A Concise Impact Assessment of Average Speed Control

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v1.4 (26 January 2014)

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1 Introduction

In this report, we present a concise impact assessment of average speed control. The current section 1 first defines what is meant by the measure, after which we shed some light on existing literature.

The next Section 2 first discusses the characteristics of a study site in Belgium along the A10/E40 motorway. The Section also gives an overview of the various data that was collected along the road stretch. It then discusses in turn the impact on total yearly traffic volumes, on traffic throughput and capacity, on mean speeds (per vehicle type and per lane), on time gaps per lane, on traffic safety (by introducing accident data), and finally shortly on the associated costs and benefits of the system.

Our main conclusion of the concise impact assessment are reported in Section 3.

1.1 Definition of average speed control

Average speed control is a technological means to measure the space-mean speed of vehicles travelling on an entire road stretch. In contrast to typical flashers which make a point measurement, the average speed control estimates the travel time between two fixed points along a road. A vehicle's licence plate (and/or other external characteristics) is scanned (by a camera that performs intelligent image processing, ALPR[1]) at an upstream location, and again at a location further downstream which matches the vehicle. Based on the time difference between the vehicle occurring at each location, and the fixed distance between the detector sites, the system can calculate the space-mean speed of the vehicle during its traversal of the road section.

The system takes snapshots at both upstream and downstream detector locations, which are then compared for a match. If, after passing the downstream detector location, a processed vehicle is found to have been speeding, then the snapshots are sent to the police, which may result in a fine. If not, they are removed from the system after 24 hours. Note that the system can also be used to make a distinction between for example passenger cars and trucks, as the latter are restricted to a speed of 90 km/h.

The benefit of the system is that it operates 24 hours per day, 7 days per week, thereby increasing the probability of apprehension to almost 100%.

> Note that in the literature various other terminology is used. Norway for example uses "*Automatic Section Speed Control*" (ASSC), Italy calls their system "*Tutor*", Austria talks about "*Section Control*", Spains uses the phrase "*Control de velocidad en tramo*". In our report we use the terminology is "*Average speed control*"[2] ("*Trajectcontrole*" in Dutch).

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[1] ALPR = automatic licence plate recognition

[2] SafetyNet, "Speed Enforcement", Project co-financed by the European Commission, Directorate-General Transport and Energy, 16 October 2009.

1.2 A note on existing literature

Considering the existing body of literature, we note that there are not many widespread documents available that report on the impact of average speed control measures. In contrast, there is more active research in variations on the measure, examples of which are dynamic speed limits[3], cruise-control, speed harmonisation, and the like. The research mainly uses traffic flow theory and traffic flow simulation models to estimate the impact of the measures on drivers and traffic flows. Considering the impact assessment from a purely data-driven perspective, most of the relevant information comes from Norway[4] and Austria[5].

There is one study[6] for the Flemish government, Department of Mobility and Public Works, which also contains research into the impact of average speed control on speeding and accidents. The difference with our study is that the former only worked with two weeks of data (one before and one after implementation of the measure), whereas we used two full years of data on both speeds and accidents, thereby giving a higher statistical accuracy to the results.

From these latter reports we conclude that an average speed control leads to a reduction in the average speed driven on the road stretches where the measure is active. According to the study, the effects can start well before passing the upstream camera, and last until well after the downstream camera, with distances of 2 to 6 km. Some possible explanations of these effects is that the speed control cameras themselves are not directly visible, and the presence of a weigh-in-motion site which is also accompanied by clearly visible cameras leading drivers to believe that the average speed control already started at that location. In addition, the number of accidents is reduced after introduction of the measure.

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[3] Andras Hegyi and Serge Hoogendoorn, "Dynamic speed limit control to resolve shock waves on freeways – Field test results of the SPECIALIST algorithm", 13th International IEEE Annual Conference on Intelligent Transportation Systems, Portugal September 2010.
Josep Torné, "Active traffic management strategies in metropolitan freeways: Modeling and empirical assessment of dynamic speed limits", PhD dissertation, Technical University of Catalonia, October 2013.

[4] Arild Ragnøy, "Automatic section speed control: Results of evaluation", Department of Traffic Safety, Environment and Technology, Directorate of Public Roads, Norwegian Public Roads Administration, 3 January 2011.

[5] Christian Stefan, "Section control: Automatic speed enforcement in the Kaisermühlen tunnel", Austrian Road Safety Board (KfV), February 2006.

[6] Ellen De Pauw, Stijn Daniels, et al., "*Rapport Snelheidscamera's en trajectcontrole op Vlaamse autosnelwegen: Evaluatie van het effect op snelheidsgedrag en verkeersveiligheid*", Instituut voor Mobiliteit (IMOB), Universiteit Hasselt, Februari 2014.

2 Concise impact assessment

2.1 Characteristics of the study site

2.1.1 *Location of the study site*

In this impact assessment, we studied the average speed control setup along the A10/E40 in Belgium, between Brussels and Ghent, as seen in Figure 1. A closeup view in shown in Figure 2. Each time, the green dots denote the entry and exit of the average speed control zone, with blue dots denoting the locations for the traffic detectors upstream and downstream of the zone. The red dots denote the location of two flashers. Because their locations are far enough outside the study area, they do not interfere when interpretating the results from the trajectory control zone.

Figure 1: Location of the average speed control setup along the A10/E40 between Ghent and Brussels.

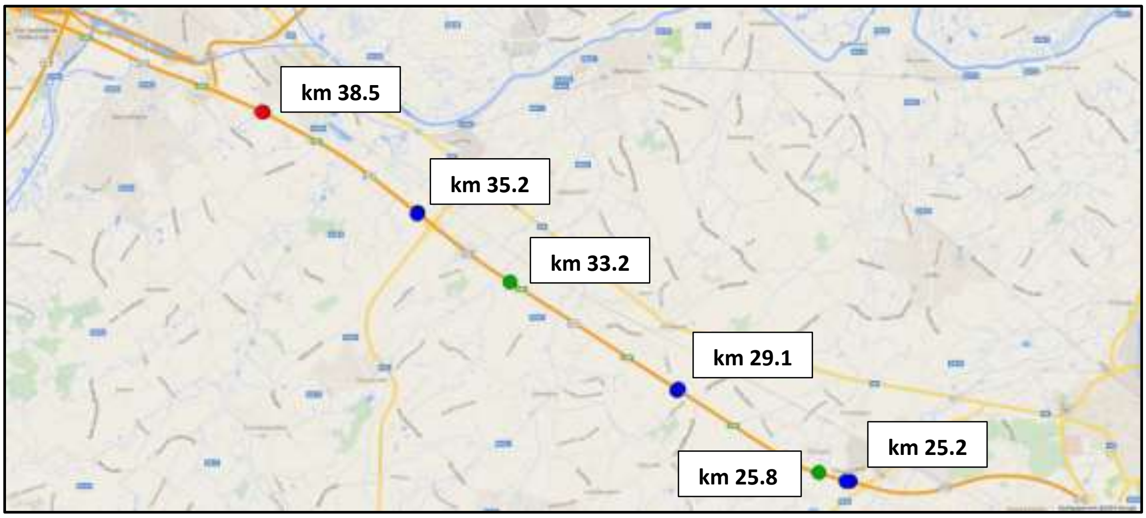

Figure 2: Closeup of the location of the average speed control setup along the A10/E40 between Ghent and Brussels.

The zone itself runs from kilometre points 25.8 until 33.2. The detectors used in this study are located at kilometre points 25.2 en 35.6 outside the zone, and 29.1 inside the zone. Each detector considers 1 lane (there are 3 lanes) in each direction separately.

2.1.2 Available traffic data

Traffic data was collected by the Flemish Traffic Centre[7] ("*Verkeerscentrum Vlaanderen*") in their datawarehouse for all 5-minute intervals:

- Between 01/02/2012 and 01/02/2013 (before implementation of the measure)
- Between 01/04/2013 and 01/04/2014 (after implementation of the measure)

There are 3,710,362 valid 5-minute records, for 3 locations x 3 lanes x 2 directions (thus corresponding to approximately 2 years of data). The data was made available by courtesy of the Flemish Region, represented by its Traffic Centre of the Department of Mobility and Public Works.

All datarecords contain the detector ID and the date-/timestamp. The detector IDs ('*meetpuntID*') correspond to the following locations:

- Wetteren (direction Ostend) → [1381 1382 1383]
- Wetteren (direction Brussels) → [1378 1379 1380]
- Trajectory control (direction Ostend) → [250 252 253]
- Trajectory control (direction Brussels) → [254 255 256]
- Erpe-Mere (direction Ostend) → [1507 1508 1509]
- Erpe-Mere (direction Brussels) → [1512 1513 1514]

We use 2 types of vehicles: cars and vans is one type, trucks and trailer-trucks is another one. For each type, we have the number of vehicles and their space-mean speed[8]. In addition, we also have the total number of vehicles, the total space-mean speed, and the total occupancy.

When calculating the total flow over C of lanes, we just sum the individual lanes up, multiplied by 12 (so they are converted into vehicles/hour). For the space-mean speed, we take the harmonic average, as follows:

$$\bar{v}_s = \sum_{c=1}^{C} q_c \Big/ \sum_{c=1}^{C} \frac{q_c}{\bar{v}_{s_c}}$$

with q_c the flow on lane c.

The average lane occupancy is found by summing all the individual lane occupancies and normalising is by dividing the result by the number of lanes.

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[7] http://www.verkeerscentrum.be/

[8] The space-mean speed of a group of N vehicles is defined as:

$$\bar{v}_s = \frac{1}{\frac{1}{N}\sum_{i=1}^{N}\frac{1}{v_i}}$$

The result of the previous calculations give rise to the combined time series of:

- Flows and space-mean speeds[9] for
  - Cars and vans
  - Trucks and trailer trucks
  - All vehicles combined
- Average lane occupancy

All measurements were grouped before and after implementation of the average speed control measure, per direction separately.

The number of records per measurement period amounts to approximately 100,000 blocks, each time denoting 5 minutes, corresponding to some 100,000 ÷ (60 ÷ 5) = 8,333 hours ~ 347 days which is approximately 1 year of data for each measurement period.

Figure 3 gives an example of the time series for the detector in the zone of the average speed control, in the direction of Brussels, after implementation of the measure. Figure 4 gives a closeup of some of the datapoints. Time series for all the other detectors can be found in Appendix A.

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[9] The space-mean speed is defined as the total distance travelled by all the vehicles in the measurement region, divided by the total time spent in this region. It can be obtained by harmonically averaging the vehicles' spot speeds recorded at the various detector locations.

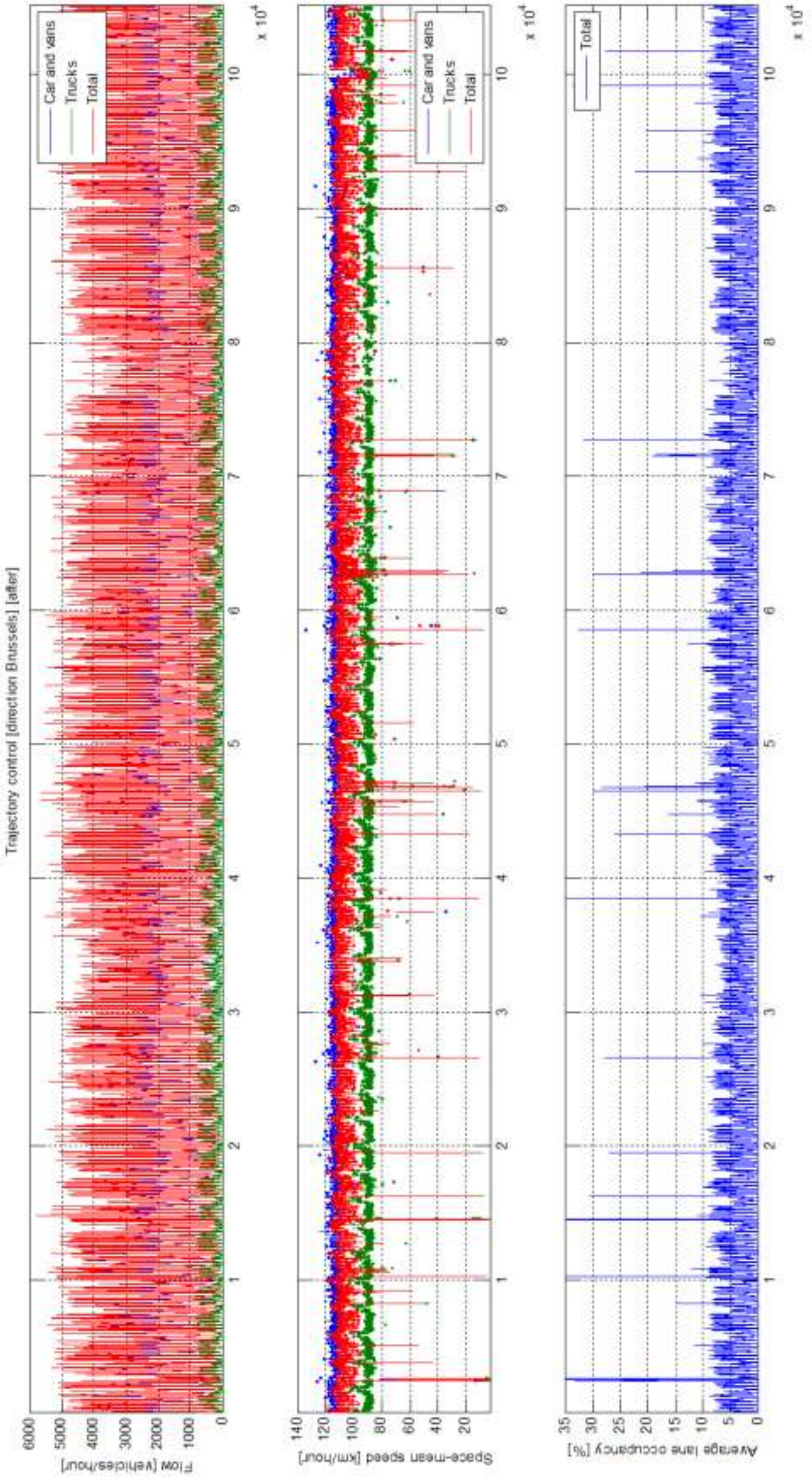

Figure 3: Example time series of the detector within the zone of average speed control.

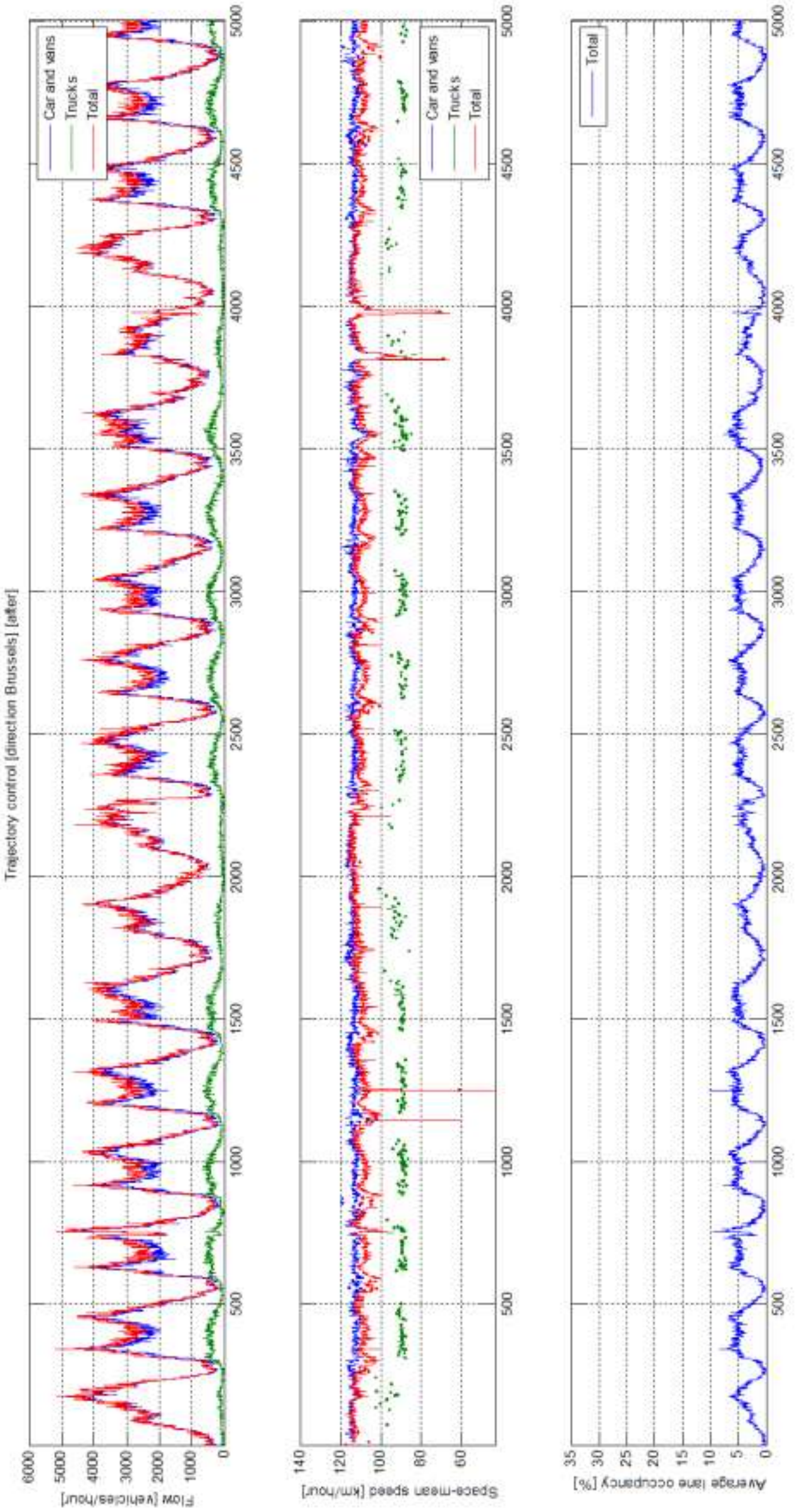

Figure 4: Closeup view on the time series of the detector within the zone of average speed control.

2.1.3 *Check for structural congestion*

Given the amount of structural congestion in Flander's motorways, we first check the state of the study site at various times during the day. The graphs below represent structural congestion[10] based on historical traffic data from 2011. The light red lines denote congestion on 1 to 2 days per working week, the dark red lines denote congestion on 2 to 3 days per working week, and finally the black lines denote congestion on more than 3 days per working week.

 6h30	 6h45	 7h00
 7h15	 7h30	 7h45
 8h00	 8h15	 8h30
 8h45	 9h00	 9h15
 9h30	 9h45	 10h00

As can be seen from the graphs, there is no structural congestion present during the morning rush hour on the motorway stretch containing the average speed control zone, nor in its direct vicinity. There is also no structural congestion recorded during the evening rush hour.

