



SH Transport operation course  
BMEKOKUM206

# Interoperability and other smart transport solutions from European cities

Miklós KÓZEL

Tamás SOLTÉSZ

St. 426.

[kozel.miklos@mail.bme.hu](mailto:kozel.miklos@mail.bme.hu),  
[soltesz.tamas@mail.bme.hu](mailto:soltesz.tamas@mail.bme.hu)

[www.kukg.bme.hu](http://www.kukg.bme.hu)

# Contents

- ⦿ Interoperability and intermodality in general
- ⦿ Interoperability and –modality: infrastructure
- ⦿ Interoperability and –modality: vehicle
- ⦿ Other smart transport solutions
- ⦿ Examples in the field of bicycle transport

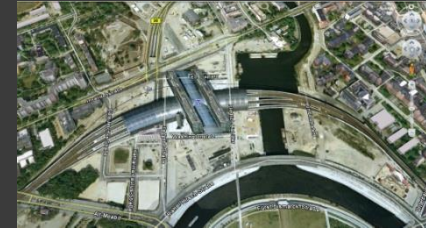
# 1. Interoperability and intermodality in general

- Intermodality:  
Connection of transport modes/vehicles to create integrated travel chains
- Interoperability:  
Technical and organizational cooperation between different transport modes (a criteria of intermodality)
- The most attractive solution is when a vehicle can use two different transportation systems
  - comfortable, fast, short transfers should be provided in case of impossible cooperation
  - physically integrated, interoperable (cooperative) systems (e.g. bimodal veh.)
  - transfers can be avoided; reliable, fast travels can be realized
  - the same comfort level like a door-to-door private ride has
  - passengers don't have to give up the seats they took in the suburbs
  - achievements of the operators (diametrical lines, less unnecessary kilometers driven to depots, etc.)
  - timetable should also fit to intermodal systems (who waits?)

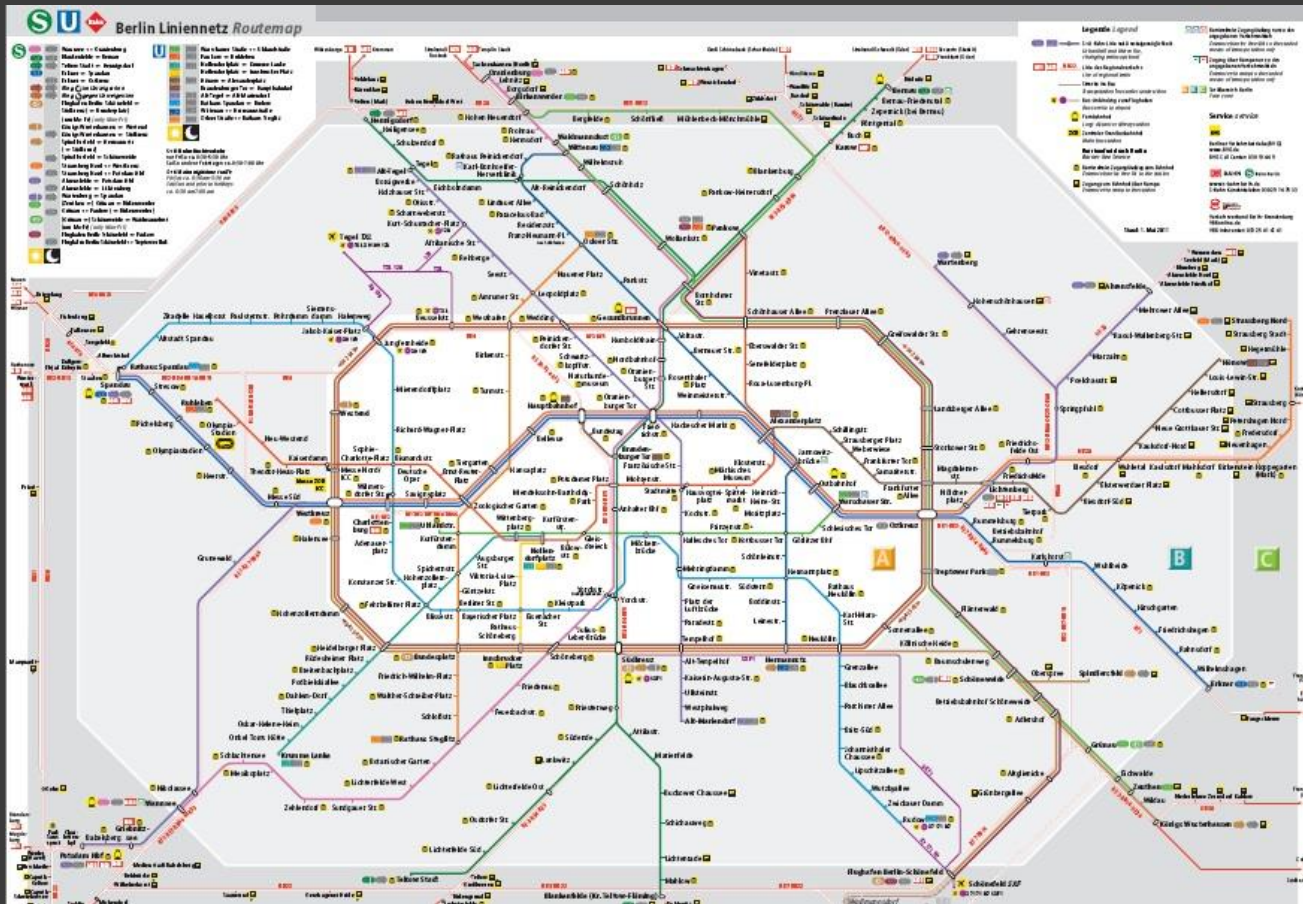
## 2. Interoperability and –modality: infrastructure

