

EVALUATION COUNTING SYSTEM FOR TRUCKS ON THE PWC OFFENBAU

Part: V&R ParkDetek

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1 Purpose of the document

This study documents the evaluation of the system »ParkDetek« of the company Volkmann and Rossbach (below V&R-system). It is a vehicle counting system for parking sites based on input and output for the parking and WC site (below PWC) at the location Offenbau (German freeway A9, direction Nuremberg, section 740, station 3.5).

At first, the system and location, methods and results are characterized. The following sections document the results of long-term observation and of detailed video counting as well as scenario test drives.

The basis for this evaluation are the results out of the first phase of evaluation, which were abstracted in the document »Evaluation LKW- Zählsystem- Vorabbericht V&R ParkDetek«. During this first phase of evaluation the V&R system proved to have a long-term stability using a general differentiation in lorry-like and motorcar-like vehicles.

During the ongoing development of a pilot lorry-park management system, the differentiating criteria have been stronger aligned with the technical terms of delivery for route stations (»Technischen Lieferbedingungen für Streckenstationen«, TLS) due to a stronger commitment by Federal Highway Research Institute (»Bundesanstalt für Straßenwesen«). In practice, this led to a lack of definition in terms of classification: short motorcar-trailer-combinations could be classified as motorcars, but are defined in TLS as lorry-like vehicles. Above, a classification with optical criteria of small delivery vans and caravans could be ambiguous, because sometimes only the registration papers can assign the vehicles correctly.

This report is based on TLS, but exemplifies occurring incongruity due to the lack of definition and possible ways to overcome those issues in a general method for evaluation of telematic counting systems for the detection of occupancy rates of goods vehicle parking facilities.

2 Test method for the location PWC Offenbau

2.1 Functional specification of the V&R-system

The system of V&R consists of two or more »MultiSens«- cross sections with an outdoor laser scanner (Class 1 infrared laser, »ScanSens-X0«) and a ground radar sensor (»GroundSens«).

The laser scanner performs the task of vehicle detection, as well as measuring height and width. The ground radar measures lengths and speeds, and also classifies the vehicles into typical vehicle categories.



Fig. 01: Ground radar »GroundSens« and laser scanner »ScanSens-X0«

In the present configuration, the vehicles are classified into lorry-like and motorcar-like vehicles based on length, width and height of typical vehicles classes.

In the local MultiSens control unit, sensor data are combined and the vehicles are classified. Information over the vehicles detected by one cross section is transmitted to the ParkDetek-control unit. The vehicle data of entrance and exit are balanced by comparing vehicle measures.

2.2 Environment for evaluation on the PWC Offenbau

The PWC terrain (built 1983) has 15 lorry- and 32 motorcar parking spots. Overall, about 34,000 vehicles pass the section of motorway A9 in direction Nuremberg every day, of which 15.8 % are trucks (in 2010). Detailed information on traffic situations can be found in chapter 7, based upon traffic counts at counting station Greiding (A9 direction Nuremberg, section 740, station 14.3).

2.2.1 Detection technique

At entry and exit, one MultiSens-X-measuring section is placed to detect, measure and classify incoming and exiting vehicles. The geometrical characteristics of a vehicle are the foundation for threshold-based classification.

The current occupancy of the parking area is calculated by balancing incoming and exiting vehicles. During that process, an exciting vehicle is assigned to the geometrically most similar incoming vehicle and will be removed from the quantity of parking vehicles.

The classification could be different for entrance and exit, because of measuring inaccuracy and defined thresholds.

Since for the operation of the PWC-site, particularly the length of a vehicle and therefore occupied parking area is of significance, the emphasis is on the correct overall balance of all vehicles.

2.2.2 Evaluation technique

At the test site, there are six cameras available for remote observation. Five cameras are documenting the occupancy of the parking area, thereof videos have been recorded by two cameras and single images have been taken by three cameras, see fig.02. Another one is aligned to the detector in the entrance. This one was observing incoming vehicles only.

Because of construction site clearing for the planned modification of the PWC-site, the vegetation was not a visual obstacle, unlike the first test phase.

The park area is not lighted, apart from the WC-site. Consequently the observation is very restricted, because of lack of light or strong cross-fading.

2.3 Verification methodology

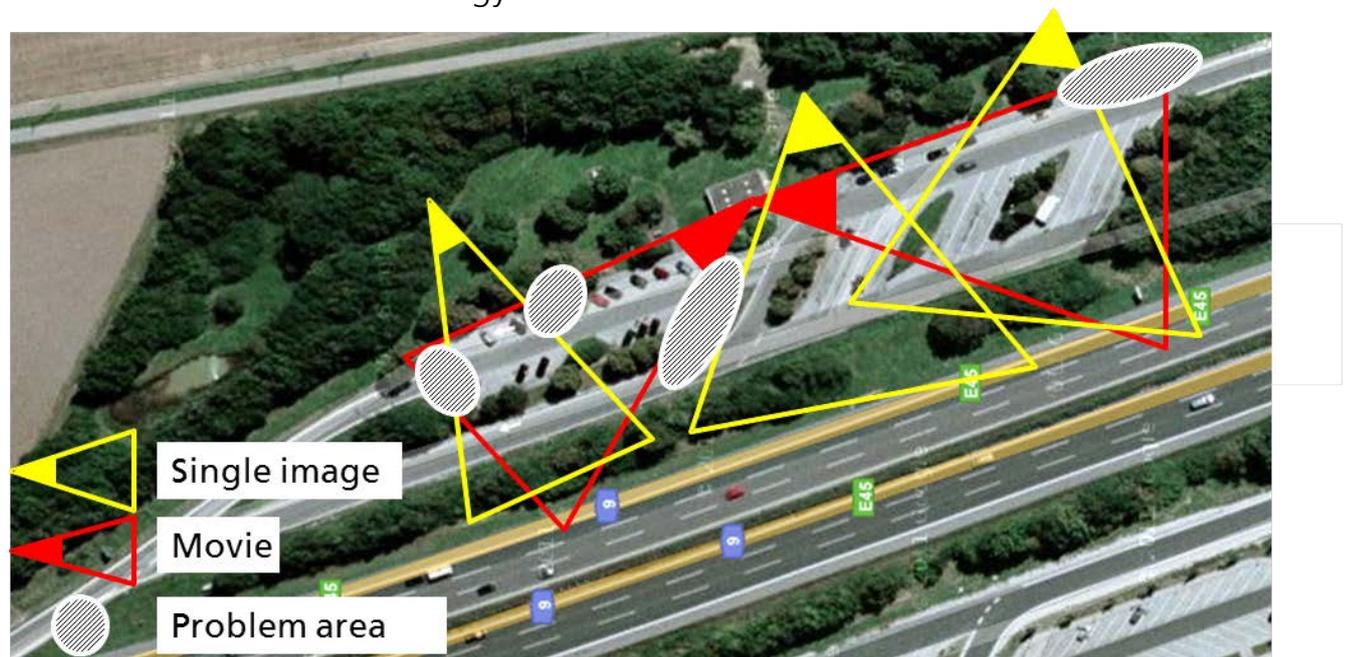


Fig. 02 : Camera locations for visual occupancy sensing

2.3.1 Method

Based on the know-how of the first phase of evaluation, following analyses have been conducted:

- Long term comparison of current occupancy of the parking area and the reported occupancy of the V&R-system from 21st May to 10th June 2012, insofar as data material is present at 4/7/10/13/16/19/22 h.
- Detailed comparison of the occupancy values named above from hourly counting on 31st Mai 2012.
- Comparison of the events at the entrance by counting video by material of the camera in the entrance for three days: 29th May., 6th June and 10th June 2012 each between 11:00 am to 3:00 pm.
- Scenario test drives to enforce complex and real occurring driving situation (overtaking, manoeuvring in the detection zone)

The comparisons of occupancy have been calculated for both TLS classes »lorry-like« (lorry, lorry + trailer, motorcar + trailer, semitrailer, bus) and »motorcar-like« (motorcar, delivery van, without motorcycle).

