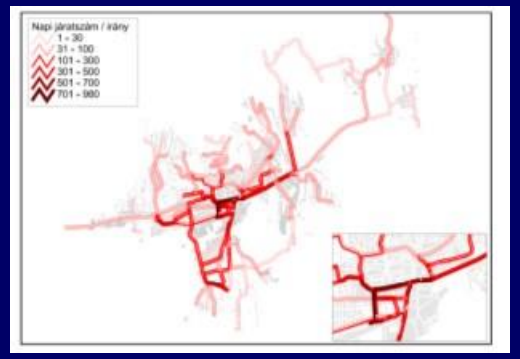
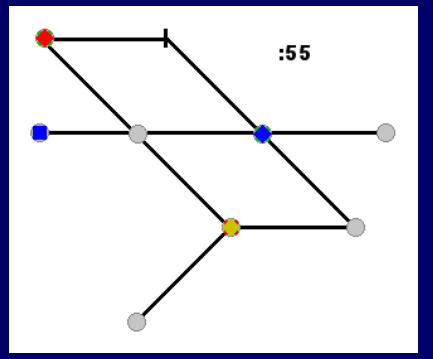
Public Transport Networks





Transport Networks 7.
András Gulyás PhD habil
associate professor

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- Principles of public transport
- Characteristics of public transport networks
- Planning of public transport networks
- Planning of public transport networks - Pécs
- Timetable planning of public transport
- Integration in urban public transport
- Management of urban public transport
- Regulation of urban public transport

Principles of public transport

Public transport (formerly mass transport or transit in the USA) 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 public transport

According to the data of the International Association of Public Transport (UITP) about 3.2 billion urban citizens daily perform 7.5 billion trips or motion, from these 16% (in Europe 15%) use public transport.

In order to promote sustainable development, this proportion shall be doubled by 2025. Assuming a global 50% growth in transport demand, this would mean triplicate of public transport trips.

This forecast provides a serious challenge to develop a more attractive public transport system.

Source: Vivier, J.: Millennium Cities Database for Sustainable Mobility. Analyses and Recommendations. UITP International Association of Public Transport

Principles of public transport

Public transport is economically the most effective solution above a population density of 20 people/ha.

A conscious parking policy may result in decreasing car usage and higher proportion of public transport trips.

In case of the modal split, the travel speed and travel time differences between car usage and public transport proved to be the most significant factor.

Low public transport fares are advantageous from a social point of view, however, it is not very important in changing from car to public transport.

Source: Vivier, J.: Millennium Cities Database for Sustainable Mobility. Analyses and Recommendations. UITP International Association of Public Transport

Principles of 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.

Principles of 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).

Characteristics of public transport networks

Some public transport related definitions:

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

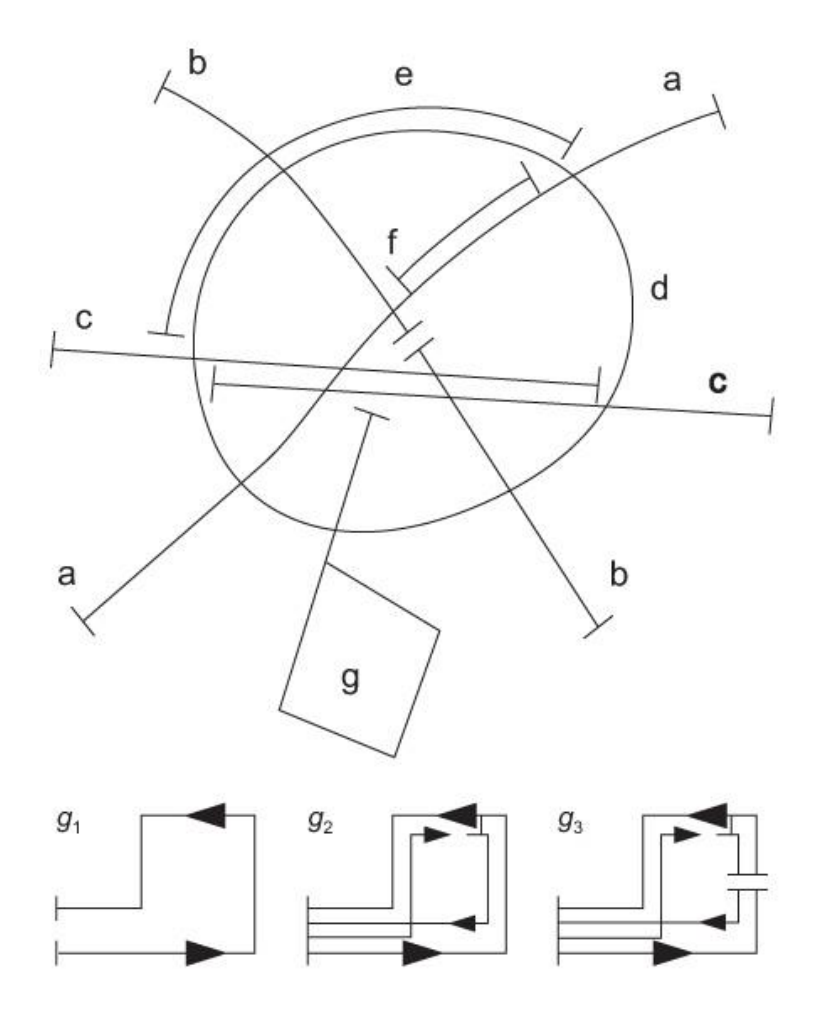
Route: part of the network where public transport is operated (physical).

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.

Characteristics 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**

Characteristics of public transport networks

Advantages and disadvantages of network elements

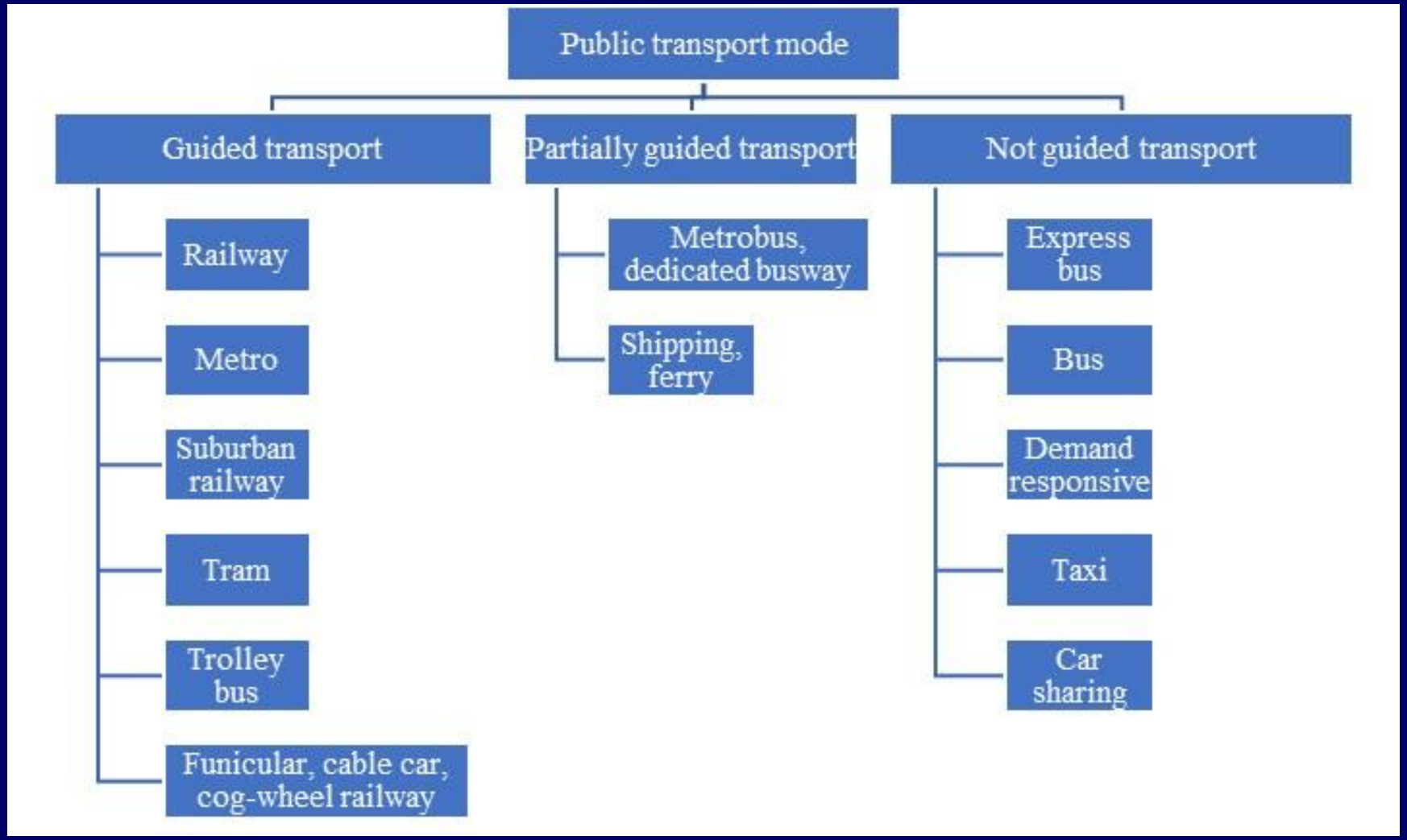
	Direct travel	Travel time	Use of capacity	Sensitivity	Area in centrum
Diagonal	+	-	-	-	+
Radial	-	+	+	+	-
Overlap	+	+	+	+	+
Circular	+	-	+	-	+
Loop-ended	+	-	+	-	+

