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VERIFICATION OF CENSUS DEVICES IN TRANSPORTATION RESEARCH

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Abstract. The article presents a comparison of three devices and two methods that are used to count traffic flow. All measurements were carried out at a roundabout in Ostrava, where the following devices were used: Viacount II, Icoms TSM-SA, and Nu-Metrics NC-200 traffic analyzers. The methods of manual counting of vehicles and of counting vehicles based on video footage were used. The article also provides a comparison of the results obtained, namely in terms of traffic intensity, and of the measurements of the length and speed of vehicles. Further, we evaluate the results and explore the deviations from reality and the reasons why they occur. The article concludes with the recommended procedure designed to eliminate the identified problems, in order to ensure the most accurate results, with no significant deviations.

Keywords: road transport; traffic engineering; traffic flow; intelligent transport system; traffic census devices.

1. Introduction

Obtaining relevant traffic data is one of the most important phases of the work of a traffic engineer. The most exact information about the intensities of traffic flows, their composition, speed, variability, etc., is very important for follow-up analyses, prognosis, etc. Actually, there are two basic ways of getting traffic data: from manual counting and from automated counting (or their combinations). Each of these methods has its advantages and disadvantages, and their choice always depends on the purpose of the measurements and the required accuracy.

During our professional work and cooperation with practice, we have encountered a problem in terms of the suitability or unsuitability of certain types of automated census devices. Some devices are able to measure only vehicles in one lane, others in two or more lanes and some devices are able to measure vehicles coming in the opposite direction. In the case of using devices for complicated measurments, the device must first be calibrated, for example based on the distance from the lane device. The procedures are described in the relevant manuals [1], but based on our experience and expertise of practitioners, such procedures are not always applicable.

This article evaluates and subsequently compares data obtained from various counting devices measuring the intensity of traffic on a roundabout in the city of Ostrava. The measurements were made using classic manual traffic counting, counting from video footage, a Nu-Metrics NC-30x traffic analyzer placed in the roadway, a Nu-Metrics NC-200 traffic analyzer placed on the road surface, and two radars in the Viacount II and Icoms TMS-SA devices [2].

The raw data obtained from all types of measurements were then processed into a form enabling a mutual comparison of the measured results, so that a conclusion determining the reliability or error rate of the respective counting methods and devices could be made. This article is based on measurements made for the SGS "Verification of recording methods in traffic monitoring" project.

2. Location of measurement

The measurements took place on the outskirts of the city of Ostrava, in its part called Plesna. This site is located in the north-western part of the city, as can be seen in Fig. 1. A roundabout with three arms is located on the I/11 road – Opavska Street, about 600 meters from the city borders. The direct direction of this intersection is formed by the already mentioned road I/11, the third arm is the Prubezna street, which serves as a collecting local road of the Ostrava - Pustkovec district, as well provides access to the Globus hypermarket. This intersection is located on one of the main access routes into the city, and the intensity measured by measuring instruments corresponds to this fact. In the morning, the traffic intensity in the direction to the city dominates, whereas in the afternoon the intensity in the opposite direction is higher.

3. Devices and methods used

3.1. NU-METRICS NC-200 and NU-METRICS NC-30x traffic analyzer

The Nu-Metrics NC-200 traffic analyser is used for measuring vehicle speed, and the intensity and com-

