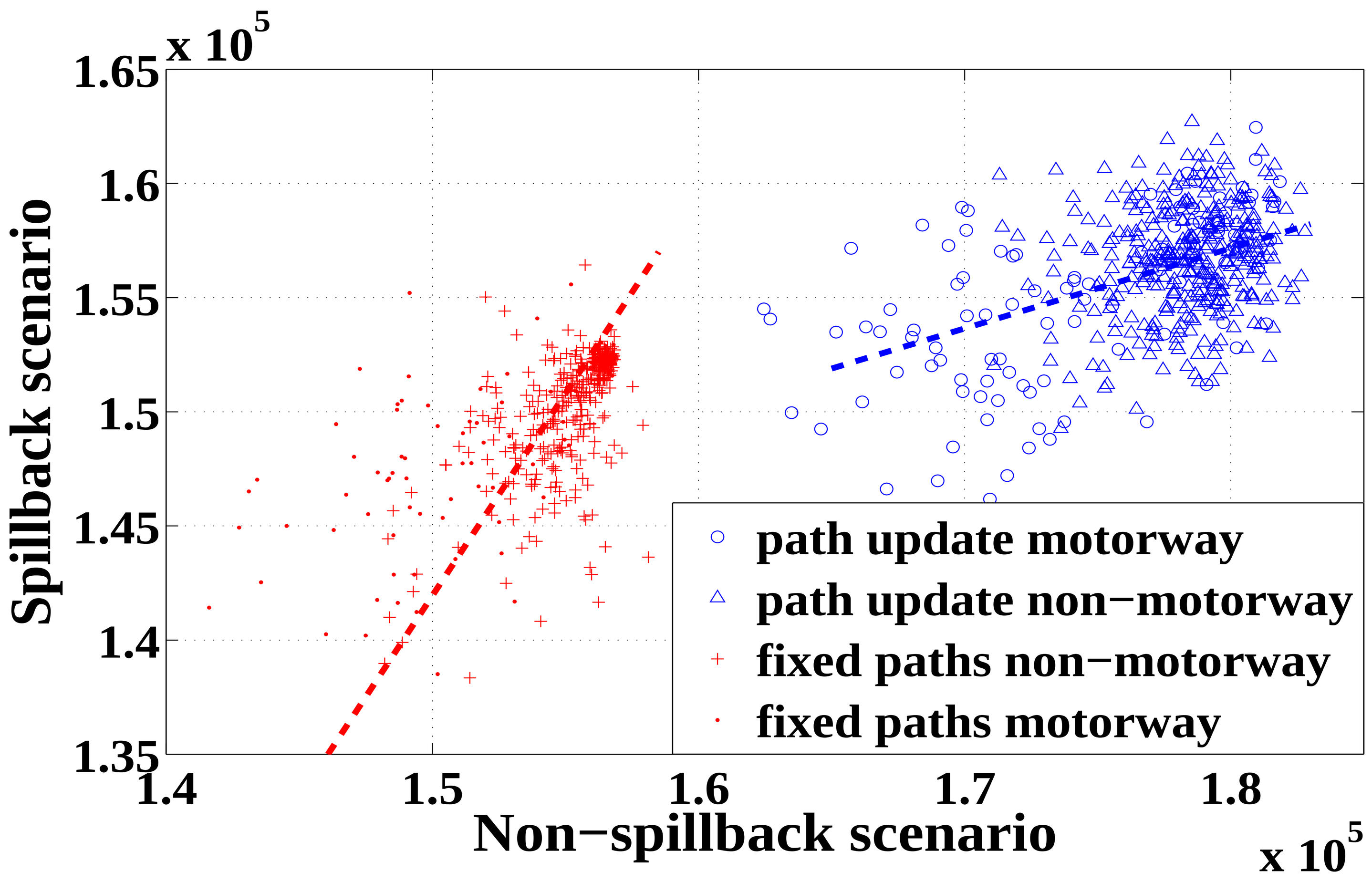
# Influence of spillback

Per blocked link, two simulation performances are calculated: one with spillback and one without. The correlation coefficients show that only 20% (rerouting) and 39% (no rerouting) of the variation of performance drop caused by an incident can be explained by a model without spillback. The advantage of giving route advice will be estimated higher if no spillback is simulated: it is easier to find an alternative route without congestion.

# Robustness

We assume that 4% network performance reduction due to an incident is accepted. The location of the incident determines the performance drop. All locations are simulated (table below). With spillback more locations are unacceptable, so the network is less robust: more traffic faces congestion.

| Large performance drop | Spillback | No spillback |
|---|---|---|
| No route advice | 41 % | 13 % |
| Route advice | 42 % | 20 % |




**Comparison of network performances with a link blocked with and without spillback (both axes). Note the low correlation.**

# Conclusions & future work

We conclude that simulation without spillback:

- overestimates the network robustness;
- overestimates the impact of rerouting;
- can not identify vulnerable links.

Future work include studies to determine the:

- DTM measures that can improve robustness;
- effects of spillback in cities;
- effects of multiple incidents at the same time.

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