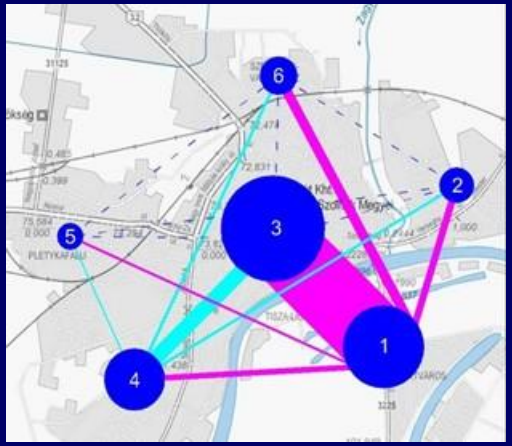
# Road traffic planning, traffic data acquisition


**Transport networks 4.**

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# Content

- Traffic planning – modal split
- Traffic planning – traffic assignment
- New directions in modelling traffic
- Software for traffic planning
- Traffic data acquisition
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# Traffic planning – modal split

- **Modal split is made by transport mode, providing the proportion of the given transport mode related to the total traffic.**
- **In this stage the traffic matrix (the result of the trip distribution) is split by transport modes, creating layers of the traffic matrix. Every layer contains one transport mode (i.e., personal and freight trips, car and public transport trips, motorised and non-motorised movements).**
- **Usually personal trips are layered as car travel, public transport travel and non-motorised (bicycle and pedestrian) movements. Within the public transport mode in big cities there can be layers by sub-mode as well (i.e., metro, tram, bus, etc.)**

# Traffic planning – modal split

- **The most popular is the Logit model that determines of choice probabilities of different traffic modes:**

$$P_{mt} = \frac{e^{v_{mt}}}{\sum_i e^{v_{mti}}}$$

**where:**

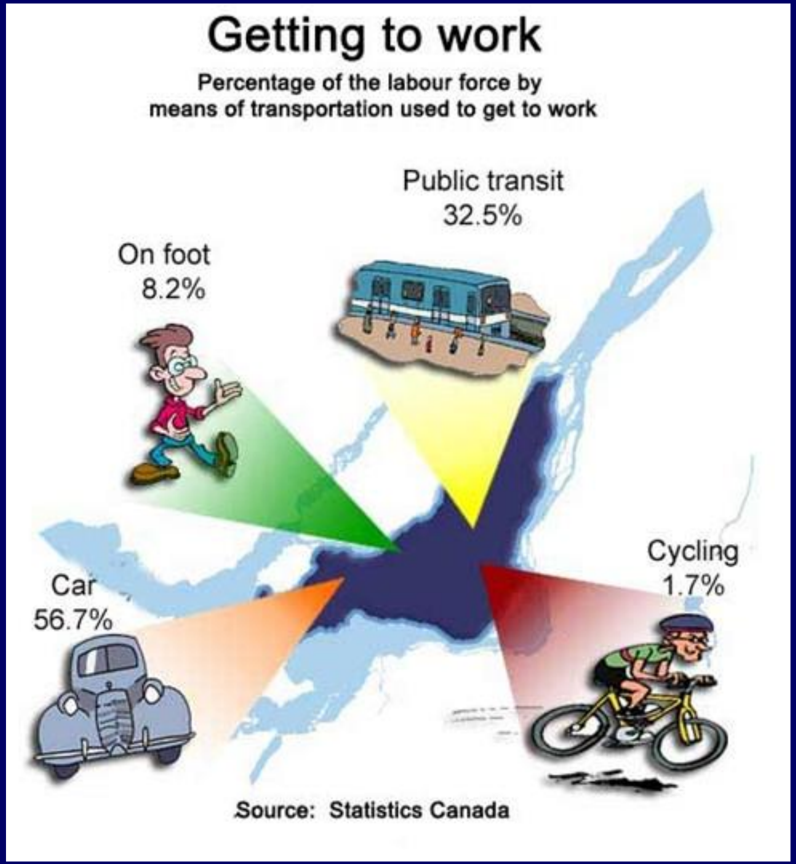
$P_{mt}$ **probability of the choice of the „m” mode by the „t” individual**

$v_{mt}$ **utility of the „m” mode for the „t” individual**

$i$ **is the transport mode**

# Traffic planning – modal split

## Presentation of modal split result



$$P_{kk} = \frac{e^{v_{kk}}}{e^{v_{ek}} + e^{v_{kk}}}$$

# Traffic planning – modal split

- **In case of a modal split between car usage and public transport usage, the formula for choice is simpler:**

$$P_{kk} = \frac{e^{v_{kk}}}{e^{v_{ek}} + e^{v_{kk}}}$$

**where:**

$P_{kk}$ **probability of the choice of the public transport,**

$v_{kk}$ **utility of the public transport,**

$v_{ek}$ **utility of the individual (car) transport.**

# Traffic planning – modal split

- In case of more than two transport modes, for example considering non-motorised transport as well, the modified Logit model is applied, providing the choice in steps. This version proved to be better than putting additional terms into the denominator.
- The step-wise choice is described by the nested Logit model, where in a given step the choice is always made between two cases (i.e., in the first step between the car and the public transport, in the second step – within the public transport – between the bus and the train).
- The outcome of the modal split this way becomes the result of a multi-level decision process.

# Traffic planning – traffic assignment

- **Traffic assignment is the last stage in the four stage traffic planning, assigning traffic to a transportation network such as roads and streets or a transit network. Traffic is assigned to available routes using an algorithm that determines the amount of traffic as a function of time, volume, capacity, or impedance factor.**
- **The outcome of the traffic assignment is the traffic volume of the road sections (network elements) for a day or for the peak hour, often split by transport modes. The assignment process includes the estimation of travel speeds and travel times on road sections, calculating and feedbacking congestion possibilities.**

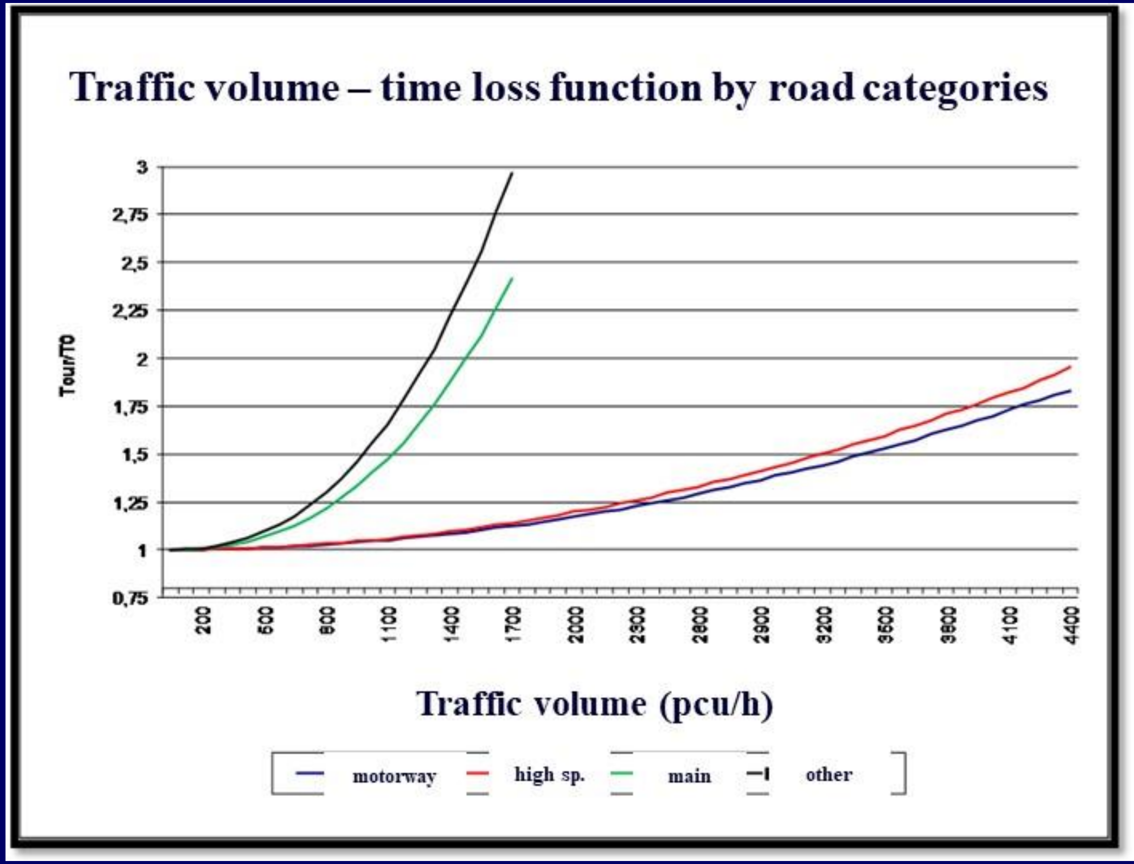
# Traffic planning – traffic assignment

- In the modelling and planning usually various traffic matrices are determined for the morning and afternoon peak hours, for daytime and night. The peak hour factors or part of the day factors are calculated for the current and future situations, depending of the type and mode or trips.
- The classical four stage traffic planning deals with personal traffic. However, in large networks the freight transport, the movements of commercial vehicles are also important, requiring specialised models.

# Traffic planning – traffic assignment

- **Traffic assignment to the elements of the current or future network (the latter in alternatives). The assignment requires parameters of the network elements.**
- **Method of the assignment can be static or dynamic, stochastic, equilibrium, capacity constrained in incremental steps.**
- **Routes between zones are determined by the values of the resistance function aiming the minimum of the network travel time or network travel cost.**

# Traffic planning – traffic assignment

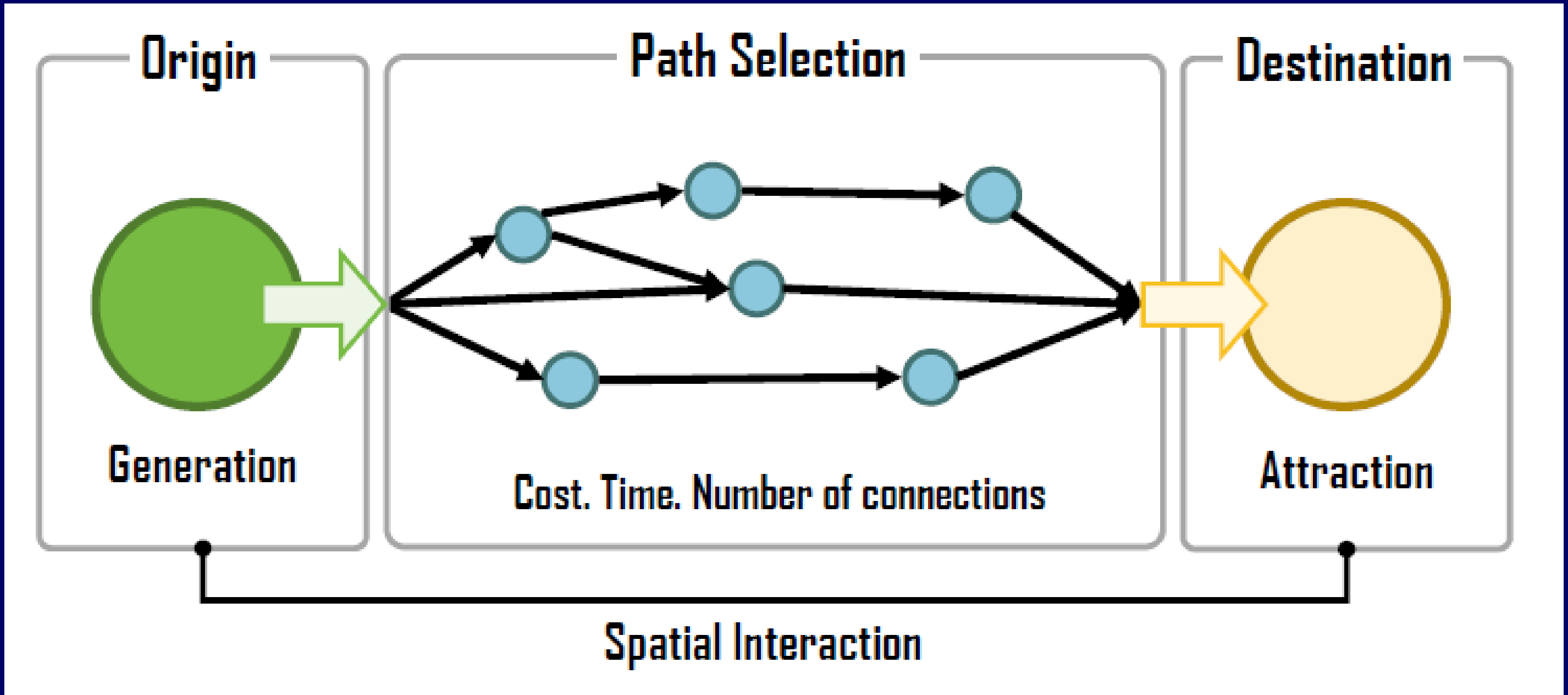



**Example for travel time based resistance functions**

# Traffic planning – traffic assignment

- **Principles of the ideal network assignment based on the „Wardrop” equilibrium: in case of equilibrium no one is able to decrease its travel cost by changing its route, and the total travel cost on the network is at minimum.**
- **Dynamic equilibrium is changing in time depending on the timely changes of traffic flow. In real life the equilibrium cannot be reached because of drivers have human behaviour.**
- **Any model needs to be calibrated and validated usually using the existing traffic volumes on the current network.**
- **New land-use or network elements may generate surplus traffic that can be taken into account.**

# Traffic planning – traffic assignment




Source: Rodrigue, J-P et al. (2020) The Geography of Transport Systems, Hofstra University, Department of Global Studies & Geography, https://transportgeography.org/

# New directions in modelling traffic

- Validation of traffic models is very important for practical use of these models. The model calibration consists of applying the model for the current situation and compare traffic volumes with the acquired ones, resulting in modified model parameters. The validation means the use of the calibrated model and compare the results with such data, that describe the current situation but did not take part in the calibration.
- Validation provides an estimation for the accuracy and applicability of the model, comparing actual traffic volumes and public transport loads with the modelled results.

