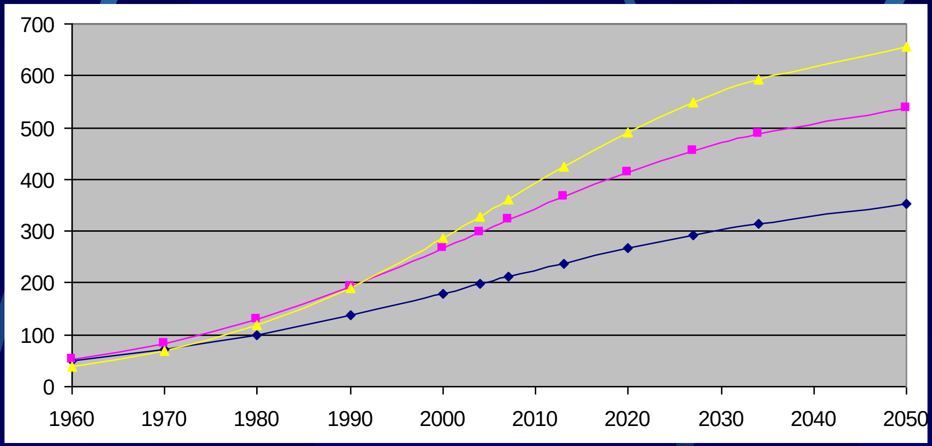
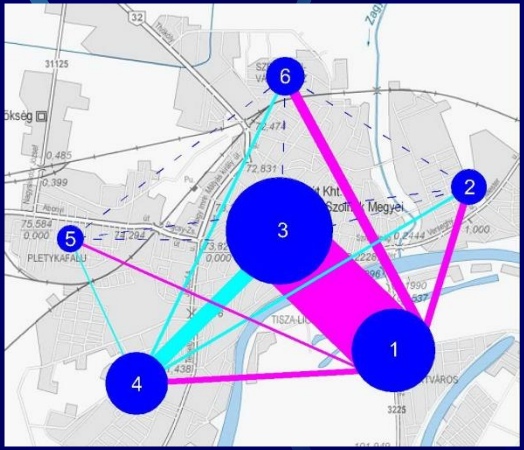
Traffic Engineering and Motorisation
Traffic Planning





Urban Transport 2.
András Gulyás PhD habil
associate professor

Contents

Role and Task of Traffic Engineering

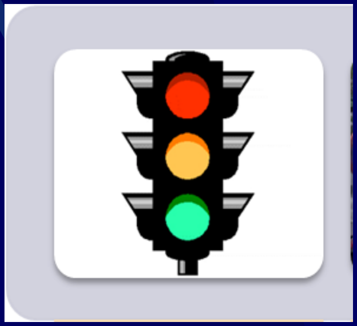
Interaction of vehicle, road and people -> traffic

Increasing vehicle fleet – increasing traffic – demand for control – traffic engineering

In the USA in 1920s years started the employment of a city engineer or traffic engineer

First traffic census in Hungary took place in 1895 (horse coaches / day)

First traffic signal in Hungary had been implemented in 1927



Role and Task of Traffic Engineering

First traffic control centre in Budapest had been deployed in 1979.

The role of the traffic engineer includes control and construction, teamwork with urbanists, coordinated land-use and traffic development.

Traffic authorities and traffic education are also important engineering tasks as well as to solve problems like environmental pollution, congestion, conflicts in urban transportation.

Society and civil organisations nowadays require participation and involvement.

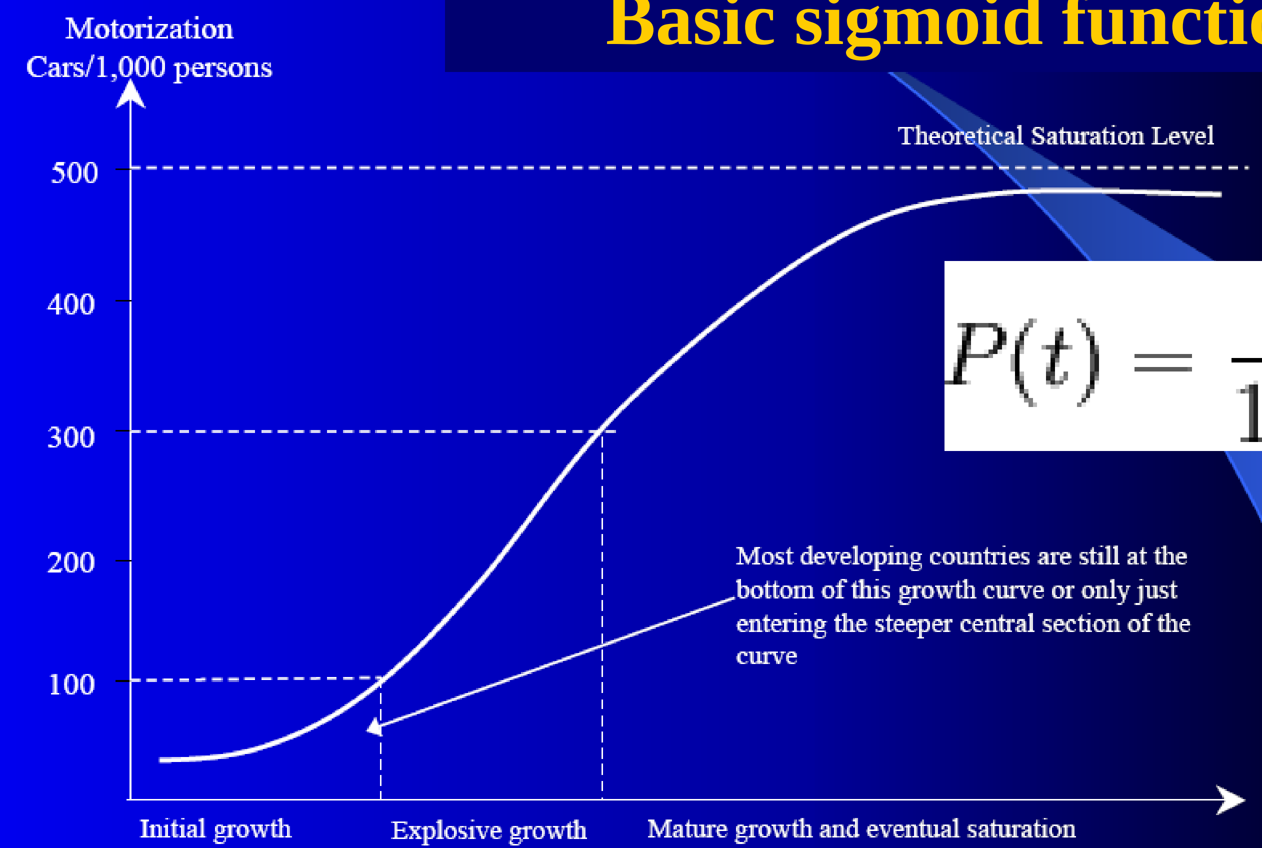
Development of Motorisation

Level or rate of motorisation (cars per 1000 inhabitants) is neither a deterministic data nor a destiny. Goal of traffic control is not only to satisfy all travel demands and serve them with new or enhanced transport infrastructure.

Traffic engineers and urbanists have means to influence the car dependence of a city or suburb, whether the use of car is of necessity or there are alternative and more sustainable solutions for mobility.

Development of Motorisation

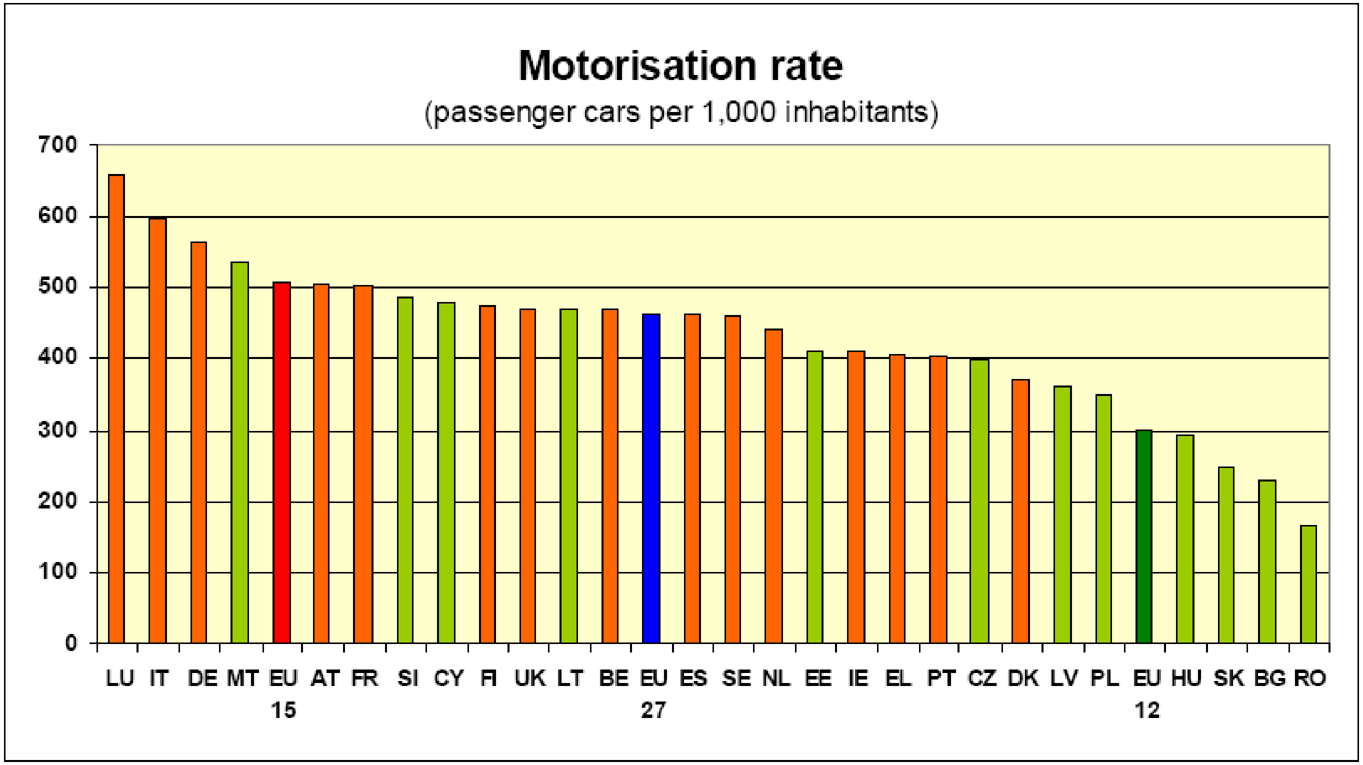
Basic sigmoid function



$$P(t) = \frac{1}{1 + e^{-t}}$$

Development of Motorisation

- Passenger cars per 1,000 inhabitants (2006)



Directorate-General for Energy and Transport

Development of Motorisation

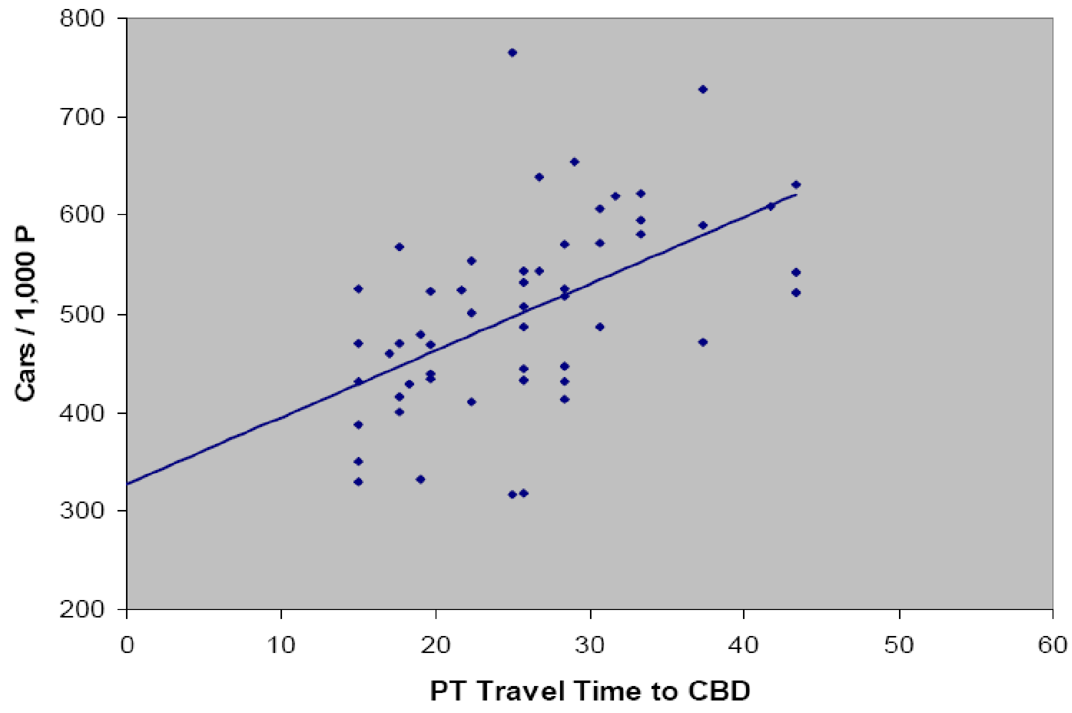
In the past the development of motorisation had been usually underestimated while currently there is a danger of overestimating because growth cannot be unlimited.

The rate of motorisation and the estimated level of saturation is higher in case of inadequate public transport accessibility.

The rate of motorisation and the estimated level of saturation is proportionally decreasing when the population density is increasing as well as by shortage in parking availability.

Development of Motorisation

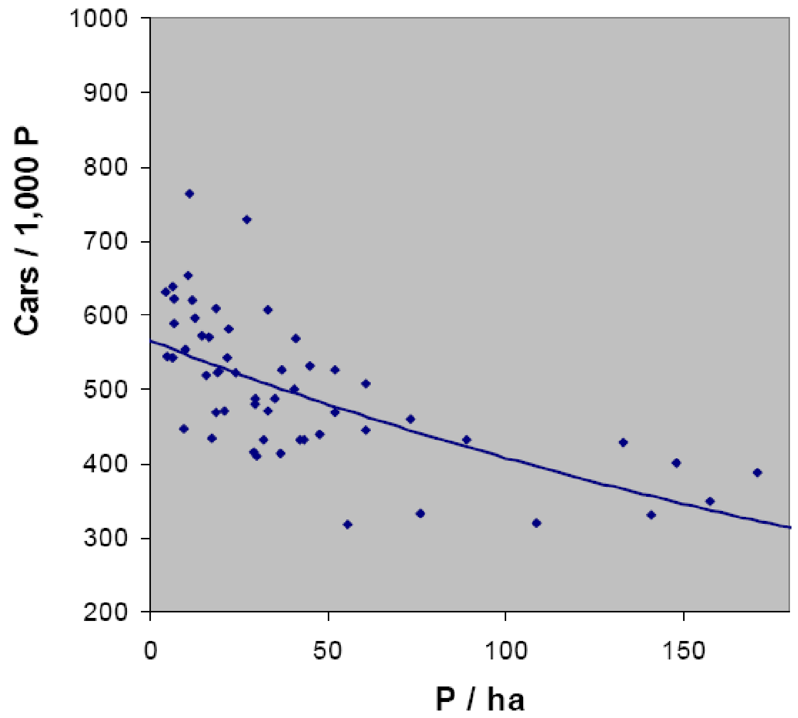
Car ownership by public transport accessibility



