Traffic modelling using software equipment presents a forceful working method in traffic engineering area. Traffic flow simulation models were created as a tool for theoretical study of different factors of analysed values of basic traffic characteristics. Specialised software products are being used presently for traffic problems solving, as these have excessive possibilities of simulations and settings. They enable us to simulate numerous scenarios of traffic infrastructure in short time period. By using the simulation it is possible to model current and future statuses of traffic for the respective traffic flow [1].

2. Traffic flow movement

Traffic flow is defined as a movement of vehicles (pedestrians) in one line or in parallel lanes in the same direction. It can consist of several driving (walking) lanes, and has its characteristics and specific features, which describe its movement under different conditions.

During the drive the situation is being changed continuously and complicated situations arise as the influences of road users, time, space and movement take effect. Vehicles have influence on other vehicles during movement both in line and parallel, move in groups and make use of their speed. Their movement is determined not only by the abilities and requirements of users, vehicles' performance, vehicles' number and types, but also by road parameters, surroundings and climate conditions. Traffic flow consists of all flow participants moving in line or in parallel in the same traffic direction. It can consist of one or more traffic lanes. Vehicles moving in traffic lane change their position in time [2].

2.1 Traffic flow characteristics

Basic characteristics of traffic lane, describing its quantity and quality, are:
- intensity,
- speed,
- density.
Indirect characteristics of traffic flow are:
- time gap,
- length gap among individual vehicles [2].

3. Monitored section characteristics

For the practical measurement a road section of I/18 Zilina - Strecno - Vrutky was chosen. It ranks among the most frequently used road sections in Slovakia. Based on the analysis of average daily traffic densities it is possible to figure out the growing traffic intensity on this section of road I/18. For comparison, in the year 2000 the intensity on entrance to the town of Vrutky was 14,784 vehicles, in the year 2010 it was already 25,463 vehicles, which...
The mobile system Polcam PC2006 is a device designed to patrol the road traffic situation, exact measurement and average vehicle speed of the vehicle in which it is installed. It is designed for indirect measurement of the vehicle speed in front of, or behind the vehicle, in which the system is installed. The respective measurement is based on time measuring and passed distance. The system measures the average speed based on the exact measurement of distance and time.

The system Polcam PC2006 consists of:
- Polcam control unit,
- Remote control,
- Display unit Polcam EC-M (optional 7"-10" monitor),
- 28 x zoom camera Polcam EC-C (C28E) [5].

To these basic Polcam PC2006 components other additional equipment is connected:
- Digital registering equipment with HDD up to 320 GB and 4 to 8 inputs of format H.264,
- Cable system (connection of individual parts of the system and installation on the vehicle),
- Overview wide-angle cameras VS,
- GSM and WiFi antenna,
- Wireless equipment for sound transfer.

The control unit is connected by cable system with individual parts of the road speed meter, to power from the dashboard and screening of the vehicle speed [5].

The control unit fulfils the following functions:
- measures distance and time and from these data calculates the average speed,
- shows the video inputs and measured data on the monitor,
- processes measured data and controls auxiliary equipment.

The control unit calculates the distance from data obtained from an ABS sensor, or from vehicle data collector CAN BUS. Based on these data - sensor equipment impulses, a constant is set (number of impulses on a precisely set track, usually 500 to 1 000 m) to calculate an instantaneous speed. For synchronization of wheel perimeter and the track passed, the central unit has a possibility of changing the constant due to wheel dimension of individual vehicles (a constant of road speedometer is the number of impulses $k_i$ on a formerly set out and passed track $k_d$ [5].

The setting up and check of the constant of road speedometer is being done during official validation of the Polcam PC2006 system. During validation the value of distance (track) $k_d$ and number of impulses on the passed distance $k_i$, are inserted into the central unit memory of the road speedometer, inserting is being done by a procedure specified by the manufacturer.

All information displayed on the screen is being saved on a hard disc of the recording equipment. Following pieces of information are continuously displayed on the monitor of the measuring device: date, time, camera identification/arrival,
6.1. Values obtained by practical measurement

Three measurements were done – morning peak hour, saddle, and afternoon peak hour.