- Berlin Hauptbahnhof (Berlin)
  - The main station of Berlin (2006) is the best example to interoperability and intermodality („everything at the same place”)
    - location of the main station, part of the transportation network

# Berlin Hauptbahnhof



# Berlin Hauptbahnhof



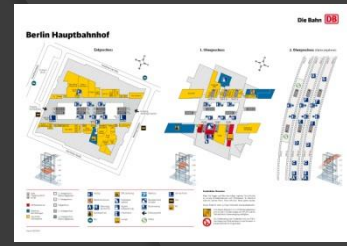
[Interoperabilitáshoz\BVG S+U-Bahn\\_0105\\_2011.pdf](#)

## 2. Interoperability and –modality: infrastructure

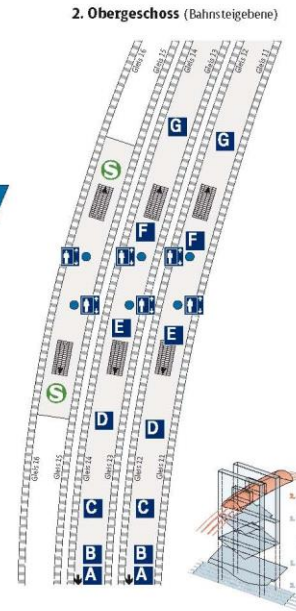
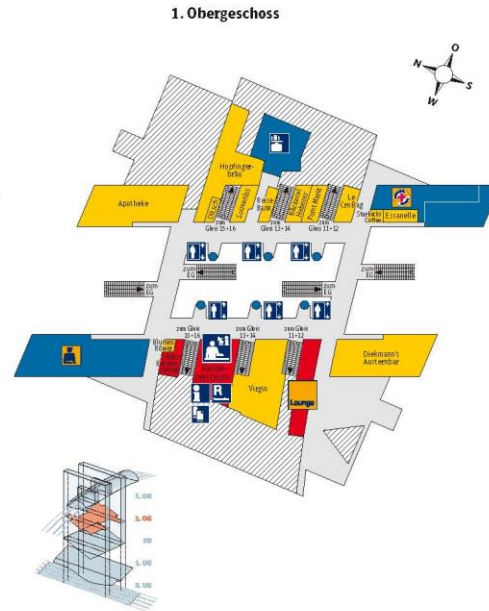
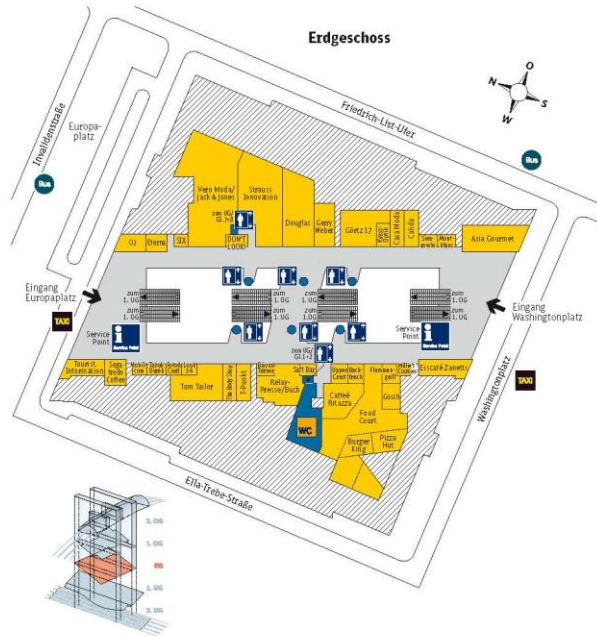
### ○ Berlin Hauptbahnhof (Berlin)

- The main station of Berlin (2006) is the best example to interoperability and intermodality („everything and the same place”)
  - location of the main station, part of the transportation network
  - "interoperable station", third rail and overhead wire at the same place
  - functioning as a junction (international, long-distance, regional, S-Bahn, U-Bahn, bus)
  - easy to change modes (like a „shopping center”, airport terminal)
  - 5 storey building

# Berlin Hauptbahnhof



## Berlin Hauptbahnhof



- |                            |                                   |                     |                    |                       |               |
|----------------------------|-----------------------------------|---------------------|--------------------|-----------------------|---------------|
| oben Treppenauftritt unten | 2. Obergeschoss (Bahnsteigebene)  | Aufzug              | DB Carsharing      | Parkhaus              | Service Point |
| 1. Obergeschoss            | Erdgeschoss                       | Bahnhofsmission     | Fahrkartenaufkauf  | Reisezentrum/Schalter | Taxi          |
| DB Reiseservice            | 1. Untergeschoss                  | Bahnsteigabschritte | Gepäckaufbewahrung | Reservierung          | WC            |
| Bahnhofs-einrichtungen     | 2. Untergeschoss (Bahnsteigebene) | Bundespolizei       | Information        | Richtungspfeil        |               |
| Geschäft, Gastronomie      |                                   | Bus                 | Lounge             | S-Bahn                |               |

### Zusätzliche Hinweise

Wenn Sie Fragen und Wünsche haben, wenden Sie sich bitte an unsere Mitarbeiterinnen und Mitarbeiter im Bahnhof oder am Service Point. Hier hilft man Ihnen gerne weiter. Dieser Bahnhof wird zu Ihrer Sicherheit kameraüberwacht.

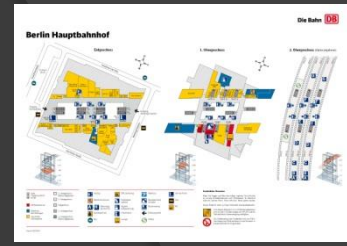
Auf diesem Bahnhof ist in Publikumsbereichen und auf den ICE Bahnsteigen ein WLAN Service für kabellosen Internetzugang verfügbar.