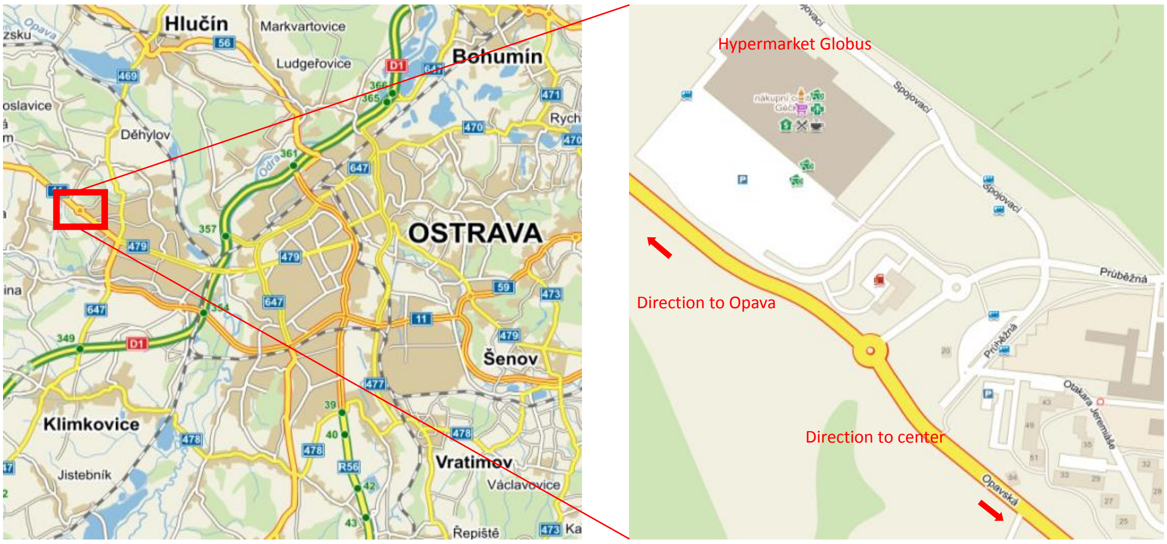

Figure 1. Location of the intersection for the purpose of the measurements

position of the traffic flow on roads. The analyzer is installed in the middle of the reference lane, directly on the roadway. The analyzer is then covered with a special rubber cover that is attached by eight screws into the road surface. To measure the number, speed and type of vehicles, the Nu-Metrics NC-200 uses VMI technology (Vehicle Magnetic Imaging). The device enables the allocation of vehicles to 13 length classification groups and 15 speed groups. The Nu-Metrics NC-200 can detect a vehicle with a traveling speed from 13 to 193 kph.

NU-METRICS NC-30X is the older type of the above-mentioned traffic analyzer. The card is installed in the middle of the reference lane into a 10 mm wide slot in the road surface, cut by a milling machine, which is then covered by a rubber strip. The device placed in the slot is sealed in a plastic bag that protects it against unfavourable conditions.

The traffic analyzers used for our measurement were borrowed from the Ostravske komunikace a.s company. See [3] (p. 16), to learn more about the use of these devices by the company.

3.2. Viacount II

Viacount II is a device used for the counting of vehicles in road transport. It is designed to measure the vehicles traveling either in one lane in one direction, or in two lanes in opposite directions. For each vehicle, Viacount II records its speed, the detail proportional to the length of the vehicle, and the time lag between two vehicles. The date of the measuring in the "dd.mm.yy" format and the time in the "hh.mm.ss" format are assigned to a block of measured data and stored in the memory of the detector. This counting device consists of a 24.165 GHz Doppler radar, integrated RAM, serial RS 232 output and lead-gel battery of values of 12 V/18 Ah. This battery enables approximately 15 days of continuous measurement.

3.3. Icoms TMS-SA

TMS-SA is an individual portable device designed for temporary counting of road traffic, classification of vehicles and measurement of their speed. The functionality is provided by Doppler radar (24.125 GHz) powered by a 6 V/12 Ah rechargeable battery, providing energy for a three-week-long measurement. The weight of the radar is 6.4 kg and a four-point mounting at the rear of the machine serves for mounting. The vehicle speed range for measurement is 10 to 255 kph. The device is able to measure the traffic in one lane or in two lanes of opposite directions. The device was borrowed from the Ostravske komunikace a.s. company, which also downloaded the data from the device [4].

3.4. Manual counting

Vehicles were also counted using the classical method of manual counting in the field into prepared forms. During the counting, different types of vehicles and their direction were distinguished. The records were made in quarter-hour intervals by four people. During the counting phase, the intersection was recorded by a video camera. Another counting was subsequently made from the recording, also with the same focus and into the same forms.

