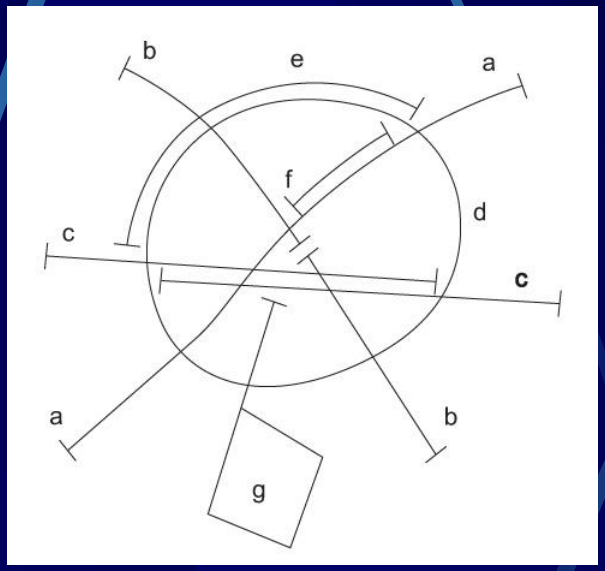
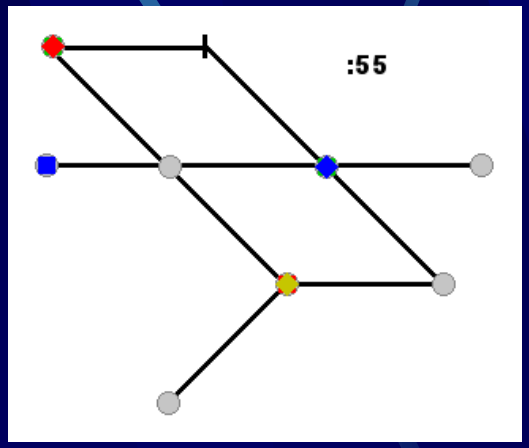
Urban Public Transport





Urban Transport 4.
András Gulyás PhD habil
associate professor

Content

- Principles of urban public transport
- Types of public transport networks
- Planning of public transport networks
- Case study of public transport (Pécs)
- Connections in urban public transport
- Operation of urban public transport
- Integration in urban public transport
- Management of urban public transport

Principles of urban public transport

Public transport (formerly mass transport or transit) is a public service operated by state and/or local or regional municipalities.

Public transport plays an important role in satisfying local and regional travel needs moreover it is advantageous for the environment.

Characteristics of coverage in space and time as well as the quality and reliability of the service determine the proportion of public transport in the modal split showing unfortunately a decreasing tendency nowadays.

Principles of urban public transport

Operation of public transit is a regulated market where the procurer is bunded by some politically determined prerequisites.

Regulation usually concerns fares and required minimum service.

Socio-economic situation usually demands some financial support for the operation of public transport and this fact is accepted even by the EU by specified conditions (i.e. a public transport company cannot gain profit from it).

Principles of urban public transport

Components of the quality of service

- **travel time**
- **travel condition**
- **timeliness**
- **reliability**
- **safety and security**
- **fare level**

There is some uncertainty in the assessment of the single components that can be improved using a multi-criteria assessment.

Types of public transport networks

Some public transport related definitions:

Network: a graph of sections and intersections in a settlement.

Route: part of the network where public transport is operated (physical).

Line: a given route within the network with predefined stops (logical).

Pach: a given vehicle moving at a given time on a given line's route.

Roster: daily movement of a given vehicle.

Types of public transport networks

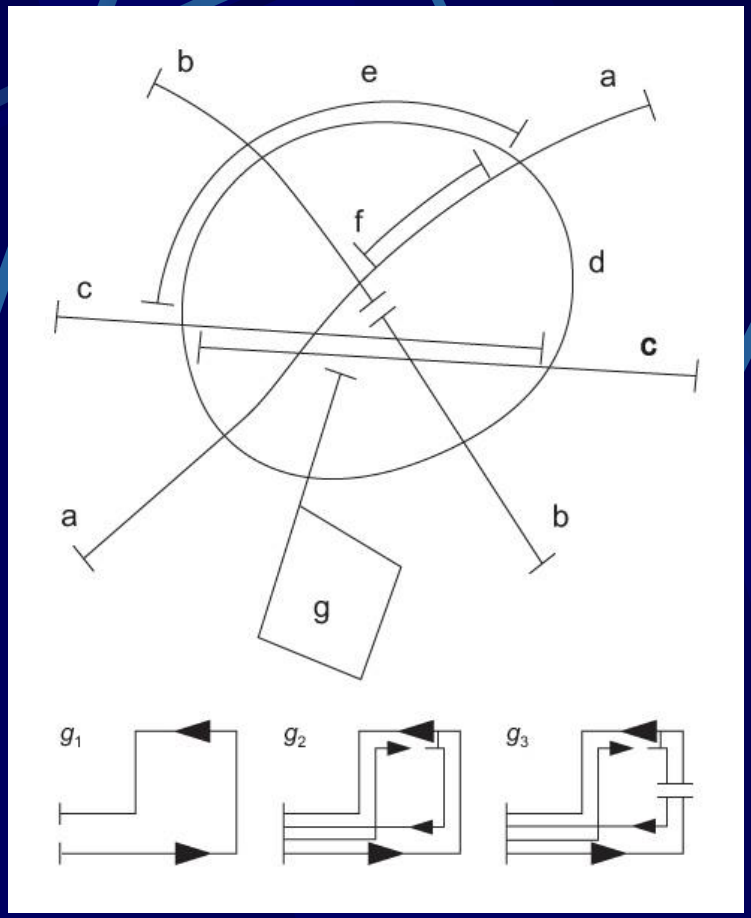
Rail types: railway, subway (metro), tram, separated tram, suburban railway trolley-bus

Road types: bus, taxi, car-share, bike-share

Capacity limits of different types:

Type	Passengers / hour / direction	
	lower limit	upper limit
Subway	15 000	40 000
Separated tram	6 000	12 000
Tram	4 000	10 000
Bus, trolley-bus	1 000	5 000

Types of public transport networks



Types of network elements:

a) **Route diagonal**

b) **Route radial**

c) **Route overlapped**

d) **Route circular**

e) **Route partly circular**

f) **Route inserted**

g) **Route loop-ended**

Types of public transport networks

Advantages and disadvantages of network elements

	Direct travel	Travel time	Use of capacity	Sensitivity	Area in centrum
Diagonal	+	-	-	-	+
Radial	-	+	+	+	-
Overlap	+	+	+	+	+
Circular	+	-	+	-	+
Loop-ended	+	-	+	-	+

Types of public transport networks

Qualitative and quantitative network characteristics

- Coverage in space, distance of stops
- Coverage in time, operation period
- Number of paches and vehicles
- Performance (passenger places * km)
- Volume and distribution of passenger traffic
- Volume / capacity ratio
- Line speed and travel time
- Suburban and regional connections
- Intermodal connections

Planning of public transport networks

Planning of public transport network is similar to the four-step traffic planning procedure using the following elements:

- **Calculation of traffic demand**
- **Calculation of the origin – destination matrix**
- **Planning of network (routes, lines and stops)**
- **Planning of timetables**
- **Passenger traffic assignment**
- **Planning of vehicle rosters**

Planning of public transport networks

It is important to get information about the distribution of travel demands in time.

Cross section and origin – destination passenger counts are recommended.

There is a need for alternatives in network routes, lines and timetables (i.e. express lines in peak hours with less stops).

Service level (i.e. travel time) and operation cost must be assessed together for a proper decision among alternatives.

Planning of public transport networks

Assignment methods: one-step, multi-step capacity constrained, frequency based, schedule based.

In the frequency based method there is a need for virtual sections in the network representing getting on and off.

Main parts of the schedule based method are shape of demand in time, supply at pach level and dynamic route choice.

Frequently used software packages: DHV PT OPT, EMME, VISUM, microsimulation software.

Planning of public transport networks

Route choice is based on the minimisation of the generalised cost

$$C_{ij} = a_1 \cdot t_{ij}^{jár} + a_2 \cdot t_{ij}^{gyal} + a_3 \cdot t_{ij}^{vár} + a_4 \cdot t_{ij}^{átsz} + a_1 \cdot \delta + a_5 \cdot V_{ij}$$

where:

$t_{ij}^{jár}$	travel time (in vehicle) between zones „i” and „j”
t_{ij}^{gyal}	sum of walking times to stop and from stop
$t_{ij}^{vár}$	waiting time at stop
$t_{ij}^{átsz}$	time for change (if necessary)
δ	penalty for change (usually a few minutes)
V_{ij}	fare between zones „i” and „j”
$a_{1..5}$	weighing factors

Planning of public transport networks

Parts of turnaround time of a vehicle on a line:

- **Effective (useful) travel time:** T_e
- **Time for staying at stops:** T_s
- **Travel time between terminals:** $T_l = T_e + T_s$
- **Staying time at terminal:** T_t
- **Total turnaround time:** $T_{ta} = 2T_l + 2T_t$

Standard passenger volume: biggest volume at a cross section which is time-dependent therefore calculations must be performed for the morning and afternoon peaks.

Planning of public transport networks

Number of paches needed:

$$J = \frac{U_m}{N_k \cdot \alpha}$$

where:

- U_m **standard passenger volume**
- N_k **capacity of the vehicle**
- α **saturation coefficient**

Time interval for paches:

$$i = \frac{T}{J}$$

where:

- **T: operation time analysed**

Planning of public transport networks

Number of vehicles needed:

$$N = \frac{T_f}{i}$$

where:

T_f is turnaround time

In the planning of vehicle rosters necessary driver rest times and vehicle technical supply time must be taken into account as well.

Travel times have a stochastic nature that affects the reliability of the public transport system.

There is a conflict between economic constraints and the demand for a better service level.