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[10] See http://www.verkeerscentrum.be/verkeersinfo/structurele-file-2011

2.2 Estimation of the impact

2.2.1 Impact on total yearly traffic volumes

Given the three detector locations, we first looked at the total volume of traffic during an entire year, both before and after implementation of the measure, resulting in the observation shown in Figure 5:

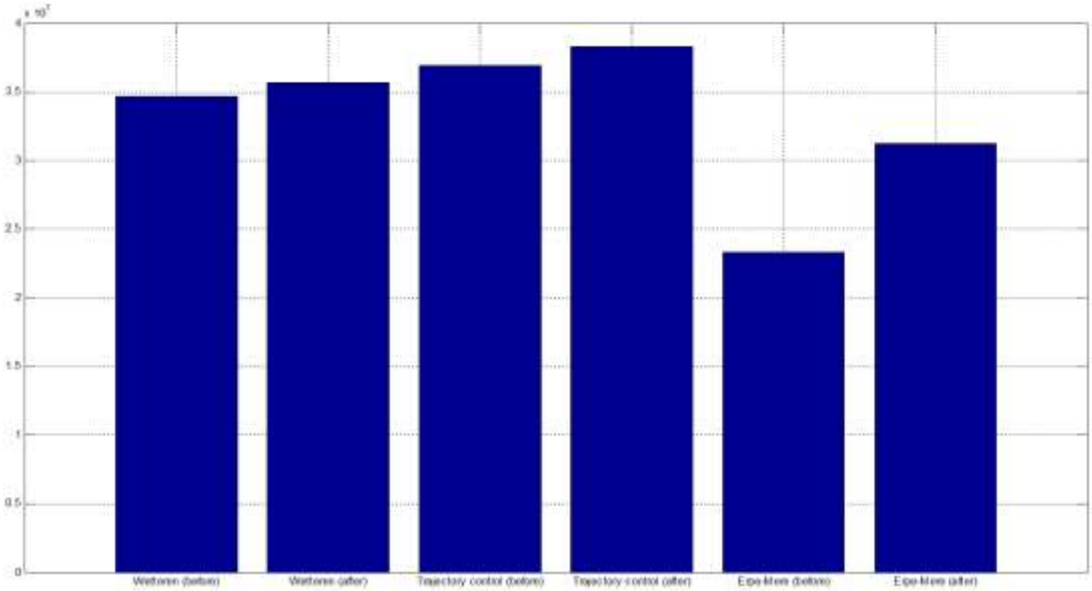

Figure 5: Total traffic volumes measured at the detector locations before and after implementation of the measure.

Here we see that all detectors measured an increase in the number of vehicles; in Wetteren the increase is about 3%, within the average speed control zone it is about 4%, and in Erpe-Mere we see an increase of some 34%. For reference, we also looked at the number of validated records within the traffic database; the corresponding increases are about 0%, 0%, and 30%. It appears that the difference is attributed to missing records for the detector of Erpe-Mere in the direction of Brussels, as shown in the following Table:

Detector complex	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Wetteren (dir. Ostend)	Before	26784	24615	26202	25920	26784	25920	26784	26784	25920	26748	25919	26784	**315164**
	After	26784	24189	26748	25893	26784	25920	26784	26784	25920	26784	25920	26784	**315294**
Wetteren (dir. Brussels)	Before	26784	24615	26202	25920	26784	25919	26784	26784	25920	26748	25920	26784	**315164**
	After	26784	24189	26748	25893	26784	25919	26784	26784	25920	26784	25920	26784	**315293**
Trajectory control (dir. Ostend)	Before	26784	25017	26748	25920	26784	25920	26784	26784	25920	26745	25920	26784	**316110**
	After	26784	24191	26747	25920	26783	25920	26784	26784	25910	26759	25920	26784	**315286**
Trajectory control (dir. Brussels)	Before	26784	25017	26748	25920	26783	25919	26784	26784	25919	26745	25920	26784	**316107**
	After	26784	24192	26748	25920	26784	25920	26784	26784	25911	26760	25920	26784	**315291**
Erpe-Mere (dir. Ostend)	Before	26784	25047	26748	21811	21037	25913	26781	26770	25916	26706	25920	26784	**306217**
	After	26784	24192	26746	25920	26784	25919	26775	26768	25889	26734	25919	26784	**315214**
Erpe-Mere (dir. Brussels)	Before	0	25050	26748	25920	26783	25920	3540	0	0	0	0	0	**133961**
	After	26784	24192	26748	6007	1836	14421	26784	26784	25920	26772	25920	26784	**258952**

These missing records were expected, as we are only working with validated original data (as opposed to a fully statistically reconstructed dataset).

In Figure 6 we show the detector volumes, but this time corrected for the discrepancy in validated records:

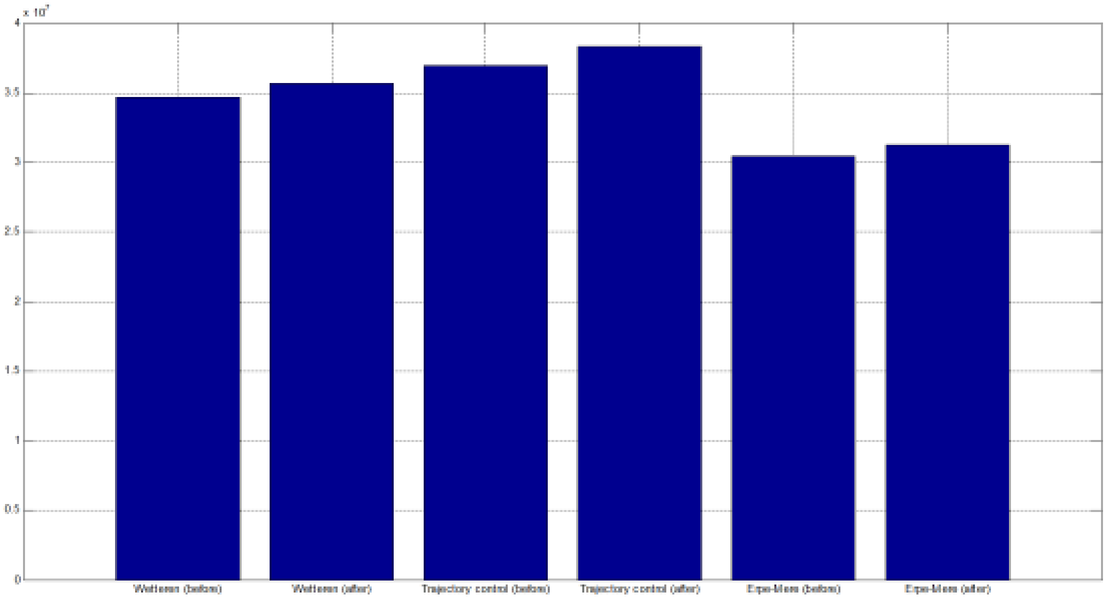

Figure 6: Overview of traffic volumes corrected by the number of records in the database.

Based on this, we conclude that <u>the slight increases are not significant</u> and are probably not related the introduction of the measure but rather to the increase in traffic demand. We obtain a similar picture looking at the trend of travelled distances on motorways in Flanders[11], as shown in Figure 7:

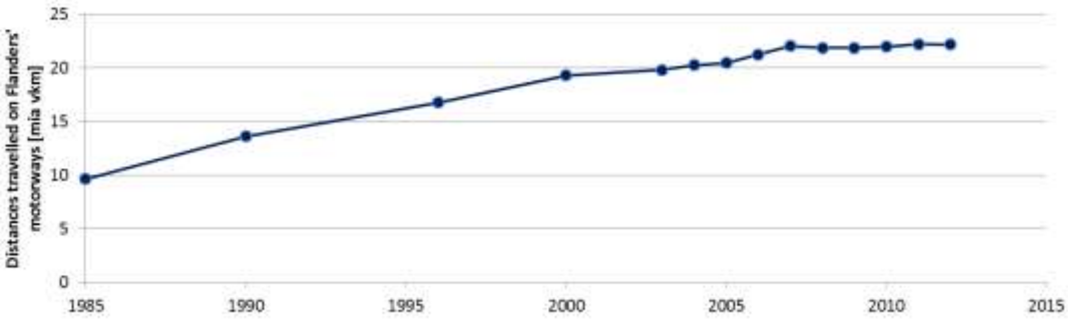

Figure 7: Distances travelled on Flanders' motorways (expressed in milliard vehicle kilometres).

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[11] See http://statbel.fgov.be/nl/statistieken/cijfers/verkeer_vervoer/verkeer/afstand/#.VD446vmSxqU

2.2.2 *Impact on traffic throughput and capacity*

Important information on the effect of the average speed control measure is revealed when looking at the fundamental diagrams of the total flow versus the space-mean speed. In these diagrams, the blue circles denote measurements of cars and vans, the red crosses those of light and heavy trucks, and the black dots those of the combined average traffic. The solid green horizontal line represents the speed limit of 120 km/h, with the dashed blue, red, and black horizontal lines representing the median speed of cars and vans, light and heavy trucks, and combined average traffic, respectively.

These diagrams typically show a dense cloud of measurements near their tops, representing traffic that is travelling fast (above 100 km/h) at all ranges of observed flows. The curved branches each time to the right and bottom in the diagrams denote congested regions, where the average speed is dropping below the free-flow speed of unimpeded traffic. As there are significantly less trucks than cars, the red crosses are typically located to the far-left in a region of low flows, at a lower average speed than those of the cars.

Going in the direction of Ostend, we first encounter the detectors at Erpe-Mere, then the ones inside the average speed control zone, and finally the ones at Wetteren, as shown in Figure 8, Figure 9, and Figure 10, respectively.

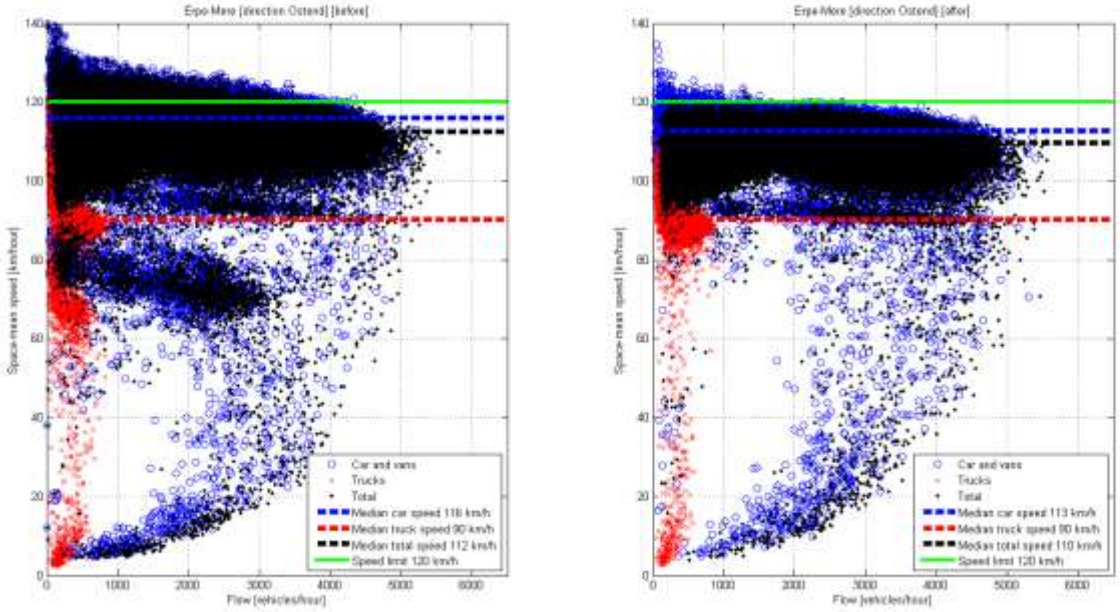

Figure 8: Fundamental diagrams (flow,space-mean speed) for the detectors at Erpe-Mere in the direction of Ostend.

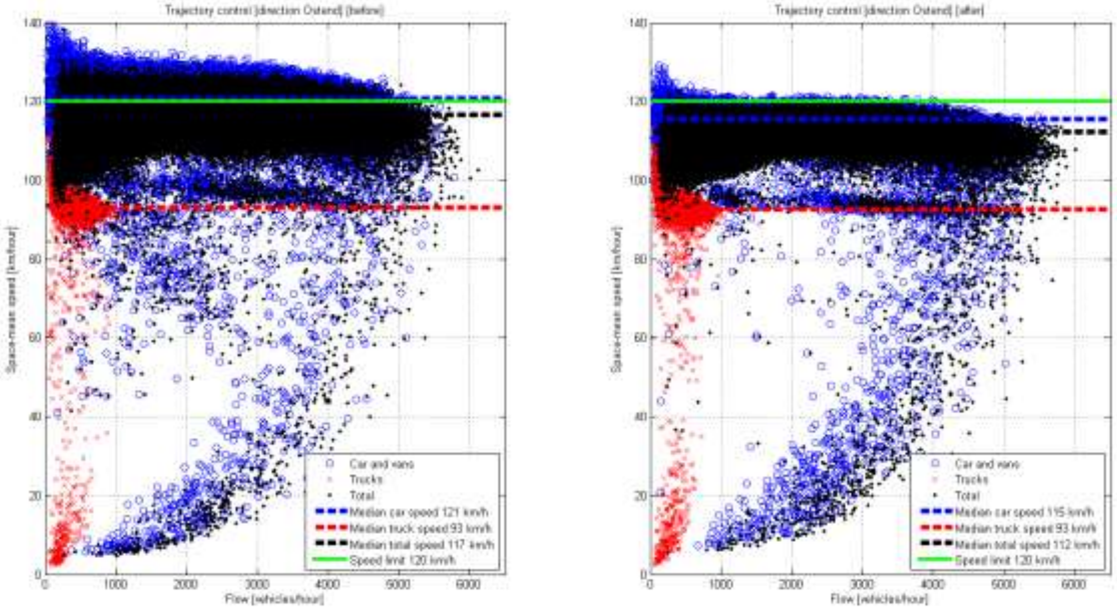

Figure 9: Fundamental diagrams (flow,space-mean speed) for the detectors inside the average speed control zone in the direction of Ostend.

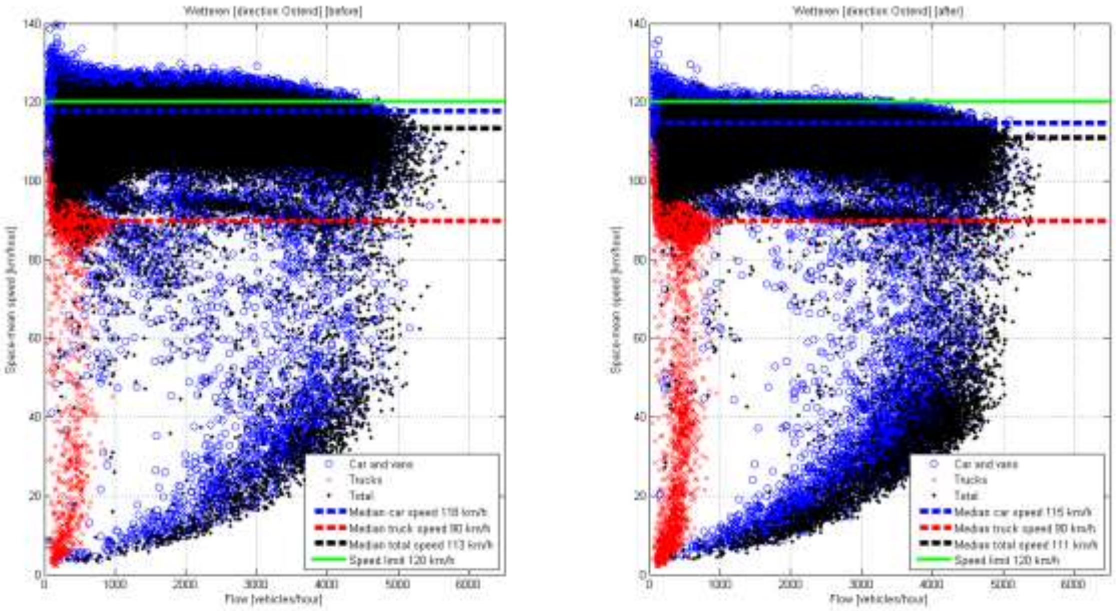

Figure 10: Fundamental diagrams (flow,space-mean speed) for the detectors at Wetteren in the direction of Ostend.

Going in the direction of Brussels, we conversely first encounter the detectors at Wetteren, then the ones inside the average speed control zone, and finally the ones at Erpe-Mere, as shown in Figure 11, Figure 12, and Figure 13, respectively.

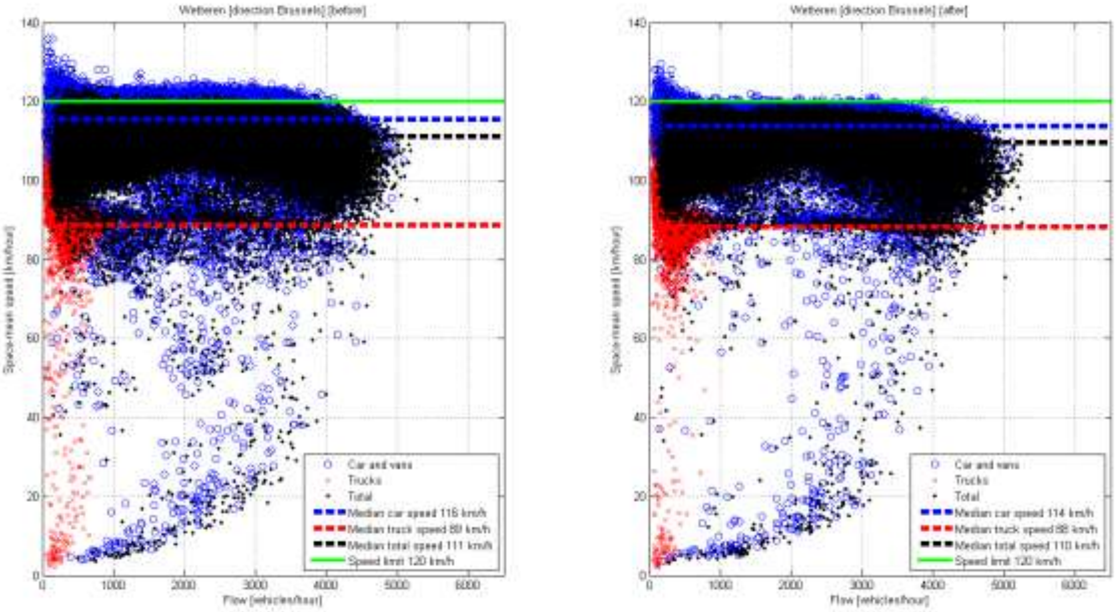

Figure 11: Fundamental diagrams (flow,space-mean speed) for the detectors at Wetteren in the direction of Brussels.