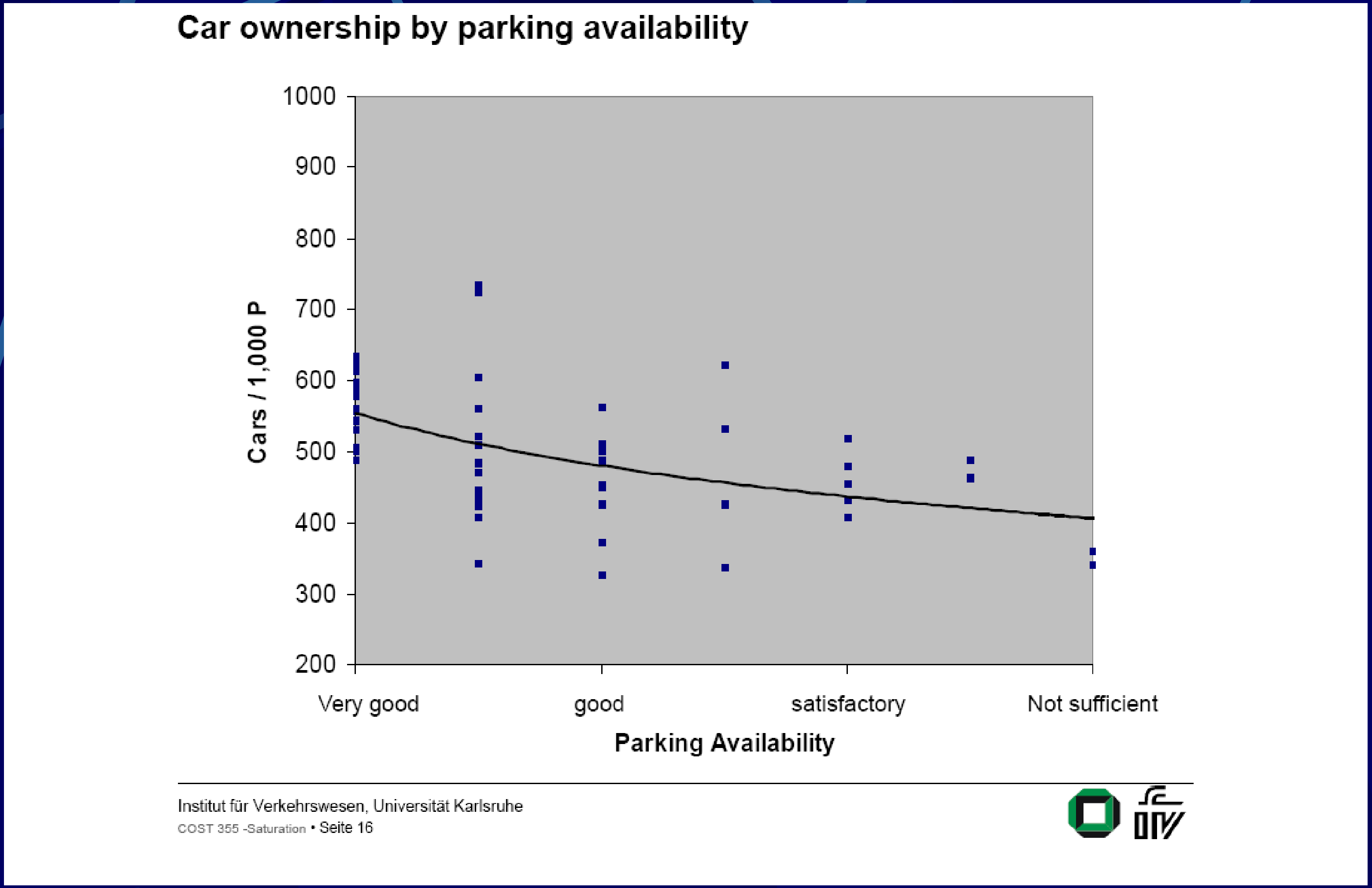
Institut für Verkehrswesen, Universität Karlsruhe
COST 355 -Saturation • Seite 13

Development of Motorisation

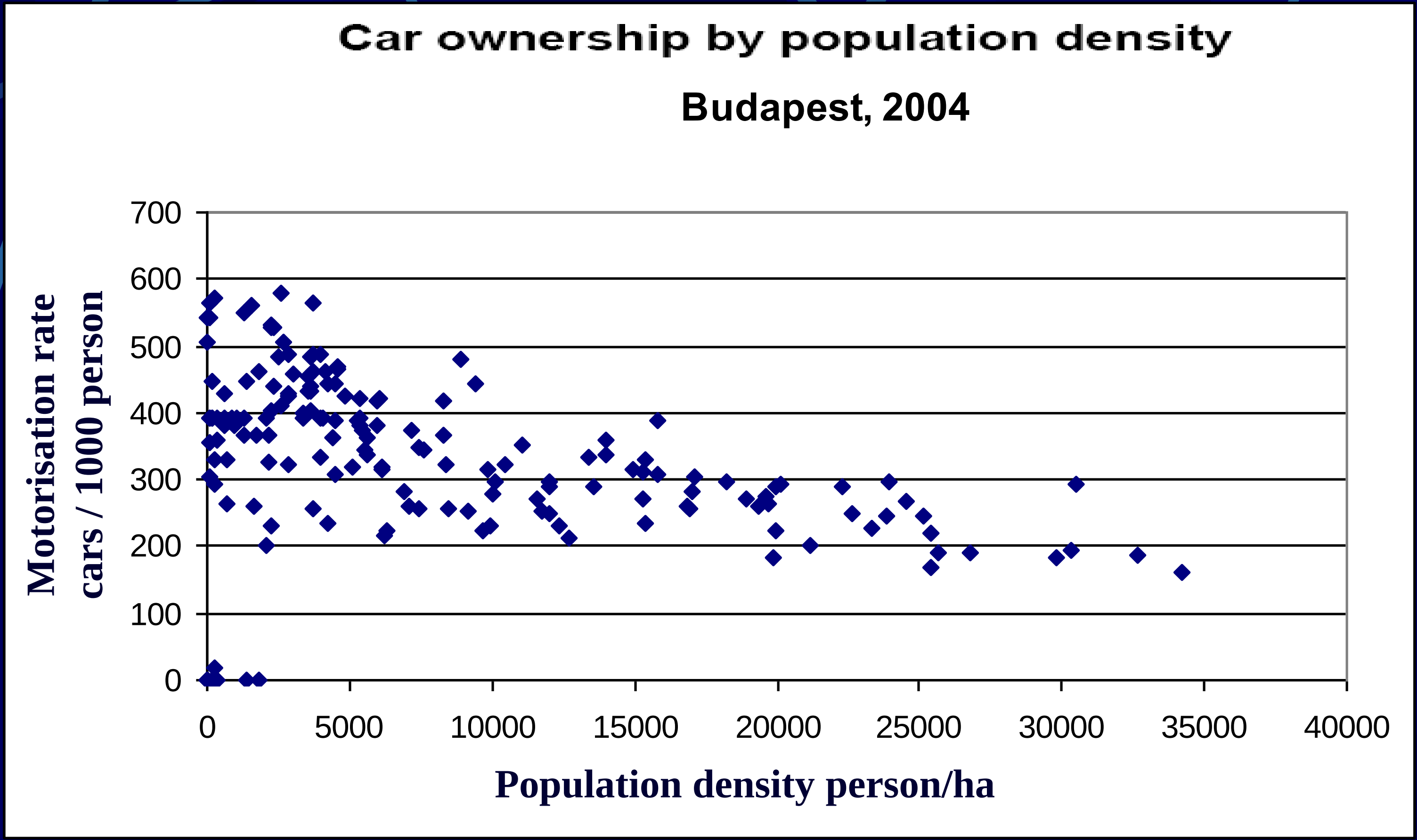
Car ownership by population density



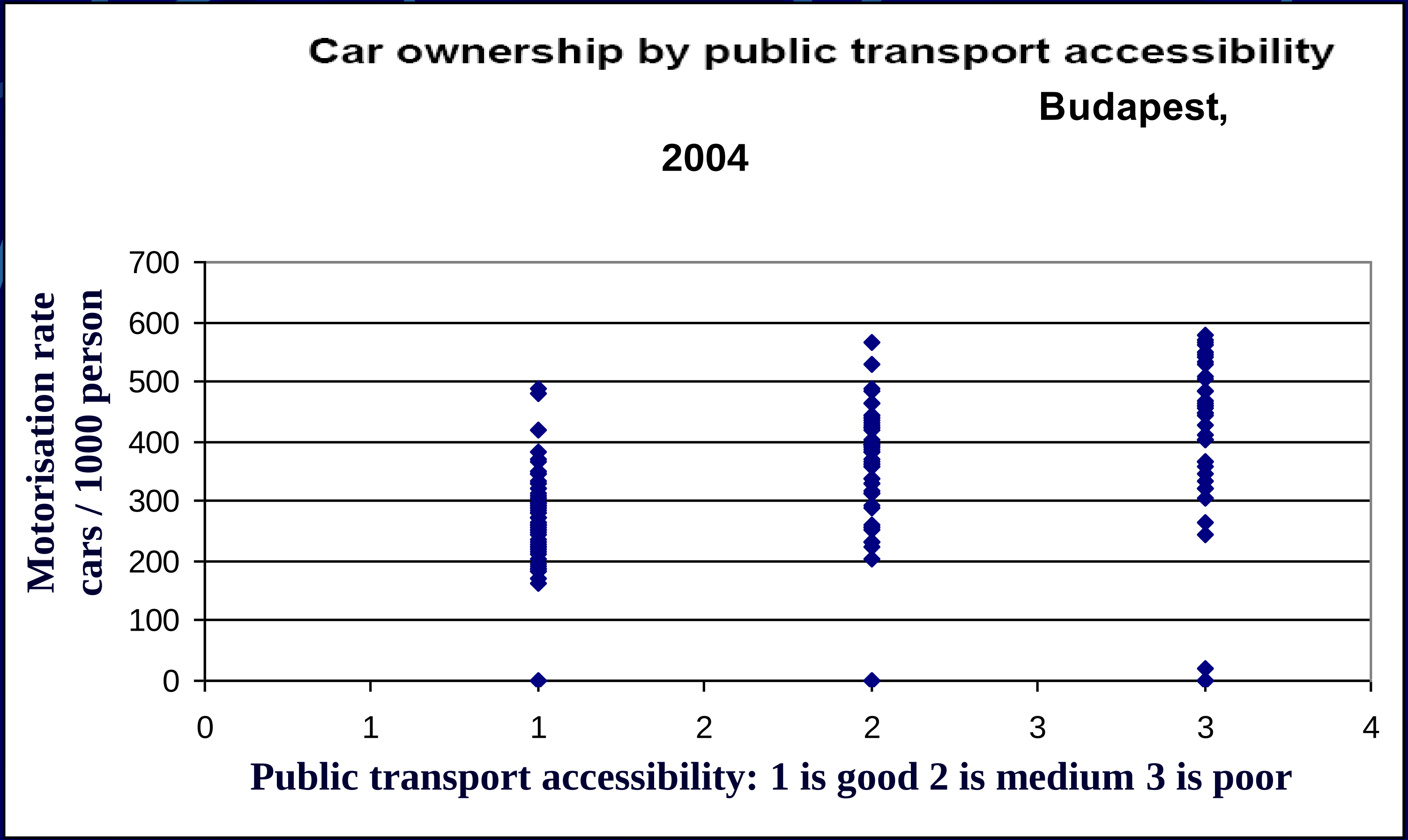
Development of Motorisation



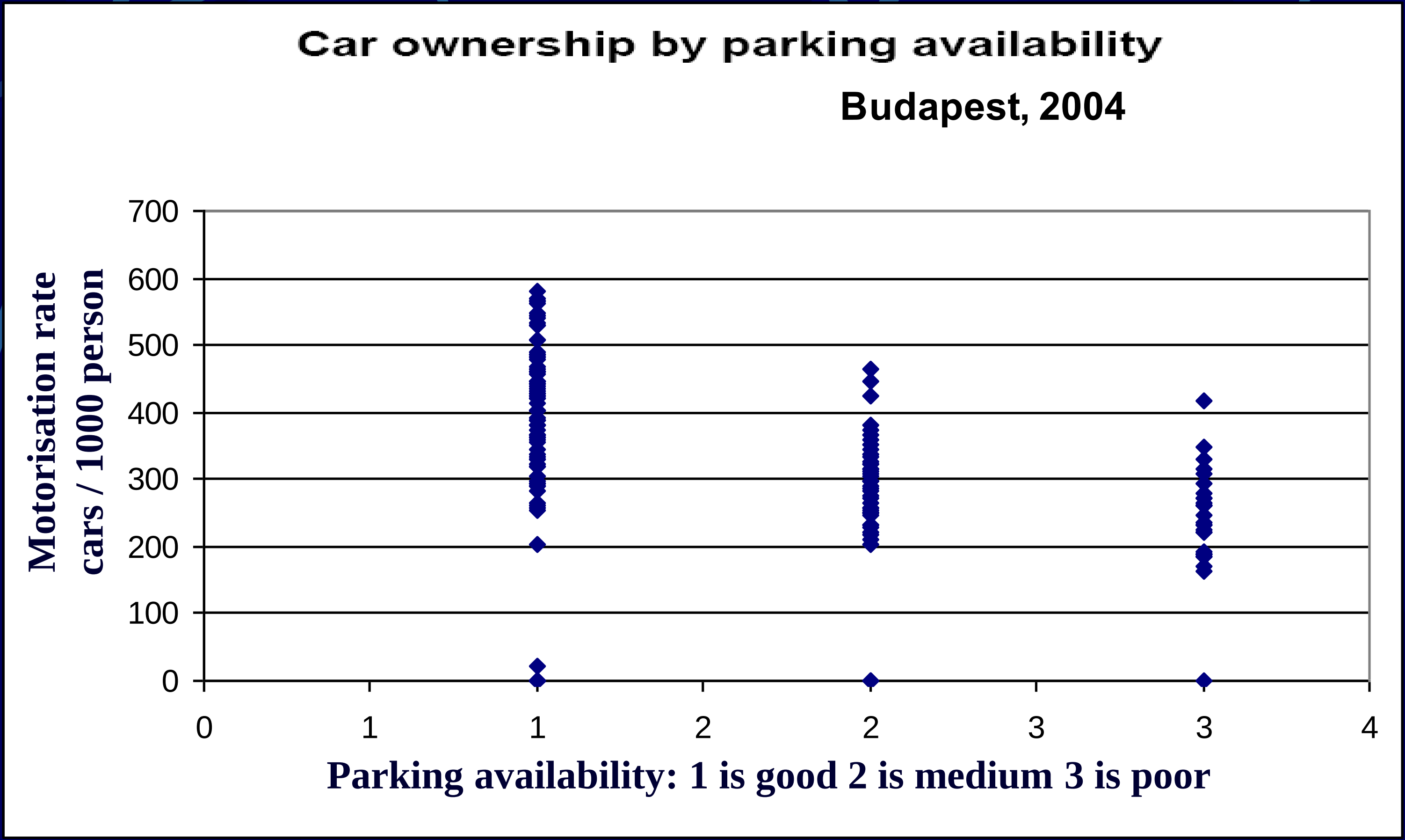
Development of Motorisation



Development of Motorisation



Development of Motorisation

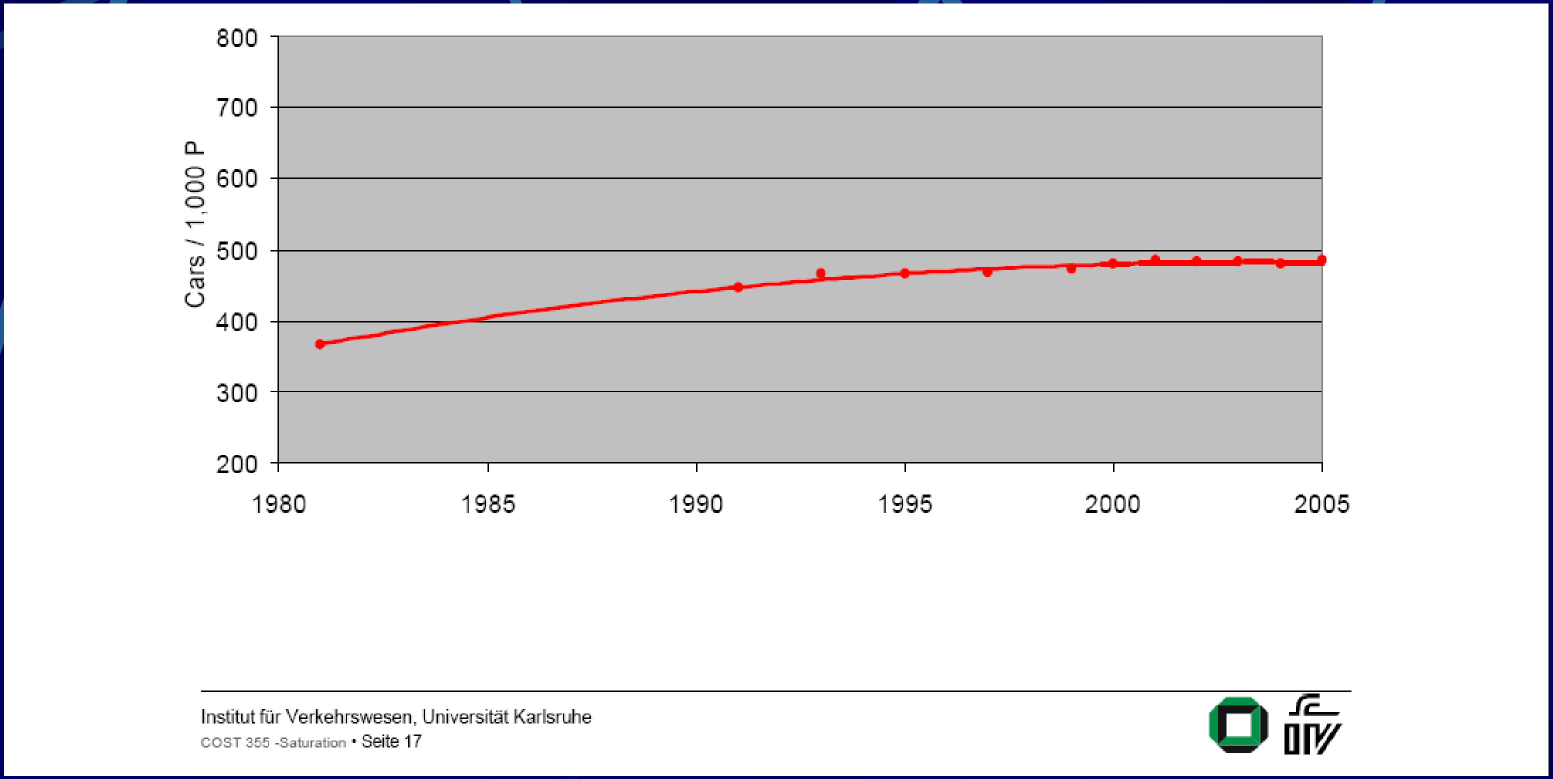


Development of Motorisation

In Karlsruhe, Germany, the motorisation curve does not exceed the 500 cars / 1000 inhabitants value, although there are differences in various parts of the city. Densely inhabited central parts with good public transport have a significantly lower saturation level of motorisation .