Planning of public transport networks

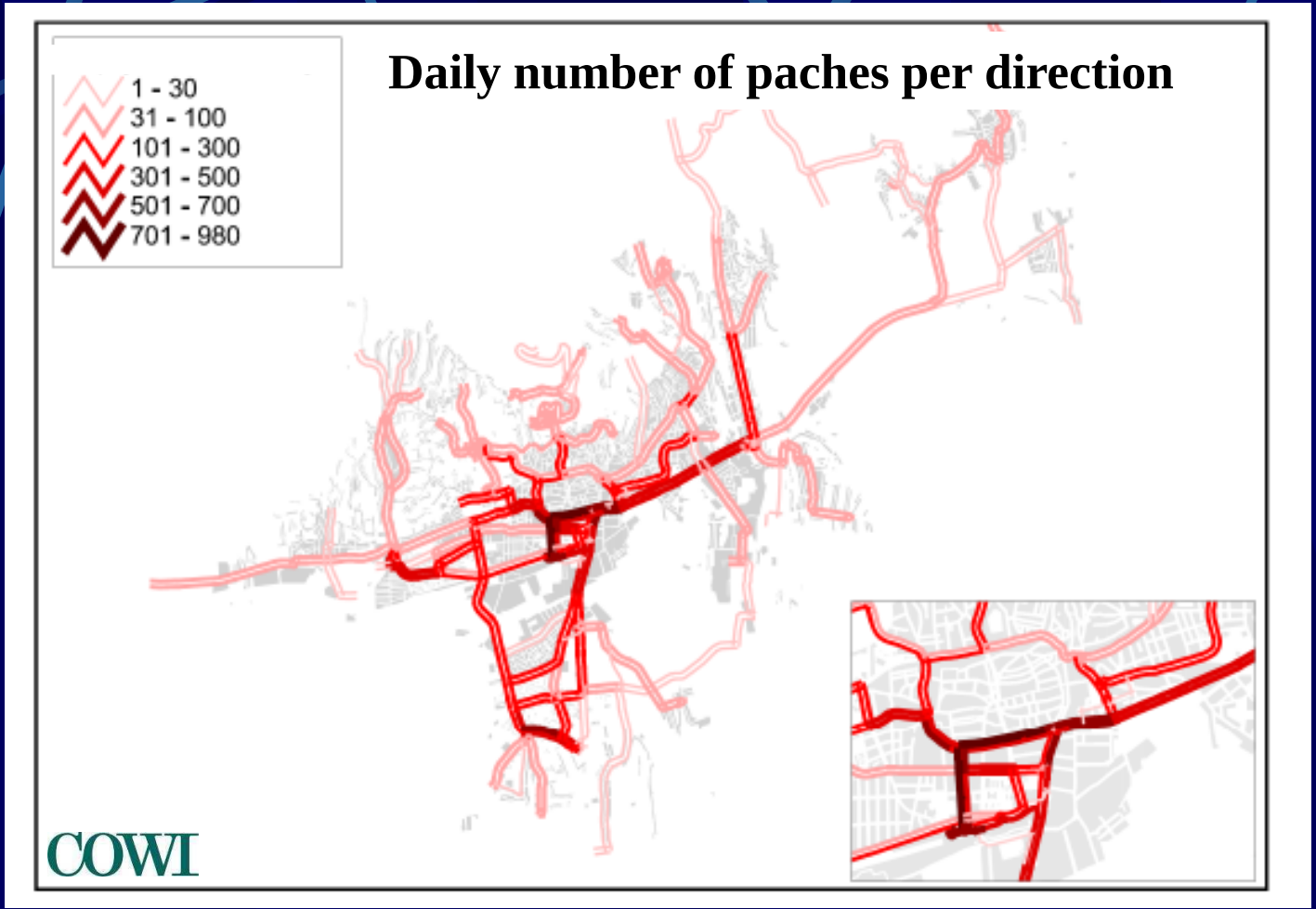
Numerical example:

- **Standard passenger volume in the morning peak (150 minutes): 1800 passengers**
- **Bus capacity is 100 passengers, saturation is 90%**
- **Number of paches needed: 1800/(100*0,9) = 20 paches**
- **Time interval for paches: 150/20 = 7,5 minutes**
- **Travel time between terminals: 16 minutes**
- **Staying time at terminal: 4 minutes**
- **Turnaround time: 2*16+2*4 = 40 minutes**
- **Number of vehicles needed: 40/7,5 = 5,33 ~ 6 buses**