2.3.2 Boundary conditions and sources of error

The evaluation was undertaken from 21st May 2012 to 10th June 2012. Within this period, the Pentecost weekend and a bank holiday weekend (Corpus Christi) took place. The bridging day was not a »normal« Friday, measured on present traffic volume. During the weekend and holiday, a considerable holiday- and recreational traffic (motorcycles, caravans, vehicle with trailer) was observed. The V&R- system detected approximately 21,000 vehicles on entrance, nearly 17,000 cars and 4,000 goods vehicles, over a period from 21st May. 3:30pm to 11th June 2012 0:00pm.

1. week					2. week					3. week												
21.05.2012 (Mon)	22.05.2012 (Tues)	23.05.2012 (Wed)	24.05.2012 (Thu)	25.05.2012 (Fri)	Pentecost weekend					28.05.2012 (Mon)	29.05.2012 (Tues)	30.05.2012 (Wed)	31.05.2012 (Thu)	01.06.2012 (Fri)	02.06.2012 (Sat)	03.06.2012 (Sun)	04.06.2012 (Mon)	05.06.2012 (Tues)	06.06.2012 (Wed)	Corpus Christi + Bridging day		
					26.05.2012 (Sat)	27.05.2012 (Sun)													07.06.2012 (Thu)	08.06.2012 (Fri)	09.06.2012 (Sat)	10.06.2012 (Sun)

Fig. 03: Overview of period

During this period, the weather was summery, with phases of rain and thunderstorm.

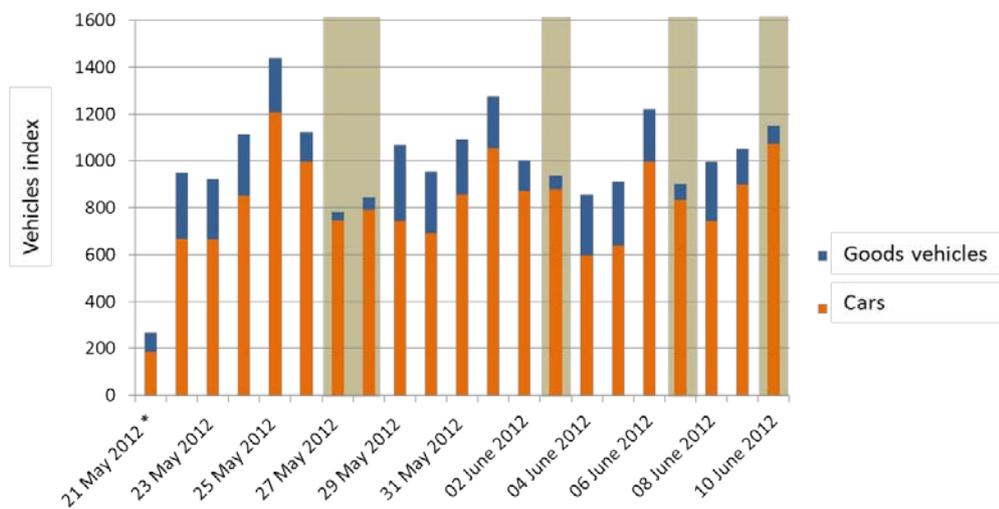


Fig. 04: Observation at the entrance (greyed: Sundays and holidays)

On the part of the evaluation system, following error sources can be documented:

- Limited field of view by siting (see fig. 02)
- Restricted view by masking and glare
- Incompleteness of recorded data (data gaps of different size)
- Offsets between the V&R-system and the different cameras.

V&R provides a system which detects vehicle length, but does not assert that a trailer exists or not.

Because the evaluation was based on TLS, deviations in the classifications are possible. They will in following be referred to as errors.

2.4 Summary of results

The long-term stability, which was shown in the first evaluation phase, could be observed again. In a limited amount of data, motorcycles were classified a motorcar, thereby the balances of vehicles were affected. Beyond, an area of classification resulted from a lack of definition of the TLS, where discrepancies could be found when only using the TLS criterion (motorcar with trailer, caravans). Additionally, interference through survey work was observed (persons, surveying devices).

2.4.1 Sample checks of occupancy

The sample checks have been carried out considering two different points of view: the observation of diurnal variations and the long-term measurement.

Observation of diurnal variations

Generally, the V&R-system reproduces the real diurnal variations very well. The hourly count at the random chosen Thursday, 31st May 2012, had the following characteristics, (see chapter 3):

- Lorry-like vehicles (maximum occupancy: 23 lorries, mean occupancy: 13)
 - Mean difference: 0.5 vehicles
 - Maximum difference: 2.0 vehicles
- Motorcar-like vehicles (maximum occupancy: 15 cars, mean occupancy: 6)
 - Mean difference: 1.0 vehicles
 - Maximum difference: 3.0 vehicles.

The classification was carried out in two stages: First, all unambiguously classifiable vehicles were assigned to their class (431 out of 445 vehicles). The remaining 14 vehicles (3 %) were classified along their measures.

It has to be pointed out that negative differences may occur due to bad visibility conditions during night or due to masking. Therefore vehicles may exist in reality, which could not be detected by the reference system.

Long-term observation

During the three weeks of measurement, the number of error detection or classification did not build up, therefore the system showed a good long-term stability. In the test period, except one measurement, the system obtained **+/- three good vehicle units** in maximum. The deviations for motorcars were in some cases considerably higher, partly due to masking and »blind angles« because of the positions of the cameras and partly due to wrong classification of motorcycles as well as of ambiguously classifiable vehicles between the classes »lorry-like« and »motorcar-like«. The last issue can be found in neutralizing deviations of lorries and cars. For both vehicle types applies that differences between reality and reference system may occur due to bad visibility during night (darkness or glare by punctiform light sources).

The following diagram depicts the deviations for all vehicle types over the whole period of observation, calculated as the difference of counted values of the reference and measured values of the V&R-system. Weekends are marked with »WE« and the holiday Corpus Christi is marked with »FT«.

The heavy deviation on the second measuring day may be attributed to a short-time heavy rain with high traffic volume. At this time, some vehicles have not been identified, for example because they followed too closely. Above, the system was disturbed on 6th June (Tuesday before Corpus Christi) because of survey work in the exit area.