# New directions in modelling traffic

- **Another procedure is the sensitivity analysis of the model. Its objective is to assess the forecasting ability and accuracy in case of varying initial conditions.**
- **Any forecast includes uncertainty, and to understand this is an important factor in the assessment. The quality of the input data and the sensitivity of the model affect the accuracy. Nevertheless, an exaggerated accuracy cannot be expected, since in the majority of practical cases, i.e., determining the number of required traffic lanes, an approximate traffic volume may be sufficient for a proper engineering decision.**

# New directions in modelling traffic

- <u>The „fifth” stage</u>
- In the traffic planning procedure there is a need for dealing with the stationary traffic (parking places) as well as non-motorised (pedestrian and bicycle) traffic.
- Presentation of traffic planning results is very important in an expressive and understandable way, on maps, graphs, etc. for non experts, decision makers, even politicians.
- Reasonable explanation of results and project proposals to inhabitants concerned is also important.

# New directions in modelling traffic

- In recent years the classical four stage traffic modelling has been developed. Nowadays not only peak hours but an entire day's traffic can be modelled with its changes. An important improvement is the wide-spread considering of the non-motorised traffic, especially in the modal split.
- New tour-based and activity-based modelling procedures have been developed recently.
- Data acquisition has been improved applying GPS technology and Geographic Information Systems (GIS).

Source: Transportation Research Board: Travel Demand Forecasting: Parameters and Techniques. National Cooperative Highway Research Program Report 716. Washington, D.C. 2012.

# New directions in modelling traffic

- **New transportation planning requirements have contributed to a number of new uses for models, such as the analysis of a variety of road pricing options, including toll roads, high-occupancy toll (HOT) lanes, cordon pricing, and congestion pricing that varies by time of day.**
- **The classical model deals with an average daily traffic, therefore it is not able to handle unexpected or special situations (accidents, adverse weather condition, significant special activities like sporting events or festivals).**
- **The next generation of traffic models may include the parking restraints in central areas affecting the attracted traffic.**

# Software for traffic planning

- There are various special software for traffic planning and modelling, these are usually very sophisticated, high quality but expensive tools.
- A new generation of travel demand modelling software has been developed, which not only takes advantage of modern computing environments but also includes, to various degrees, integration with geographic information systems (GIS).
- There has been an increased use of integrated land use – transportation interaction (LUTI) models, in contrast to the use of static land use allocation models.

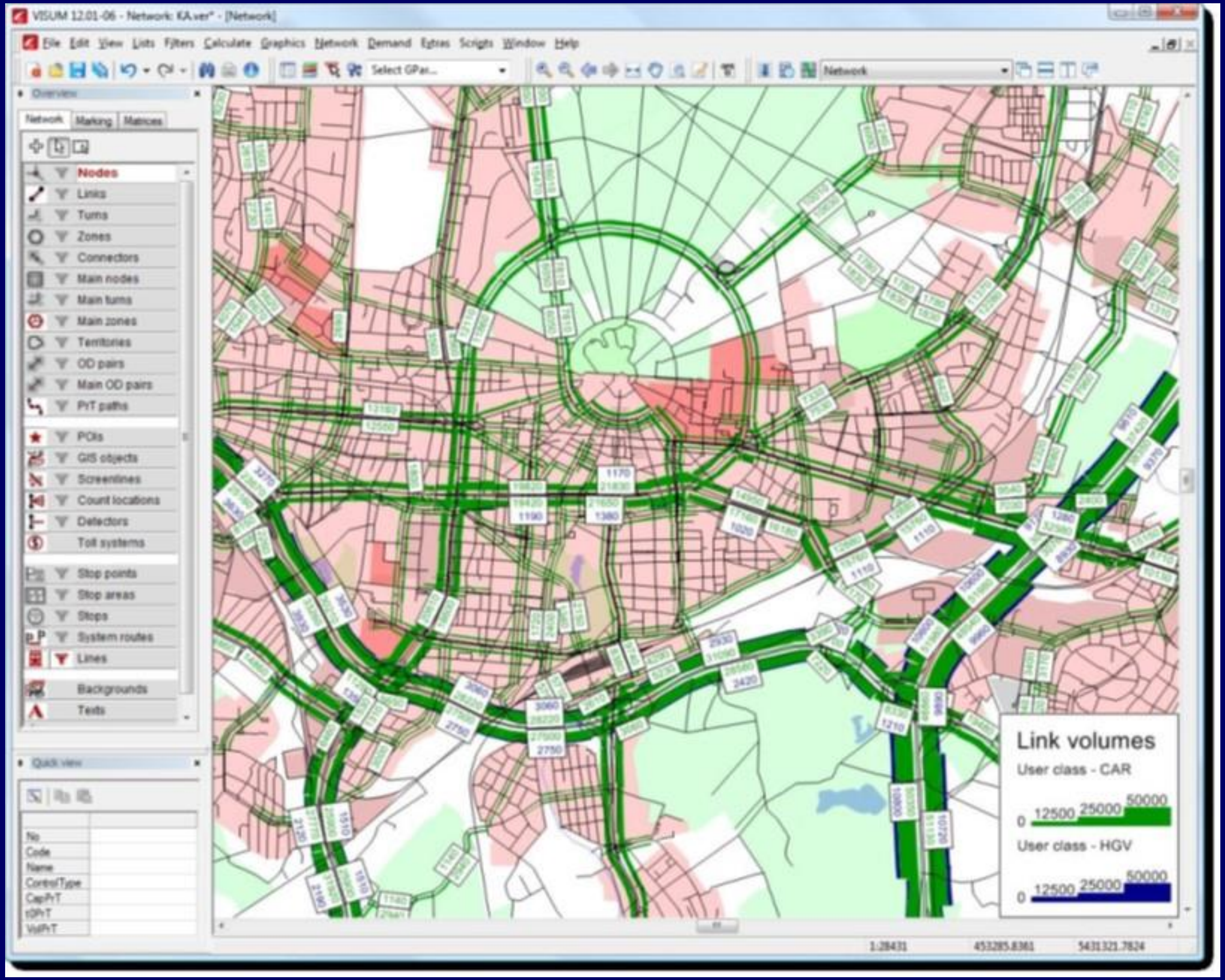
Source: Transportation Research Board: Travel Demand Forecasting: Parameters and Techniques. National Cooperative Highway Research Program Report 716. Washington, D.C. 2012.

# Software for traffic planning - VISUM

- **VISUM – International software with Hungarian applications**
- **It is the standard for macroscopic simulations and macroscopic modelling of transport networks and transport demand, public transport planning, and for the development of transport strategies and solutions.**
- **The software is suitable for creating and analysing transportation models that provide insights for long-term strategic planning and short-term operational use, even for a larger area (big city or agglomeration).**

Source: https://www.myptv.com/en/mobility-software/ptv-visum

# Software for traffic planning - VISUM

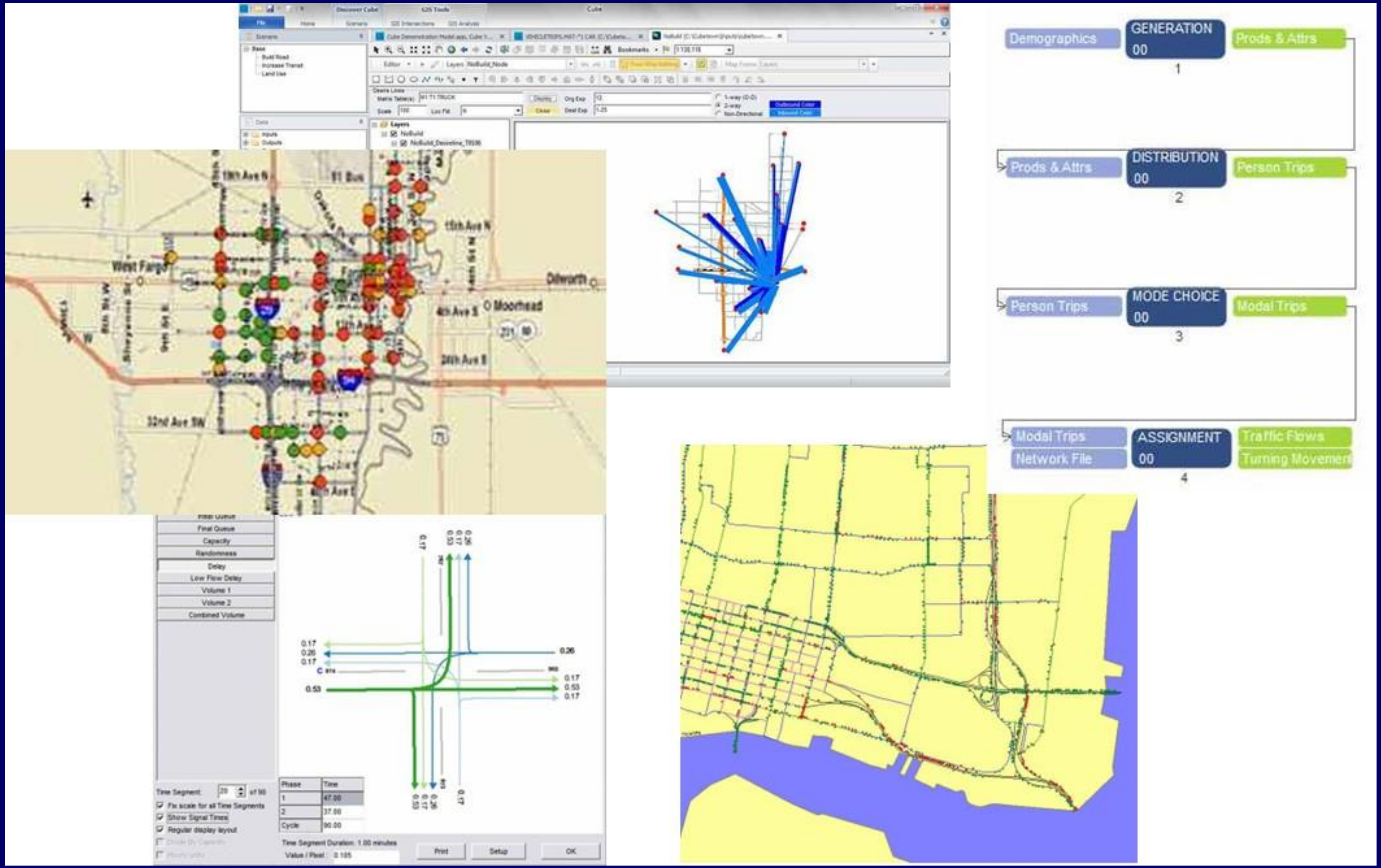


# Software for traffic planning - CUBE

- **CUBE is an open modelling software used by planners and engineers to analyse the effects of new projects and policies on a city's transportation network, land-use, and its population.**
- **It is used to develop and apply predictive multi-modal transportation models, as part of a city's overall digital twin, to simulate how changes in infrastructure, operations, technology, and demographics will impact movement and accessibility of a given area.**

Source: https://www.bentley.com/en/products/brands/cube

# Software for traffic planning - CUBE



# Software for traffic planning - EMME

- **EMME is a complete transportation forecasting system for planning the urban, regional and national movement of people, based on a multimodal transport planning philosophy.**
- **It is a flexible tool for consultants and decision makers for modelling transport demand, analysing and assessing the traffic volumes on transport networks as well as their environmental consequences (noise and air pollution).**