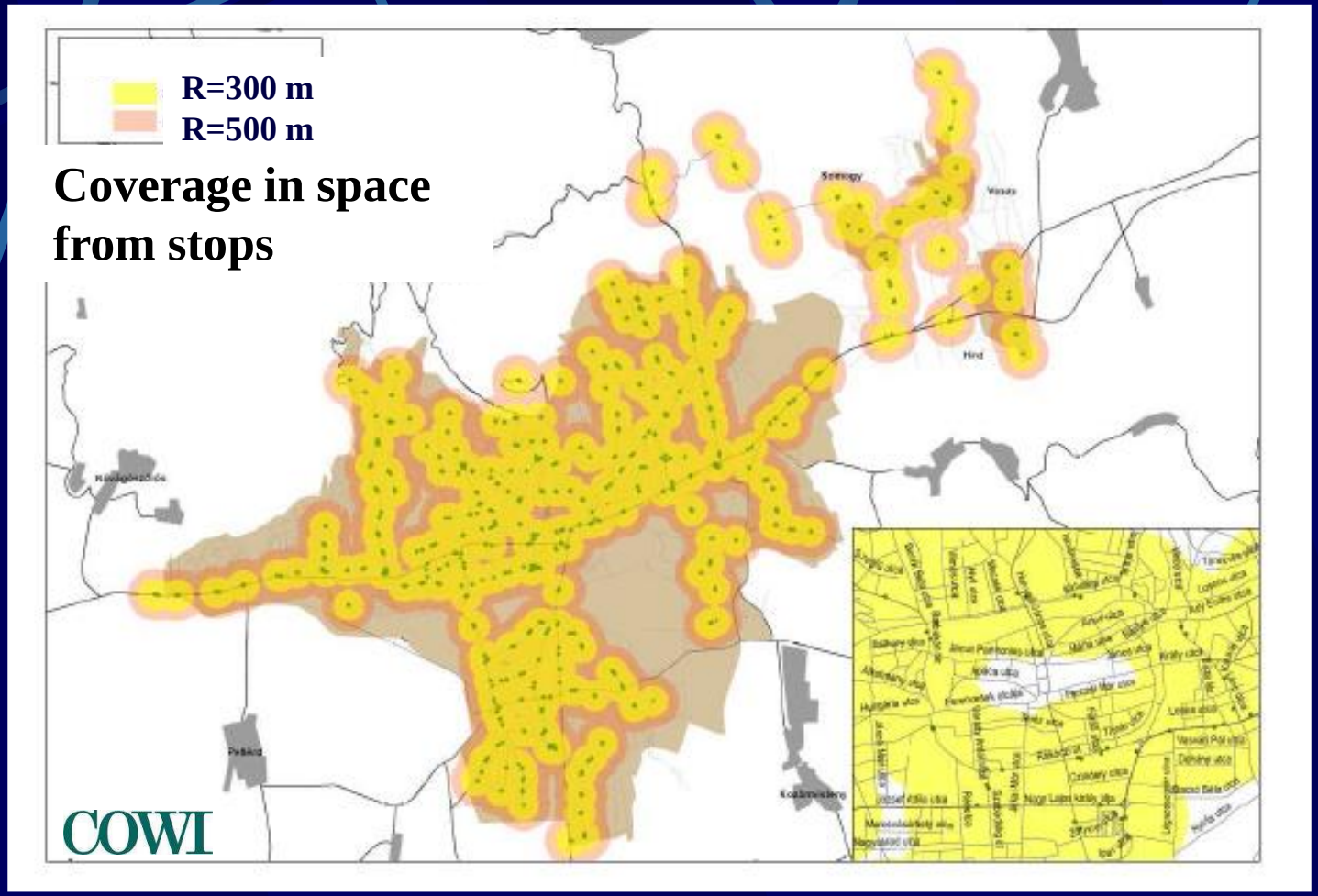
Case study of public transport

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

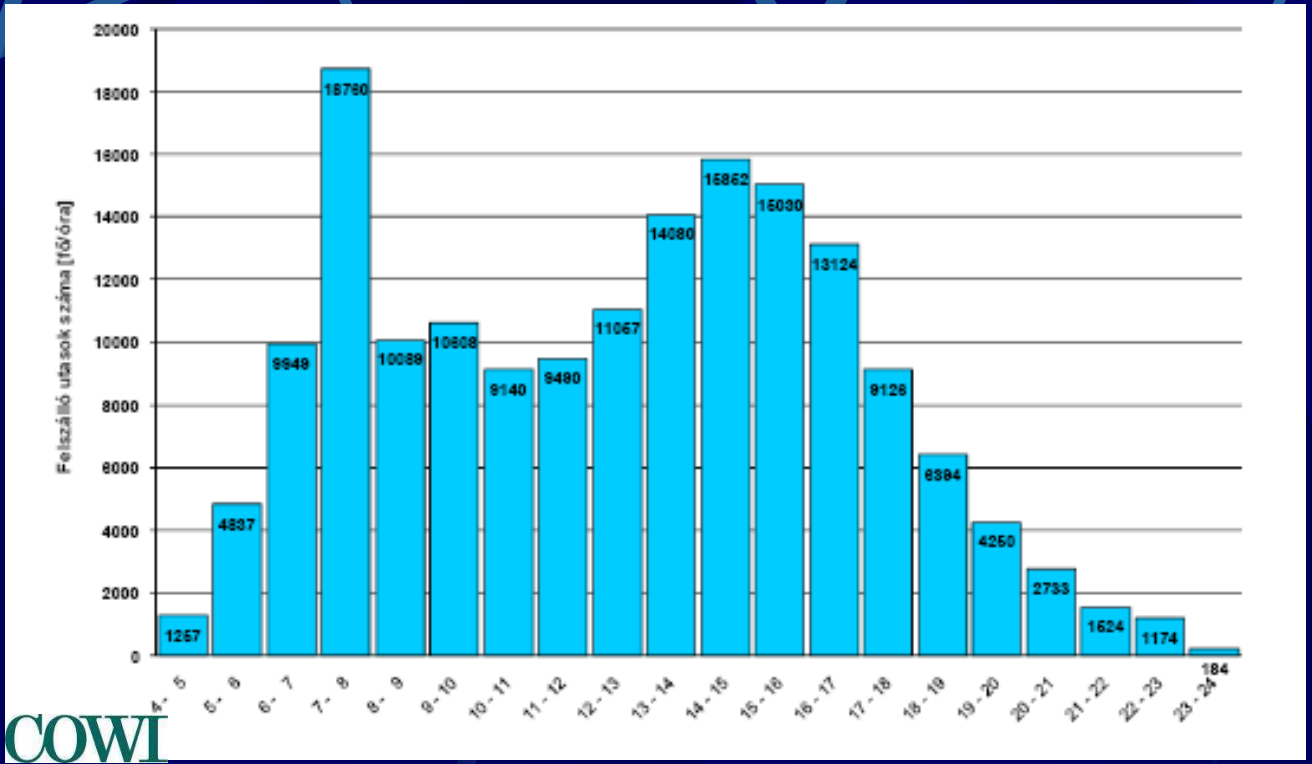
Case study of public transport



Case study of public transport

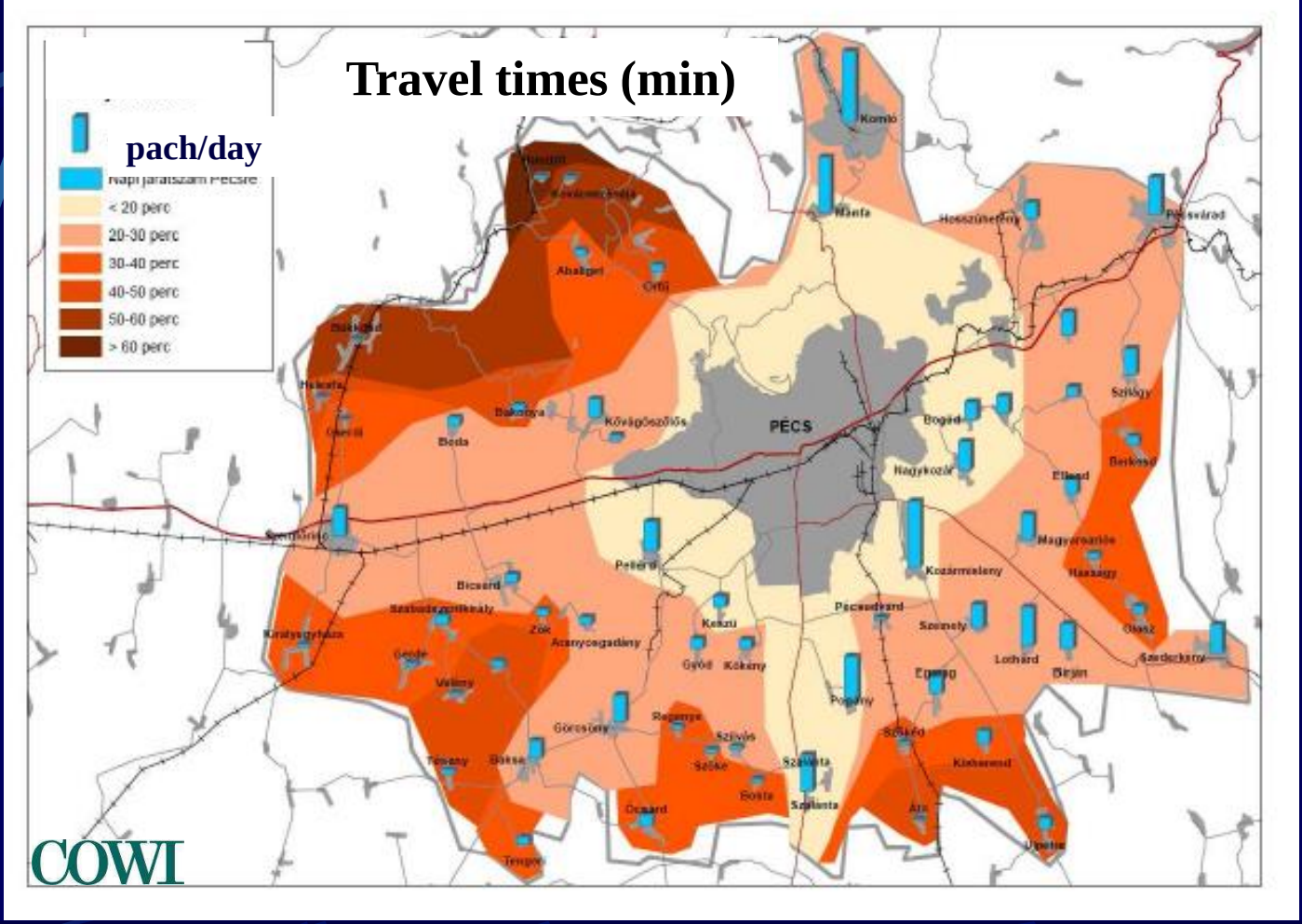


Case study of public transport

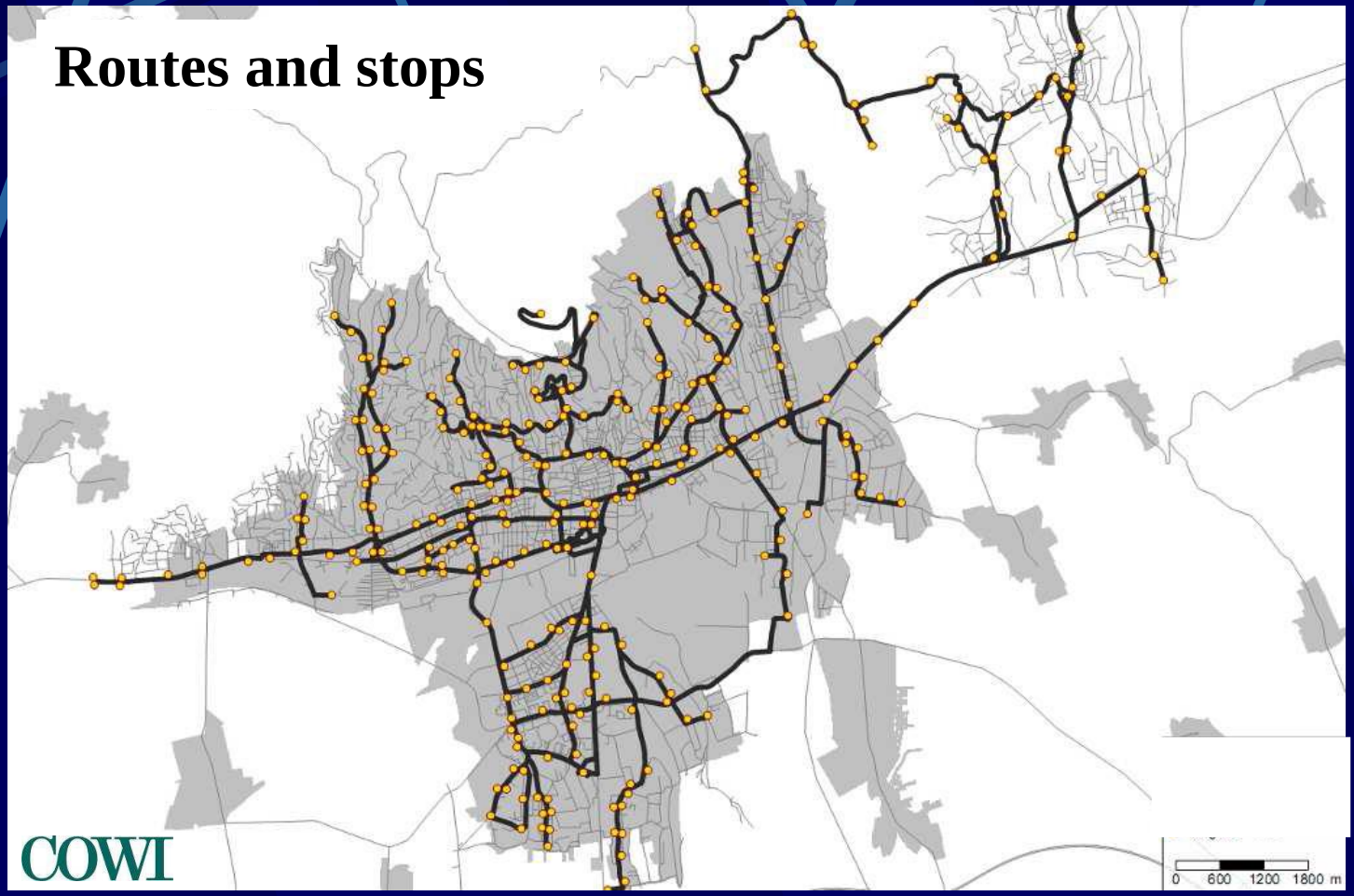


Number of passengers getting on at workdays

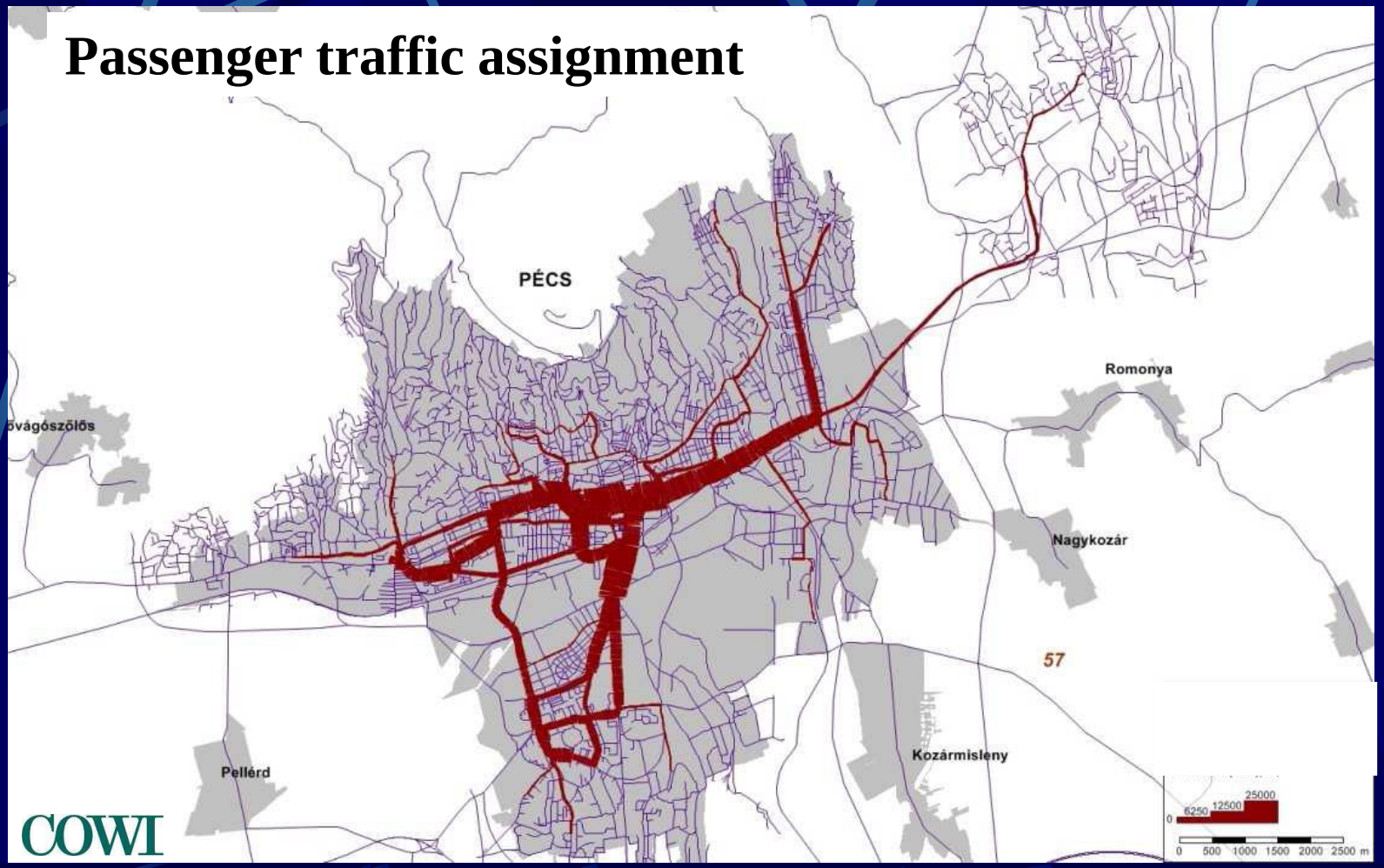
Case study of public transport



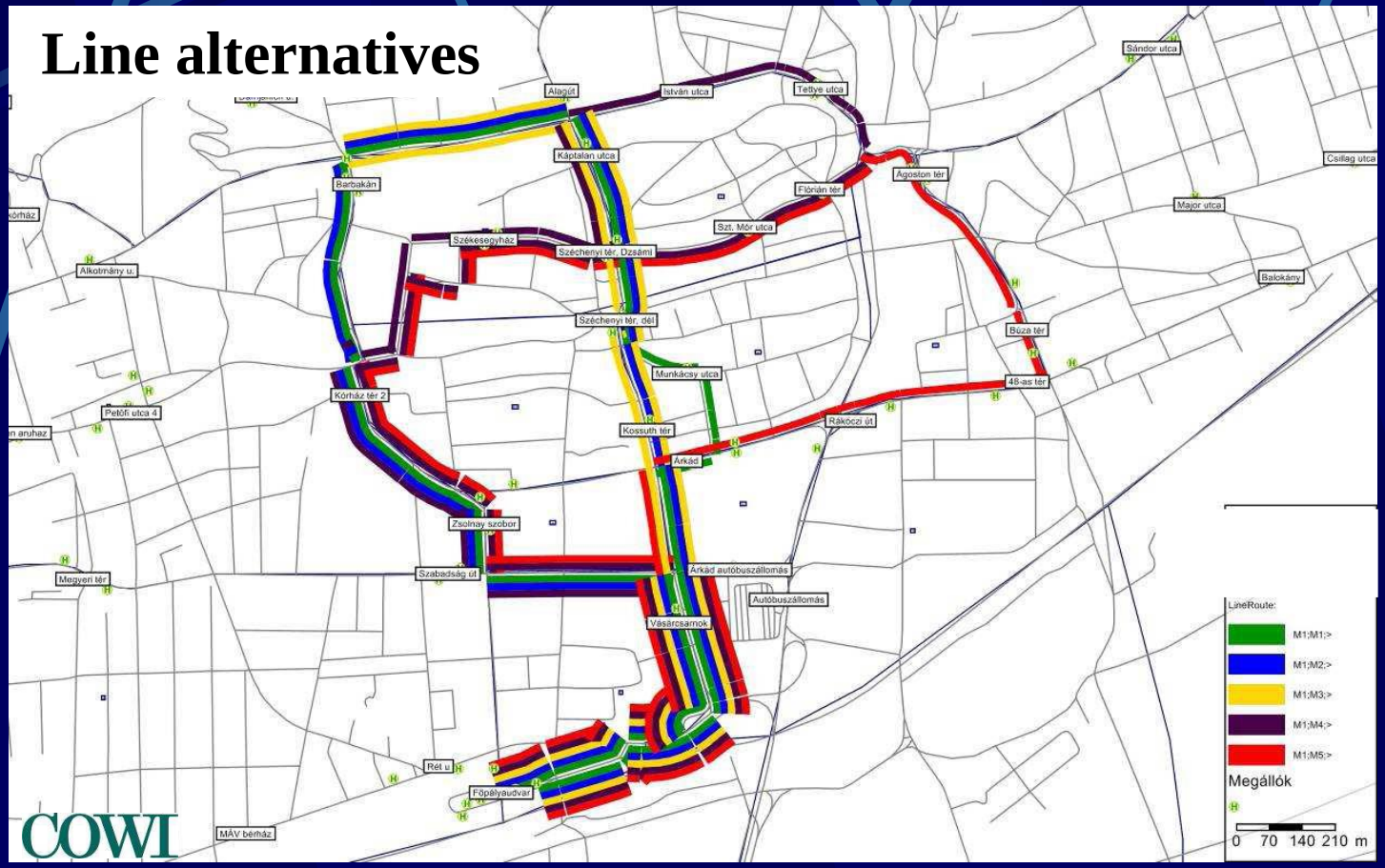
Case study of public transport



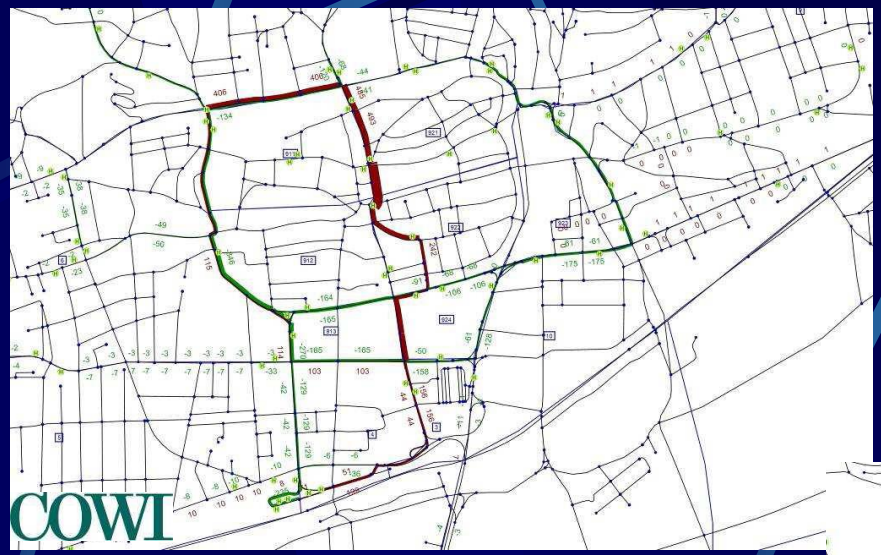
Case study of public transport



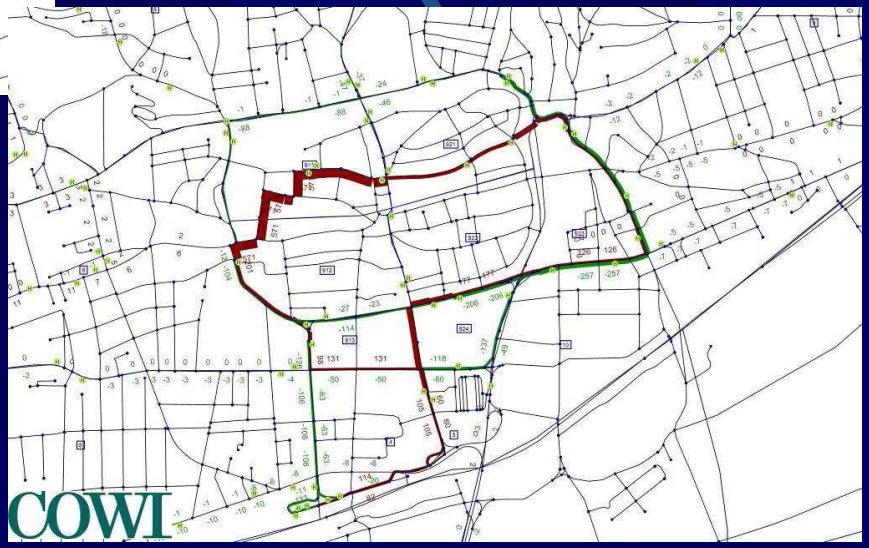
Case study of public transport



Case study of public transport



Passenger volumes at the line alternatives



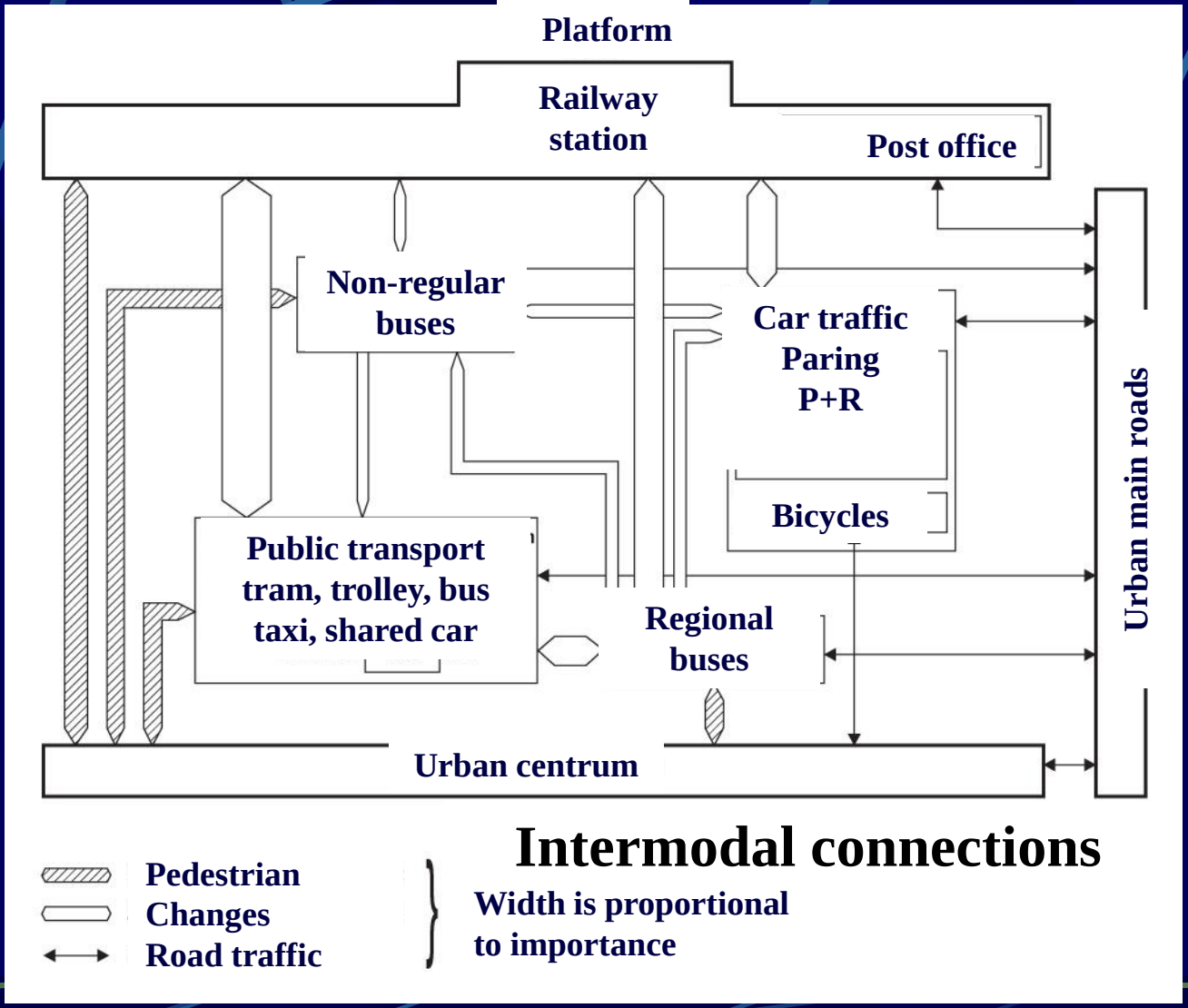
Connections in urban public transport

Connections are possible:

- **Within a given mode of public transport (transfer points),**
- **Between different modes of public transport (stations, public transport junctions),**
- **Between public and individual transport (park and ride P+R, bike and ride B+R).**

Especially important are bus lines connected to rail modes (suburban railway, tram line, metro).

Connections in urban public transport



Connections in urban public transport

Connections in urban public transport