Characteristics of public transport networks

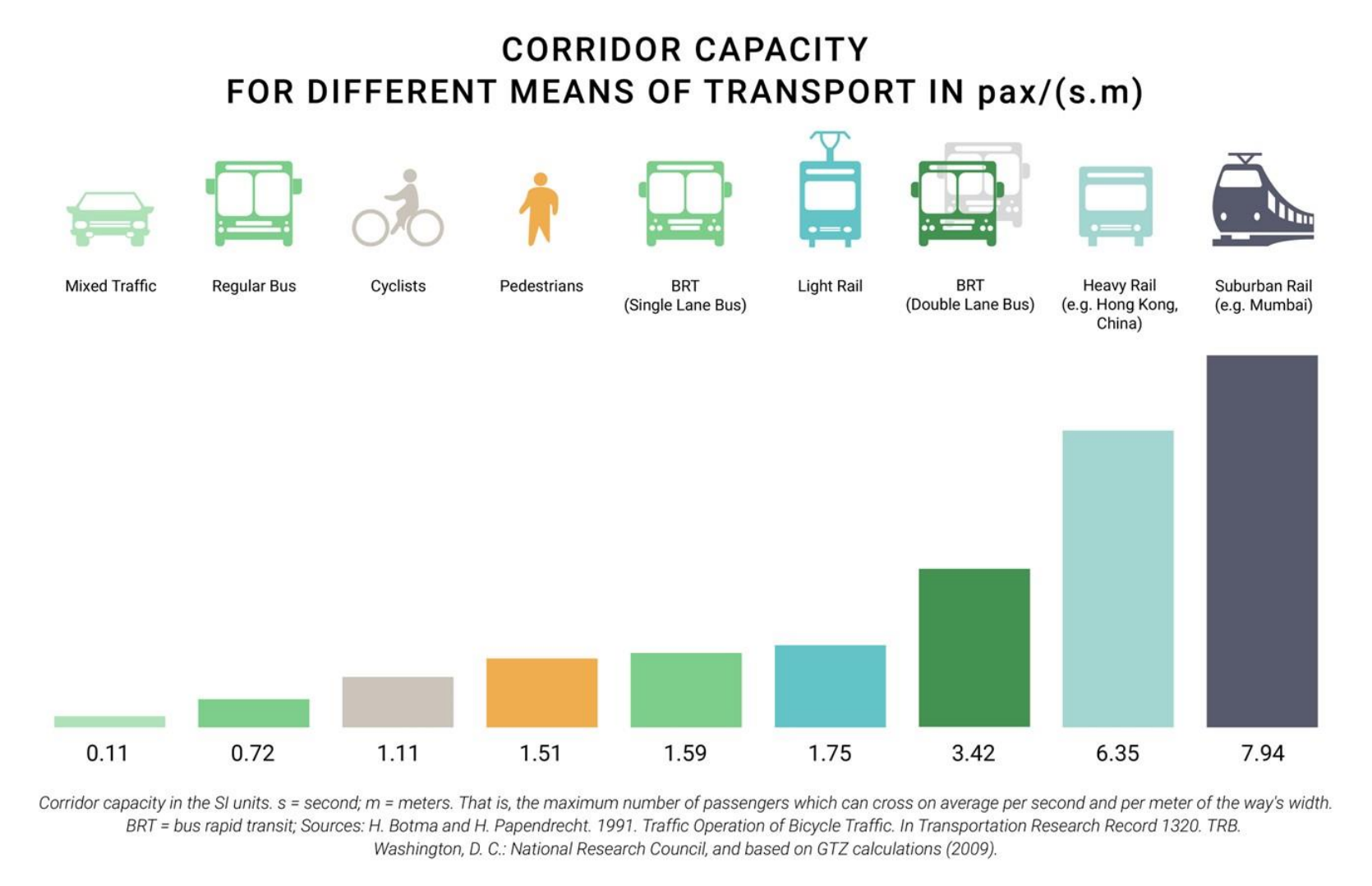
Qualitative and quantitative network characteristics