Zur Verbesserung der Sauberkeit und aus Rücksichtnahme auf Nichtraucher ist das Rauchen in diesem Bahnhof nicht gestattet.



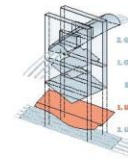
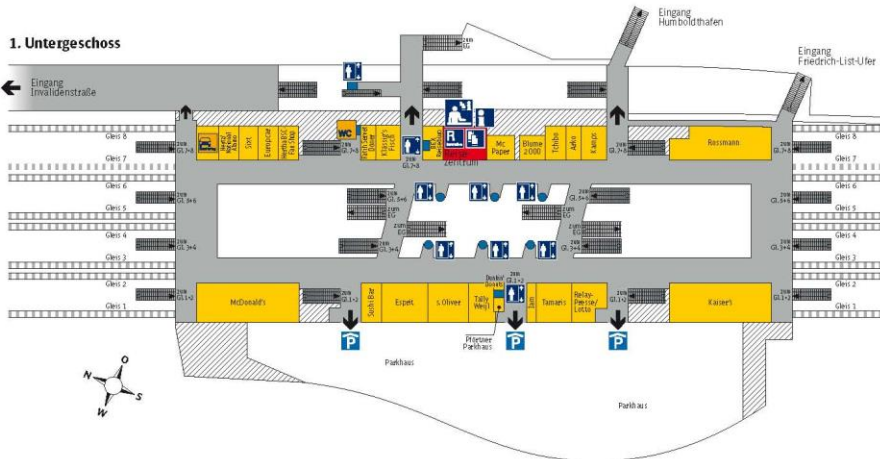


# Berlin Hauptbahnhof

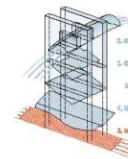
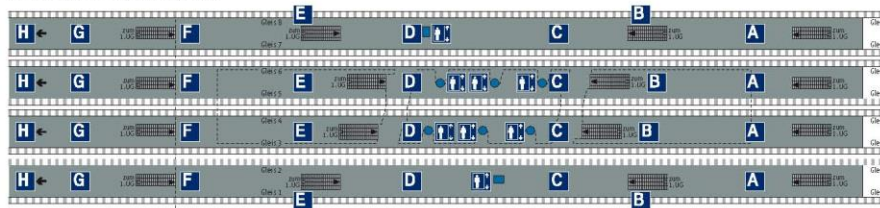


## Berlin Hauptbahnhof

### 1. Untergeschoss



### 2. Untergeschoss (Bahns teigebene)



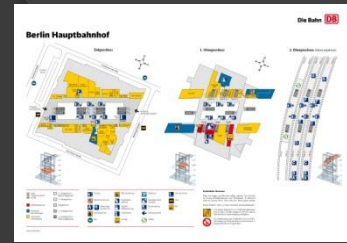
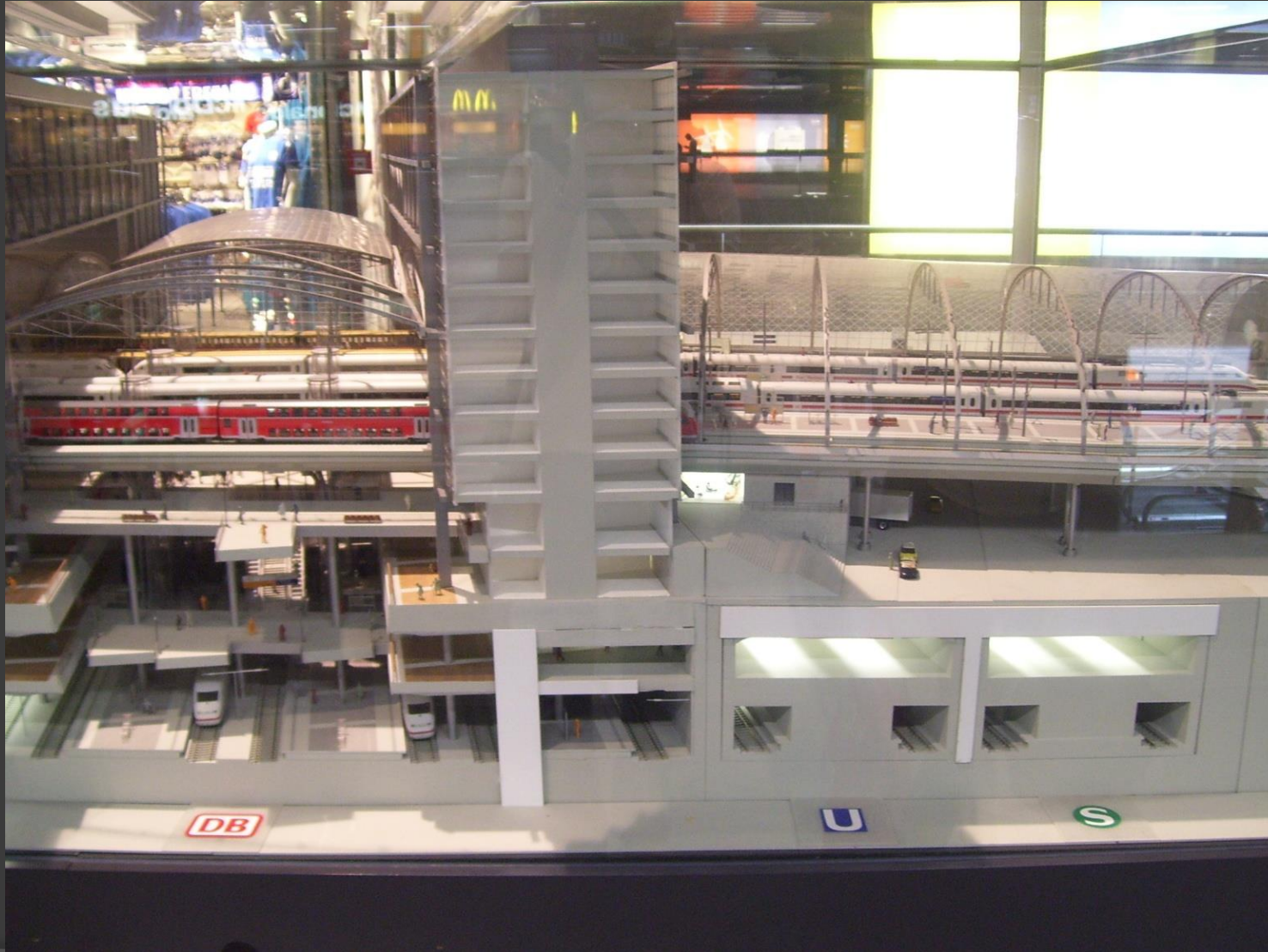
- |  |                                  |  |                                      |
|--|----------------------------------|--|--------------------------------------|
|  | oben<br>Treppenauftritt<br>unten |  | 2. Obergeschoss<br>(Bahns teigebene) |
|  | DB Reiseervice                   |  | 1. Obergeschoss                      |
|  | Bahnhofs-<br>einrichtungen       |  | Erdgeschoss                          |
|  | Geschäfte,<br>Gastronomie        |  | 1. Untergeschoss                     |
|  | Aufzug                           |  | Lounge                               |
|  | Bahnhofsmit-<br>telstation       |  | Parkhaus                             |
|  | Bahnsteig-<br>abschnitte         |  | Polizeizentrum/<br>Schalter          |
|  | Bundespolizei                    |  | Reservierung                         |
|  | Bus                              |  | Richtungspfeil                       |
|  | DB Carsharing                    |  | S-Bahn                               |
|  | Fahrkarten-<br>verkauf           |  | Service Point                        |
|  | Gepäck-<br>aufbewahrung          |  | Taxi                                 |
|  | Information                      |  | WC                                   |