A rákoskerti térség utazási körülményeinek javítása érdekében új autóbuszjáratot indítunk, ami közvetlen átszállást biztosít a MÁV-Start Zrt. elővárosi vonataira.
A 197-es buszok menetrendjét úgy alakítottuk ki, hogy Rákoskert vasútállomáson várakozás nélküli csatlakozást biztosítsunk mind a buszról a belváros felé tartó vonatokra, mind a belváros felől érkező vonatokról az autóbuszokra. Ezzel jelentősen csökkenthető a belváros és Rákoskert között ingázók utazási ideje.
A Budapest-bérlettel rendelkező utasok külön útiköltség nélkül utazhatnak a vonatokon.
A reggeli csúcsidő kivételével az autóbuszok könnyen megjegyezhető, ütemes menetrend szerint közlekednek. Kiadványunk részletesen tájékoztat a buszok és a vonatok menetrendjéről.
Bérlettel nem rendelkező utasaink a vonaton külön menetjeggyel tudnak utazni.

Továbbutazási lehetőségek a Keleti pályaudvartól:

M2 → Örs vezér tere / → Déli pályaudvar
24 → Vágóhíd
73 → Arany János utca, 76 → Jászai Mari tér
78 → Kossuth Lajos tér, 79 → Dózsa György út
80A → Csertő utca
5 → Rákospalota, Kossuth utca / → Pasaréti tér
7 →Bosnyák tér / → Budafok-Albertfalva vasútállomás
7E →Bosnyák tér / → Kelenföldi pályaudvar
20E →Káposztásmegyer, Szilas-patak
30 30A →Káposztásmegyer, Mogyoródi patak
173 →Újpalota, Nyírpalota út / → Bornemissza tér
173E →Újpalota, Nyírpalota út / → Kelenföldi pályaudvar
178 178A →Naphegy tér

3 AZ 1-BEN BUDAPEST-BÉRLET