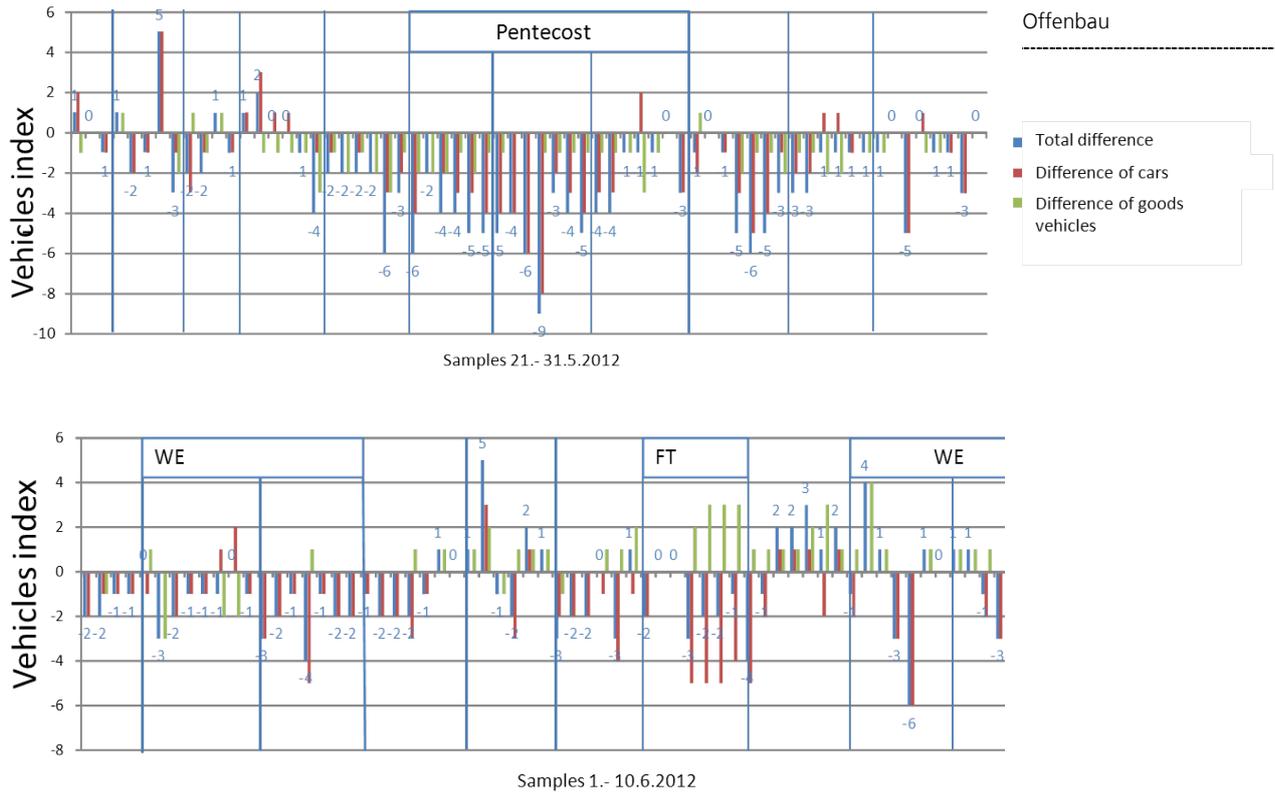


Fig. 05: Total deviations

2.4.2 Video counts

For video counting, those three days with the highest daily traffic volume were counted where video material existed.

The videos of entrance were compared with the protocols of the V&R-system for Tuesday, 29th May, Wednesday 6th June and Saturday 10th June from 11am to 3pm. As for this video material, small data gaps also occurred due to data transmission errors from camera to the recording computer, only those vehicles were compared where video pictures existed.

Over all three days, all vehicles have been detected by V&R. 1108 events of entrance were detected by V&R. 1083 of all vehicles have been detected correctly in terms of TLS (97.7 %), another 1.8 % were only ambiguously classifiable vehicles (car-trailer-combinations, caravan). The remaining 0.5 % of all wrong classifications (motorcycles classified as cars) are distributed over the three days as follows:

- Tuesday 29th May: 368 detected events, 1 wrong classification (0.3 %),
- Wednesday 6th June: 328 detected events, 0 wrong classifications (0.0 %)
- Sunday 10th June: 412 detected events, 4 wrong classifications (1.0 %).

In total, the system achieved a **classification quality of 99.5 %** for the periods on the chosen days. That equals the part of correctly classified events of all detected events by V&R-system.

2.4.3 Scenario test drives

In addition to the comparison of occupancy, scenario test drives have been carried out with another V&R-System at the petrol station and resting facility Brohtal-Ost (German motorway A61, between exits Mending and Niederzissen). 13 scenarios have been tested, which occur in practice, but are relatively rare to detect in normal traffic:

- Goods vehicle/ car stops on the left/right in the scanning area, Goods vehicle/ car passes by on the right/ left (eight scenarios in total, tested eight times each)
- Goods vehicle/ car follows closely to goods vehicle (two scenarios, tested five times each)
- Car follows closely to a car (one scenario, tested eight times)
- Goods vehicle/ car manoeuvres in the scanning area (two scenarios, tested five times each).

91 test drives (92.9 %) delivered correct results. Two wrong tests are due to a classification with TLS-scale based on TLS. There were three failed tests with closely following vehicles. Even though it has to be discussed, how much space vehicles leave between each other in practice, it is estimated that at least one test case featured a situation which could have happened in practice and therefore should have been detected correctly. Two scenarios failed, when a car stops in the scanning area and a goods vehicle passes on the left. Because the scanner is on the left side of road, the car was masked by the goods vehicle and »disappeared«. During the test, two goods vehicles with trailer were classified as goods vehicle and one car each. The complete protocol can be found in chapter 6.

2.5 General evaluation method of detection for BAB-lorry-parking guidance systems

In consultation with the Federal Highway Research Institute, department V5, the following general evaluation method is proposed for balancing counting systems on parking sites:

1. **Test of long-term stability:** The test comprises a long-term monitoring of occupancy, collecting at least 100 samples during a two week period. Collection should be started on the day after the last manual calibration or at least 1000 counted vehicles. It is proposed to collect occupancies at following daily times: hourly from 5:00 to 9:00, 13:00, and hourly from 17:00 to 21:00, corresponding to the times of the largest vehicle flows. It is not allowed to manually calibrate the system during the test phase of two weeks. During the test the given measurement tolerance is exceeded.
2. **Test of classification correctness:** This test compares the system classification and the classification along a given criterion at entrance and exit for 100 vehicles each. At the entrance, it is proposed to evaluate normal weekdays (no holidays or weekend traffic, thus Monday evening to Friday morning) between 17:00 and 19:00, and at the exit between 5:00 and 7:00.
3. **Analysis according to system requirements:** When considering two systems facing the same system requirements, one system is 'better' than another system, if the share of wrong classified vehicles and the share of occupancy measurements exceeding the system tolerance are lower.

An important basis of the evaluation is the classification criterion which classifies cars and goods vehicles. As a TLS-based criterion has a certain lack of definition (as described above), the following two stage procedure is proposed:

- 1) Decision based on an apparent membership to the TLS-classes (apparently lorry-like: large goods vehicles, goods vehicles with trailer, buses; apparently motorcar-like: cars)
- 2) If a classification is ambiguous, the circumscribed cuboid of a vehicle defines the class membership according to the thresholds for length, width and height. Thresholds were thereby defined in a way that a motorcar-like vehicle can use a parking lot assigned to motorcars.

In that case, the evaluation system has to be able to measure length, width and height. Octocopters taking orthophotos at a greater height could serve as one solution. Such an evaluation system also avoids masking and glare, which can only be avoided at great technical expense when using land-based video cameras. For capturing night scenes, infrared cameras are useful.

In addition, a pre-defined catalogue of scenario test drives is recommended in order to test seldom occurring but critical scenes at entrance and/or exit.

3 Short-term observation

The following chapter depicts the hourly observation and measurements of occupancy for goods vehicles, cars and vehicles in general from 31st May 2012.

