sciendo

DOI: 10.2478/rjti-2025-0014

ROMANIAN JOURNAL
OF TRANSPORT INFRASTRUCTURE

TRAFFIC DATA COLLECTION SYSTEMS: VEKPI - COUNT.

Sandu Robert Adrian, Ph.D. Student Eng., Technical University of Civil Engineering of Bucharest, robert-adrian.sandu@phd.utcb.ro
Răcănel Carmen, Ph.D. Eng. Professor, Technical University of Civil Engineering of Bucharest, Romania, e-mail: carmen.racanel@utcb.ro

Abstract

The paper presents the existing situation of automatic traffic recording systems located on the national road and motorway network in Romania, highlighting their technical and operational limitations, as well as the need to modernize and expand the traffic counter network. In addition, the implementation of an innovative vehicle counting and classification system based on the Raspberry Pi platform – VEKPI-count is developed and tested within a pilot project. The operating principles, technical and economic advantages of this system are presented, alongside comparative results obtained against conventional equipment currently in use.

The results of the study indicate that the use of the VEKPI-count system leads to an improvement in the quality of traffic data and a reduction in classification errors, while providing a cost-effective solution for expanding the monitoring network. The large-scale implementation of such systems can significantly contribute to the analysis of the correlation of road accidents with road characteristics and to increasing traffic safety.

Keywords: traffic monitoring, road safety, automatic traffic counters, vehicle classification, Raspberry Pi, VEKPI-count

1. INTRODUCTION

In Romania, one of the primary methods for obtaining long-term road traffic data is automatic counting systems [1], [2]. However, a significant number of the equipment currently in use consists of totalizing counters with limited functionality, lacking both vehicle classification and real-time data transmission. [5], [6]. These limitations affect the quality and operational efficiency of the analyses required for both traffic studies and road safety assessments.

In this context, modernizing and expanding automatic counting networks is a necessity, being further supported by European policies on increasing road safety and optimizing transport infrastructure. [3], [7].

The present paper aims to analyze the current situation of automatic traffic recording systems used on the national road network, managed by CNAIR S.A. through CESTRIN, to highlight the need for their modernization, and to present a new solution for vehicle counting and classification. The VEKPI-count system, based on Raspberry Pi and the exclusive use of inductive loops for vehicle classification, is analyzed from a technical, functional, and economic perspective, in comparison with existing conventional equipment. [6].

2. CURRENT SITUATION

One of the primary methods for obtaining road traffic data is the automatic counting system. Currently, the Romanian national road network is equipped with 322 totalizing traffic counters (ISAF) and 209 classifiers and Weigh-in-Motion classifiers (ADR 3000, ADR 2000 Plus, and SABRE), covering approximately 45% of the national road network managed by C.N.A.I.R. S.A.

The data collected using the traffic counters is utilized for determining the traffic composition, the number of vehicles using the road section where the counter is installed, calculating the Annual Average Daily Traffic (AADT), monthly daily averages, and hourly distribution. Traffic volume data is used within transport models during the calibration and validation stages. Transport models can be of several types, namely: at the AADT level, or hourly (at morning or afternoon peak hours, or average hourly traffic); therefore, to develop them, highly detailed traffic values are required for as many days of the year as possible, so that the model reflects reality as accurately as possible. [9], [10]. Furthermore, traffic volumes are utilized to determine the technical classification of roads and to facilitate the structural design of pavements.

Additionally, due to the sustained growth of road traffic within our country, the national road network is experiencing significant congestion phenomena, traffic bottlenecks, and excessive strain on pavement bearing capacity. [4], [7], [11].

2.1. The technological framework utilized by automated traffic counters

Automated traffic counting systems utilize intrusive technologies based on inductive loops and piezoelectric sensors, which are widely used internationally due to their high precision in vehicle detection and classification [9], [12], namely:

- ✓ **Inductive loop detector**

An inductive loop 'senses' the presence of an object containing metallic mass through electromagnetic field variations; the loop is embedded within a

traffic lane, into the pavement, at a predetermined depth, and subsequently sealed with specific types of resins.

This represents the conventional approach for vehicle detection. Inductive loops are utilized across a wide range of equipment (especially when high detection of vehicles is required) and counts the number of vehicles passing through a specific road section.

✓ **Piezoelectric sensors**

Piezoelectric sensors are placed in transverse grooves on the surface of the monitored lane of the roadway and then covered with certain types of special resins.