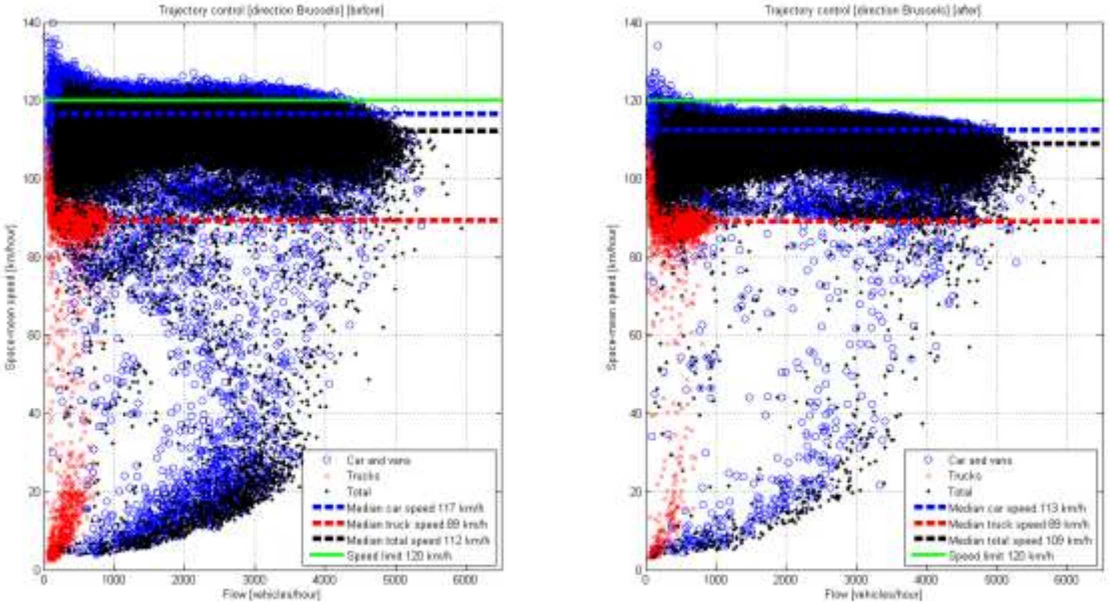

Figure 12: Fundamental diagrams (flow,space-mean speed) for the detectors inside the average speed control zone in the direction of Brussels.

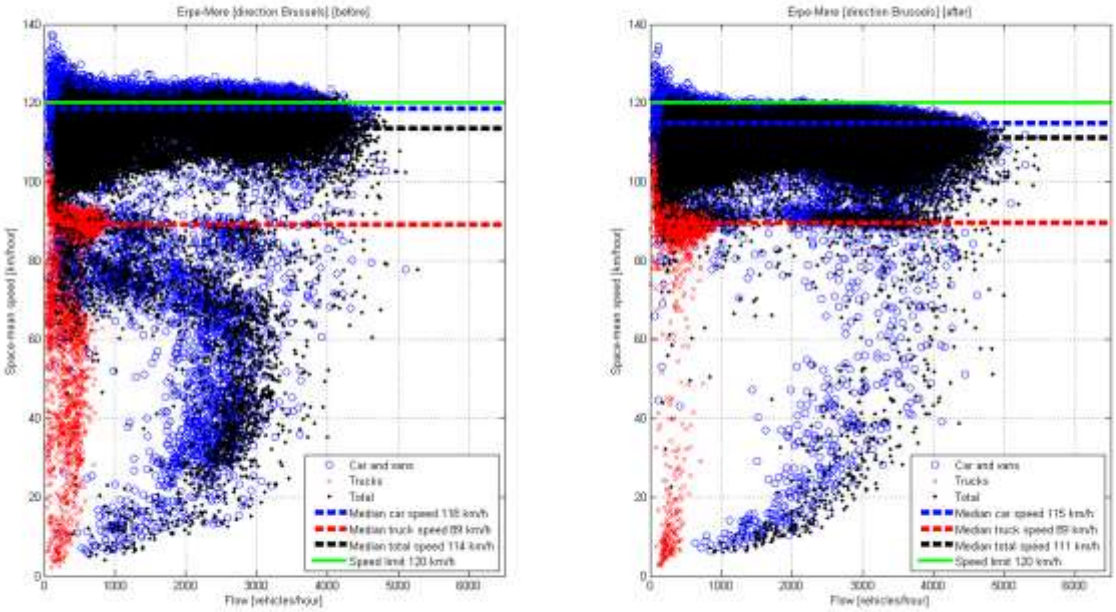

Figure 13: Fundamental diagrams (flow,space-mean speed) for the detectors at Erpe-Mere in the direction of Brussels.

In general, we see that the average speed of cars and vans is lowered through the implemented measure (dashed blue lines), whereas the average speed of trucks remains unchanged (dashed red lines). As a result, the average speed of traffic is lowered (dashed black lines). Note that these observations are not only encountered within the zone of the average speed control, but also at the other detector locations. This is also further elaborated upon in Section 0.

Looking at the upper-right tails of the diagrams, we see that the average speed control measure apparently has <u>no influence on the capacity of the road</u>. At all detector locations the outermost-right points remain invariant, albeit a bit lower. The most probable conclusion is that over-capacity is never reached with traffic volumes before and after implementation of the measure.

Note that there are also points in the 'bellies' of the diagrams; these denote moments when lower volumes of traffic were travelling at lower-than-normal speeds. They are however not significant relative to the total volumes of traffic, as can be seen in the example in Figure 14 with a heatmap for the location inside the average speed control zone in the direction of Brussels, before implementation of the measure. The red regions are associated with high probabilities of observing a certain average speed at a certain traffic volume, the green and blue regions with lower probabilities, respectively (the dashed red horizontal line denotes the 120 km/h speed limit). From the previous diagrams we observe that these belly-points tend to disappear after introduction of the average speed control measure. This is probably an indirect stabilisation effect of having less accidents during low-flow conditions (see also Section 2.2.6).

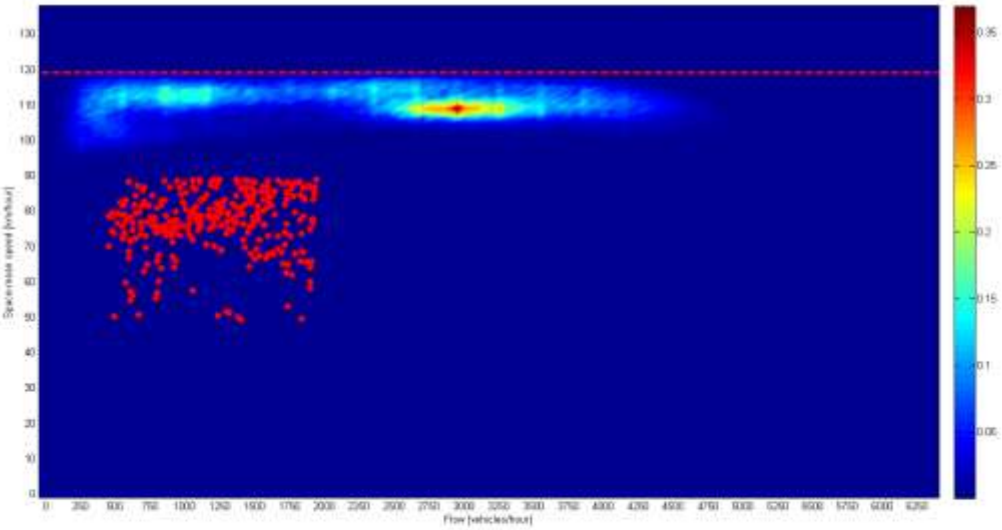

Figure 14: Example heatmap of the fundamental diagram at the location inside the average speed control zone in the direction Brussels, before implementation of the measure.

Figure 14 also contains some example measurements from the belly, denoted with red dots. These denote observations of low flows (between 500 and 2000 vehicles per hour), with an associated lower average traffic speed (between 50 and 90 km/h). Closer investigation yields for example that 19 of these points all occurred on Monday 02/07/2012. The time series in Figure 15 show us that this is an isolated event with low average speeds, probably due to road works.

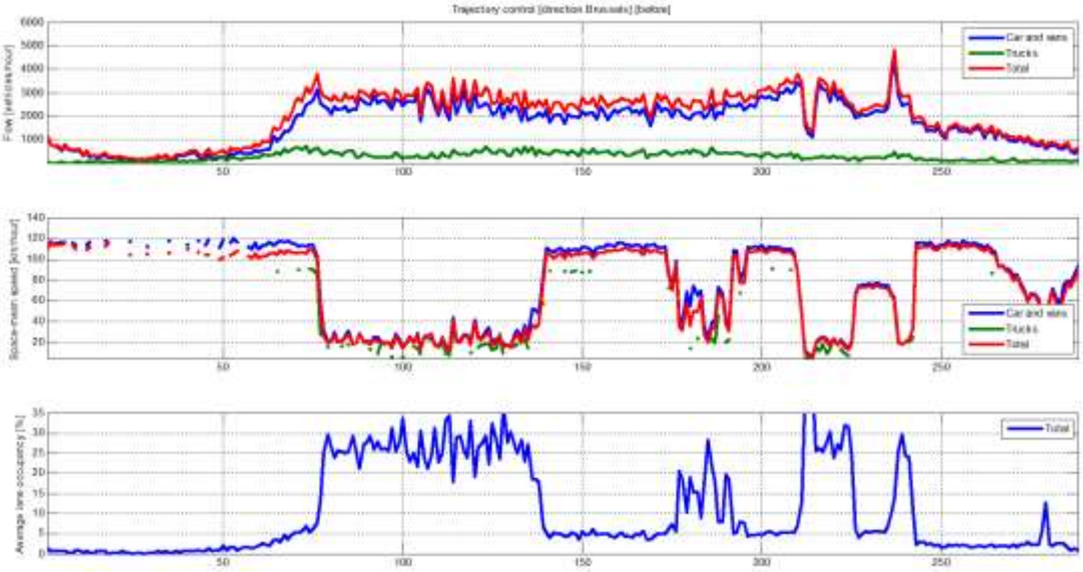

Figure 15: Time series for the detectors inside the average control zone in the direction of Brussels, measured at Monday 2 July 2012.

Even though these points appear to be statistically not significant, we feel it would we worthwhile to investigate such 'tail events' in more detail, as they can lead to more refined insights into the effects of the average speed control measure.

2.2.3 *Impact on mean speeds per vehicle type*

Looking at the average speed of traffic before and after implementation of the average speed control measure, we obtain the probability distributions in Figure 16, Figure 17, and Figure 18, for the detectors located at Erpe-Mere, inside the zone, and Wetteren, respectively. Each time, the blue curves denote cars and vans, red curves denote light and heavy trucks, and the black curves denote the combined average traffic. The dashed and solid curves each time denote the situation before and after implementation of the measure, respectively.

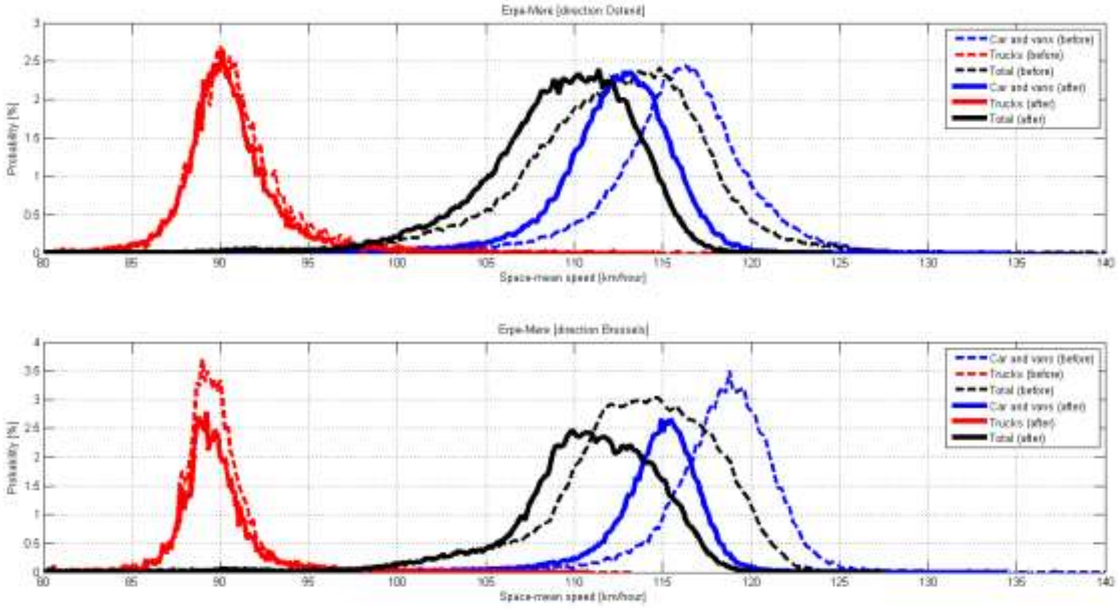

Figure 16: Probability distributions of the average speeds observed at the detectors in Erpe-Mere.

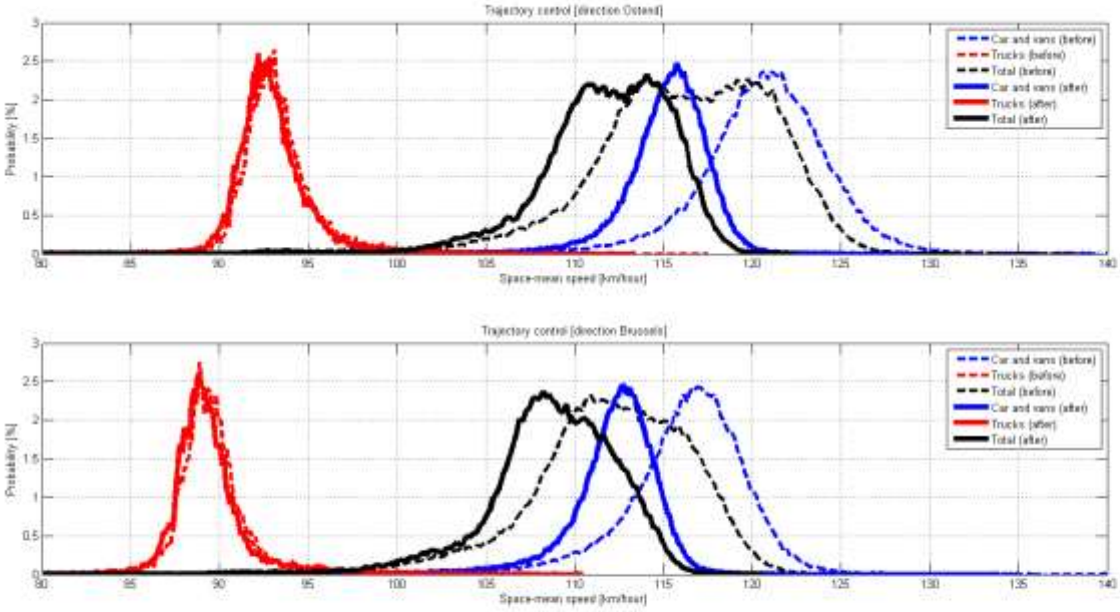

Figure 17: Probability distributions of the average speeds observed at the detectors inside the average speed control zone.

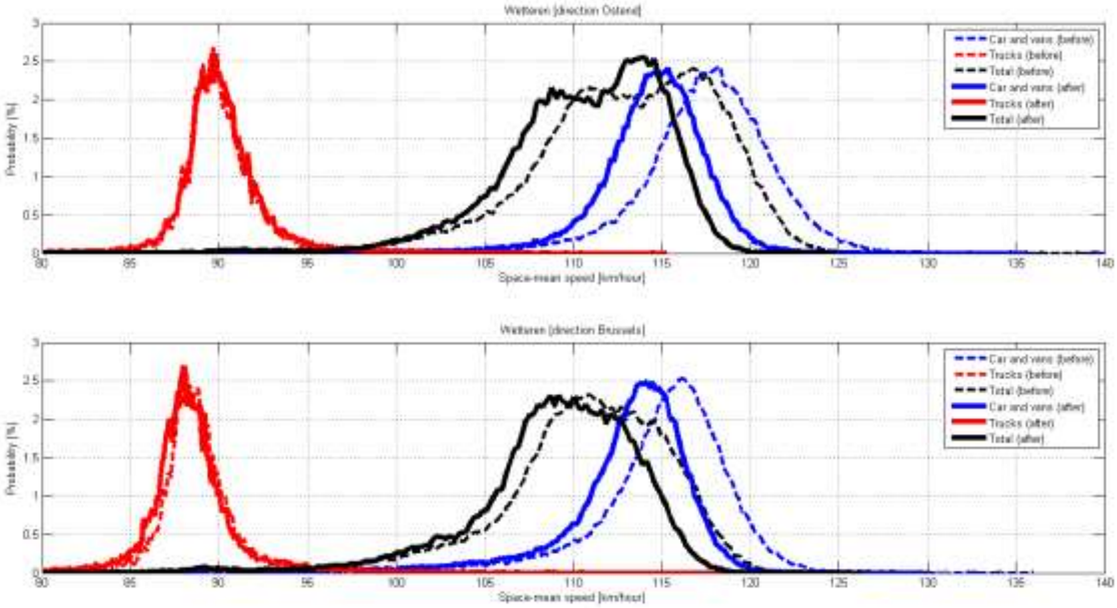

Figure 18: Probability distributions of the average speeds observed at the detectors in Wetteren.

The following Tables represent the summary information (using the median average speed), each time indicating the absolute and relative difference between after and before implementation of the measure.

Median speeds	Erpe-Mere				Trajectory control				Wetteren			
Direction Ostend	**Before**	**After**	**Difference**		**Before**	**After**	**Difference**		**Before**	**After**	**Difference**	
Median car speed	115.93	112.61	-3.33	-2.9%	120.80	115.43	-5.38	-4.5%	117.67	114.58	-3.09	-2.6%
Median truck speed	90.27	90.18	-0.10	-0.1%	92.94	92.68	-0.26	-0.3%	89.71	89.70	-0.01	0.0%
Median total speed	112.45	109.60	-2.85	-2.5%	116.51	112.12	-4.39	-3.8%	113.37	110.90	-2.47	-2.2%

Median speeds	Wetteren				Trajectory control				Erpe-Mere			
Direction Brussels	**Before**	**After**	**Difference**		**Before**	**After**	**Difference**		**Before**	**After**	**Difference**	
Median car speed	115.54	113.64	-1.89	-1.6%	116.56	112.52	-4.04	-3.5%	118.44	114.92	-3.52	-3.0%
Median truck speed	88.54	88.19	-0.35	-0.4%	89.31	89.08	-0.23	-0.3%	89.16	89.44	0.28	0.3%
Median total speed	111.09	109.54	-1.54	-1.4%	112.19	108.95	-3.23	-2.9%	113.61	111.04	-2.56	-2.3%

Concluding we state that the average speed drops the most inside the average speed control zone, with about 4.5% and 3.5% in the directions of Ostend and Brussels, respectively. The drop in speed is only noticed with the cars and vans, and not for the trucks (these latter are already speed limited by design).

Interestingly, we also see that in the direction of Ostend the speed already drops at Erpe-Mere, which is before the average speed control zone. Conversely, the speed drop is lower in the other direction towards Brussels at Wetteren. A possible reason for this observed behaviour is that the detectors in the direction of Ostend lie right next to the sign that announces the average speed control, as can be seen in Figure 19.

Map data © 2014 Google (Aug/14)

Figure 19: Location of the detectors in the vicinity of the sign that announces the average speed control zone.

Additionally, there is also the vicinity of a weigh-in-motion installation, which might cause drivers to slowdown as they expect that the average speed control measure is already in effect at that location (as the site is equipped with clearly visible cameras).

Furthermore, we also observe that the speed still drops after the average speed control zone, near Wetteren and Erpe-Mere in the directions of Ostend and Brussels, respectively. This behaviour is likely to be attributed to a short-distance halo-effect of the measure[12]. The effect is slightly more pronounced in the direction of Brussels.

