Budapest University of Technology and Economics
Faculty of Transportation Engineering and Vehicle Engineering
Department of Transport Technology and Economics

SH Transport operation course
BMEKOKUM206

Basics of transport network planning

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Traffic simulation – transport modeling

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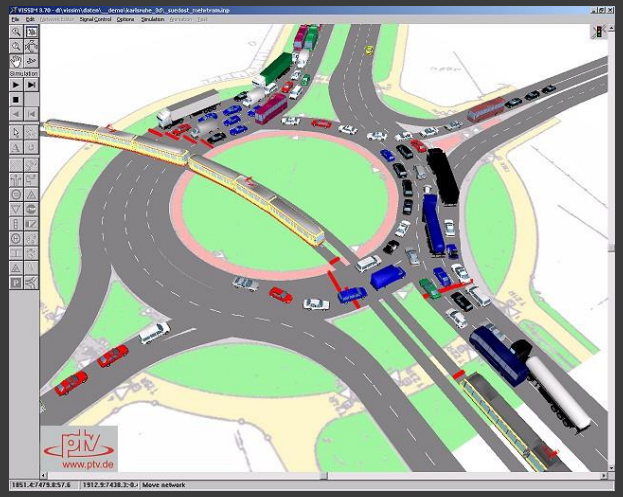
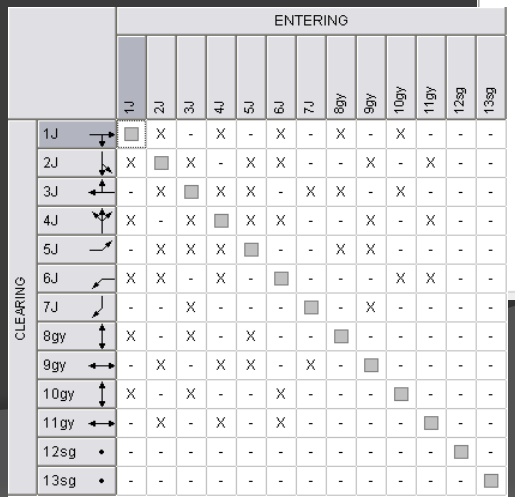
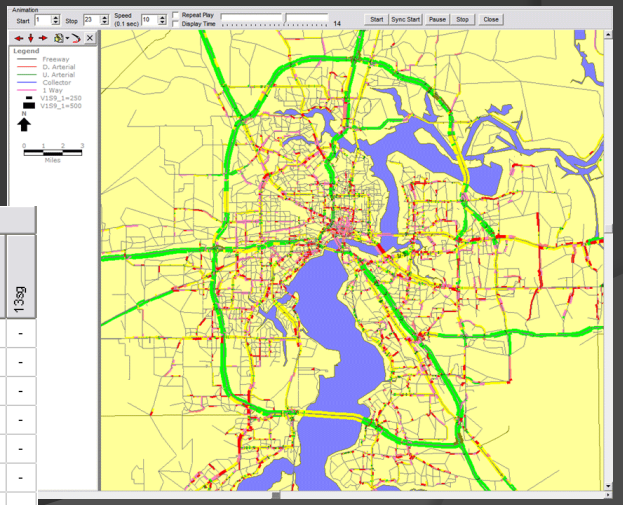






1. Necessity and basics of network planning

- The parts of the transport system:
  - Vehicles
  - Object of transportation (goods or persons)
  - Network
    - nodes
    - and links
- The point of the network planning is:

  To create an optimum network (infrastructure) for handling transportation demands (both freight- and passenger transport)

Needed: **1:** detailed examination of the current traffic (e.g traffic counts), **2:** detailed knowledge about the demands (number of potential traffic volumes), and **3:** prediction to the future

Network planning is a tool → Four step modeling (FSM) is the most common

1. Necessity and basics of network planning

- The basic questions of network planning
  - „What is the appropriate route of bus line Nr. 7?” ☺

    for an answer we need: how many people, in what relations, on which route will travel in the future

  - HOW MANY? (who or what, how many times (in aggregate)?)

    magnitude of total daily travel from origin zones
  - IN WHAT RELATIONS? TO WHERE?

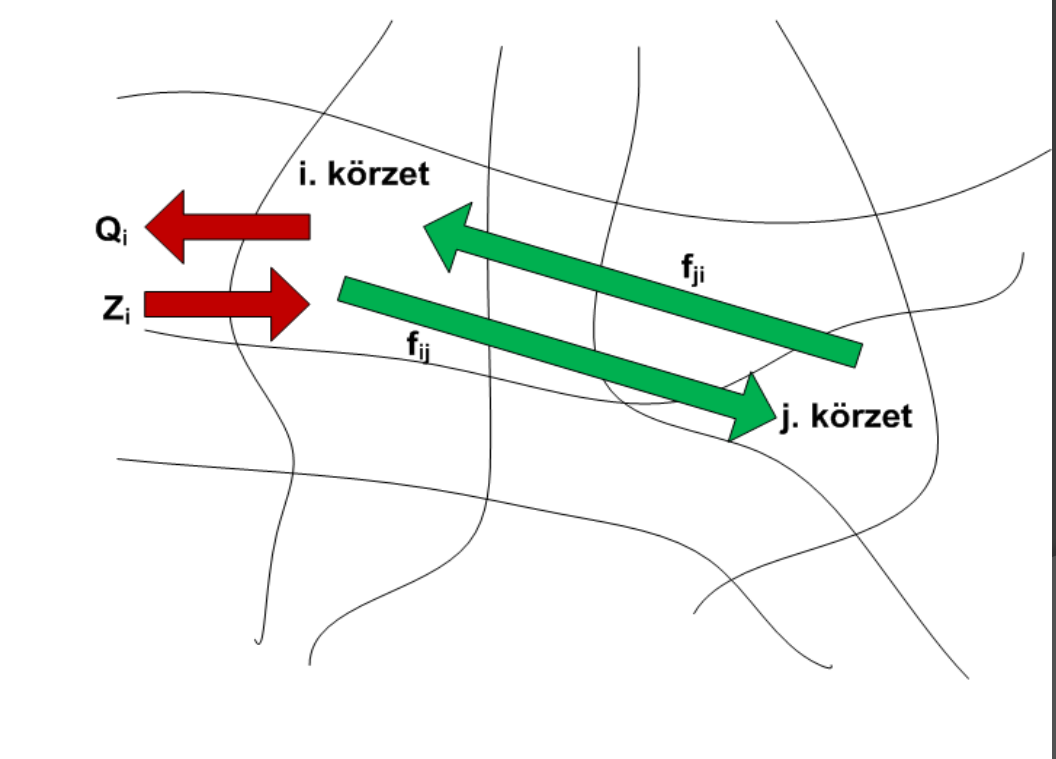
    how does the generated traffic divided between zones
  - BY WHAT? WHAT KIND OF TRANSPORTATION MODE IS CHOSEN?

    share of each transportation mode (e.g. private riders, bus transport, on foot) from the traffic
  - WHERE? ON WICH ROUTE?