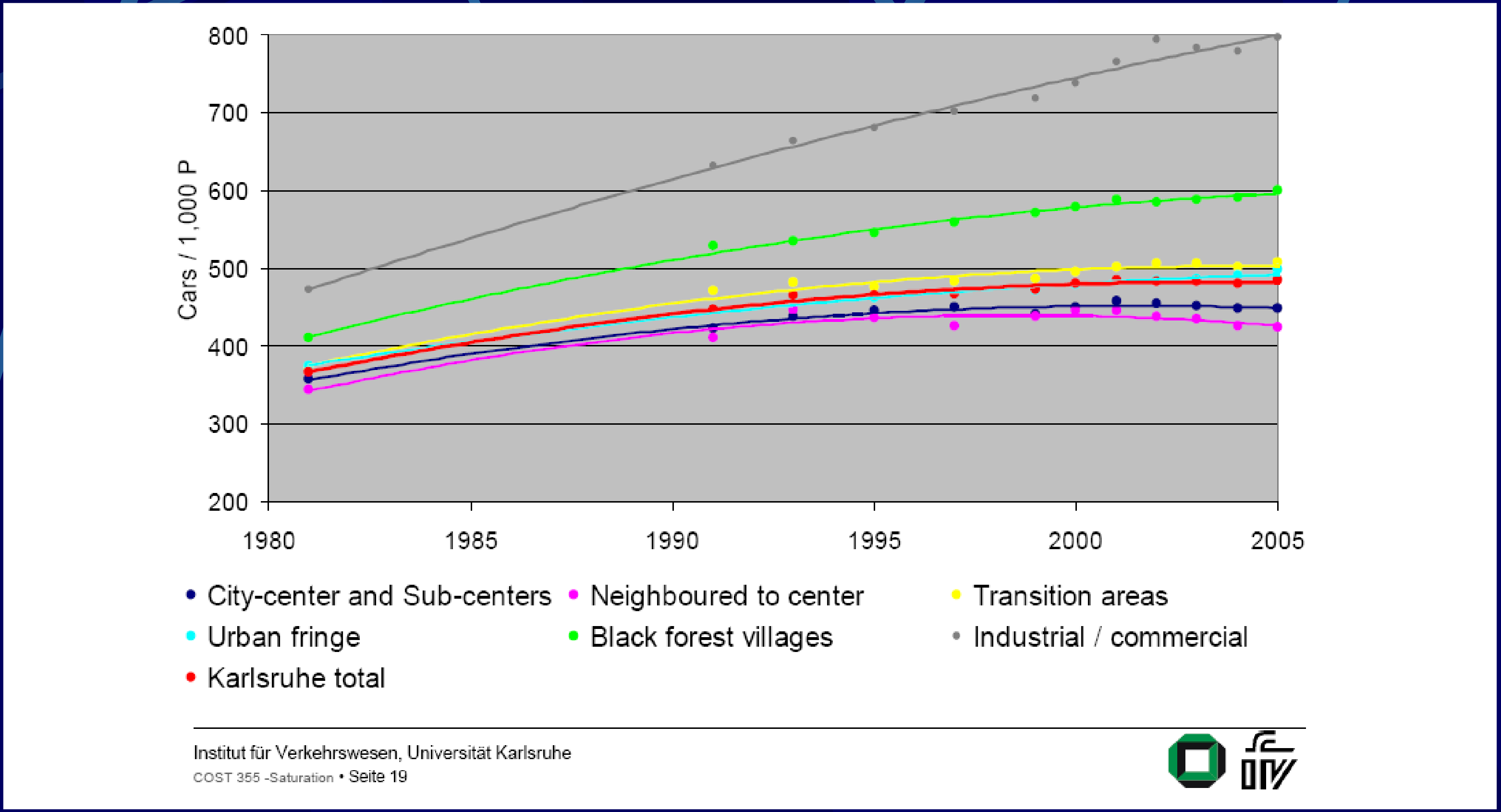
In Budapest similarly there are different and constrained expected saturation levels of motorisation depending on land-use, density and transport characteristics.

Development of Motorisation



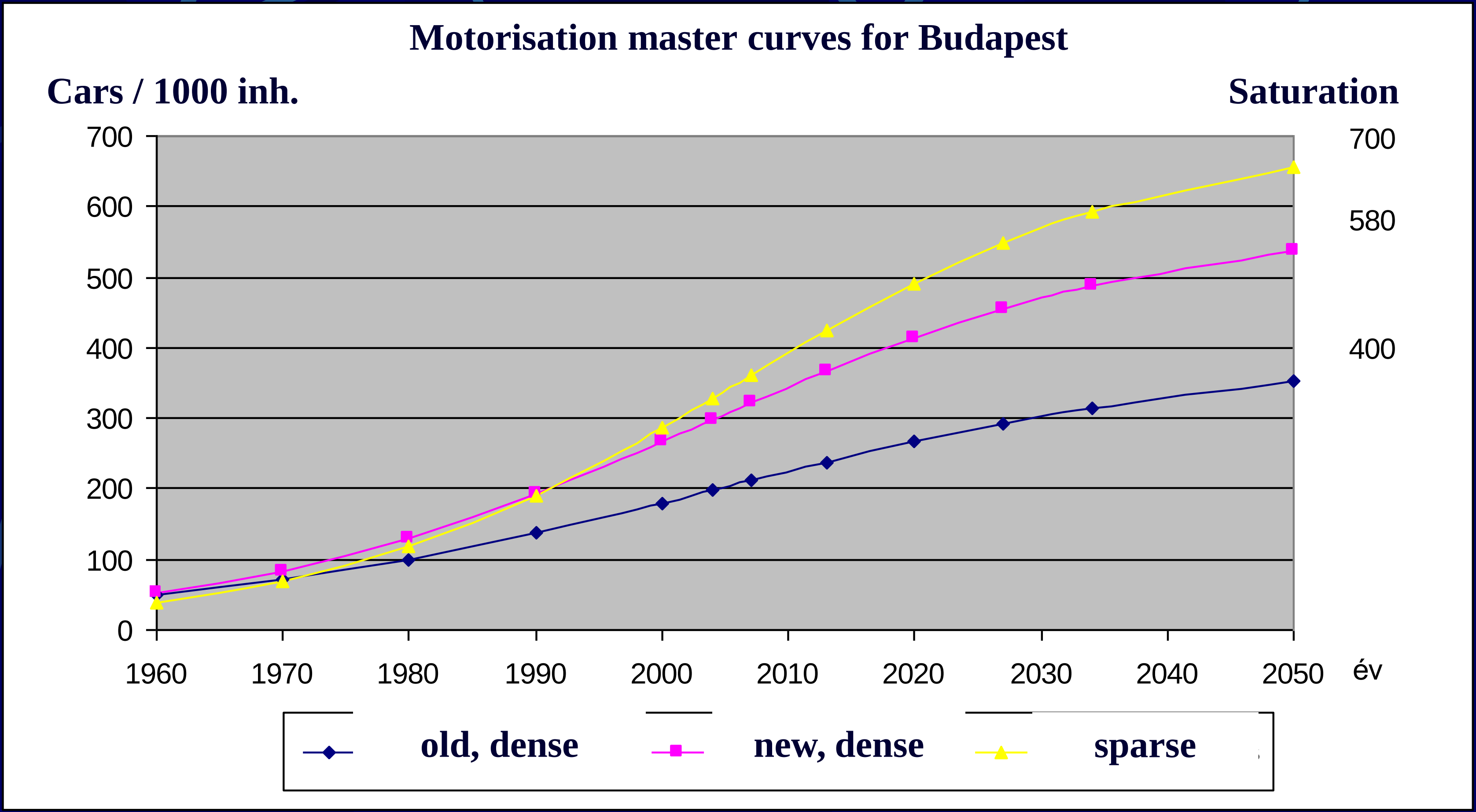
Karlsruhe, Germany

Development of Motorisation



Karlsruhe, Germany

Development of Motorisation

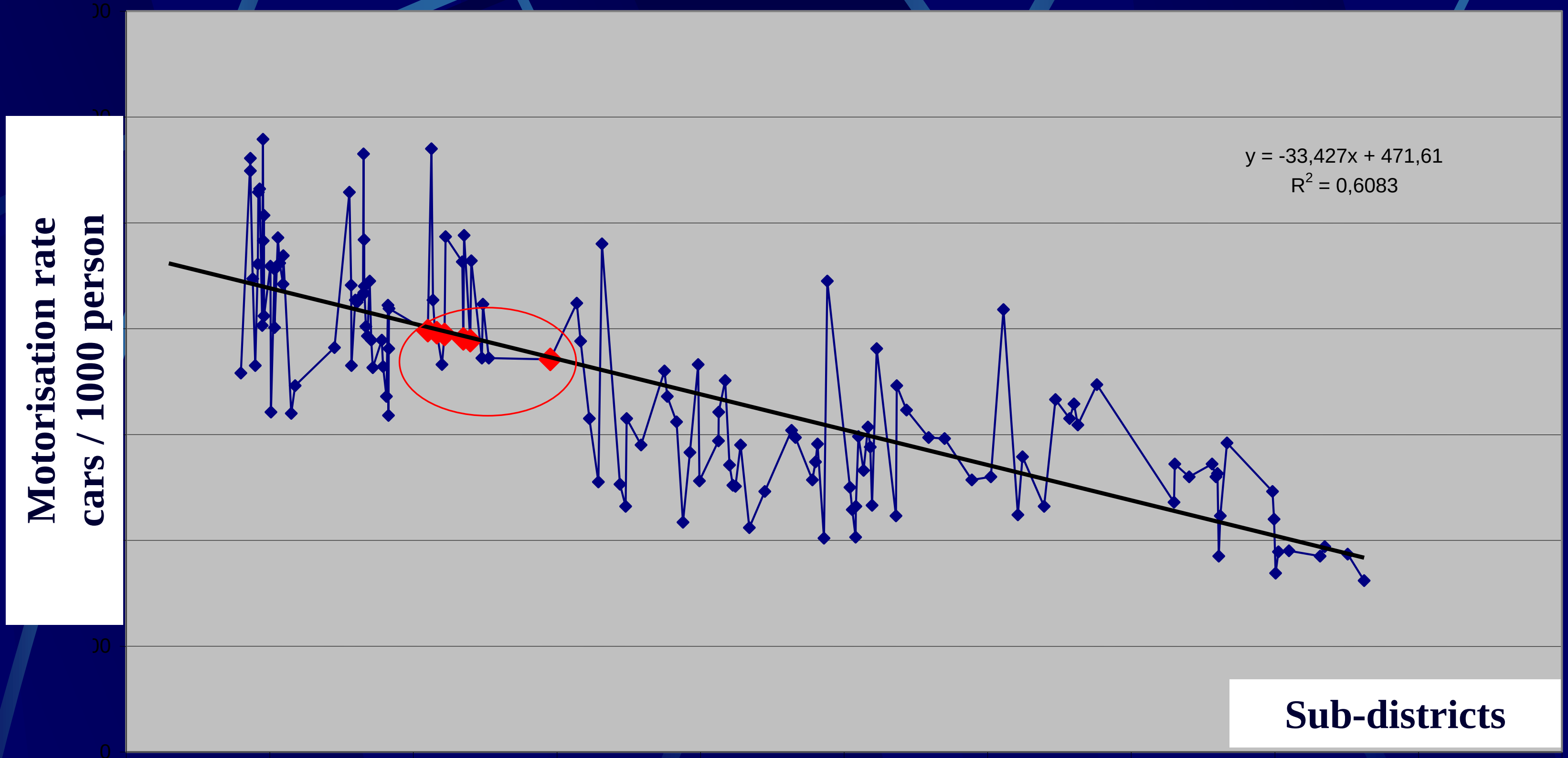


Development of Motorisation

In case of the Budapest motorisation rate calculations and predictions, grouping of capital sub-districts has been made based on economic activity, type of land-use, attraction of land-use, population density, public transport and parking characteristics.

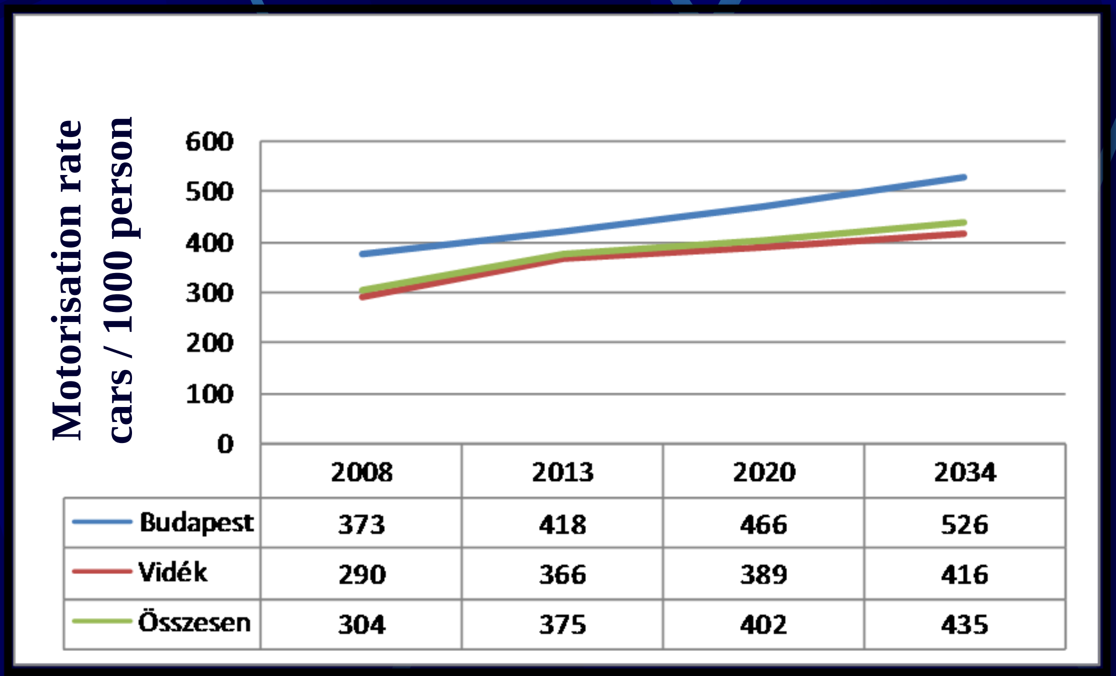
In the future in case of land-use change the predicted value of motorisation level can be considered using linear regression as a group average corresponding to new land-use type.

Development of Motorisation



In the future in case of land-use change the predicted value of motorisation level can be considered using linear regression as a group average corresponding to new land-use type (red points).