- **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**

Characteristics of public transport networks

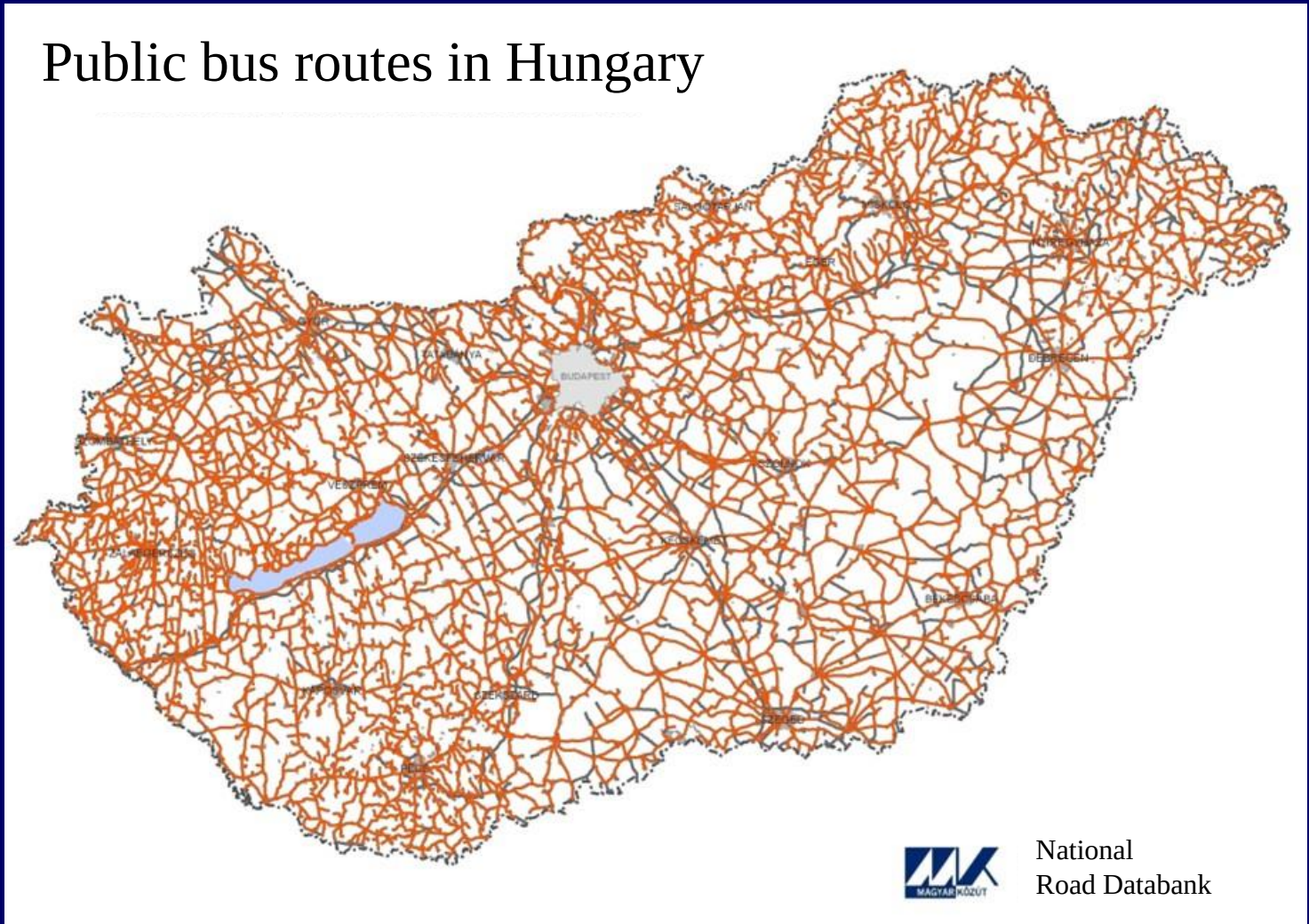


Characteristics of public transport networks

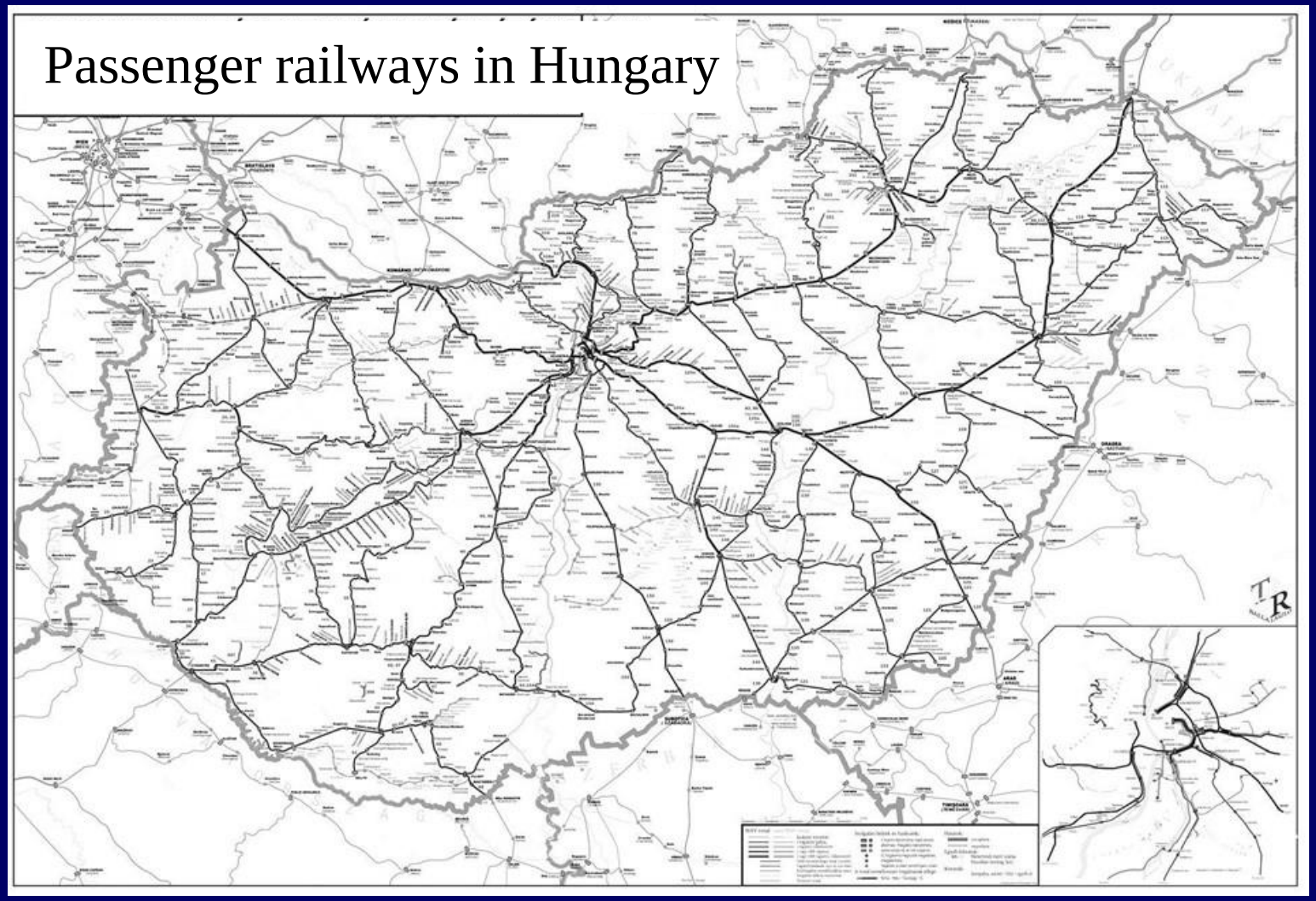


Source: https://upload.wikimedia.org/wikipedia/commons/3/3b/Corridor_Capacity.png

Characteristics of public transport networks



Characteristics of public transport networks



Planning of public transport networks

Planning of public transport network is similar to the four-stage 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 roster**

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

- **The public transport assignment determines routes between origin and destination zones for trips in the public transport traffic matrix layer, than assigns these trips to routes and sections.**
- **The result of the public transport assignment is the traffic and volume of passengers on public transport routes as well as the volume of passengers getting on and off at stops.**
- **The time element is very important as usually the public transport assignment is performed for the morning peak hour or peak period.**

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

$$C_{ij} = a_1 \cdot t_{ij}^{trav} + a_2 \cdot t_{ij}^{walk} + a_3 \cdot t_{ij}^{wait} + a_4 \cdot t_{ij}^{trans} + a_1 \cdot \delta + a_5 \cdot F_{ij}$$

where:

t_{ij}^{trav}	travel time (in vehicle) between zones „i” and „j”
t_{ij}^{walk}	sum of walking times to stop and from stop
t_{ij}^{wait}	waiting time at stop
t_{ij}^{trans}	time for transfer (if necessary)
δ	penalty for transfer (usually a few minutes)
F_{ij}	fare between zones „i” and „j”
$a_{1..5}$	weighing factors

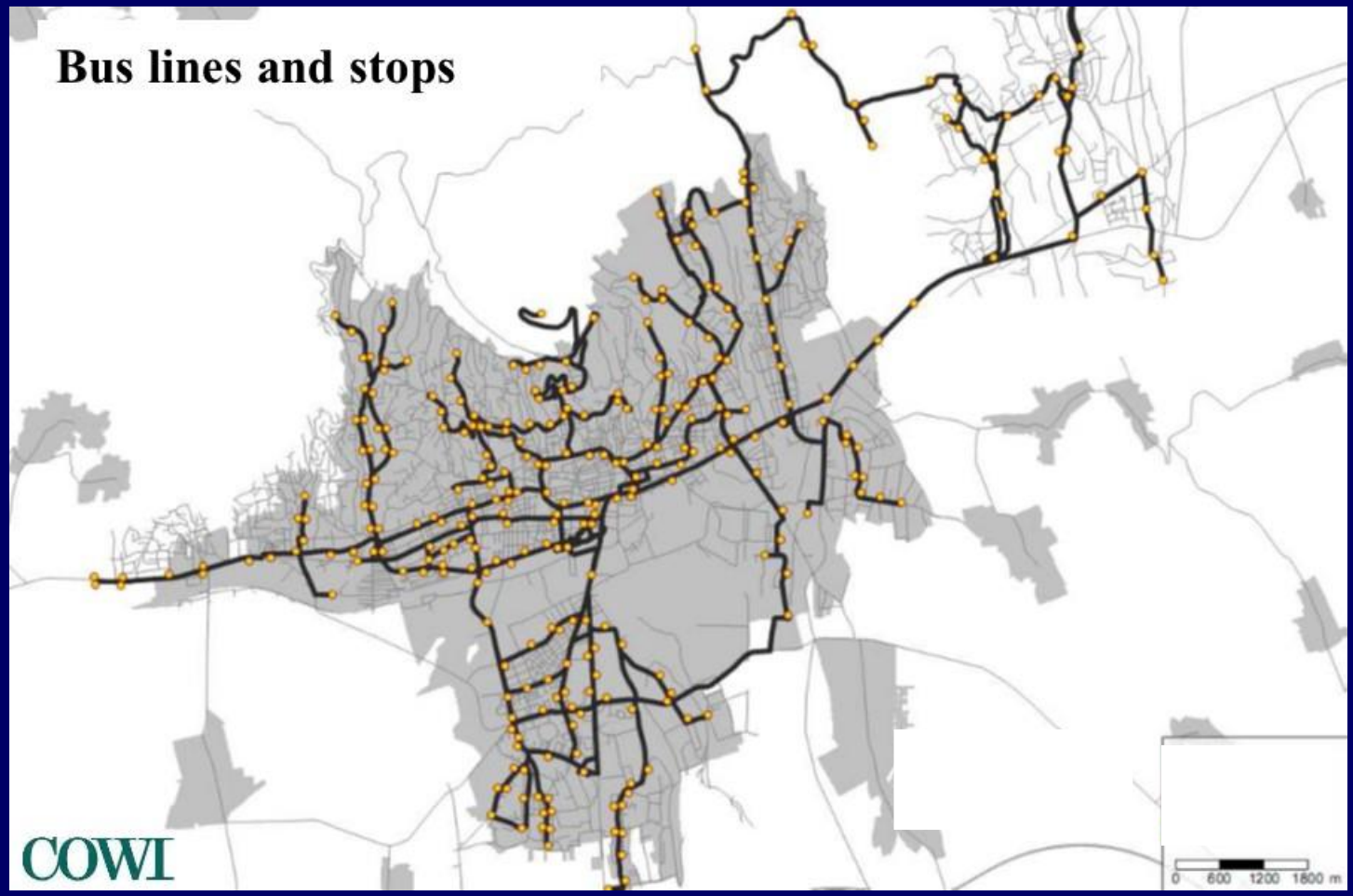
Planning of public transport networks - Pécs