- morning peak hour - measurement performed on April 16, 2015
  - direction Zilina - Vrutky: start 7:48:21, finish 8:03:03
  - direction Vrutky - Zilina: start 8:05:38, finish 8:19:53
- saddle - measurement performed on March 30, 2015
  - direction Zilina - Vrutky: start 12:48:23, finish 13:00:30
  - direction Vrutky - Zilina: start 13:01:58, finish 13:14:47
- afternoon peak hour - measurement performed on April 20, 2015
  - direction Zilina - Vrutky: start 16:00:17, finish 16:13:03
  - direction Vrutky - Zilina: start 16:14:06, finish 16:27:56

Measurement method

During the execution of a measurement with the use of a floating vehicle, firstly the vehicle moves in the direction of the measured section of the traffic flow, then in the opposite direction. In both cases measurements and numbers of overtaken and overtaking vehicles are being recorded. When driving back, the vehicles driving in opposite direction are being counted. In our particular measurement the number of vehicles passing (passed) in the same direction was zero.

Intensities \((M)\) obtained by practical measurements were recalculated into hours. Individual intensities are shown in the following Table 1. Only the saddle case is shown.

### Table 1

| SADDLE | **DIRECTION** | **Zilina - Vrutky** | **Vrutky - Zilina** |
|--------|---------------|---------------------|---------------------|
| Vehicle type | Intensity obtained by measurement | Intensity converted to hours | Intensity obtained by measurement | Intensity converted to hours |
| Personal vehicles | 219 | 504 | 174 | 401 |
| Trucks | 12 | 28 | 23 | 53 |
| Buses | 2 | 5 | 1 | 2 |
| Truck semitrailers | 47 | 108 | 53 | 123 |
| Total | 280 | 645 | 251 | 579 |

Section speed \((V_u)\)

Section speed was obtained from Polcam device, which evaluated the respective section upon measurement completion.
Maximum distance, 9 999.9 m, is predefined in Polcam device. After exceeding this distance we continued the measurement after repeatedly pressing the START/STOP button. When calculating the section speed we used the weighted arithmetic average (Table 2).

**Density (H)**

Model calculation for saddle is shown below as an example. Density is calculated based on the formula below:

\[ H = \frac{M}{V_r} \]

Overview of basic characteristics for “saddle period” is in the following Table 2.

### Basic characteristics overview

| Measurement | Measurement direction | Vehicle type | Intensity - M | Section speed (km/h) | Density (vehicle/km) |
|-------------|-----------------------|--------------|---------------|----------------------|---------------------|
| **Saddle**  | Zilina – Vrutky       | Personal vehicles | 506           | 76.22                | 8.46                |
|             |                       | Trucks        | 27            |                      |                     |
|             |                       | Buses         | 4             |                      |                     |
|             |                       | Truck semitrailers | 108         |                      |                     |
|             |                       | **Total**     | 645           |                      |                     |
| **Measurement time** | 13 minutes 49 seconds |                      |               |                     |

| Measurement | Measurement direction | Vehicle type | Intensity - M | Section speed (km/h) | Density (vehicle/km) |
|-------------|-----------------------|--------------|---------------|----------------------|---------------------|
| **Saddle**  | Vrutky – Zilina       | Personal vehicles | 402          | 81.39                | 7.11                |
|             |                       | Trucks        | 53            |                      |                     |
|             |                       | Buses         | 2             |                      |                     |
|             |                       | Truck semitrailers | 122         |                      |                     |
|             |                       | **Total**     | 579           |                      |                     |
| **Measurement time** | 12 minutes 7 seconds |                      |               |                     |

7. **The use of results for the purpose of traffic flow modelling**

7.1. **SW Aimsun**

To verify and evaluate the actual state, the respective road section I/18 was modelled in the programme Aimsun. This programme enables both macroscopic and microscopic simulation. Input parameters for modelling were obtained from practical measurement.

Traffic model, created in such a way as to represent the real situation in the respective section to the most possible extent, is based on traffic net. Matrixes for all types of traffic were created. Although the road is predominantly used by personal vehicles, there are also trucks and buses on it. The model was created in the time period of morning peak hour, afternoon peak hour, and saddle [11].

The model is based on a map imported into the programme from a map database Open Street Map. Gradually the lines of individual communications were created, connected in joints in the spots where in the reality cross-roads are situated.