Development of Motorisation



	2008	2013	2020	2034
Budapest	373	418	466	526
Vidék	290	366	389	416
Összesen	304	375	402	435

Predicted motorisation levels in the National Long-term Road Network Development Plan for Budapest, countryside and national cases

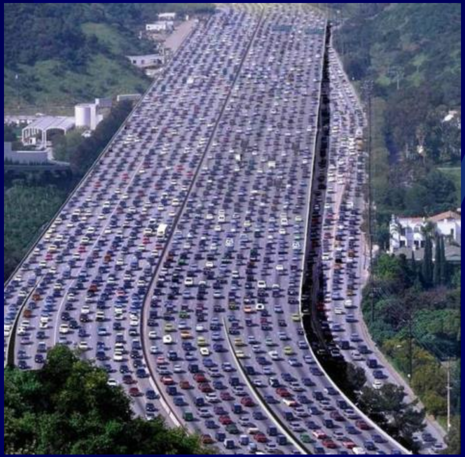
Traffic Planning – Traffic Surveys

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 Planning – Traffic Surveys

- 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 Planning – Traffic Surveys

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

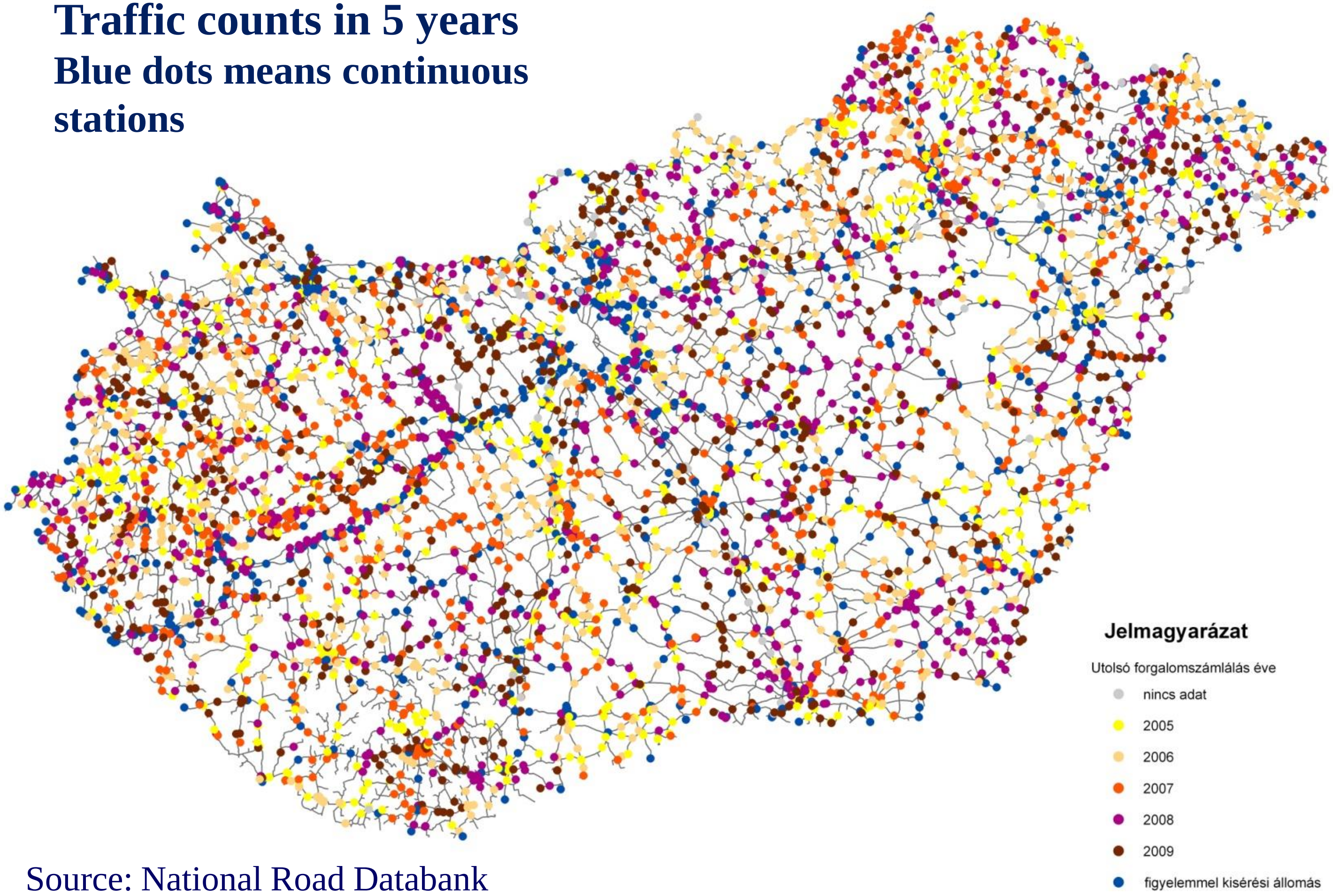
Temporary stations – video or manual counts – work on a few days in every fifth year.

Traffic data for mid-years are calculated.

Traffic Planning – Traffic Surveys

Traffic counts in 5 years

Blue dots means continuous stations

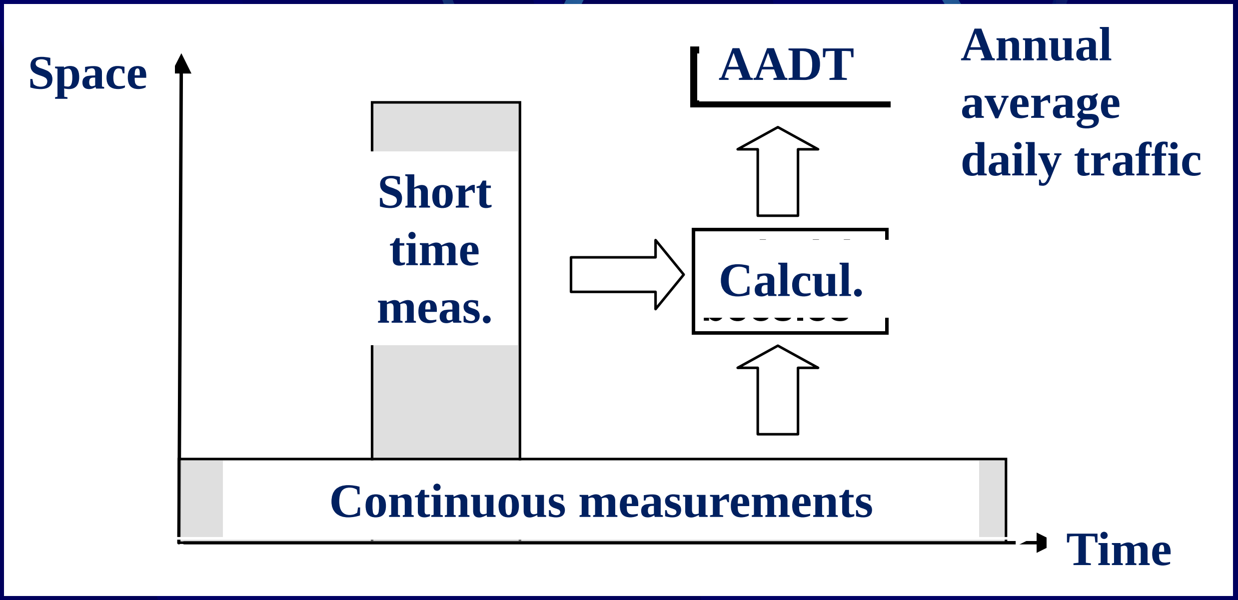


Source: National Road Databank

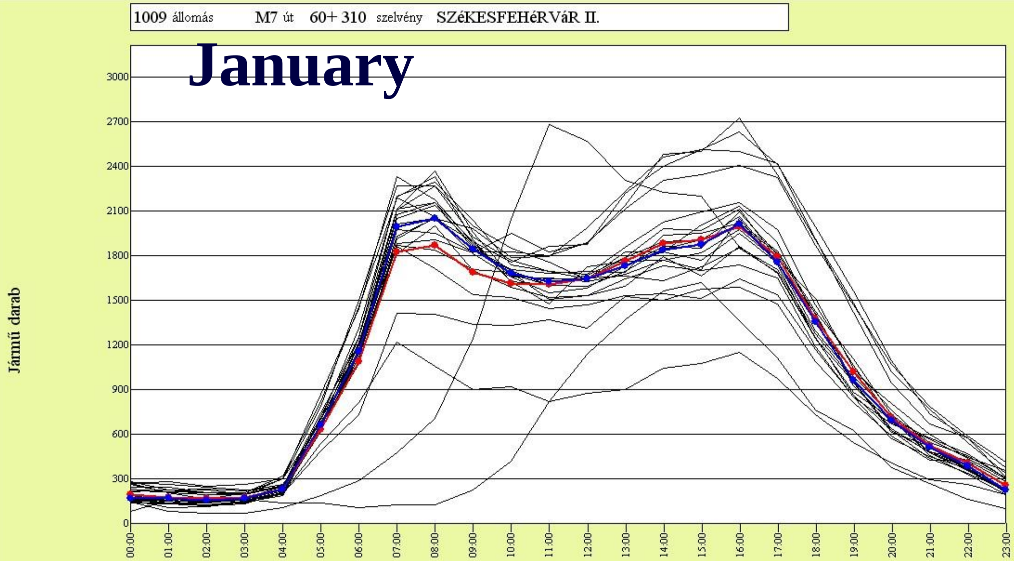
Traffic Planning – Traffic Surveys

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 Planning – Traffic Surveys



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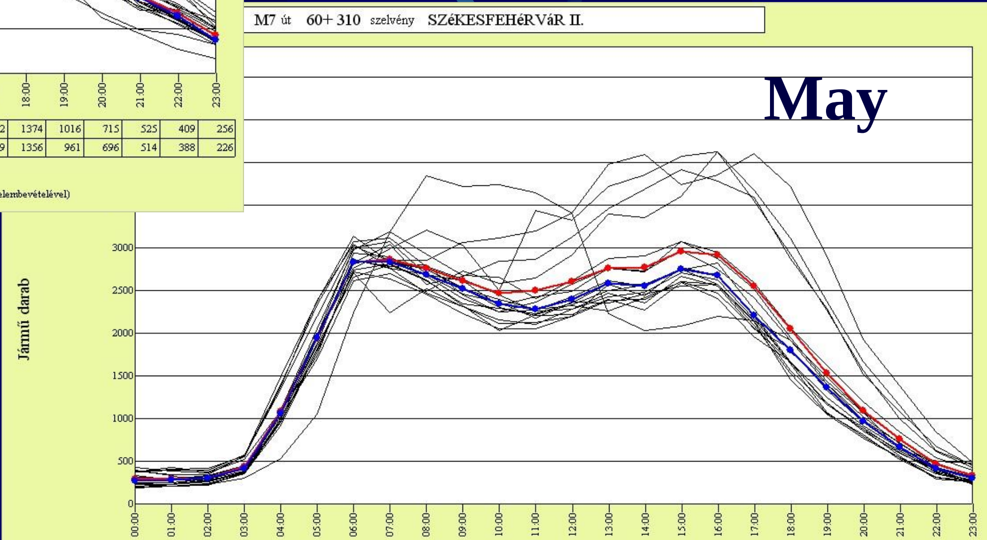
Átlag érték	192	178	166	174	230	630	1088	1824	1867	1689	1613	1609	1645	1763	1883	1905	1994	1792	1374	1016	715	525	409	256
Medián érték	166	168	156	167	230	662	1158	1992	2053	1845	1682	1624	1644	1732	1836	1876	2012	1759	1356	961	696	514	388	226

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 Planning – Traffic Surveys

Definitions:

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

$AADT = f \cdot a \cdot b \cdot c$

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

<u>Standard peak hour traffic</u> is the value which the hourly traffic equals or exceeds in 50 hours in a year

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

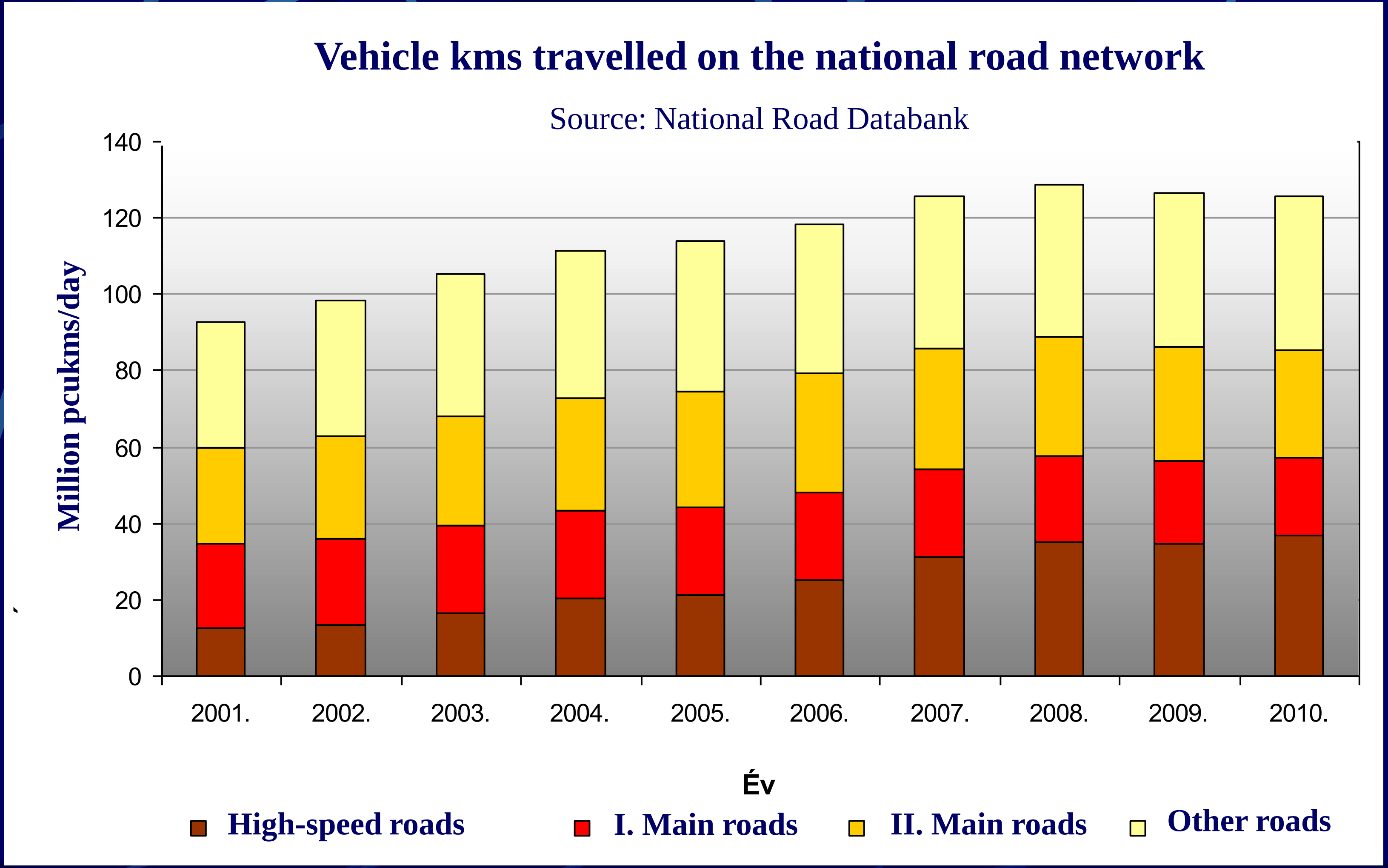
where ω – peak hour factor

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

<u>Vehicle kms (or miles) travelled</u> (performance metric):

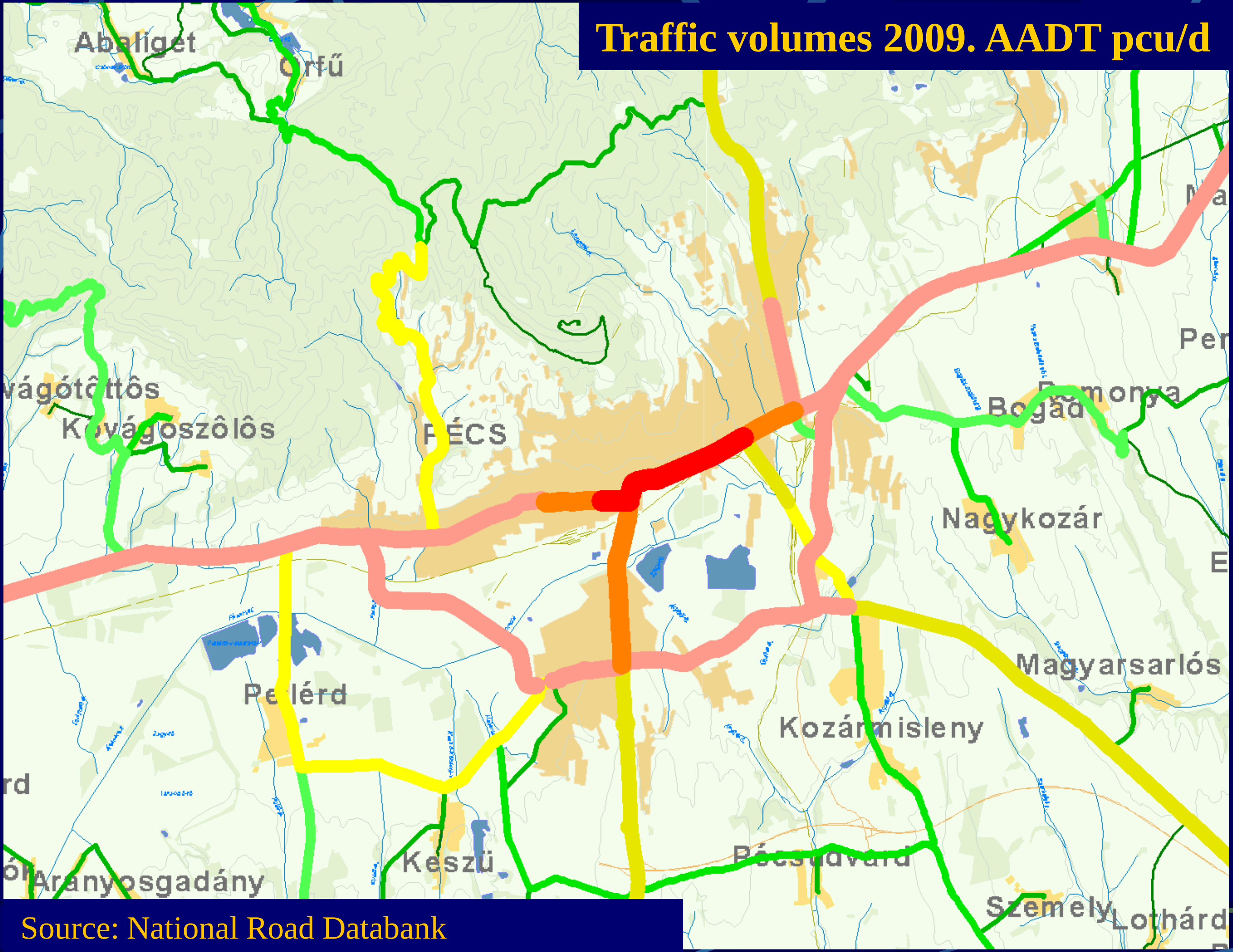
$VKT = \Sigma\,(AADT \cdot \text{length of road section})$ [vehkms/nap]

Traffic Planning – Traffic Surveys



Traffic Planning – Traffic Surveys

Traffic volumes 2009. AADT pcu/d



Source: National Road Databank

Traffic Planning – Traffic Surveys

- 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 Planning – Traffic Surveys

O-D roadside interview – safety is very important

Preliminary local communication is indispensable for success

Traffic Planning – Main Steps

The main goal of traffic planning is to satisfy travel or motion needs.