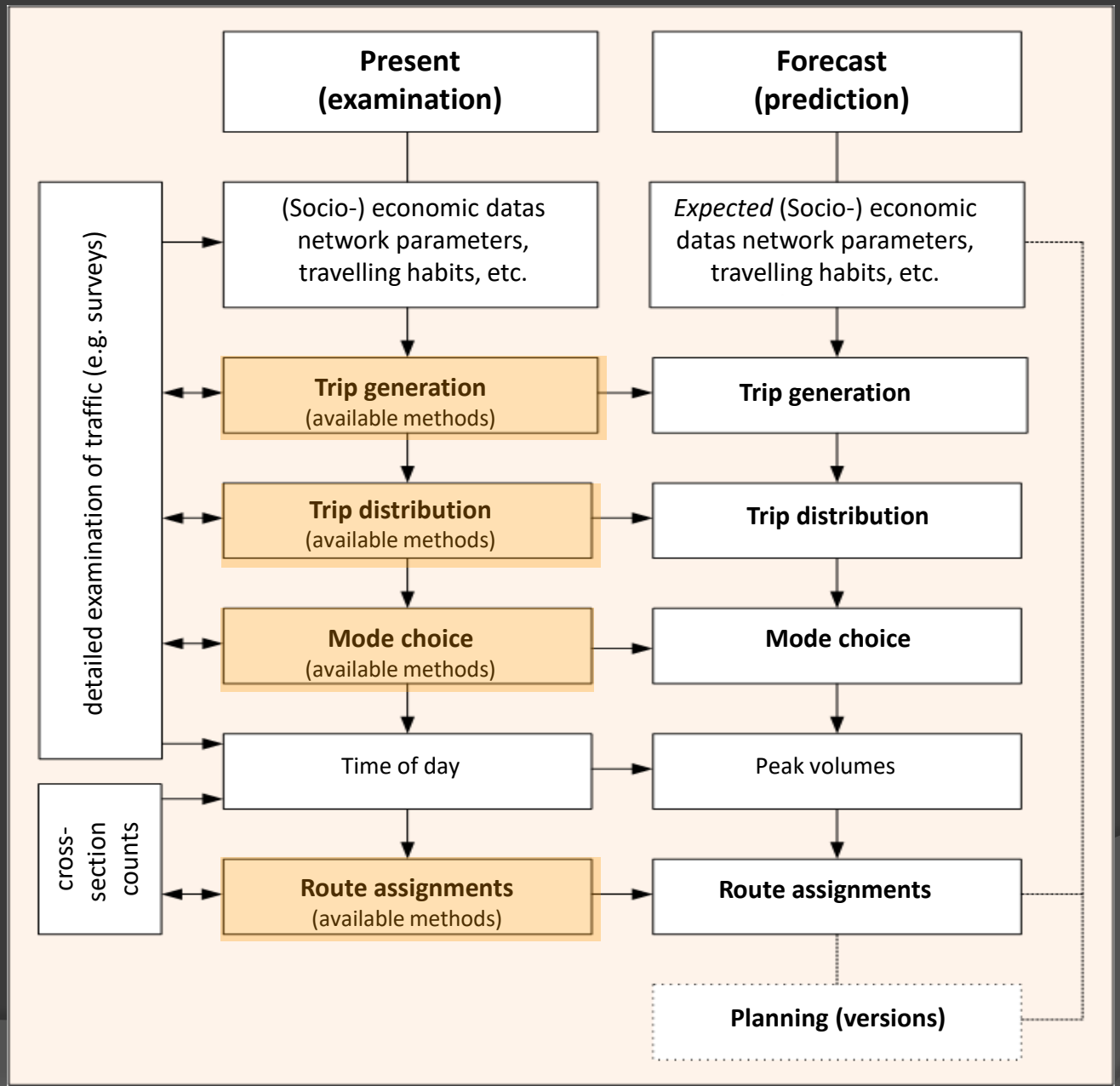
    assignment of traffic volumes to particular routes („connection” of the demand to the network)

2. The four-step modeling (FSM)

1. **Trip generation:** determines the frequency of origins or destinations of daily trips in each zone (Q_i, Z_i) *„how many”*
2. **Trip distribution:** matches origins with destinations (f_{ij}, f_{ji}) *„to where”*
3. **Mode choice:** splits the trips between transportation modes (f_{ij}^{PuT}, f_{ij}^{PrT}) *„by what”*
4. **Route assignment:** allocates each trip to a particular route *„which route”*



2. The four-step modeling (FSM)



Q_i Z_i

f_{ij} f_{ji}

f_{ij}^{PuT} f_{ij}^{PrT}

3. Necessity of transport modeling

- The aim of transport modeling (simulation) is to predict the expected results of the planned measure during
  - implementation of a new system (investment, strategic),
  - improvement of an existing system,
  - control (operational, real time).
- The most important parts of modeling are to
  - set up (build up),
  - calibrate ($\sum (f_{ij}, \text{model} - f_{ij}, \text{measured})^2 \longrightarrow \text{min.!}$ (verified network),
  - and maintain the modell.

  based on:
  - traffic (demand), network (supply), and time profile datas.
- Efficient way to forecast traffic demands, volumes, situations or other parameters (e.g. pollution) in the future