3.5. Hand radar

A handheld Speed II Radar was used. It is a model with measurement accuracy of ±2 kph in the speed range from 16 kph to 322 kph. The device measures at the distance of 27 m for small and slowly moving targets to up to 457 m. In our measurements, it was used to verify the proper operation of the Viacount II and TMS-SA devices at the beginnings of the measurements.

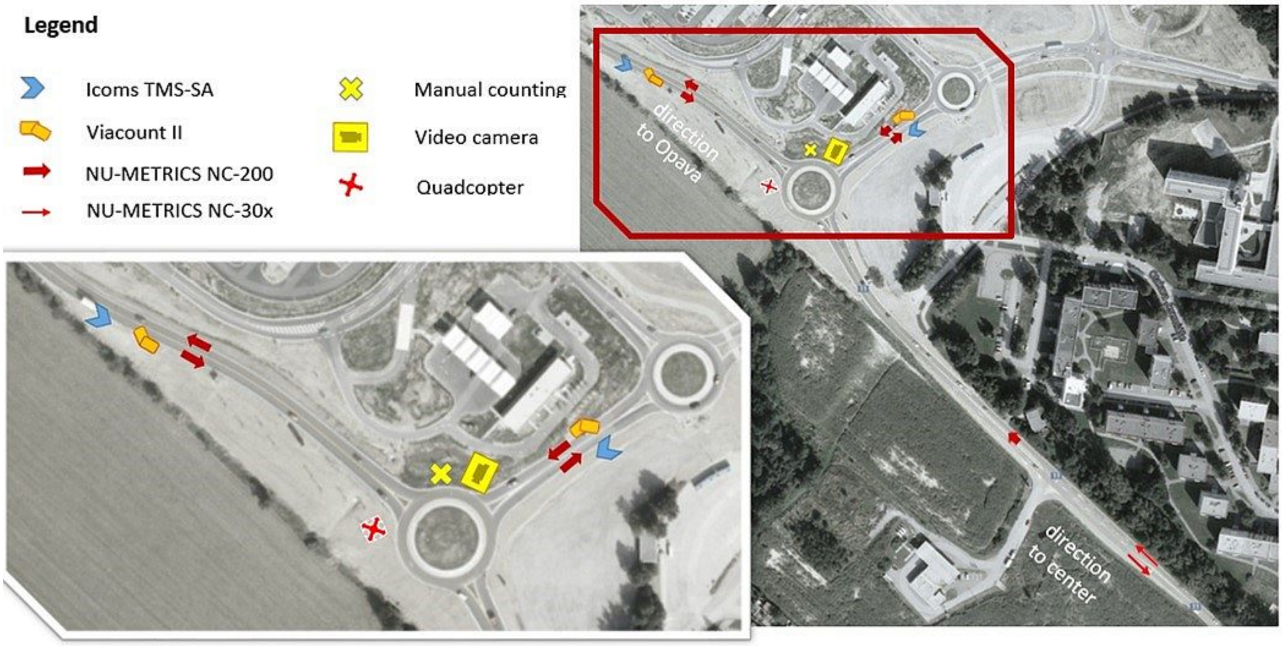

Figure 2. Location of the respective devices in the field.

	Measured intensity	Difference from reference value	The percentage difference from the reference value
Video record (reference value)	363	0	0.00 %
Icoms TMS-SA	352	−11	−3.13 %
Manual counting	351	−12	−3.42 %
NU-METRICS NC-200	343	−20	−5.83 %
Viacount II	339	−24	−7.08 %

Table 1. The measured values on the Prubezna street leg — Intensity for direction from the hypermarket GLOBUS.

3.6. Location of devices in the field

Seven counting devices and methods were used at the roundabout. The location of the respective elements in the field was as shown in Fig. 2.