The principle used is the conversion of mechanical energy into electrical energy. Mechanical deformations of piezoelectric materials change the density of the material so that a potential difference appears between the electrodes. The amplitude and frequency of the signal is directly proportional to the degree of deformation. This system can be used to count the axles of vehicles and measure the weight of each axle.

✓ **Combination of inductive loop sensors with piezoelectric sensors**

This configuration ensures the most accurate determination of information related to vehicle class, speed and vehicle mass [12], [13].

2.2. Types of automatic traffic counters

On the national road network in our country, the following types of automatic traffic counters are used:

- **PEEK type traffic counter – ADR 3000 —** is a device that provides individual vehicle data (vehicle classification, instantaneous speed, axle mass and total mass and distance between axles) and vehicle classification by hourly intervals (figure 1). These counters perform continuous measurements providing real data on axle loads and perform automatic vehicle classification.

Figure 1. *ADR 3000 –WIM system (Weight in Motion)*

- **PEEK type traffic counter – ADR 2000 Plus and SABRE –** device that provides data on the classification of vehicles by time intervals (figure 2).

Figure 2. *ADR 2000 Plus / ADR Sabre*

On the national road network in Romania, there are 209 automatic traffic counting stations (daily recordings) that provide hourly traffic data and by vehicle category (figure 3). These include 44 WIM (Weight in Motion) stations –with equipment that allows the classification and weighing of vehicles while in motion and provides individual vehicle data (vehicle classification, instantaneous speed, mass on axles and total mass, distance between axles). The traffic data provided by the classifier and classifier-with- weight in motion are downloaded either using the VIPER automatic traffic download software provided by PEEK (figure 4), monthly, or by remotely accessing each meter, whenever needed.