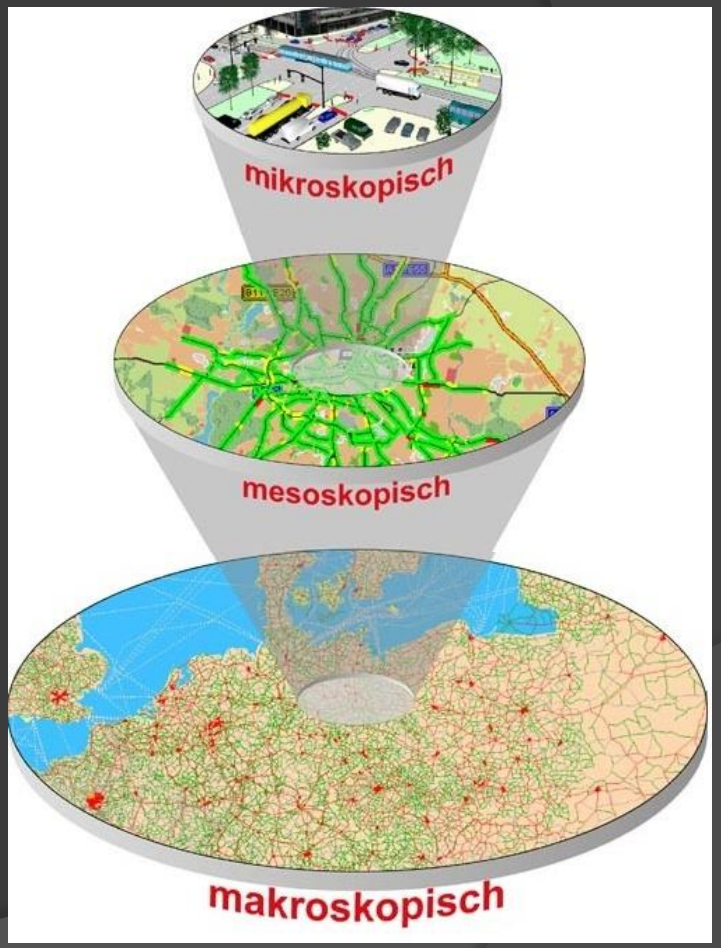
3. Necessity of transport modeling

- By the use of modeling techniques investments can be examined in advance, like
  - different traffic situations can be examined at low cost,
  - it gives the opportunity for testing the effects of planned changes on the network (e.g. adding new elements, changing traffic system, etc.) before construction,
  - it makes possible to compare different plan versions,
  - it helps to examine the system in extreme situations.

3. Levels of transport modeling

- According to elaboration models can be categorized as the following
  - **Macroscopic:**
    - Modeling traffic volumes and parameters
    - Examining cities, countries or large areas
    - Applied to test network plans or forecast future traffic parameters
    - Based on route assignments (and FSM)
  - (**Mesoscopic)**
  - **Microscopic:**
    - Modeling each vehicle and pedestrian
    - Examining junctions or small areas
    - Applied to try new traffic systems (constructions) and meet traffic situations in details

Less plan horizon
More detailed datas



3. Levels of transport modeling

Macroscopic transport model

- The aim: define (forecast) loads/volumes/demands on links or other network elements
  - Examines whole cities or regions (or even countries) – long horizon
  - Does not care about specific vehicles (individuals) or time segments (static)
  - Splits the examined area to zones and symbolizes the network with a graph
  - Based on the FSM – it supports the four-step modeling method, especially route assignment
- 3 input data group:
  - traffic demands – OD matrices (demand between origin and destination zones)
  - transport system (map, network, links and nodes and its parameters)
  - routing preferences (weights e.g. for transfers)

3. Levels of transport modeling

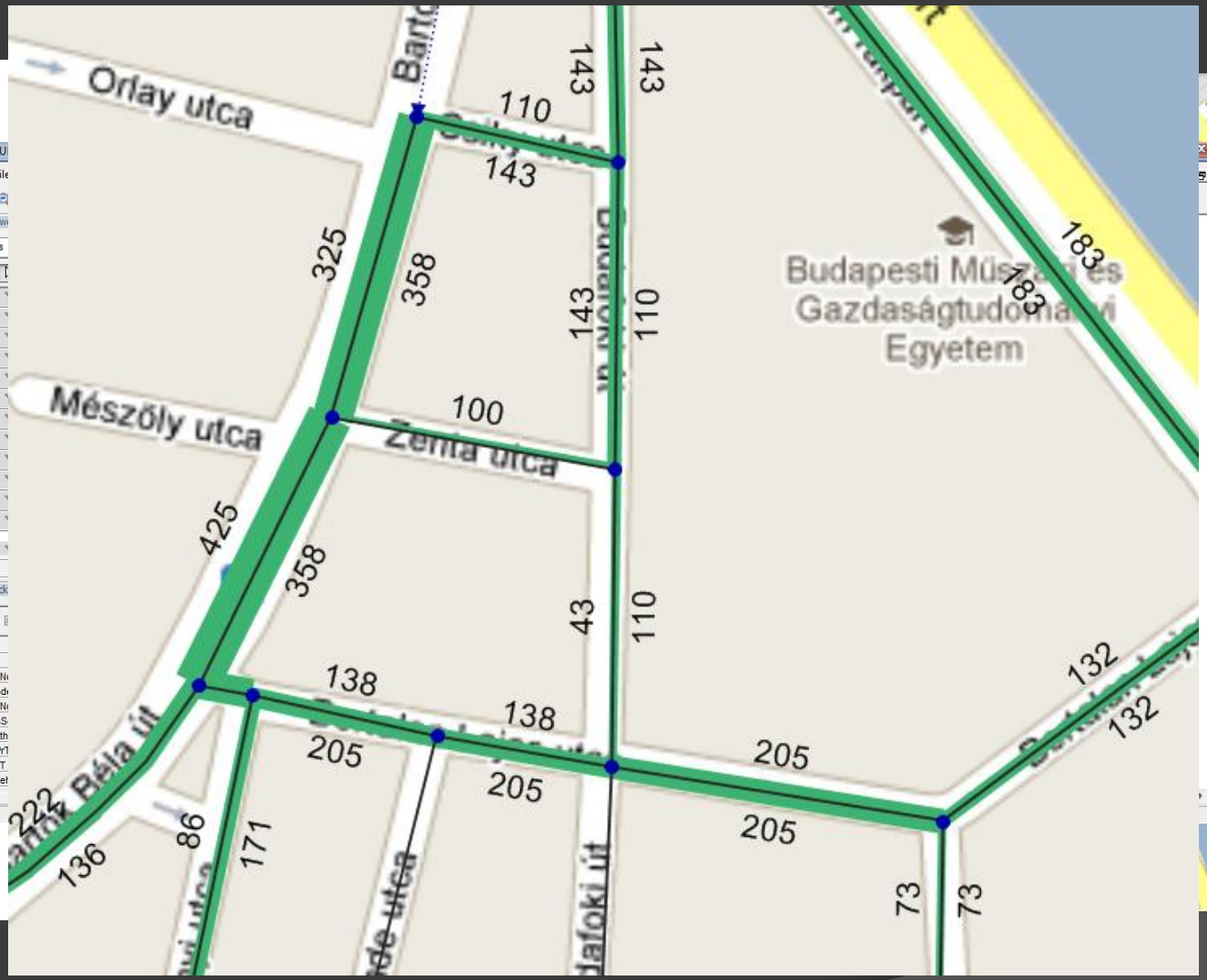
Microscopic transport model

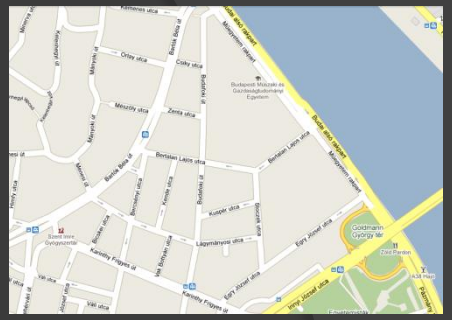
- The aim: simulates the behavior of vehicles and drivers independently, used to predict performance of a part of the network (single node or couple of nodes and links)
  - Examines smaller part of the network, based on vehicles
  - All the vehicles and its movements can be simulated
  - Driving behaviors and traffic rules are considered as well
  - It is like a „virtual world” – capacity and utilization of an intersection can be examined
- 3 input data group:
  - traffic demands - OD flows in the junction, number of vehicle in each categories
  - transport system (geometry, control, signal plan, etc.)
  - routing preferences (driving style, overtaking maneuvers and habits, etc.)

