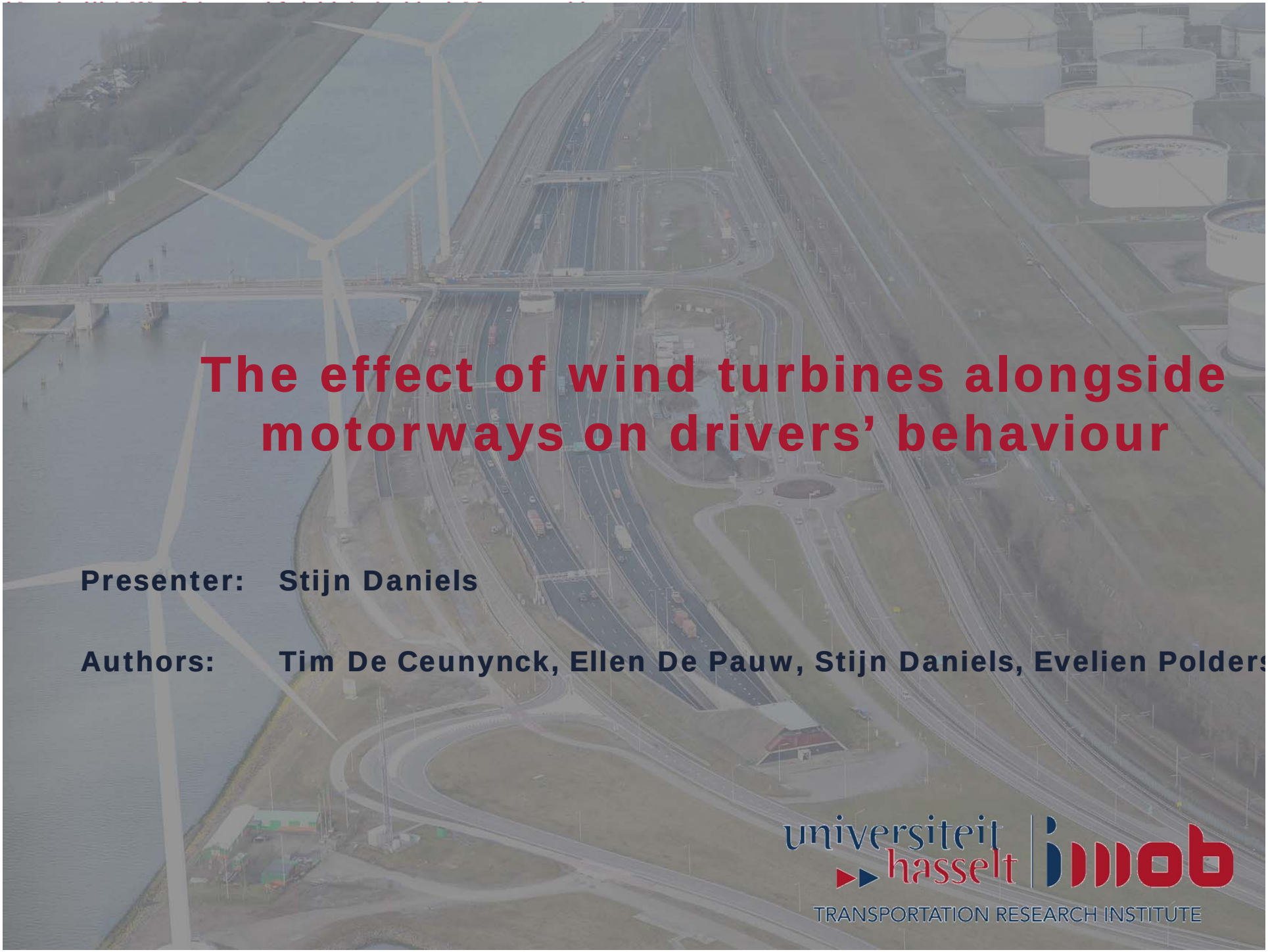

The effect of wind turbines alongside motorways on drivers' behaviour

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Wind turbines?

- Increasing use as renewable energy source
- Possible visual and acoustic impact
- Location close to motorways?
  - Favourable wind conditions
  - Less environmental impact
- But what about effects on
  - Distraction?
  - Behaviour?
  - Road Safety?

