Hur kan förbättrad ramp metering minska köerna i Södra Länken?

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Motivation

Motorway congestion

• ↓ infrastructure capacity
• ↑ travel delay
• ↓ traffic safety
• ↑ environmental pollution

Control measures

• **Ramp metering** (direct impact on density → congestion)
• Link control (Variable Speed Limits, congestion warnings, etc.)
• Route guidance (VMS, etc.)
• Mainstream traffic control (mainline metering, work zones, bridges, etc.)
Ramp metering

Why ramp metering?
- Congestion covering on- and off-ramps
- Incident response
- Safer merging

Where?
- Localized bottlenecks
- Downstream bottlenecks
- Random-location bottlenecks

Metering strategies
- Local:
  - fixed-times,
  - responsive strategies (e.g. ALINEA)
- Coordinated:
  - multiple bottlenecks,
  - restricted storage space

Objective: Maximize throughput ↔ Minimize travel delays
Tunnel closures: Södra Länken

- Tunnel length: 4.7 km
- Designed to serve **60-70k veh/day**
- Demand: **90k-100k veh/day**
Previous research

- Effective control strategy depends on underlying causes of congestion
- Metering is the most promising strategy
Bottleneck analysis

Congestion patterns:

• Södra Länken - weaving bottlenecks (2014, 2017)
• Essingeleden bottlenecks and weaving bottlenecks (2014)

- MCS speeds, counts (April 2014, October 2017)
- Morning peak: 5 – 10 am
Study objectives

Identify suitable metering strategies to alleviate congestion

• Critical bottlenecks

• Critical ramps where metering is feasible and beneficial

• Adequate metering strategies, and their requirements

• Implementation and evaluation through traffic simulation
Control methods

Metering strategies:

- Fixed-time: historical traffic measurements (demand)
- Responsive strategies: real-time measurements (occupancy, density)
  - ALINEA (Papageorgiou et al., 1991)
Study network

- 77 Origin-Destination pairs
- 57 segments

Microscopic simulation - TransModeler 4.0
Results – No control

Scenario 1:

**One-car-per-green** metering at entrance 5 (Silver) (6:00 – 8:00 am):
- Cycle 4 sec, rate: 900 veh/h
- Cycle 6 sec, rate: 600 veh/h
- **Cycle 7 sec, rate: 500 veh/h**

Scenario 2:

Metering at entrance 5 (Silver) (6:00 – 8:00 am): rate 500 veh/h

Metering at entrance 1 (Sickla) (7:00 – 7:30 am): rate 900 veh/h
Results – Metering

Scenario 1: Metering entrances 5

Silver tunnel – E5
Skradder – E4
Hammarby – E2

Scenario 2: Metering entrances 5 + 1

Time-Space Contour for [Average Speed] (06:00:00 - 09:00:00)
Scenario 1: Metering entrances 5

Entrance 4 - Skräddar

Results – Metering
Results – Metering

Scenario 1: Metering entrances 5
Results – Metering

Scenario 1: Metering entrances 5

Downstream entrance 4 – mainstream

Flow (veh/h)

Time (hh:mm)

No control

Control

Speed (km/h)

Time (hh:mm)

Control

No
Results – Travel time

Travel times are for select OD pair (6 km)

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<tr>
<th>Time</th>
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<th>Control - Scenario 1</th>
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Conclusions

- Metering helps mitigate congestion and reduce travel times
- Control is critical for some on-ramps
- Control strategy that considers distant bottlenecks
Future work

• Sensitivity analysis for different
  o Demand levels
  o Metering activation time
  o Combination of metered on-ramps

• Integration of different traffic management strategies
• Extended ALINEA (PI-controller) for distant bottlenecks
• Impact of metering on local network – drivers’ routing behavior
Thank you!