3.7. Evaluation of the data

The evaluation was carried out in several stages. The first stage consisted of obtaining raw data from all devices. For this step, specific software provided by the manufacturer of each device was used. During the second stage, the raw data from individual counting methods and devices were unified to the same format; it was necessary to unify the numerical outputs so that they could be subsequently compared. The last stage consisted of entering all collected data into MS Excel, which offers the possibility to create a visual comparison of the values measured by individual devices or methods.

Measuring by the devices took place throughout the whole day; the manual counting method and the video record (video analysis) were made in the morning and afternoon rush hours [5]. As an example, in this article the counting leg of Prubezna Street will be used. This leg was selected because the largest number of counting methods was used.

3.8. The intensity of vehicles

The first compared criterion was the value of traffic intensity, as measured by the respective measuring devices and methods.

Traffic levels have a major impact on the design of the roadway and the parameters of the subsoil [5, 6]. The measured value was subsequently compared with the actual value which was determined based on the video record. The video record was analysed independently by three persons in order to count the true number of vehicles and eliminate the error that an individual can make.

The difference between the values measured by the respective methods or devices used and the actual number of vehicles is noticeable in Tab. 1. The difference between the highest and the lowest value is 24 vehicles, which at the detected hourly intensity of 363 vehicles means 7.08 %. The measured value most similar to reality was the value of the Icoms TMS-SA radar, which differed by 11 vehicles. Conversely, the biggest difference between the measured values, and therefore the worst result, was from the Viacount II device.

	Speed categories (kph)					Total number of vehicles
	0–10	11–20	21–30	31–40	41–50	
Viacount II	30	109	831	1302	158	2430
Icoms TMS-SA	22	219	785	1237	218	2481
NU-METRICS NC-200	94	142	738	1208	271	2453
Average value	49	157	785	1249	216	

Table 2. Comparison of the number of vehicles in different speed categories.

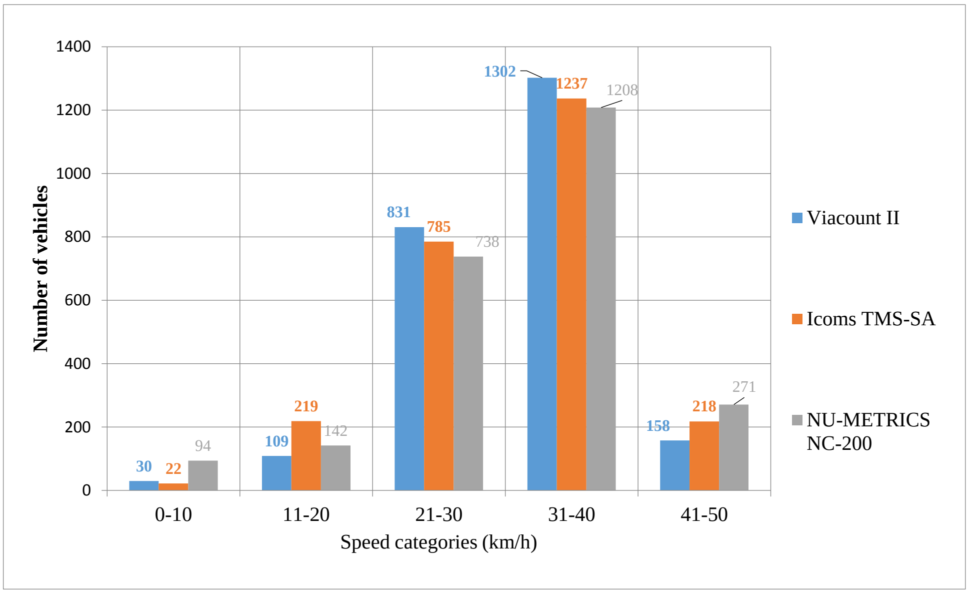

Figure 3. Comparison of the number of vehicles in different speed categories.