Travel purposes: work, school, other

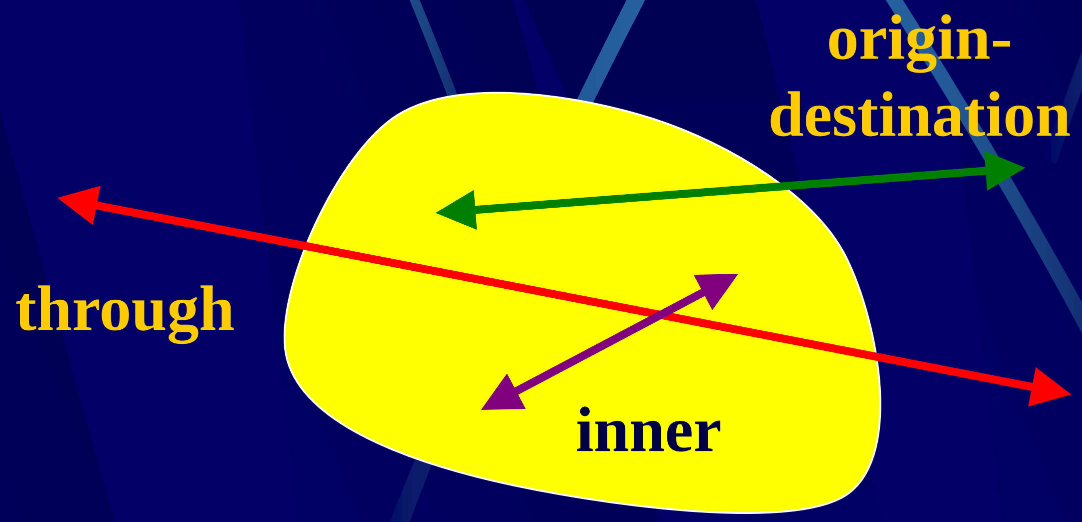
Travel modes: personal (car or car sharing, public transport, bicycle, pedestrian

Work items of urban transport development plans:

- **survey (actual condition),**
- **analysis (prediction),**
- **strategy,**
- **plan and projects.**

Traffic Planning – Main Steps

Relations of settlement and traffic: through traffic, origin – destination traffic, inner traffic.



Traffic Planning – Main Steps

The proportion of through traffic and origin-destination traffic can be surveyed by roadside interview or license plate reading.

The inner traffic can be surveyed by a statistically well established household interview or travel survey on the Internet or by mobile phones.

The proportion of private and public transport is the modal split.

Traffic Planning – Main Steps

Population of the area surveyed	Recommended sample size dwelling units	Minimum sample size dwelling units
below 50 000	20 %	10 %
50 000 – 150 000	12,5 %	5 %
150 000 – 300 000	10 %	3 %
above 300 000	4 %	1 %

Traffic Planning – Main Steps

The four steps of traffic planning:

1. **Trip generation (per spatial zones)**
2. **Modal split (cars, public transport, freight)**
3. **Trip distribution (between zones, matrix)**
4. **Assignment (current and future network)**

Zones in the city – detailed for the goal, basic input data (population, car ownership or motorisation rate, economic parameters, land-use of the zone) are available.

Traffic Planning – Main Steps

1. Trip generation – method can be projective or analytic, models can be category based or regression based.

Basic formula of the projective or growth factor model:

$$T_i = F_i \cdot t_i$$

where:

T_i number of predicted trips

t_i current amount of trips

F_i growth factor

Traffic Planning – Main Steps

Example of a regression function for trip generation

$$P_i = a_1 L_i + a_2 M_i + a_3 I_i + a_4 S_i$$

where:

P_i	trips originated from the i^{th} zone
L_i	population of the i^{th} zone
M_i	workplaces of the i^{th} zone
I_i	school spaces of the i^{th} zone
S_i	service sector employees of the i^{th} zone
$a_{1 \dots 4}$	weighing parameters

Traffic Planning – Main Steps

2. Modal split – most popular is the Logit model that determines of choice probabilities of different traffic modes.

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

or

$$Ptk = \frac{e^{V\,tk}}{e^{V\,auto} + e^{V\,tk}}$$

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**

„tk” means public transport *(in Hungarian)*

Traffic Planning – Main Steps

3. Trip distribution –frequently used models growth factor model, generalised gravity model.

Trips between zones or elements of the trip matrix are calculated individually. The row and column sums of the matrix must be equal to the trip generation (and attraction) values which can be provided by an iteration process.

In the gravity model the value of the resistance is usually depending on the distance or more often on the cost of the trip.

Traffic Planning – Main Steps

Formula of the generalised gravity model:

$$f_{i,j} = \alpha \cdot \frac{P_i \cdot A_j}{r_{i,j}}$$

where:

f_{ij}	trips or traffic between the i^{th} and the j^{th} zones
α	connection factor
P_i	trips generated from the i^{th} zone
A_j	trips attracted to the j^{th} zone
$r_{i,j}$	resistance between the i^{th} and the j^{th} zones

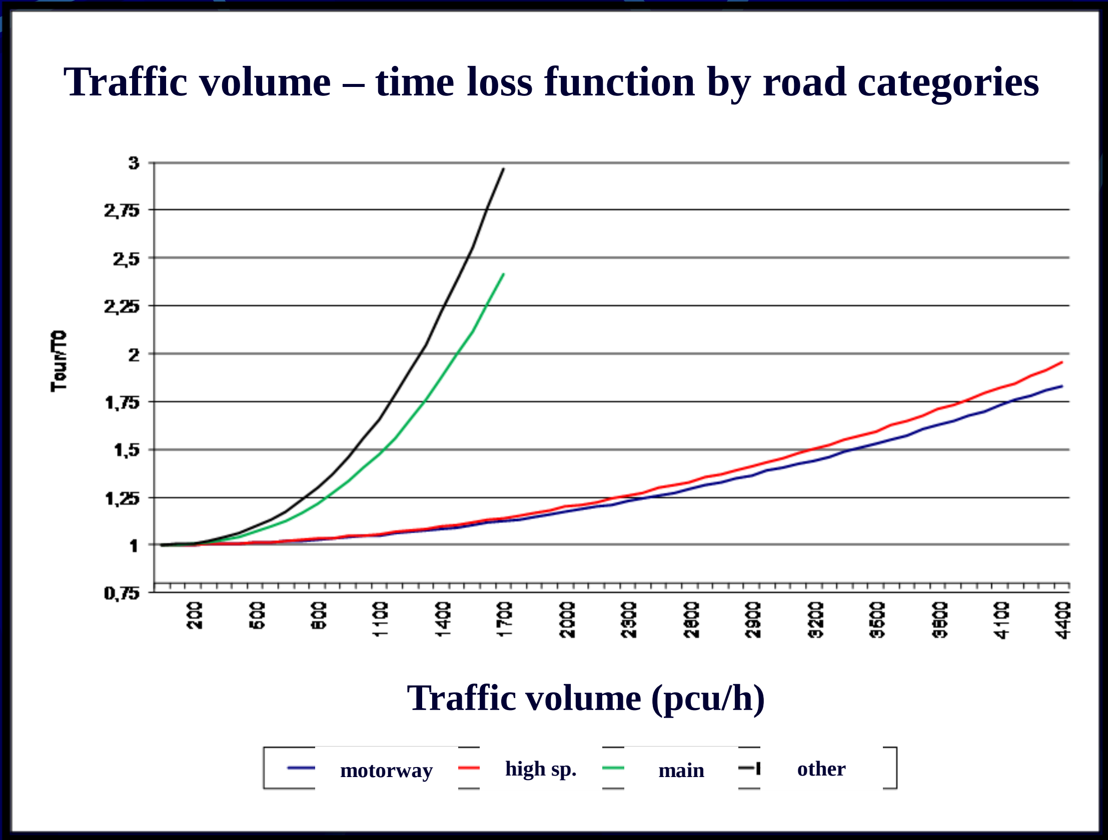
Traffic Planning – Main Steps

4. 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 – Main Steps



Example for a travel time based resistance function

Traffic Planning – Main Steps

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.

In case of equilibrium 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.

Traffic Planning – Main Steps

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.

Nowadays traffic planning is performed by special CAD based programs (EMME, VISUM, etc.) – these are expensive, input demanding but effective systems.

Last step of the planning is the assessment and presentation of the future network alternatives.

Traffic Planning – Main Steps

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 (*later in details*).

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.

Explanation of results and project proposals to inhabitants concerned is also important.

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

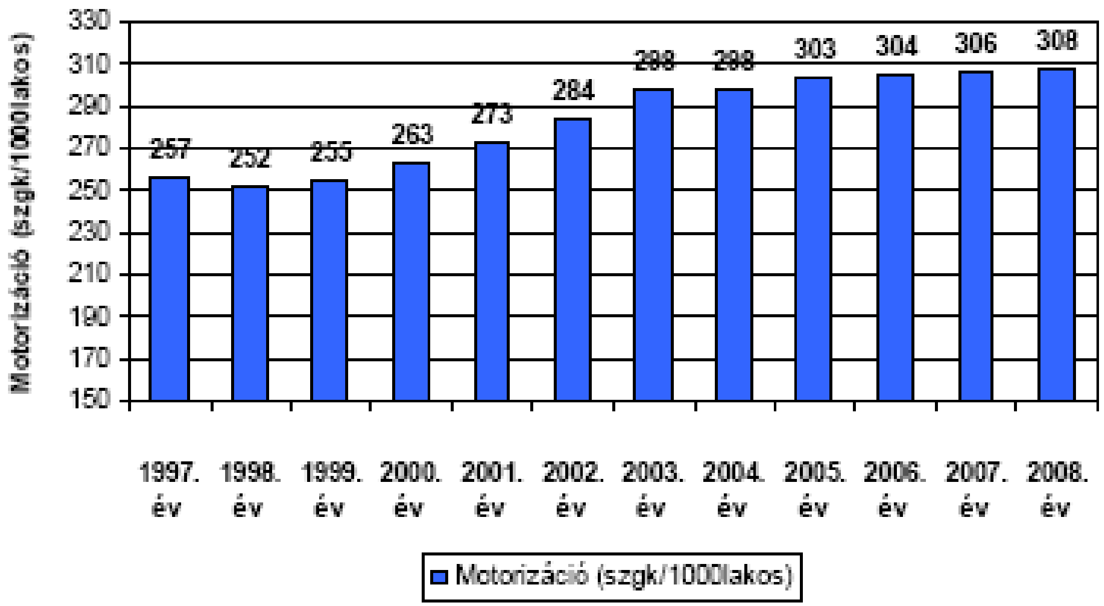
Zone based input data for present and future cases: number of inhabitants, GDP/person, rate of motorisation

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

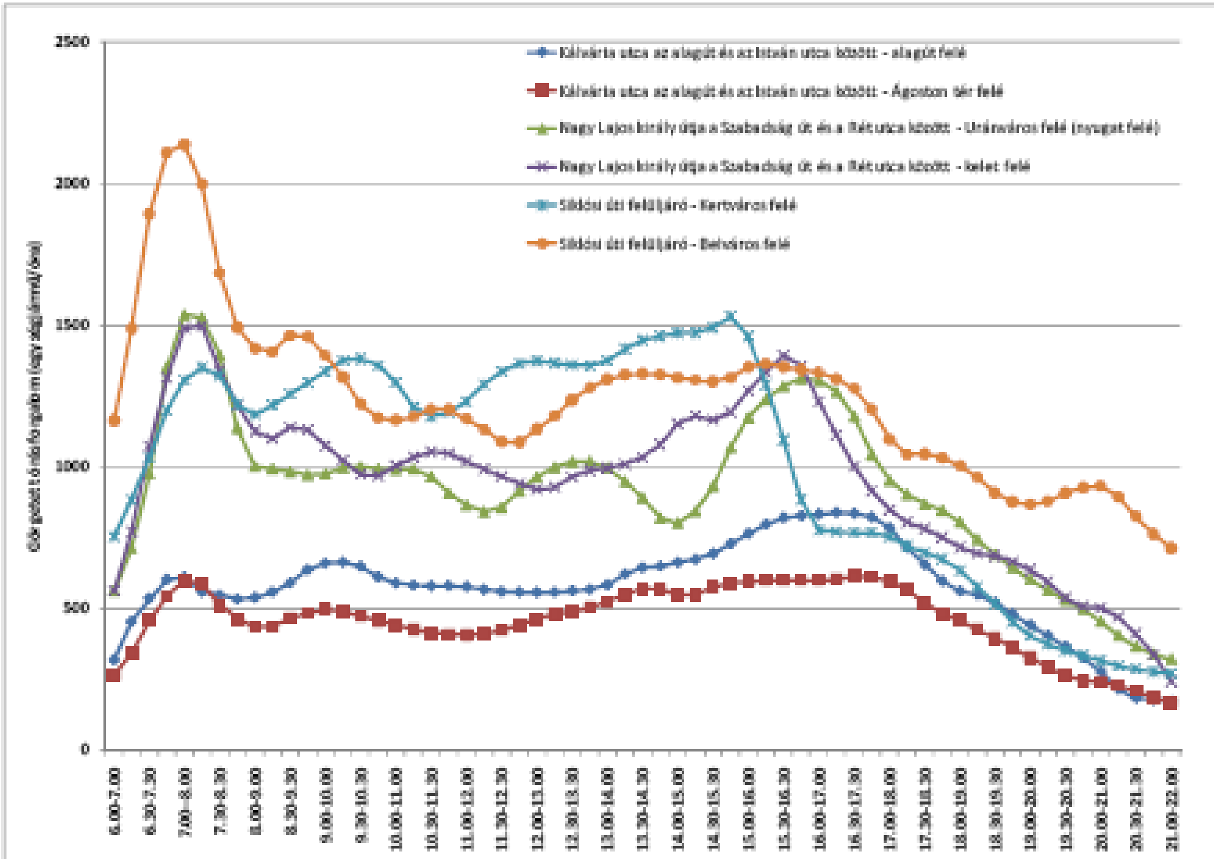


COWI

7. ábra A motorizációs szint növekedése Pécsett (adatok: KSH)

Motorisation in Pécs (car/1000inh.)