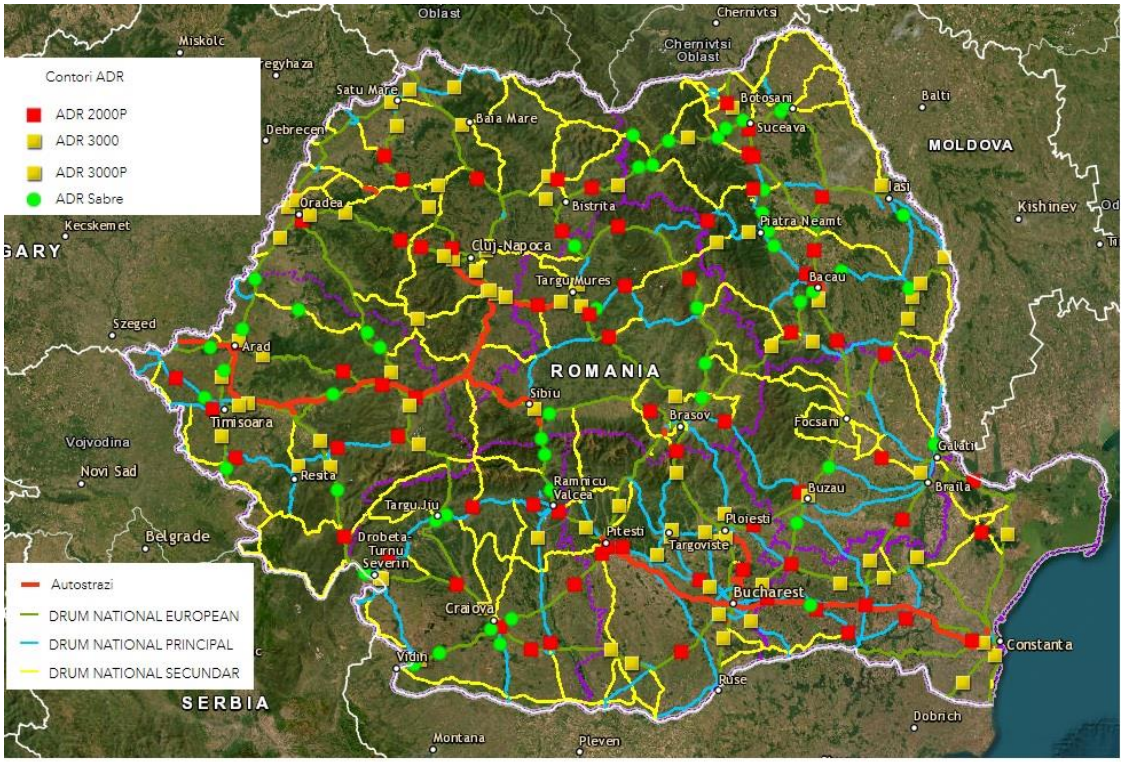

Figure 3. Map of classifier and dynamic Weight in Motion classifier stations

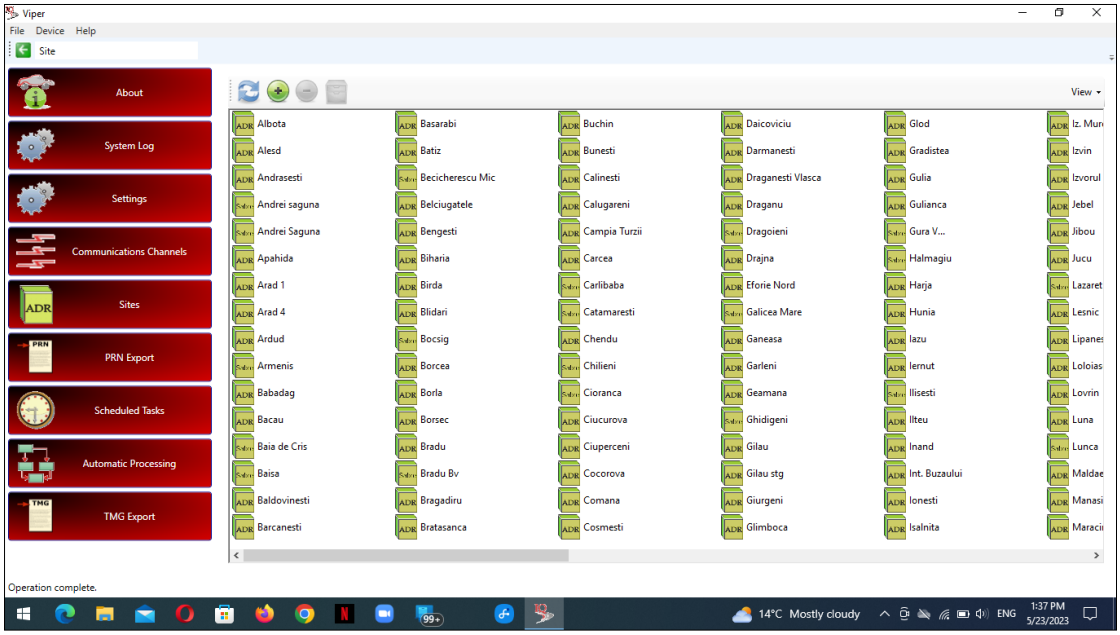

Figure 4. Automatic download of traffic data via VIPER software

In order to adopt a classification scheme as close as possible to the European TLS classification, this equipment uses the **RO 23 classification** scheme (table 1).

Table 1. Vehicle categories, RO23 classification scheme

Class	Types of vehicles
1	Motorcycles
2	Passenger cars
3	Cars with trailers
4	2-axle trucks
5	3 or 4 axle trucks
6	Trucks with trailers
7	Articulated vehicles: Tractor units with semi-trailers (TIR)
8	Buses and coaches
9	Unidentified (vehicles with more than 7 axles)

- **Totalizer traffic counter – ISAF –** equipment that provides data on the total number of vehicles per hour (figure 5).

ISAF traffic counter provide traffic data at the level of total vehicles per hour. Currently, traffic data obtained from these meters is extracted monthly from the equipment, using a laptop, and transmitted via a common FTP server.