3.9. The speed of vehicles

The second carried-out comparison was the comparison of the following three devices: Viacount II, Icoms TMS-SA and NU-METRICS NC-200 traffic analyzer. The determined vehicle speeds were compared. For better clarity, the results were divided into five speed categories. For each category, the number of vehicles that moved at this speed was determined. The measurement was based on the values on the Prubezna Street leg as of July 17, 2014 between 10 a.m. and 5 p.m. All the measuring devices were placed in such a way that they were focused on the same spot on the road, so as to ensure the most accurate comparison possible.

From the three acquired values, the arithmetic average was determined, and it was then taken into account in the mutual comparison of the devices. Tab. 2 and Fig. 3 show the number of vehicles that were moving at a certain speed during the measurement. The values show that the devices mostly match in the speed range of 20 to 40 kph. There are significant differences between the devices at low speeds. The traffic analyzer recorded a much larger number of vehicles traveling at a speed of up to 10 kph than both radar devices. Also worth mentioning is the significantly higher number of vehicles traveling at a speed of 11 to 20 kph measured by the Icoms TMS-SA device, and, on the other hand, a significantly lower number of vehicles traveling at a speed of 41 to 50 kph measured by the Viacount II device.

Tab. 3 shows the percentage difference of the measured values. The sign indicates whether the device counted more or fewer vehicles than the average measured value. The total inaccuracy of the devices compared to the average value was then calculated based on all the deviations. The smallest deviation, namely 19.33 %, which is, however, still a relatively high value, was measured by the Icoms TMS-SA device. In general we can say that all devices, except for the speed range between 20 to 40 kph, differ quite a lot from each other in their meaasurements. Otherwise, comparatively significant deviations occurred, which can be seen in Fig. 4.

3.10. The length of the vehicles

The last comparison looked at the Viacount II, Icoms TMS-SA devices and the NU-METRICS NC-200 traffic analyzer with respect to the measured length of the vehicles. The Viacount II device measures the so-called electronic length; for further use it was necessary to convert it to length in meters, using tables provided by the manufacturer of the device. The mea-

	Speed categories (kph)					Average deviation of devices
	0–10	11–20	21–30	31–40	41–50	
Viacount II	−38.36 %	−30.43 %	5.90 %	4.24 %	−26.74 %	21.13 %
Icoms TMS−SA	−54.79 %	39.79 %	0.04 %	−0.96 %	1.08 %	19.33 %
NU−METRICS NC−200	93.15 %	−9.36 %	−5.95 %	−3.28 %	25.66 %	27.48 %

Table 3. The percentage difference from the average number of vehicles.

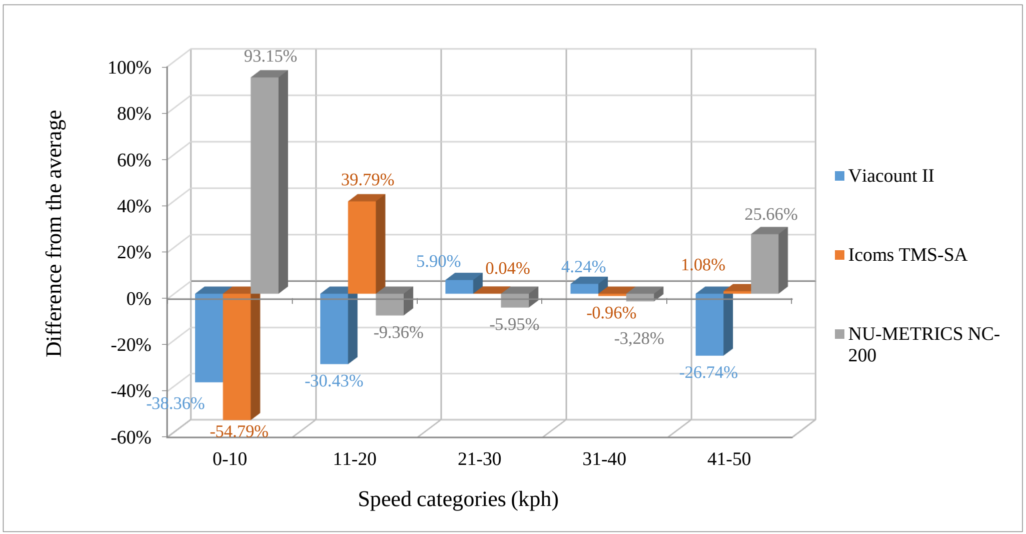

Figure 4. The percentage difference from the average number of vehicles.

sured length of the vehicles allows classification of the vehicles into five categories.