Source: https://www.inrosoftware.com/en/products/emme/

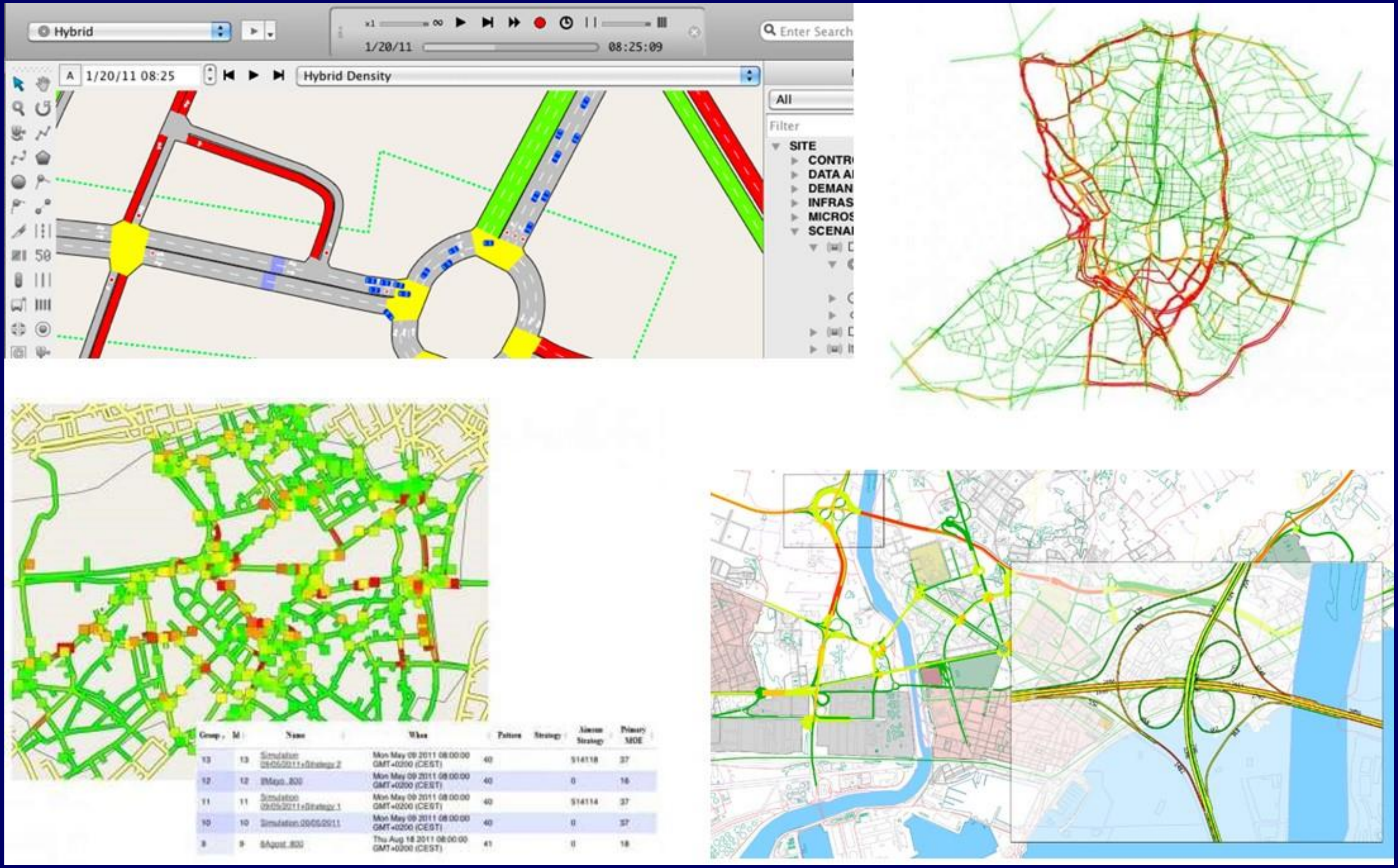
# Software for traffic planning - EMME

# Software for traffic planning - AIMSUN

- Traffic simulation software is a rapidly developing field, both in case of microsimulation for traffic engineering and in case of macrosimulation for traffic planning.
- AIMSUN software combines simulation and machine learning to give deep insights into mobility, setting up transportation models as cloud-based frameworks for testing schemes and scenarios. It helps cities move towards smart, sustainable transportation, incorporating new technologies like autonomous vehicles (AVs) and demand responsive transit (DRT).

Source: https://www.aimsun.com/

# Software for traffic planning - AIMSUN



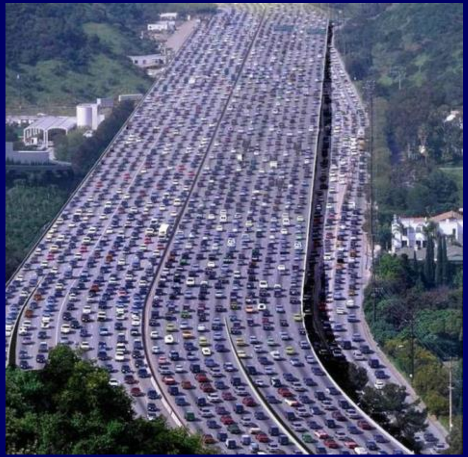
# Traffic data acquisition

**There is a need for information on traffic data, traffic time series, traffic composition for:**

- **Physical planning – traffic planning, pavement structural planning**
- **Operation and maintenance – classification of roads by service levels**
- **Calculation of harmful environmental effects – noise, air pollution etc.**
- **Road administration, road related research, road network development, land-use development programs**

# Traffic data acquisition

- **Traffic census**
  - **Quantitative (volume)**
    - **Road cross sections**
    - **Public transport passengers**
  - **Qualitative (origin-destination)**
    - **O_D interviews**
      - **Road cordon**
      - **Household**
      - **Public transport**
    - **License plate reading**



## Types of traffic data acquisition (census)

# Traffic data acquisition

**Cross section traffic counting has two kinds: continuous and temporary stations at sites.**

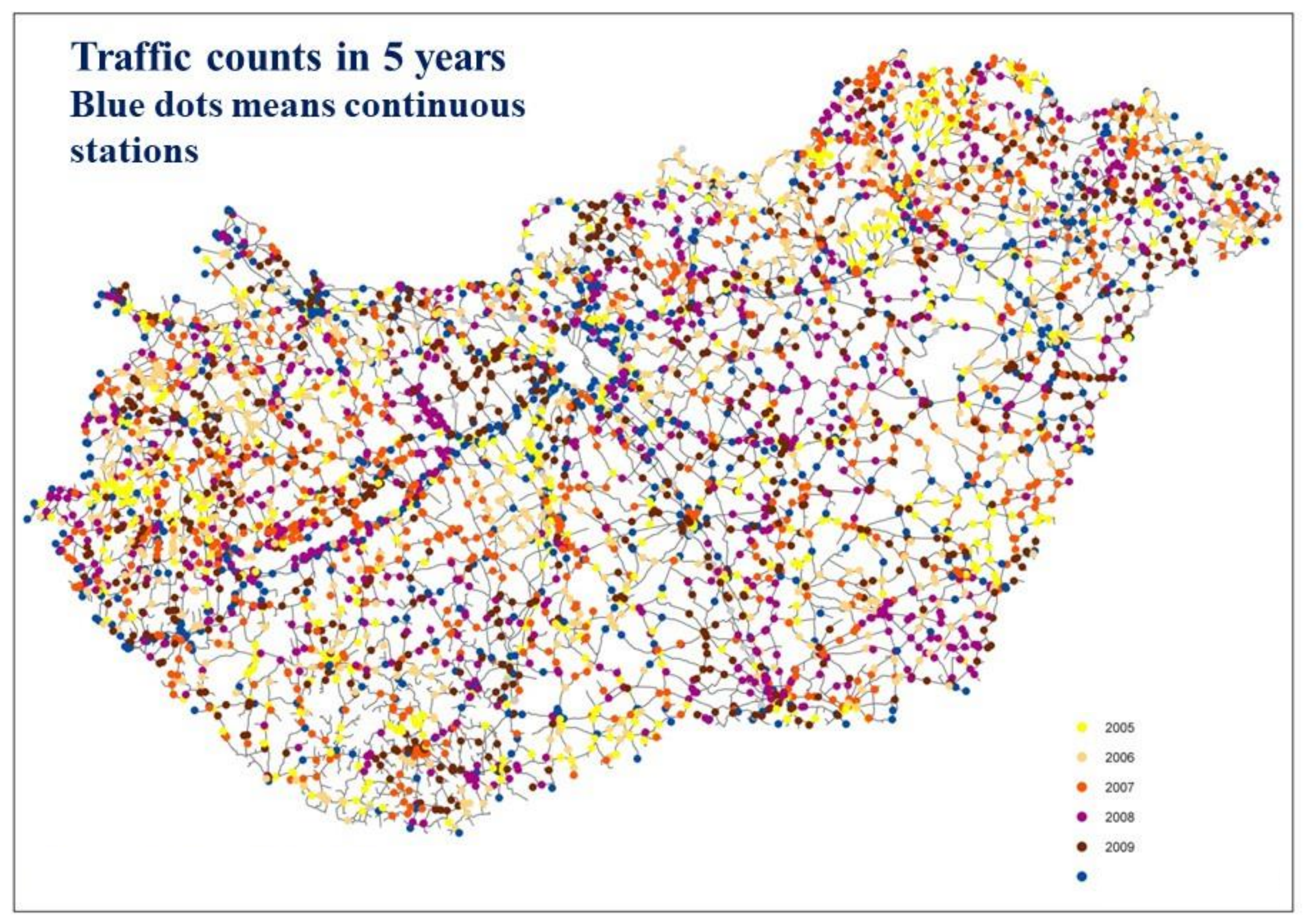
**In Hungary there is a 5 year cycle for the traffic census on national roads.**

**Continuous stations – usually automated – work on each day and hour in all five years**

**Temporary stations – video or manual counts – work on a few days in every fifth year.**

**Traffic data for mid-years are calculated.**

# Traffic data acquisition

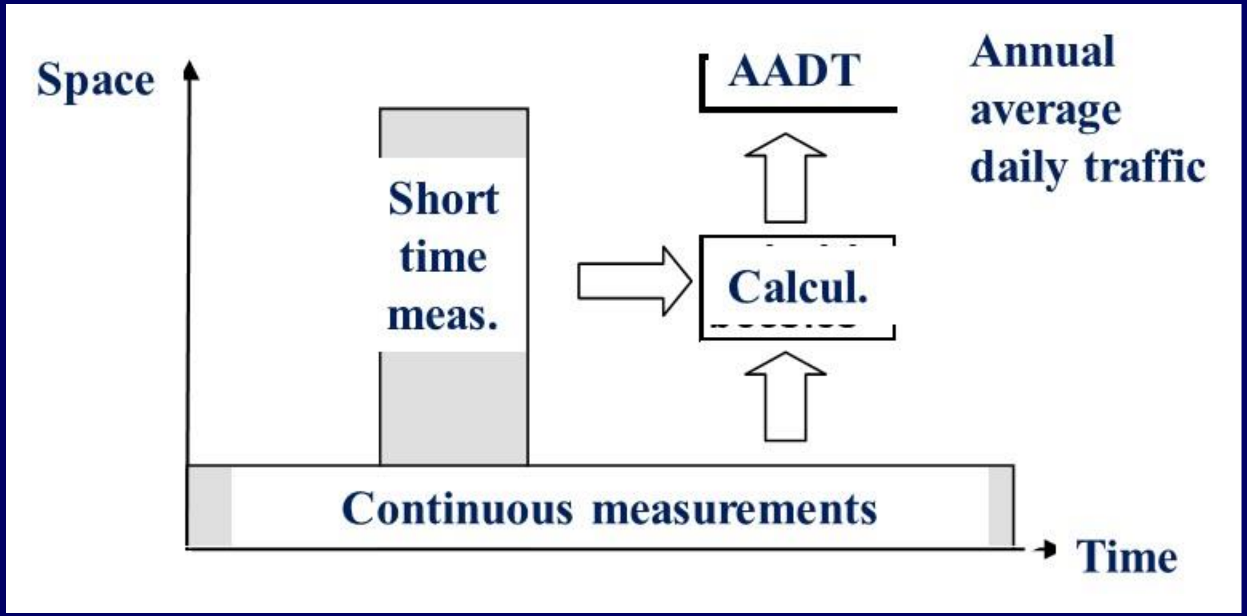



Source: National Road Databank

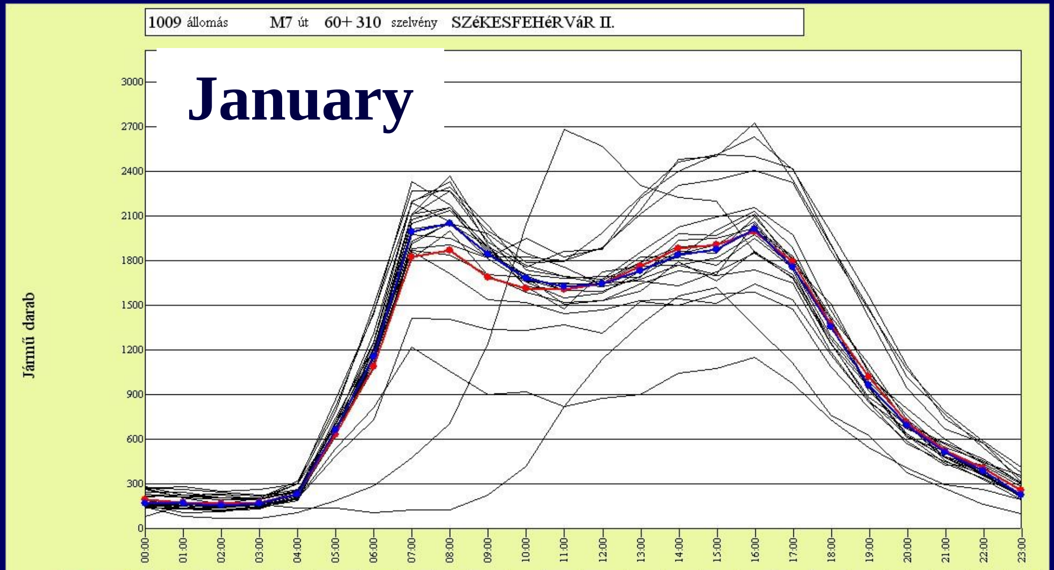
# Traffic data acquisition

Each cross section has its validity section (1-5 km).

