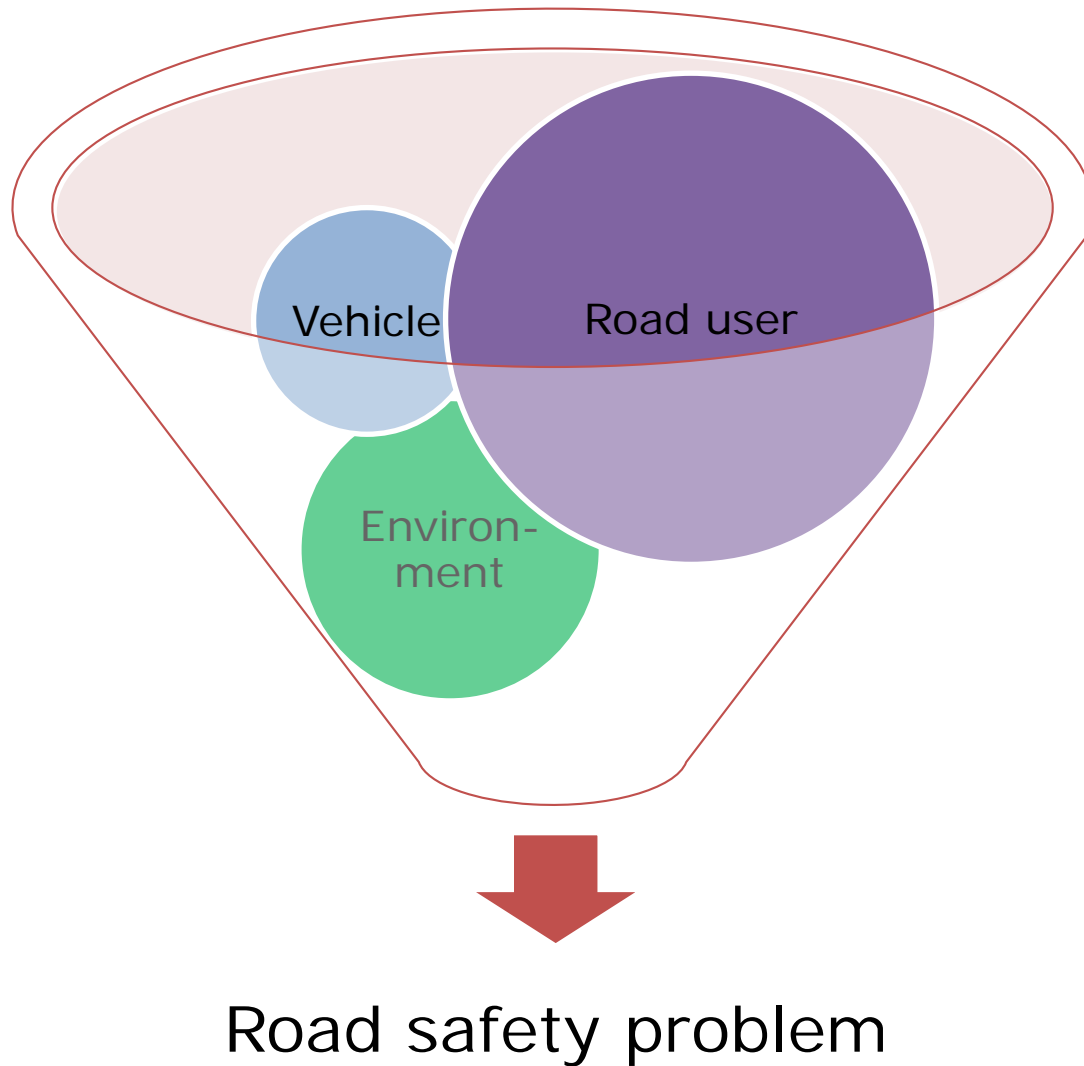

The effects in distance and time of traffic calming measures near road transitions and discontinuities by means of driving simulator research

Caroline Ariën
23 August 2016

Content

1. Introduction
2. Driving simulator research
3. Rural-to-urban transitions
4. Tangent-to-curve discontinuities
5. Conclusions

1. Road safety problem



- Fatalities per year
 - EU: 25.700
 - Belgium: 724
 - Flanders: 374



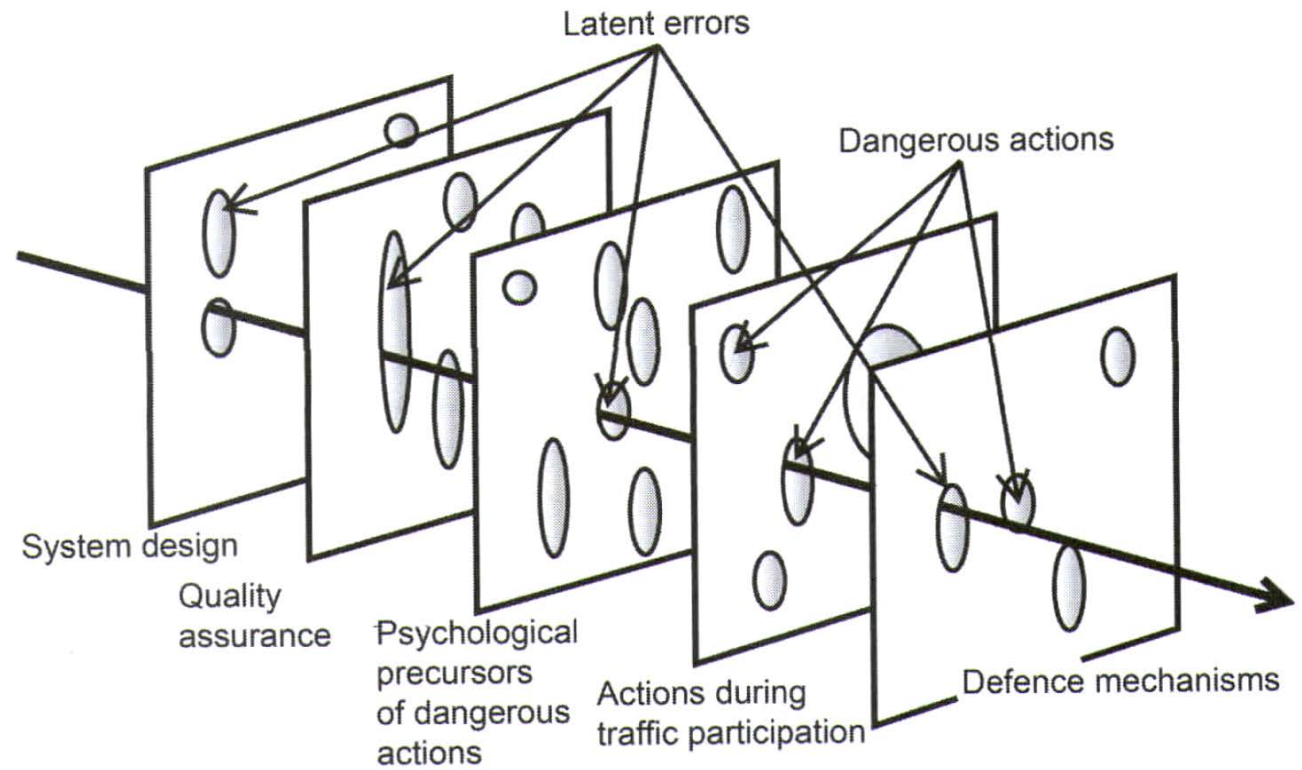
➔ Safe System Approach

1. Safe System Approach

- Pro-active approach: limitations of road user at the center of attention
 - Limited cognitive characteristics
 - Limited vulnerability

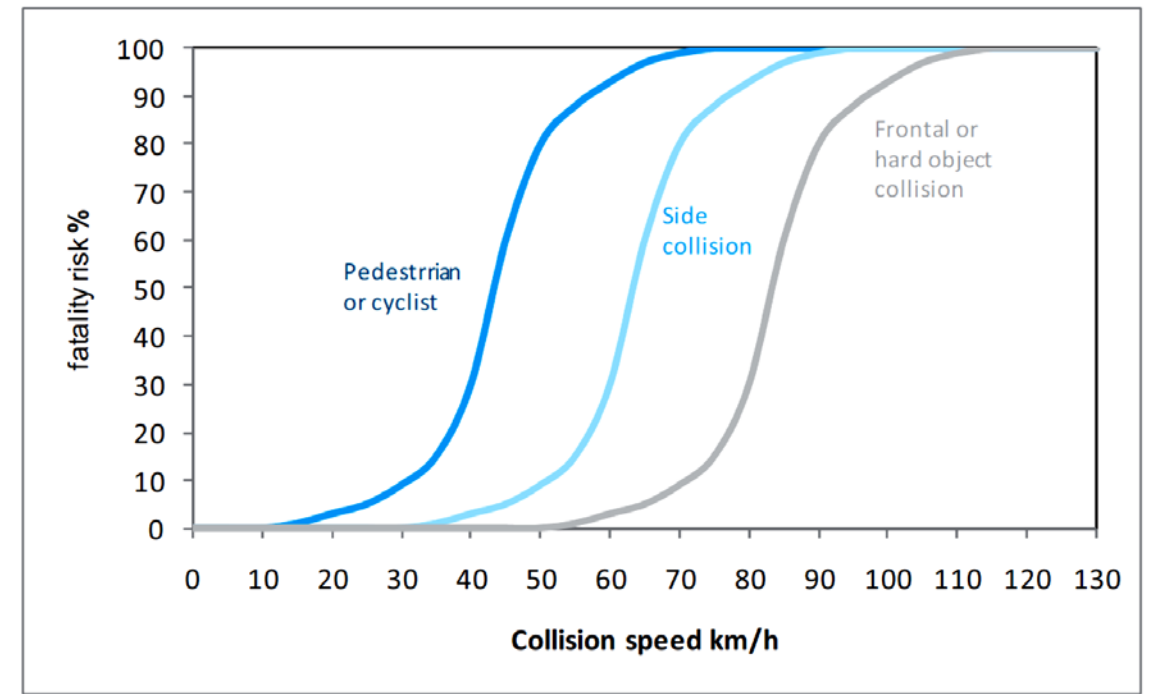
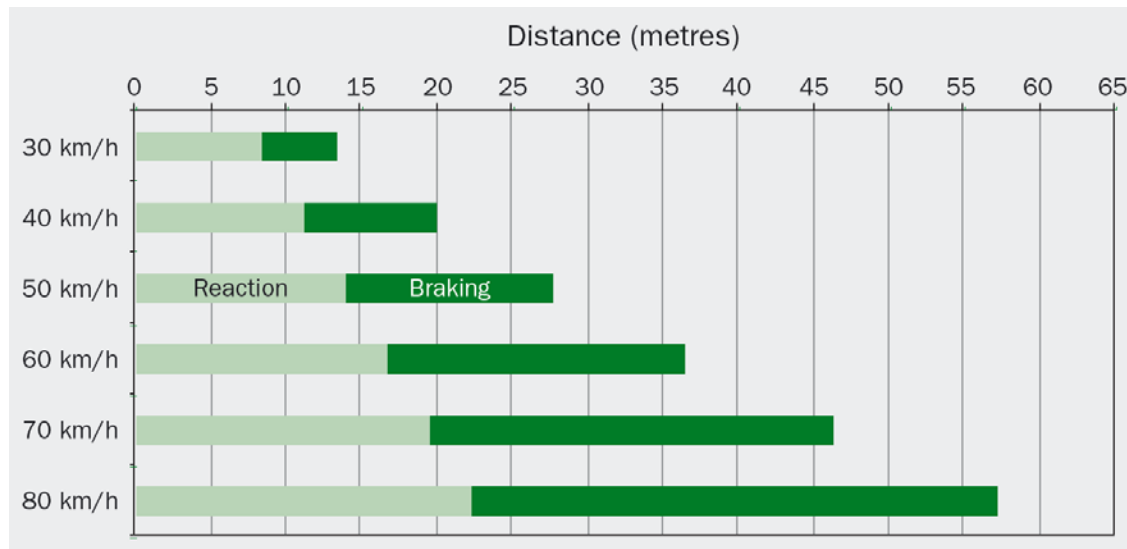
- Swiss Cheese Model

➔ Ergonomic or human-centered road design

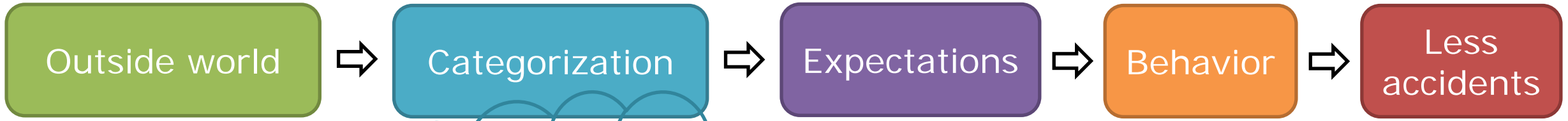


1. Relationship speed – road safety

- Speed perception
 - Visual, auditory, haptic and proprioceptive senses
 - Speed ~ amount of information
- 30% of fatal accidents are related to speed



1. Road categorization & self-explaining roads



Predictable
Homogeneous



Driver experience

- Own behavior
- Behavior of others
- Road elements
- Transitions

* Theeuwes et al. (2012) ⁶

1. Transitions & discontinuities

- **Transitions** = short road segment where a change in road category or road functionality takes place and where an adaptation of the behavior of the driver is required through a set of correct expectations on how one has to behave in order to be driving safely.