Case study of public transport network planning:

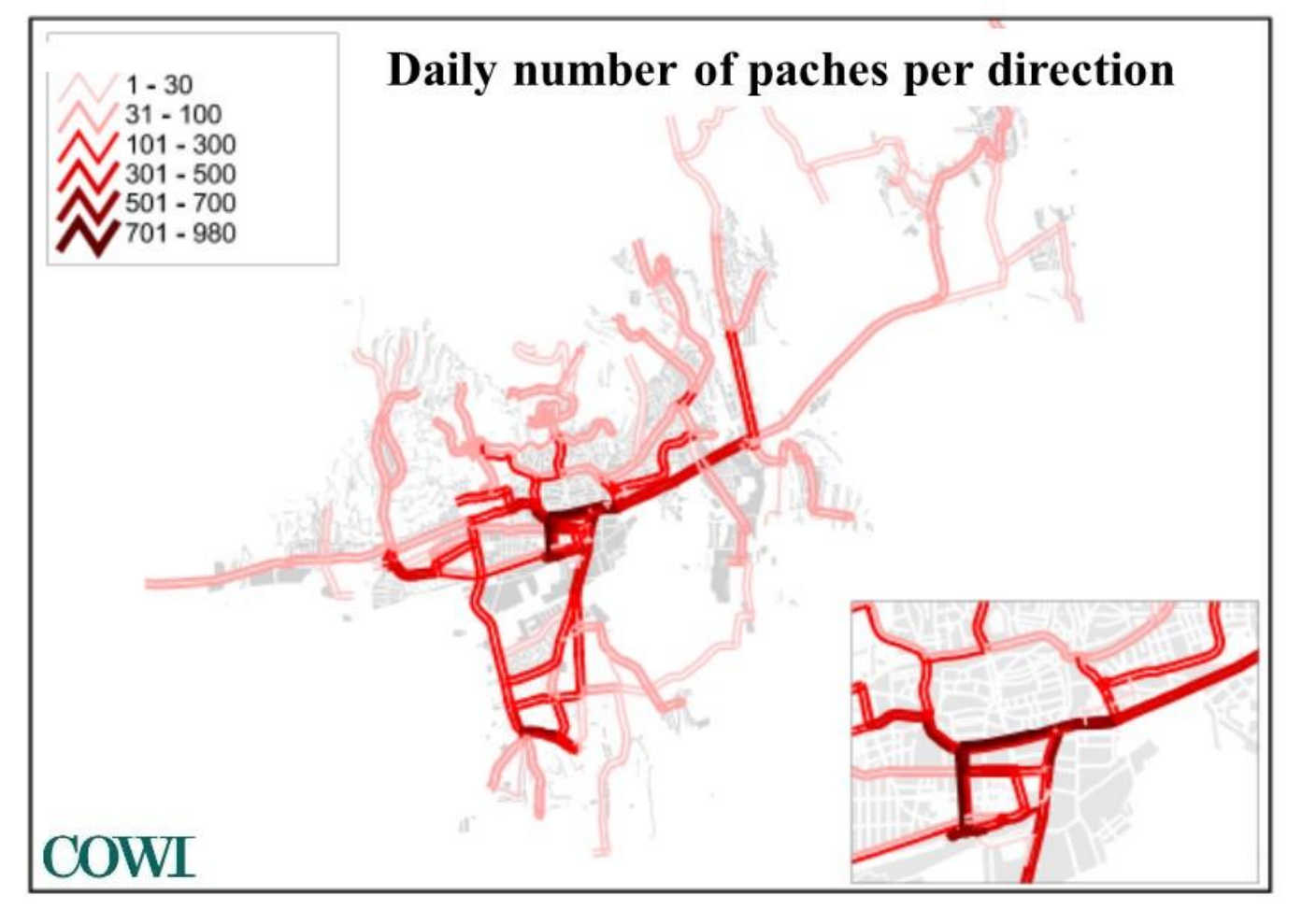
Long-term transportation development plan of Pécs and its neighbourhood - COWI Hungary Kft. 2010.

Study has been performed by planning software modelling.

Planning of public transport networks - Pécs



Planning of public transport networks - Pécs



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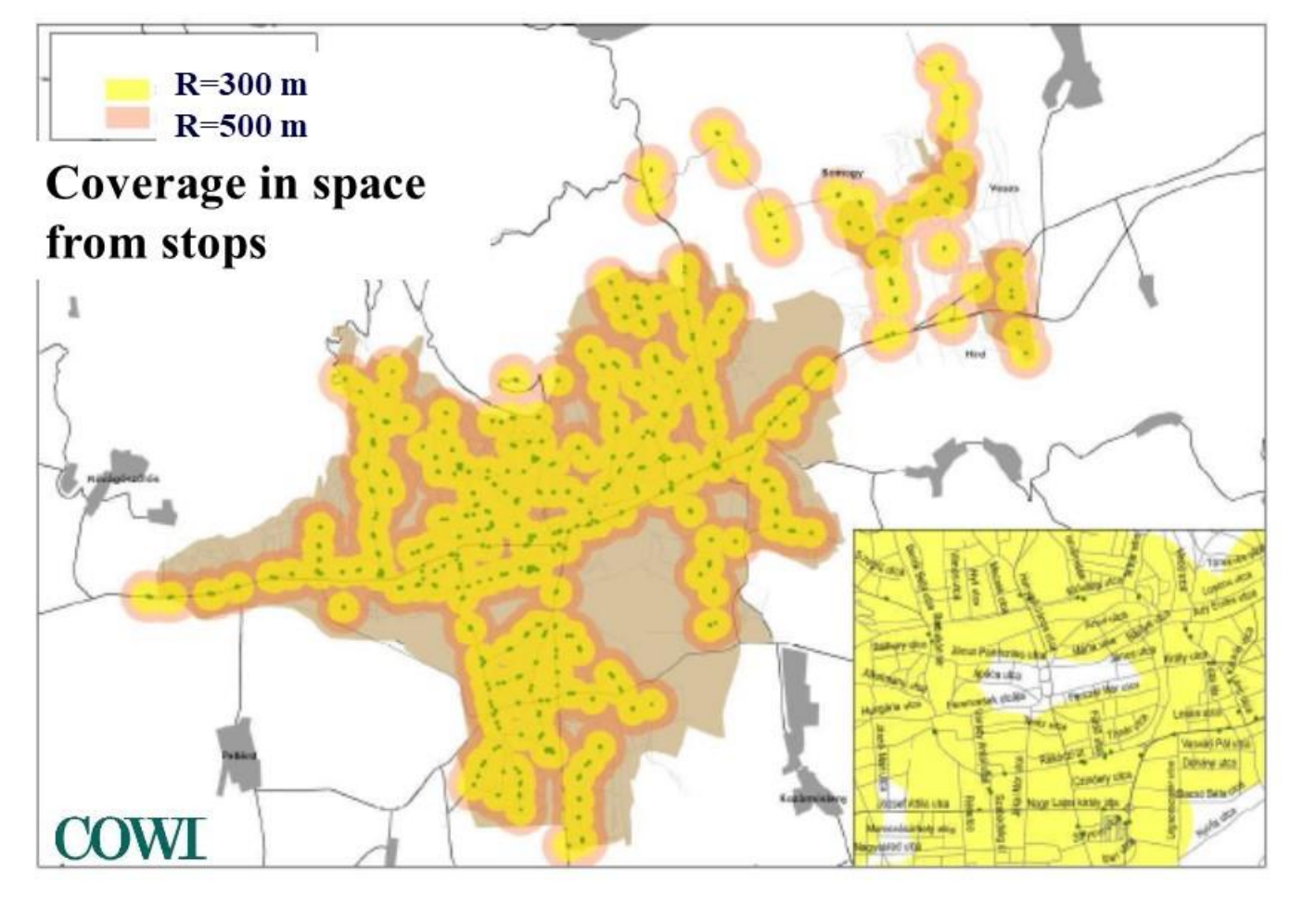