The essence of the sampling method is estimates based on temporal and spatial sampling of traffic



# Traffic data acquisition

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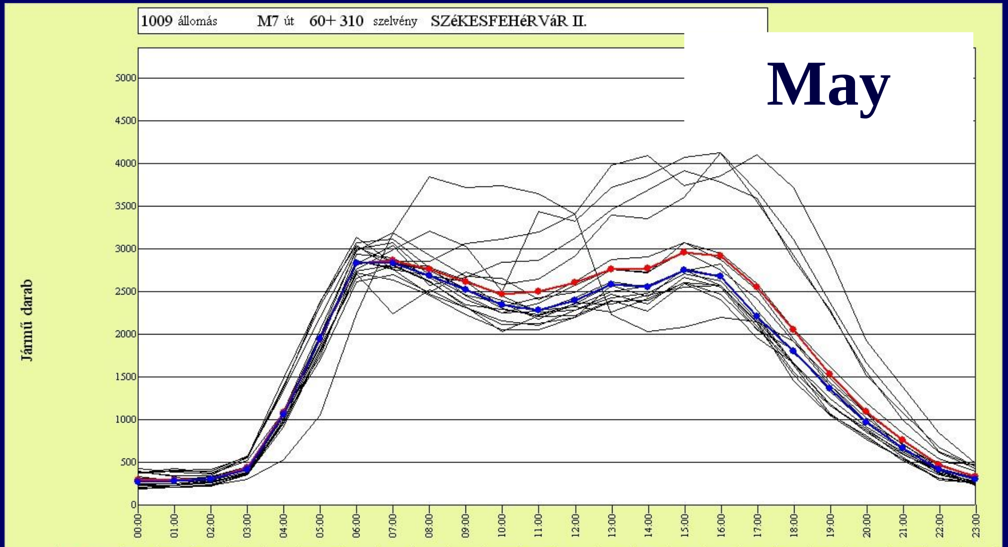
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Átlag érték | 192 | 178 | 166 | 174 | 230 | 630 | 1088 | 1824 | 1867 | 1689 | 1613 | 1609 | 1645 | 1763 | 1883 | 1905 | 1994 | 1792 | 1374 | 1016 | 715 | 525 | 409 | 256 |
| Medián érték | 166 | 168 | 156 | 167 | 230 | 662 | 1158 | 1992 | 2053 | 1845 | 1682 | 1624 | 1644 | 1732 | 1836 | 1876 | 2012 | 1759 | 1356 | 961 | 696 | 514 | 388 | 226 |

**Vizsgált időszak :** **2009 Január**
**Vizsgált napok száma :** **22**
(csak hétköznapok figyelembevételével)

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Átlag érték | 291 | 292 | 305 | 433 | 1083 | 1934 | 2833 | 2862 | 2761 | 2611 | 2469 | 2496 | 2602 | 2763 | 2770 | 2959 | 2921 | 2551 | 2052 | 1536 | 1098 | 756 | 465 | 333 |
| Medián érték | 274 | 280 | 304 | 418 | 1058 | 1948 | 2838 | 2838 | 2690 | 2525 | 2345 | 2278 | 2398 | 2582 | 2554 | 2750 | 2678 | 2209 | 1802 | 1368 | 970 | 665 | 418 | 302 |

**Vizsgált időszak :** **2009 Május**
**Vizsgált napok száma :** **18**
(csak hétköznapok figyelembevételével)

# Traffic data acquisition

**Definitions:**

**Annual average daily traffic (AADT, vehicle/day or personal car unit (PCU) / day) yearly average of vehicles moving through a given cross section in both directions**

**AADT = f · a · b · c**

**where f – measured traffic volume, a – daily factor, b – weekly factor, c – monthly factor**

**Standard peak hour traffic is the value which the hourly traffic equals or exceeds in 50 hours in a year**

$$PHT_{50} = \omega_{50} \cdot AADT$$

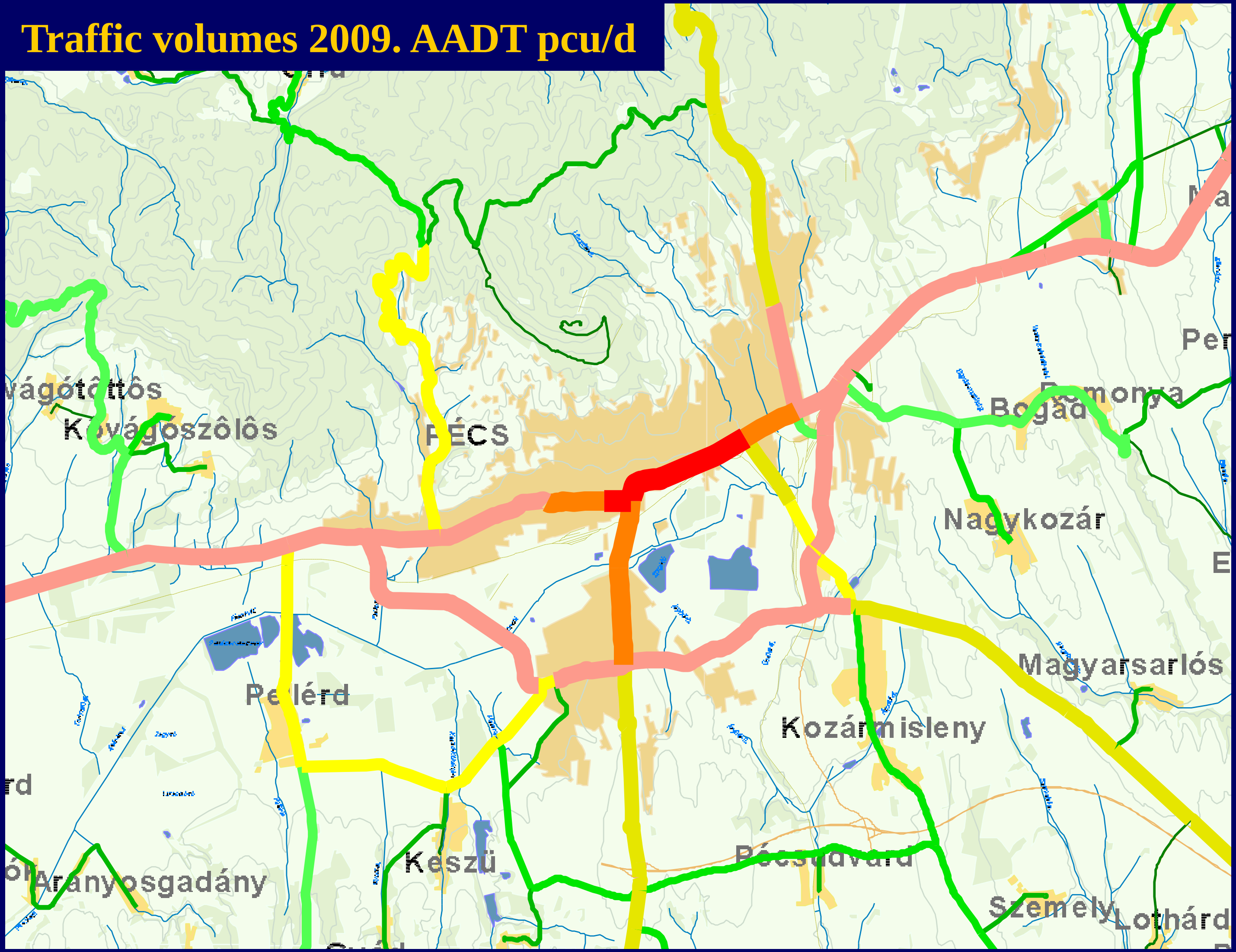
**where ω – peak hour factor**

**In urban areas (with no recreation activities) $\omega_{50} = 0,1$**

**Vehicle kms (or miles) travelled (performance metric):**

**VKT = Σ (AADT · length of road section) [vehkm/day]**

# Traffic data acquisition



# Traffic data acquisition

Origin – destination survey at national level: Institute for Transport Sciences 2016-2017

Personal and public, road and rail, passengers and freight traffic

Personal trips based on household interviews at a stratified sample

Special public transport and freight surveys

Results: national layered O-D matrices (current and predicted) for use in network development

# Traffic data acquisition

- **O-D roadside interview – safety is very important**
- **Preliminary local communication is indispensable for success**

# Traffic Planning – Case Studies

1. **Long-term transportation development plan of Pécs and its neighbourhood - COWI Hungary Kft. 2010. – study performed by planning software modelling.**

2. **Szolnok new city bridge on river Tisza – traffic prediction and assignment study by manual modelling – Krea-TURA Kft. 2009.**

# Traffic Planning – Case Study Pécs

Trip distribution between zones has been performed by the VISUM software

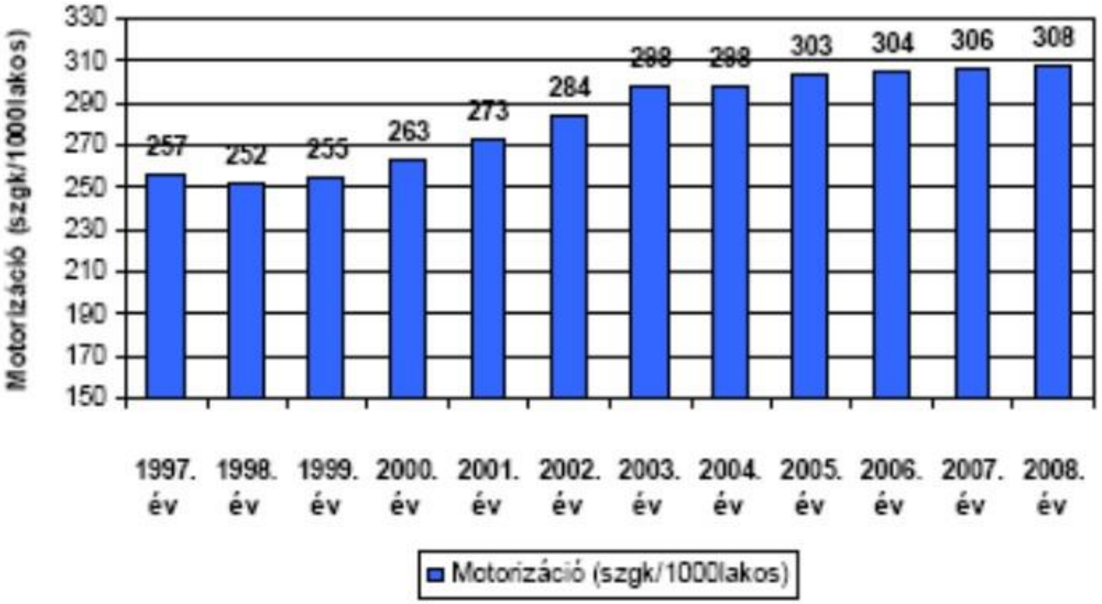
Zone based input data for present and future cases: number of inhabitants, GDP/person, rate of motorisation

Prediction made by the growth factor method

Land-use in the future: changes at zone level, effects of planned developments, public transport connections

Result: transport network alternatives and their assessment.