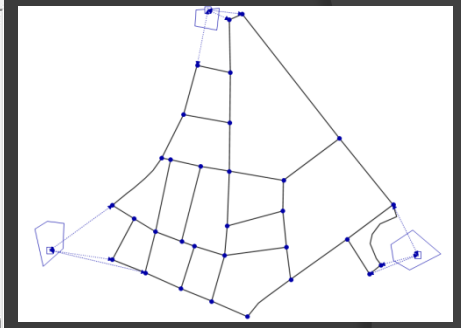
4. Examples of transport modeling

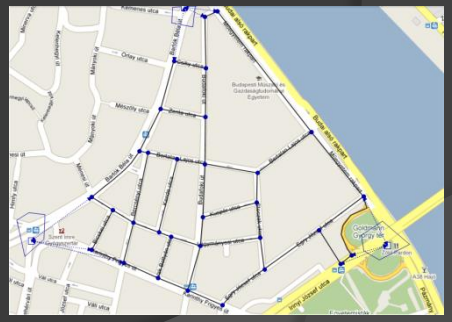
- Setting up a macroscopic model:
  - For a simulation it is necessary to
    - build up the network - nodes (intersection or a stop), links (roads or PuT lines), zones, connectors, turning possibilities)
    - connect traffic demands (between zones) to the model

Building up the model







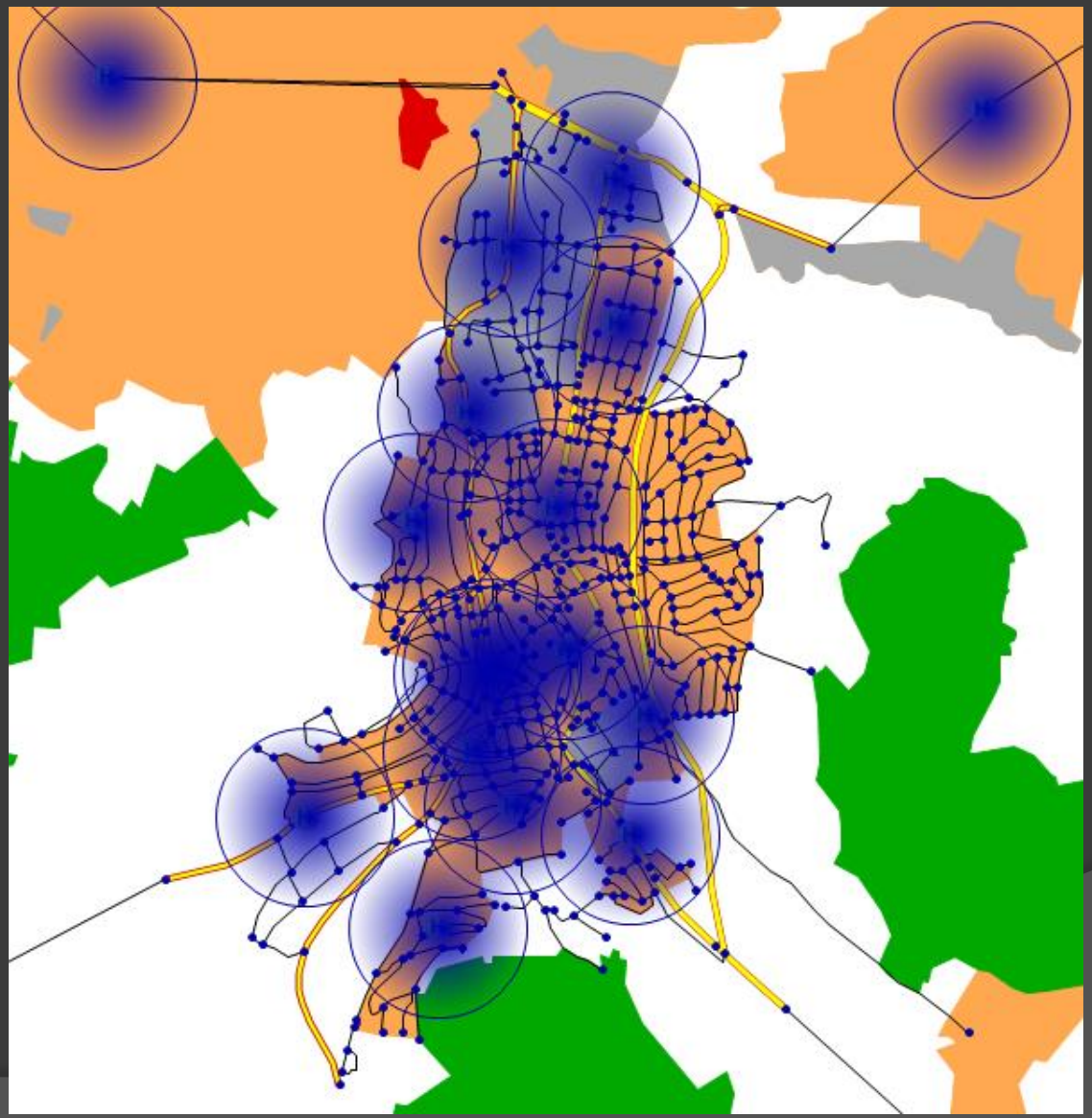


Zones			1	2	3
	Name	1850.000			
	1850.000	Sums	560.000	650.000	640.000
1		560.000	0.000	285.000	275.000
2		650.000	285.000	0.000	365.000
3		640.000	275.000	365.000	0.000