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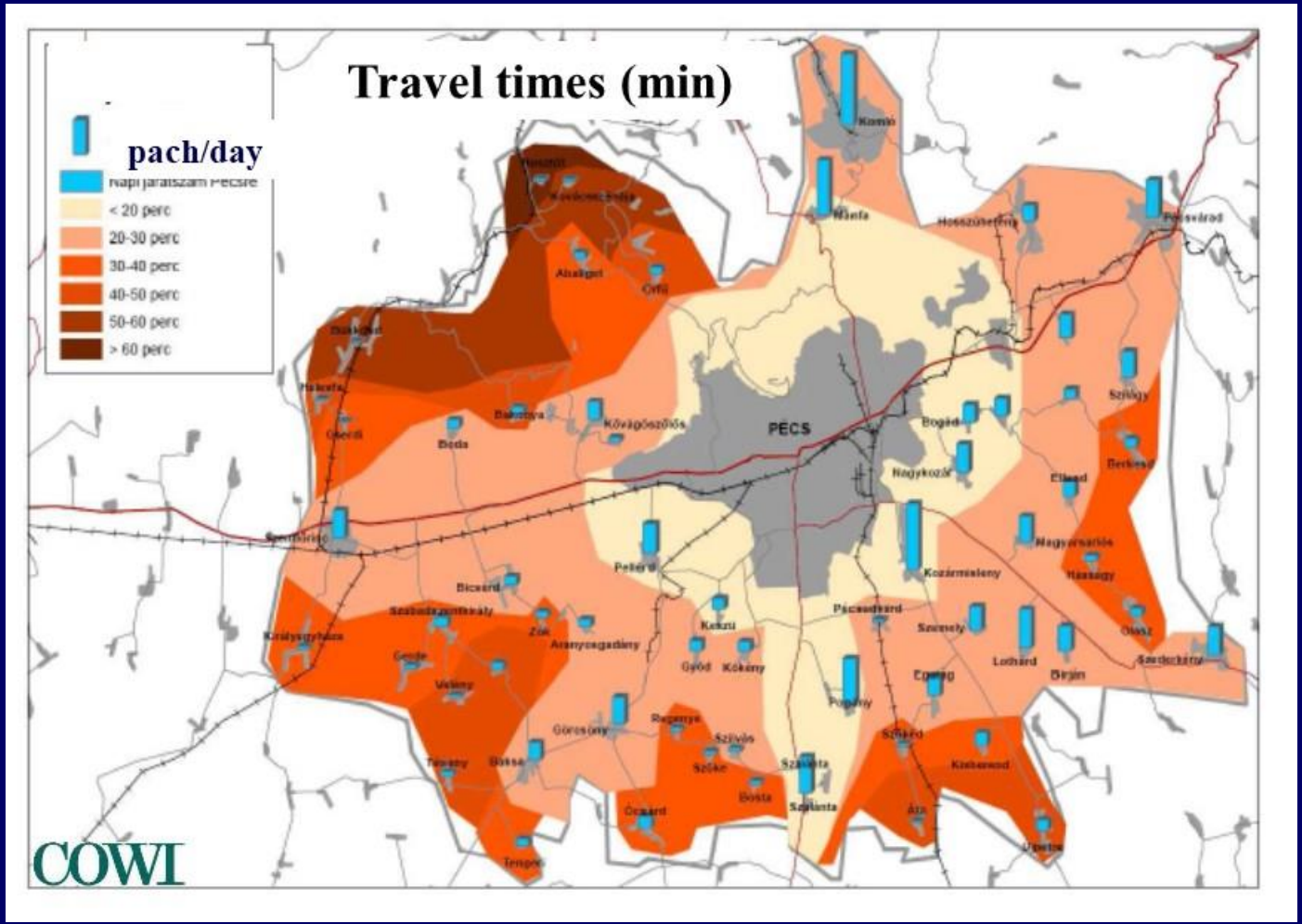

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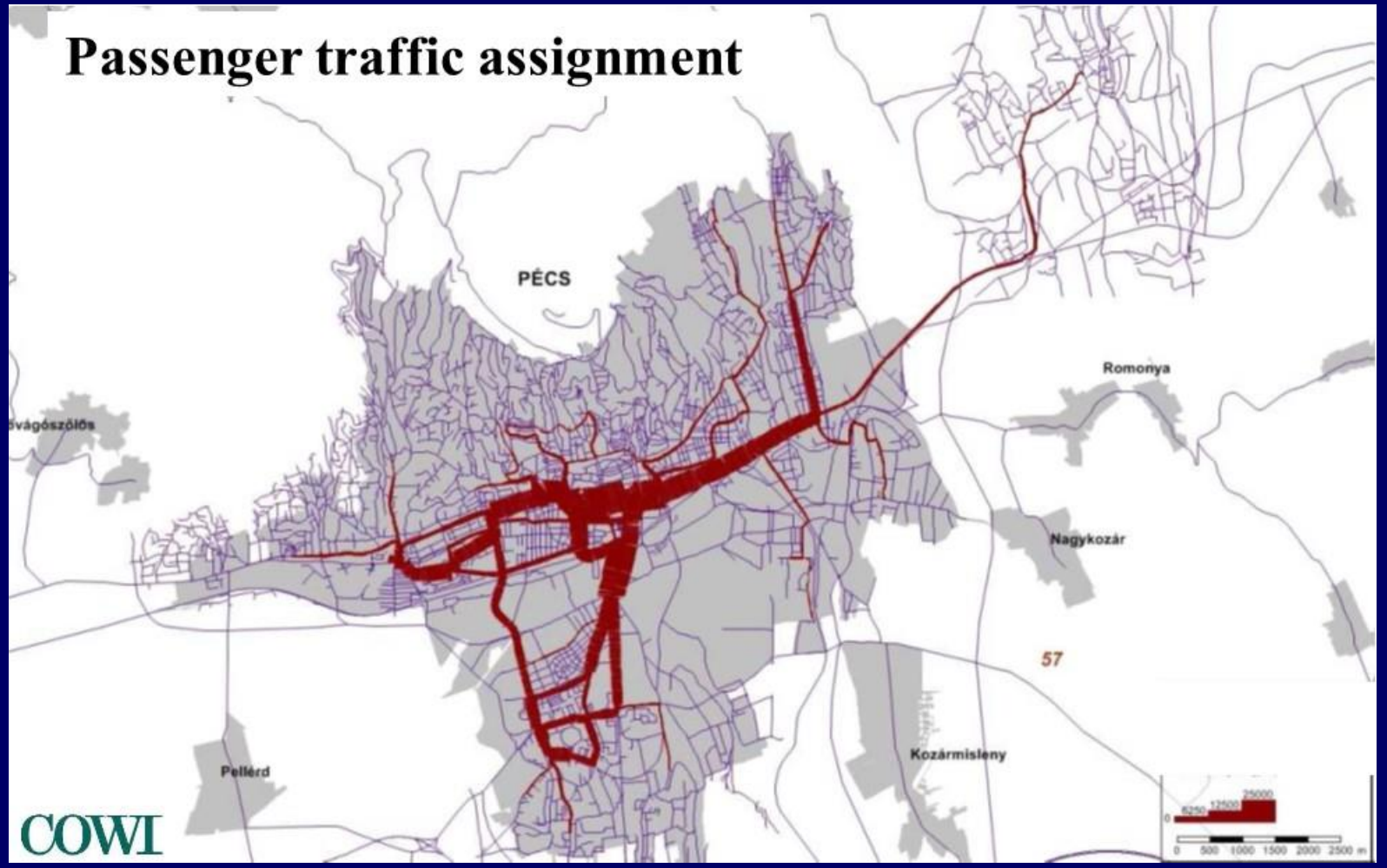