Tab. 4 shows the number of vehicles in each category, where the vehicles were divided according to the measured length of the vehicle. With the Nu-Metrics NC-200 traffic analyzer the figure for bicycles and motorcycles is missing, because the device is not able to measure these vehicles, unless they pass directly over it.

The comparison of the measured lengths of the vehicles showed that in this case Viacount II came out as the best device, having the total deviation of 2.73 %. Icoms TMS-SA and the traffic analyzers had deviations of around 6.25 %, as can be seen in Tab. 5. The radar counted more vehicles than average, whereas the traffic analyzers counted fewer. Fig. 5 provides a clear presentation.

4. Discussion

The obtained measurement results pose several questions about the reliability and suitability of the respective devices for the actual measurement. Before the measurement commences, it is necessary to ask how long the actual measurement will last, so that we can achieve relevant results. Based on the final evaluation, we can choose the method that will work best for us. This article only discusses a measurement using the devices on one roundabout. However, the devices were tested at more roundabouts with a similar placement of the devices, and similar deviations occurred.

It would be advisable to also place the devices on a different type of intersection or on straight sections, and to subsequently compare the results from the obtained data and evaluate the placement of the respective devices on the given type of intersection, or to recommend just a certain type of device for the counting itself. Currently, further measurements and testing of the devices are taking place for example in [7, 8]. The devices are placed on communications with two and more lanes, with variable distances and heights of the mounted devices. Subsequently, the results of these projects will be analyzed and published in other articles.

5. Errors in measurement

During the measurement we could observe several situations that caused the inaccuracy of the measurement, and this paragraph describes the most important of them.

The problem with the method of manual counting of vehicles in field forms consists mainly in the fact that with the increasing length of the measurement the attention of the person who performs the counting decreases. Also, if the intensity of the traffic increases significantly, the person carrying out the counting is no longer able to write down all the vehicles and put them into correct categories. In our experimen-

	Length category					Total number of vehicles
	Bicycle, motorbike	Car	Lorry	Bus, truck	Truck with semi-trailer	
Viacount II	39	2007	332	35	17	2430
Icoms TMS-SA	43	2038	341	40	19	2481
NU-METRICS NC-200	–	2101	303	33	16	2453
Average value	41	2049	325	36	17	

Table 4. Comparison of the number of vehicles in different length categories.

	Length category					Average deviation of devices
	Bicycle, motorbike	Car	Lorry	Bus, truck	Truck with semi-trailer	
Viacount II	−4.88 %	−2.03 %	2.05 %	−2.78 %	−1.92 %	2.73 %
Icoms TMS−SA	4.88 %	−0.52 %	4.82 %	11.11 %	9.62 %	6.19 %
NU−METRICS NC−200	–	2.55 %	−6.86 %	−8.33 %	−7.69 %	6.36 %

Table 5. The percentage difference from the average number of vehicles.