#### Zusätzliche Hinweise

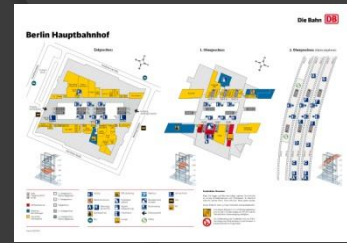
- Wenn Sie Fragen und Wünsche haben, wenden Sie sich bitte an unsere Mitarbeiterinnen und Mitarbeiter im Bahnhof oder am Service Point. Hier hilft man Ihnen gerne weiter.
- Dieser Bahnhof wird zu Ihrer Sicherheit kameraüberwacht.
- Auf diesem Bahnhof ist in Publikumsbereichen und auf den ICE Bahnsteigen ein W-LAN Service für kabellosen Internetzugang verfügbar.
- Zur Verbesserung der Sauberkeit und aus Rücksicht auf Nichtraucher ist das Rauchen in diesem Bahnhof nicht gestattet.



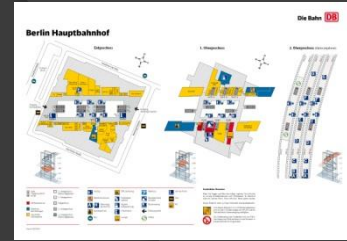
# Berlin Hauptbahnhof



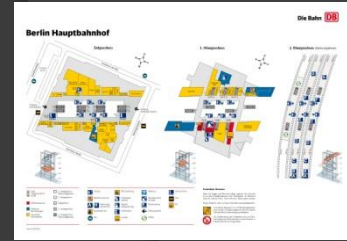
# Berlin Hauptbahnhof



# Berlin Hauptbahnhof



# Berlin Hauptbahnhof



## 2. Interoperability and –modality: infrastructure

### ○ Berlin Hauptbahnhof (Berlin)

- The main station of Berlin (2006) is the best example to interoperability and intermodality („everything and the same place”)
  - location of the main station, part of the transportation network
  - "interoperable station", third rail and overhead wire at the same place
  - intermodal junction (international, long-distance, regional, S-Bahn, U-Bahn, bus)
  - easy to change mode (like a „shop”)
  - 5 storey building
  - 8 tracks downstairs  
4+2 upstairs
  - special roof construction method



## 2. Interoperability and –modality: infrastructure

- København H (Copenhagen), Hamburg Hbf (Hamburg)
  - Conditions of intermodality are met here too
    - overpass stations
    - international, long-distance, suburban (S-Tog and S-Bahn), private (pl. Metronom) and Oresundstag (DSBFirst) railways at the same place
    - suburban trains operate generally on side tracks (short walking distances)

# København H, Hamburg Hbf





# København H, Hamburg Hbf



# København H, Hamburg Hbf



# København H, Hamburg Hbf



# København H, Hamburg Hbf



# København H, Hamburg Hbf



## 2. Interoperability and intermodality of infrastructure

- ◎ Stuttgart: conversion of tramways to Stadtbahn
  - The city started to develop a new rapid transit system from the 1960's
    - conventional metro system was rejected
    - there are both surface-level and underground sections
    - high-floor vehicles with high platforms at most stations
    - conversion has been lasted for decades
    - compatibility was kept with the narrow-gauge tram system