Research question

"Is driving behaviour on motorways observably affected due to the presence of wind turbines in close proximity? "

Methodology

- One study site
- Before-and-after study design
- 3 types of analysis:
  - Analysis of driving speed (loop detector data)
  - Observed lateral lane position (video)
  - Traffic conflict observation (video)

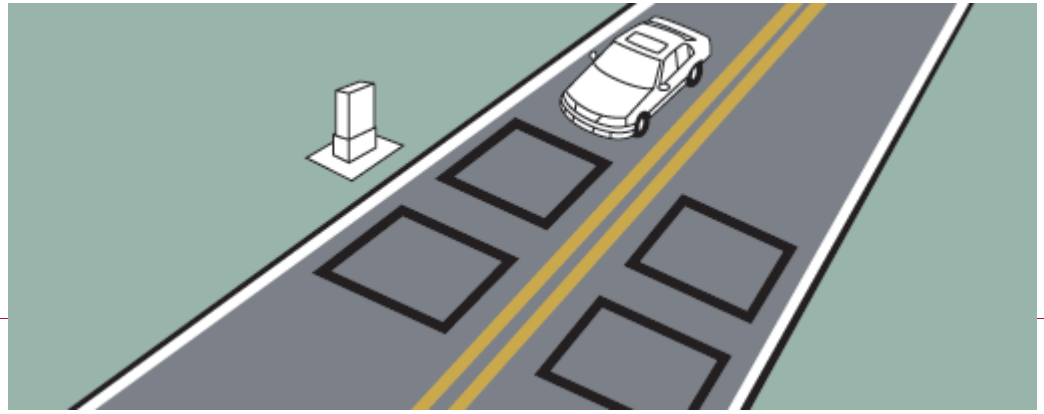
Methodology – study site

- Motorway section of N15 near Rotterdam, The Netherlands

Methodology – analysis of speed

- Inductive loop data
- 2 months before, 2 months after (2 conditions)
- Treatment sites: 5 consecutive loop detectors near the first wind turbines
- 2 comparison sites
- Only daytime data are used (6h00 – 21h59)
- Effect on mean speed and SDDS analysed
- Model form:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_1 X_2 + \varepsilon$$



Methodology – analysis of lateral position

- Temporary cameras on 3 consecutive lamp posts
  - Each covering about 200 m
  - Close to the first wind turbine
- 3 conditions:
  - No wind turbines (=before)
  - Wind turbines parallel to roadway
  - Wind turbines perpendicular to roadway