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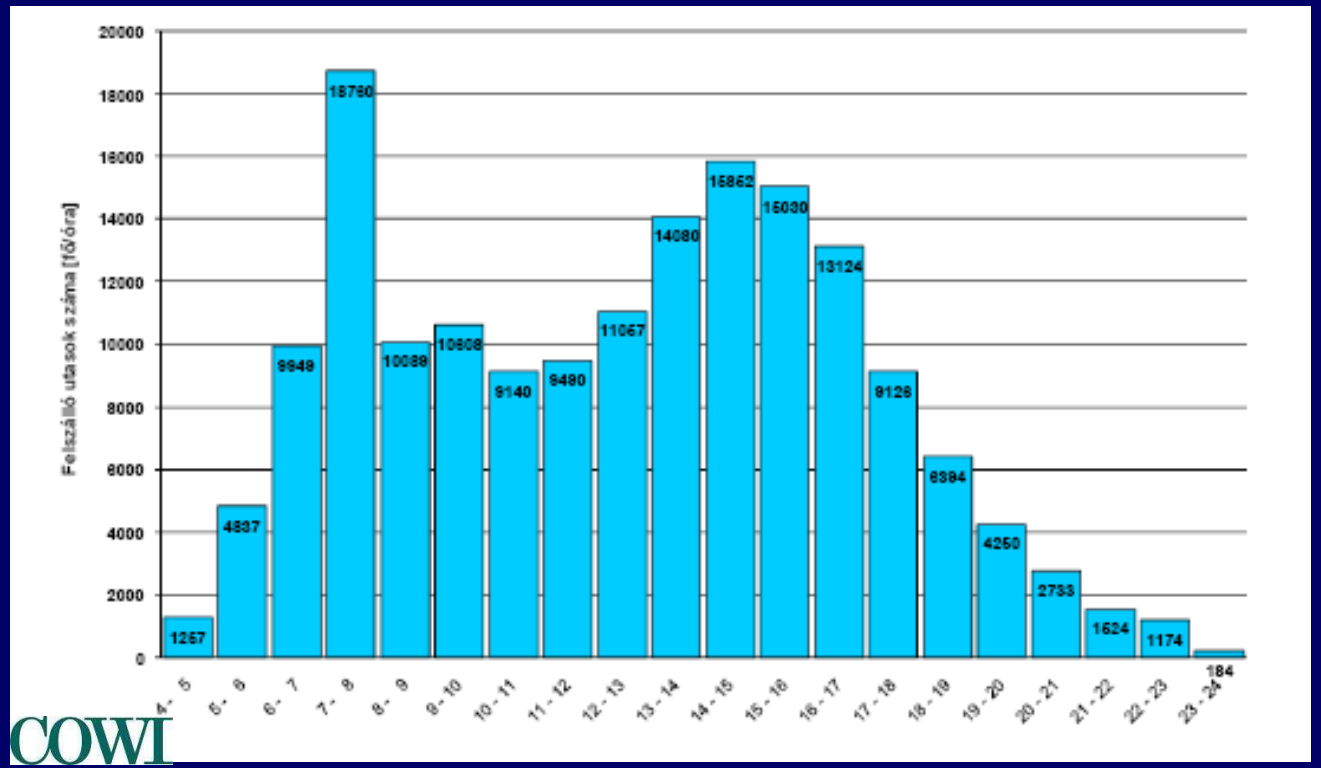
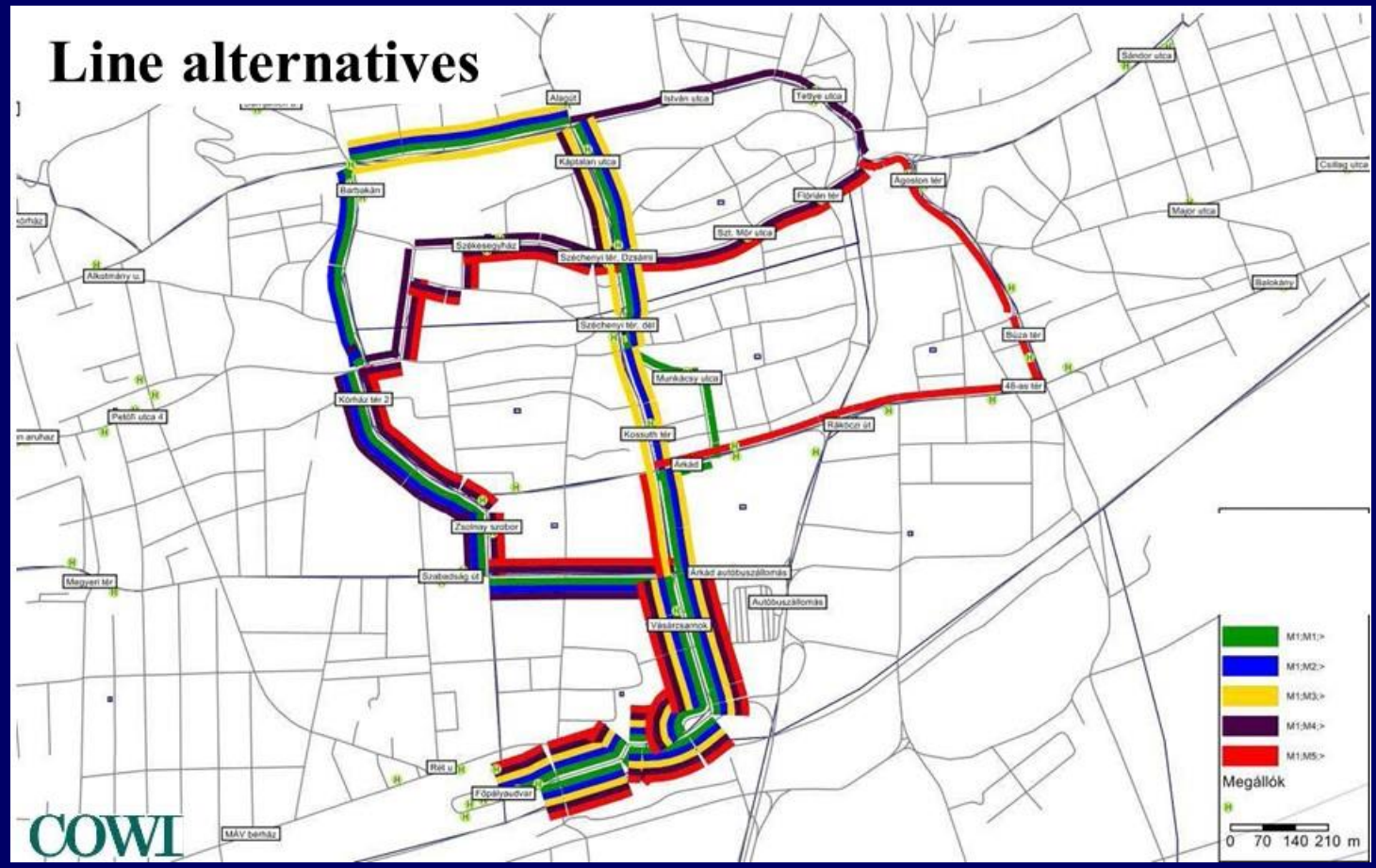


Number of passengers getting on at workdays

Planning of public transport networks - Pécs



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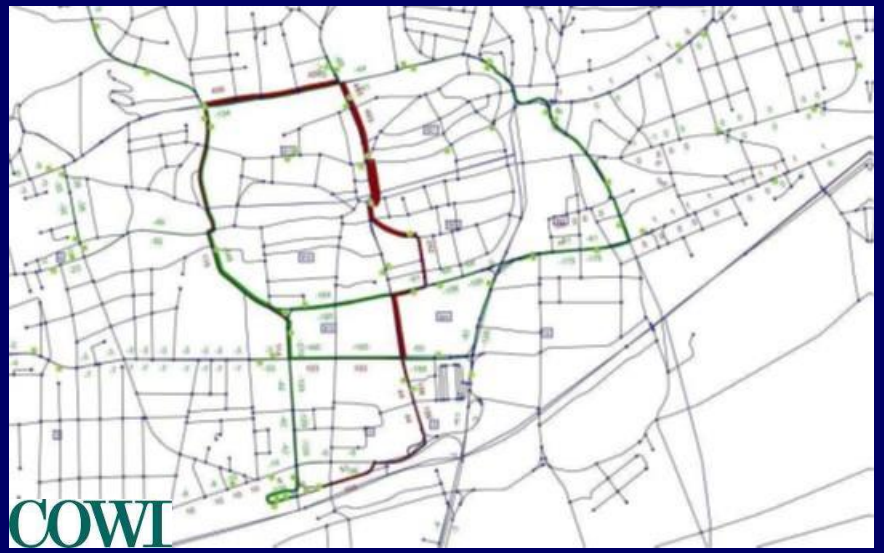


Passenger volumes at the line alternatives

Timetable planning of public transport

- **Parts of journey time:**
  - **useful journey time:** T_u
  - **staying time in stops:** T_{ss}
  - **journey time:** $T_j = T_u + T_{ss}$
  - **staying time at terminal:** T_{st}
  - **turnaround:** $T_f = 2T_j + 2T_{st}$
- **Design passenger volume: in the most crowded cross-section at peak hour or peak period (varying daily and hourly)**

Timetable planning of public transport

Paches required:

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

where:

- U_m **design passenger volume**
- N_k **vehicle capacity**
- α **saturation coefficient**

Line frequency:

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

where:

- **T: operation time**

Timetable planning of public transport

Vehicles required:

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

- **In case of roster design, the necessary driver rest times and the vehicle technical support time shall be taken into account.**
- **The reliability of the public transport system is affected my the probabilistic nature of journey times.**
- **The economical restraint and the level of service are in conflict, where an optimal solution shall be reached.**

Timetable planning of public transport

- **Numerical example:**
  - **design passenger volume in the morning peak period (150 min):**
    1800 passengers
  - **paches required, using buses for 100 passengers at 90% saturation rate:**
    1800 / (100 * 0,9) = 20 paches
  - **line frequency: 150 / 20 = 7,5 min**
  - **journey time: 16 min**
  - **staying time at terminal: 4 min**
  - **turnaround: 2 * 16 + 2 * 4 = 40 min**
  - **vehicles required: 40 / 7,5 = 5,33 ~ 6 buses**