UTAZZON SZABADON A FŐVÁROSBAN A BKV JÁRATAIN, AZ ELŐVÁROSI VONATOKON ÉS A VOLÁN-BUSZOKON IS!

BUDAPESTI KÖZLEKEDÉSI SZÖVETSÉG
KÖZLEKEDJEN OKOSAN!

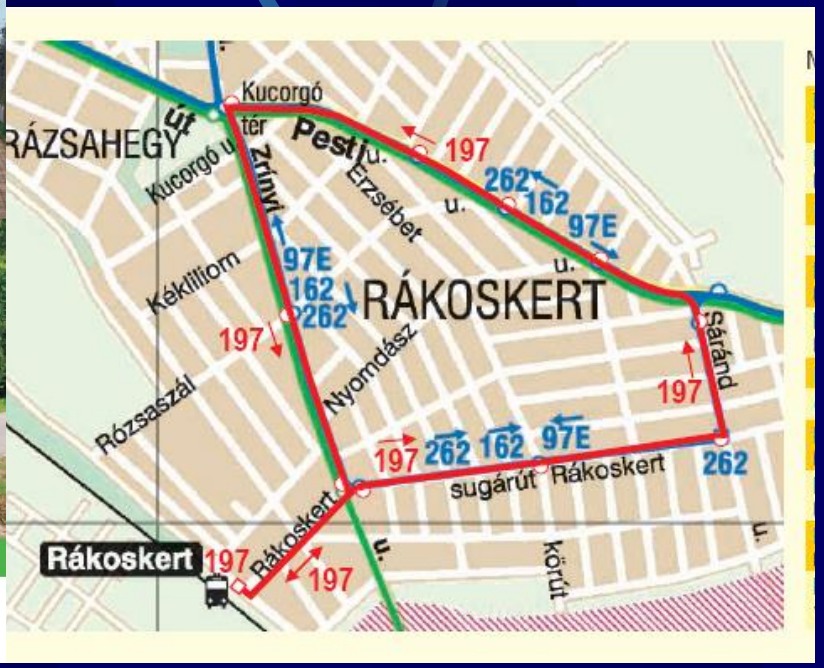
Használja ki Budapest-bérletét!

Utazzon gyorsabban az új 197-es autóbusz és a vasút használatával!

BUDAPEST

Budapesti Közlekedési Zártkörűen Működő Részvénytársaság
1980 Budapest, Akácfa utca 15.
Tel: +36 1 258-4636 (+36 1 BKV-INFO)

Budapest - new bus line connected to suburban railway by EU co-financing



Connections in urban public transport

In 2010 an intermodal connection has been constructed at a suburban railway station: P+R car parking, bike parking and bus terminal.

The timetable of the new bus line is co-ordinated with the timetable of the railway. In case of rail delay the bus waits at the terminal for a certain time.

The intermodal connection considerably decreases travel time between the suburb and the capital centrum.

Connections in urban public transport

Connections in urban public transport

Bus terminal

Bike parking

Connections in urban public transport

Passenger information, timetable

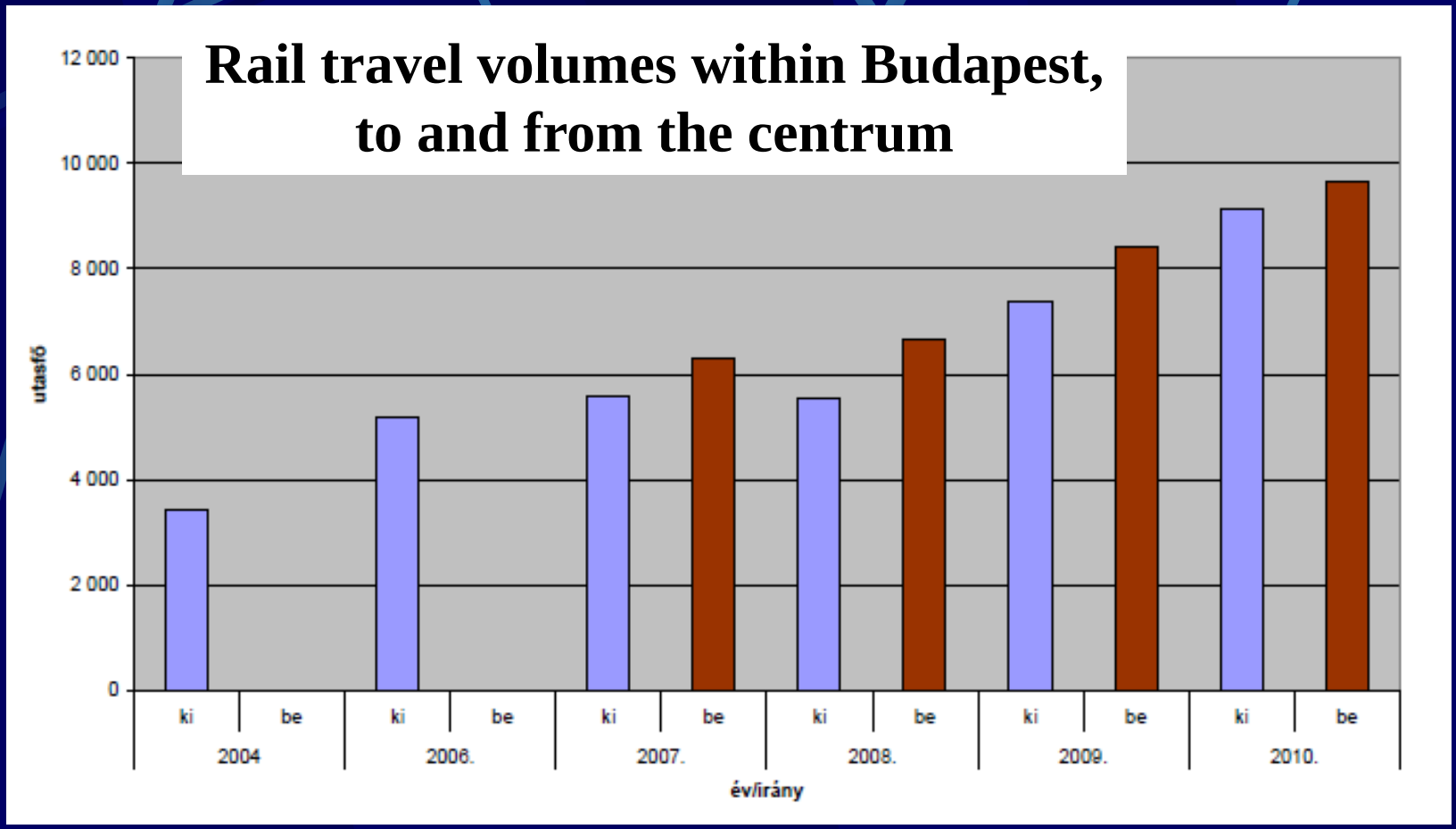
P+R parking

Connections in urban public transport

There was a competition among transport modes starting from the P+R and B+R parking of the new terminal mentioned before, to the capital centrum, as an event of the European Mobility Week in September 2010 at a weekday morning.