3.1 Goods vehicles

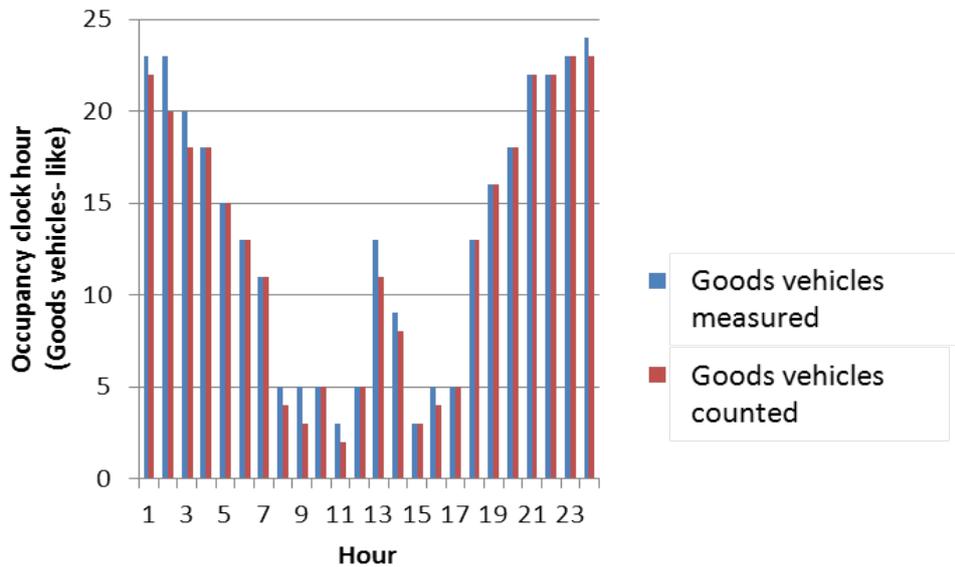


Fig. 06: Goods vehicles-samples for 24 hours

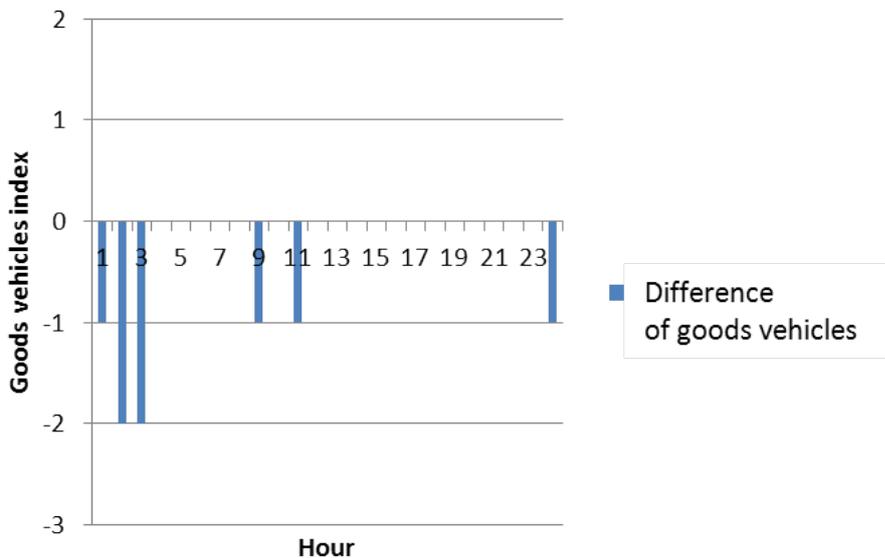


Fig. 07: Difference of samples of goods vehicles for 24 hours

3.2 Cars

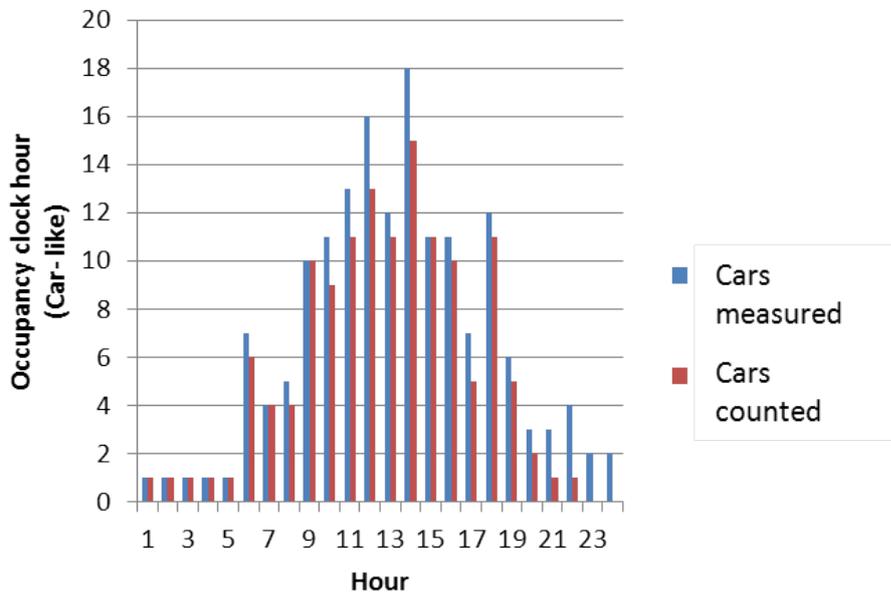


Fig. 08: Sample of cars for 24 hours

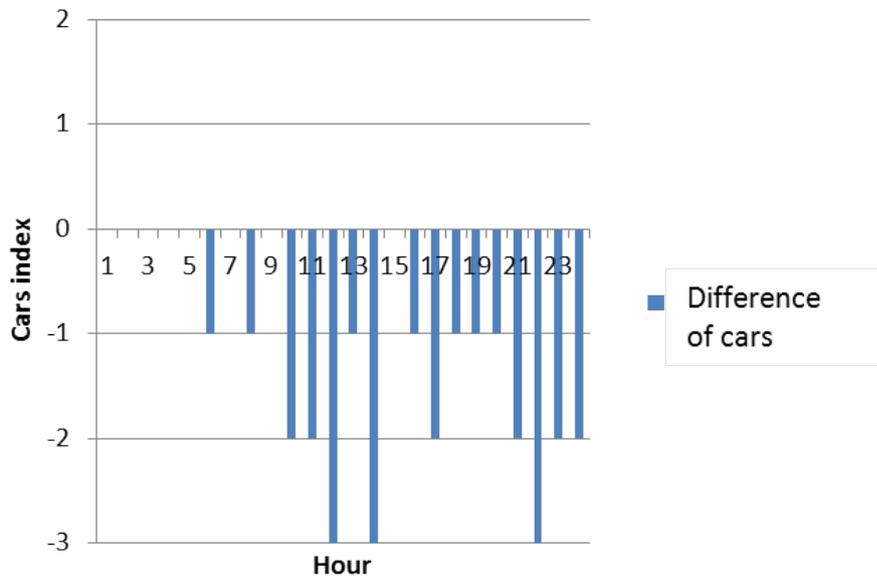


Fig. 09: Difference of sample of cars for 24 hours

3.3 Total

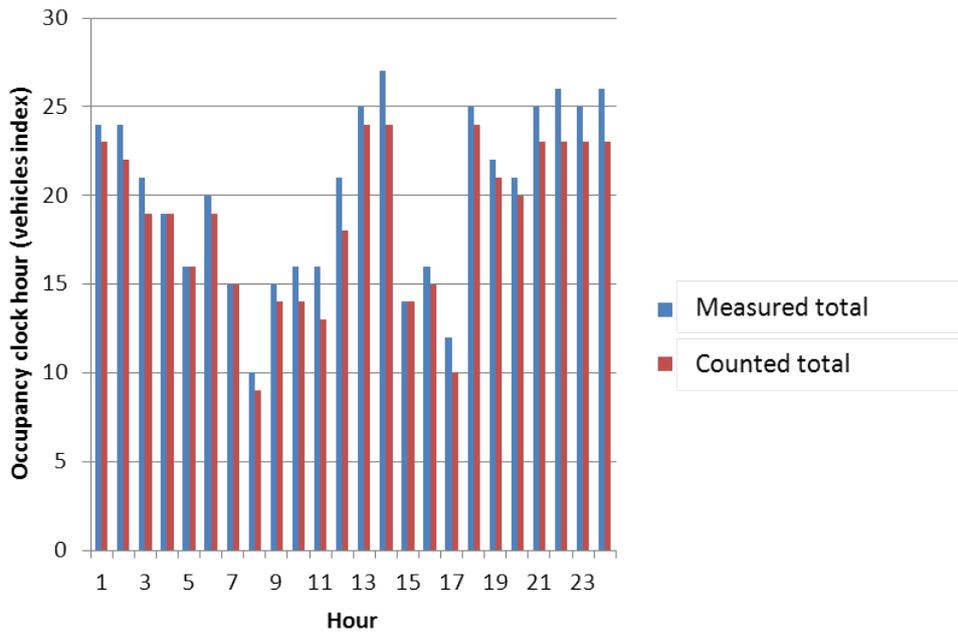


Fig. 10: Total number of vehicles in one day

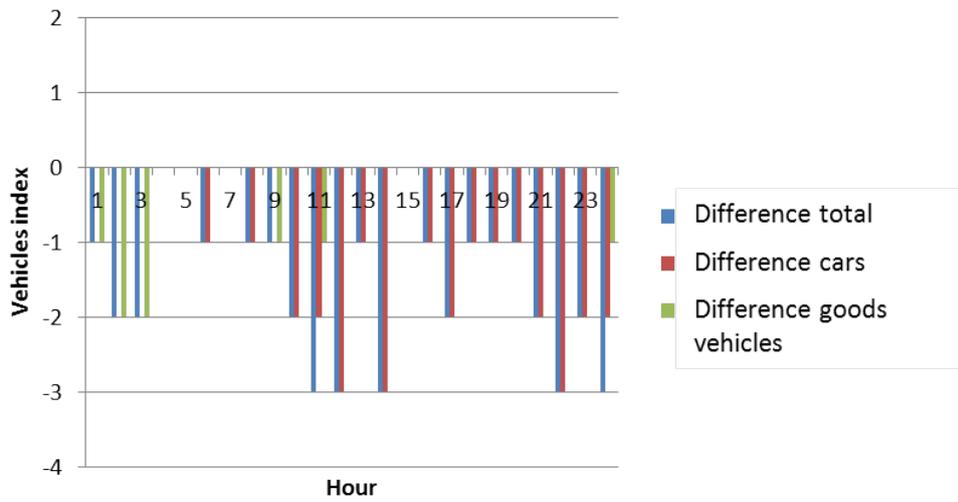


Fig. 11: Difference of all types of vehicles

4 Long-term observation

The following charts show occupancy measurements for the complete period for goods vehicles, cars and vehicles in general. Data were collected only if enough video data were available. In the chart, weekends are marked with »WE« and the holiday Corpus Christi is marked with »FT«.