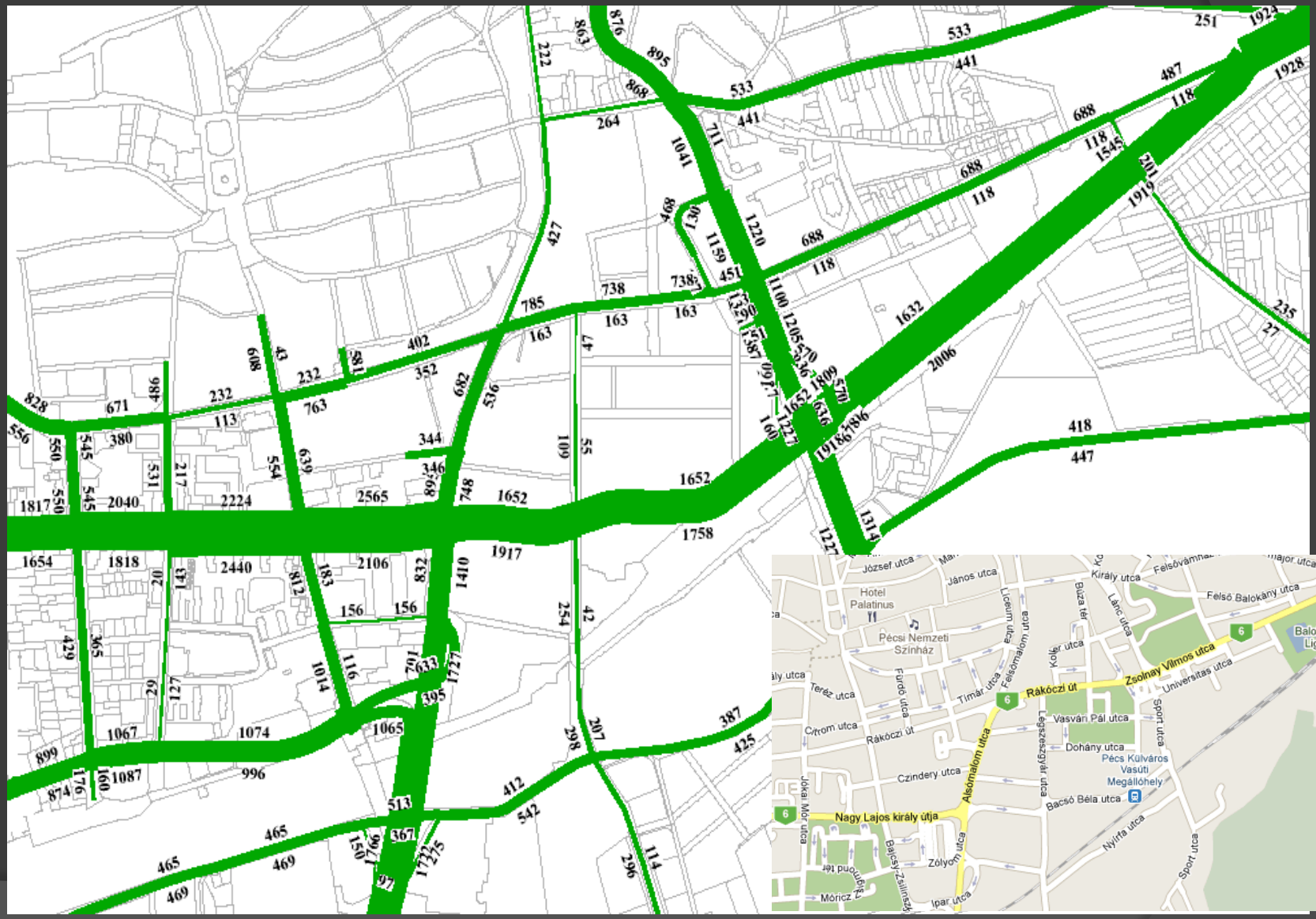
4. Examples of transport modeling

- Setting up a macroscopic model:
  - For simulation it is necessary to
    - build up the network - nodes (intersection or a stop), links (roads or PuT lines), zones, connectors, turning possibilities)
    - connect traffic demands (between zones) to the model
  - The route assignment consists if the following:
    - route assignment = routing + assignment (taking capacity into consideration or not)
    - Routing: finding the route that has the least sum of weights between two nodes on the graph – there are many known algorithms for this
    - Assignment: based on weight (or resistance) of connectors/nodes/links: travel time, cost, or complex parameters - a route that has less weight get more traffic assigned
    - Assignment procedures: incremental, equilibrium, stochastic, tribut, etc.

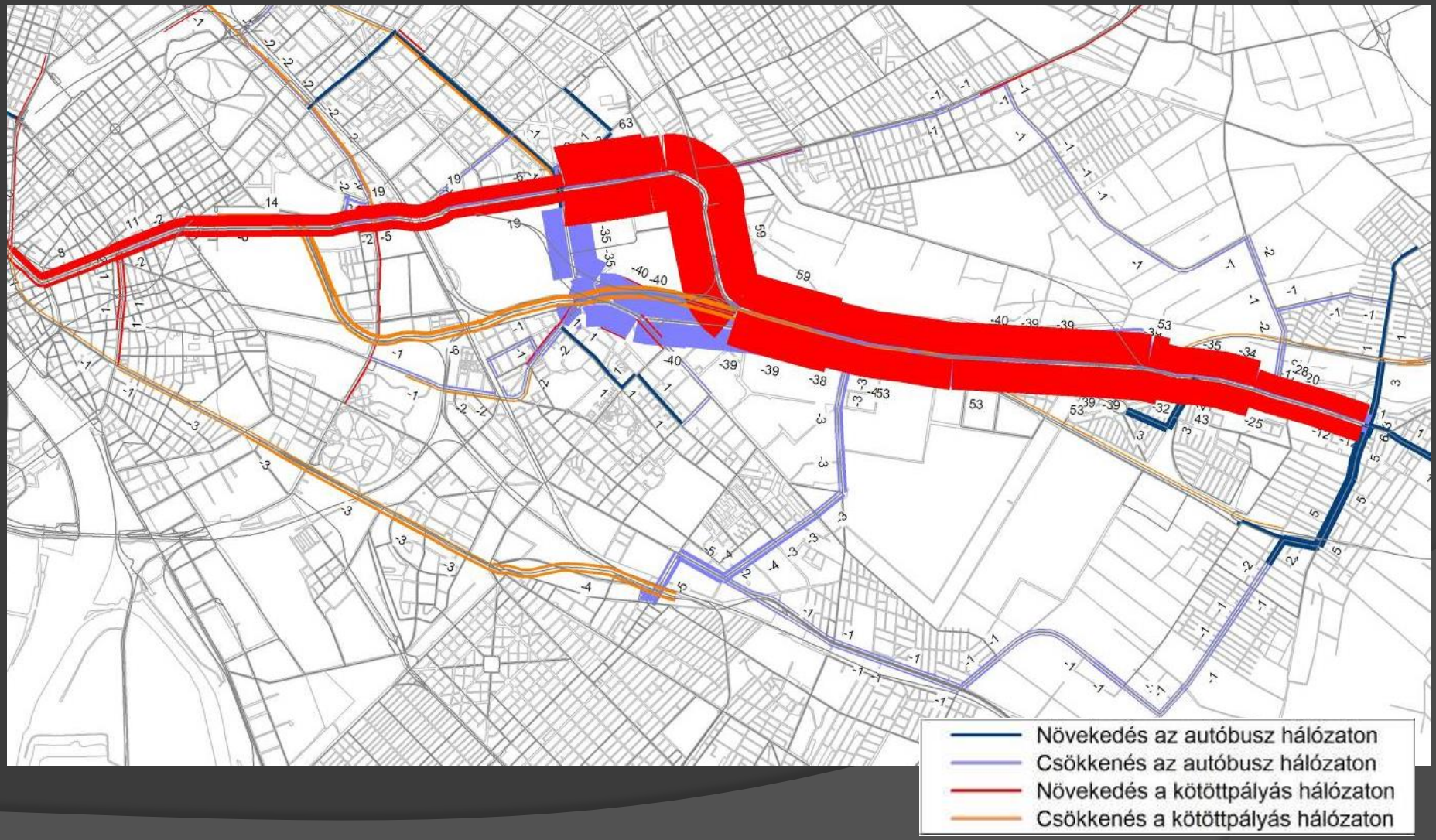
Example 1: PuT supply examination (static) (sample network, accessibility (400 meters))