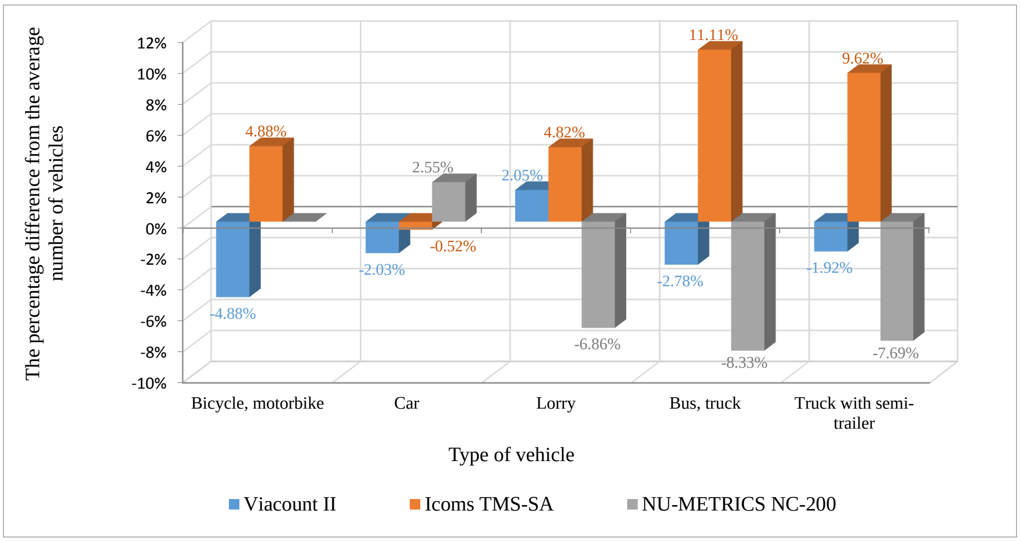

Figure 5. The percentage difference from the average number of vehicles.

tal measurement this method worked best, but the measurement took place at a leg with a relatively low intensity of traffic and the duration of the measurement in the afternoon peak was only two hours. Similar problems occur with the method of manual counting from video record since there is a possibility that the view would be blocked, for example, by a large vehicle.

With the NU-METRICS NC-200 and NU-METRICS NC-30x traffic analyzers the accuracy of measuring the traffic intensity is also high; inaccuracy occurs when the vehicle does not pass directly over the device. This occurs while overtaking another vehicle or when the vehicle passes the card only with a tire. If there is a traffic jam and the vehicle stops above the device, it will also result in an inaccurate measurement, especially in terms of speed and length, which are determined by the time the vehicles spend above the card.

With systems with radars (Viacount II Icoms TSM-SA), there is a problem when the transmitted beam is blocked. This occurs most often when a bigger vehicle is passing at a low speed through the radar beam. The radar beam does not reach the farther lane, through the bigger vehicle in the closer line, and the vehicles that pass there at that time are not included.

6. Recommendations

To ensure the most accurate measurements, it is necessary to consider the above-mentioned findings, whether it concerns the detected accuracy of measurement or the problems causing inaccuracy. In the case of long-term measurement, it is definitely beneficial to use one of the available devices. However, it is necessary to choose a good spot to place the device and to take into consideration the possibility of the occurrence of traffic jams, or of conditions that do not enable accurate measurement.

We recommend choosing the station for a video camera in such a way that the view of the measured section is not blocked. The same applies for the station of the people performing the manual counting. For the manual counting method it is also important to ensure a sufficient number of people to carry out the measurements, and to make sure that they are properly trained on how the survey is conducted.

The location of Nu-Metrics traffic analyzers should be chosen to ensure their being positioned in the middle of the roadway vehicles, and the analyzers should also be placed at a sufficient distance from the intersection to prevent any stopping of vehicles above them. Sections with no overtaking, or those where the roadway is narrowed so that the position of the traffic analyzer does not allow vehicles to pass the analyzer in the wrong way are suitable. This device is not suitable for counting bicycles and motorbikes [9].

Devices using radar should be placed on constructions next to the roadway that provide a direct view of the place of interest. It is necessary to avoid places where vehicles go too slowly, or even stand still. If the device is used for counting traffic flow in both direction, it is necessary to take into account the fact that if the transmitted beam is blocked in the adjacent lane (for example, by a standing truck with a semitrailer), the vehicles passing in the second lane are not recorded at all, and there is sometimes considerable distortion of the actual number of vehicles. It seems advisable to place the device above the roadway (for example on a bridge structure) where a view of both lanes independently should be ensured [10].

Acknowledgements

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