# Stuttgart: Stadtbahn and tram



# Stuttgart: Stadtbahn and tram



(C) Hamster, <http://hampage.hu/>





# Stuttgart: Stadtbahn and tram



# Stuttgart: Stadtbahn and tram



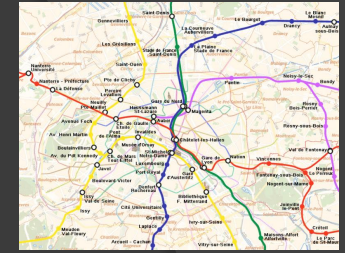
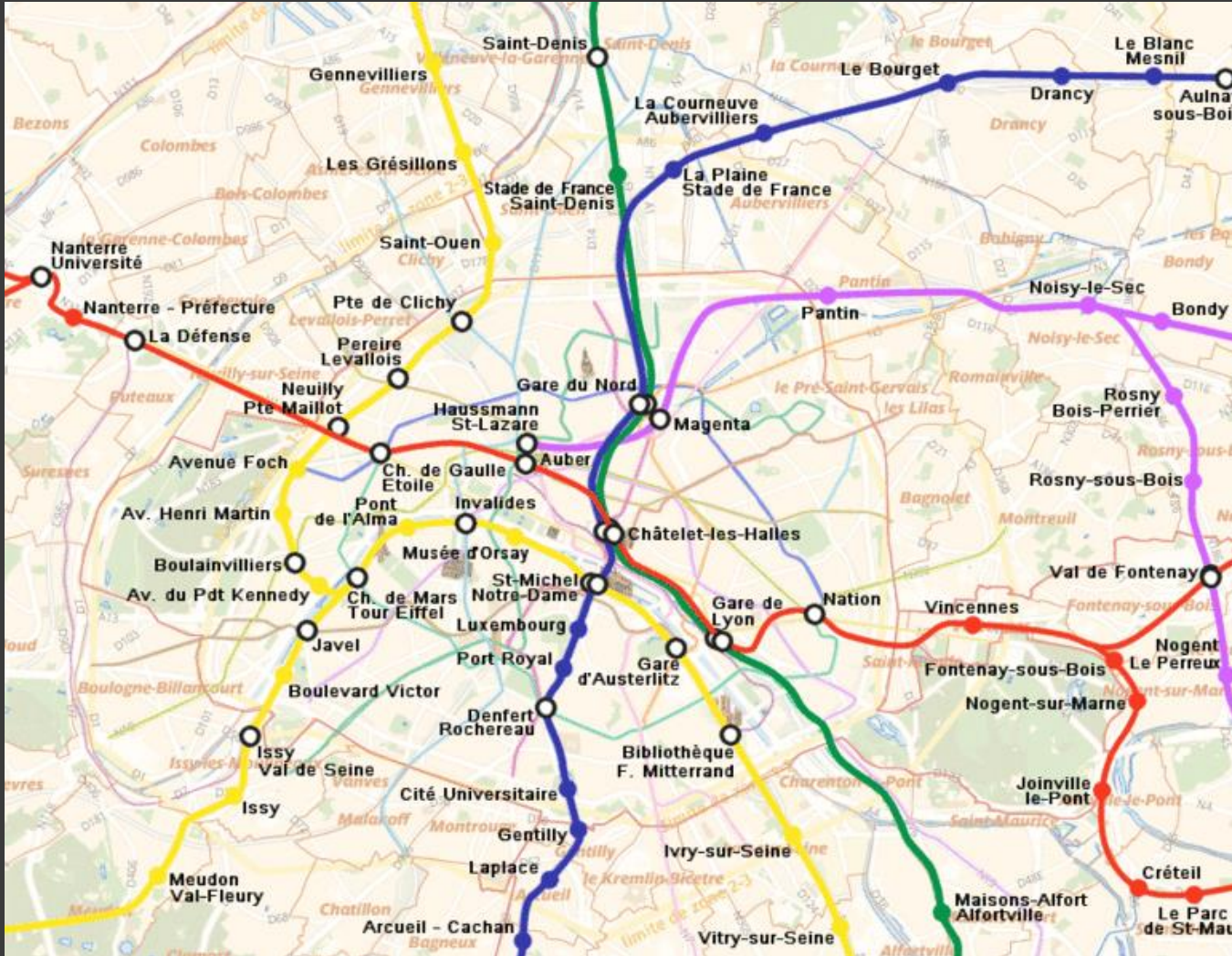
(C) Hamster, <http://hampage.hu/>



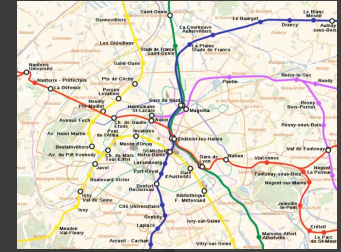
## 2. Interoperability and intermodality of infrastructure

- Paris RER: suburban railways as express metro lines
  - Metro system of Paris likes to trams in many parameters (station distance, steep curves etc.), therefore a faster, and higher capacity network was needed
    - lengthening national railway lines into city centre under surface
    - capacity likes metro lines, travel speed is high
    - there are double-decker cars on some lines
    - diverging lines, branches
    - straight connection to suburbs, without transfer
    - long walking distances at junctions

# Paris RER



# Paris RER



# Paris RER



# Paris RER



## 2. Interoperability and intermodality of infrastructure

- London, Wimbledon: transfer on the same platform
  - Trams and trains use the same platform
    - tramway was built to the place of a former railway
    - the terminus is situated at the railway station
    - in continuation of the railway track there is the tram line, on a higher level



- Guided buses on a tram line
  - Bus transport was needed to be introduced on an uncovered tram line section
    - used railway sleepers were laid along the track
    - guiding is ensured by vertical plates
    - buses can go independently from road traffic