Another effect of the average speed control measure is that it reduces speed variations among traffic participants. This can clearly be seen in the following summary Tables, where the deviations in speeds of passenger cars and vans inside the average speed control zone drop with some 30% and 24% in the directions of Ostend and Brussels, respectively. Note that for the estimation of the speed variations, we only looked at observed speeds above 90 km/h for passenger cars and vans, and above 80 km/h for light and heavy trucks.

Speed deviations	**Erpe-Mere**				**Trajectory control**				**Wetteren**			
Direction Ostend	**Before**	**After**	**Difference**		**Before**	**After**	**Difference**		**Before**	**After**	**Difference**	
Std car speed (> 90)	4.32	3.64	-0.69	-15.9%	4.20	2.94	-1.25	-29.9%	4.24	3.58	-0.66	-15.5%
Std truck speed (> 80)	3.69	2.41	-1.28	-34.6%	2.06	2.06	0.00	0.1%	2.14	2.36	0.22	10.2%
Std total speed (> 90)	5.13	4.19	-0.94	-18.3%	5.04	3.74	-1.30	-25.8%	5.15	4.39	-0.76	-14.7%

Speed deviations	**Wetteren**				**Trajectory control**				**Erpe-Mere**			
Direction Brussels	**Before**	**After**	**Difference**		**Before**	**After**	**Difference**		**Before**	**After**	**Difference**	
Std car speed (> 90)	3.50	3.45	-0.05	-1.4%	3.92	2.98	-0.94	-24.0%	4.47	4.07	-0.39	-8.8%
Std truck speed (> 80)	2.11	2.52	0.42	19.7%	2.40	2.64	0.24	10.0%	2.84	2.90	0.06	2.1%
Std total speed (> 90)	4.56	4.12	-0.43	-9.5%	4.55	3.69	-0.86	-18.9%	4.75	4.35	-0.40	-8.5%

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[12] In general, automatic speed enforcement effects are limited in terms of both time and space. 'Time halo' can be defined as the length of time that the effects of enforcement on drivers' speed behaviour continue after the enforcement operations have been ended. 'Distance halo' is defined as the distance over which the effects of an enforcement operation last after a driver passed the enforcement site.
See also http://erso.swov.nl/knowledge/content/21_speed_enforcement/time_and_distance_halo_effects.htm and SafetyNet, "Speed Enforcement", Project co-financed by the European Commission, Directorate-General Transport and Energy, 16 October 2009.

2.2.4 Impact on mean speeds per lane

Whereas the previous Section 2.2.3 analysed the mean speeds of individual vehicle types for all lanes combined, we now look at the average speed of traffic per lane separately, before and after implementation of the average speed control measure. This results in the probability distributions in Figure 20, Figure 21, and Figure 22, for the detectors located at Erpe-Mere, inside the zone, and Wetteren, respectively. Each time, the blue curves denote right lane, red curves denote middle lane, and the black curves denote left lane. The dashed and solid curves each time denote the situation before and after implementation of the measure, respectively.

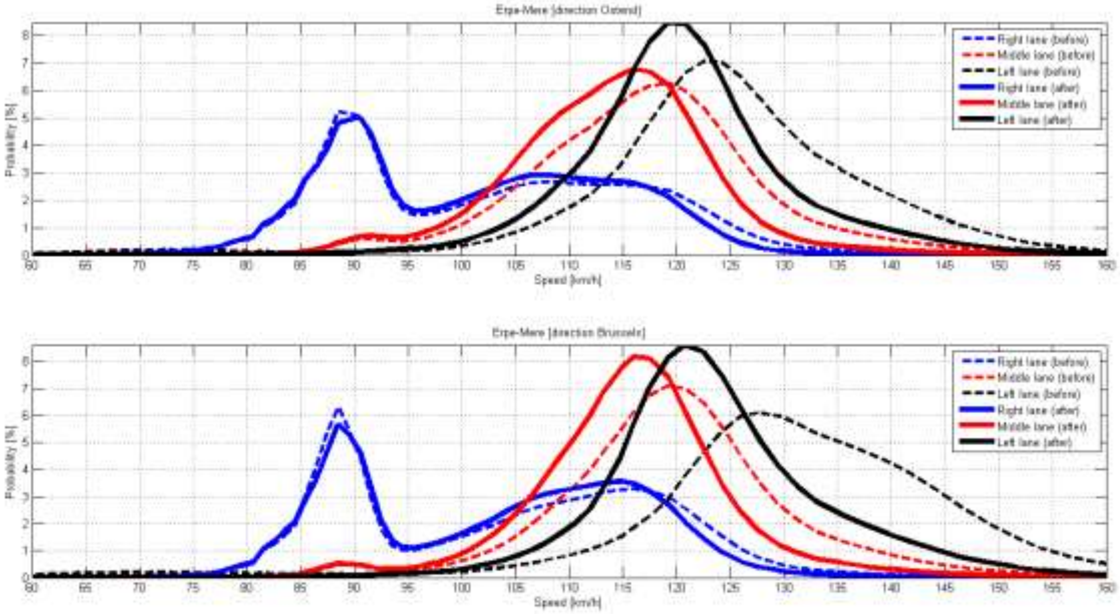

Figure 20: Probability distributions of the average speeds per lane observed at the detectors in Erpe-Mere.

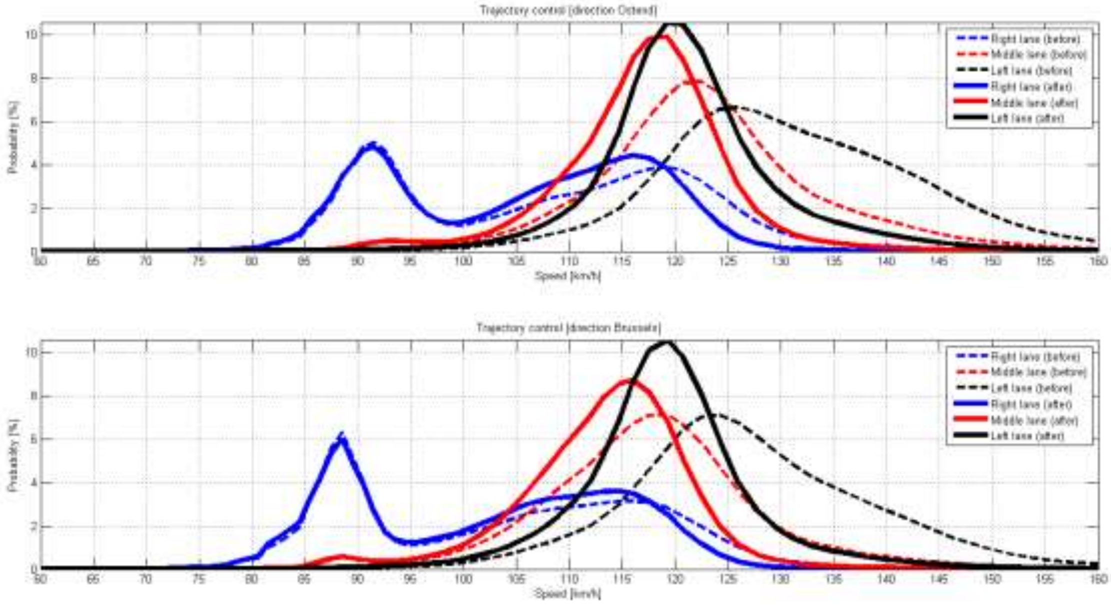

Figure 21: Probability distributions of the average speeds per lane observed at the detectors inside the average speed control zone.

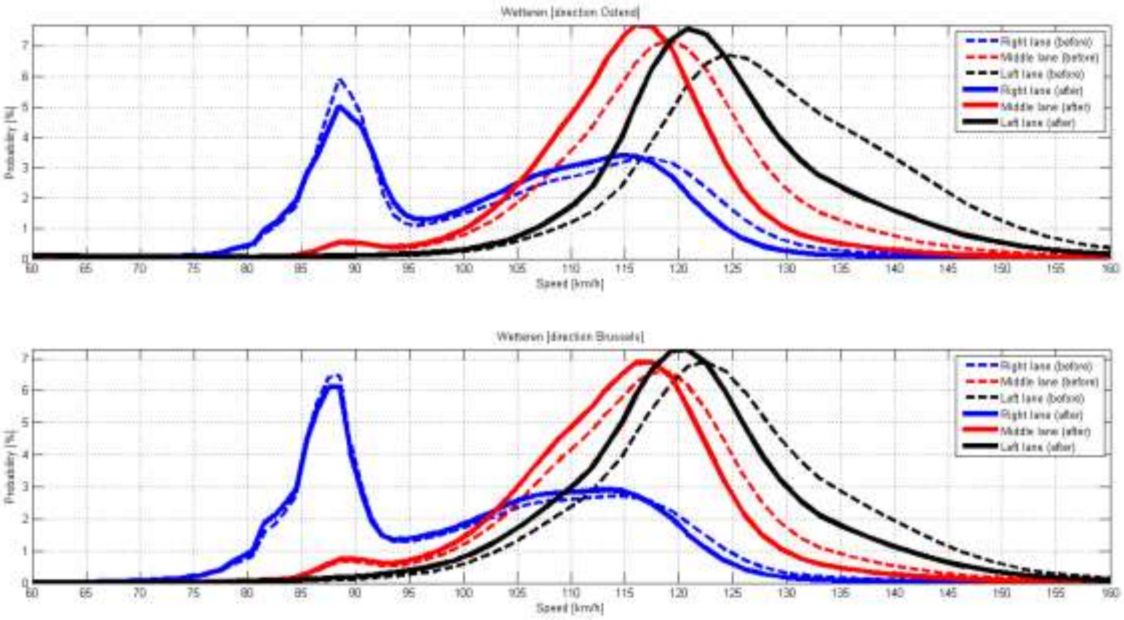

Figure 22: Probability distributions of the average speeds per lane observed at the detectors in Wetteren.

The following Tables represent the summary information, each time indicating the absolute and relative difference between after and before implementation of the measure.

Direction Ostend	Before			After			Difference					
Location	**Left**	**Middle**	**Right**	**Left**	**Middle**	**Right**	**Left**	**Middle**	**Right**	**Left**	**Middle**	**Right**
Erpe-Mere	122.5	119.3	88.5	119.3	116.0	90.5	-3.3	-3.3	2.0	-2.7%	-2.7%	2.3%
Trajectory control zone	126.0	122.5	91.5	119.3	119.3	91.5	-6.8	-3.3	0.0	-5.4%	-2.7%	0.0%
Wetteren	124.3	119.3	88.5	120.8	116.0	88.5	-3.5	-3.3	0.0	-2.8%	-2.7%	0.0%

Direction Brussels	Before			After			Difference					
Location	**Left**	**Middle**	**Right**	**Left**	**Middle**	**Right**	**Left**	**Middle**	**Right**	**Left**	**Middle**	**Right**
Wetteren	122.5	119.3	88.5	120.8	117.5	88.5	-1.8	-1.8	0.0	-1.4%	-1.5%	0.0%
Trajectory control zone	124.3	119.3	88.5	119.3	116.0	88.5	-5.0	-3.3	0.0	-4.0%	-2.7%	0.0%
Erpe-Mere	127.8	119.3	88.5	120.8	116.0	88.5	-7.0	-3.3	0.0	-5.5%	-2.7%	0.0%

As seen in the Tables, there is virtually no effect on speeds in the right lane, as it is mostly dominated by the slower moving light and heavy trucks (and shown in Section 2.2.3). Additionally, the distribution of speeds observed in the right lane is double peaked (as shown in the previous Figures): one very pronounced peak related to lower speeds (mostly attributable to trucks because there is virtually no congestion inside the trajectory control zone), and one quite broad related to higher speeds. The latter is typically associated with right-driving passenger cars in low-flow conditions. In the middle lane, the speed drops with about 3%.

The speed in the left lane experiences the most effect from the average speed control measure: in the zone itself in the direction of Ostend, the average speed drops from 126 km/h to some 119 km/u, corresponding to a drop of over 5%. In the direction of Brussels the highest speeds are initially recorded downstream at the complex in Erpe-Mere (almost 128 km/h). Here, the measure leads to a significant drop of almost 6%.

2.2.5 Impact on time gaps per lane

With each vehicle passing by, a detector records the time between successive vehicles. Counting the bumper-to-bumper time gives us the time gap, as shown in the time-space diagram[13] of Figure 23.

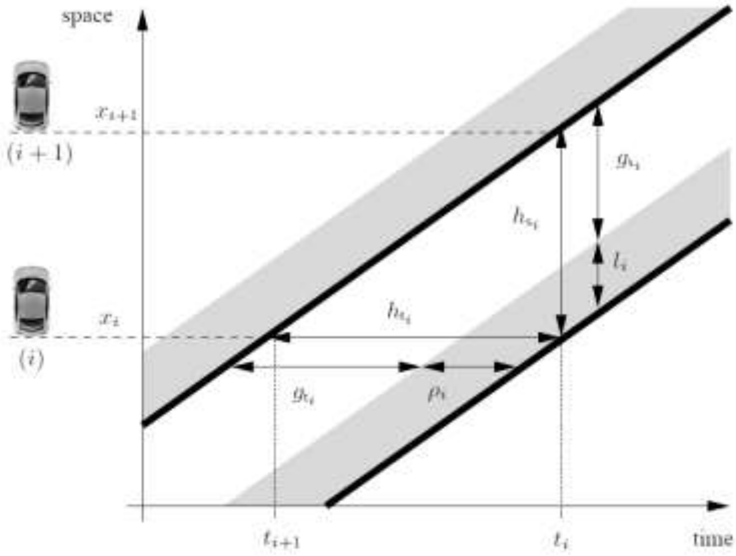

Figure 23: A time-space diagram showing two vehicle trajectories i and i + 1, as well as the space and time headway h_{si} and h_{ti} of vehicle i. Both headways are composed of the space gap g_{si} and the vehicle length l_i, and the time gap g_{ti} and the occupancy time ρ_i, respectively. The time headway can be seen as the difference in time instants between the passing of both vehicles, respectively at t_{i+1} and t_i.

Similar to Section 2.2.4, we now analyse the time gaps per lane separately, before and after implementation of the average speed control measure. This results in the probability distributions in Figure 24, Figure 25, and Figure 26, for the detectors located at Erpe-Mere, inside the zone, and Wetteren, respectively. Each time, the blue curves denote right lane, red curves denote middle lane, and the black curves denote left lane. The dashed and solid curves each time denote the situation before and after implementation of the measure, respectively.

Note that original data of the probability distributions contained an error in sampling. To remediate this, we smoothed the probability distributions with a symmetric filter (using a homothesis), thereby keeping their shapes intact.

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[13] Sven Maerivoet, “Modelling Traffic on Motorways”, Chapter 2 (Traffic flow theory), PhD dissertation, KU Leuven, June 2006.

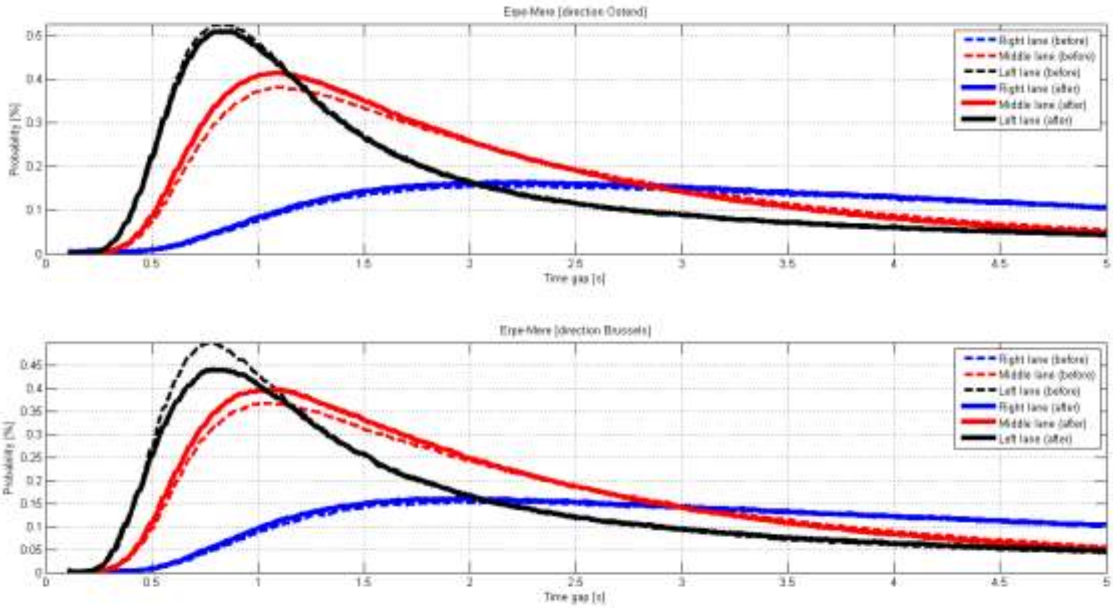

Figure 24: Probability distributions of the time gaps observed at the detectors in Erpe-Mere.

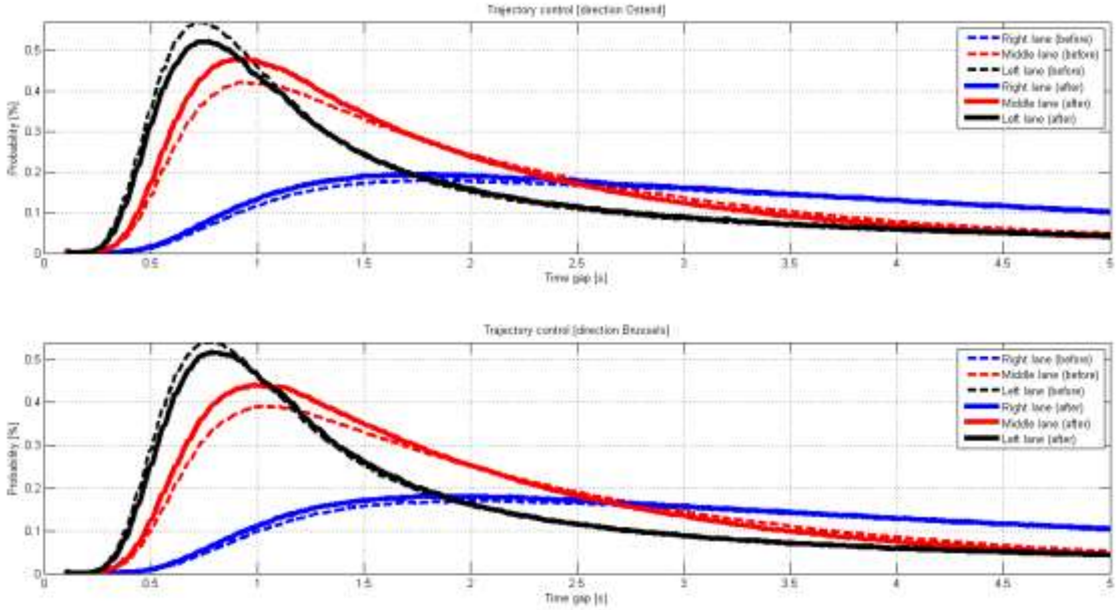

Figure 25: Probability distributions of the time gaps observed at the detectors inside the average speed control zone.