During modelling the focus was put on the true resemblance of all items of net, and maximum permitted speeds and lanes structure were taken into account. An identical model of the existing status was created, which, after filling with values, can be considered reliable. To create the modelling the supporting information from maps was used, mainly for obtaining the distances measurements, which in real traffic would be very difficult to measure.

### The model load

After communication model creation it was possible to start with model loading. Loading of traffic model was done based on a practical measurement performed by the floating vehicle, equipped with the Polcam device. Values of all intensities were inserted into matrices in programme Aimsun and the traffic model was loaded with them.

7.2 **Data obtained from the model**

We compared the data obtained from the traffic model with the data obtained by the practical measurement. Individual measurements were divided into morning peak hour, afternoon peak hour and saddle. A 30 minutes heating up was predefined in traffic model. All calculations and values in the tables were calculated by the authors themselves.

### Intensity

Individual intensities, evaluated by the traffic model, copy the intensities obtained by a practical measurement, which shows that the respective traffic model mirrors the real conditions on the road. In most cases the intensities obtained by the practical measurement were a bit higher compared to the model (Table 3).
The highest amount of emissions was produced during the morning peak hour in the section Vrutky - Zilina by personal vehicles. The lowest emissions reached were in the section Vrutky - Zilina produced by buses. The overall lowest produced emissions were reached in section Zilina - Vrutky during the morning peak hour. The CO₂ emissions are in the following Table 5 stated in grams.

| Saddle | Emissions CO₂ (g) |
|--------|-------------------|
| Vehicle type | Zilina - Vrutky | Vrutky - Zilina |
| Personal vehicles | 669 24.66 | 574 694.85 |
| Trucks | 103 239.30 | 97 005.35 |
| Buses | 7 008.03 | 13 719.18 |
| Truck semitrailers | 131 917.71 | 268 255.02 |
| Total | 911 412.70 | 953 674.40 |

The section speed

To draw a comparison we herein state section speeds obtained from the traffic model and the ones obtained from the practical measurement. The section speeds obtained from the traffic model were evaluated for the individual types of vehicles. In case of the measurement we obtained section speed data only for the individual sections (Zilina - Vrutky / Vrutky - Zilina). Section speed of the traffic model and practical measurement can be compared by comparison of average section speed of the traffic model (76.58 km/h) and section speed evaluated from the measurement (76.22 km/h); see Table 6.

| Section speed (km/h) | Table 6 |
|----------------------|---------|
| Vehicle type | Zilina - Vrutky | Vrutky - Zilina |
| Personal vehicles | 76.91 | 76.42 |
| Trucks | 75.68 | 76.43 |
| Buses | 76.58 | 76.53 |
| Truck semitrailers | 75.67 | 76.58 |
| Average value | 76.58 | 76.58 |

The density

The density of the traffic flow obtained from both traffic model and the practical measurement reached similar values. Different aspects, such as section speed obtained from evaluation device Polcam PC2006 and traffic flow intensity, influenced the density in the traffic model (Table 7). With growing traffic flow
intensity also the density grew, and, on the contrary, with growing section speed the density dropped.

| Saddle | Zilina - Vrutky | Zilina - Vrutky | Vrutky - Zilina | Vrutky - Zilina |
|--------|----------------|----------------|----------------|----------------|
| Vehicle type | Traffic model | Measurement | Traffic model | Measurement |
| Personal vehicles | 7 | 5 |
| Trucks | 1 | 8 | 1 |
| Buses | 0 | 0 |
| Truck semitrailers | 1 | 2 |
| Average value | 9 | 8 | 7 |

8. Conclusion

Traffic modelling with the use of information technologies (IT) represents a powerful working method in the field of Traffic engineering. This broadens the possibilities of complex task and problem solving. The Traffic modelling included not only the traffic simulation, but a broad scale of assisting tools, from simple, single-purpose applications, to complex tools for proposing and verification of the communication networks. The results obtained from traffic model are nowadays considered to be sufficiently reliable and relevant and they create base for reviewing current state of basic characteristics in the traffic flow. The outcomes from the traffic model can be used at different stages of urban planning and development, as well as for the evaluation of impact on particular solutions of traffic situations in the respective system.

In the traffic model we created, also the environmental influences of vehicles were considered.

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