1. Transitions & discontinuities

- Traffic safety problem at **rural-to-urban transitions***



- Inadequate speed reduction
 - Speed adaptation
 - Mental underload

➔ Traffic Calming Measures (TCM)



* Charlton & O'Brien (2002); Galante et al. (2010); Taylor & Wheeler (2000)

1. Transitions & discontinuities

- **Discontinuities** = where an adaptation of the driving behavior is required due to a major change in road design within the same road category or road functionality and the resulting set of correct expectation on how one has to behave in order to be driving safely.



1. Transitions & discontinuities

- Traffic safety problem in **tangent-to-curve discontinuities***

Speed

Attentional demand

Lateral position



1. Transitions & discontinuities

- Appropriate speed and lateral control
- ↓
- Redesign of curve: but not always possible
 - Additional infrastructural traffic control devices
 - Signs
 - Pavement markings



1. Objective & research questions

Objective: To examine the effects in distance (along the road) and time (under repeated exposure during 5 consecutive days) of traffic calming measures near road transitions and discontinuities.

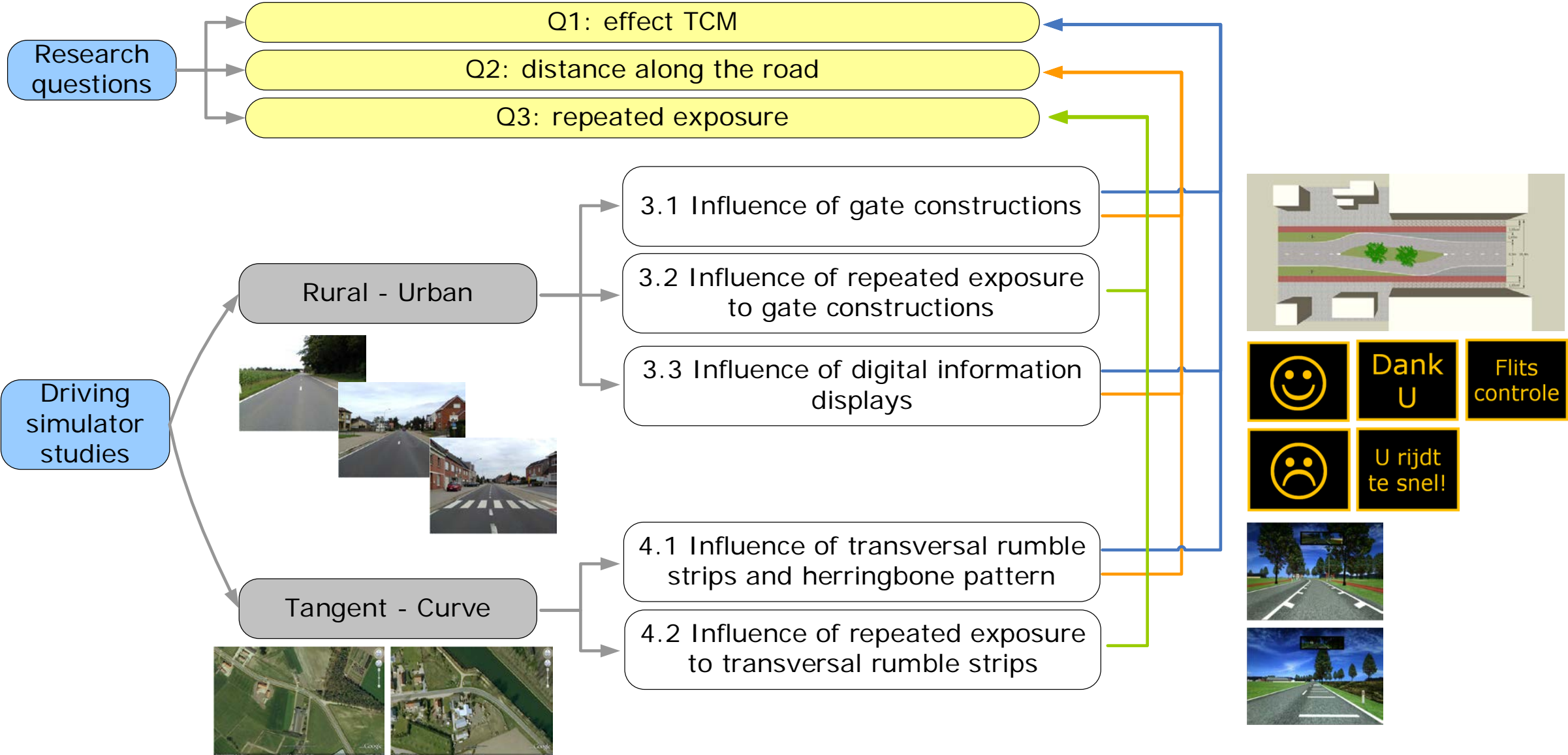
Research questions

Q1: Can we obtain a desired behavioral adaptation contributive to road safety in distance (along the road) by means of traffic calming measures?

Q2: With respect to distance along the road: Is there a difference between the different traffic calming measures in terms of the extent to which they contribute to a desired behavioral adaptation supporting road safety?

Q3: With respect to time (i.e., under repeated exposure during 5 consecutive days): Does the repeated exposure to the traffic calming measures have an influence on driving behavior near transitions or discontinuities?

Objective: Effects of traffic calming measures



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1. Introduction
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2. Driving simulator research



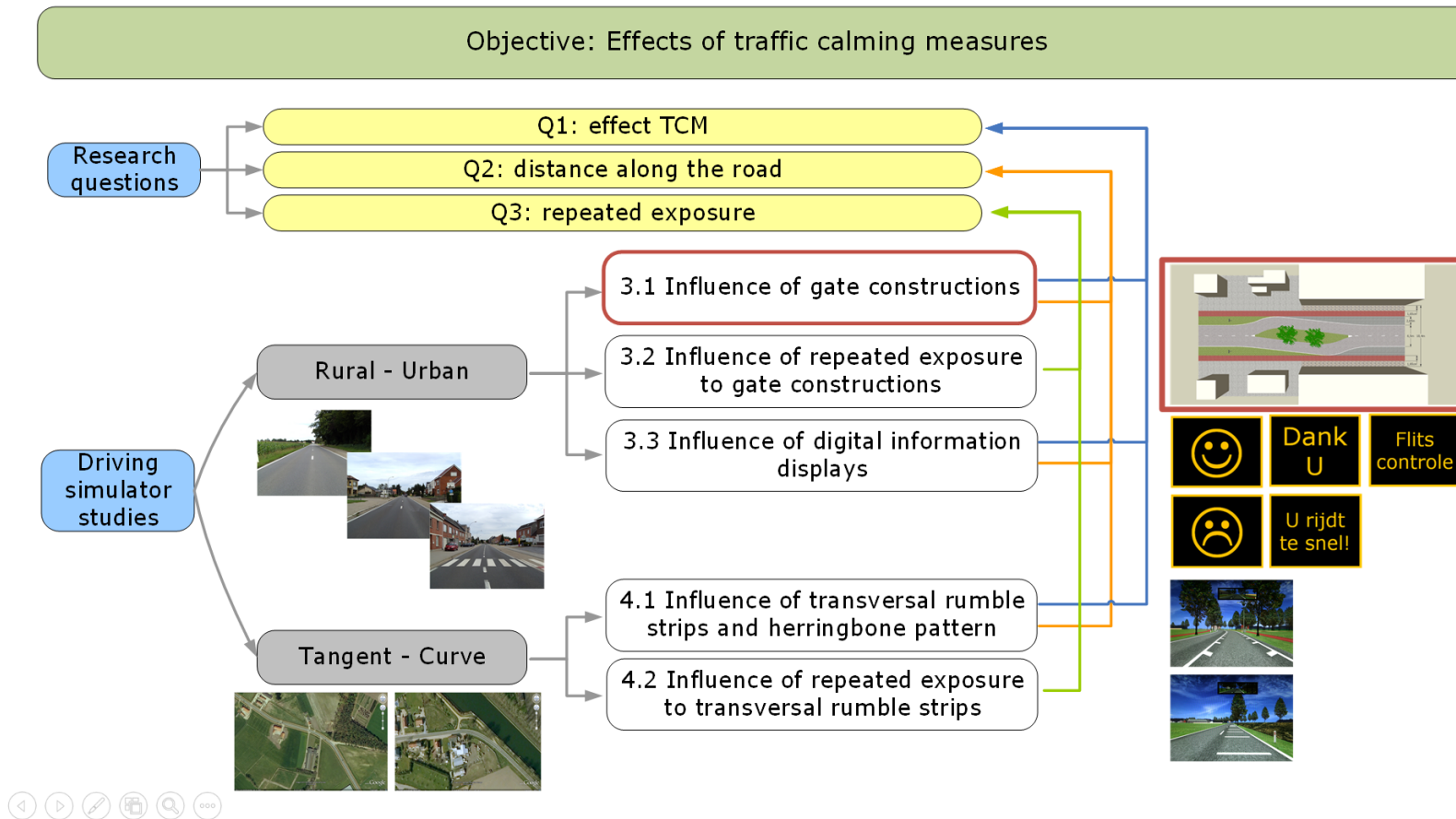
- Longitudinal control: speed, acc/dec
- Lateral control: lateral position

- Advantages
 - PRO-active ⇔ RE-active
 - Safe
 - Easy data collection
 - Selective manipulation and control
- Challenges
 - Validity
 - Simulator sickness

Content

1. Introduction
2. Driving simulator research
- 3. Rural-to-urban transitions**
4. Tangent-to-curve discontinuities
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A simulator study on the impact of traffic calming measures in urban areas on driving behavior and workload



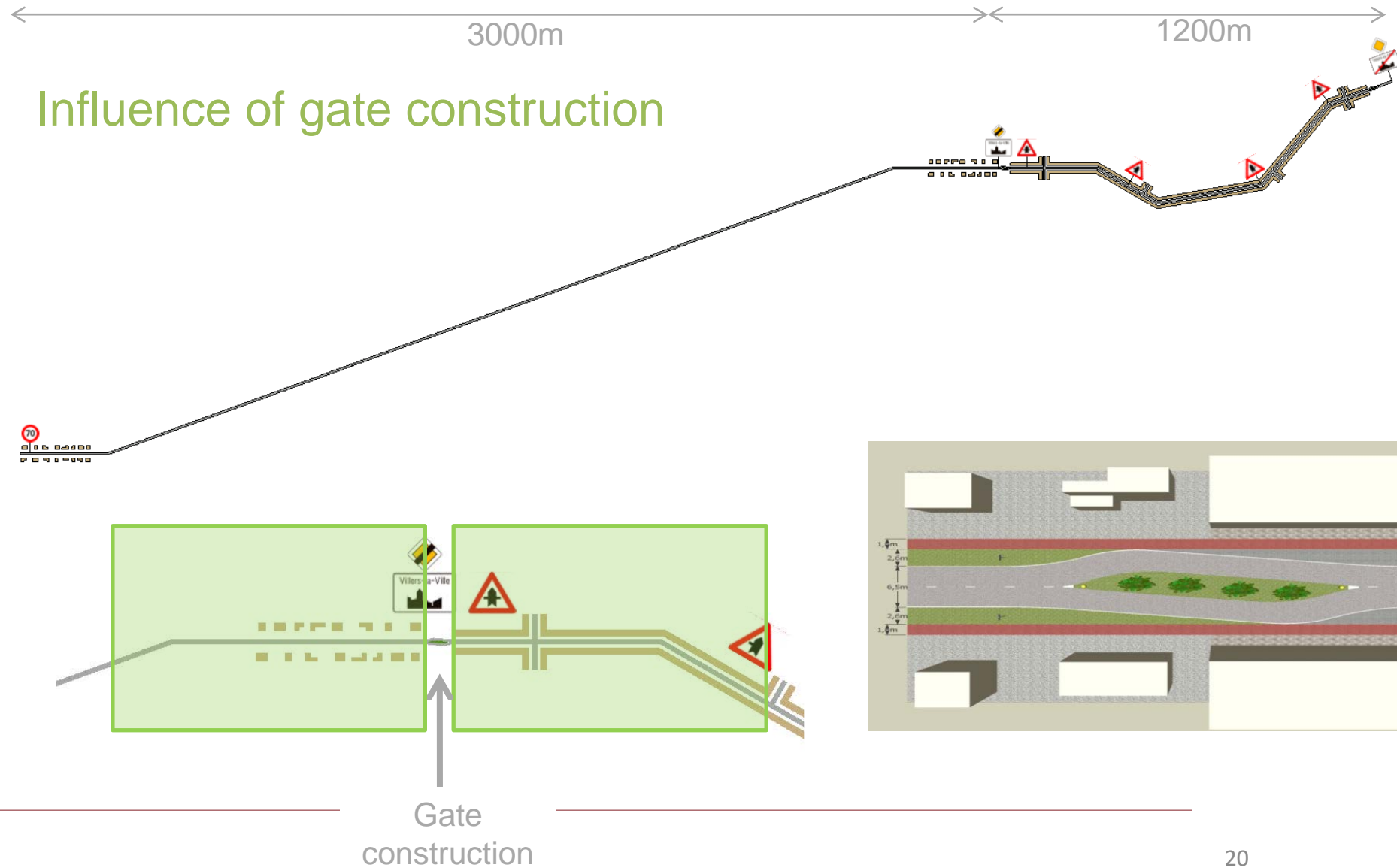
Ariën, C.; Jongen, E.M.M.; Brijs, K.; Brijs, T.; Daniels, S.; Wets, G. (2013)
Accident Analysis & Prevention