4.1 Goods vehicles

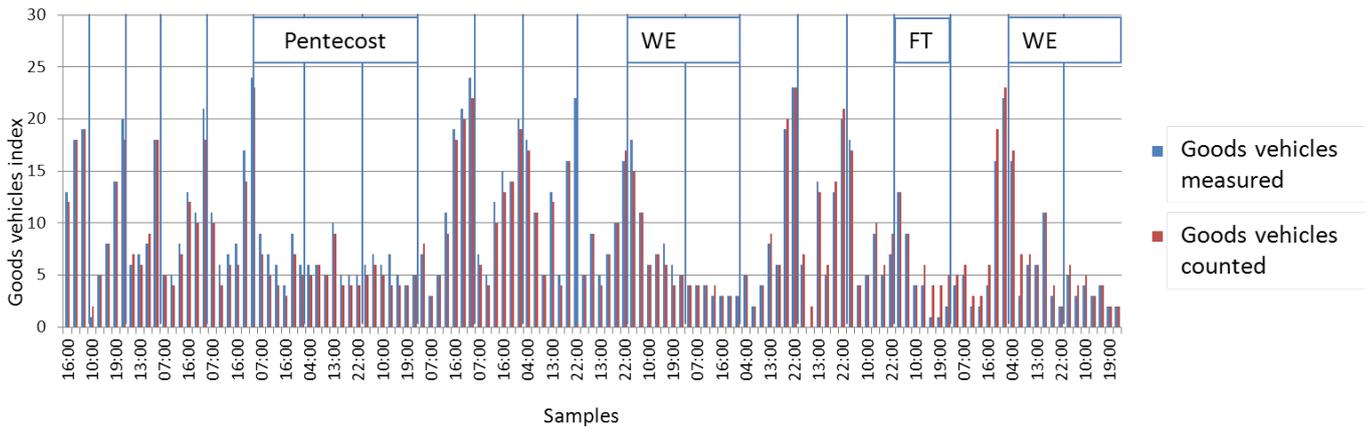


Fig. 12: Sample of goods vehicles for total period

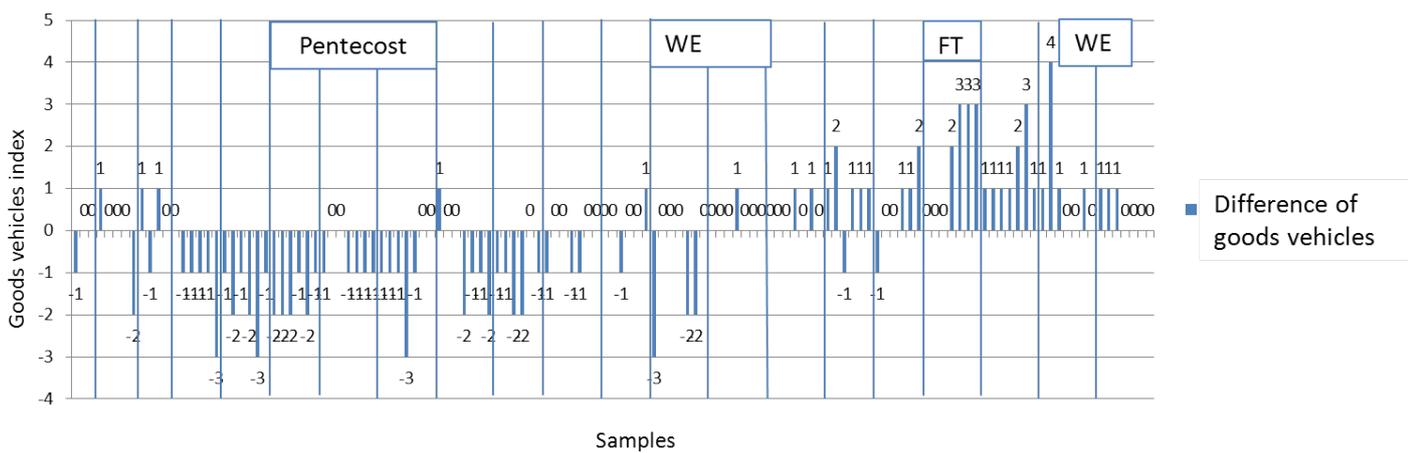


Fig. 13: Difference of sample of goods vehicles for total period

4.2 Cars

Long-term observation

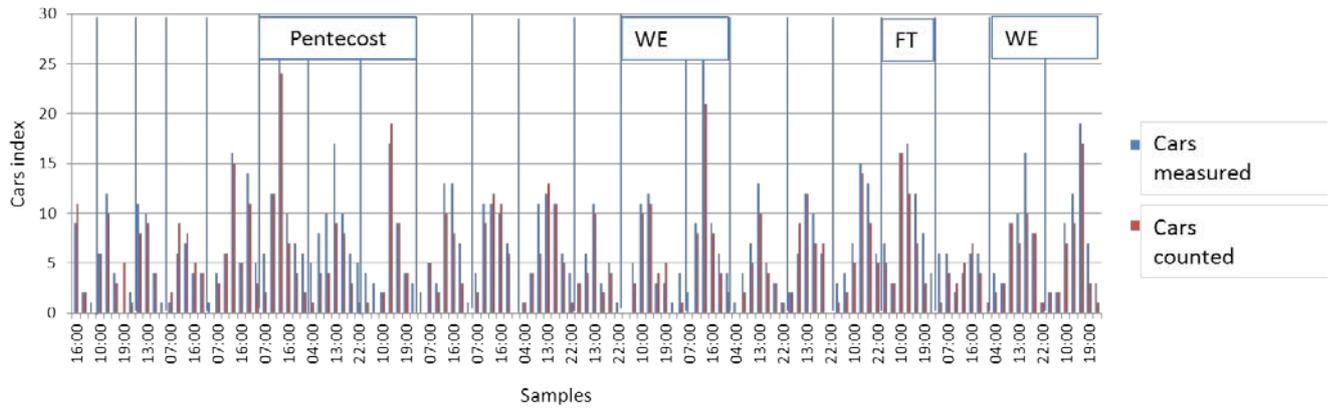


Fig. 14: Sample of cars for total period

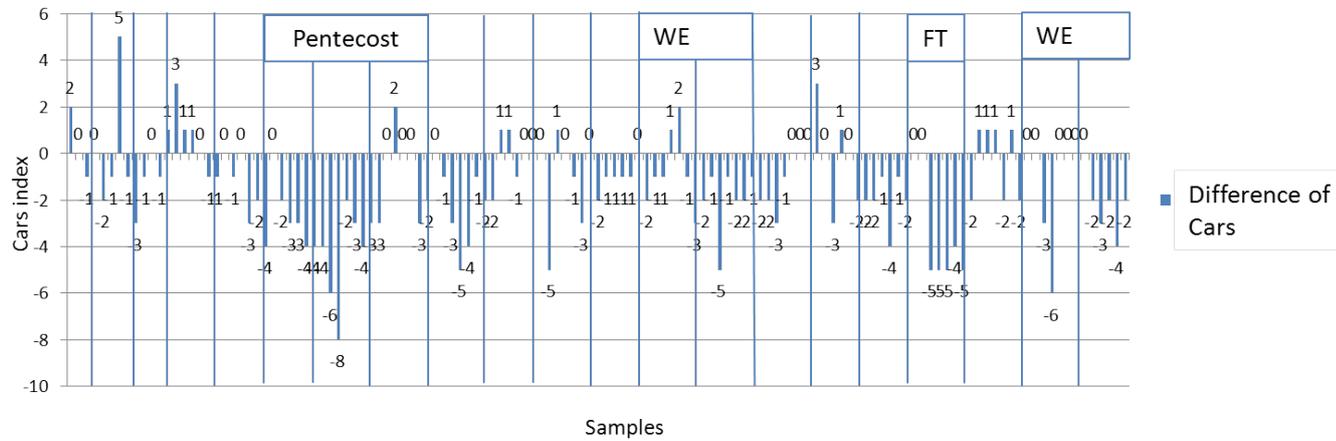


Fig. 15: Sample of difference of cars for total period

4.3 Total number of vehicles

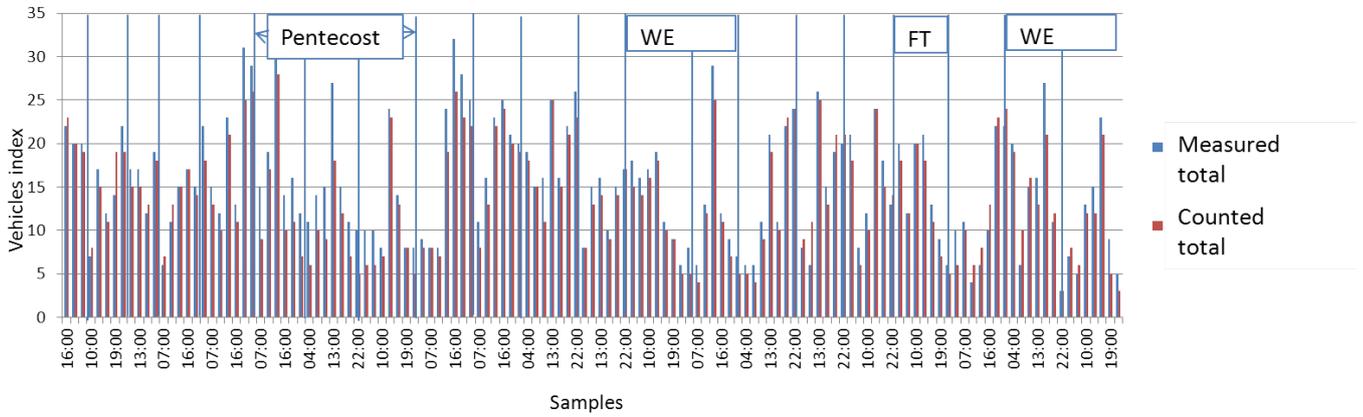


Fig. 16: Sample of all vehicles for total period

In the following chart, the total differences are given in blue numbers.

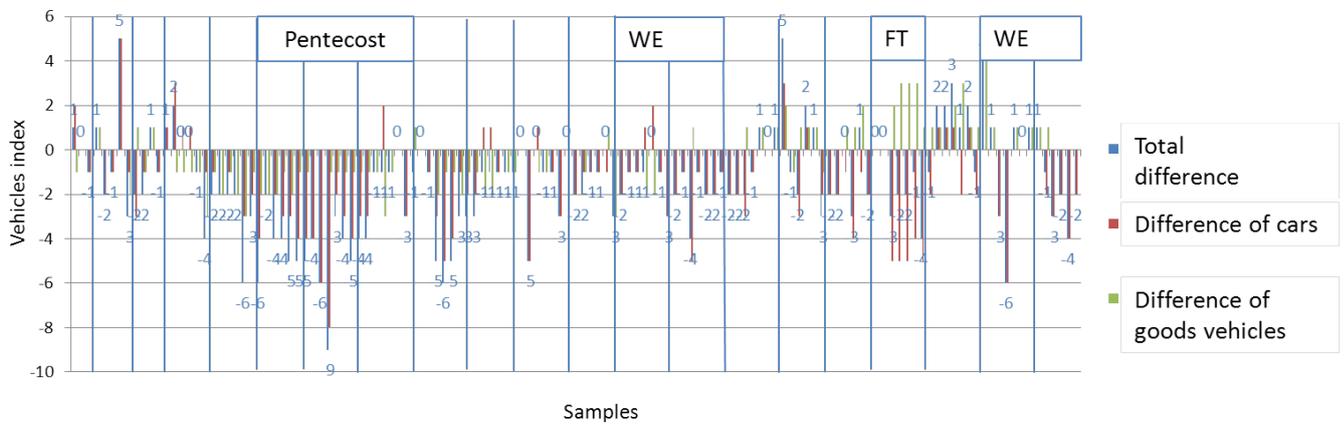


Fig. 17: Difference for all types of vehicles for total period

5 Results of video counting

The following two sections summarize the results of video counting. The first section shows the number of measured vehicles and the number of errors for each period. Causes of errors are shown in detail in the second section with corresponding pictures.

5.1 Overview of results

Tuesday, 29th May 2012:

time	V&R- Motorcar	V&R- Lorry	Motorcar counting	Lorry counting	non analogy	error
11-12:00	73	21	73	21	0	0
12-13:00	66	22	65	23	1	0
13-14:00	65	16	64	16	1	1
14-15:00	70	35	68	37	2	0