The suburban railway passengers got the first place, the bike team has got the second place and the car users have got the third place.

Connections in urban public transport



Operation of urban public transport

Principles of sustainable development:

- **More efficient operation**
- **Decrease of harmful environmental effects**
- **Reduction of travel demand**

Competitiveness of public transport against car usage is determined by the level of service as a complex parameter including travel times, reliability, passenger information and comfort.

Operation of urban public transport

Enhancement of the service level of public transport 1.

Public transport network development	Better space coverage	better supply, rationalisation
		less changes
		P+R, B+R
	Better time coverage	operation time
		bigger frequency
Management, preference, travel time decrease	Signals at junctions	green time
	Infrastructure development	bus lock
		transit corridor
	Accuracy	traffic management
	Intermodality	better changes
		co-operation

Operation of urban public transport

Enhancement of the service level of public transport 2.

Better passenger information	Based on static data	changes, tourism
		timetable data
	Based on dynamic data	route proposal by Internet, mobile app
		information points
		real time in stops audio and/or visual
		real time on board audio and/or visual
Comfort and quality	On vehicles	comfort, cleanness, disabled friendly
	In stops	waiting condition: roof, seat, lighting
		disabled friendly access

Operation of urban public transport

Types of public transport preference:

Road infrastructure development, traffic management:

- **Minor construction works, relocating stops**
- **Decrease of delays by advanced traffic management methods**

Preference at signalised junctions:

- **Immediate green phase for public transport vehicles by approaching**
- **Elongation of green time for public transport vehicles starting from stops**

Operation of urban public transport

Operation organisation measures:

- **Low floor vehicles**
- **Simple fare pay system**
- **Traffic control centre**

Bus lane (separated lane for public transport vehicles, including taxis, shared vehicles and sometimes even bicycles) – enforcement is important

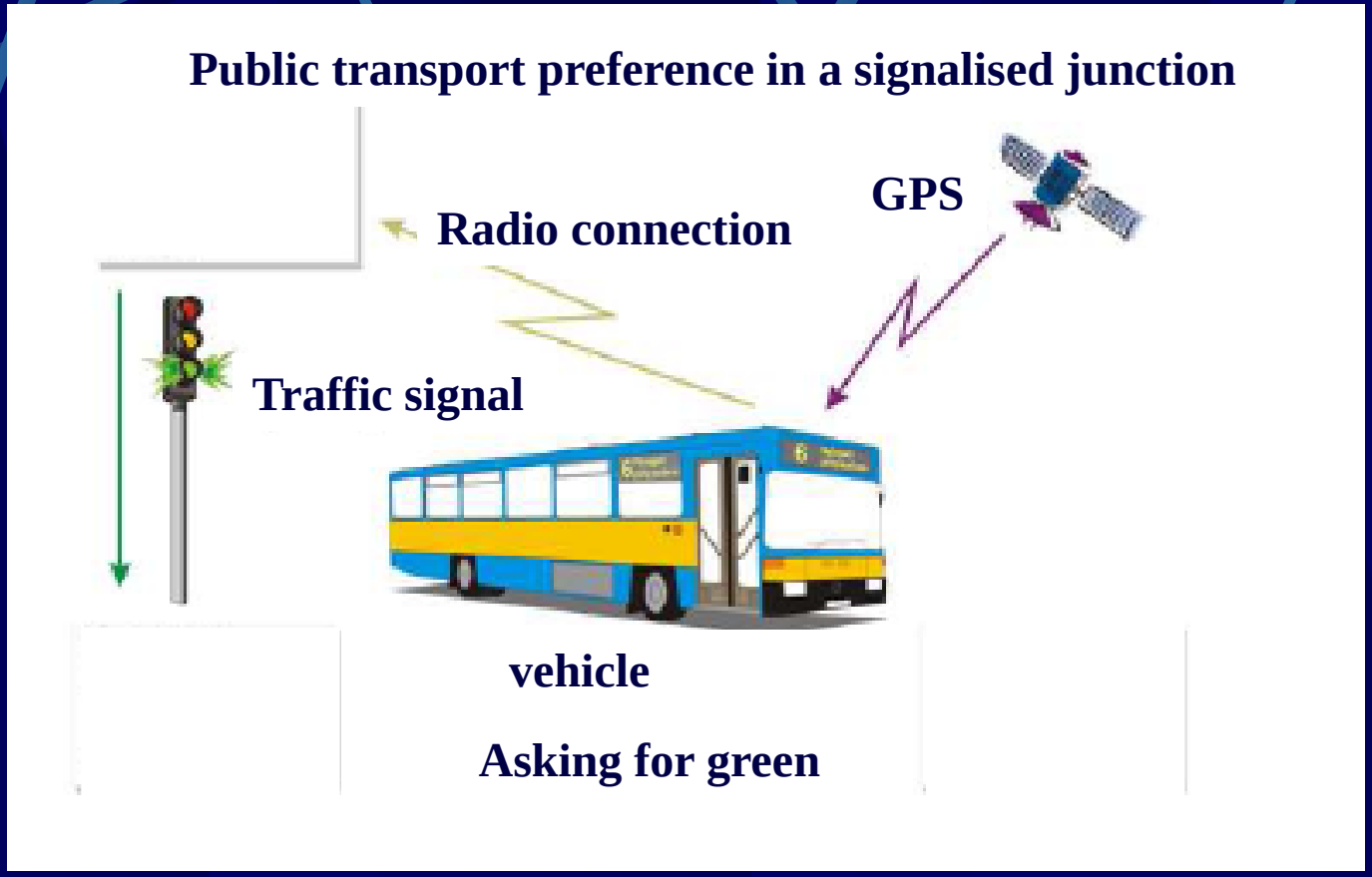
The most efficient solution is to organise a comprehensive program of the possible measures.

Operation of urban public transport

In Pécs there has been implemented a GPS based bus traffic management system and passenger information system.

Public transport preference has been deployed at bigger signalised junctions. The signal control unit receives a radio signal from the on board computer of the bus 10 sec before expected crossing, than the signal control unit - according to possibilities - gives earlier green phase of extends the green phase, decreasing travel time.