Traffic Planning – Case Study Pécs



COWI

Daily traffic flows on main routes

Traffic Planning – Case Study Pécs

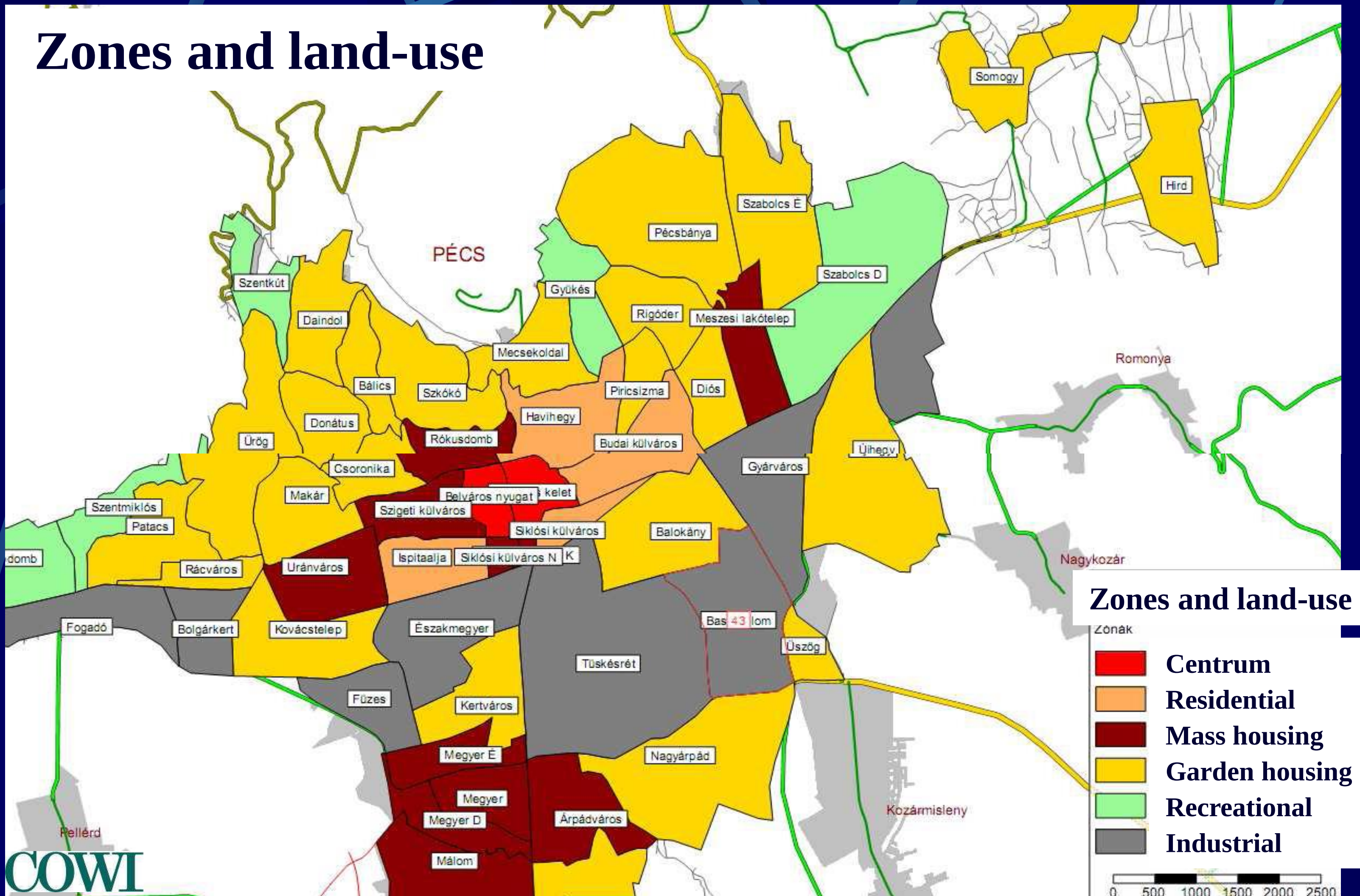
The city has been splitted up to zones that are origin and destination points.

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.

Traffic Planning – Case Study Pécs



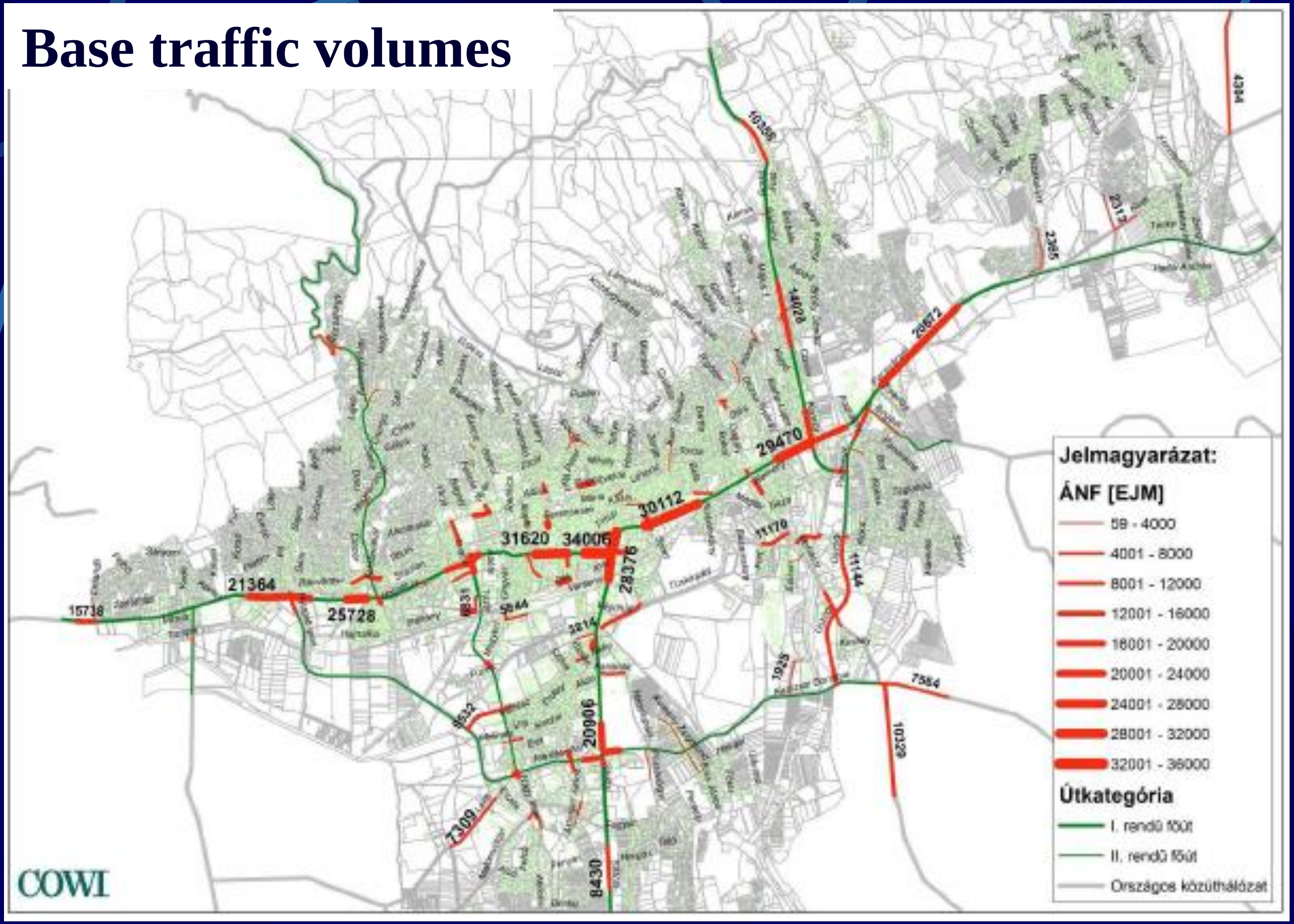
Traffic Planning – Case Study Pécs

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.

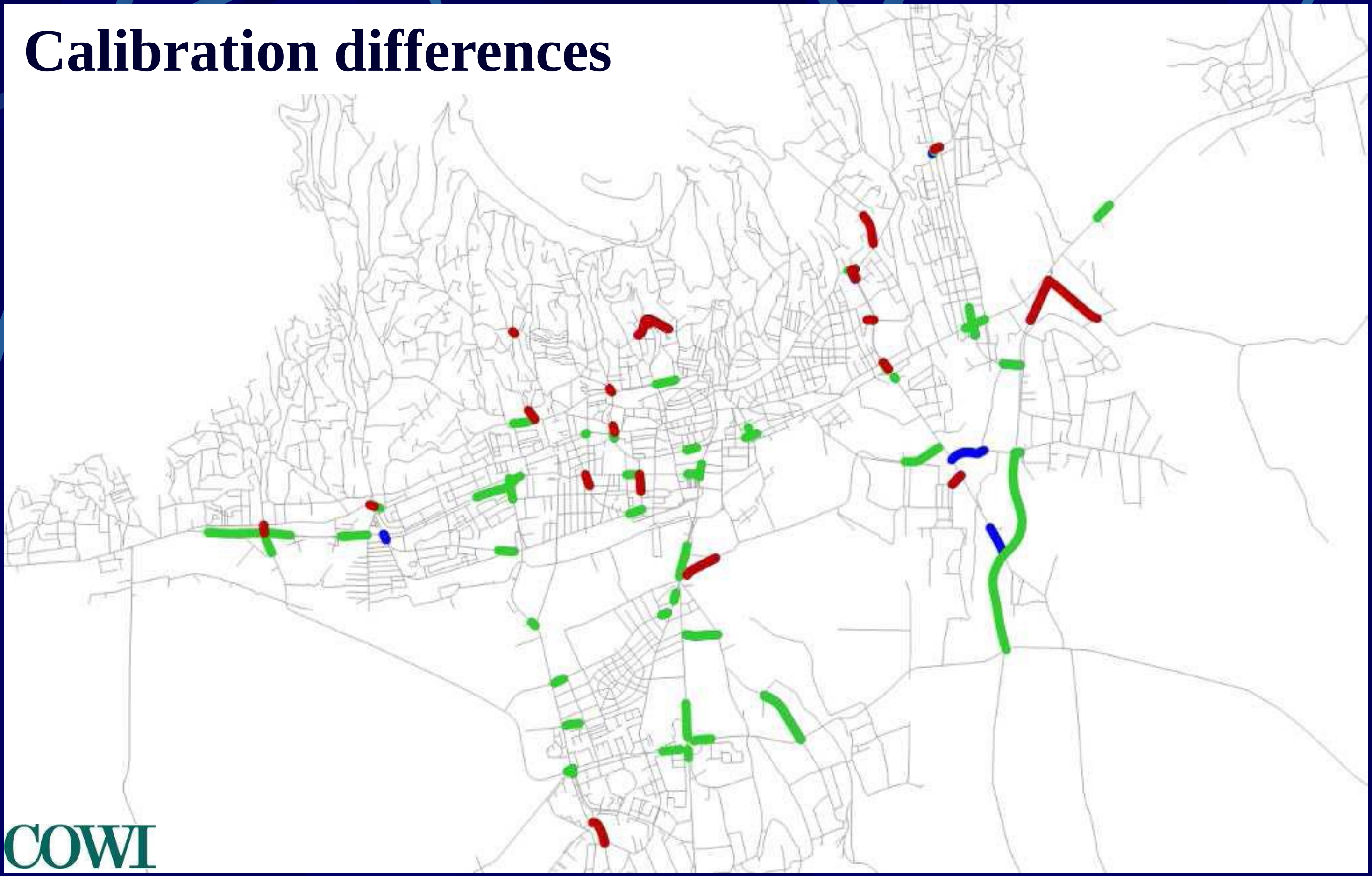
Calibration of the model has been performed based on cross section traffic counts on the existing road network at 110 cross section (220 sections by directions).