Timetable planning of public transport

- **Connections in public transport (transfer and interchange):**
  - **within a sub-mode (i.e., bus) – transfer stop or terminal,**
  - **between different sub-modes (i.e., bus and railway) – public transport interchanges, railway stations,**
  - **between public transport and individual (personal car or bicycle) transport - P+R = park and ride, B+R = bike and ride.**
- **Special interest shall be given to routes and terminals of feeder buses, providing connection with guided transport sub-modes.**

Integration in urban public transport

- **Integrated public passenger transport services means interconnected transport services within a determined geographical area with a single information service, ticketing scheme and timetable.**
- **An integrated public transport network combines different transport modes to maximise ease and efficiency for passengers in terms of time, cost, comfort, safety, accessibility, and convenience, streamlining schedules, stops, fares, and passenger information.**

Integration in urban public transport

- **The integrated public transport system usually applies regular interval timetables (periodic or constant frequency timetable).**
- **The recommended organisational solution of an integrated public transport system is the transport association (linked transport system). Examples for transport associations:**
  - **IDS JMK - Integrovaný dopravní systém Jihomoravského kraje – Czech**
  - **IS - Transporto Integrato Alto Adige – Italy**
  - **ZVV - Zürcher Verkehrsverbund – Switzerland**
  - **VOR - Verkehrsverbund Ost-Region – Austria**

Integration in urban public transport

- **Regular interval timetable means constant frequency of a given public transport line, applying a constant headway (equal time periods) in both directions.**
- **In practical cases the frequency or interval can spread from 120 minutes (i.e., intercity trains between Pécs and Budapest) to 5 minutes or even less (usually 60, 30, 20, 15, 10, 7,5 or 5 min).**
- **The regular interval timetable provides for passengers a transparent, calculable, readily memorized time schedule. „Clockface" timing is easy to remember i.e., in leaving of paches in every hour at 0, 20 and 40 minutes.**

Source: Borza Viktor - István György - Kormányos László - Vincze Béla György: Integrált ütemes menetrend. Közlekedéstudományi Szemle 2007. 11. p. 402-416., 12. p. 450-465., 2008. 1. p. 33-53. (in Hungarian)

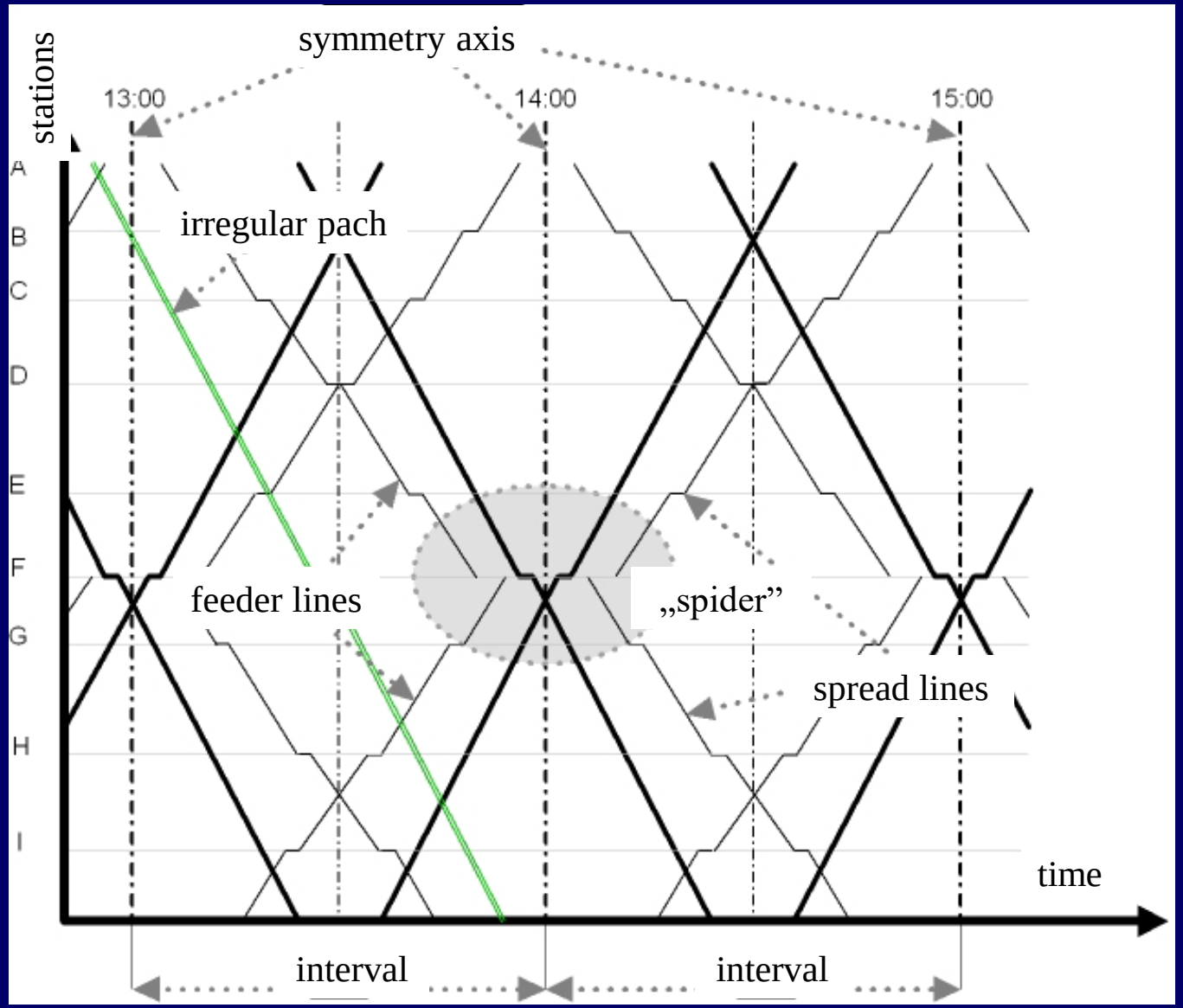
Integration in urban public transport

- **Regular interval timetable provides a clear transfer system at network interchanges, since vehicles arrive at the same time from various directions (and leave at the same time as well).**
- **In the time-space diagram of a graphical timetable this is called a „spider”, consisting of two phases:**
  - **incoming or arriving vehicles – collection or feeder phase,**
  - **outcoming or leaving vehicles – distribution or spread phase.**
- **This type of scheduling provides transfer possibilities for each direction pair within the network.**

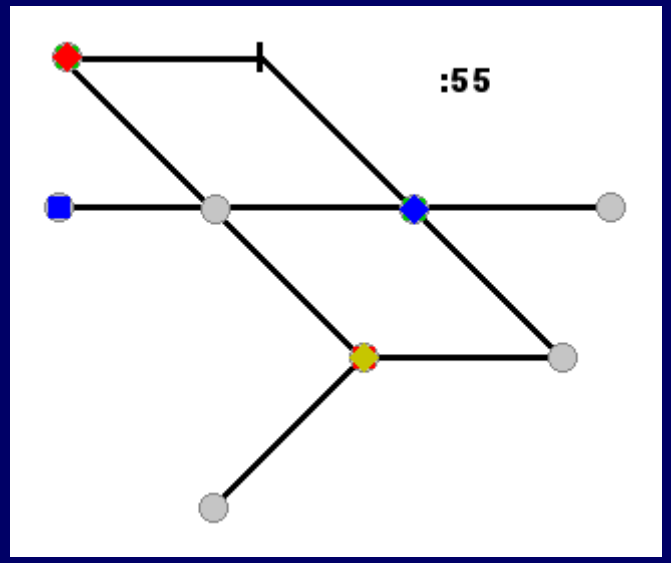
Source: Borza Viktor - István György - Kormányos László - Vincze Béla György: Integrált ütemes menetrend. Közlekedéstudományi Szemle 2007. 11. p. 402-416., 12. p. 450-465., 2008. 1. p. 33-53. (in Hungarian)

Integration in urban public transport

„Spider” timetable



Integration in urban public transport



„Spider” animation: Knooppuntdienstregeling.gif

Source: Borza Viktor - István György - Kormányos László - Vincze Béla György: Integrált ütemes menetrend. Közlekedéstudományi Szemle 2007. 11. p. 402-416., 12. p. 450-465., 2008. 1. p. 33-53. (in Hungarian)