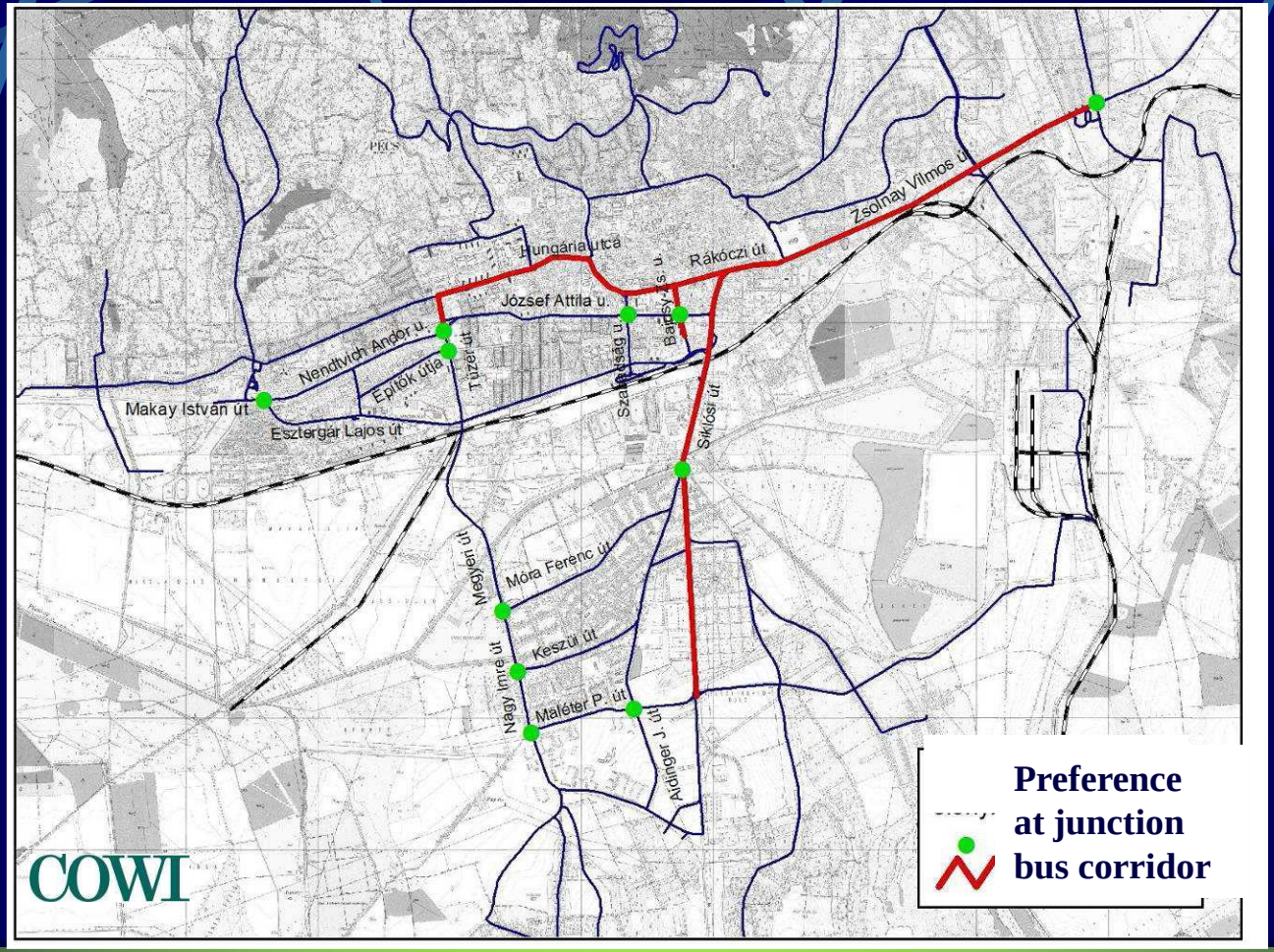
Operation of urban public transport



COWI

Operation of urban public transport

Proposed public transport preference solutions in Pécs



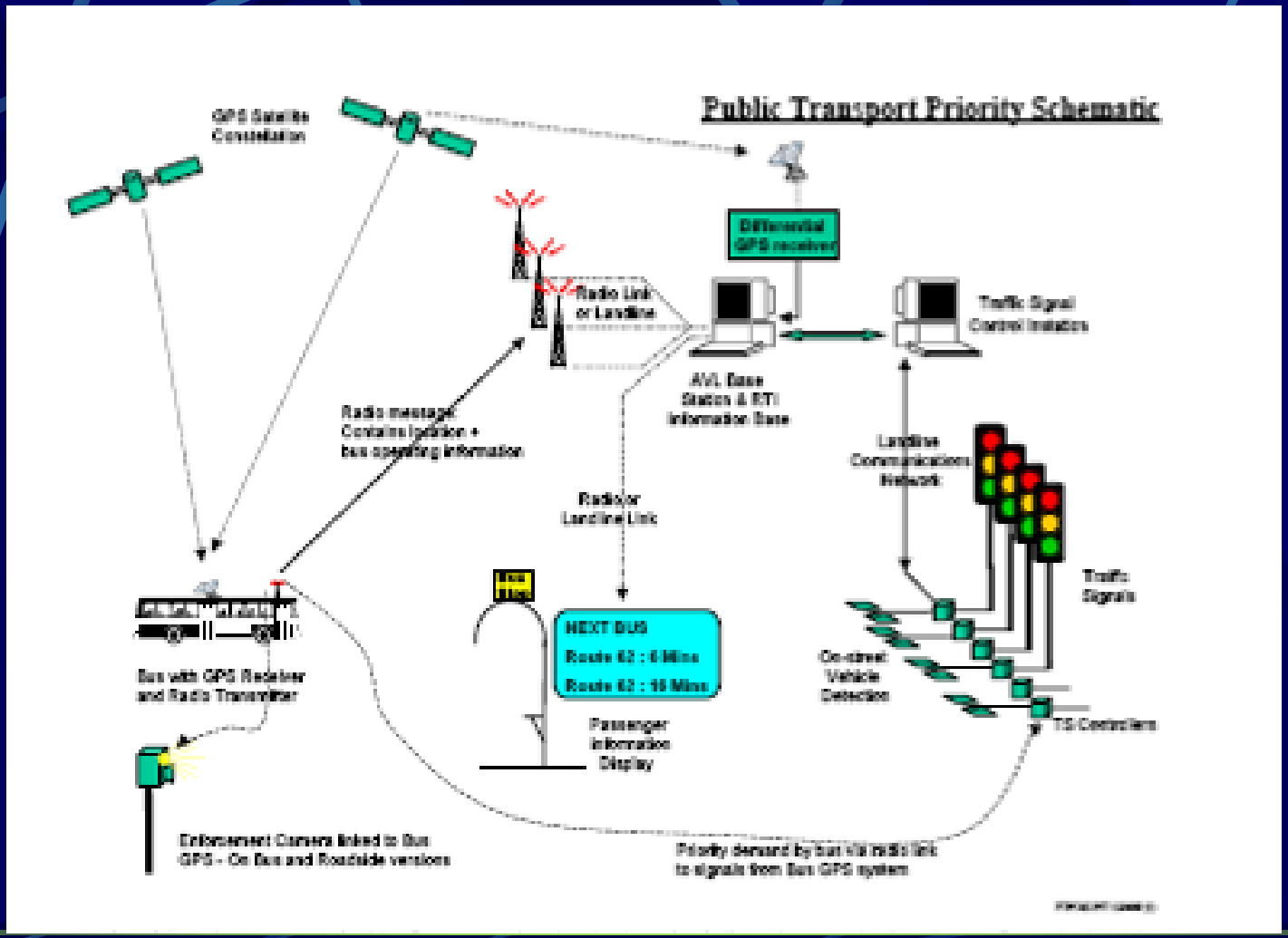
Operation of urban public transport

A high quality bus corridor, on board units on 460 buses and a new urban traffic control centre has been developed in Glasgow, UK, 2004.

In case of a sign from the approaching bus the signal control centre provides green phase and optimises further control.

Based on GPS, reliable waiting times at stops can be provided to passenger. This solution is rather general in Hungary as well.

Operation of urban public transport

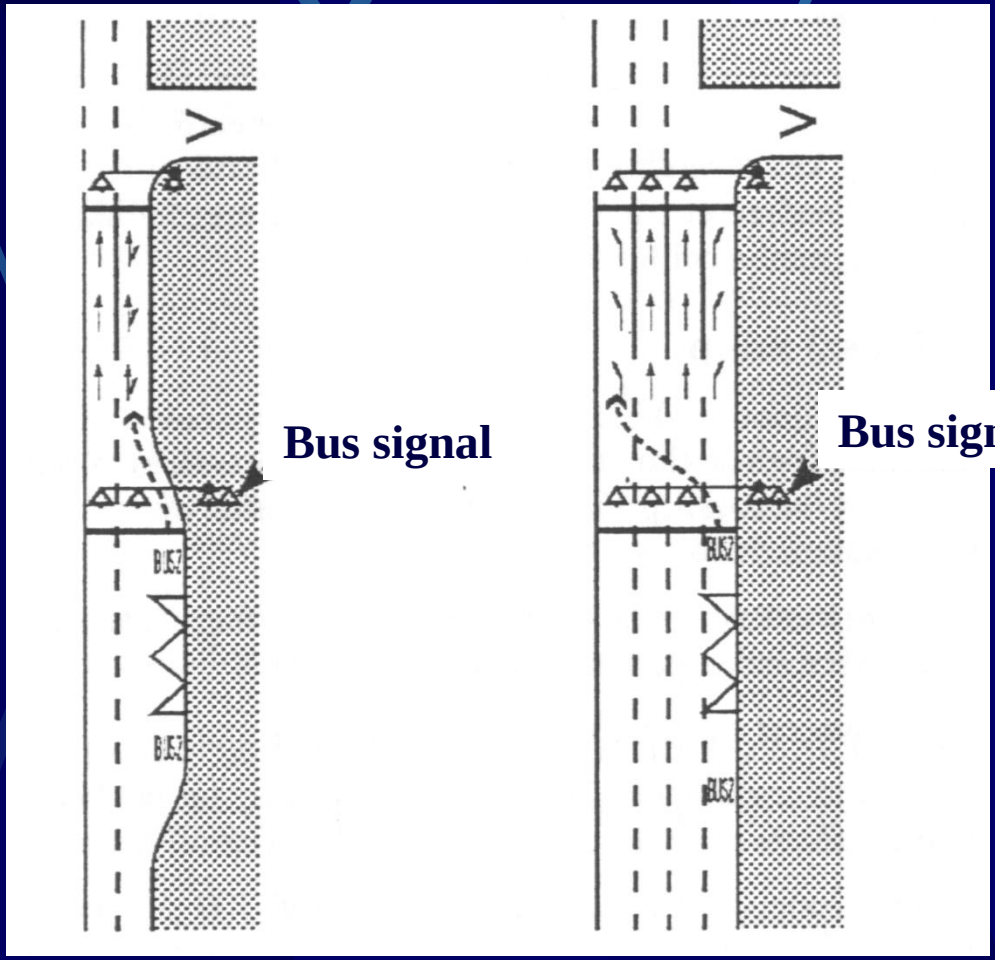


Operation of urban public transport

Preference for a turning tram in Zurich, Switzerland, based on previous signing in.

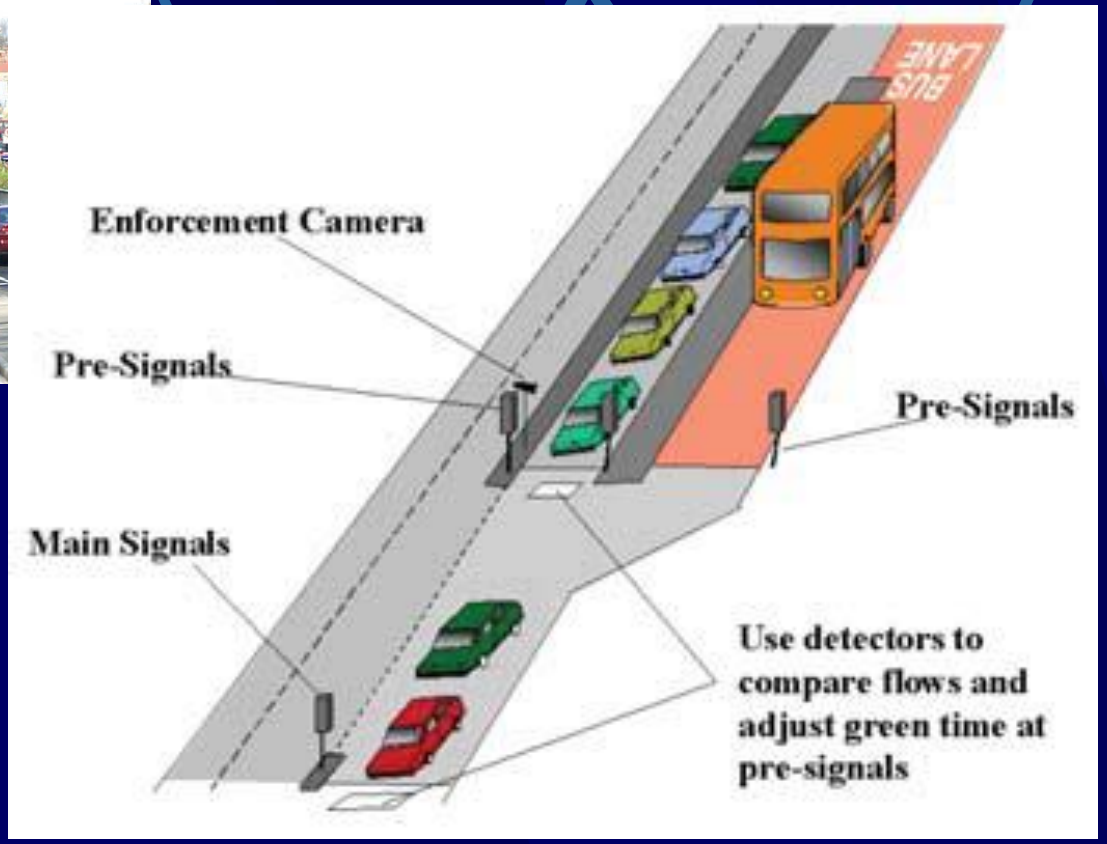
Operation of urban public transport

Bus lock before a signalised junction in Budapest



Operation of urban public transport

Bus lock in England



Integration in urban public transport

The former monopolistic, regulated public transport market has been transformed because of the market liberalisation in the European Union. Operation and management conditions have been changed and a stronger competition occurred.