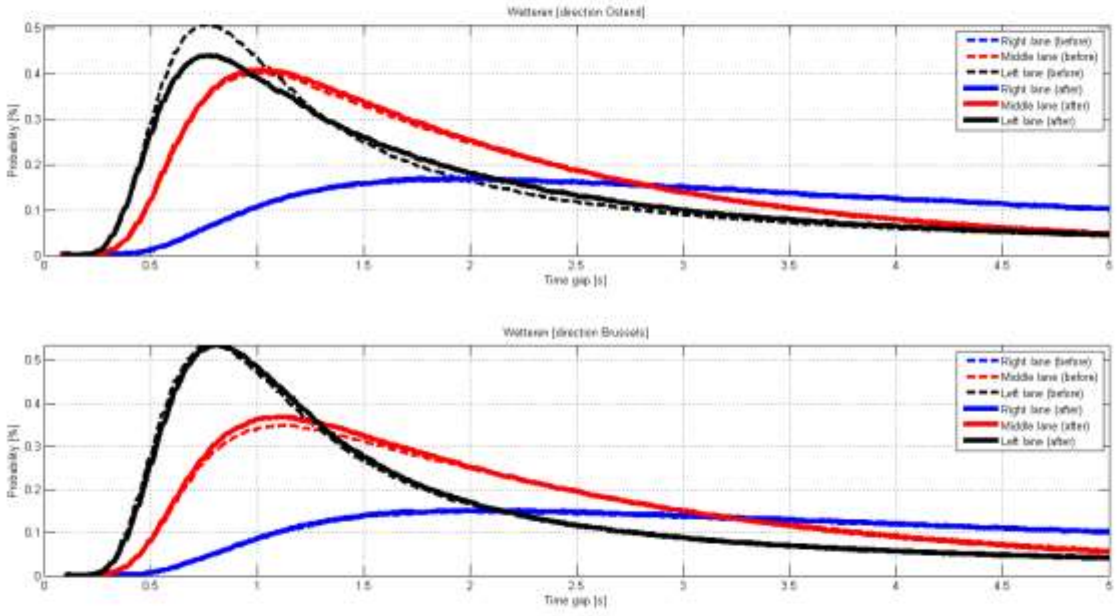

Figure 26: Probability distributions of the time gaps observed at the detectors in Wetteren.

The following Tables represent the summary information, each time indicating the absolute and relative difference between after and before implementation of the measure.

Direction Ostend	Before			After			Difference					
Location	Left	Middle	Right	Left	Middle	Right	Left	Middle	Right	Left	Middle	Right
Erpe-Mere	0.79	1.09	2.06	0.85	1.08	2.17	0.06	-0.01	0.11	7.6%	-0.9%	5.3%
Trajectory control zone	0.73	0.91	1.75	0.72	0.91	1.81	-0.01	0.00	0.06	-1.4%	0.0%	3.4%
Wetteren	0.73	0.96	1.69	0.75	0.99	1.99	0.02	0.03	0.30	2.7%	3.1%	17.8%

Direction Brussels	Before			After			Difference					
Location	Left	Middle	Right	Left	Middle	Right	Left	Middle	Right	Left	Middle	Right
Wetteren	0.75	1.08	1.81	0.80	1.09	2.04	0.05	0.01	0.23	6.7%	0.9%	12.7%
Trajectory control zone	0.75	1.05	2.04	0.80	0.97	1.81	0.05	-0.08	-0.23	6.7%	-7.6%	-11.3%
Erpe-Mere	0.78	0.97	2.16	0.74	0.97	1.93	-0.04	0.00	-0.23	-5.1%	0.0%	-10.6%

From the Tables we see how the time gap typically increases when going from the left to the right lane. This corresponds to a decrease in the flow[14] (as the 'keep right unless to pass' rule leads to less vehicles in the left-most lanes).

In contrast to the previous observation, there seems to be no clear indication of the measure on the time gap. There is – based on the loop detector measurements – no unique direction in which the the time gaps evolve due to the measure (sometimes they increasing, sometimes they are decreasing). Neither is there a correspondence in observations between both driving directions; an increase or decrease of the time gap in the direction of Brussels does not necessarily agree with an increase or decrease in the direction of Ostend.

There is however one observation that stands out from Figure 24, Figure 25, and Figure 26: looking at the height of the peaks in the distributions, we see how the solid black lines lie lower than their dashed counterparts, and the converse is the case for the red lines. The blue curves do not change. This means that less vehicles are driving in the left lane due to measure; they are shifted to the middle lane (the right lanes remains invariable).

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[14] Traffic flow is inversely proportional to the average time headway (which is the sum of the average time gap and the average vehicle length).

2.2.6 *Impact on traffic safety*

Based on accident data we received by courtesy of the Belgian Police[15], we assess the impact of the average speed control measure on traffic safety, i.e., the amount of accidents and their characteristics. The data spans the same time period as covered by our data (see also Section 2.1.2):

- Between 01/02/2012 and 01/02/2013 (<u>before</u> implementation of the measure)
- Between 01/04/2013 and 01/04/2014 (<u>after</u> implementation of the measure)

All recorded accidents occurred within the zone of the measure, as can be seen in Figure 27 (note that the locations if the accidents are shown offset to the A10/E40 road). It appears that the locations of the accidents, both before and after implementation of the measure, are somewhat randomly distributed along the motorway stretch.

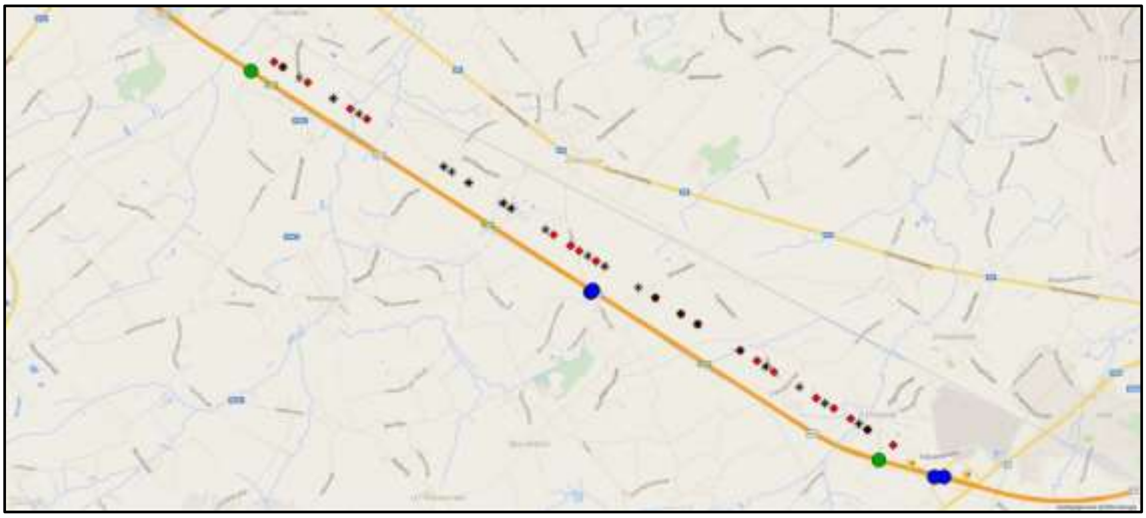

Figure 27: Locations of the recorded accidents inside the average speed control zone (red diamonds and black stars are before and after implementation of the measure, respectively).

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[15] Data was provided by the "*Centraal Georganiseerd Overleg Politie*", CGOP/B bureau Verkeer.

After processing the raw data, we gain more insight into the amount and severity of the accidents, as shown in Figure 28. Here we vertically list the accidents in chronological order, with the black dashed line indicating the distinction before and after introduction of the measure. Each horizontal line is associated with a traffic accident occurring on a specific date and time, with its length indicating the number of parties involved. The green, blue, and red segments denote each time the number of unharmed, light, and heavy wounded persons (there were no deaths or death-within-30-days recorded in the database).

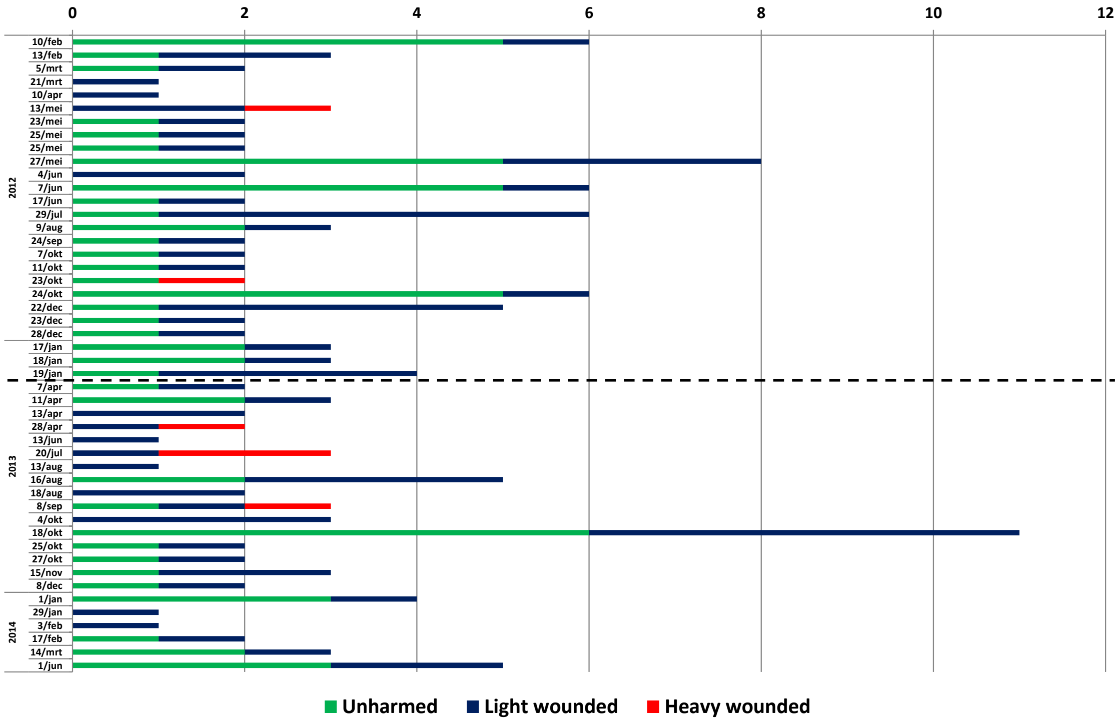

Figure 28: The severity of the accidents occurring inside the average speed control zone.

For example, the long line at 18/10/2013 (05h37) shows 11 parties involved. Looking back at reported traffic accidents in the Belgian press[16], we found that this was a chain collision:

> *"Bij een kettingbotsing op de E40 richting Brussel ter hoogte van Wetteren raakte een chauffeur zwaargewond. Bij het ongeval waren in totaal zeven voertuigen betrokken. "Als bij wonder geraakten slechts twee anderen lichtgewond", verklaarde parketwoordvoerster Caroline Jonckers. Om de takelwerkzaamheden te vergemakkelijken was de snelweg een tijdlang afgesloten, waardoor files ontstonden."*

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[16] http://www.hln.be/hln/nl/17542/Kettingbotsing-Zonnebeke/article/detail/1751576/2013/12/03/Kettingbotsingen-op-Belgische-wegen-een-overzicht.dhtml

Based on the gender of the people involved in the accidents, we see from the following Table that their number reduces after introduction of the measure (with 2 to 3 times more males than females involved in the accidents).

Gender	Before	After	Difference	
Male	50	44	-6	-12%
Female	21	15	-6	-29%
Unknown	11	4	-7	-64%

The histogram in Figure 29 shows the distribution of the age of people involved in the accidents. It has a mean around 38 years, with a standard deviation of 14 years. The distribution is skewed towards higher ages.

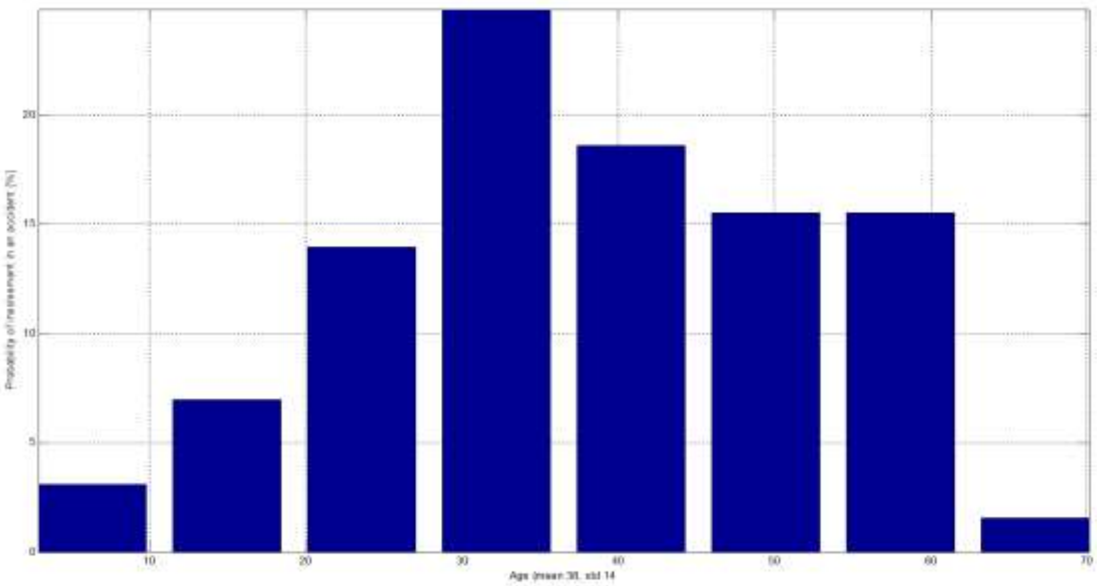

Figure 29: Age distribution of the people involved in the accidents (both before and after introduction of the measure).

The following Table present the processed accident information in more detail. It expresses the number of accidents, the number of vehicles and the number of people involved (unharmed, light wounded, and heavy wounded), as well as the types of vehicles involved (grouped into passenger cars, vans, and trucks).

Type	**Before**	**After**	**Difference**	
Accidents	**26**	**22**	**-4**	**-15%**
People	**82**	**63**	**-19**	**-23%**
In passenger cars	68	39	-29	-43%
In vans	12	14	2	17%
In trucks	2	10	8	-
Unharmed	41	25	-16	-39%
Light wounded	39	34	-5	-13%
Heavy wounded	2	4	2	-

Based on the information contained in the Tables, we assume that the average speed control measure has a positive effect on traffic safety.

- The number of accidents drops 15% from 26 to 22; the number of vehicles involved goes from 82 to 63, implying a 23% decline.
- This is reflected in significantly less people involved (82 before, 63 after, giving a 23% decline).
- The most reduction is found with the passenger cars where there are 43% less people involved.
- There largest decline is found with unharmed people: before there were 41 people involved, afterwards 25, giving a 39% decrease.
- Note that in contrast to these observations, the number of people in accidents with vans and trucks involved has increased: from 12 to 14 for vans, and from 2 to 10 for trucks. The reason for this is as of yet unclear. It should be noted that because of the low numbers involved, the statistical significance is rather low, implying that these are results that still lie within the error band.

Note that although the accident data sometimes gives insight into their causes (loss of control, tail gating, inappropriate speed, …), the previously mentioned statistics do not allow us to make any statement regarding the parties responsible for the traffic accidents.

Irrespective of the average speed control measure, we should also look at the decrease in accidents due to other causes. To that end, we consult the "*Verkeersveiligheidsbarometer*"[17] for the number of accidents, wounded, and dead on motorways in Flanders. The evolution between 2004 and 2014 (Q3 and Q4 are extrapolated) is shown in Figure 30, showing a overall decreasing trend.

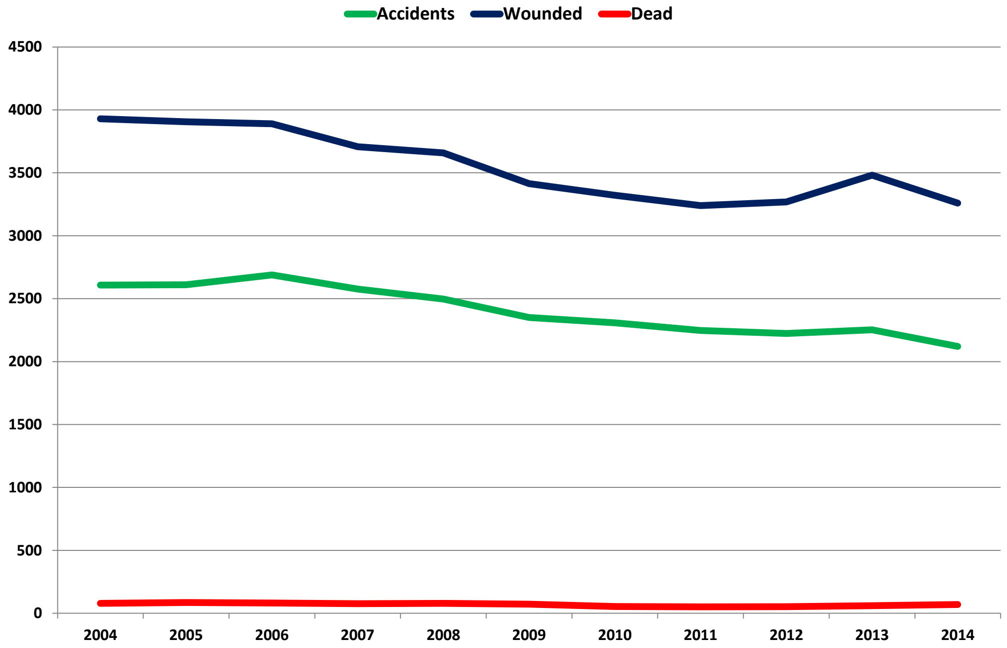

Figure 30: Evolution of the number of accidents, wounded, and dead on motorways in Flanders, from 2004 until 2014 (partial, extrapolated) according to the Verkeersveiligheidsbarometer.

Looking only at the measurement periods used in our analyses, we find that the number of accidents, wounded, and dead has actually increased slightly, as shown in the following Table.

	Accidents	Wounded	Dead	Total
Before	2766	4051	65	4116
After	2770	4329	82	4411

We therefore conclude that the change in the number of accidents inside the average speed control zone can be attributed to the measure itself.

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[17] Verkeersveiligheidsbarometer, Belgisch Instituut voor de Verkeersveiligheid (BIVV), 2014
See also: http://bivv.be/nl/pers/verkeersveiligheids-barometer
(VV_Baro_SR_-_2014_Q1+Q2_-_Fichier_Online_Bestand_-_Vlaanderen-Flandre.xls)

2.2.7 *Impact on spot speed infractions*

Another interesting statistic to consider is the number of non-truck vehicles (i.e., with lengths shorter than 6.9 m) that are effectively speeding throughout the zone with average speed control. We use the independent traffic measurements at the loop detectors inside the trajectory control zone as a proxy for the number of speed infractions, with the understanding that these concern spot measurements in contrast with the spatial measurement that is fined in case of speeding over the entire section. The data was again made available by courtesy of the Flemish Traffic Centre, as mentioned in Section 2.1.2.