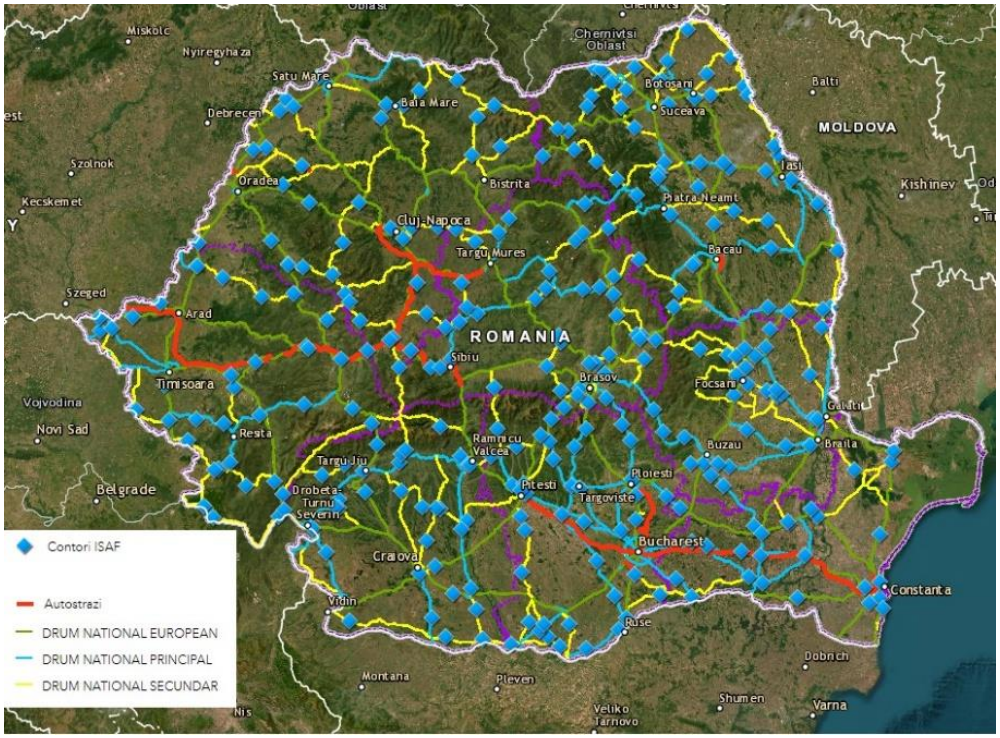

Figure 5. Map of totalizer stations

2.3. Classifier counter type using Raspberry PI - VEKPI-count

Due to the need to cover all census sectors with automatic traffic counters, as well as due to the low reliability of the currently used automatic equipment, a

classifier traffic counter (VEKPI-count) was developed and tested. This system is of the intrusive type and involves classifying vehicles according to length through a technology that uses only inductive loops (*VEKPI-count*) [14].

The intrusive systems currently used are composed of two inductive loops and a piezo-electric sensor, the estimated cost of a classification system for two traffic lanes being €6,000 for a classifying system and €15,000 for a weighing system (WIM).

The system tested within the project has the following advantages over the ones currently used:

- The cost of a classification system for two traffic lanes is approximately €1200;
- The system consists of two inductive loops on each lane, without the need for a piezoelectric sensor;
- The installation time is shorter, and weather conditions are no longer such an important factor as they are in the case of installing the piezoelectric sensor;
- System reliability is higher due to the reduction in the number of components installed in the roadway.
- In the event of failure of the inductive loops due to road degradation or following its rehabilitation, the cost of replacing them is significantly lower than the current system that involves the installation of piezoelectric sensors.

Software development has the following advantages:

- Local data storage and automatic transmission at a definable time period;
- Real-time data visualization;
- Easy and intuitive access to view the operating mode (even on your mobile phone);
- Sending automatic alerts regarding the operation of the equipment;
- The possibility of adding new functions that can provide other types of data by adding additional sensors to the Raspberry Pi development board.

To test the classifier-type counter using Raspberry PI - VEKPI-count, equipment was installed in the following locations (figure 9, 10, 11):

- DN1 Km 149+450 (installed on 11.03.2024 without interruptions to date);
- DN71 Km 42+500 (installed on 30.05.2024 without interruptions to date);
- DN19 Km 125+510 (installed on 14.08.2024 without interruptions to date).

Vehicle classification is done according to the TLS 8+1 class standard (table 2).

Table 2. Vehicle categories according to the TLS 8+1 class standard

Class	Types of vehicles
1 Motorbike	Motorcycles
2 Car	Passenger cars
3 Car with trailer	Cars with trailers
4 Van	2-axle trucks
5 Lorry	3 or 4 axle trucks
6 Lorry with trailer	Trucks with trailers
7 Truck	Articulated vehicles: Tractor units with semi-trailers (TIR)
8 Bus	Buses and coaches
9 Other	Unidentified (vehicles with more than 7 axles)