## 2. Interoperability and intermodality of infrastructure



## 2. Interoperability and intermodality of infrastructure



(C) Hamster, <http://hampage.hu/>



## 2. Interoperability and intermodality of infrastructure

- Common platform transfer between rapid transit lines
  - Vienna Längenfeldgasse: U4 and U6
    - U4: conventional „heavy” metro line
    - U6: so-called „light rail” line (LRT)
    - common station with separate, cross-free paths
    - transfers are timed
  - Berlin Wuhletal: U5 and S5
    - U5: so-called „gross profil” metro line
    - S5: S-Bahn line
    - common station with separate, cross-free paths
    - transfers are timed

# Vienna, Längenfeldgasse    Berlin, Wuhletal



# Vienna, Längenfeldgasse    Berlin, Wuhletal



# Vienna, Längenfeldgasse    Berlin, Wuhletal

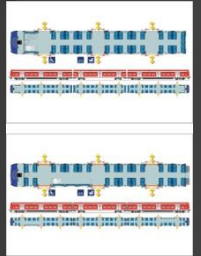


### 3. Interoperability and –modality: vehicle

- Interoperable vehicles

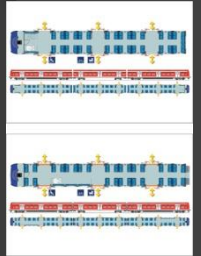
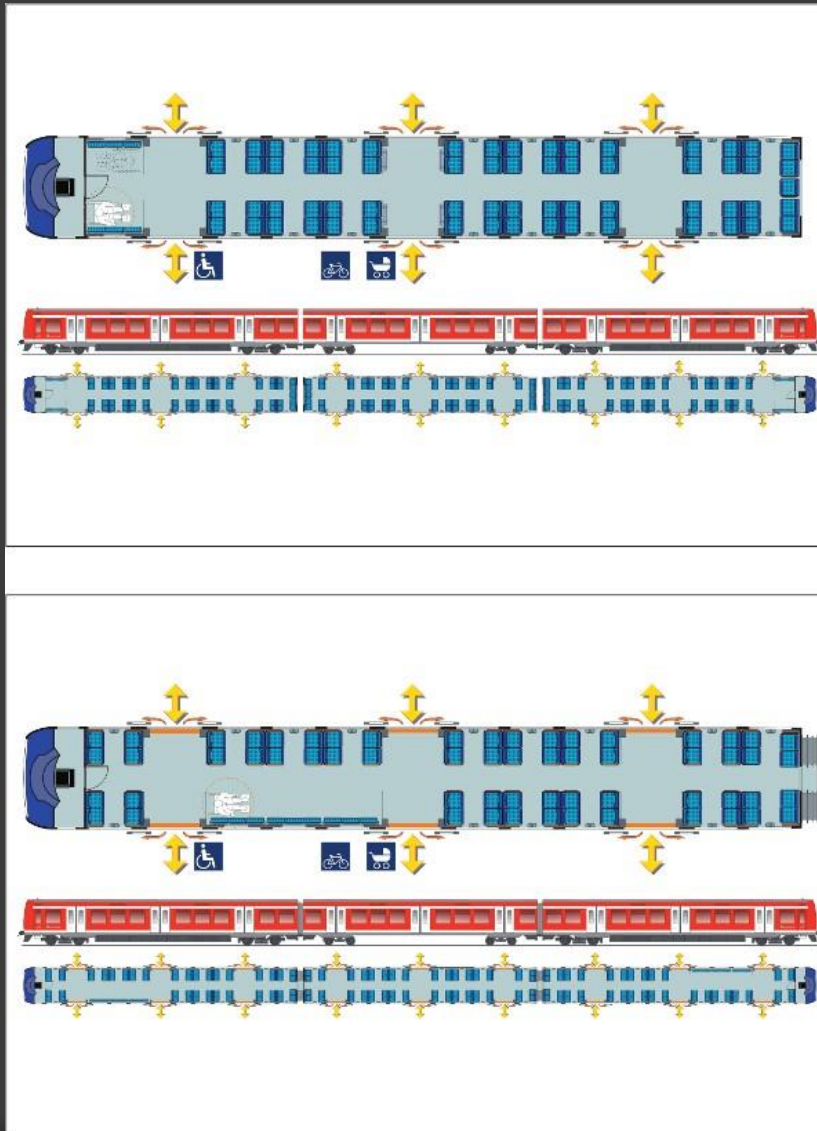
- Cooperation is provided by the vehicle itself, by
  - different energy power supply (current type AC/DC, voltage) is possible
  - different physical contact to power supply (third rail or overhead line)
  - tracks are also suitable (platform, carrying capacity)
- Reconstruction of series 474 in Hamburg (S3) (33 old + 9 new veh.)
  - 3 sectional self-propelled train carriage (2 motor-unit and 1 not, 3x66m)
  - no electric devices in the centre unit (appropriate place)
  - equipments under the floor (new chassis, boogies)
  - pantograph and an inverter was implemented at the top of the vehicle
  - DC supply (1200V) in the city and AC supply in the suburbs (common track with trains)

# Series 474 (S3)

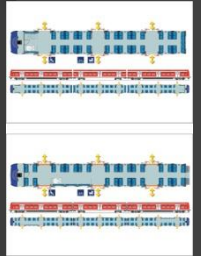




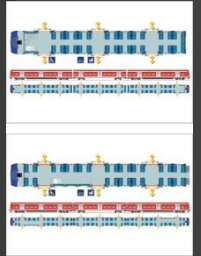
# Series 474 (S3)