Integration in urban public transport

- **Transport association – challenges in Germany:**
  - **accurate survey of passenger demands in order to increase the number of public transport trips,**
  - **attractive tariffs and active communication,**
  - **co-ordination of everyday operation,**
  - **co-ordination with long-term development plans,**
  - **efficient organisational model,**
  - **focusing on financial issues and cost reduction.**

Integration in urban public transport

- **Transport association – main tasks:**
  - **establishment of a unified tariff policy, as well as its acceptation and further development,**
  - **distribution of incomes,**
  - **determination of frames of ticket selling systems,**
  - **co-ordination of timetables,**
  - **management of travel information,**
  - **marketing and PR (public relations),**
  - **announcement of transport tenders, their assessment and contracting.**

Integration in urban public transport

- **Transport association – organisational forms:**
  - **Entrepreneurs' association – unification of transport companies operating in a given region.**
  - **Mixed association − unification of transport companies and purchasers.**
  - **Purchasers' association − the transport association is the purchaser of the private transport companies.**

Management 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.**

Management of urban public transport

- **Public transport network development**
  - **Better space coverage**
    - **better supply, rationalisation**
    - **less transfer**
    - **P+R, B+R**
  - **Better time coverage**
    - **operation time**
    - **higher frequency**

Management of urban public transport

- Management, preference, travel time decrease
  - Signals at junctions
    - providing green time
  - Infrastructure development
    - bus lock
    - transit corridor
  - Accuracy
    - traffic management

Management of urban public transport

- Intermodality
  - better transfer
  - co-operation of operators
- Comfort and quality
  - On vehicles
    - comfort, cleanness, disabled friendly
  - In stops
    - waiting condition: roof, seat, lighting
    - disabled friendly access

Management of urban public transport

- **Better passenger information**
  - **Based on static data**
    - **transfer, 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**

Management of urban public transport

Passenger information

Real-time system based on GPS fleet management

Pécs Kertváros bus terminal

COWI

Management of urban public transport

In case of smaller population density the public transport can be provided by a flexible Demand Responsive Transport (DRT).

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.

Source: http://en.wikipedia.org/wiki/Demand_responsive_transport

Management of urban public transport

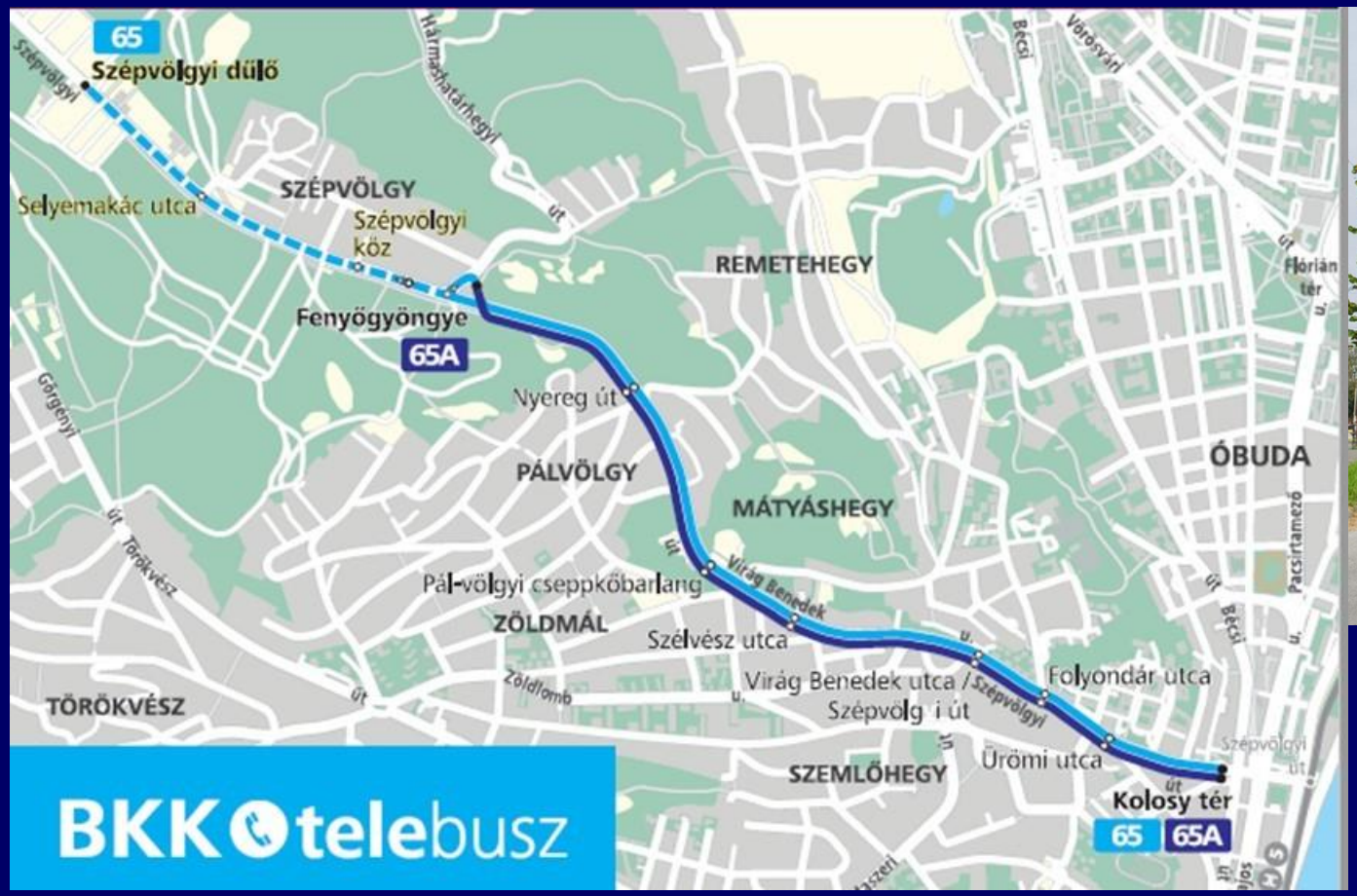
DRT example: RadioBus – in the Czech Republic at some cities with predefined routes and timetables, smaller vehicles.

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.

Source: http://www.audis.cz/en-info.htm

Management of urban public transport

Budapest – demand responsive transport at hilly areas



Uphill – demand at driver

Downhill – demand by phone or internet 30 minutes before

Source: https://bkk.hu/utazasi-informaciok/kozossegi-kozlekedes/telebusz/

Regulation of urban public transport

- **Regulation of the public transport as a public service in the European Union:**
- **Regulation (EC) No 1370/2007 of the European Parliament and of the Council of 23 October 2007 on public passenger transport services by rail and by road and repealing Council Regulations (EEC) Nos 1191/69 and 1107/70**
- **In Hungary: Act 2012. XLI. on passenger transport services**

Regulation of urban public transport

- **The purpose of the EU Regulation is to define how, in accordance with the rules of Community law, competent authorities may act in the field of public passenger transport to guarantee the provision of services of general interest which are among other things more numerous, safer, of a higher quality or provided at lower cost than those that market forces alone would have allowed.**

Regulation of urban public transport

- To this end, this Regulation lays down the conditions under which competent authorities, when imposing or contracting for public service obligations, compensate public service operators for costs incurred and/or grant exclusive rights in return for the discharge of public service obligations.
- This Regulation shall apply to the national and international operation of public passenger transport services by rail and other track-based modes and by road, except for services which are operated mainly for their historical interest or their tourist value.

Regulation of urban public transport

- **In order to prevent overcompensation, in the case of public service contracts awarded, the parameters (on the basis of which the compensation payment is to be calculated) shall be determined in such a way that no compensation payment may exceed the amount required to cover the net financial effect on costs incurred and revenues generated in discharging the public service obligations, taking account of revenue relating there to kept by the public service operator and a reasonable profit.**

Regulation of urban public transport

- **Public service contracts and general rules shall clearly define the public service obligations with which the public service operator is to comply, and the geographical areas concerned.**
- **Public service obligation means a requirement defined or determined by a competent authority in order to ensure public passenger transport services in the general interest that an operator, if it were considering its own commercial interests, would not assume or would not assume to the same extent or under the same conditions without reward.**

Regulation of urban public transport

- In Hungary the legal regulation does not define the transport association but rather it establishes the notion of the „transport organiser” in a broader sense.
- Any municipality may choose a transport organiser for fulfilling tasks determined in the legal regulation. After a successful procurement, the municipality transfers the necessary resources to the transport organiser.
- In Budapest, the transport organiser is the Centre for Budapest Transport, responsible for the operation and development of the public transport.

Summary

- 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-stage traffic planning procedure, completed by the timetable planning.
- An integrated public transport network combines different transport modes to maximise ease and efficiency for passengers.
- Competitiveness of public transport against car usage is determined by the level of service.

Thank you for your attention!

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