Figure 9. Installation of inductive loops in the roadway VEKPI - count

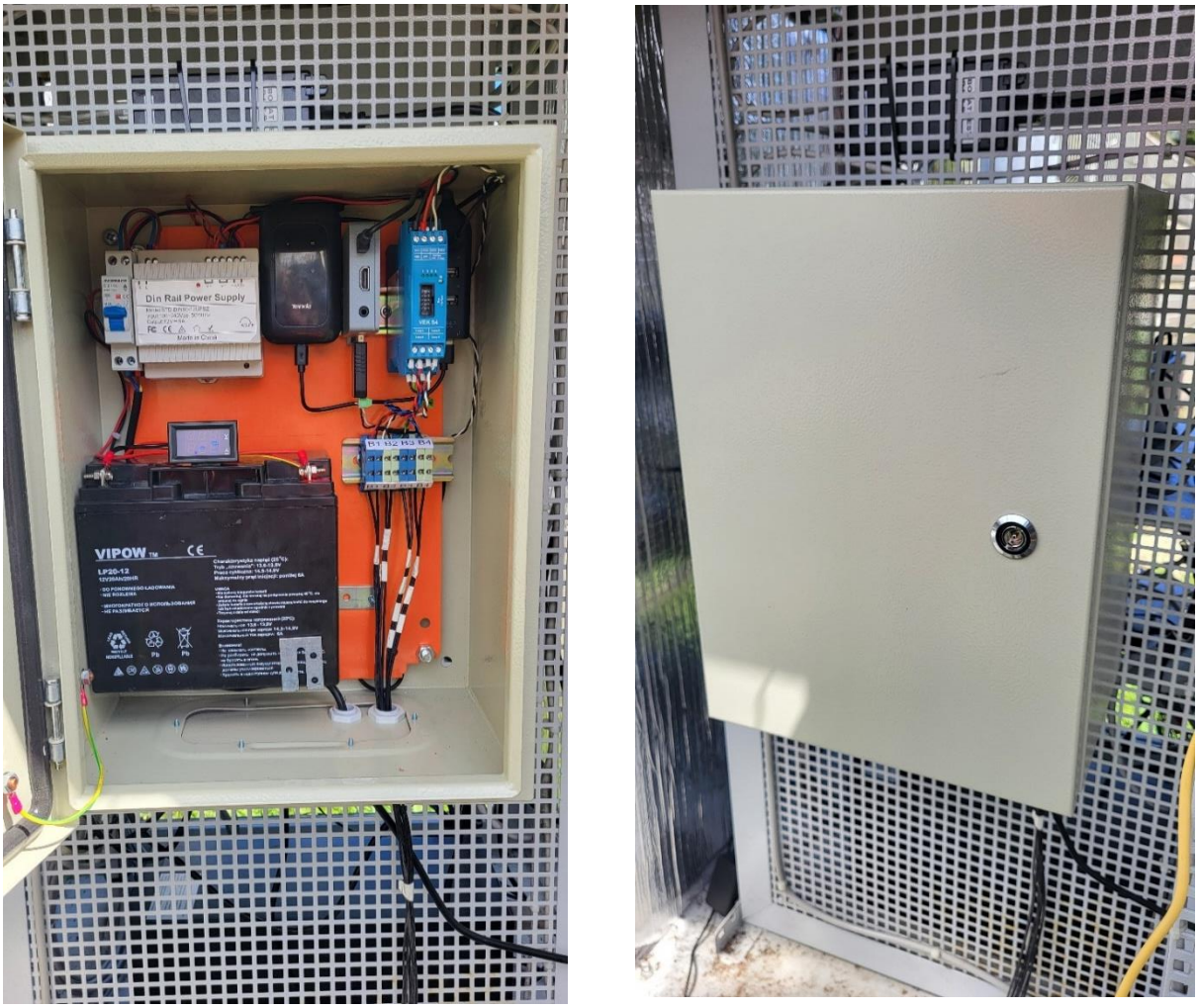

Figure 10. Installation of VEKPI– count - traffic counting equipment

16384;	48;	2;	1;	Car;	61;	51;	0;	0;	03.06.2024;	08:06:44
16385;	48;	1;	1;	Car;	36;	43;	0;	0;	03.06.2024;	08:06:47
16386;	48;	1;	1;	Car;	37;	57;	0;	0;	03.06.2024;	08:06:49
16387;	48;	1;	1;	Car;	37;	45;	0;	0;	03.06.2024;	08:06:51
16388;	48;	2;	1;	Car;	52;	45;	0;	0;	03.06.2024;	08:06:57
16389;	48;	1;	1;	Car;	51;	48;	0;	0;	03.06.2024;	08:06:57
16390;	48;	1;	1;	Lorry;	57;	92;	0;	0;	03.06.2024;	08:07:04
16391;	48;	2;	1;	Car;	63;	44;	0;	0;	03.06.2024;	08:07:06
16392;	48;	1;	1;	Car;	60;	48;	0;	0;	03.06.2024;	08:07:09