3.1 Literature review

- Large influence of context and type of gate constructions on speed
 - Field experiments
 - Speed reduction between 5 and 24 kph
 - 8 to 10 kph more typical
 - Simulator studies
 - Speed reduction between 6.4 and 17 kph
 - No consistent speed reduction beyond vicinity of gate (300 to 400m)

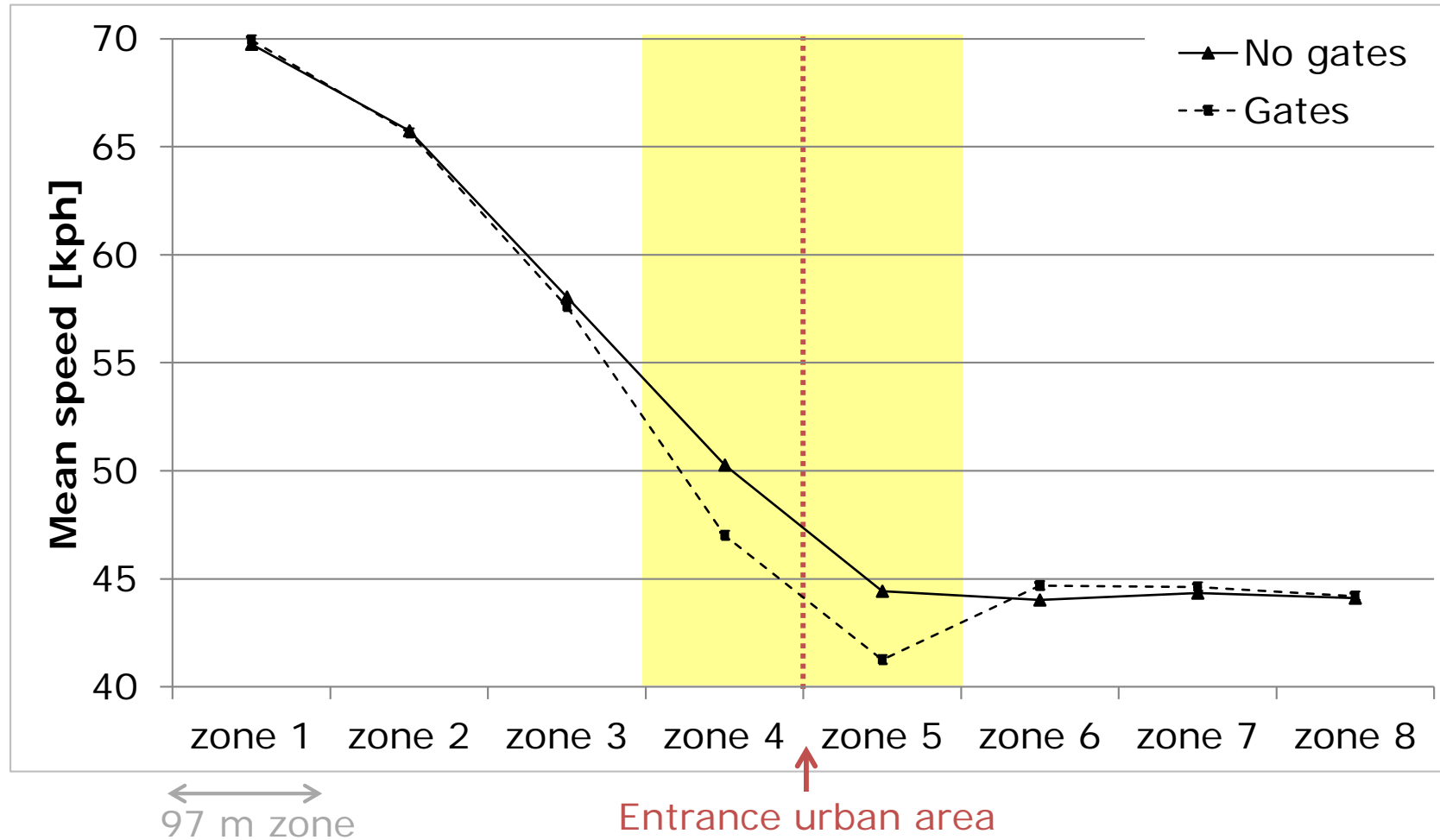


3.1 Methodology

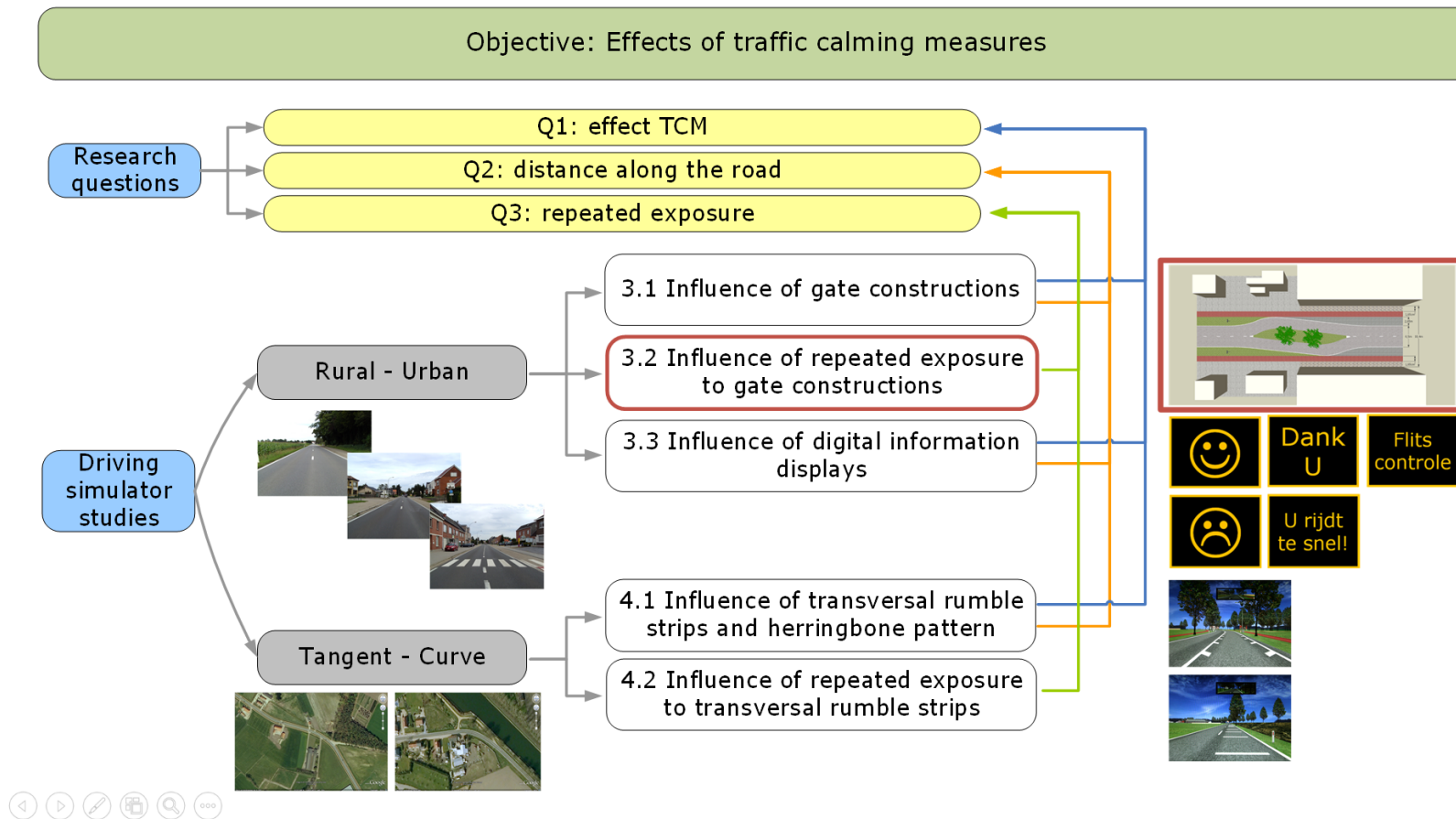


3.1 Results

- Influence of gate constructions on mean speed



Does the effect of traffic calming measures endure over time? – A simulator study on the influence of gates



Ariën, C.; Brijs, K.; Brijs, T.; Ceulemans, W.; Jongen, E.M.M; Daniels, S.; Wets, G.
(2014) *Transportation Research Part F*

3.2 Repeated exposure

- Driving simulator studies

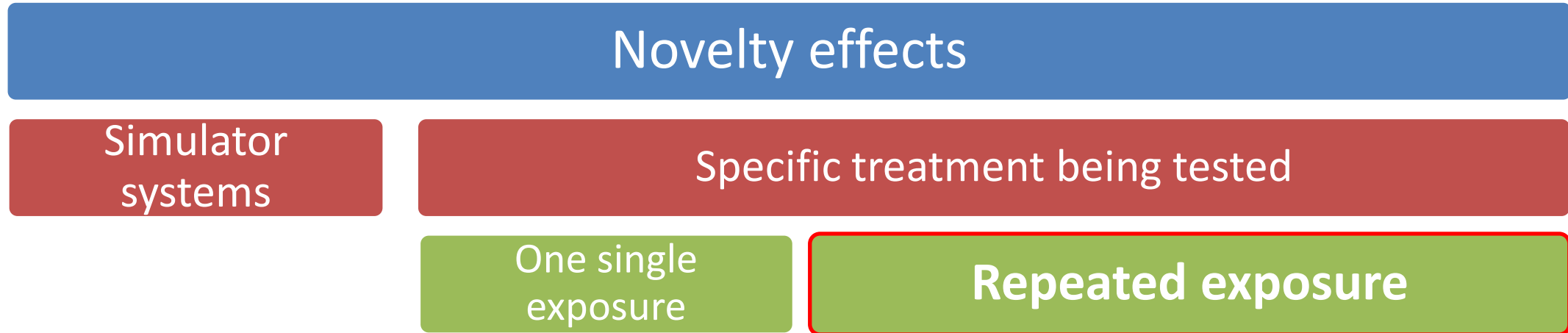
Jamson & Lai*: “potential influence of novelty effects”



* Jamson & Lai (2011)

3.2 Repeated exposure

- Driving simulator studies
Jamson & Lai*: “potential influence of novelty effects”

