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A local non-restrictive Ramp Metering strategy based on stochasticity of capacity

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Abstract
A local non-restrictive ramp metering strategy PRO is introduced. It is based on the stochasticity of capacity. The ramp metering algorithm shows innovative features:

- upstream time shifted measurements for anticipation
- measurements are actuated every second
- up to three vehicles per green are allowed

Details of the theory of this strategy are described in the first part. At freeway B27 three ramp meters with the PRO algorithm were installed. In the second part, based on extensive detailed traffic and accident data the effects on traffic flow and safety are described. The impact is positive regarding vehicle speed, queue duration and length as well as capacity and traffic safety. The improvements of speeds, travel times and capacities are statistically significant. The ramp metering systems are highly cost effective.

Keywords: freeway operation, traffic control, ramp metering, stochastic capacity

1 Introduction

Freeway B27 passes through the center of Stuttgart and is an important commuter route from north and south to the state capital. The B27 south of Stuttgart is grade separated with two lanes per direction up to interstate A8. The AAWT is >80,000 veh/24h. In 1995 a corridor traffic management system (CTMS) was installed over a distance of 18 km to improve safety and harmonize traffic flow.

Three freeway junctions upstream of the airport junction are the starting point of disturbances caused by high entering volumes. Congestion caused by these bottlenecks has lengths of 8 km and lasts 2 hours.

A feasibility study by the Baden-Württemberg state authority for Road Technology (LST) suggests ramp metering as a cost-effective means to improve traffic flow. Therefore, in August 2012 three ramp metering systems in northbound direction were installed and operated in trial at junctions (Figure 1)

- Leinfelden-Echterdingen-South (Stetten),
- Filderstadt-West (Plattenhardt) and
- Filderstadt-East (Bonlanden)

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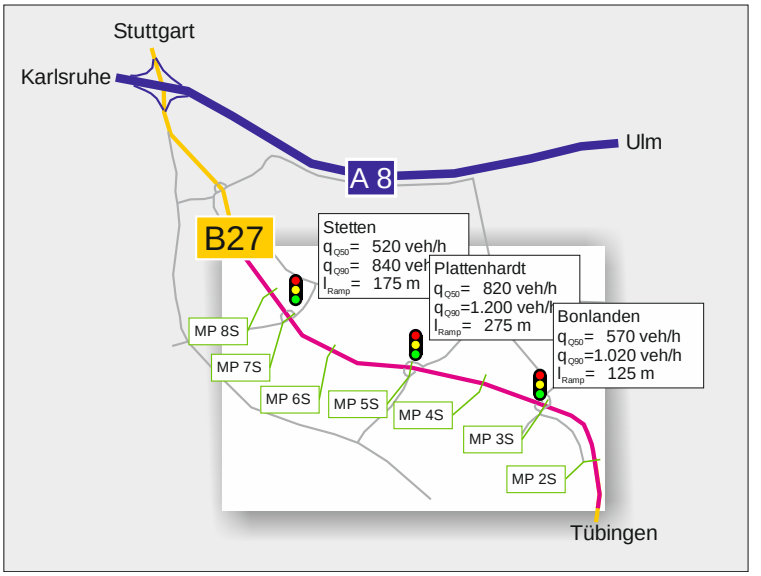

Figure 1: Study area of northbound B27 and junctions with ramp metering and measurement points „MP 2S“ to „MP 8S“

As volumes frequently reach values of ~1,000 veh/h (see Figure 1, 90th quantiles) and ramp lengths are normal or short a special focus had to be set on queue management.

These ramp metering systems (RMS) may be described innovative in various ways:

- It anticipates oncoming mainline volumes in order to harmonize merging volumes.
- The RMS are operated autonomously by the controller cabinet instead of a control by the distant traffic management center (which is German standard).
- The RMS act on basis of dynamic traffic data intervals that are actuated every second as opposed to the 60 second discrete intervals (German standard).
- Finally, these RMS are the first that provide green light for up to three vehicles per cycle. Currently (in Germany), only a few cases are operated with a maximum of two vehicles per green.

This report will first discuss the traffic engineering behind the algorithm PRO in comparison to another local strategy - ALINEA (most common in Germany). Finally, the effects of the three RMS are evaluated.

2 Theory

Ramp metering is the control of the entering traffic by a traffic signal at an on-ramp shortly before the merge area to a freeway. Ramp metering is based on the two principles

- Controlling the entering traffic volume and
- Simplifying merging maneuvers by dissolving large entering vehicle platoons in individual vehicles or small groups.

RMS may be fixed time or traffic responsive. Furthermore, local or area-wide strategies are available (Jacobson, Stribiak, & Nelson, 2006). Ramp metering basically is the control and optimization of a compromise between the traffic of the mainline and the entering traffic.