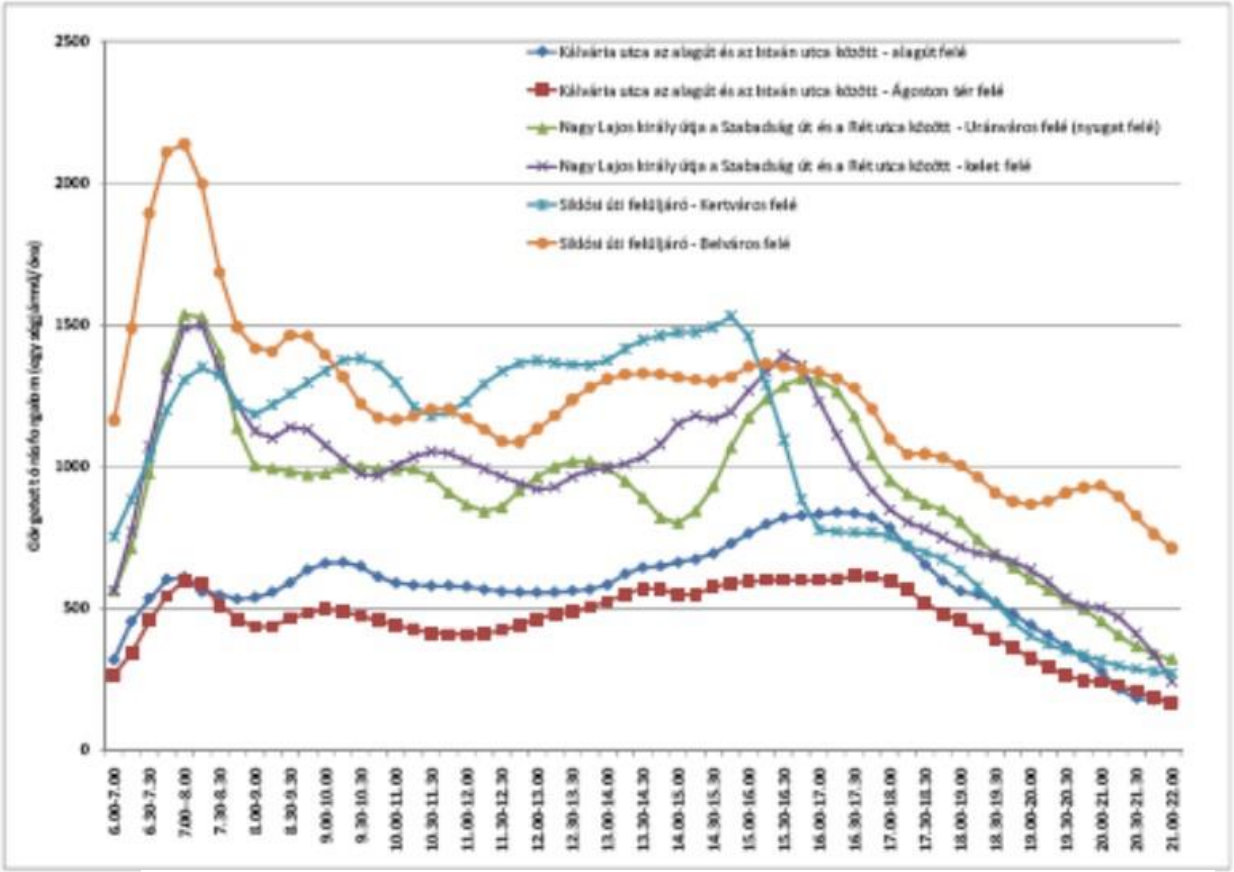
# Traffic Planning – Case Study Pécs




COWI

**Motorisation in Pécs (car/1000inh.)**

# Traffic Planning – Case Study Pécs




COWI

**Daily traffic flows on main routes**

# Traffic Planning – Case Study Pécs

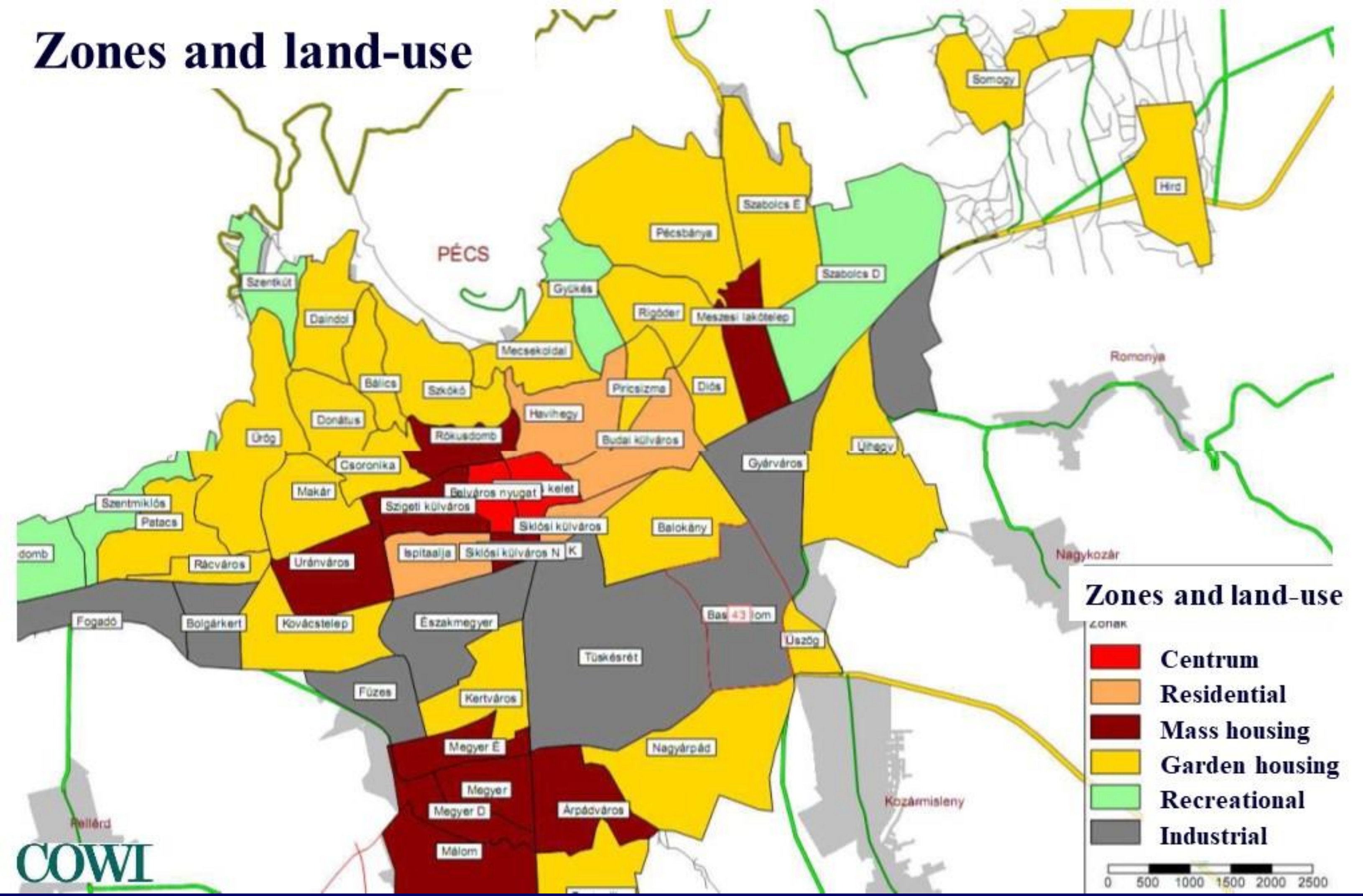
The city has been split up to zones that are origin and destination points.

Trips and traffic between zones are described by the O-D matrix.

Trip generation is based on demographic and land-use data as well as results of household and cordon traffic interviews.

The future trip matrix has been predicted based on the current one, after calibration.

# Traffic Planning – Case Study Pécs



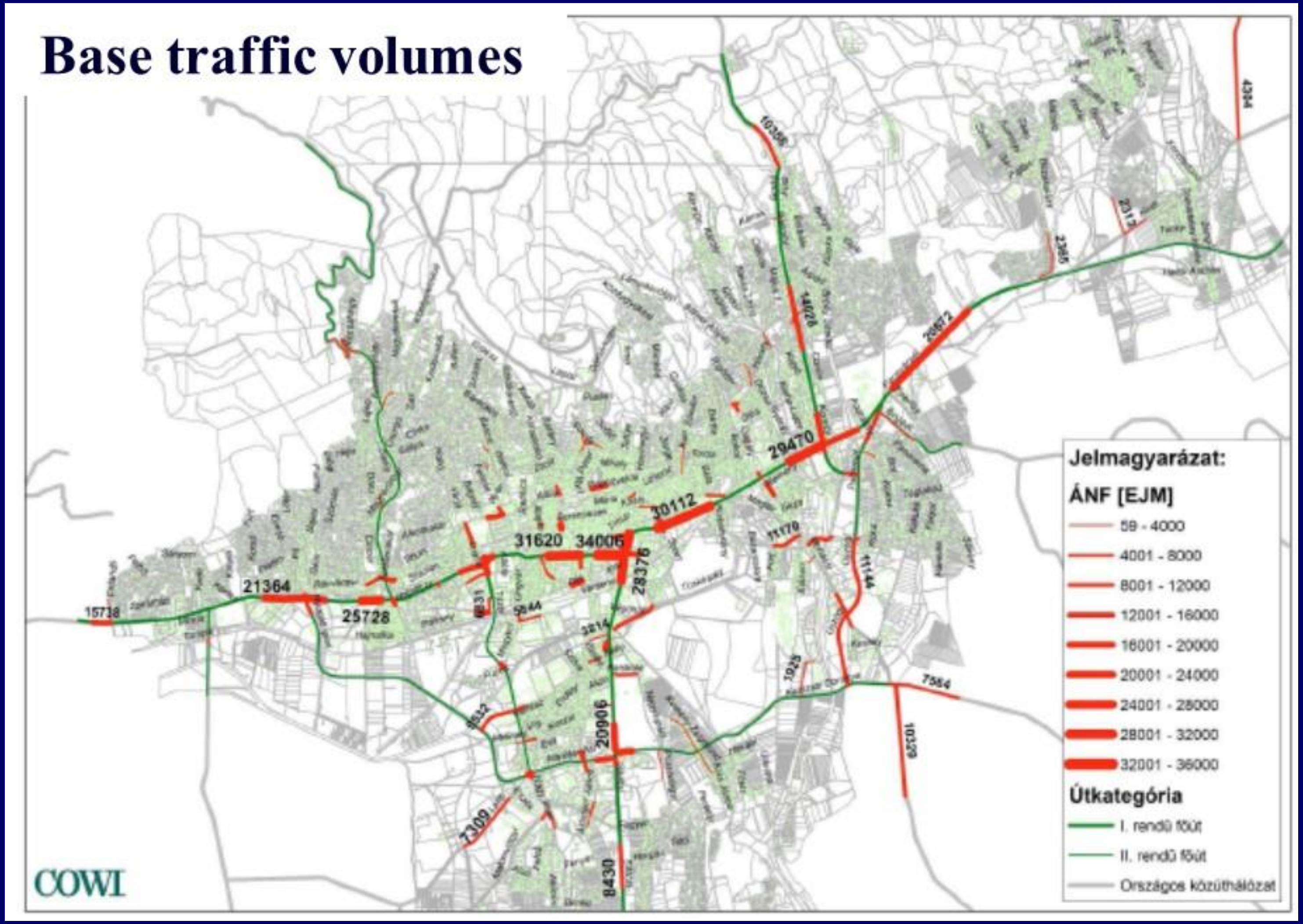
# Traffic Planning – Case Study Pécs

**The individual road traffic matrix has two levels: personal cars and freight (trucks). A different matrix contains public transport trips.**

**Originally matrices contained daily traffic. Peak hour values have been calculated by spatially differentiated peak hour factors for the morning and afternoon peaks.**

**Calibration of the model has been performed based on cross section traffic counts on the existing road network at 110 cross section (220 sections by directions).**

# Traffic Planning – Case Study Pécs



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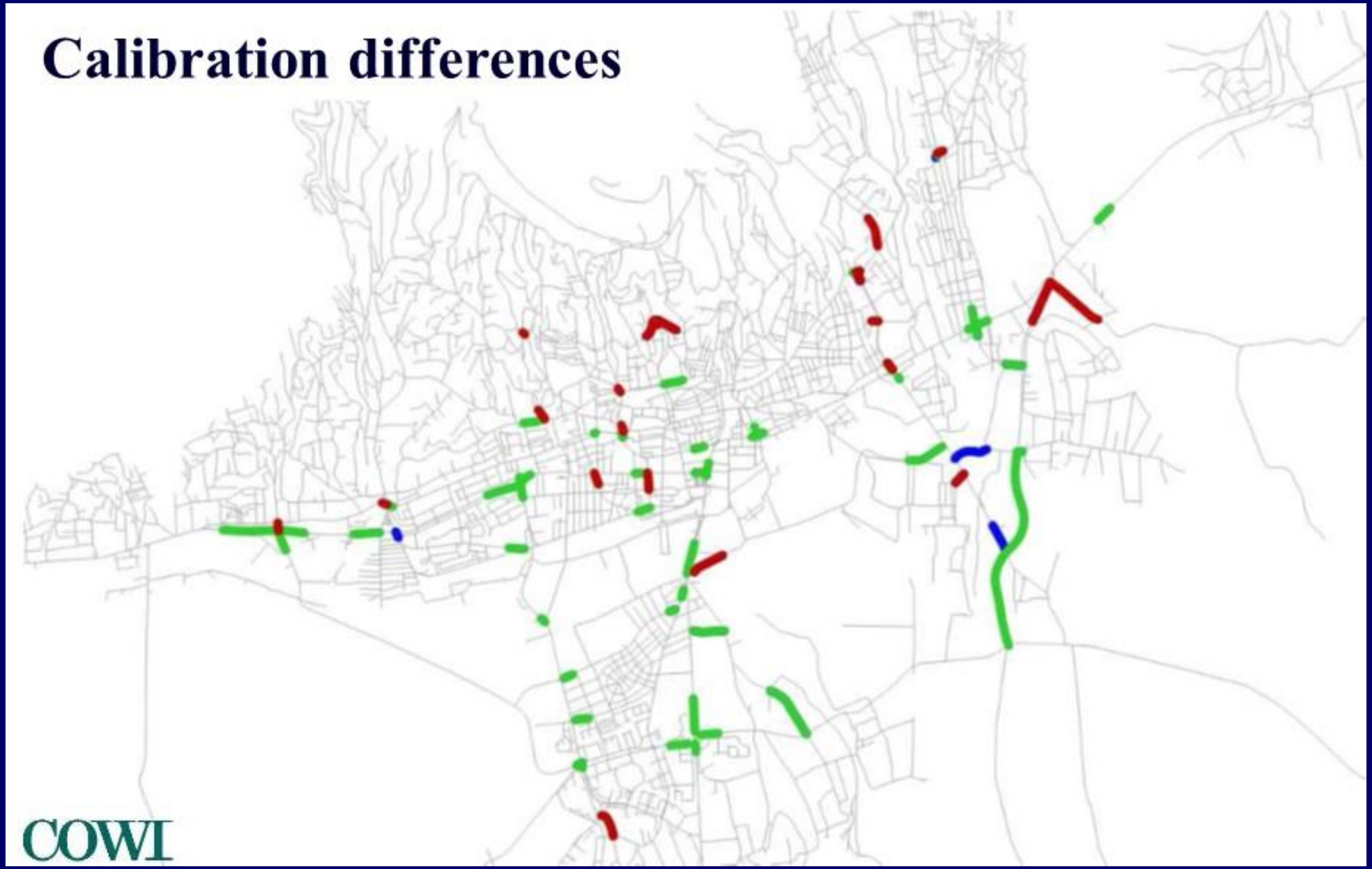