Example 2: Bypass examination in Pécs (road construction for PrT, absolute traffic volumes)



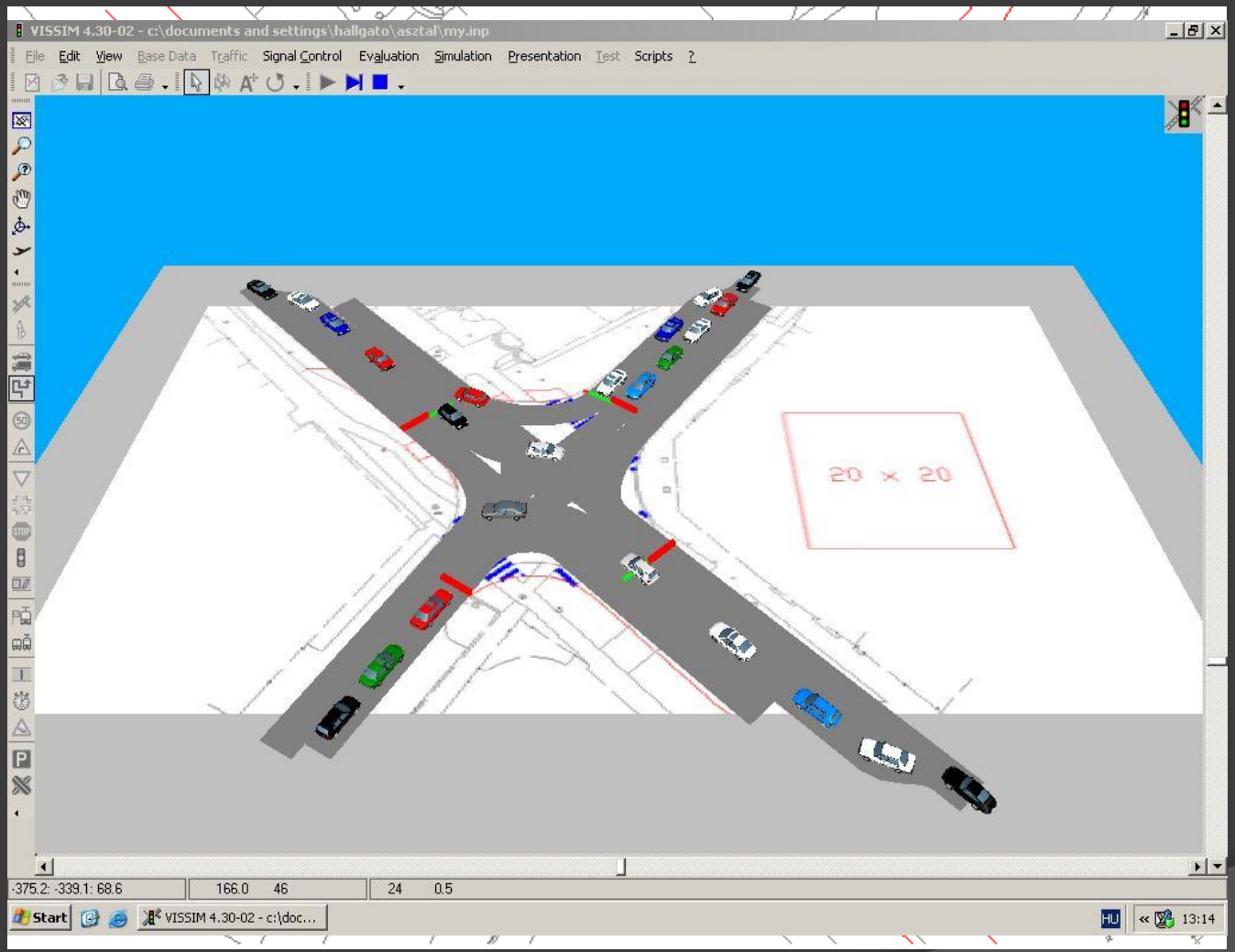
Example 3: PuT development in Budapest (rail connection to the 17th district, differences in traffic volumes)

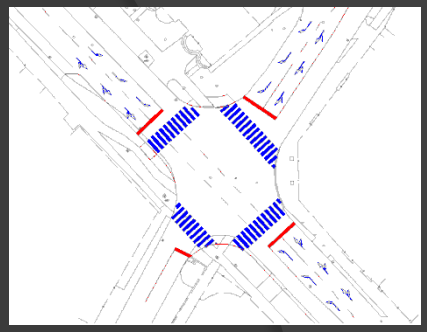


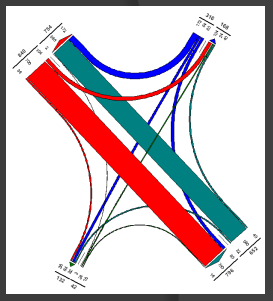
4. Examples of transport modeling

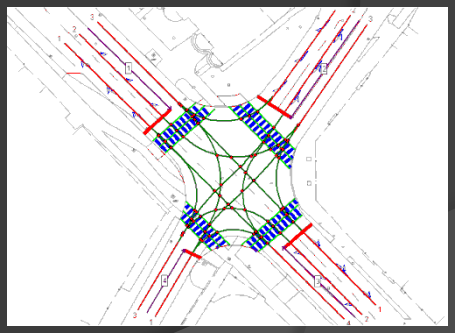
- Setting up a microscopic model:
  - For a simulation static and dynamic datas are necessary
    - static datas belongs to the infrastructure (links, stop lines, width of lanes, place of traffic lights, etc.)
    - dynamic datas are for the simulation (traffic volume, number of vehicles and categories, split by quarters and directions)