Total		368		367	4 (1,1 %):	1 (0.3 %)

Wednesday, 6th June 2012:

time	V&R- Motorcar	V&R- Lorry	Motorcar counting	Lorry counting	non analogy	error
11-12:00	77	18	76	19	1	0
12-13:00	55	24	55	24	0	0
13-14:00	67	11	67	11	0	0
14-15:00	60	16	59	17	1	0
Total		328		328	2 (0,6 %)	0 (0.0 %)

Sunday, 10th June.6. 2012:

time	V&R- Motorcar	V&R- Lorry	Motorcar counting	Lorry counting	non analogy	error
11-12:00	58	5	61	3	4	2
12-13:00	95	9	95	9	2	0
13-14:00	120	10	117	10	9	1
14-15:00	111	4	110	5	5	1
Total		412		409	19 (4,6 %)	4 (1.0 %)

5.2 Causes for non-analogy

Causes for non-analogy	frequency
Motorcycles classified as car	5 (4 on Sunday)
Vehicle with trailer not classified as goods vehicle-like	13 (8 on Sunday)
Caravan not classified as car-like	7 (all on Sunday)
	25 (19 on Sunday)

Table 1: Error causes

Motorcycles, which were classified as cars, are counted as 'real' errors; this is the case for 5 of 1108 events (0.5 %). The remaining 20 cases (1.8 %) of non-analogy are due to the lack of definition between lorry-like and motorcar-like vehicles, (vehicle-trailer combinations classified as motorcars and not as goods vehicle as specified in TLS, caravans classified as goods vehicle along their size and not as motorcar as specified in TLS).