Traffic Planning – Case Study Pécs



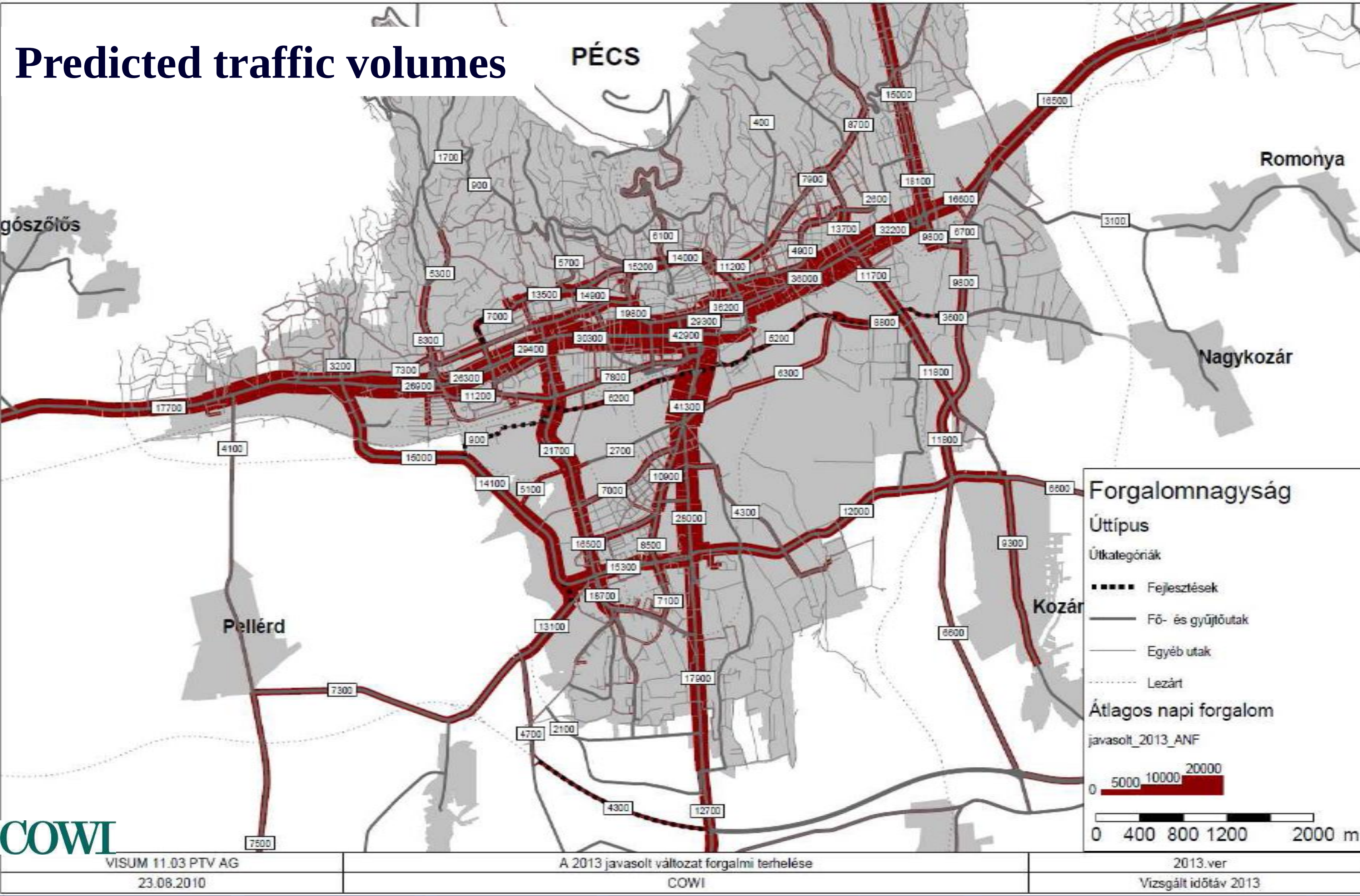
Traffic Planning – Case Study Pécs

Calibration differences

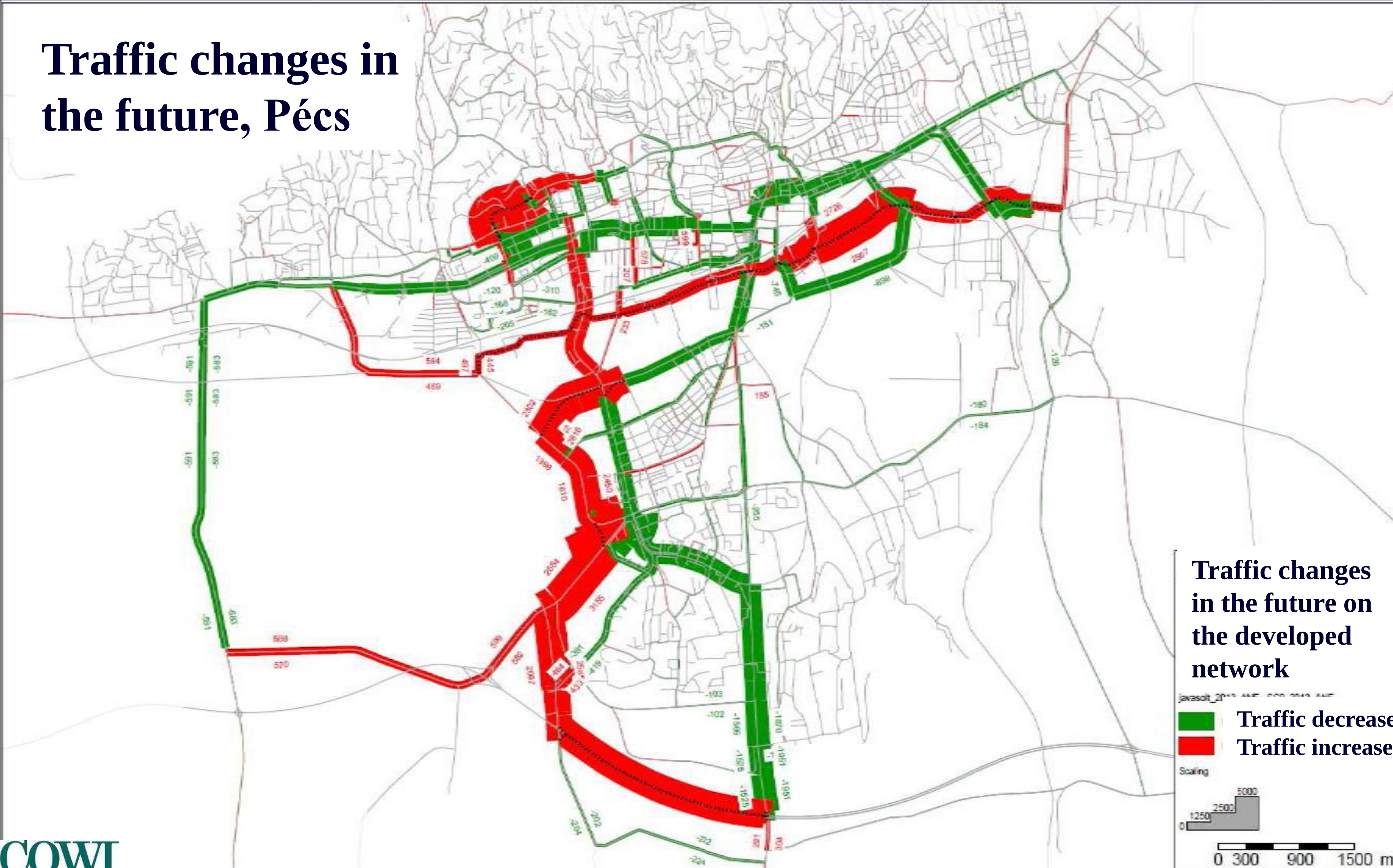


COWI

Predicted traffic volumes



Traffic changes in the future, Pécs



VISUM 11.03 PTV AG	A forgalom átrendeződése a javasolt 2013-as hálózat esetén	2013.ver
23.08.2010	COWI	vizsgált időtáv: 2013

Traffic Planning – Case Study Szolnok

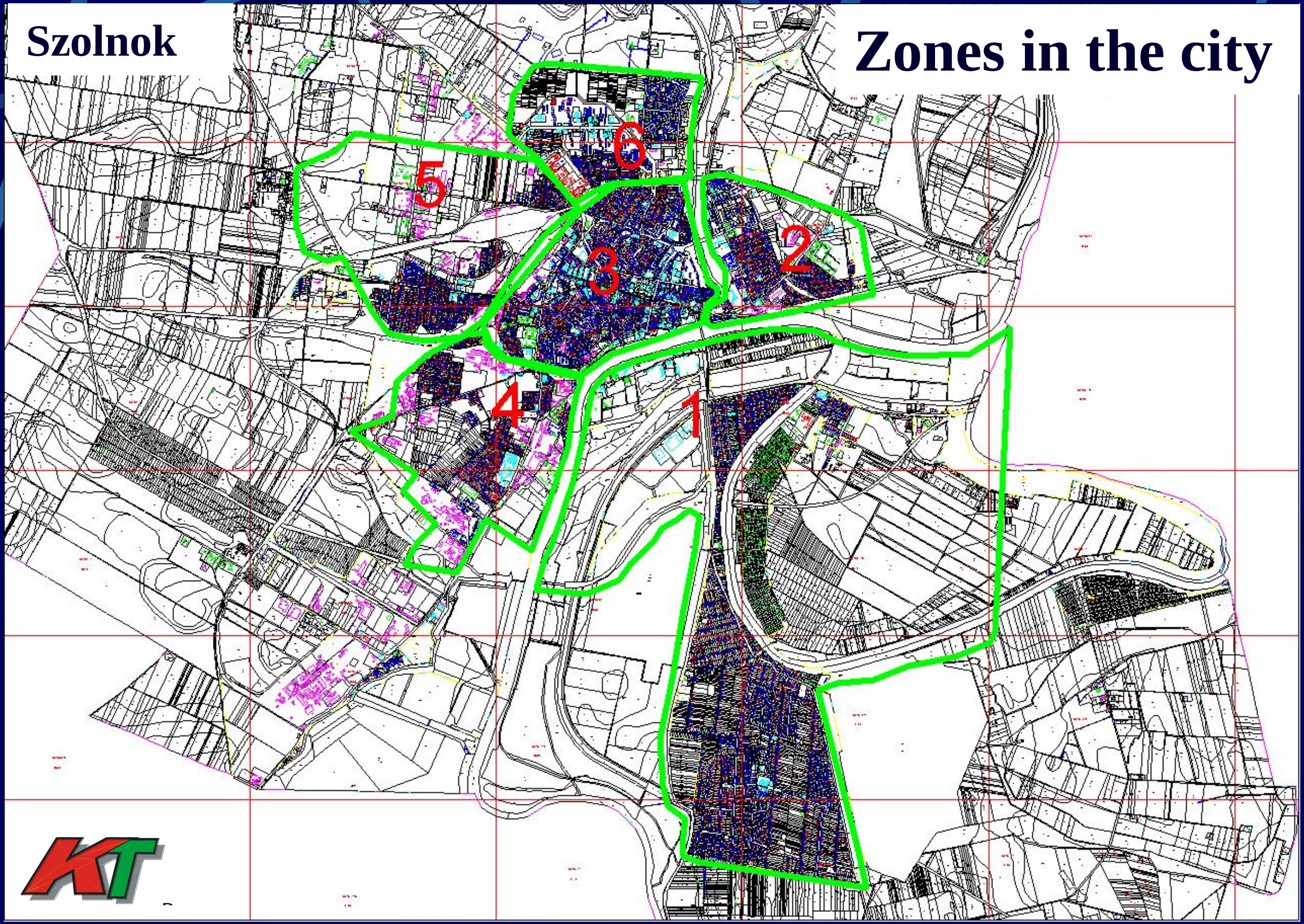
The aim of the study was to assess traffic changes on the urban road network in case of a new bridge (the third bridge in the city area).

A road cordon O-D survey has been made.

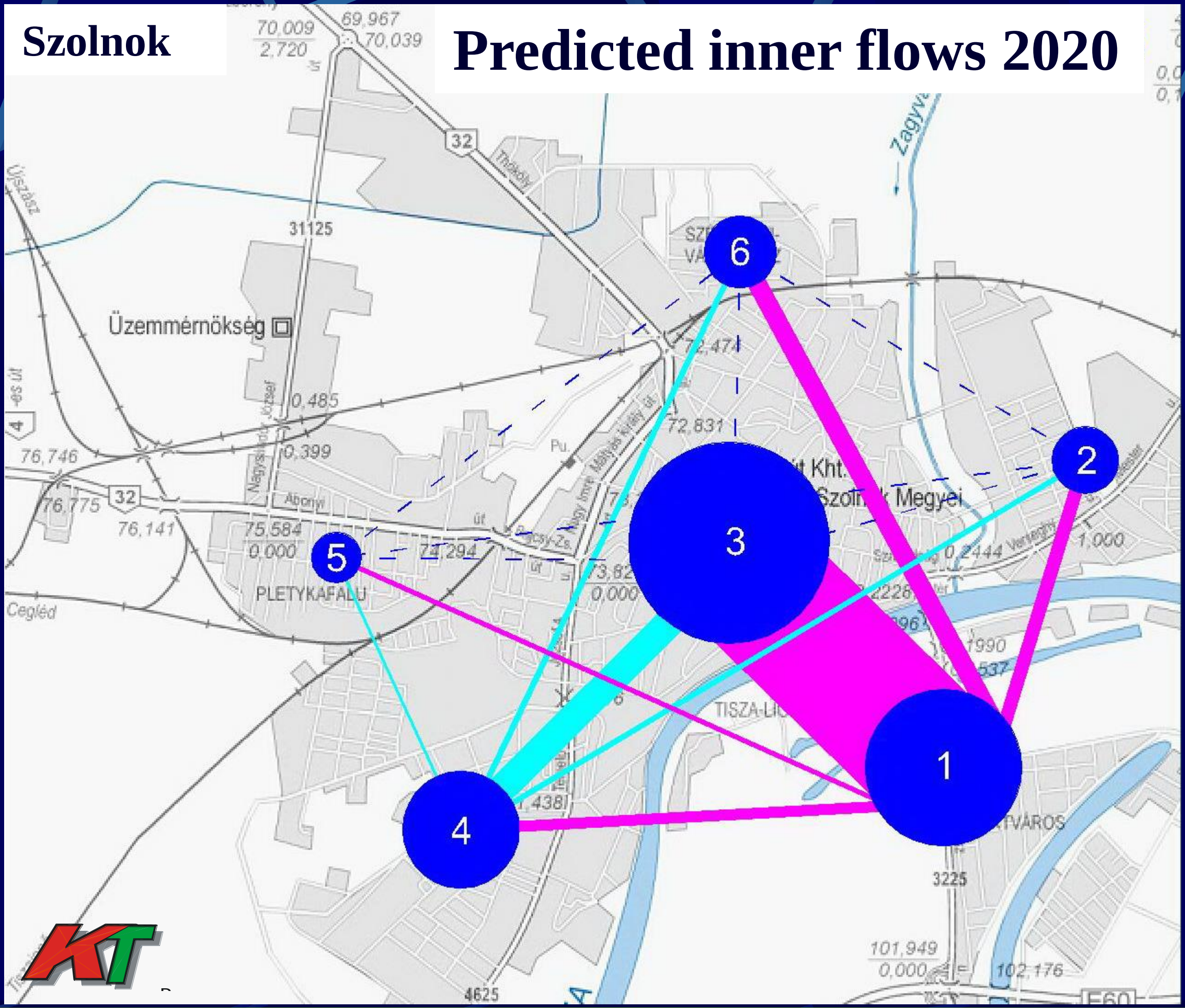
The predicted O-D matrix has been assigned to the future road network alternatives – with the new bridge and without it.

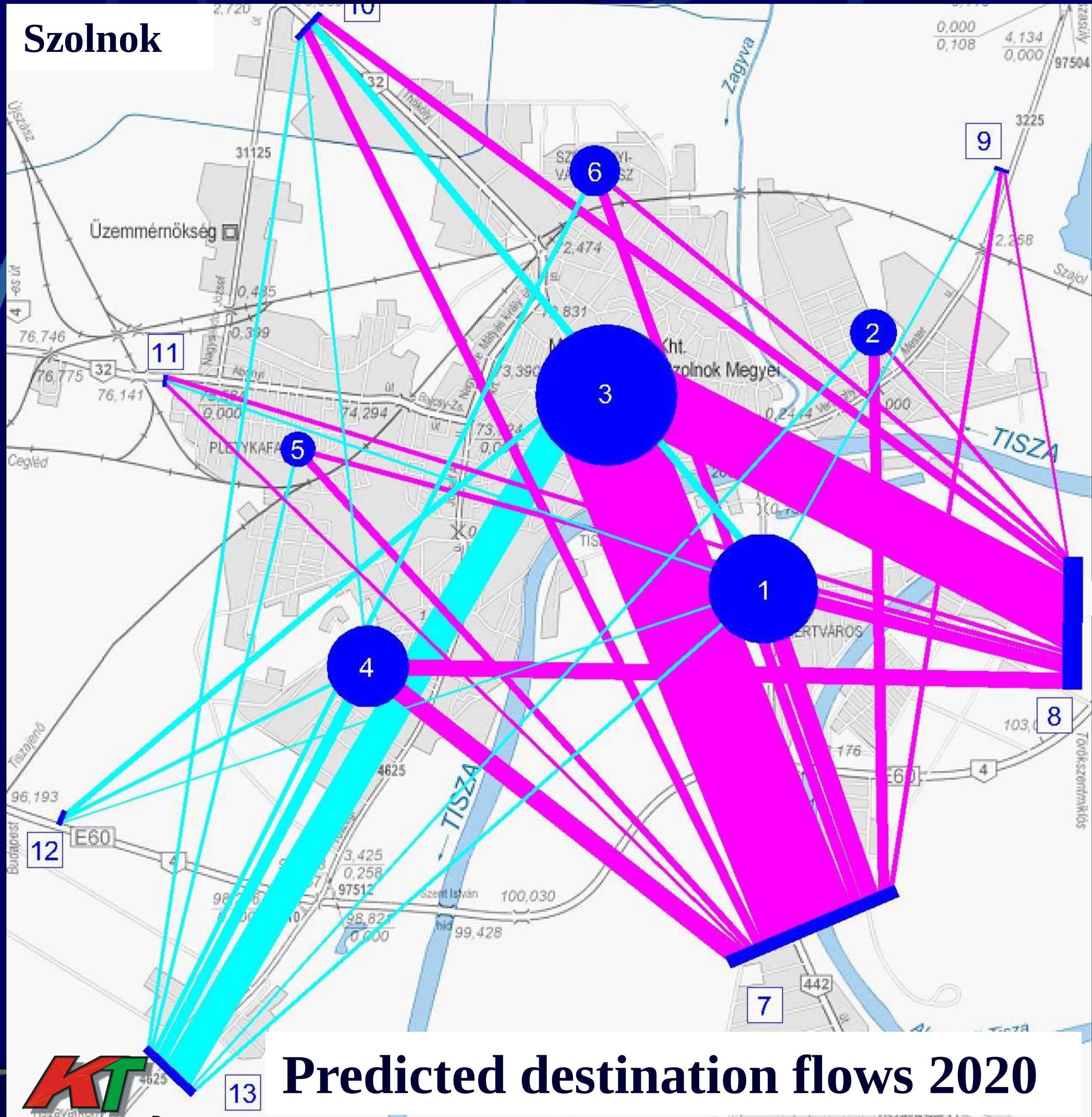
Section traffic loads on network elements have been calculated by summarising the O-D assignment results.