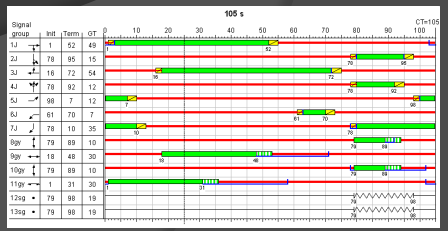
Building up the model







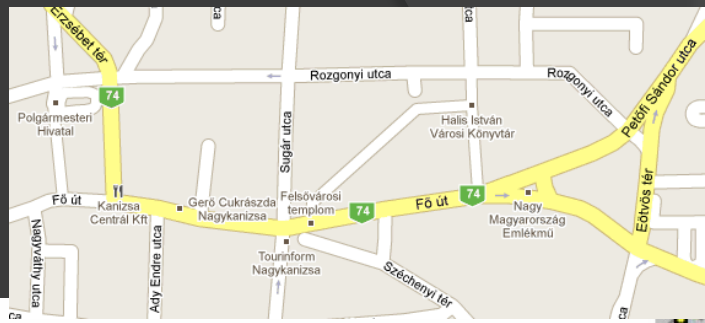




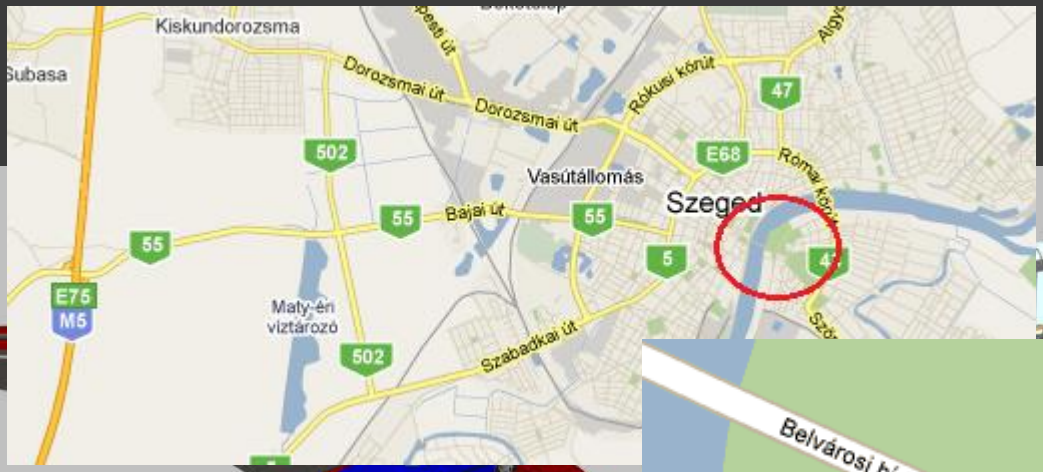
4. Examples of transport modeling

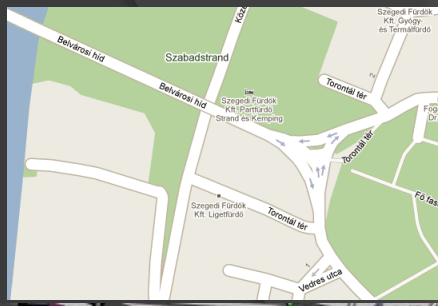
- Setting up a microscopic model:
  - For simulation static and dynamic datas are necessary
    - static datas belongs to the infrastructure (links, stop lines, width of lines, place of traffic lights, etc.)
    - dynamic datas are for the simulation (traffic volume, number of vehicles and categories, split by quarters and directions)
  - Also taken into consideration during simulation
    - Human behavior and vehicle parameters (e.g. acceleration ability)
    - Physical conditions, traffic rules (e.g. priority rules like stop sign)
    - Interaction between vehicles (drivers)
    - Reactions of the planned traffic control system
    - Stochastic effects during moving from the entering point to exit point
    - Necessary datas are continuously collected during simulation (delay time, length of queues, number of stops, travel time, emission, etc.)

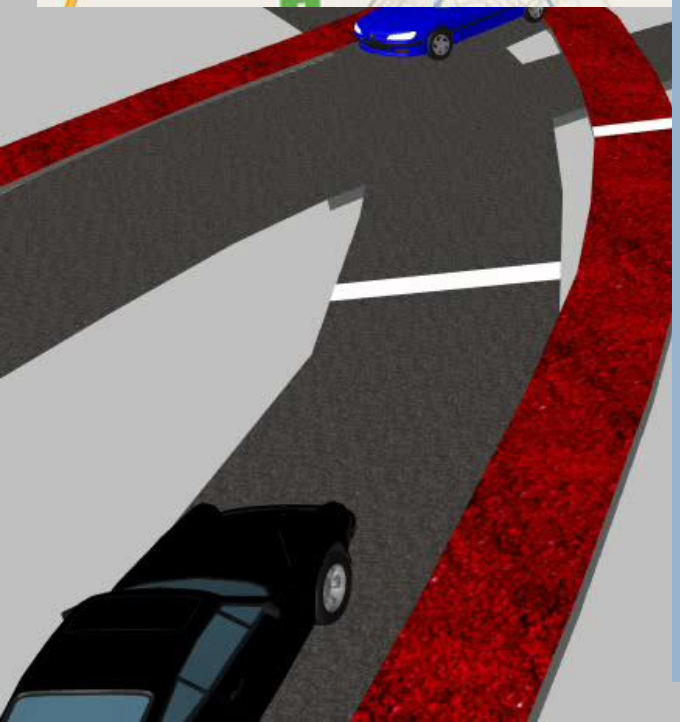
Example 1: Vehicle actuated, „green wave” signal control (Nagykanizsa, 2D)