5.3 Error images

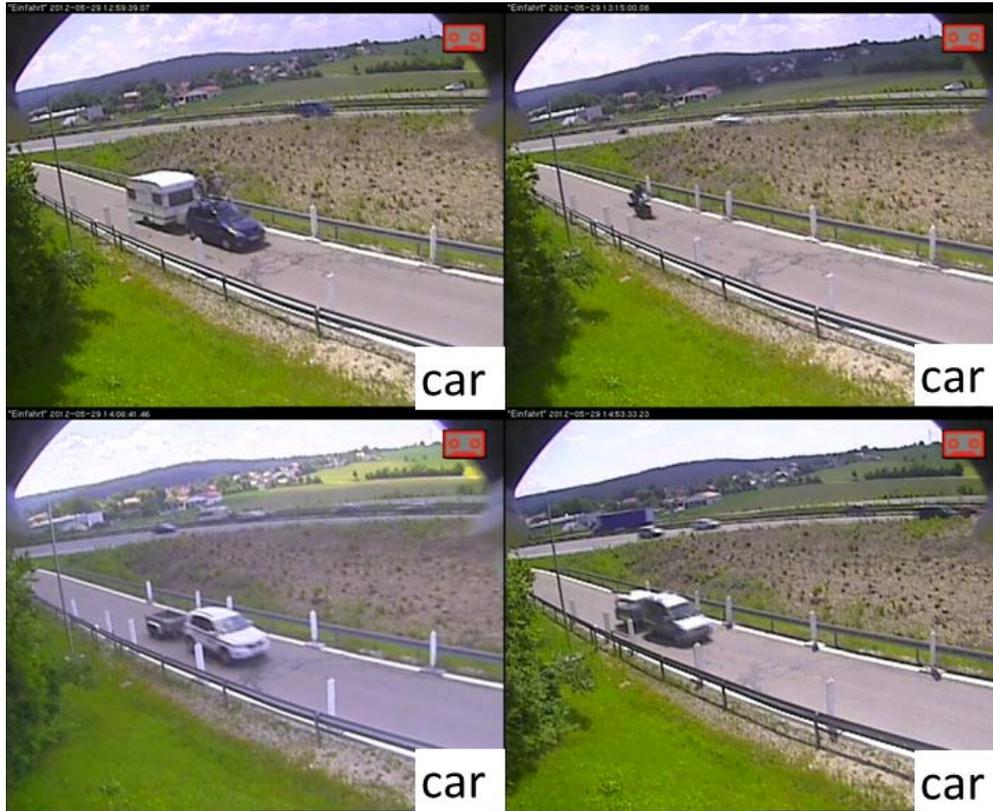


Fig. 18: Error images from 29th May 2012 with V&R-classification



Fig. 19: Error images from 6th June 2012 with V&R-classification

Fig. 20: Error images from 10th June 2012 with V&R-classification



6 Protocol of single test drives

Arrangement of test sequence ParkDetek		Monday 16.07.2012									
	vehicle 2	vehicle 1		1. test	2. test	3. test	4. test	5. test	6. test	7. test	8. test
1			Red goods vehicle stops in the scanning area								
			Blue goods vehicle passes by								
2			Red goods vehicle stops in the scanning area								
			Green motorcar passes by								
3			Red goods vehicle passes by								
			Blue goods vehicle stops in the scanning area								
4			Red car passes by								
			Blue goods vehicle stops in the scanning area								
5			Red goods vehicle follows blue goods vehicle closely (distance <2m)								
6			Green car follows yellow car closely (distance <2m)								
7			Blue goods vehicle passes by								
			Green car stops in the scanning area								
8			Green car stops in the scanning area								
			Blue goods vehicle passes by								
9			Green car follows blue goods vehicle closely (distance <2m)								
10			Green car stops in the scanning area								
			Yellow car passes by								
11			Yellow car stops in the scanning area								
			Green car passes by								
12			Blue goods vehicle drives into the scanning area, stops and backs out of the scanning area								
13			Green car drives into the scanning area, stops and backs out of the scanning area								

legend
successful
faultily
not successful

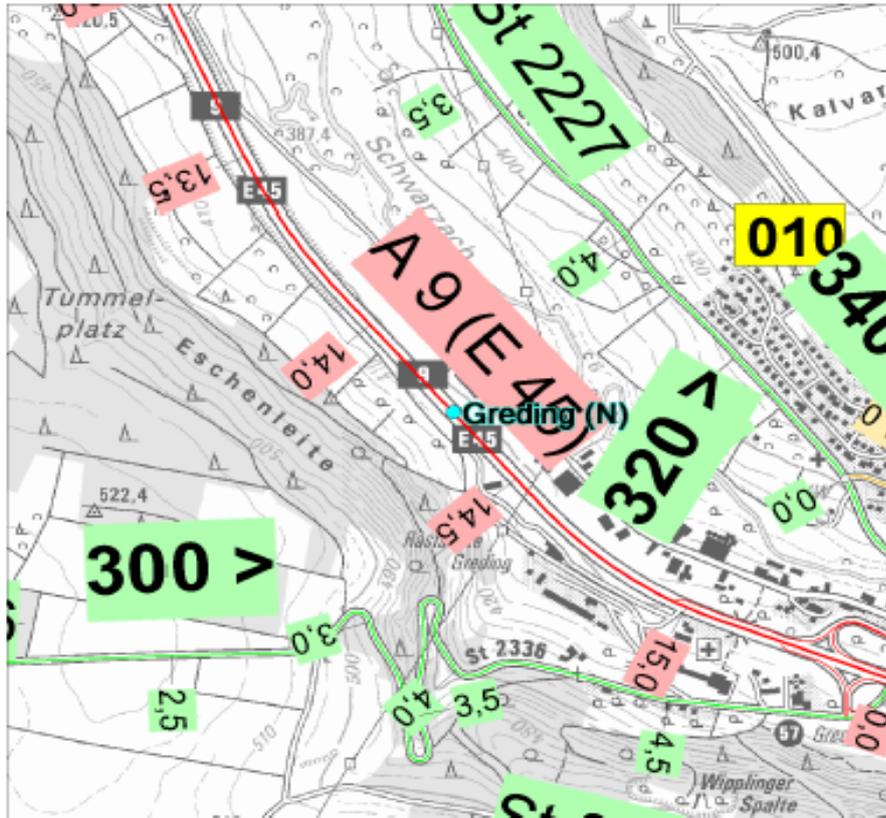
Fig. 21: Protocol of single test drives

7 Detailed traffic situation

Dauerzählstelle: Greding (N)

BASt-Nummern:
9061

Zählstellengruppe:
Statistik



Lage der Zählstelle

Straße
A 9

Abschnitt
740

Station
14,285000

Von Netzknoten:
68330280

Nach Netzknoten:
69340140

Länge des Zählabschnittes:
15,496km

Verwaltungsangaben

Dienststelle:
Autobahndirektion Nordbayern (0902)

Meisterei:
AM Greding (14)