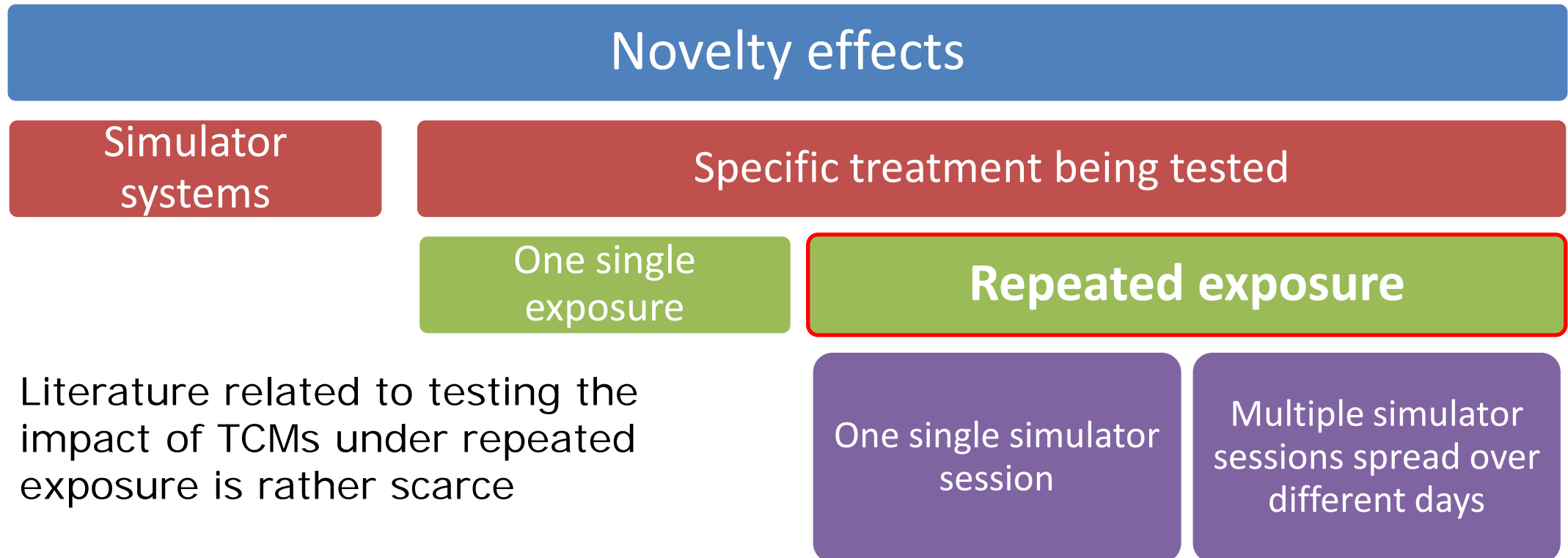


* Jamson & Lai (2011)

3.2 Repeated exposure

- Driving simulator studies

Jamson & Lai*: “potential influence of novelty effects”



Literature related to testing the impact of TCMs under repeated exposure is rather scarce

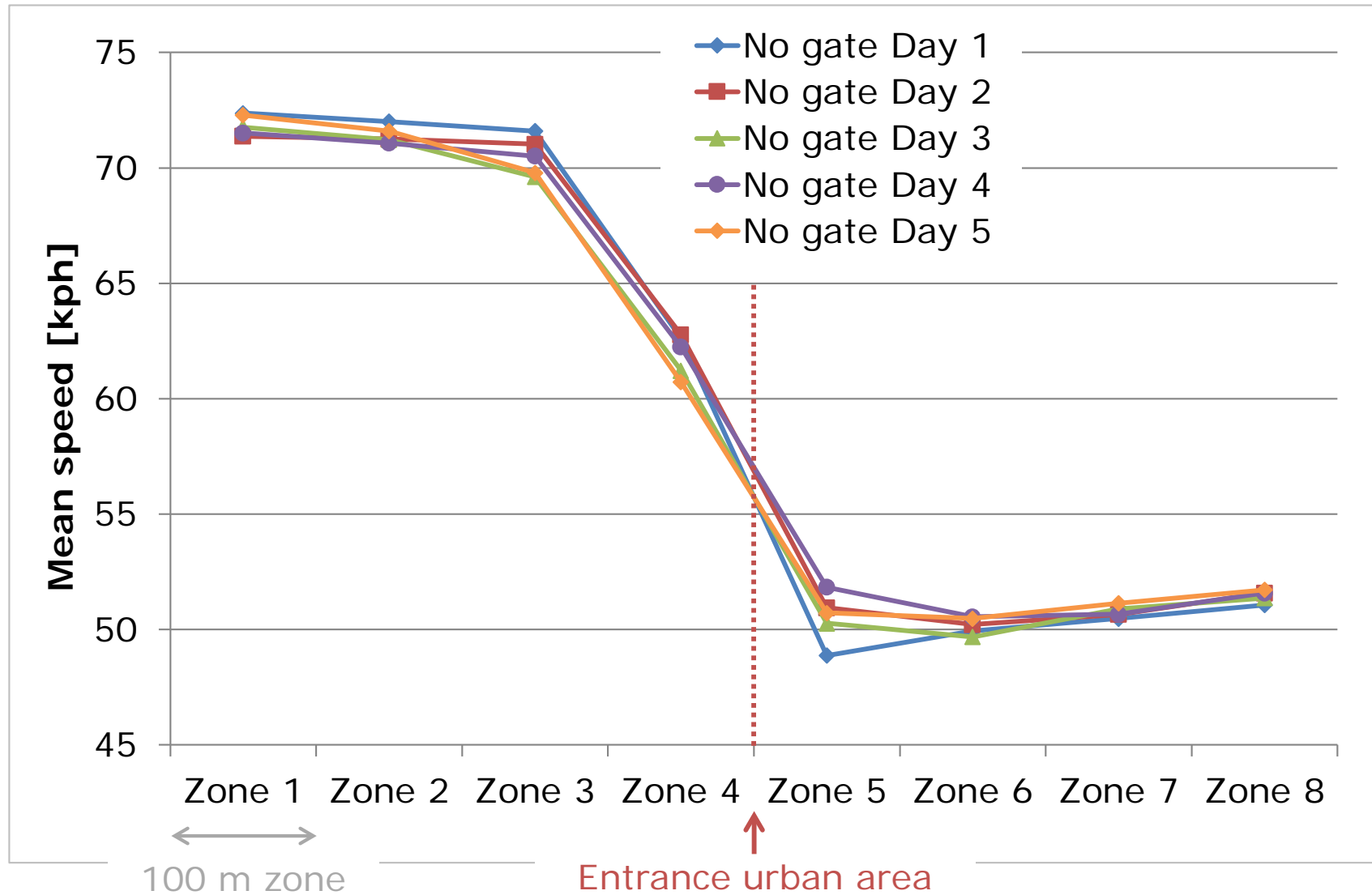
Except: Jamson & Lai (2011), Rossi et al. (2013a, 2013)

* Jamson & Lai (2011)

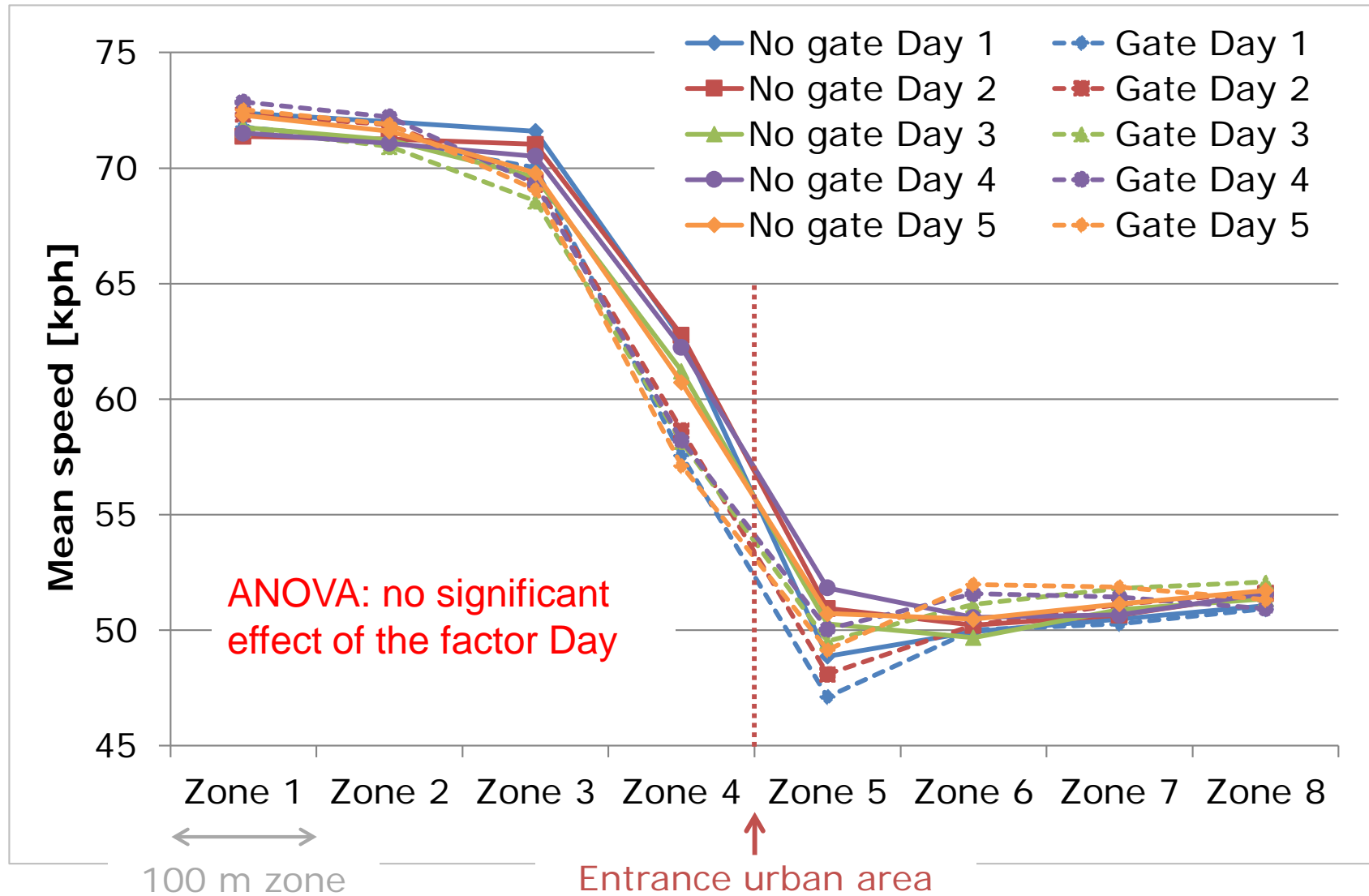
3.2 Methodology

- Participation during 5 consecutive weekdays
 - Day 1: introduction, practice session + 17 km test trip
 - Day 2-5: practice session + 17 km test trip
 - 1 urban area with gate and 1 without gate