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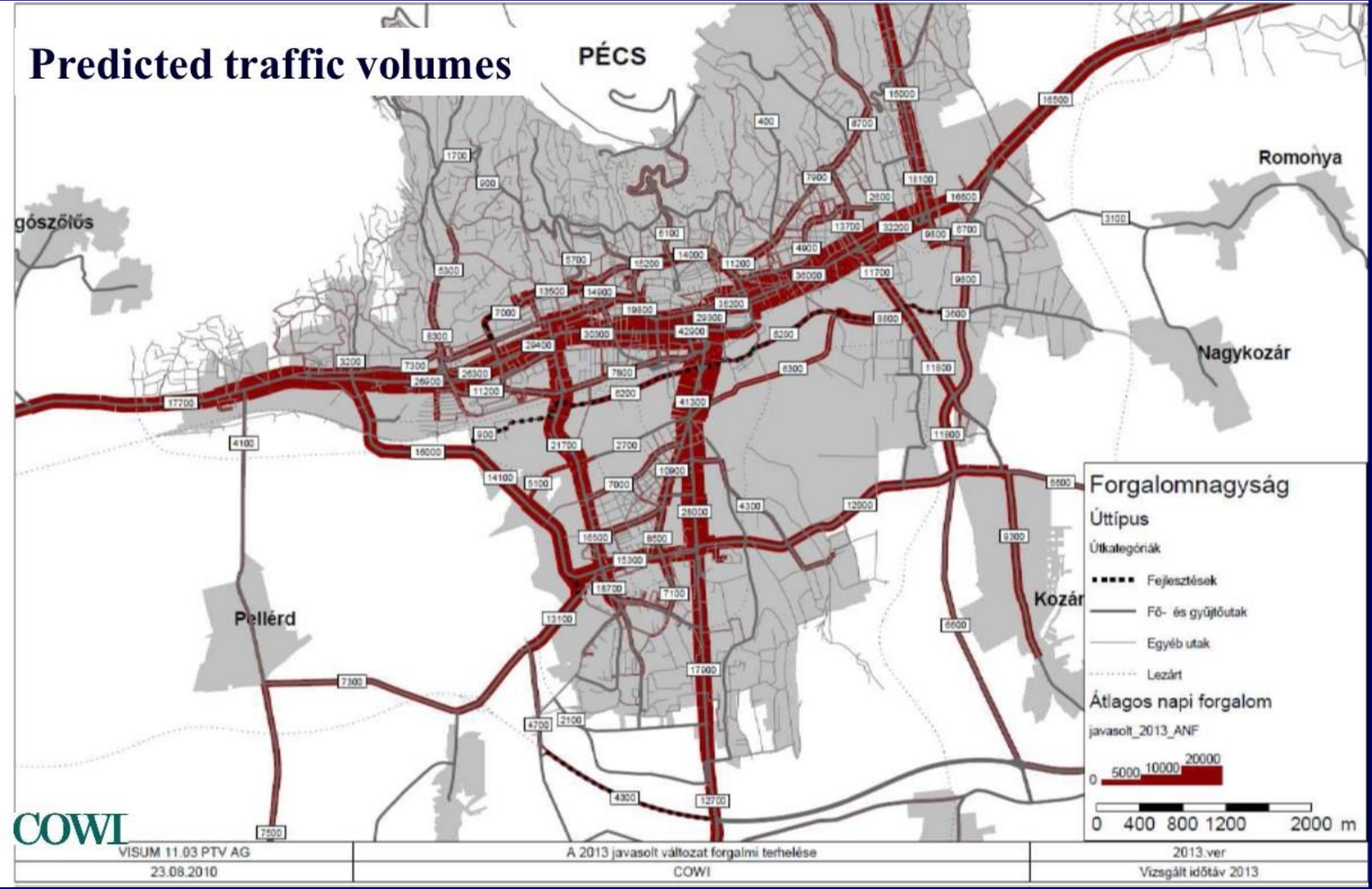
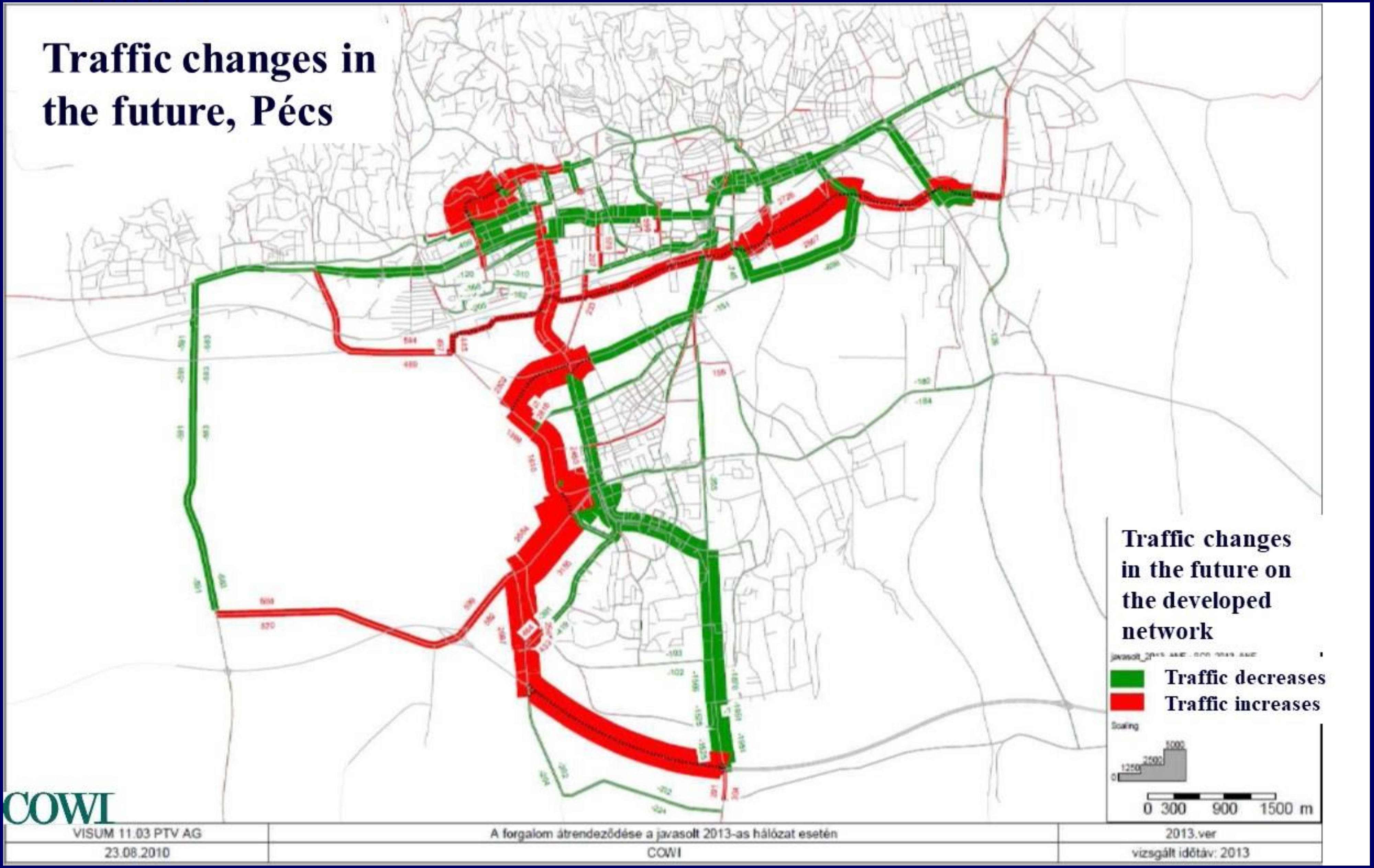


# Traffic Planning – Case Study Pécs



# Traffic Planning – Case Study Szolnok

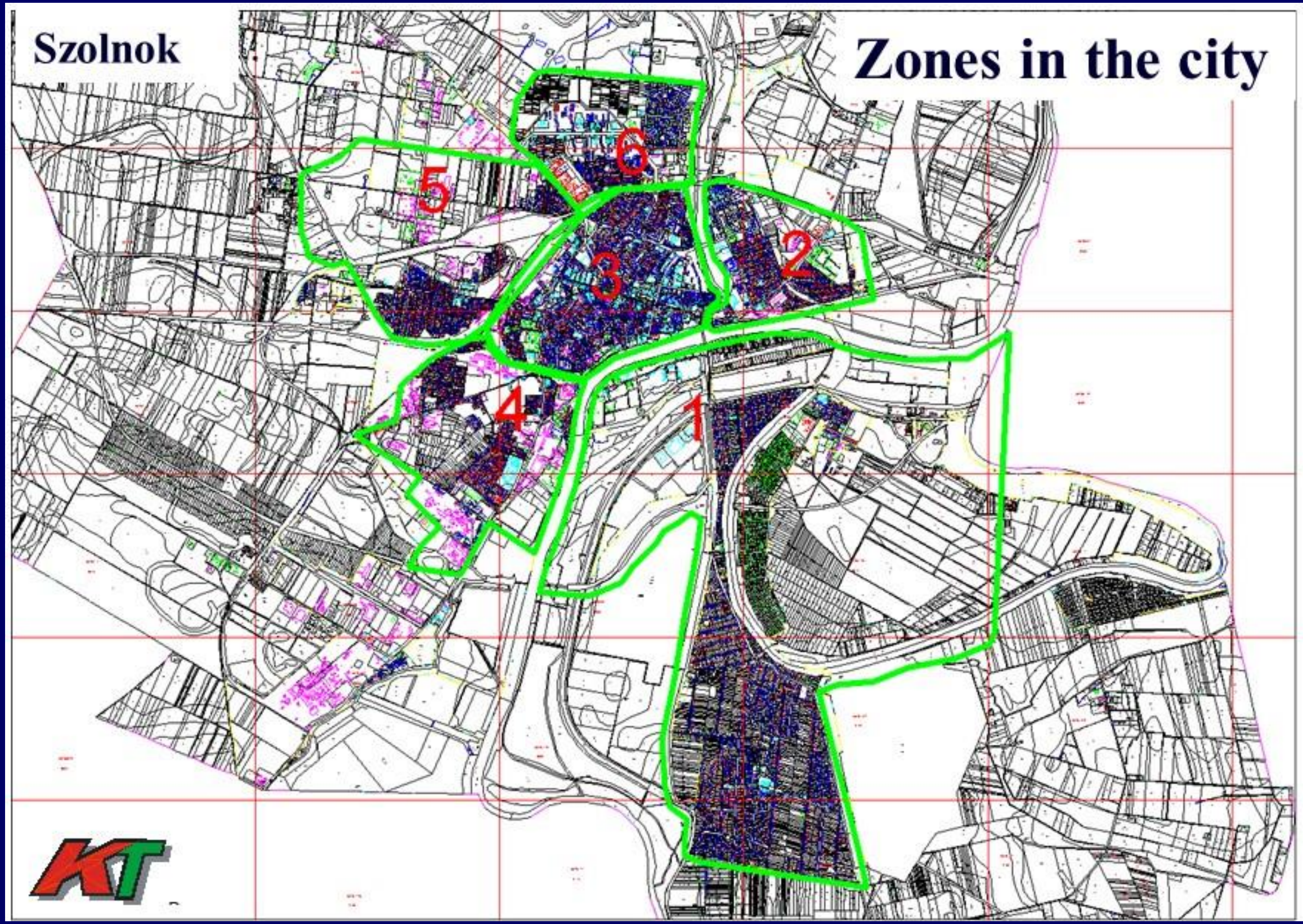
The aim of the study was to assess traffic changes on the urban road network in case of a new bridge (the third bridge in the city area).

A road cordon O-D survey has been made.

The predicted O-D matrix has been assigned to the future road network alternatives – with the new bridge and without it.

Section traffic loads on network elements have been calculated by summarising the O-D assignment results.