Methodology – analysis of lateral position

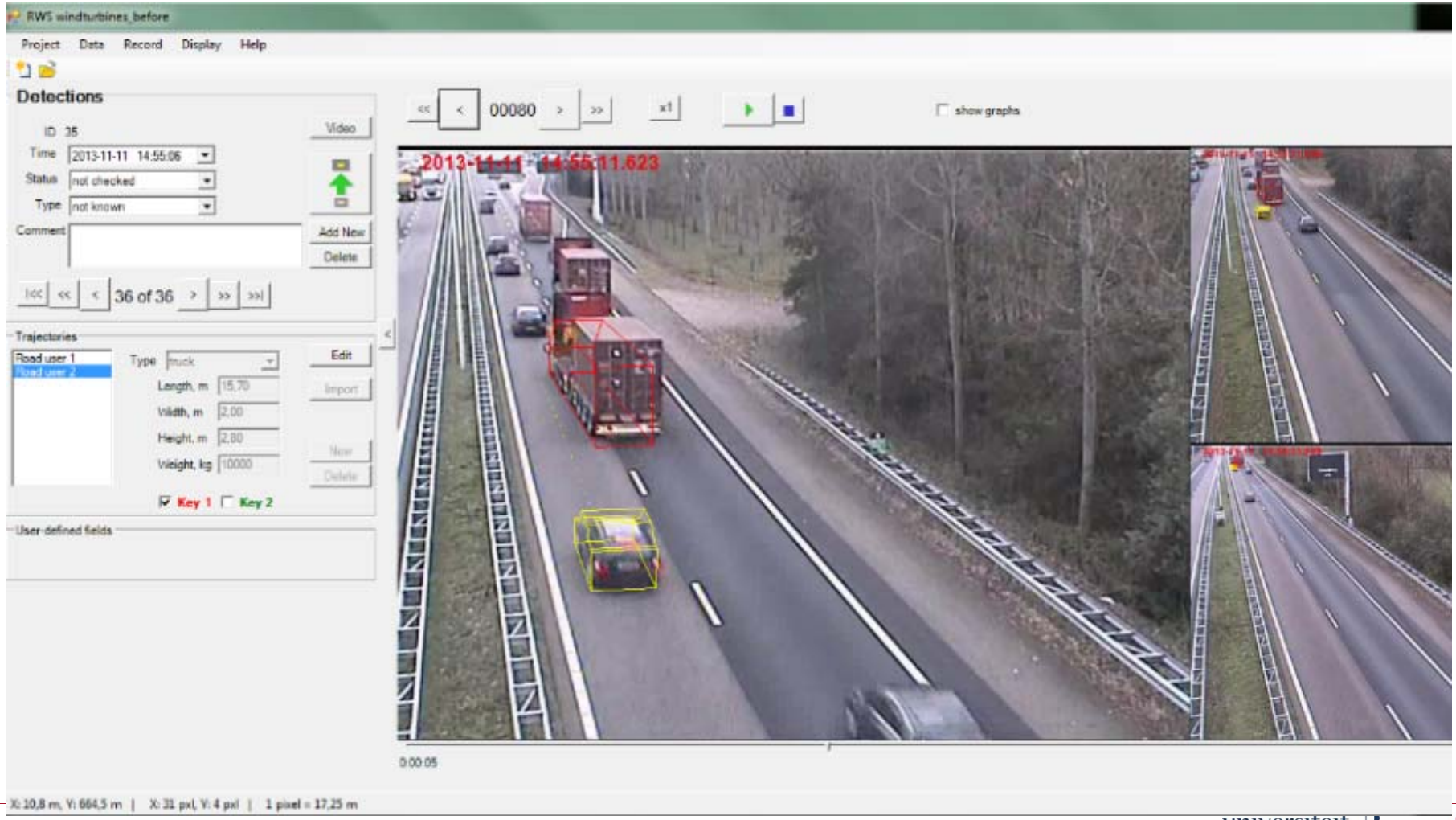
- B&A: 2x24h analysed (matched hours)
- Absolute lane position & SDLP analysed
- Lateral position of every 10th vehicle
  - 3,649 vehicles in total
- 3 measurement points (at entry of each camera view)
- Also registered:
  - Driving lane
  - Vehicle type
  - Day/night
- 2 regression models built

Methodology – analysis of traffic conflicts

- Situations considered as serious conflicts if:
  - Serious according to STCT
  - $TTC_{min} \leq 1.5s$

Methodology – video analyses

- Lateral positions & conflict severity measured using T-Analyst



Results – driving speed (mean)

	Overall effect		
	-2.24 km/h [-2.25; -2.24][1]		
Location	Mean speed before (km/h)	Mean speed after (km/h)	Evolution before-after (km/h) [95%CI]
Study site 1	99.75	99.31	**-0.44** [-0.44; -0.44]
Study site 2	99.70	98.65	**-1.05** [-1.06; -1.05]
Study site 3	99.58	98.78	**-0.79** [-0.80; -0.79]
Study site 4	100.11	98.36	**-1.75** [-1.75; -1.74]
Study site 5	98.99	97.39	**-1.60** [-1.61; -1.60]
Comparison site 1 (upstream)	95.36	96.59	**+1.23** [+1.23; +1.24]
Comparison site 2 (downstream)	107.85	110.51	**+2.29** [+2.28; +2.29]

Results – driving speed (SDDS)

Location	SDDS before (km/h)	SDDS after (km/h)	Evolution of SDDS (km/h)
Study site 1	9.24	10.57	**+1.33**
Study site 2	9.70	10.67	**+0.97**
Study site 3	9.45	10.33	**+0.88**
Study site 4	9.67	10.29	**+0.62**
Study site 5	9.86	10.07	**+0.21**
Comparison site 1 (upstream)	7.67	7.69	**+0.02**
Comparison site 2 (downstream)	11.09	9.90	**-1.19**

Results – lateral position (absolute)

Variable	p-value of variable	Category	Estimate (in meter)	S.E.	p-value of category
Constant	< 0.001		**0.847**	0.008	< 0.001
Vehicle type	< 0.001	HGV	**-0.165**	0.008	< 0.001
		Minivan	**-0.045**	0.015	0.003
		Passenger car	**0 (ref.)**		
Lane	< 0.001	Left	**-0.156**	0.009	< 0.001
		Right	**0 (ref.)**		
Time	< 0.001	Night	**-0.066**	0.015	< 0.001
		Day	**0 (ref.)**		
Condition	< 0.001	Blades parallel (after)	**-0.136**	0.009	< 0.001
		Blades perpendicular (after)	**-0.078**	0.009	< 0.001
		No turbines (before)	**0 (ref.)**		