# Series 474 (S3)



# Series 474 (S3)

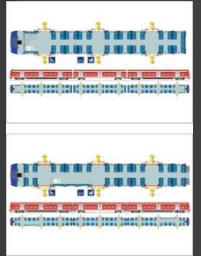


© 09.08.2007 Arne Wiehern

# Series 474 (S3)



© 09.08.2007 Arne Wiechern



© 09.08.2007 Arne Wiechern

### 3. Interoperability and –modality: vehicle

- ⊙ Interoperable vehicles

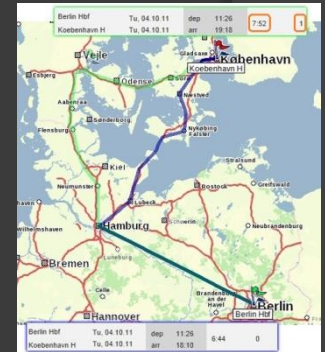
- DSB (DB) – Scandlines „cooperation”,

- train transported by ferry! (train-ferry or modified Ro-Ro)

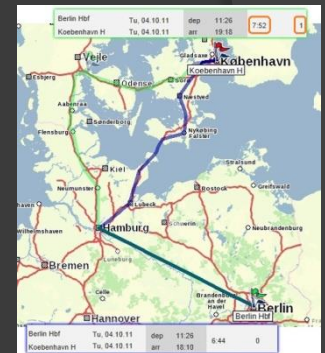
- ICE-T ("weisswurst")

- Berlin (Hamburg) – Puttgarden (Fehmarn- és Lolland-islands) –  
Copenhagen route

# Puttgarden (DSB, Scandlines)



# Puttgarden (DSB, Scandlines)



### 3. Interoperability and –modality: vehicle

- Interoperable vehicles

- DSB (DB) – Scandlines „cooperation”,

- train transported by ferry! (train-ferry or modified Ro-Ro)

- ICE-T ("weisswurst")

- Berlin (Hamburg) – Puttgarden (Fehmarn- és Lolland-islands) – Copenhagen route

- Owing to interoperability:

- travel time savings

- number of transfers are diminished

- shorter route

- at the same price



### 3. Interoperability and intermodality of vehicles

#### ○ Hannover Stadtbahn

- Main features of Stadtbahn systems in Germany:
  - flexible, it can serve several functions on transport network
  - vehicles' technical parameters are between metro and tram lines
  - few compromises are needed on the side of different type sections, tracks
- The system of Hannover
  - underground, rapid surface-level and on-road sections
  - unified energy supply and clearance
  - all urban fixed-rail lines are compatible
  - high platforms at most stops, but not all
  - high-floor, two-direction vehicles

# Hannover Stadtbahn



(C) Hamster, <http://hampage.hu/>



# Hannover Stadtbahn



# Hannover Stadtbahn



Foto: Lars Brüggemann [www.larsbrueggemann.de](http://www.larsbrueggemann.de)