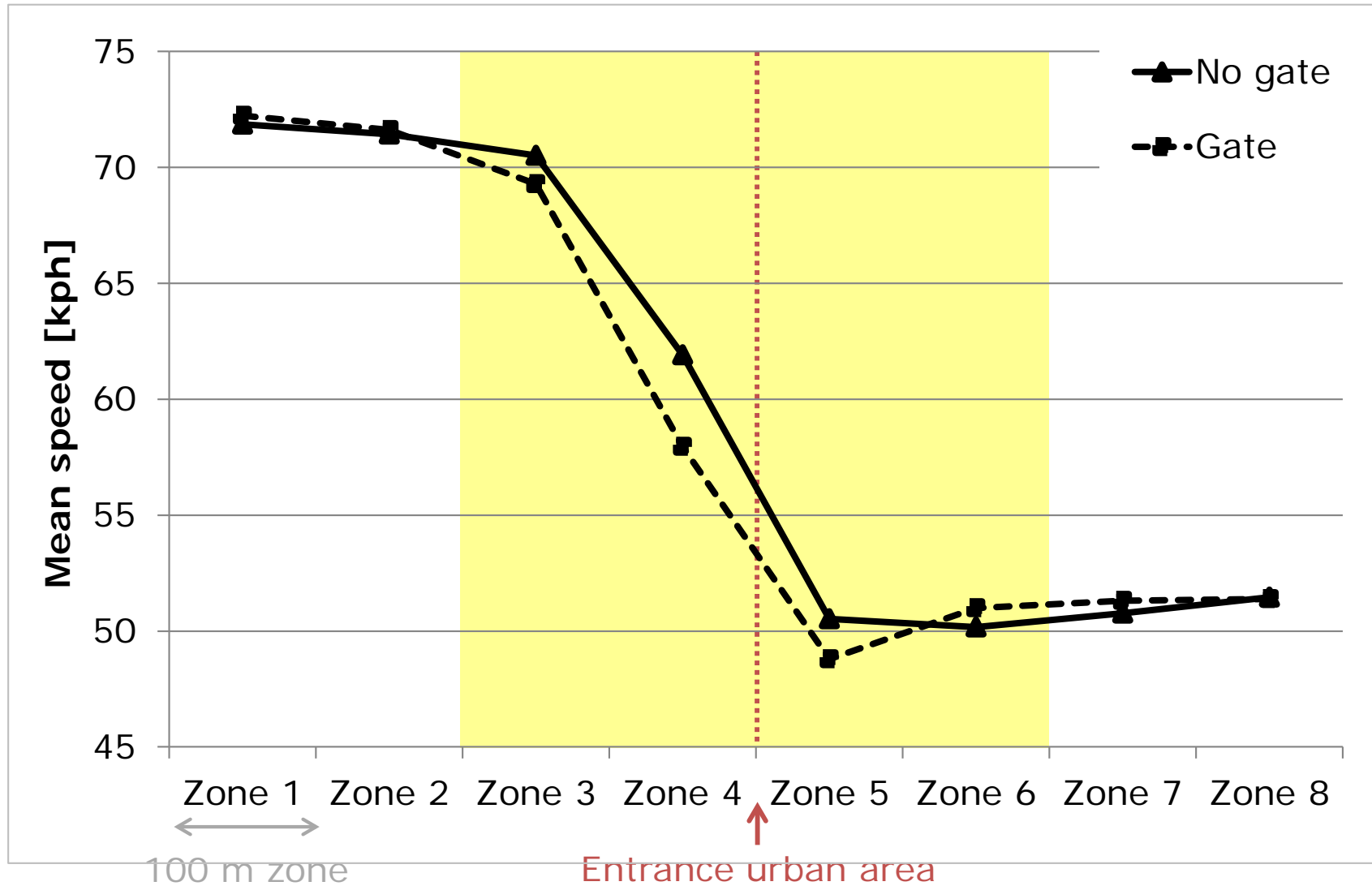
3.2 Results



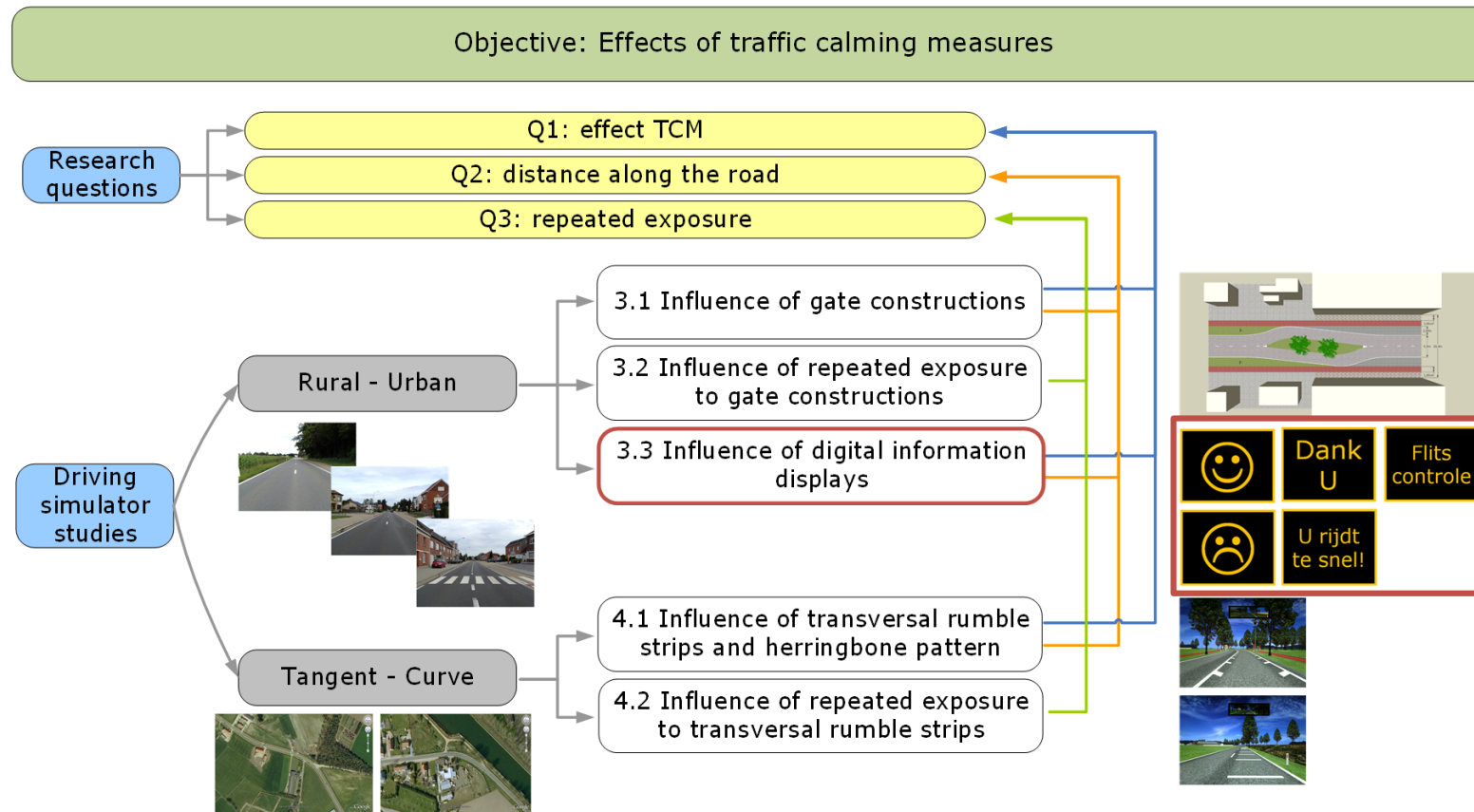
3.2 Results



3.2 Results



Measuring the impact of digital information displays on speed: A driving simulator study



Ariën, C.; Cornu, J.; Brijs, K.; Brijs, T.; Vanroelen, G.; Jongen, E.M.M; Daniels, S.; Wets, G. *Submitted in Accident Analysis & Prevention*

3.3 Literature review

- Digital information displays (DID): speed reeducation in case of speeding and at problem locations*



- Wrapson*: posted feedback of speeding information is effective
 - It introduces social comparison → approval/disapproval
 - It implies police surveillance → deterrence

* Ullman & Rose (2005); Santiago-Chaparro et al. (2012)
Wrapson et al. (2006)

3.3 Methodology

- Effectiveness of 3 DID messages

Social approval/disapproval

Happy smiley



Sad smiley



"Thank you"



"You are speeding"



Explicitly related to
police enforcement
→ Fear for fine

"Speed
enforcement"



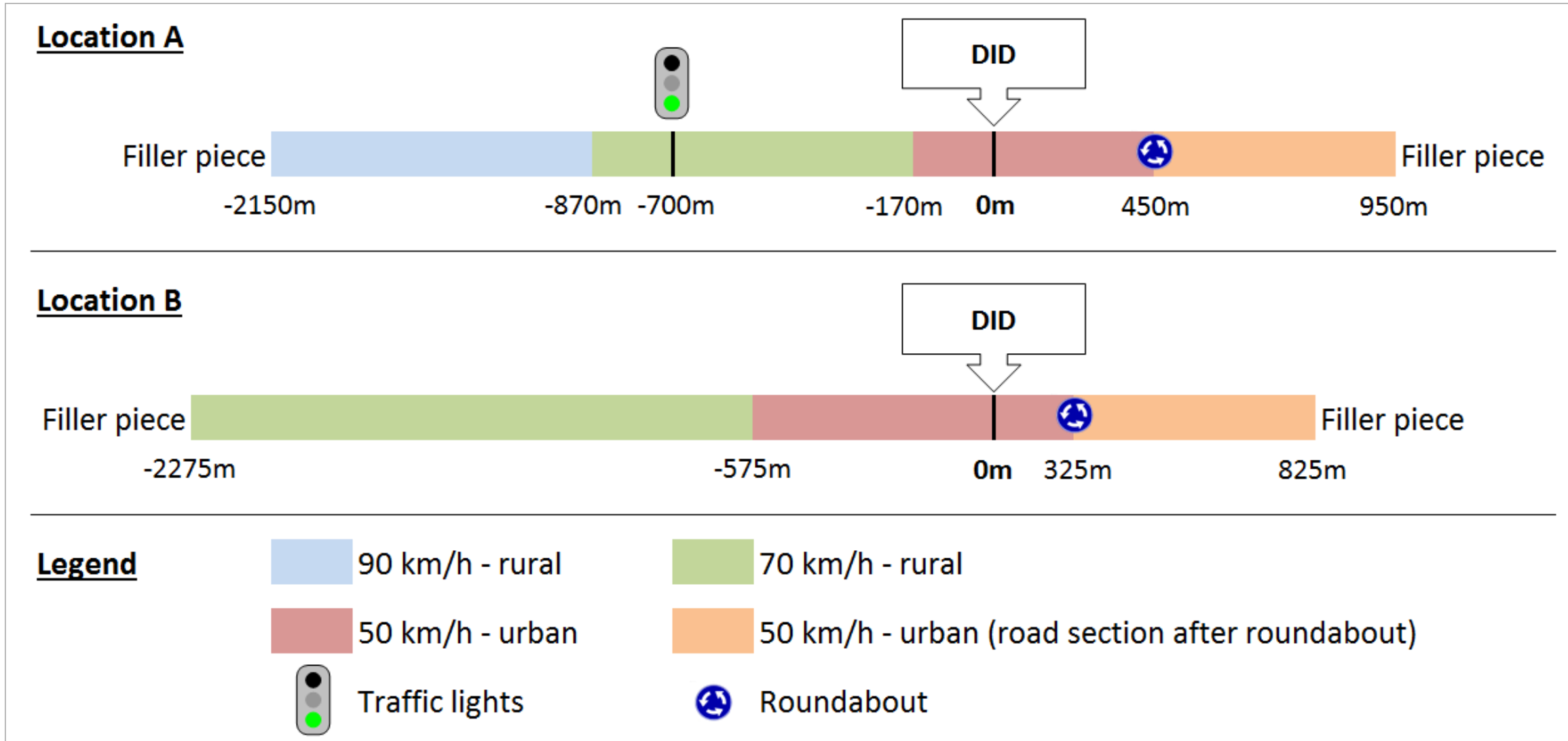
3.3 Methodology

- 2 rural-to-urban transitions
→ Geo-specific database modelling*

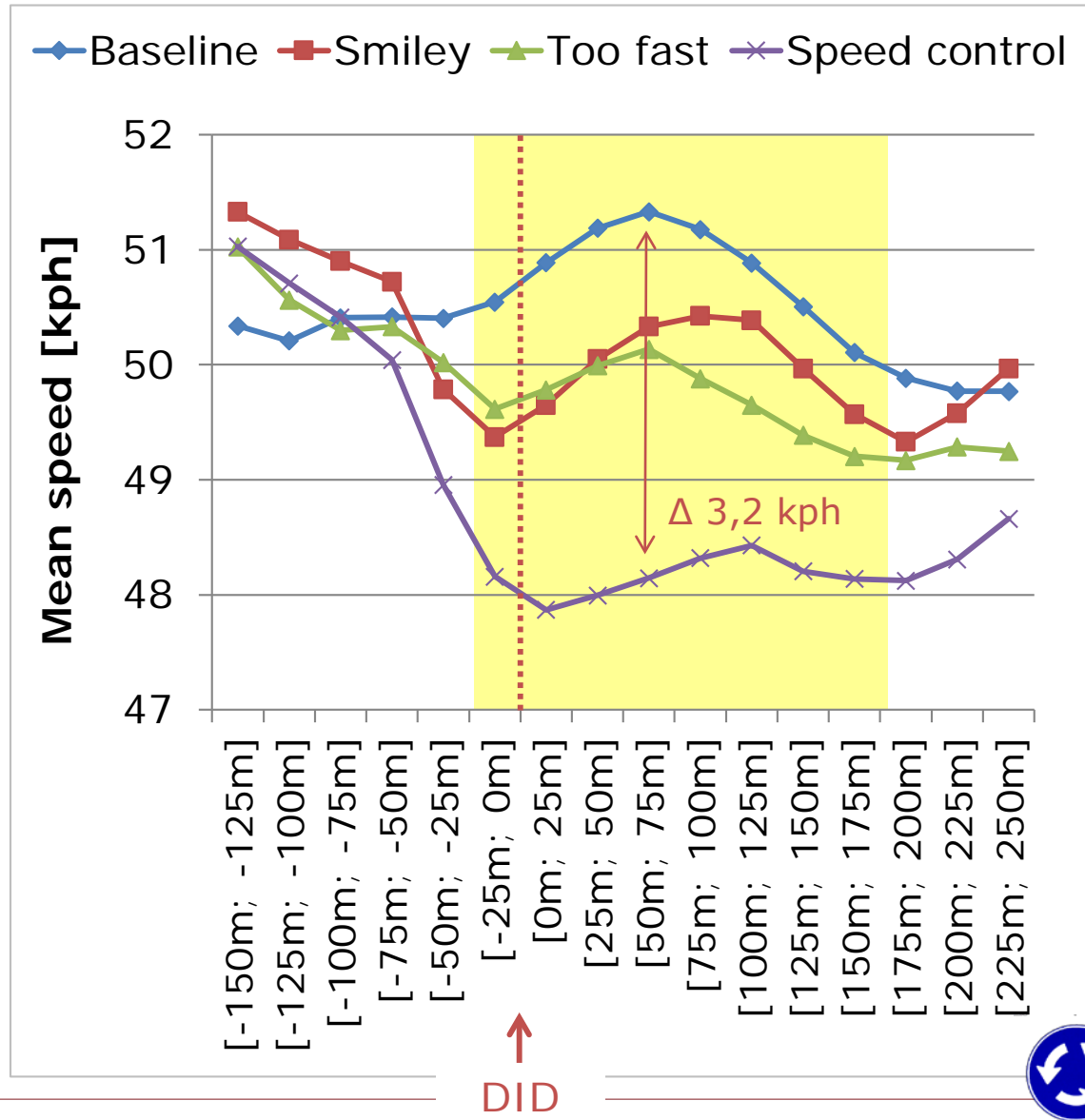


* Yan et al. (2008)