Considering the conditions for Belgian fines, there is a legal tolerance margin of 6% taken into account for maximum allowed speeds above 100 km/h. Applying the margin to a maximum allowed speed of 120 km/h on Belgian motorways (as is the E40/A10), results in 120 * 1.06 = 127.02 km/h. So measured speeds below this speed are not fined, whereas those above are (50 euro immediate collection, 60 euro via amicable settlement "*minnelijke schikking*"). Given this margin, we make a distinction between:

- Light offenders with speeds > 120 km/h and ≤ 127 km/h
- Heavy offenders with speeds > 127 km/h and ≤ 127 km/h.

The analysed data considered again both the period before and after implementation of the average speed control measure, each time recording the number of on-the-spot-infractions at the previously discussed detector locations. The temporal resolution of the data was 15 minutes.

Plotting a time series of the number of offenders inside the average speed control zone, for both driving directions simultaneously and aggregated on a monthly basis, gives us the graph in Figure 31.

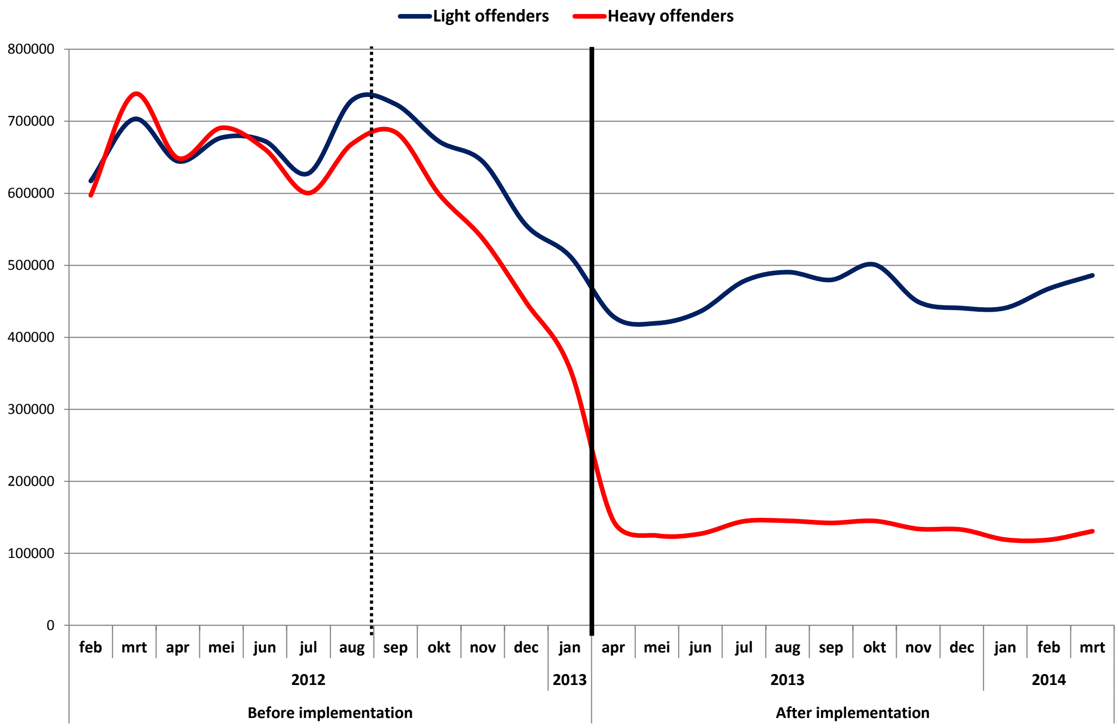

Figure 31: Time series of the number of light and heavy offenders at a spot measurement inside the average speed control zone.

Note that the vertical axis shows the total number of offenders per month. Because there are missing records as detectors give no valid information from time to time, we have rescaled all the data proportionally to the month with the most data. This method gives sound results, as even using the average number of offenders instead of the sum exhibits virtually the same behaviour.

From the previous graph we immediately see how the number of offenders is reduced drastically because of the average speed control measure. There is a drop of around 29% in light offenders, and an even more pronounced drop of around 78% in heavy offenders, compared between before and after implementation of the measure. Analysing the change in light and heavy offenders at the detectors at Wetteren, we conclude that their drops are 17% and 42%, respectively. For the detectors at Erpe-Mere we observe a small increase of 3% for the light offenders, and a drop of some 41% for the heavy offenders.

Finally, note that the number of effective fines (see also the beginning of Section 2.2.8) is much lower than the monthly numbers shown in the previous graph. This is logical, as the former concerns spot speed measurements whereby drivers occasionally drive faster, as opposed to the latter which looks at drivers' spatially averaged speed over the entire control zone.

2.2.8 *Insight into the costs and benefits*

Performing a full social cost-benefit analysis (SCBA) is beyond the scope of this study. Based on the publicly available data, we can however try to give a quick estimate. For the initial deployment cost this results in a number of approximately 1 million euro[18].

In order to calculate the direct benefits from the traffic fines, we first estimate the number of speed infractions in the average speed control zone, which amounts to 92,678 (direction Ostend) + 83,185 (direction Brussels), giving a total of 175 ,863 speed infractions[19].

Next, we estimate the height of the fines associated with the speed infractions. Given that the speed limit is set at 120 km/h, we assume that infractions lie between 120 km/h and 140 km/u (sustained speed on the section). This translates into an average fine of 55 euro ("*directe inning*")[20]. The total amount of fines collected in this way is thus equal to 55 euro times 175,863 speed infractions, or 9,672,465 euro.

Summarising, we have an initial deployment cost of some 1 million euro, with an associated direct benefit to the state's taxes of some 9.7 million euro. This gives an initial benefit-cost ratio of about 9.7:1 for the first year; after that, the benefit-cost ratio is higher as there are only maintenance costs for subsequent years involved.

In order to calculate the benefits to society, we need to multiply the number of avoided traffic accidents *within* the zone of average speed control with the value of a life. For the various categories these are[21]:

- Light wounded: 21,300 euro per person
- Heavy wounded: 330,400 euro per person
- Dead (within 30 days): 2.178 million euro per person

Based on the differences in people involved in accidents (see also the right Table near the end of Section 2.2.6), we conclude that there are 5 less light-wounded, and 2 less-heavy wounded. This results in a total extra benefit to society based on avoided traffic accidents of some 106,500 + 660,800 = 767,300 euro.

Note that as people are driving at a slower speed, their travel time over the motorway stretch increases. In principle, this leads to additionally accumulated vehicle-loss-hours. However, we deem the differences too small to be significant, hence we do not take them into account in the cost-benefit analysis. Moreover and in contrast with the previous observation, less accidents imply less incidental congestion; as such, there are probably additional benefits to all road users due to these avoided traffic accidents. It is however beyond the scope of this study to assess the impact of an average speed control on total yearly vehicle-loss-hours.

We also do not take into account the effect of the measure on exhaust emissions, nor on the impact of the measure on noise levels.

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[18] See http://www.groenlicht.be/2012/10/16/installatie-trajectcontrole-op-e40-gestart/

[19] See http://deredactie.be/cm/vrtnieuws/binnenland/1.1853501

[20] See http://www.wegcode.be/boeteberekening

[21] See HEATCO Handbook of External Costs of Transport, Study for Belgium, 2006 D5 updated for 2010, predicted towards 2012

3 Conclusions

The main conclusions of our concise impact assessment of average speed control, based on traffic measurements and accident data on the A10/E40 motorway stretch in Flanders, are:

- There is no impact on the total yearly traffic volumes.

- There is no impact on the capacity of the road (probably because over-capacity is never reached with traffic volumes before and after implementation of the measure).

- Traffic conditions with low volumes and lower-than-normal speeds tend to disappear, probably as an indirect effect of having less accidents during low-flow conditions. This leads us to conclude that the measure increases stability of the traffic streams.

- The average travel speed drops the most inside the average speed control zone with around 4%. This drop in speed is only noticed with the cars and vans, and not for the trucks (as these latter are already speed limited by design).

- The speed still drops further downstream of the average speed control zone, which is likely to be attributed to the halo-effect of the measure. The speed also drops right before the average speed control zone, possibly due to the presence of a weigh-in-motion installation that causes drivers to slowdown.

- The measure reduces speed variations among traffic participants, with a drop of deviations in speeds of passenger cars and vans inside the average speed control zone of about 25-30%.

- There is virtually no effect on speeds in the right lane, as it is mostly dominated by the slower moving light and heavy trucks. The speed in the left lane experiences the most effect from the average speed control measure, with drops of over 5%.

- There is no clear indication of the impact the measure has on the time gap between vehicles. It would seem that vehicles driving in the left lane are shifted to the middle lane.

- There is a positive impact on traffic safety, with the number of accidents dropping with some 15% (implying 23% less vehicles involved). This is reflected in significantly less people involved (a 23% decline). The most reduction is found with the passenger cars, where there are 43% less people involved.

- Inside the zone with average speed control we observe a drop of around 29% in light offenders, and an even more pronounced drop of around 78% in heavy offenders, considering their spot speeds compared between before and after implementation of the measure.

- Given the cost for initial deployment and direct benefits from fines, the measure seems to have an initial benefit-cost ratio of about 9.7:1 for the first year. After that, the benefit-cost ratio is higher as there are only maintenance costs for subsequent years involved. There is an extra benefit to society of 767,300 euro, related to avoided traffic accidents after introduction of the measure.

Given these conclusions, an average speed control is a useful measure to reduce the number of accidents, without hampering traffic flows. Given the nature of the measure, we also encourage its use on non-motorways, such as city rings and secondary roads.

The current report presents the conclusions of a concise impact assessment on average speed control. Although the study was quite exhaustive in that it used around two years of data, there are still certain observations that are not satisfactorily explained with the current dataset (e.g., the impact of the measure on time gaps). In reference to this, we recommend to extend the current study to include a more detailed analysis of the various observations that occur due to the introduction of an average speed control measure. In addition, we also propose to research traffic behaviour further up- and downstream of the zone.

Let us finally note that an average speed control measure provides a more righteous approach, as drivers are encouraged to avoid speeding over longer distances, as opposed to single-location flashing cameras. The latter are nevertheless still very useful, for example in built-up areas. We believe good policy is made by a fruitful combination of both approaches to enforcement, coupled with the sensitising of road users, explaining the motivation and effects of these measures.

4 Press releases

4.1 Dutch

De trajectcontrole meet de reistijd van een voertuig tussen twee vaste punten langs een weg, en leidt uit die waarnemingen de gemiddelde snelheid af. In deze effectbeoordeling bestudeerden we de trajectcontrole langs de A10/E40 in België, tussen Brussel en Gent. We gebruikten verkeersgegevens die werden verzameld door het Verkeerscentrum Vlaanderen in hun datawarehouse. In tegenstelling tot eerdere studies over trajectcontrole, is deze data vrij gedetailleerd aangezien informatie van alle 5 minuten gedurende meer dan 2 jaar bevat. Daarnaast hebben we ook de verkeersveiligheid geanalyseerd dankzij gegevens over ongevallen die we van de Belgische politie ontvingen.

Onze belangrijkste conclusies sommen we even op. Er is geen impact op de wegcapaciteit op die locatie. Er is een merkbare daling van circa 4% in de snelheid van auto's en bestelwagens. Spectaculairder is de daling van ongeveer 25% tot 30% van de snelheidsafwijkingen van deze voertuigen, waar we ondermeer uit afleiden dat de verkeersafwikkeling stabieler verloopt dankzij de maatregel.

We constateren ook een positief effect op de verkeersveiligheid, het aantal ongevallen daalt met ongeveer 15% (dit impliceert dat er 23% minder voertuigen bij betrokken zijn). Bovendien schatten we een daling in van circa 29% lichte overtreders, en een nog meer uitgesproken daling van ongeveer 78% zware overtreders. Gezien de kosten voor de aanvankelijke uitrol en de directe voordelen van de boetes, lijkt de maatregel een initiële kosten-batenverhouding van ongeveer 9,7:1 voor het eerste jaar te hebben. Daarna is de kosten-batenverhouding hoger aangezien het slechts gaat om onderhoudskosten voor de volgende jaren.

Trajectcontrole is een nuttige maatregel om het aantal ongevallen te verminderen, zonder belemmering van de verkeersstromen. Gezien de aard van de maatregel moedigen we ook het gebruik ervan aan op niet- autosnelwegen, zoals de stadsringen en secundaire wegen. Merk op dat vaste knipperende camera's nog altijd zeer nuttig zijn, bijvoorbeeld in de bebouwde kom. Wij geloven dat een goed beleid bestaat uit een gezonde combinatie van beide benaderingen tot handhaving. Dit in combinatie met de sensibilisering van de weggebruikers, door het uitleggen van de motivatie en de effecten van deze maatregelen.

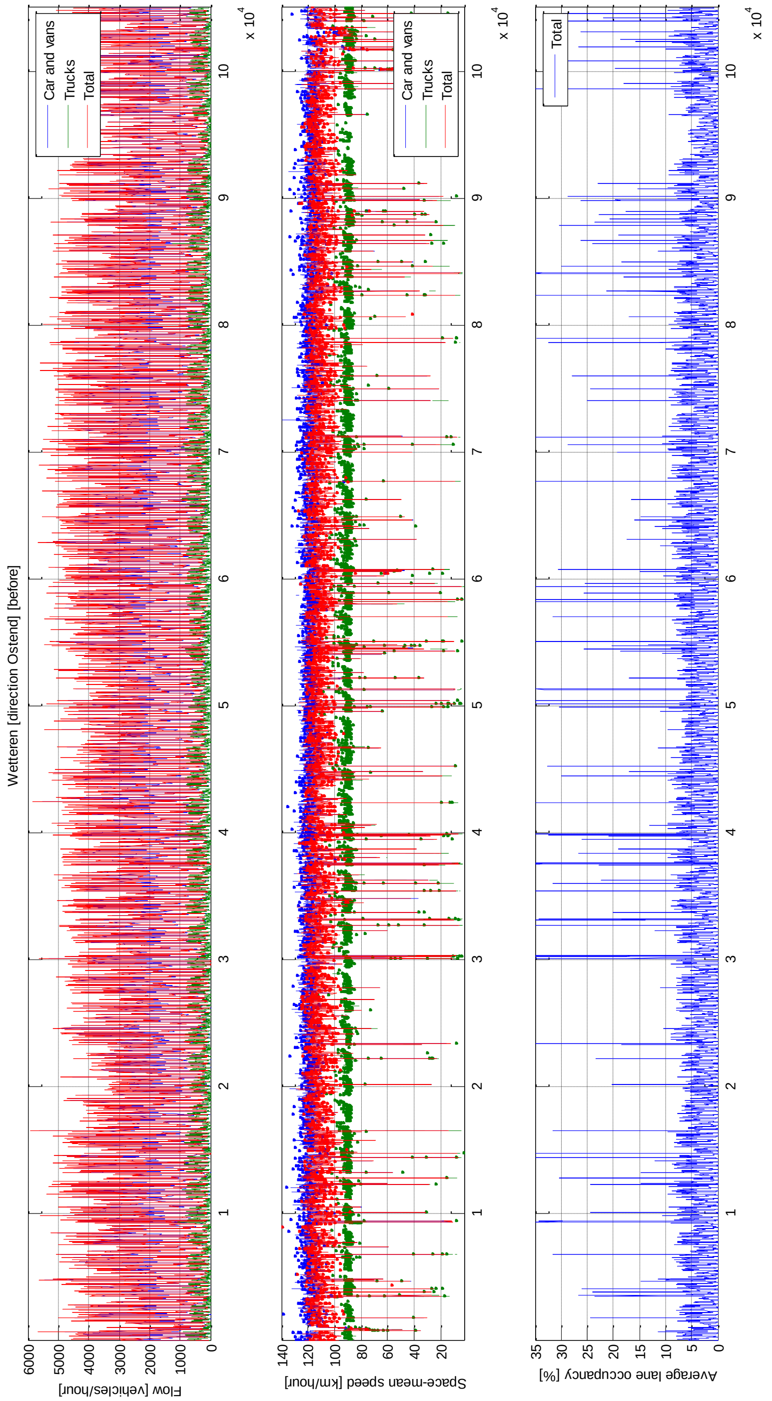
4.2 English

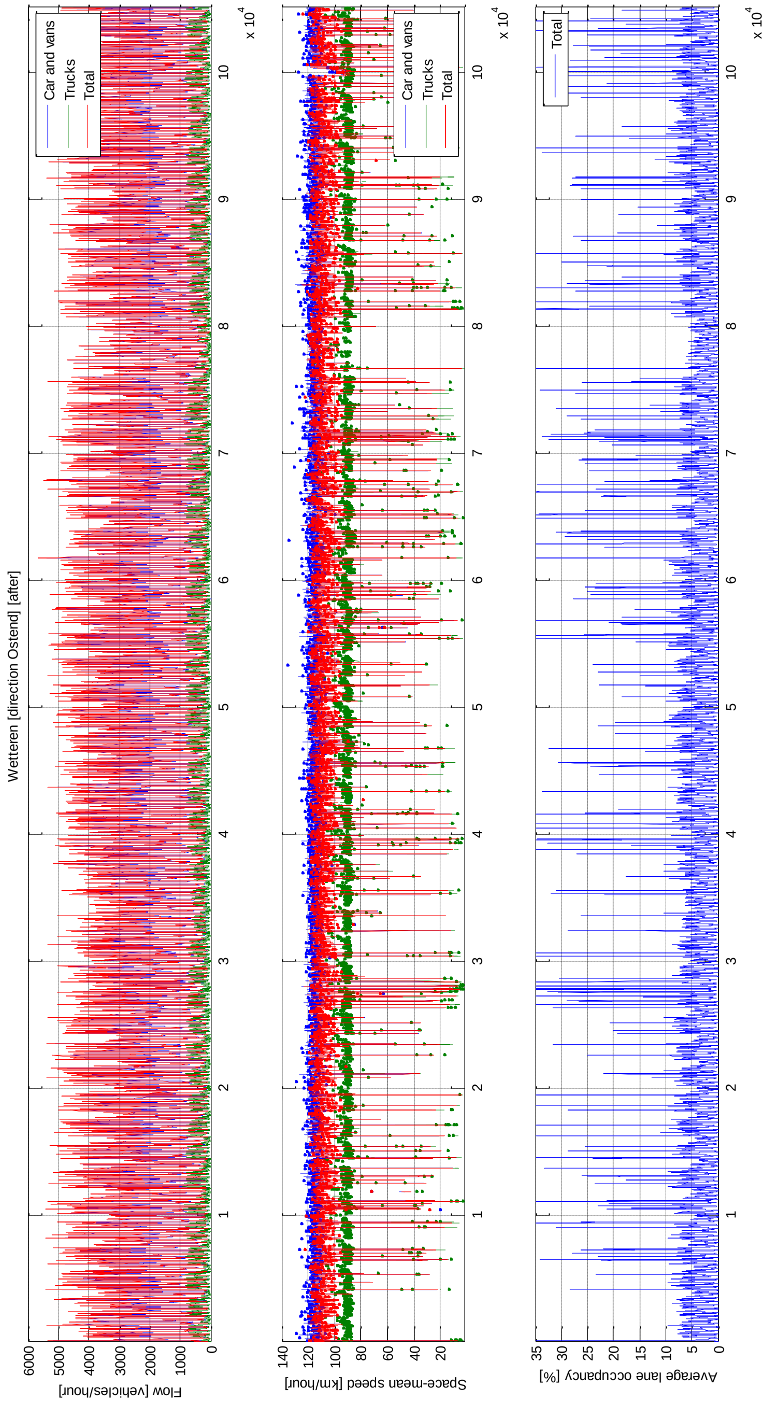
Average speed control measures a vehicle's travel time between two fixed points along a road, and infers its average speed from those observations. In this impact assessment, we studied the average speed control setup along the A10/E40 in Belgium, between Brussels and Ghent. For the study, we used traffic data that was collected by the Flemish Traffic Centre in their data warehouse. In contrast to previous studies of average speed control, the data here is quite rich as it encompasses all 5-minute intervals for over 2 years. In addition, we also analysed traffic safety by means of accident data we received by courtesy of the Belgian Police.