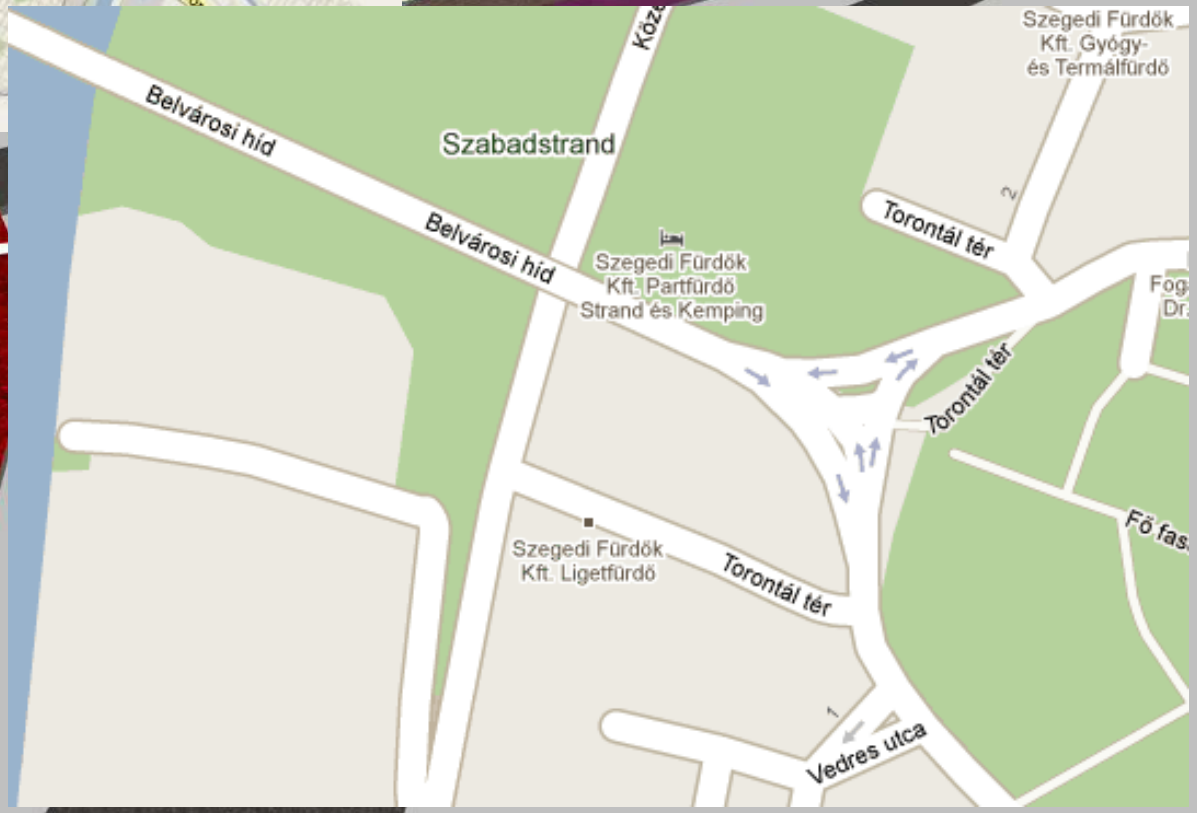


Example 2: Examination of PuT prioritization (Szeged, 3D)









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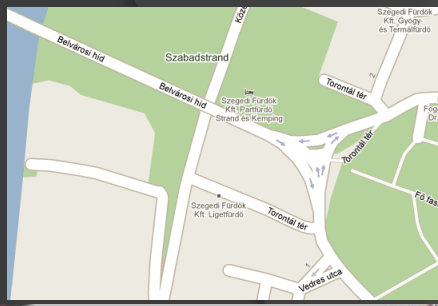
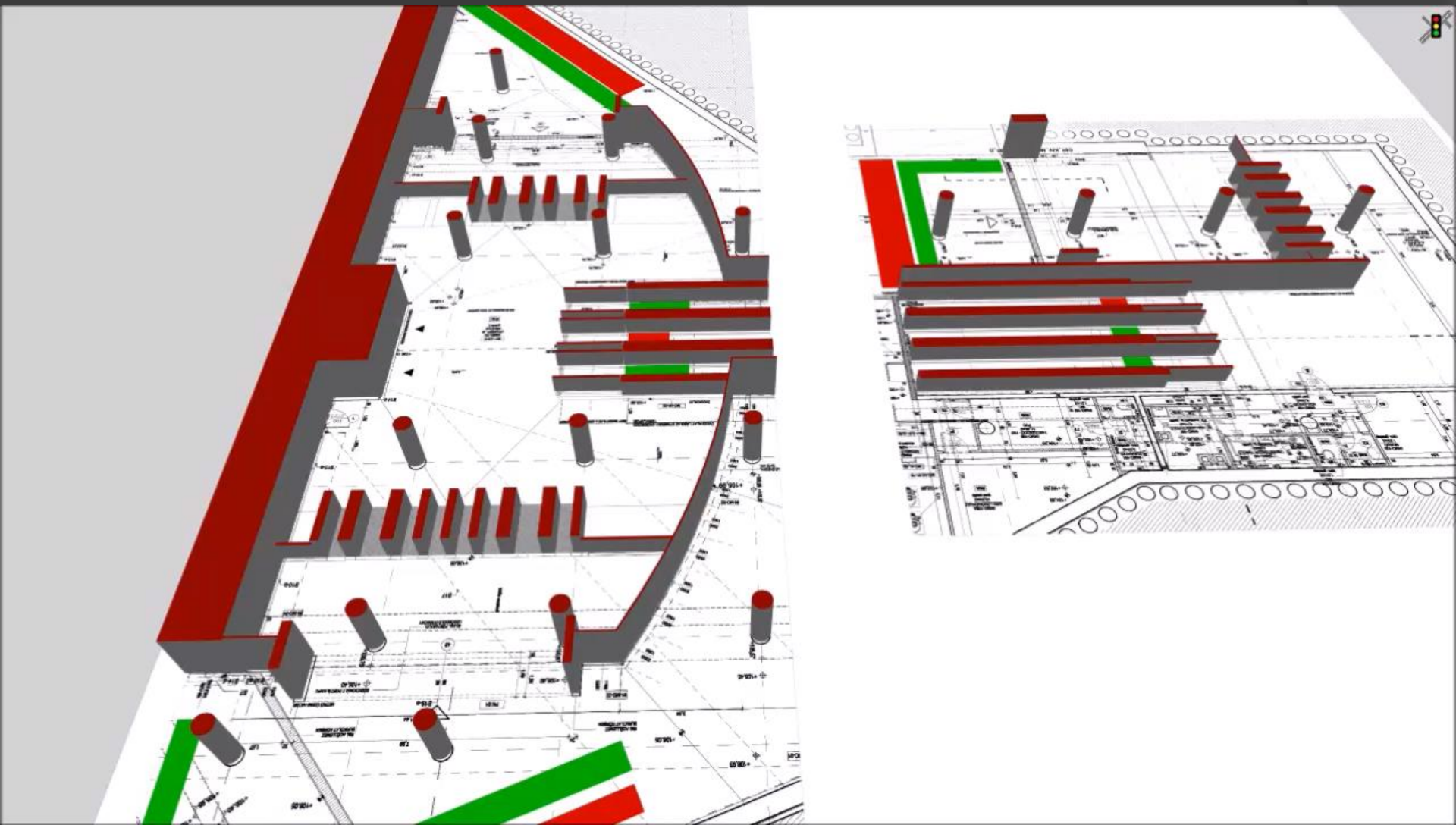


Example 3: Advanced visualization (Budapest, 3D, built environment)

Example 4: Pedestrian flow modeling (M4 Móricz Zsigmond körtér, station gating)



Thank you for your kind attention!

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