# Traffic Planning – Case Study Szolnok



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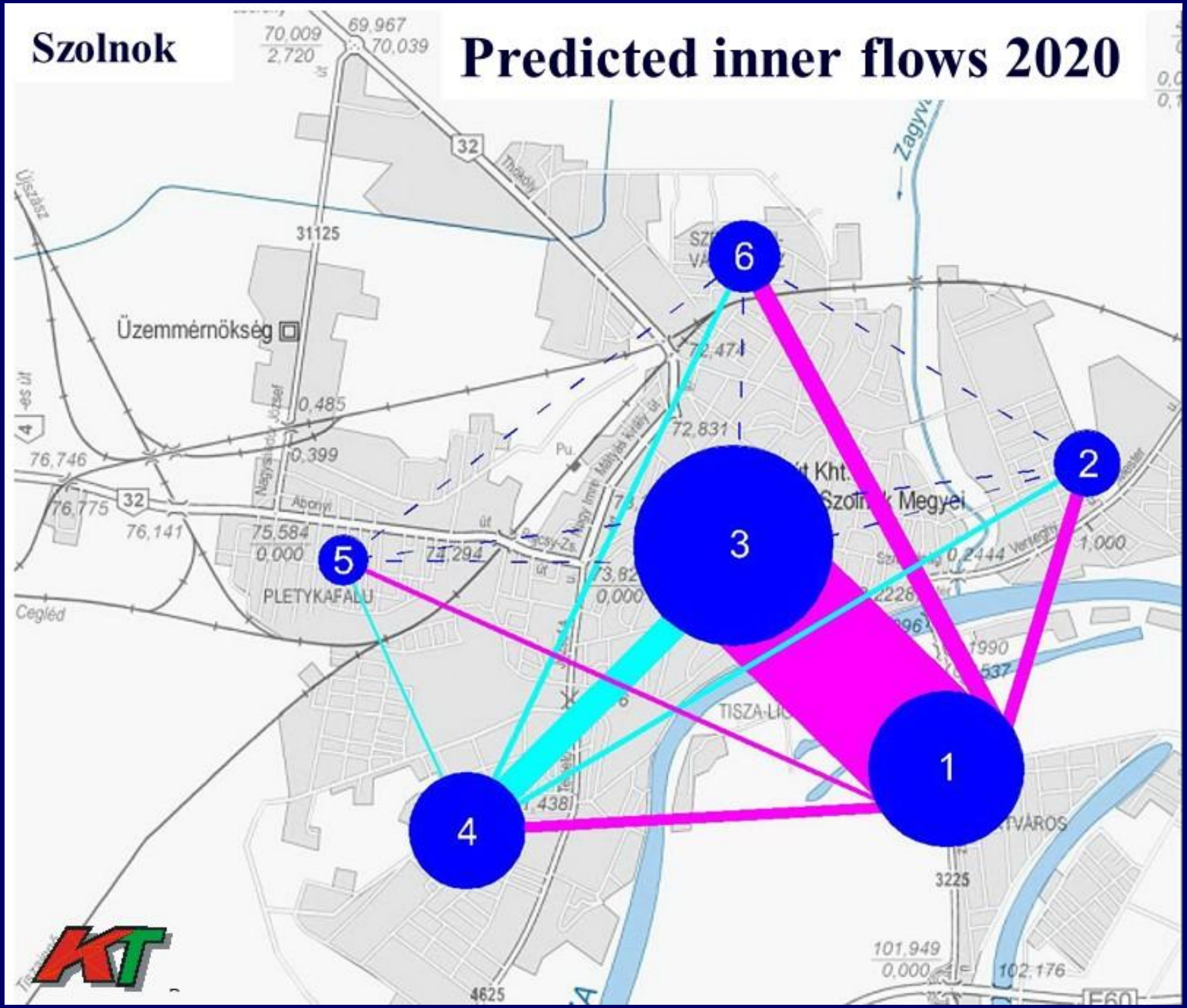

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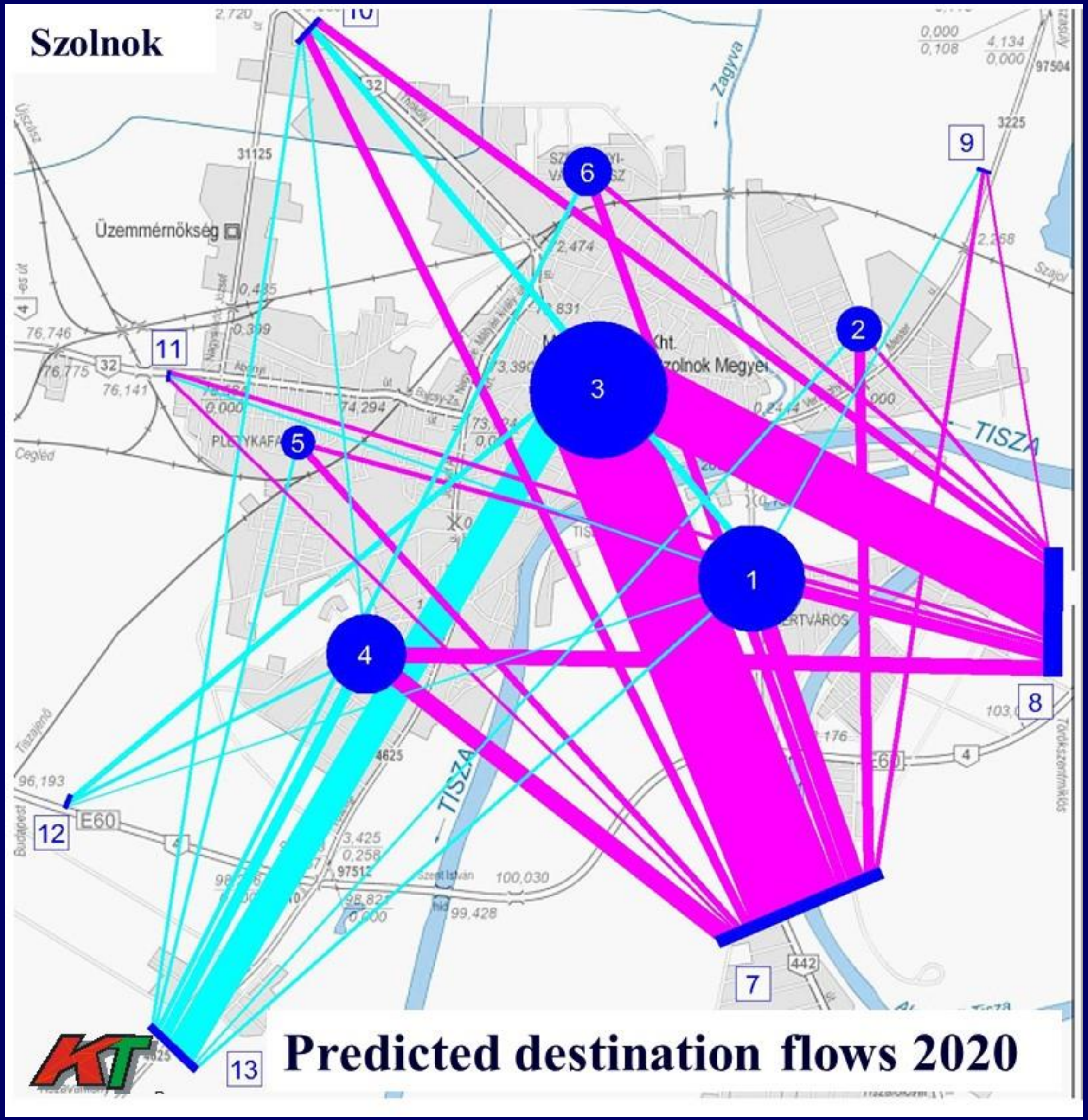

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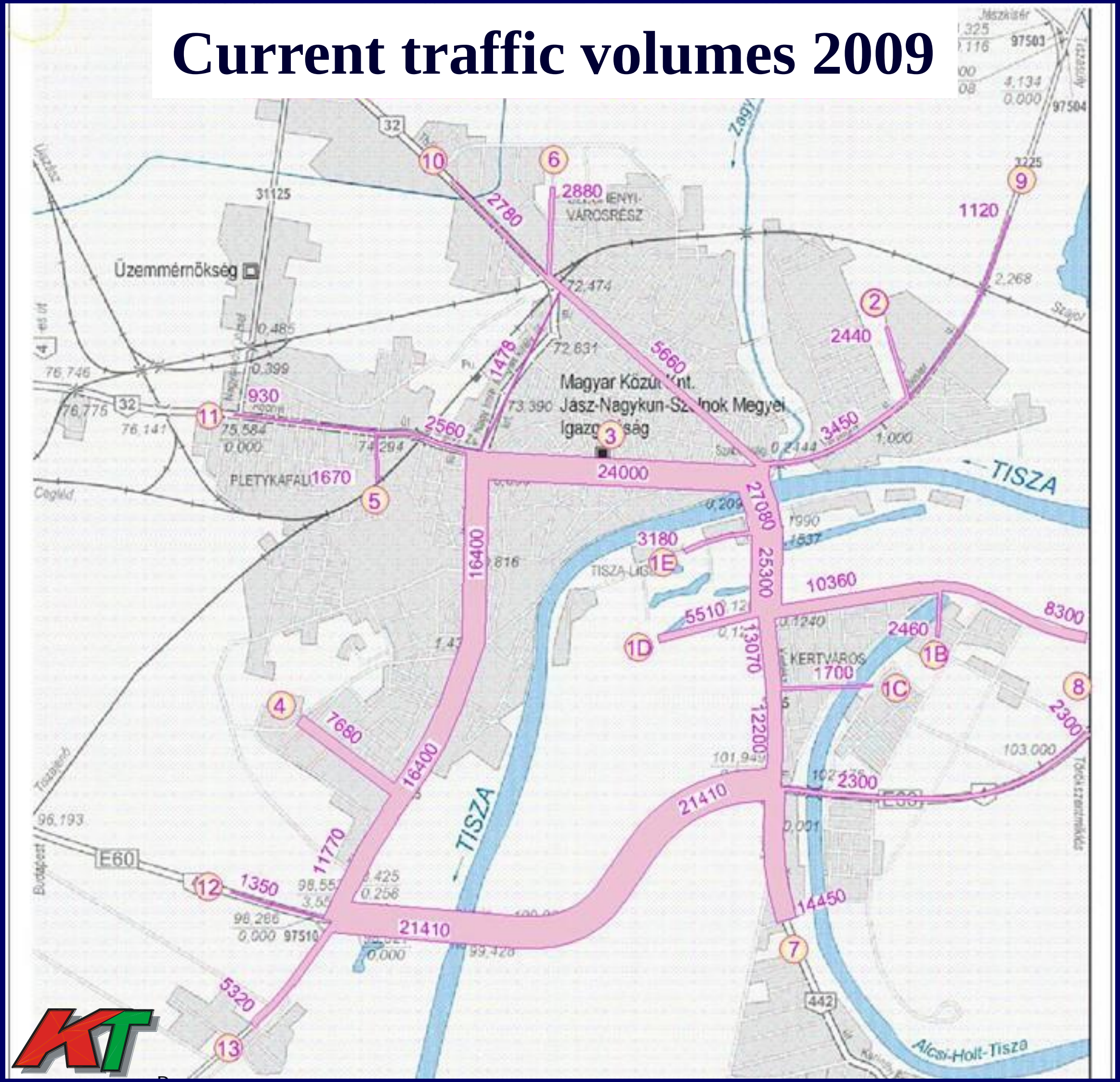
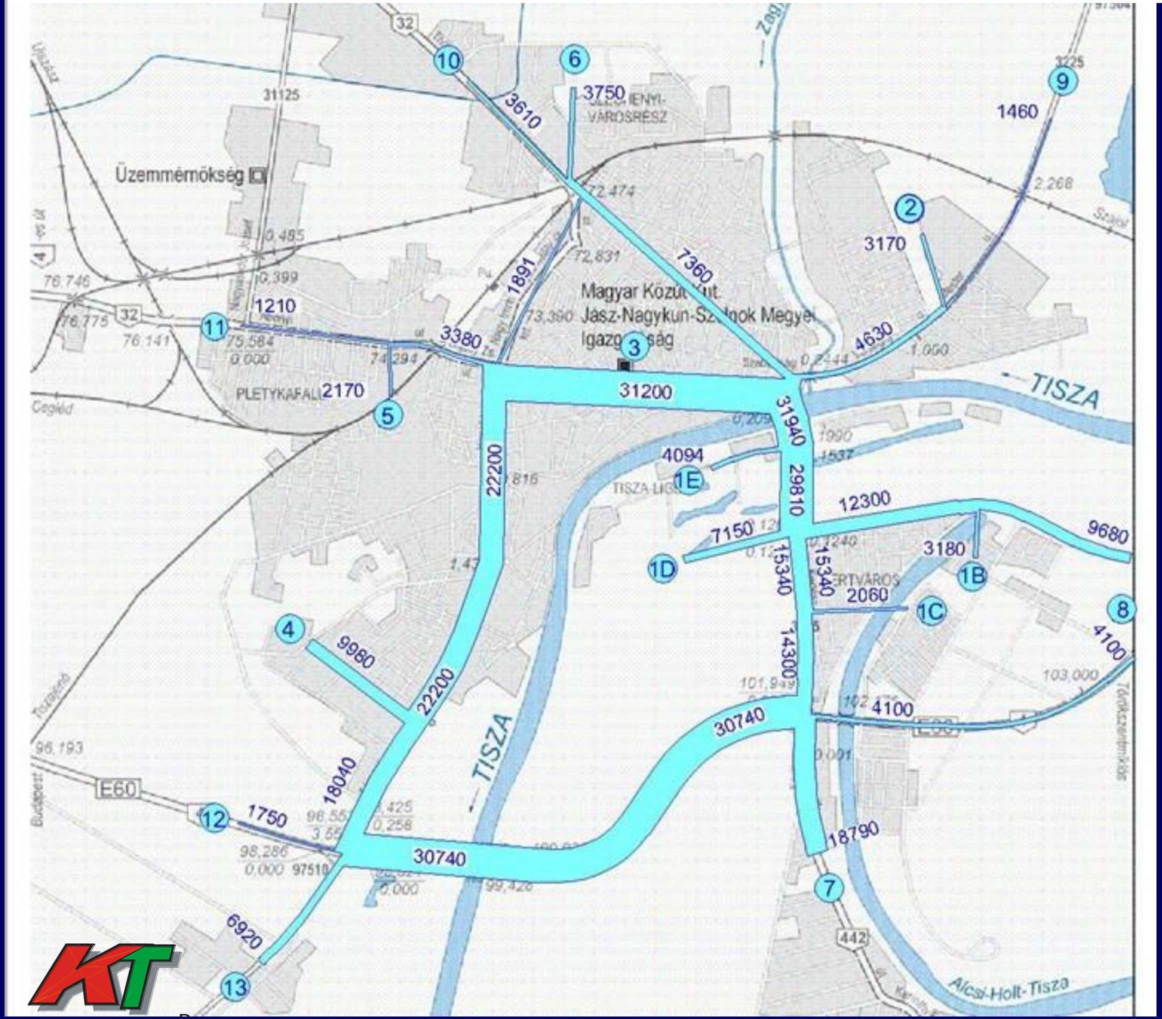