Traffic Planning – Case Study Szolnok



Traffic Planning – Case Study Szolnok




Szolnok
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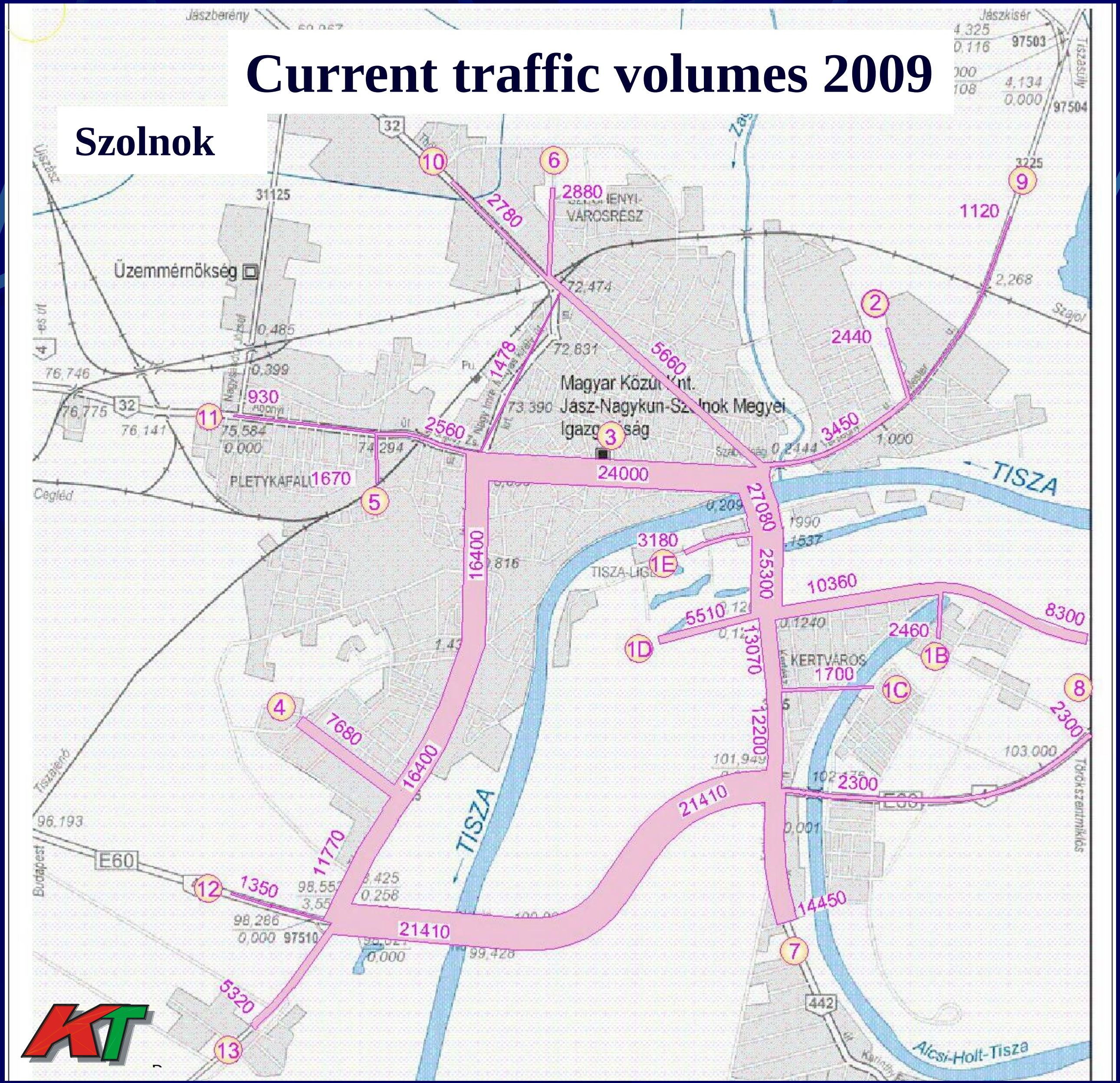
TISZA
Zagyva
Üzemmérnökség
PLETYKAFA
E60
Predicted destination flows 2020

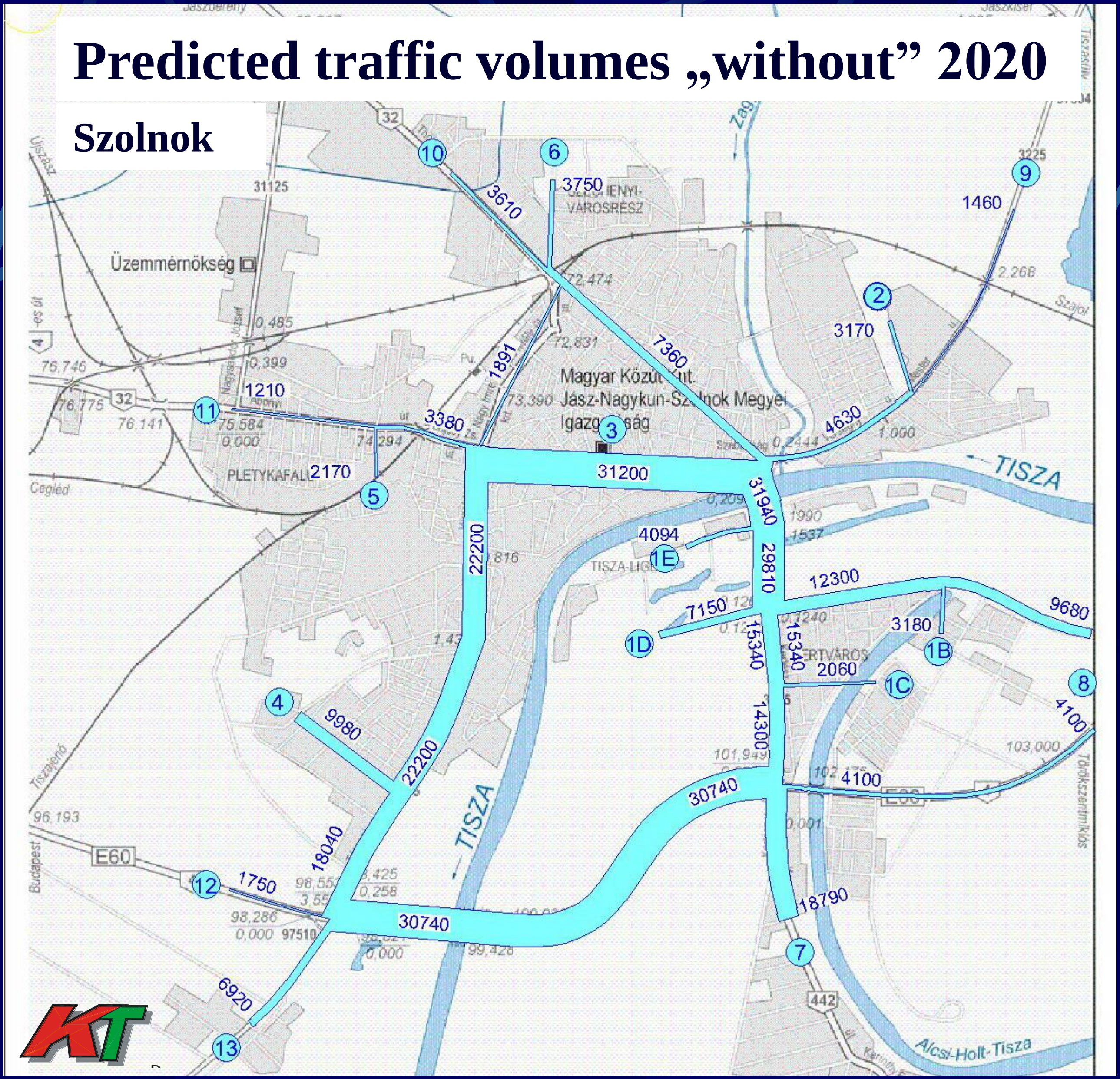
Current traffic volumes 2009

Szolnok



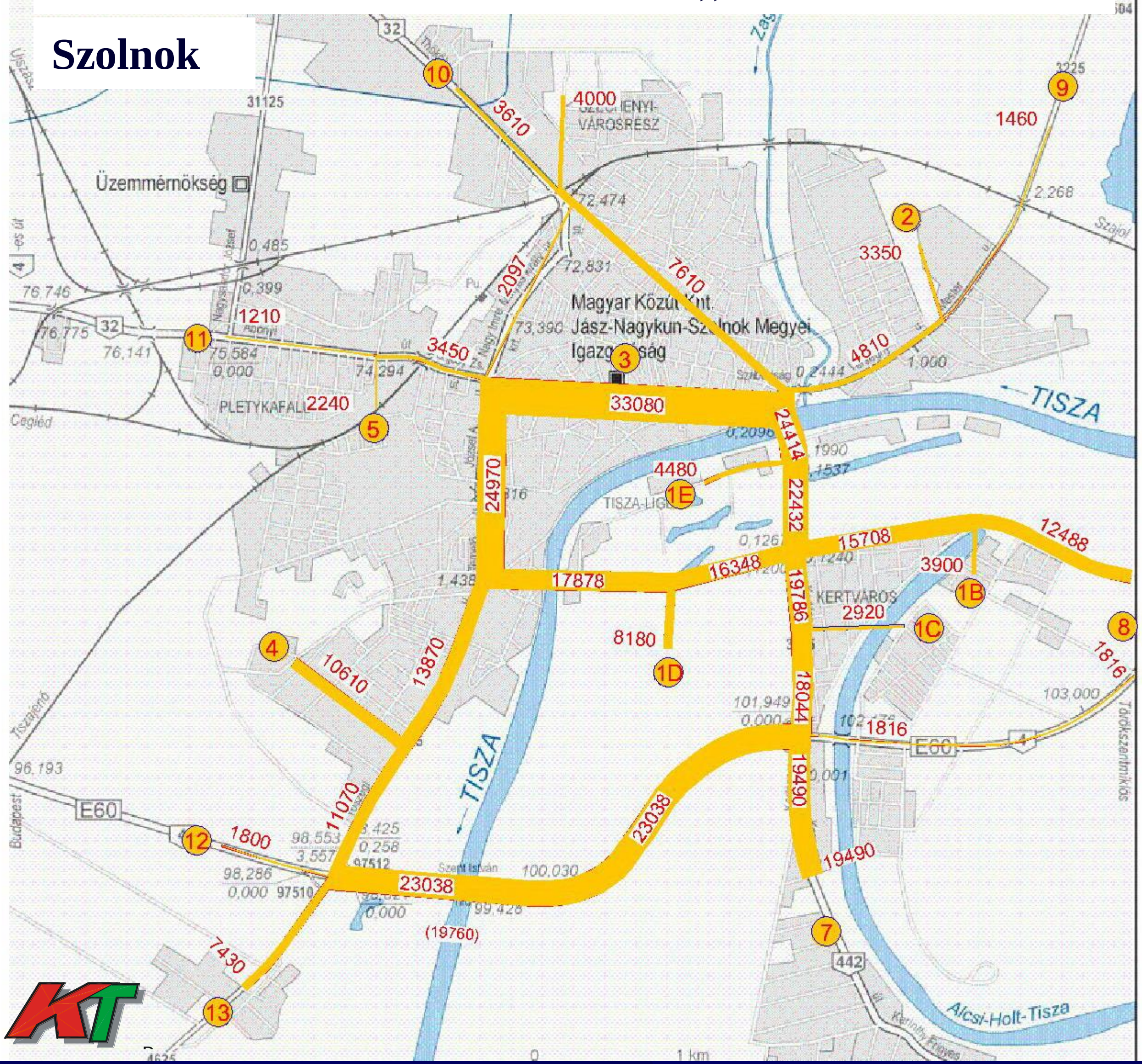
Predicted traffic volumes „without” 2020

Szolnok



Predicted traffic volumes „with” 2020

Szolnok



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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.

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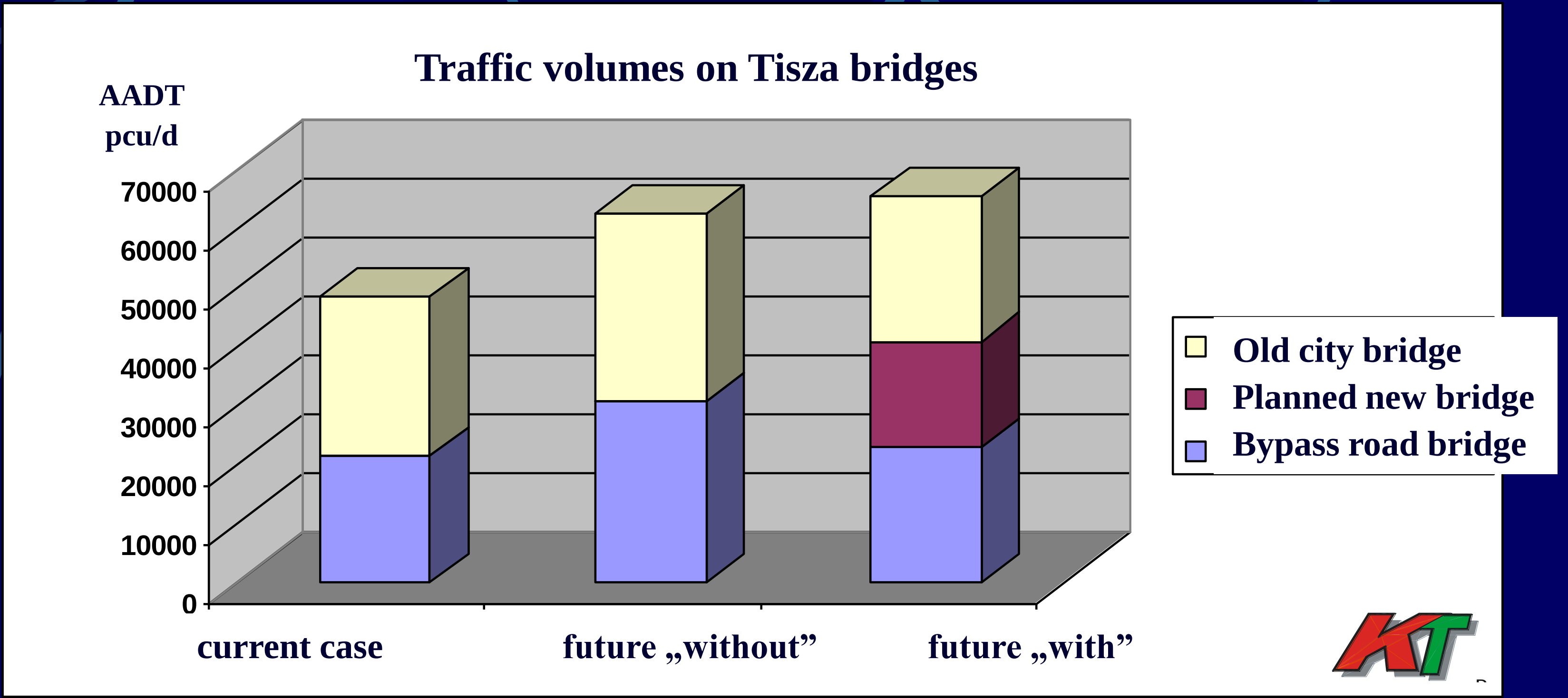

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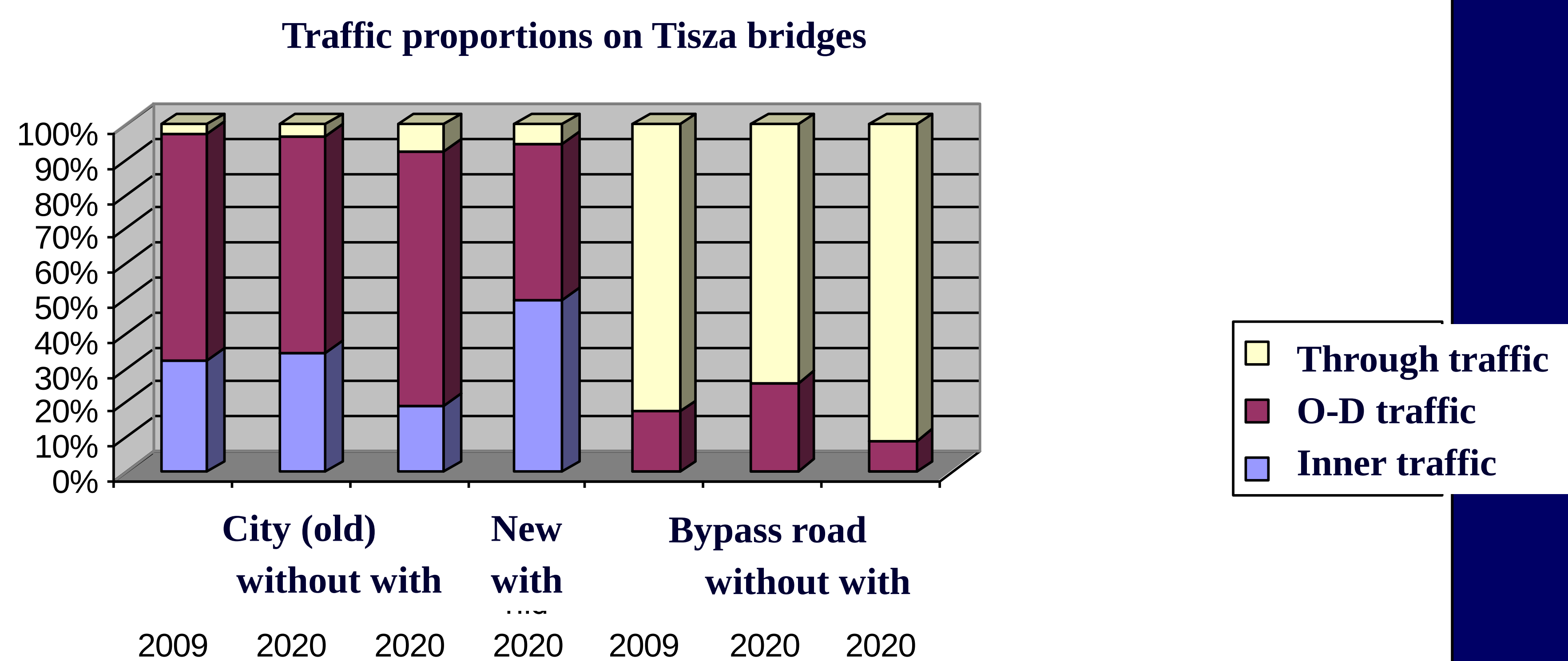

Summary

Development of the rate of motorisation can be influenced by urban planning and politics.

All traffic planning activity requires the knowledge on the existing traffic situation.

The aim of traffic planning is to satisfy travel and mobility demand.

The four steps of traffic planning:

trip generation, modal split, trip distribution, traffic assignment.

Summary of the planning is the assessment and presentation of the future network alternatives.

Thank you for your attention!

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