3.3 Methodology

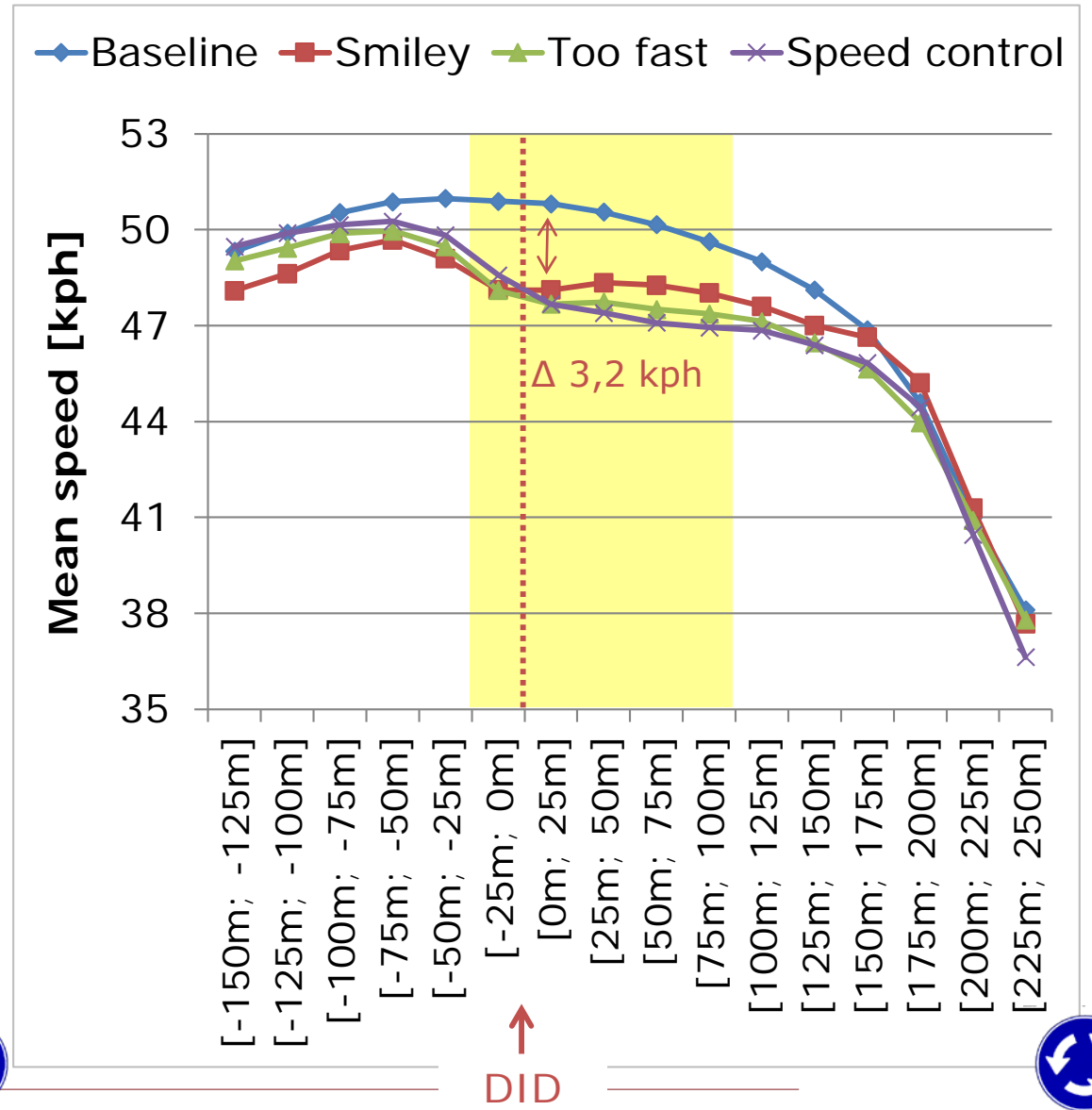


3.3 Results



Location A

450m



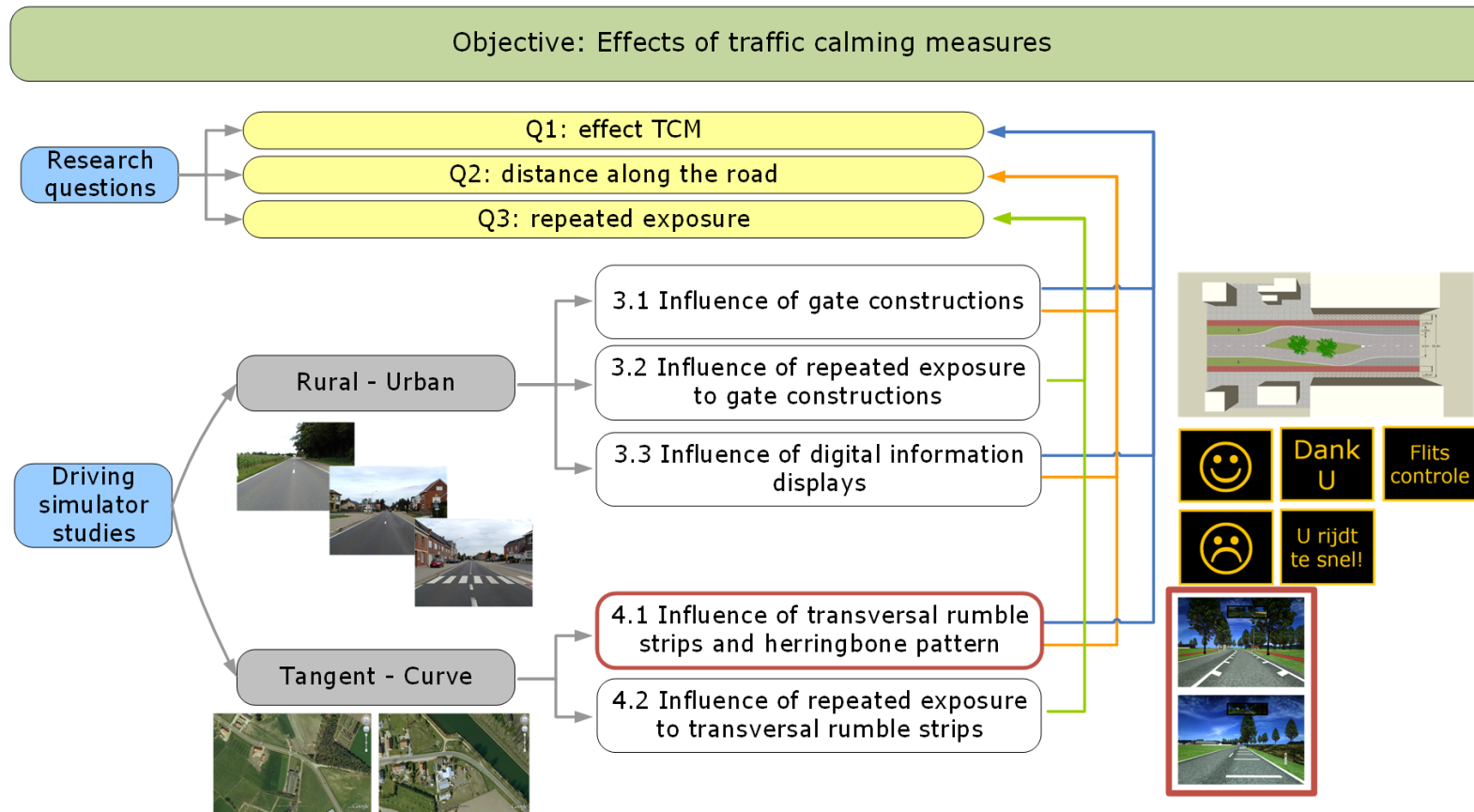
Location B

325m

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The effect of pavement markings on driving behavior in curves: A simulator study

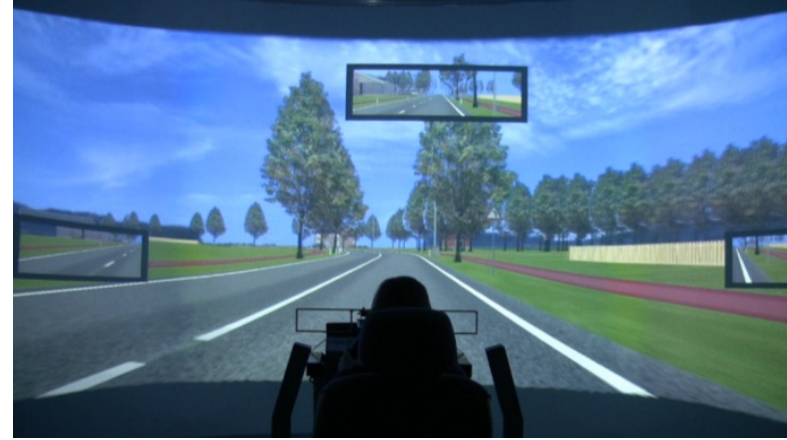


Ariën, C.; Brijs, K.; Vanroelen, G.; Jongen, E.M.M; Daniels, S.; Brijs, T.; Wets, G. (2016) *Ergonomics*

4.1 Dangerous curves

- 2 dangerous curves
→ Geo-specific database modelling*

90



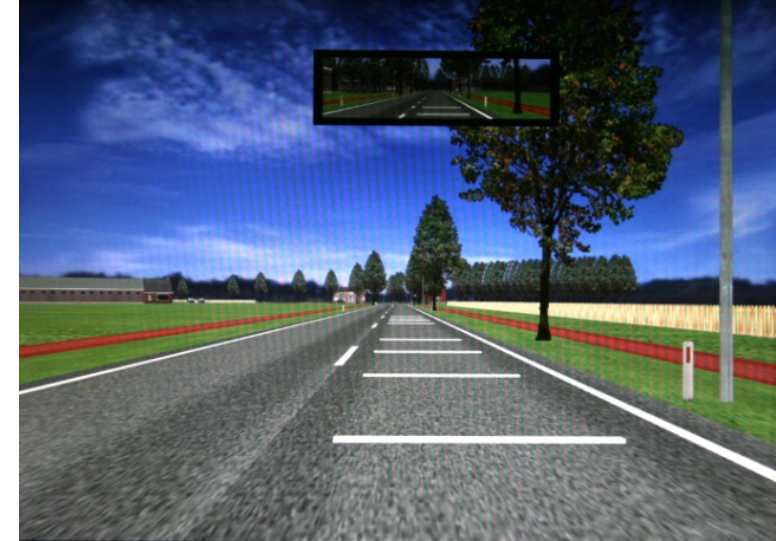
70



* Yan et al. (2008)

4.1 Pavement markings

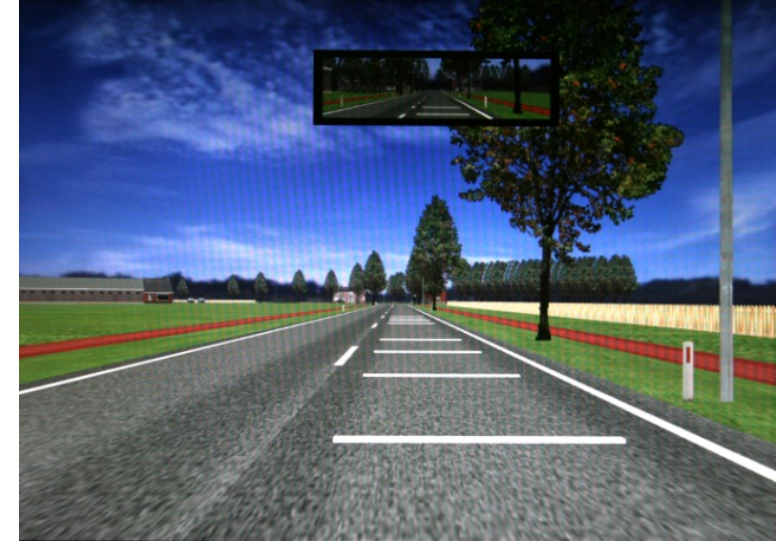
- Pavement markings qualified as perceptual countermeasure
 - Transversal rumble strips (TRS)
 - ➔ Impression of increased motion