Our main conclusions are that there is no impact on the capacity of the road at that location. There is a noticeable drop of around 4% in the speeds of cars and vans. More spectacularly is a drop of some 25% to 30% in the speed deviations of these vehicles, implying that the traffic stream is more stable due to the measure. We also observe a positive impact on traffic safety, with the number of accidents dropping with some 15% (implying 23% less vehicles involved). Furthermore, we estimate a drop of around 29% in light offenders, and an even more pronounced drop of around 78% in heavy offenders. Given the cost for initial deployment and direct benefits from fines, the measure seems to have an initial benefit-cost ratio of about 9.7:1 for the first year. After that, the benefit-cost ratio is higher as there are only maintenance costs for subsequent years involved.

Average speed control is a useful measure to reduce the number of accidents, without hampering traffic flows. Given the nature of the measure, we also encourage its use on non-motorways, such as city rings and secondary roads. Note that single-location flashing cameras are still very useful, for example in built-up areas. We believe good policy is made by a fruitful combination of both approaches to enforcement, coupled with the sensitisation of road users, explaining the motivation and effects of these measures.

Appendix A: Detailed time series

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Flow [vehicles/hour]
Space-mean speed [km/hour]
Average lane occupancy [%]
Car and vans
Trucks
Total
x 10^4
0
1000
2000
3000
4000
5000
6000
20
40
60
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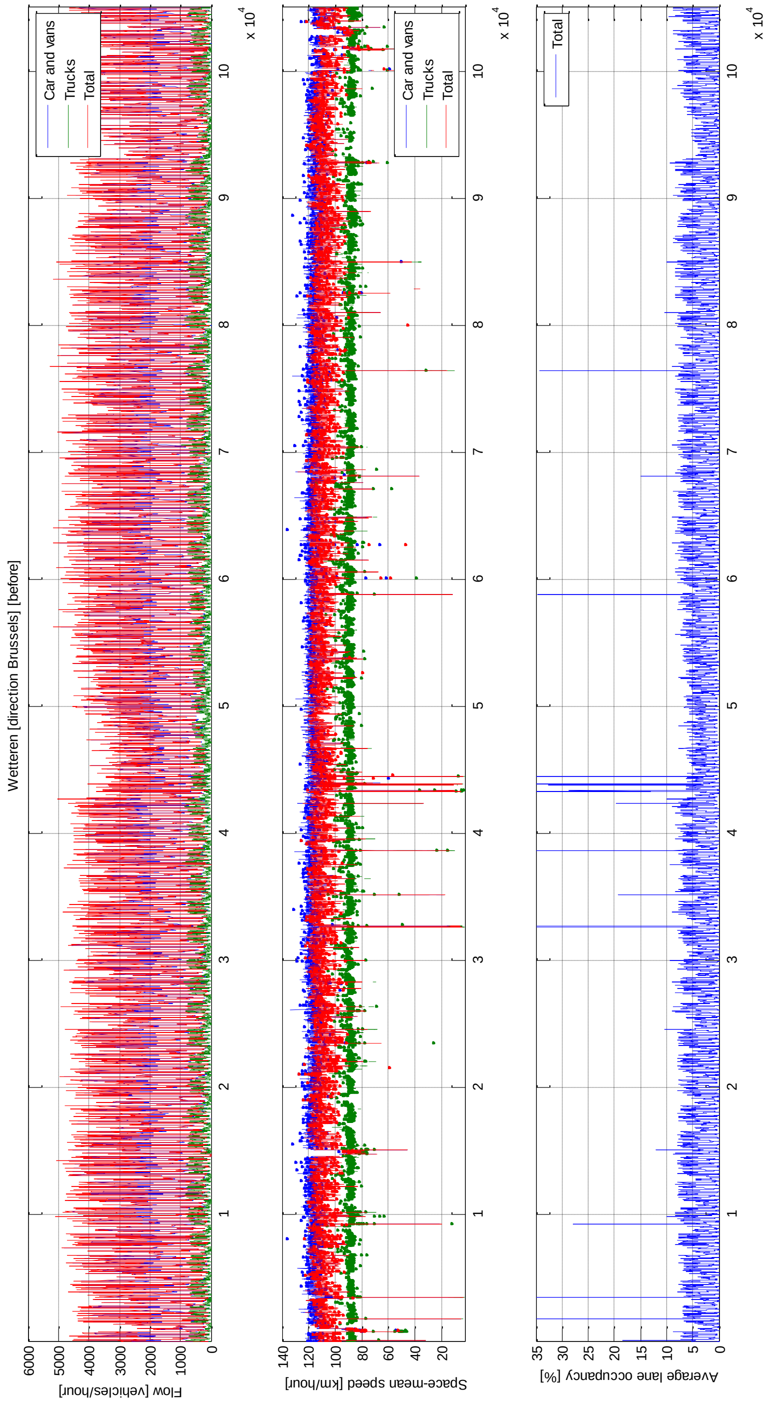
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Flow [vehicles/hour]
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5000
4000
3000
2000
1000
0
Car and vans
Trucks
Total
Space-mean speed [km/hour]
140
120
100
80
60
40
20
Car and vans
Trucks
Total
Average lane occupancy [%]
35
30
25
20
15
10
5
0
Total
1
2
3
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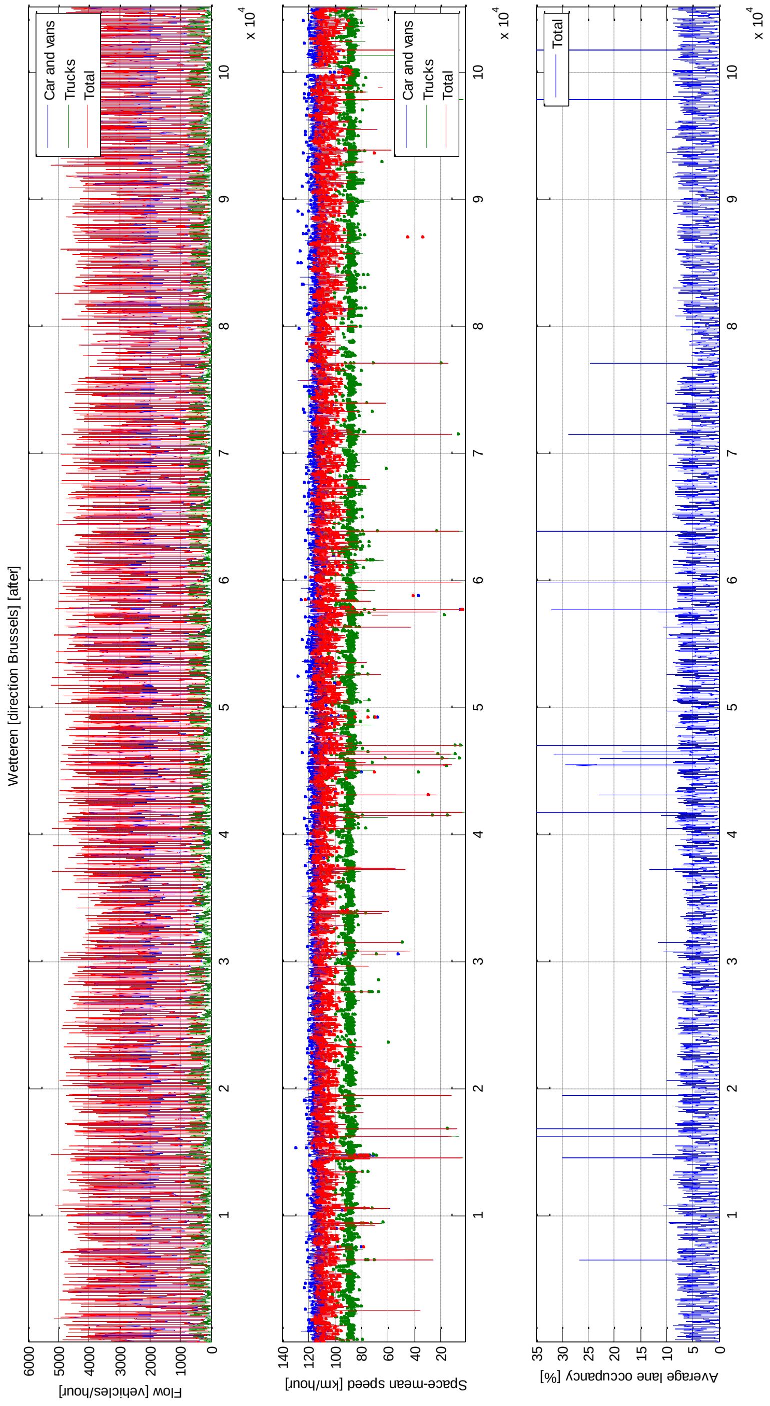
6
7
8
9
10
$x\ 10^4$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Flow [vehicles/hour]
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5000
4000
3000
2000
1000
0
Car and vans
Trucks
Total
Space-mean speed [km/hour]
140
120
100
80
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40
20
Average lane occupancy [%]
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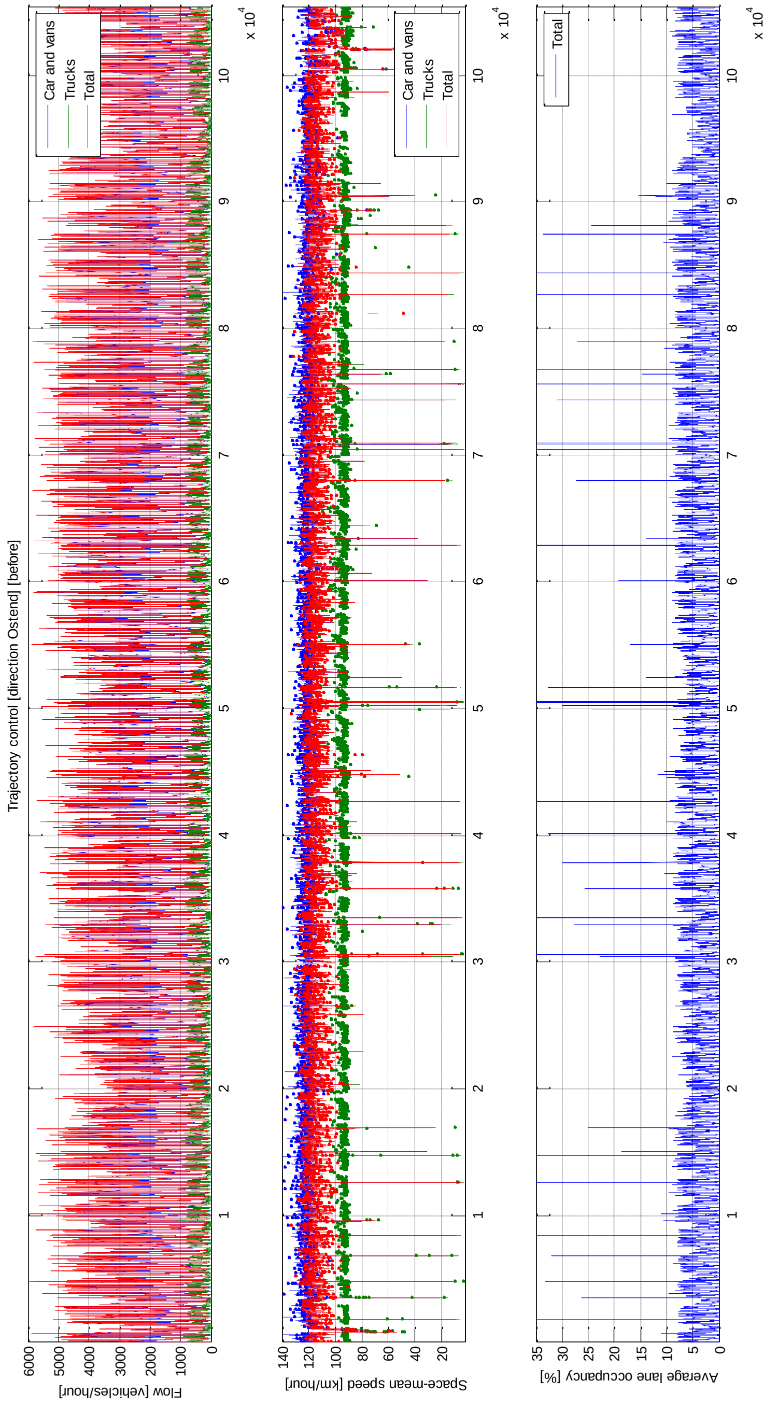
x 10^4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Flow [vehicles/hour]
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0
Car and vans
Trucks
Total
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x 10^4
Space-mean speed [km/hour]
140
120
100
80
60
40
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Car and vans