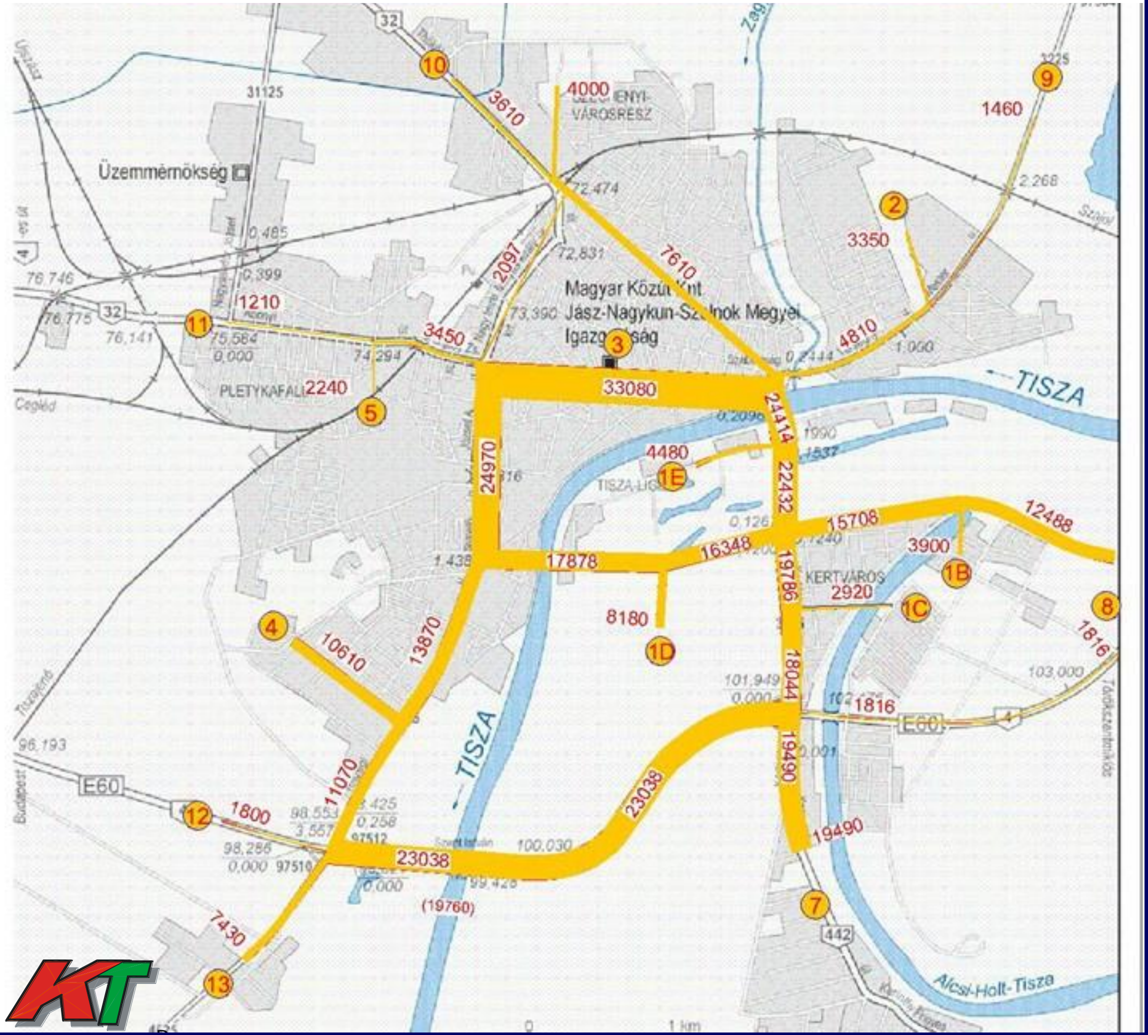
# Traffic Planning – Case Study Szolnok

**Predicted traffic volumes „without” 2020**



# Traffic Planning – Case Study Szolnok

**Predicted traffic volumes „with" 2020**



# Traffic Planning – Case Study Szolnok

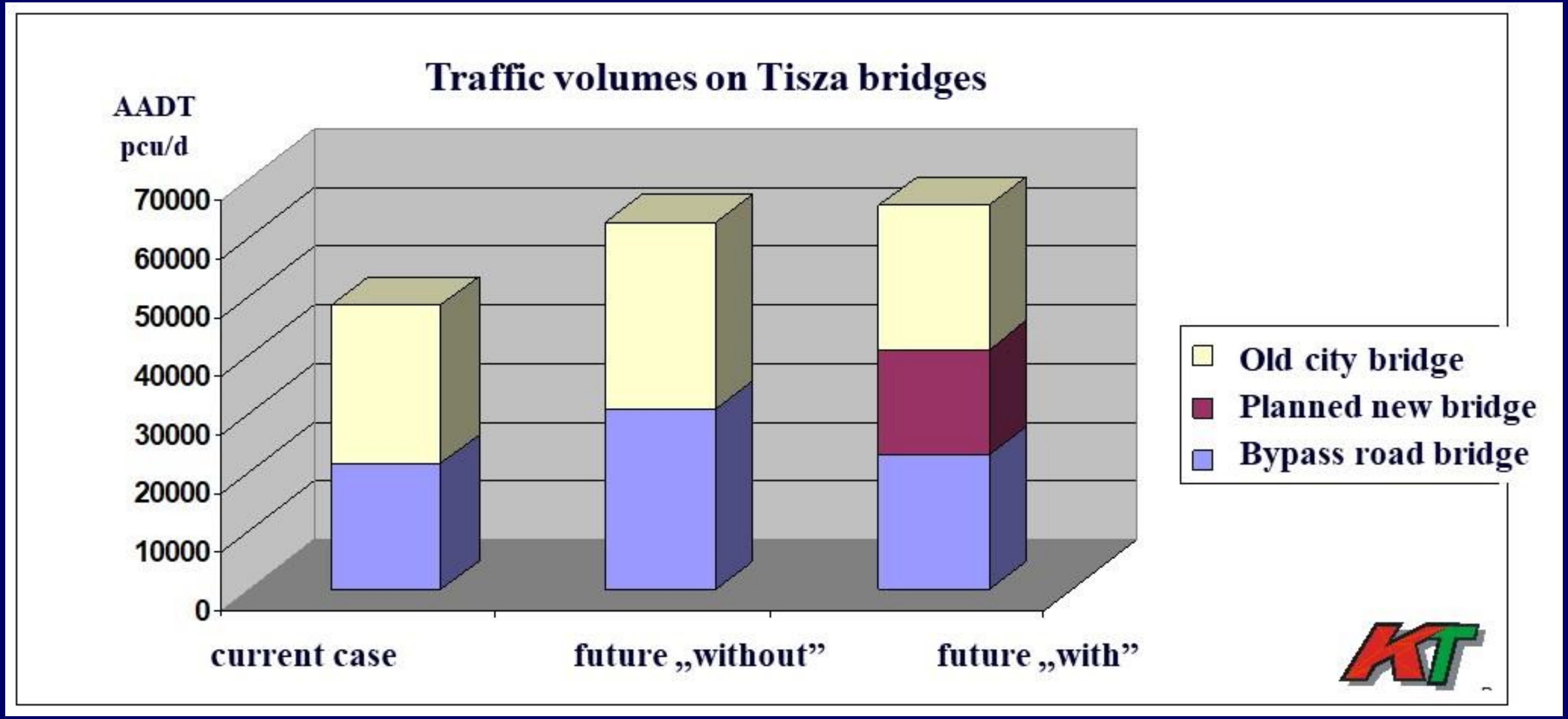
**Results of the traffic study:**

**The planned new bridge in 2020 decreases the traffic of the saturated old bridge by 24 % comparing to the „without” case.**

**In case of three bridges there will be sufficient and proportional capacity reserves on all bridges (24-28%).**

**Consequence: the construction of the new bridge is reasonable both by traffic and land-use structure points of view.**

# Traffic Planning – Case Study Szolnok



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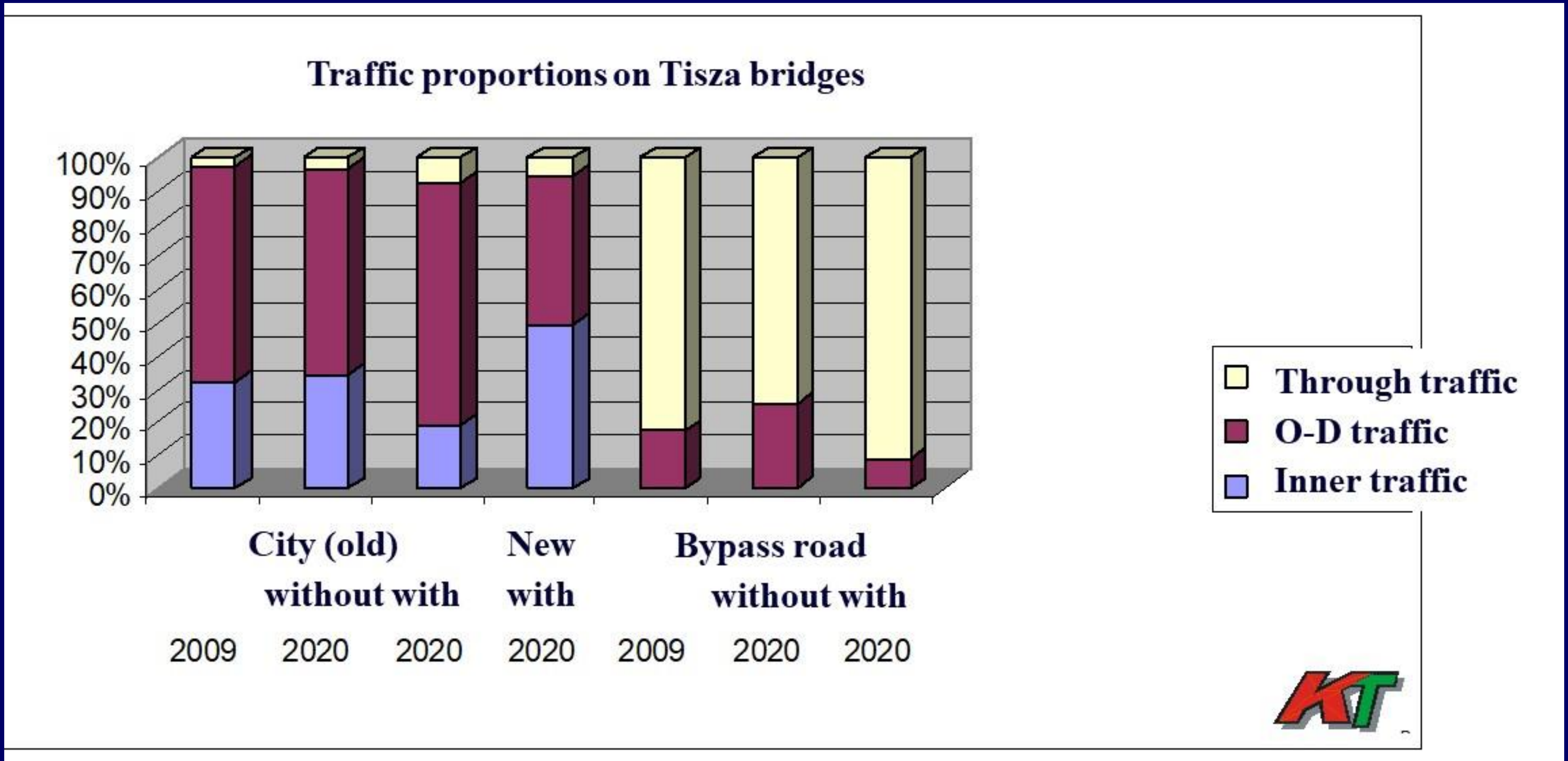

# Summary

- Modal split is made by transport mode, usually including at least car usage and public transport usage.
- Traffic assignment is the last stage in the four stage traffic planning, assigning traffic to a transportation network such as roads and streets or a transit network.
- There is a need for information on traffic data, traffic time series and traffic composition for traffic planning.
- Presentation of traffic planning results is very important in an expressive and understandable way for decision makers and inhabitants concerned.

Thank you for your attention!

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