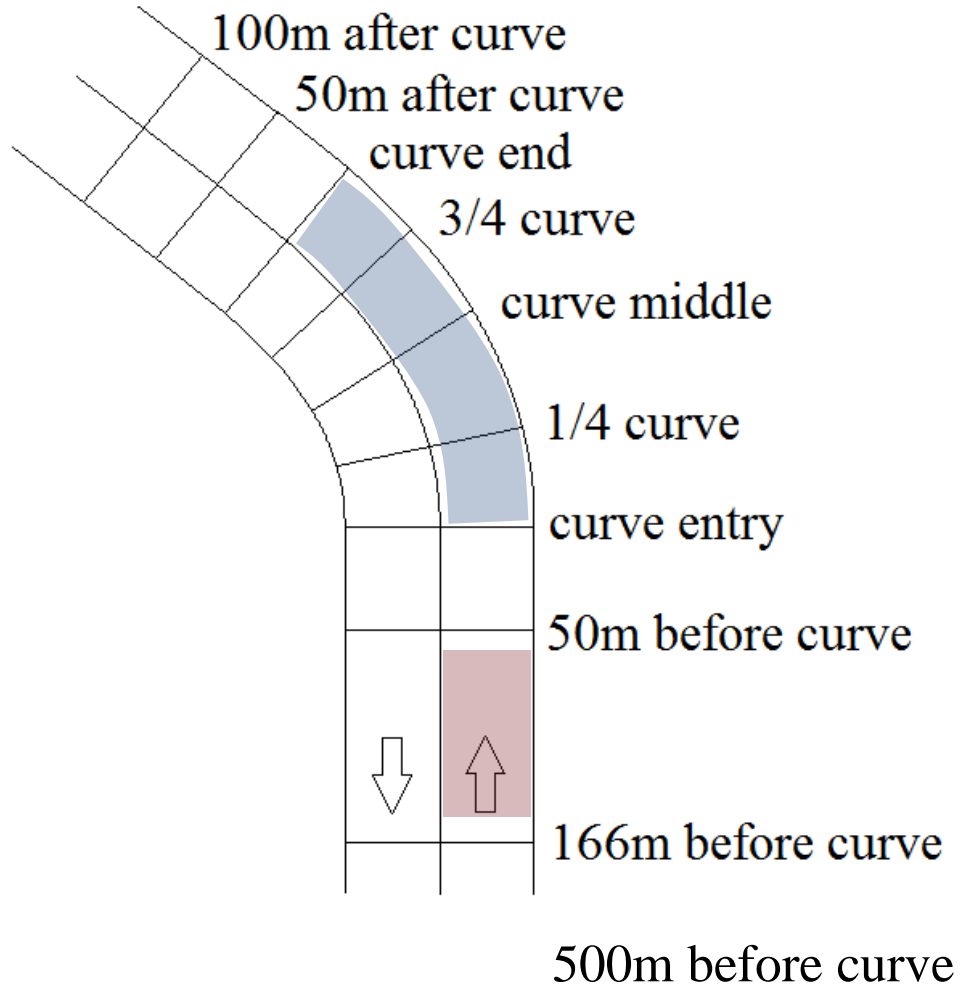
4.1 Pavement markings

- Pavement markings qualified as perceptual countermeasure
 - Transversal rumble strips (TRS)
 - ➔ Impression of increased motion

 - Herringbone pattern (HP)
 - ➔ Impression of lane narrowing



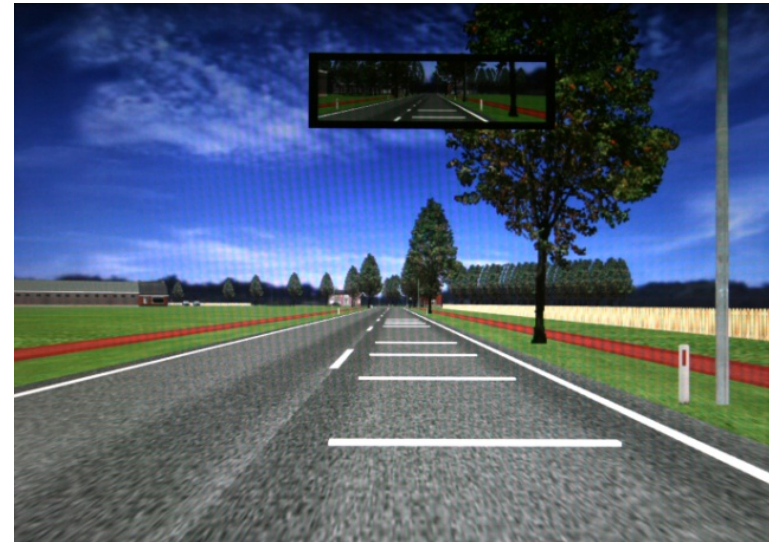
4.1 Methodology



HP

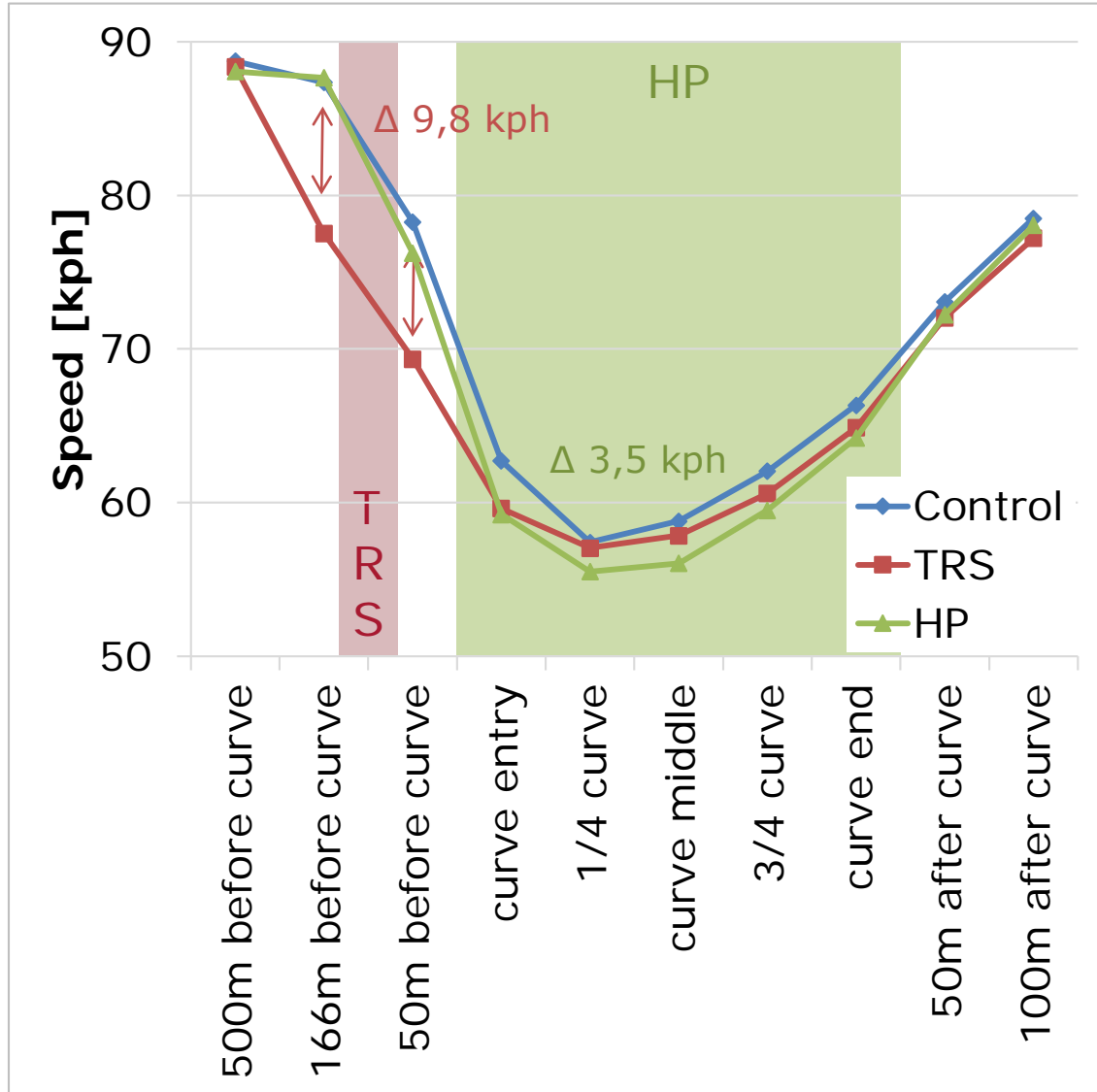


TRS

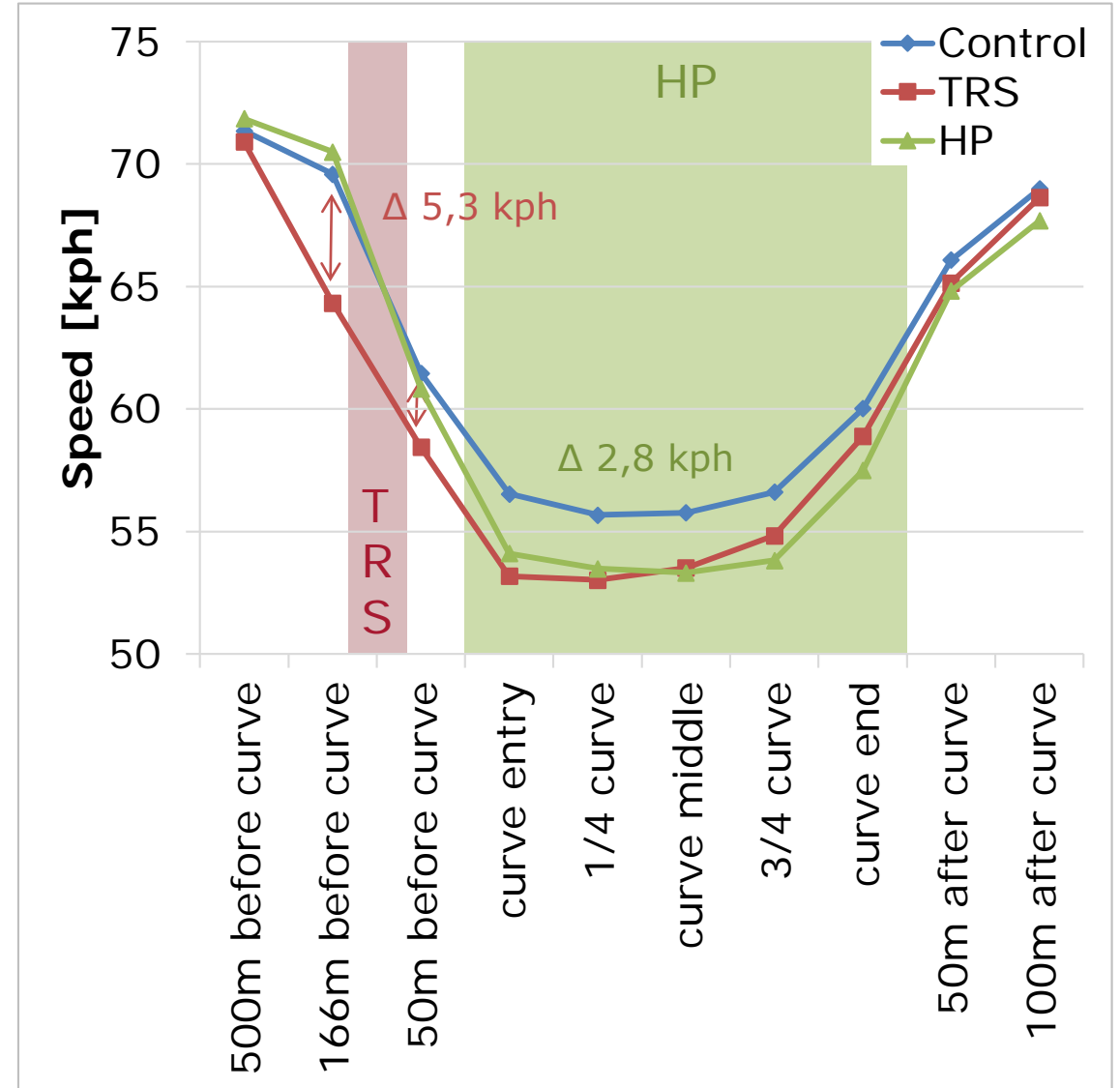


4.1 Results

Curve A



Curve B

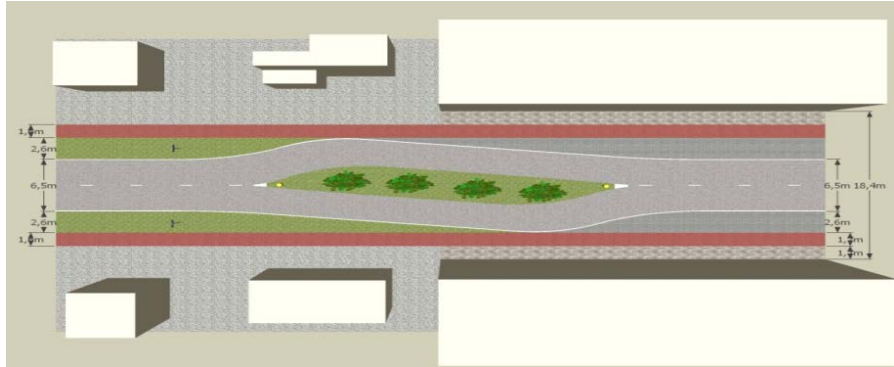


Content

1. Introduction
2. Driving simulator research
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5. Overview of main results