Results – lateral position (SDLP)

Variable	p-value of variable	Category	Estimate	S.E.	p-value of category
Constant	< 0.001		**0.141**	0.003	<0.001
Vehicle type	< 0.001	HGV	**-0.027**	0.003	<0.001
		Minivan	**-0.003**	0.006	0.609
		Passenger car	**0 (ref.)**		
Lane	< 0.001	Left	**-0.020**	0.004	<0.001
		Right	**0 (ref.)**		
Time	0.011	Night	**-0.015**	0.006	0.011
		Day	**0 (ref.)**		
Condition	0.156	Blades parallel (after)	**0.001**	0.004	0.736
		Blades perpendicular (after)	**0.007**	0.004	0.057
		No turbines (before)	**0 (ref.)**		

Results – traffic conflicts

- Few situations preselected for further analysis
  - Mainly lane changing in front of approaching vehicle

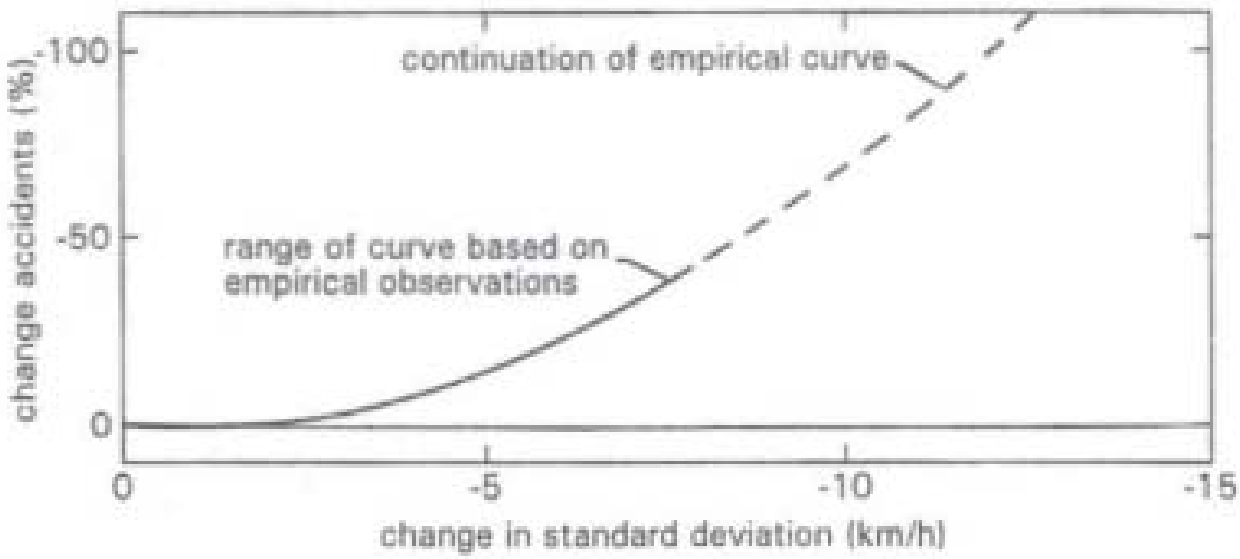
- None were serious conflicts

Discussion

- Shift in lateral position:
  - No effect on safety in itself
  - Possible indication for distraction
- SDLP:
  - Increase in SDLP is generally unfavourable for road safety
  - Limited effect (ns)

Discussion

- SDDS
  - Increase in SDDS tends to have a negative effect on road safety
  - Small increases are not expected to have an effect



Salusjärvi (1990)

Discussion

- Driving simulator study (Alferdinck et al., 2012)
  - Increase of SDDS and SDLP when turbines are located close to the motorway
  - Longer gaze
  - Slightly lower average speed
- Present results are well in line with DS study

Conclusions

- Wind turbines lead to some observable behavioural adaptations:
  - Reduction of mean speeds
  - Shift in lateral position towards the left
  - Small increases in SDLP and SDDS
- Resulting effect on safety not yet clear, although not likely to be substantial

Acknowledgement

- Study funded by the Ministry of Infrastructure and the Environment, The Netherlands.
- Content is the sole responsibility of the authors

Thank you for your attention!

Questions?