Figure 11. Viewing records from the VEKPI - count counter, in real time

3. CONCLUSIONS

In order to ensure proper operation of the road network, a network of automatic traffic counters is required to cover the entire national road network. With the coverage of the entire network of national roads and motorways in Romania with automatic classifying traffic counters, the national traffic census can be simplified to a single 24-hour recording day. The manual traffic counts on this day are absolutely necessary since the classification in the census includes

vehicle classes that cannot be independently deduced from the classification of the counters (Minibuses with a maximum of 8+1 seats, Minibuses with more than 8+1 seats and Trucks and special vehicles with a maximum GVW of 3.5 tons), the classification in the census being made exclusively according to the bodywork, in comparison to the classification used by the traffic counters, which is made according to the distance between the axles/length of the vehicle.
The traffic data recorded on the above-mentioned vehicle categories are used in this form in the development of traffic studies that form the basis for the Cost-Benefit analyses necessary for the economic justification of projects and funding applications, as well as the sizing of road structures.
The low reliability of existing ISAF counters, the lack of vehicle classification, as well as the lack of tele transmission that does not allow real-time monitoring of traffic records, lead to the need to replace this type of equipment.
To establish the quality of the recorded data, a short-term traffic census was conducted to verify the performance of the VEKPI – count. This was conducted at the station located on DN71 at km 42+500. A VEKPI - count equipment and a PEEK - ADR 3000 are installed at this location.

The analysis compared the traffic values recorded during the short-term census with the data from the VEKPI - count type counter and the data from the ADR3000 counter, by vehicle categories. As a result, it turned out that the ADR 3000 type recorder has a 9% error in vehicle classification, and the VEKPI - count type counter only 4%. We consider this 4% percentage reduction in errors to be a major advantage.

In Table 3, a comparison was made between the 3 types of automatic traffic recorders existing on the road network under the administration of CNAIR and VEKPI-count, using essential comparison criteria.

Table 3. Comparison between types of automatic traffic recorders

Comparison criteria	ISAF	PEEK	VEKPI - count
Type	Totalizer	Classificatory	Classificatory
Estimated cost in euros	-	6.000	1.200
Classification error	-	9%	5%
Installation time	1 day	2 days	1 day
Difficulty of installation	Easy	Hard	Medium
Data access	Hard	Medium	Easy

Note: The analysis was performed for a station located on a 2-lane road.

Acknowledgements

The authors would like to express their gratitude to CNAIR S.A., through the Center for Road Technical Studies and Informatics — CESTRIN, for the support provided in carrying out this research by making the necessary technical data available.

REFERENCES

[1] C.N.A.I.R. S.A: Rețeaua de drumuri naționale din România – date generale, 2025

[2] CESTRIN, Baza de date de trafic. 2025

[3] European Commission, Road Safety in the European Union – Trends, statistics and main challenges, 2018.

[4] World Road Association (PIARC): Traffic Data Collection and Analysis, Technical Report.

[5] CESTRIN: Manual contoar de trafic de tip ISAF, 2001.

[6] PEEK Traffic Ltd., ADR 3000: Technical Specifications and User Manual.

[7] European Transport Safety Council: Reducing traffic congestion and improving road safety.

[9] Federal Highway Administration (FHWA), Traffic Monitoring Guide, U.S. Department of Transportation, 2022

[10] Ortúzar, J. D., Willumsen, L. G., Modelling Transport, Wiley, 2011.

[11] Austroads, Traffic Monitoring and Analysis, Sydney.

[12] Haider, M., "Inductive Loop and Piezoelectric Sensors in Traffic Monitoring", Journal of Transportation Engineering.

[13] Jacob, B., O'Brien, E., Jehaes, S., Weigh-In-Motion of Road Vehicles, Springer.

[14] Upton, E., Halfacree, G., Raspberry Pi User Guide, Wiley.com, 2012