Trucks
Total
x 10^4
Average lane occupancy [%]
35
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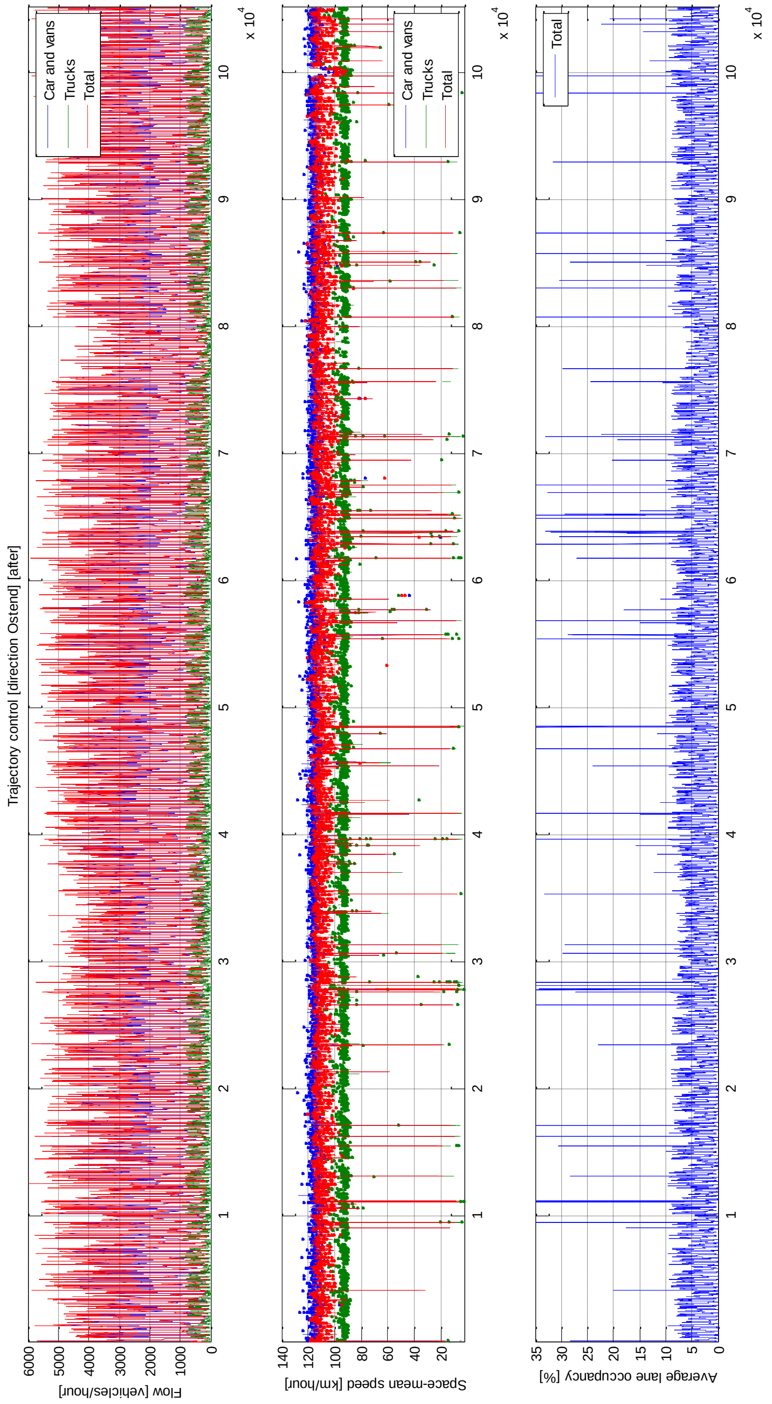
15
10
5
0
Total
x 10^4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Car and vans
Trucks
Total
Space-mean speed [km/hour]
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Average lane occupancy [%]
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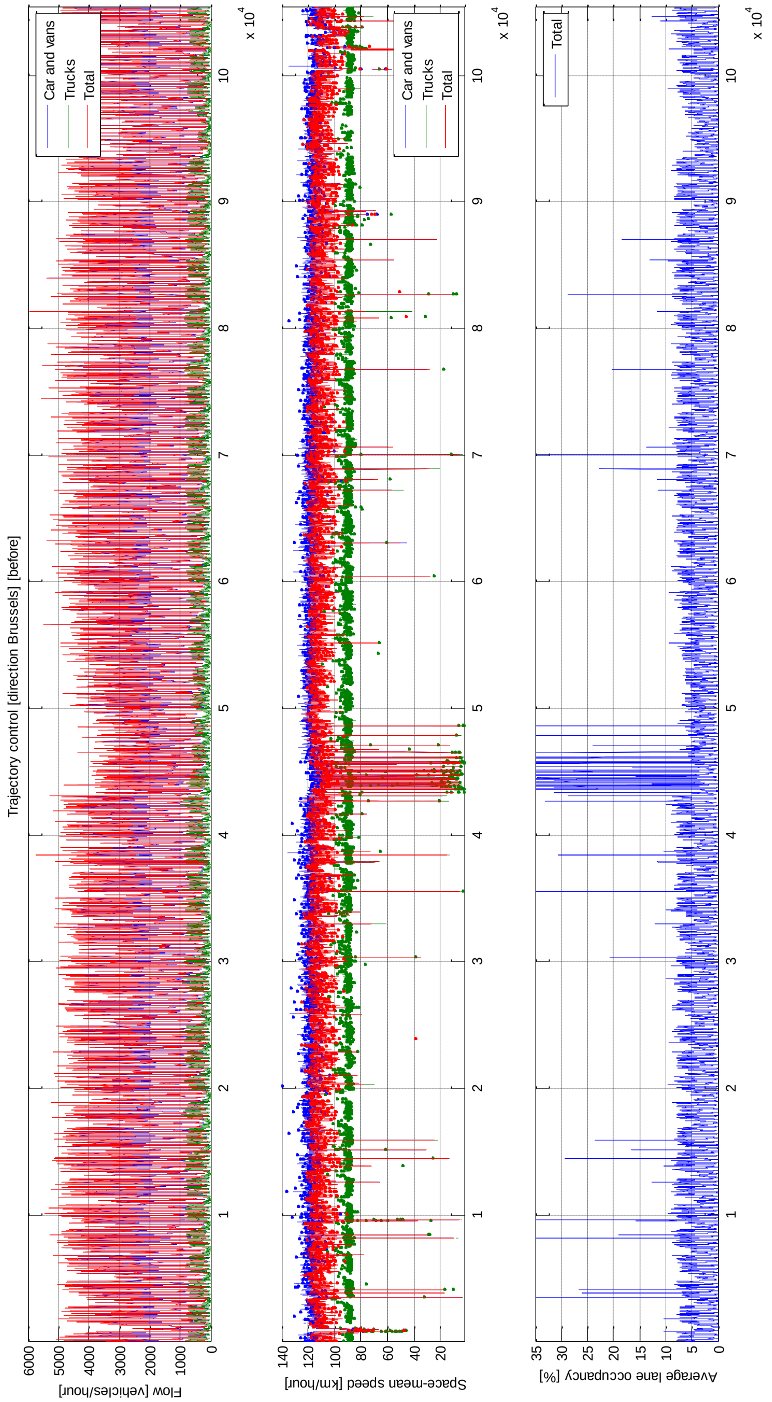
x 10^4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Flow [vehicles/hour]
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6000
Car and vans
Trucks
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x 10^4
Space-mean speed [km/hour]
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140
Car and vans
Trucks
Total
x 10^4
Average lane occupancy [%]
0
5
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15
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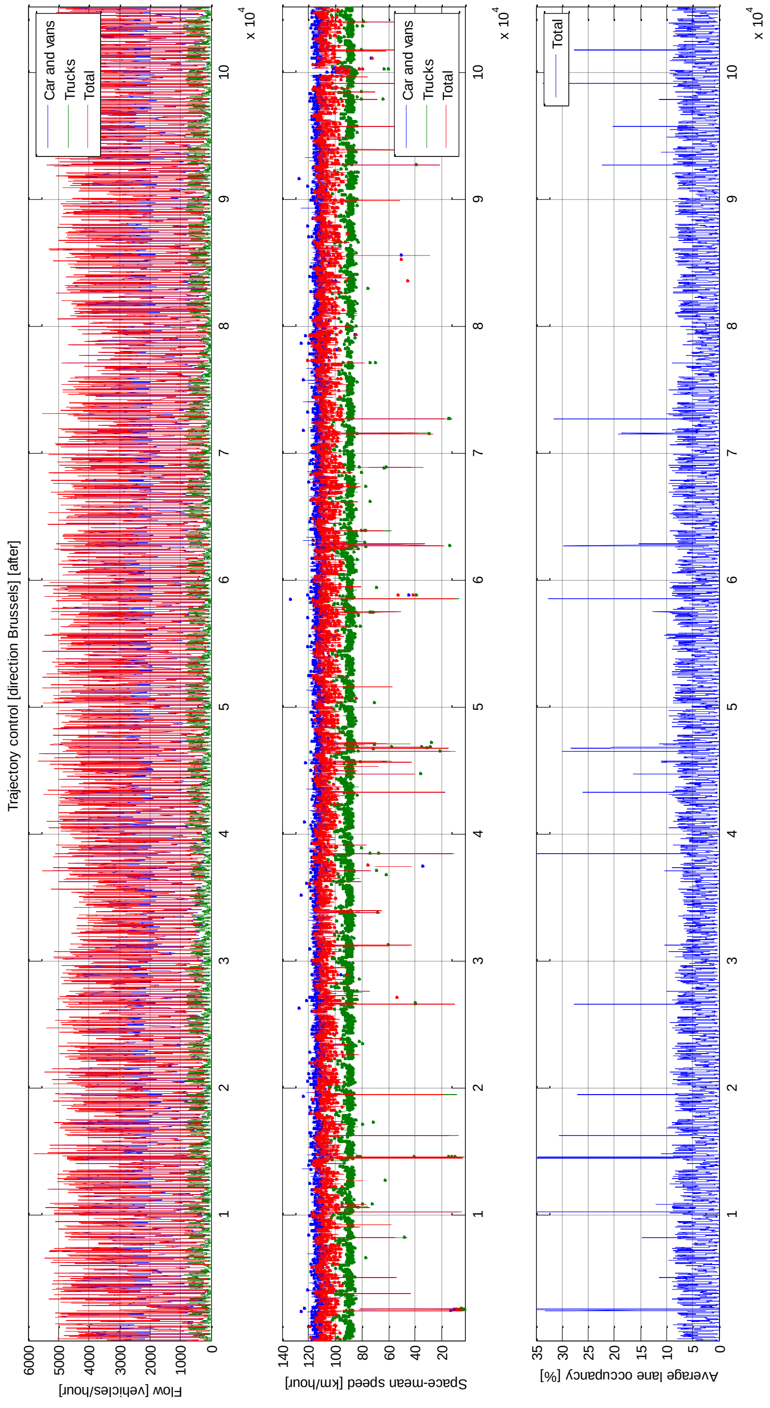
25
30
35
Total
x 10^4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Car and vans
Trucks
Total
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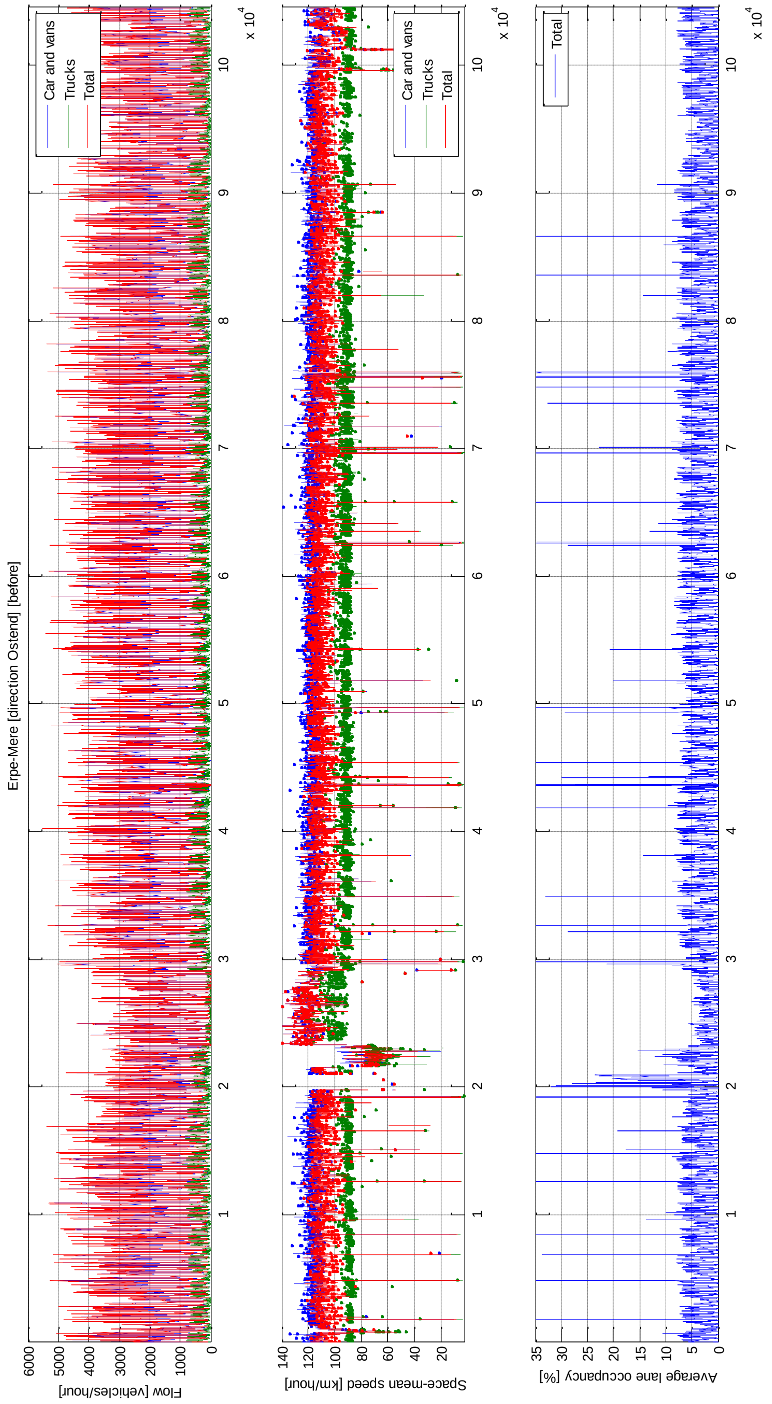
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Flow [vehicles/hour]
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5000
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Car and vans
Trucks
Total
Space-mean speed [km/hour]
140
120
100
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Car and vans
Trucks
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Average lane occupancy [%]
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Total
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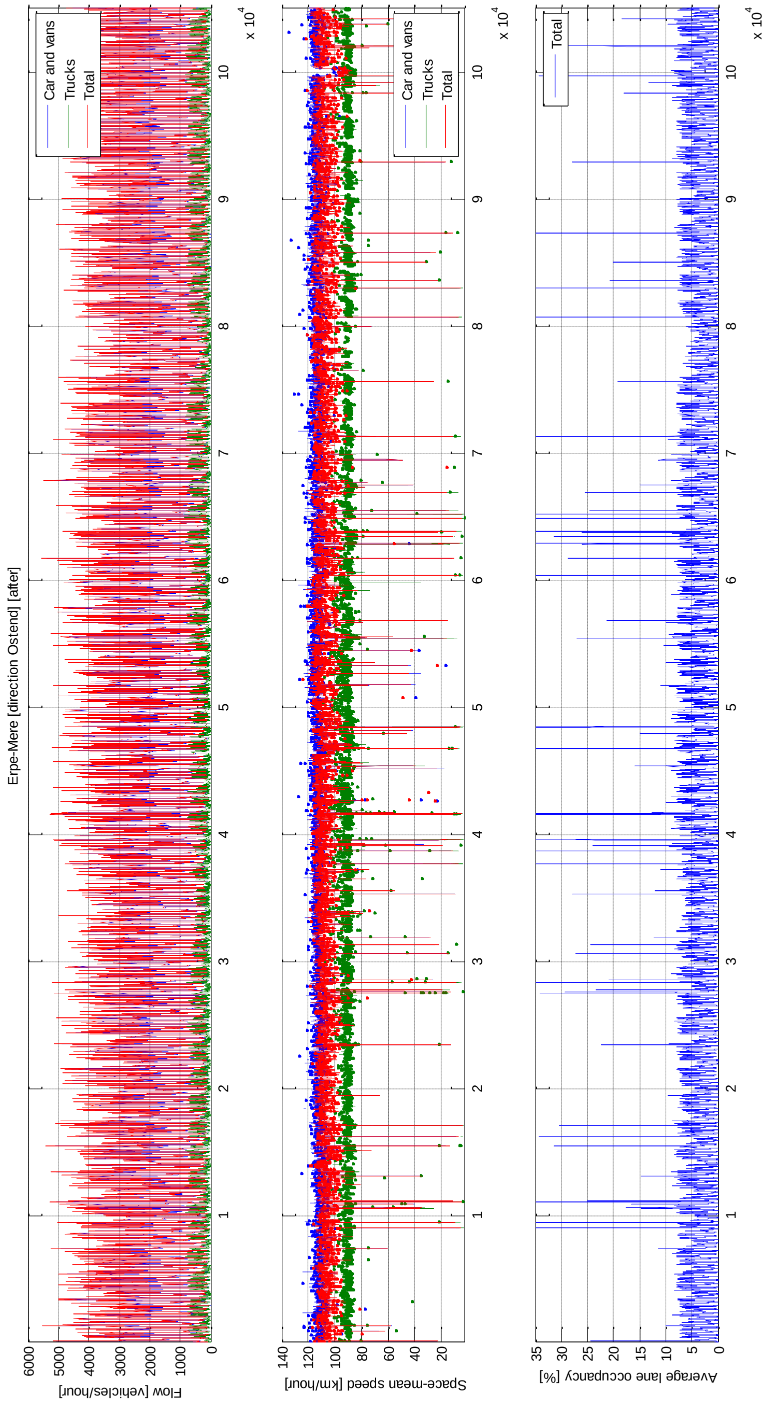
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Flow [vehicles/hour]
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Car and vans
Trucks
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Average lane occupancy [%]
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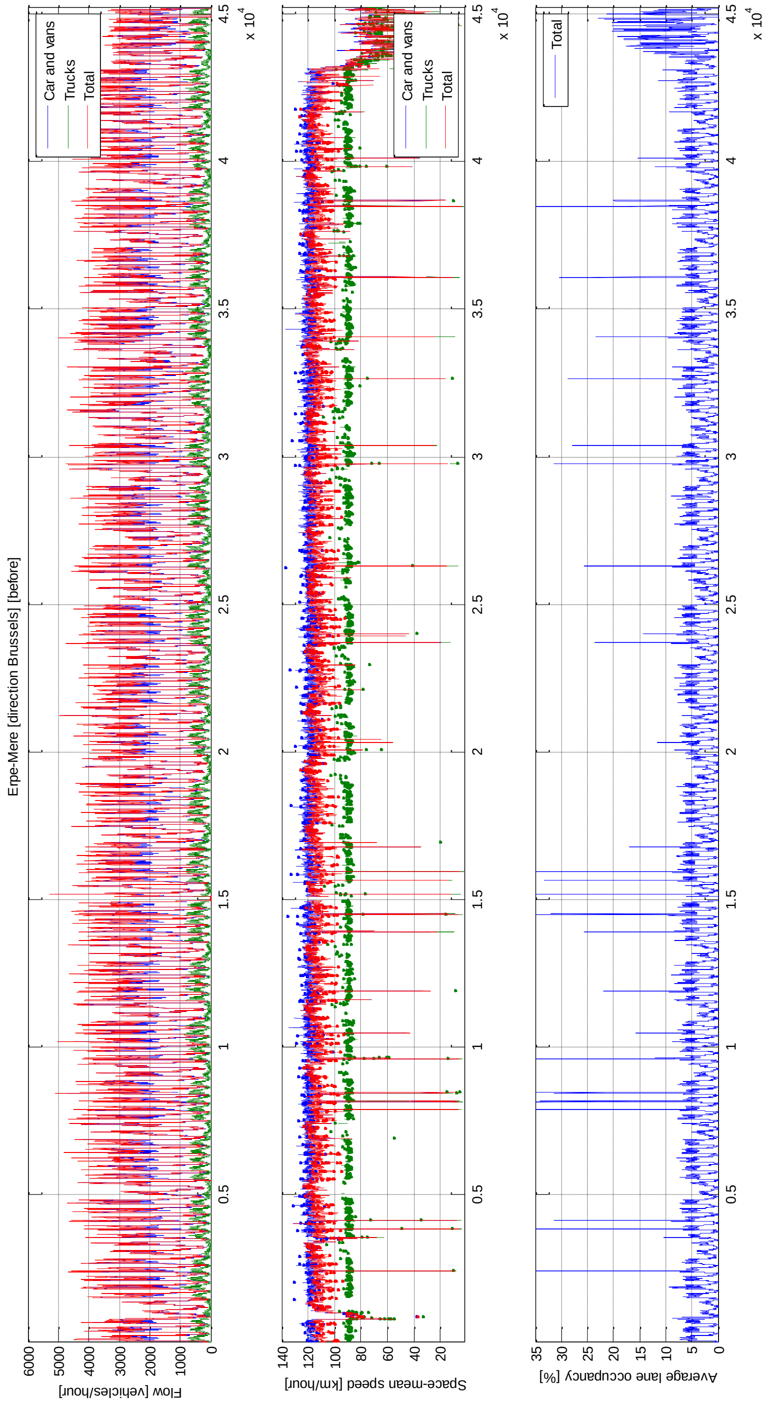
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Flow [vehicles/hour]
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Car and vans
Trucks
Total
Space-mean speed [km/hour]
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Average lane occupancy [%]
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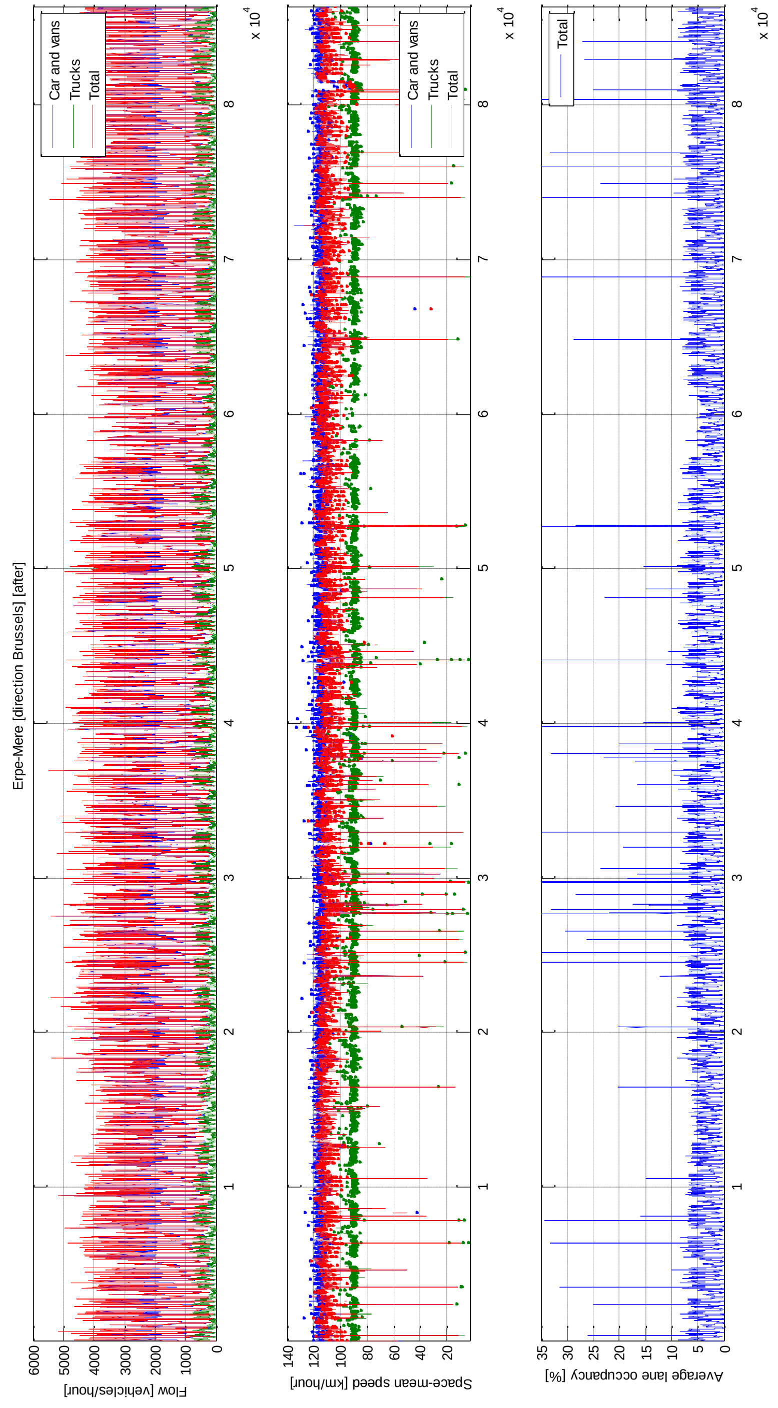
x 10^4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Flow [vehicles/hour]
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Car and vans
Trucks
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x 10^4
Space-mean speed [km/hour]
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Car and vans
Trucks
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Average lane occupancy [%]
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Total
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