Main elements of the up-to-date public transport service activities are:

- **market-oriented management,**
- **survey of demand,**
- **services according to demand or surplus services.**

Integration in urban public transport

A prerequisite of the euro-compatible operation is the development of the transport infrastructure according to the market demand.

Further factors in public transport are: quality development, effectiveness, acceptance of the EU regulation, co-operation, integrated services and management systems.

Foreign companies may soon take part in the competition for public transport services in Hungary, that is a challenge for Hungarian firms.

Integration in urban public transport

An integrated public transport system is based on an integrated periodic timetable, where services of different transport modes are unified and coordinated as well as the fare system, passenger information etc.

A common form of an integrated public transport system is the transport association including service providers and procurers.

An integrated public transport system can be connected to individual transport as well, like a P+R ticket that can be used on public transport vehicles.

Integration in urban public transport

Examples of successful integrated transport systems:

- **IDS JMK - Integrovaný dopravní systém Jihomoravského kraje – Czech Republic,**
- **IS - Transporto Integrato Alto Adige – Italy,**
- **ZVV - Zürcher Verkehrsverbund – Switzerland,**
- **VOR - Verkehrsverbund Ost-Region – Austria,**
- **Budapest, Hungary: BKV + MÁV Start + Volánbusz unified monthly pass and coordinated timetables**

Integration in urban public transport

Periodic timetable: a timetable of a given public transport line is periodic if vehicles follow each other in equal time periods in a calculable manner.

In the practice the period is usually

120 – 60 – 30 – 15 – 10 – 7,5 – 5 – 3,75 minutes.

A periodic timetable is transparent and understandable for passengers and can be easily memorised.

Integration in urban public transport

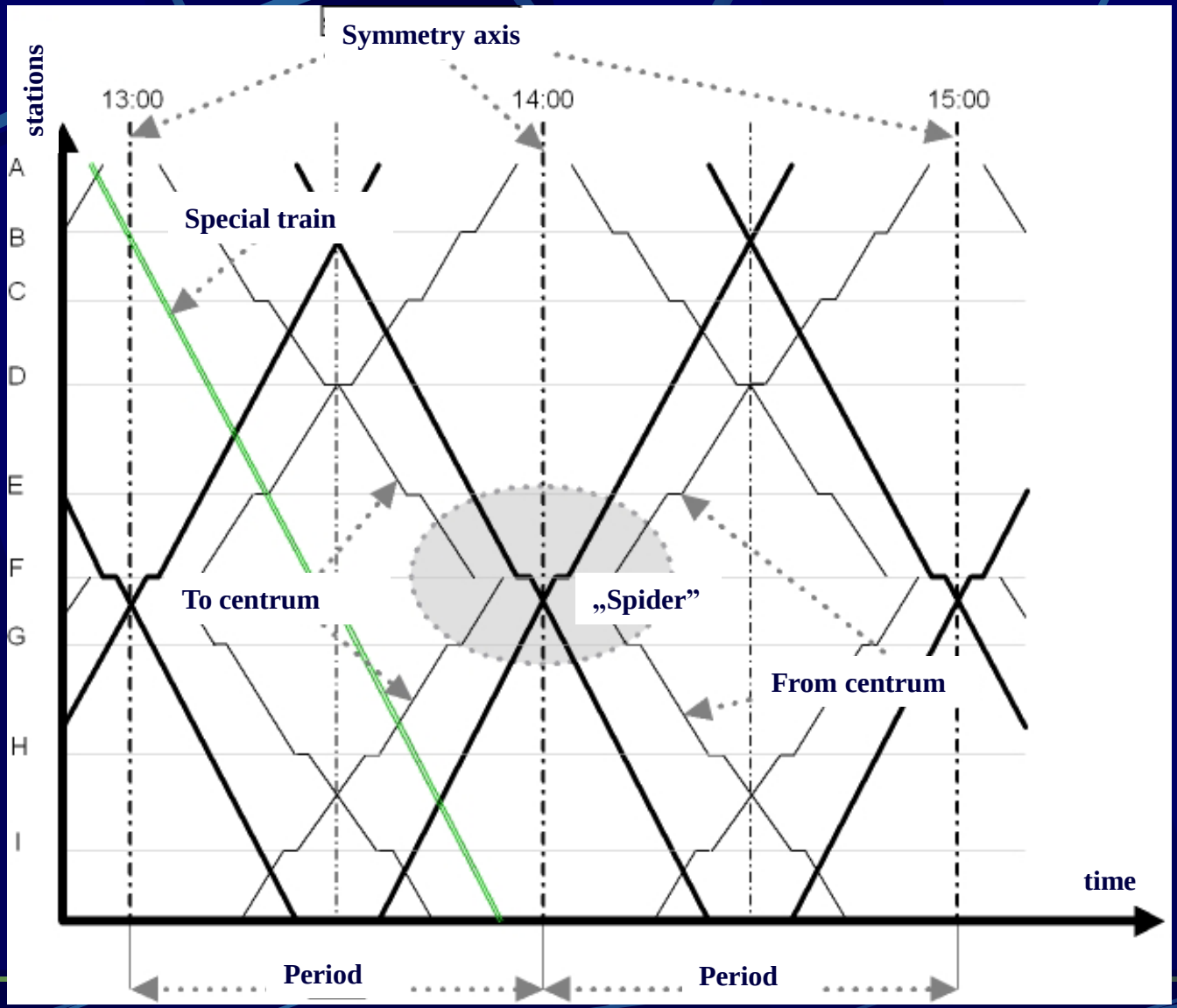
Change system in the integrated periodic timetable is called „spider” because of the typical graphic picture of a time-space type timetable diagram.

In a simple case there are two phases in the spider-like timetable: the collection phase (vehicles arriving to centrum) and the distribution phase (vehicles starting from centrum).

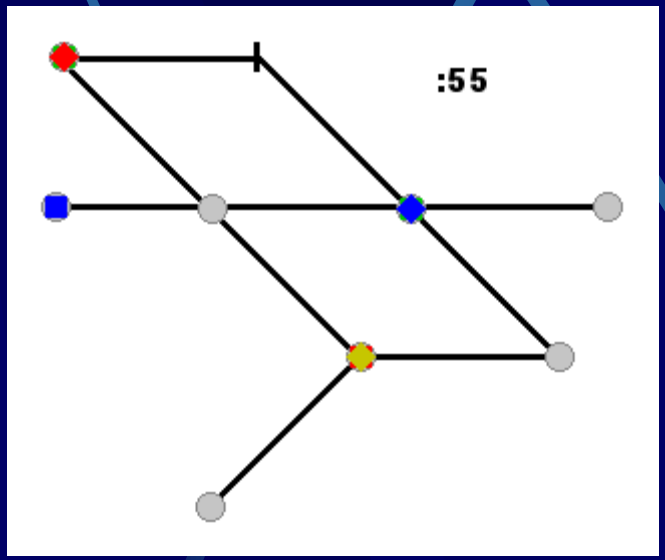
In a spider-like periodic timetable at the central junction every kind of changes are provided.

Integration in urban public transport

Spider-like periodic timetable



Integration in urban public transport



Spider animation: Knooppuntdienstregeling.gif

Management of urban public transport

Current development in management is the „e-ticketing” – electronic ticket and pass system together with an advanced traffic management and passenger information system.

First e-ticketing system started in Hong Kong, then it has been implemented in some other big European cities (London, Paris, Madrid, Amsterdam, Rome).

The Budapest Transport Centre and Budapest Transport Company have got an e-ticketing development underway.

Management of urban public transport

In case of smaller population density the Public transport can be provided by a flexible Demand Responsive Transport system.

DRT characteristics: smaller vehicles, previous signing in, modifiable route, flexible stops. Any DRT system requires an operator centre.

Working DRT systems are among others in Hungary, the Netherlands, Canada, USA, UK, Australia, Czech Republic, Italy

DRT is different from paratransit that is a transport system for handicapped people.

Management of urban public transport

DRT example: RadioBus – in the Czech Republic at some cities with predefined routes and timetables, smaller vehicles.

The given pach starts only if there has been at least one previous signing in by phone or SMS before 30 minutes of the scheduled start.

Management of urban public transport

Passenger information,

real time system,

GPS based vehicle tracking

Pécs Kertváros urban bus station

COWI

Summary 1.

Public transport plays an important role in satisfying local and regional travel needs moreover it is advantageous for the environment.

Planning of public transport network is similar to the four-step traffic planning procedure.

In a multimodal connection bus lines connected to rail modes are especially important.

Service level (i.e. travel time) and operation cost must be assessed together for a proper decision among alternatives.

Summary 2.

Competitiveness of public transport against car usage is determined mainly by the level of service.

Providing public transport preference by technical and organisational measures help attractiveness.

An integrated public transport system provides higher quality level in satisfying travel demand.

In case of smaller population density a flexible Demand Responsive Transport system can be operated.

Thank you for your attention!

András Gulyás
associate professor
e-mail: gulyasandras@hotmail.com