Kreis
Roth

Regierungsbezirk:
Mittelfranken

Richtungsangaben

In - Richtung:
München

Gegen - Richtung:
Berlin

Querschnittsangaben

Anzahl gezählter Spuren:
In - Richtung: 3

Anzahl gezählter Spuren:
Gegen - Richtung: 3

Anzahl Fahrstreifen: 6

Geräteangaben

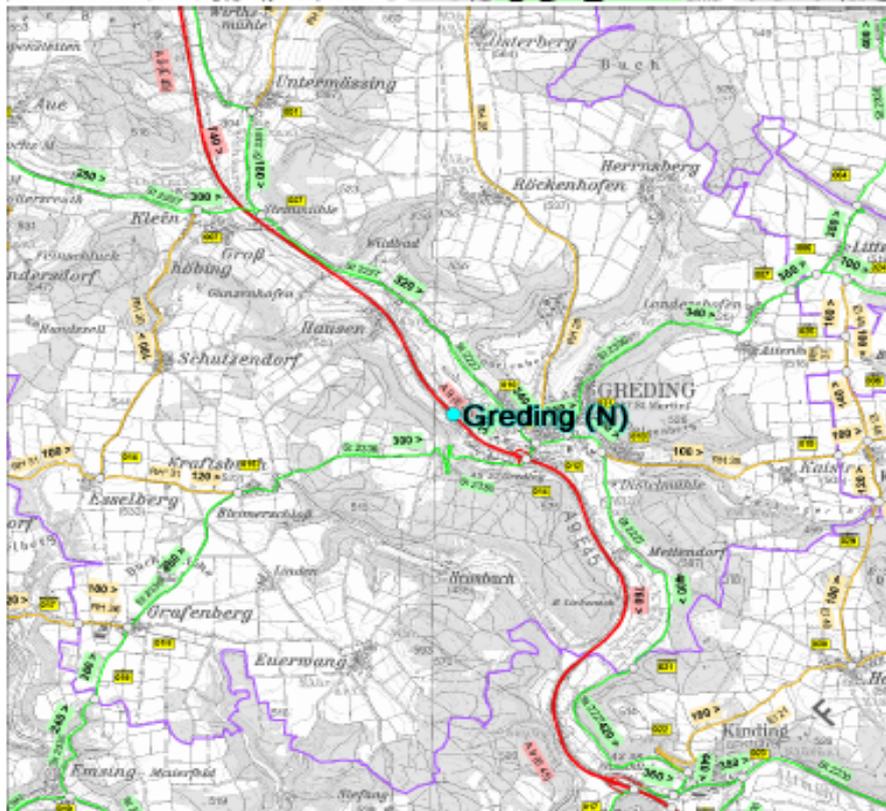
Zählgerät:
Weiss-Trier, MC 2002-4

Zählstelle eingerichtet:
1980

Zählstelle aufgehoben:
nein

Erfassungsart:
8+1

Bemerkung:



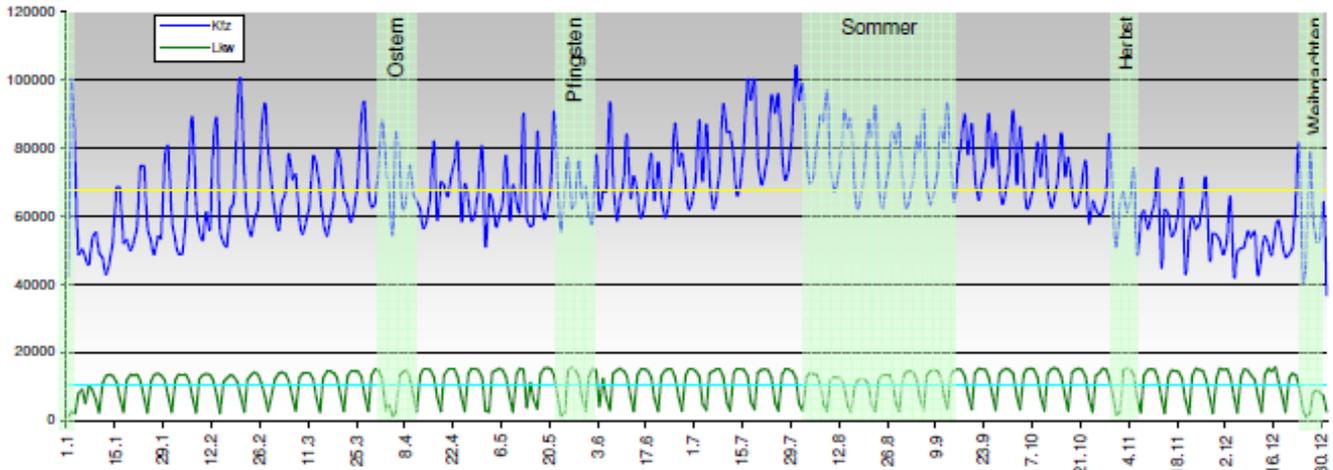
gedruckt am: Dienstag, 20. Dezember 2011

Geobasisdaten:
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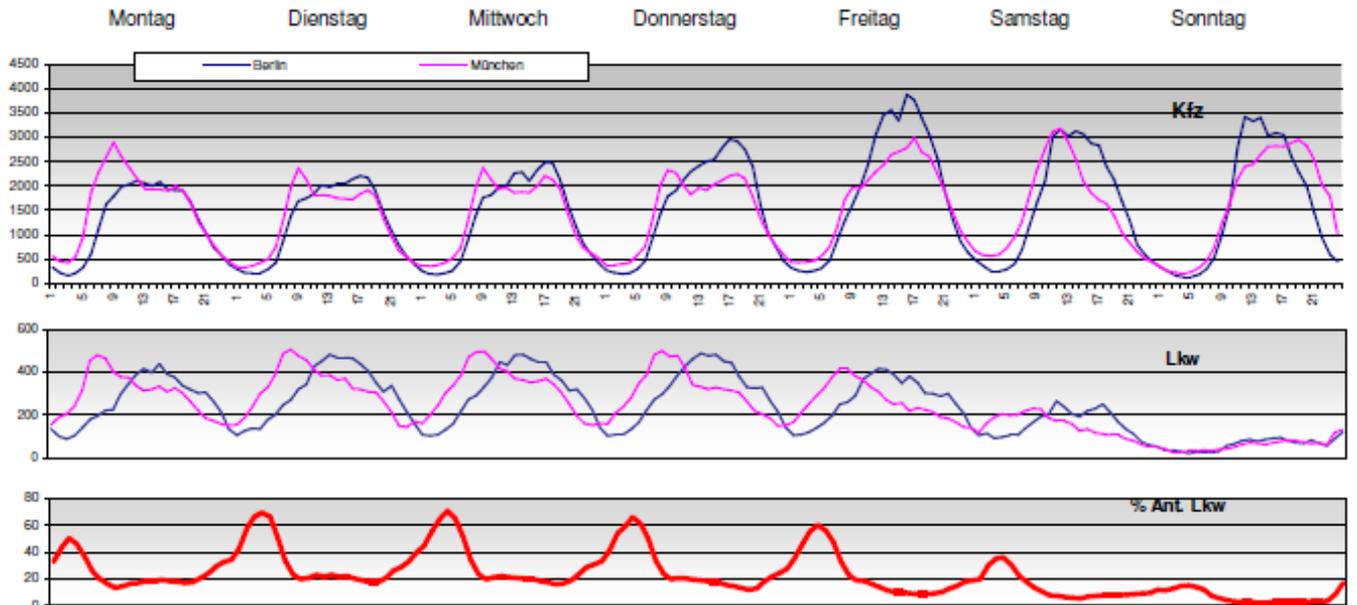
Bayerisches
Straßeninformationssystem



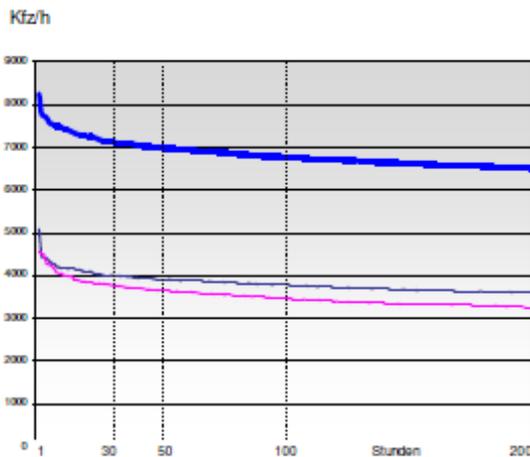
Jahresganglinien der täglichen Kfz- und Lkw-Verkehrsstärken - Gesamtquerschnitt



Mittlere Tagesganglinien der stündlichen Kfz- und Lkw Verkehrsstärken sowie Lkw-Anteile (Normalwochen)



Dauerlinien der stündlichen Verkehrsstärken



Verteilung der 200 höchsten Stunden des Jahres nach Tageszeit und Wochentagen