- Local speed reductions



1 day	3 kph	-97m ... +97m
5 days	1,2 - 4 kph	-200m ... +100m
	-0,8 kph	+100m ... +200m

"Speed enforcement"



2,0 - 3,2 kph	-25m ... +100m
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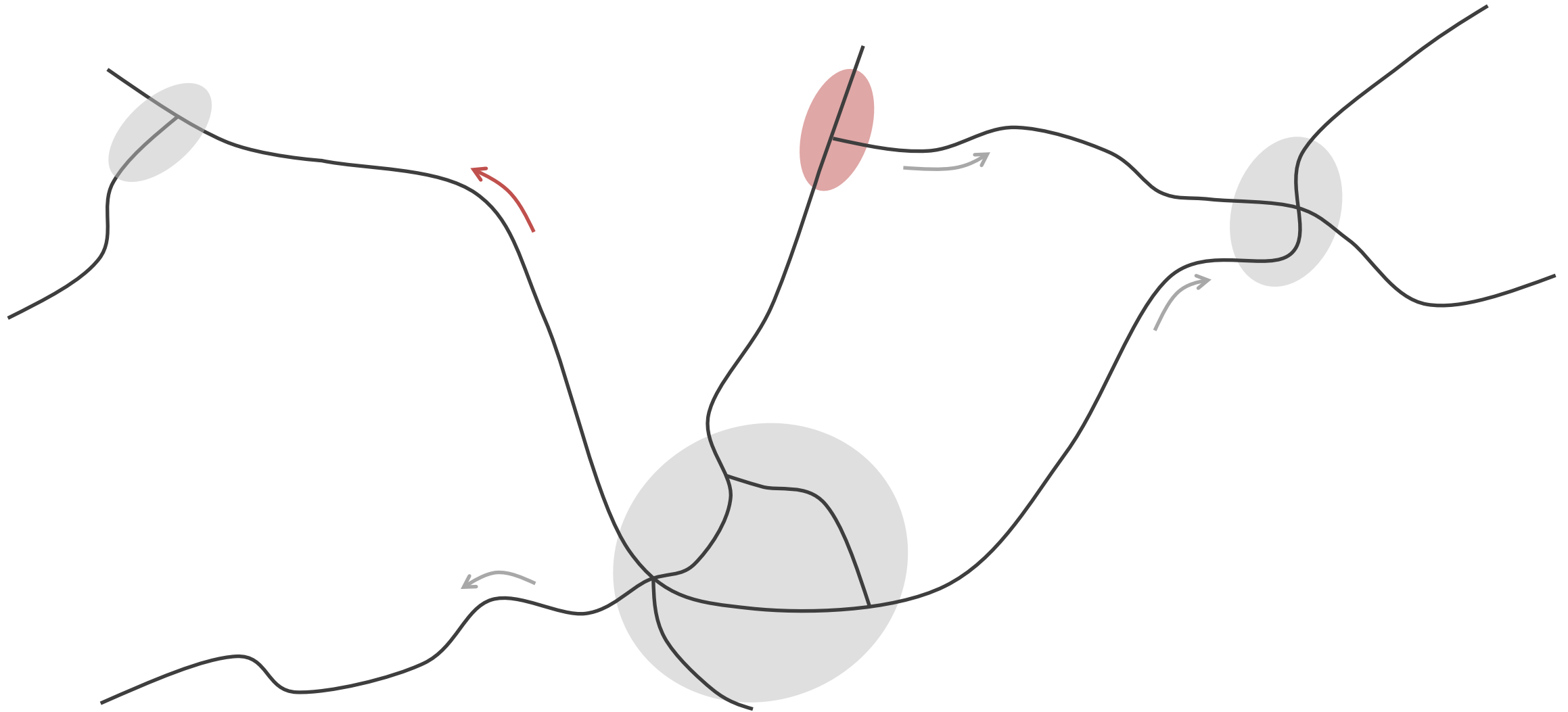


2,2 - 3,5 kph	0m ... curve end
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1 day	2,3 - 9,8 kph	-166m ... ½ curve
5 days	2,3 - 5,9 kph	-166m ... 0m
Smoother deceleration		

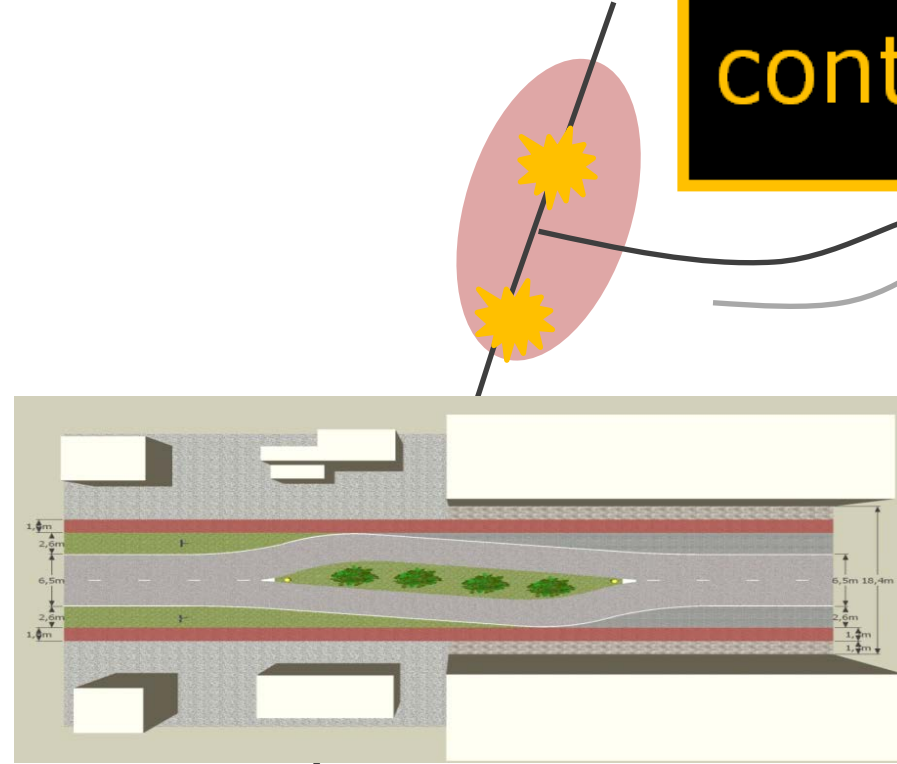
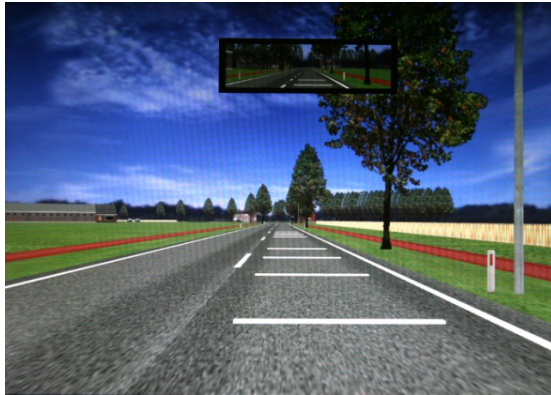
- Limited influence on lateral position



5. Policy recommendations

Meso

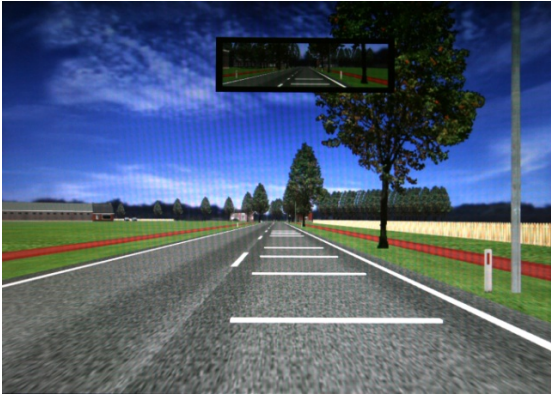
Flits controle



5. Policy recommendations

Micro

Flits controle



5. TCM as part of self-explaining road network

- Future research
 - Different design configurations
 - Optimal distance between TCM and transition / discontinuity
 - Complementary TCMs
- Role of TCM in completely self-explaining road network
 - Mitigating & signaling function
- Integration of research results in design standards

Thank you for your interest

Questions?

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Journal publications

- **ARIËN Caroline**; JONGEN Ellen M.M.; BRIJS Kris; BRIJS Tom; DANIELS Stijn; WETS Geert (2013). A Simulator Study on the Impact of Traffic Calming Measures in Urban Areas on Driving Behavior and Workload. *Accident Analysis & Prevention*, 61, 43–53. doi: 10.1016/j.aap.2012.12.044. [web of science: 5 year impact factor 3.096].
- BABAEE, Seddigeh; SHEN, Yongjun; HERMANS, Elke; WETS, Geert; BRIJS, Tom; **ARIËN, Caroline** (2014). Combining driving performance information in an index score: a simulated curve-taking experiment. *Transportation Research Record*, 3952 (2434), p. 44-51.
- **ARIËN Caroline**; BRIJS Kris; BRIJS Tom; CEULEMANS Wesley; VANROELEN Giovanni; JONGEN Ellen M. M.; DANIELS Stijn; WETS Geert (2014). Does the effect of traffic calming measures endure over time? – A simulator study on the influence of gates. *Transportation Research Part F: Traffic Psychology and Behaviour*, 22, 63–75. doi: 10.1016/j.trf.2013.10.010. [web of science: 5 year impact factor 2.349].
- DE CEUNYNCK, Tim; **ARIËN, Caroline**; BRIJS, Kris; BRIJS, Tom; VAN VLIERDEN, Karin; Kuppens, Johan; Van der Linden, Max & WETS, Geert (2015). Proactive Evaluation of Traffic Signs Using a Traffic Sign Simulator. *European Journal of Transport and Infrastructure Research*, 15 (2), p. 184-204. [web of science: 5 year impact factor 1.144].
- **ARIËN, Caroline**; BRIJS, Kris; VANROELEN, Giovanni; CEULEMANS, Wesley; JONGEN, Ellen M.M.; DANIELS, Stijn; BRIJS, Tom; WETS, Geert (2016) The effect of pavement markings on driving behavior in curves: a simulator study. In *Ergonomics*, doi: 10.1080/00140139.2016.1200749. [web of science: 5 year impact factor 1.804].
- **ARIËN, Caroline**; BRIJS, Kris; VANROELEN, Giovanni; CEULEMANS, Wesley; JONGEN, Ellen M.M.; DANIELS, Stijn; BRIJS, Tom; WETS, Geert (n.d.) A driving simulator study on the effect of transversal rumble strips located nearby dangerous curves under repeated exposure. Submitted for first review in *European Journal of Transport and Infrastructure Research* [web of science: 5 year impact factor 1.144].
- **ARIËN, Caroline**; VANROELEN, Giovanni; BRIJS, Kris; JONGEN, Ellen M.M.; CORNU, Joris; ROSS, Veerle; MOLLU, Kristof; DANIELS, Stijn; BRIJS, Tom; WETS, Geert (n.d.) Processing driving simulator data before statistical analysis by means of interpolation and a simple integral formula. Submitted for first review in *Transportation Research part B* [web of science: 5 year impact factor 4.116].
- **ARIËN, Caroline**; CORNU, Joris; BRIJS, Kris; BRIJS, Tom; VANROELEN, Giovanni; JONGEN, Ellen M.M.; DANIELS, Stijn; WETS, Geert (n.d.) Measuring the impact of digital information displays on speed: A driving simulator study. Submitted for first review in *Accident Analysis and Prevention*. [web of science: 5 year impact factor 2.699].