# Hannover Stadtbahn



### 3. Interoperability and intermodality of vehicles

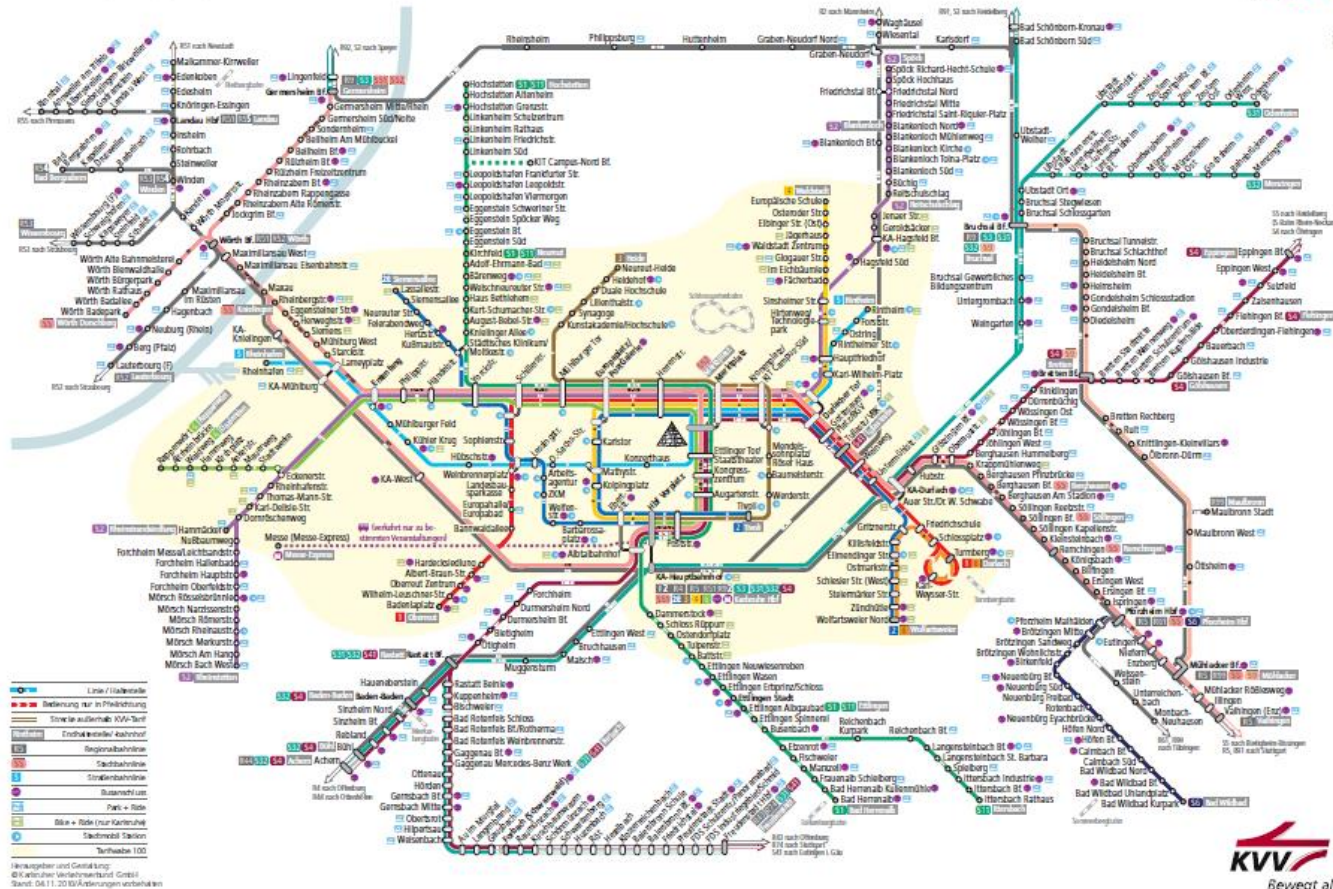
- Karlsruhe tram-train

- Special tram cars can go on national railways also
  - formerly abandoned diesel rail lines were used first by trams
  - later: purchase of special vehicles which can use railway also
  - some towns built own branches connected to the system
  - straight connection even from nearby towns to the main shopping street of Karlsruhe
- Main technical problems:
  - electric system (750 V DC, and 15 kV 16 2/3 Hz AC)
  - clearance, platform width
  - vehicle solidity, strength (safety concerns)

# Karlsruhe tram-train

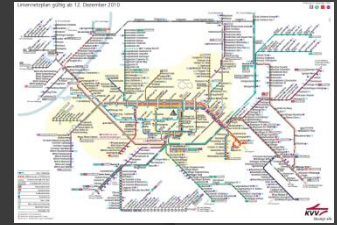


Liniennetzplan gültig ab 12. Dezember 2010



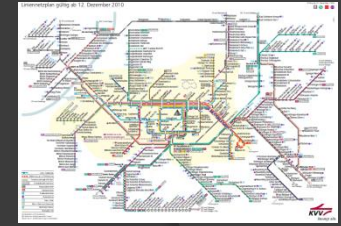
Herausgeber und Gestaltung:  
 © KVV, Karlsruhe Verkehrsamt, GmbH  
 Stand: 04.11.2010 Änderungen vorbehalten

# Karlsruhe tram-train

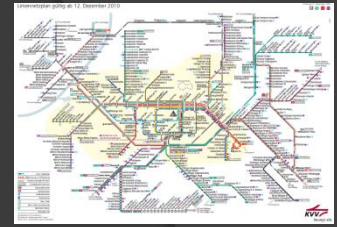




# Karlsruhe tram-train



# Karlsruhe tram-train



### 3. Interoperability and intermodality of vehicles

- ⊙ „Duo” trams of Nordhausen
  - Connection of tram and narrow-gauge railway lines of the town
    - same gauge, but diesel operation on the railway
    - first step: common stop next to the railway station
    - later: purchase of special tram cars, which have diesel engines, too
    - trams can move on to the railway network

# „Duo” trams of Nordhausen



# „Duo” trams of Nordhausen



(C) Hamster, <http://hampage.hu/>



# „Duo” trams of Nordhausen



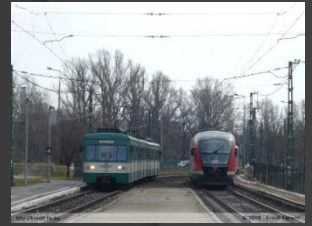
# „Duo” trams of Nordhausen



### 3. Interoperability and intermodality of vehicles

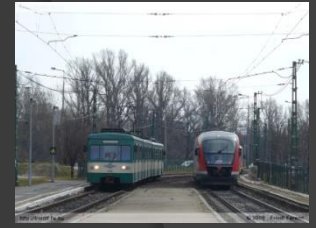
#### ○ Hungarian examples:

- Traffic of trains from Esztergom railway line on the suburban railways
  - when railway bridge was under construction
  - through an existing connection track
  - both operators accepted each others passes
- Common operation of tram and narrow-gauge railway at Nyíregyháza
  - the two networks had a common part between the railway station and Sóstó through the city centre
  - the was a dual system locomotive also
- Cars of Metro line 1:
  - same energy supply and gauge as trams, only clearance height is lower
  - cars could go on tram lines with an other collector

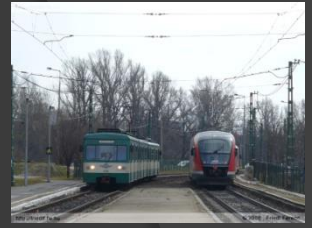




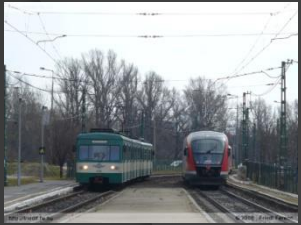
### 3. Interoperability and intermodality of vehicles



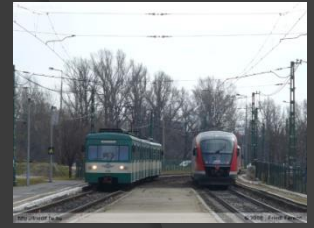
### 3. Interoperability and intermodality of vehicles



# 3. Interoperability and intermodality of vehicles



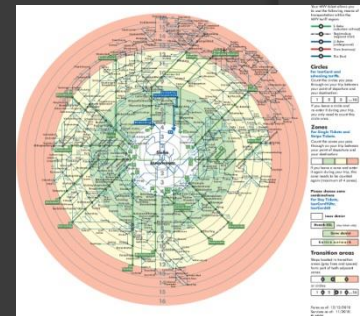
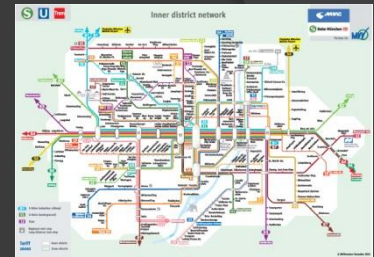
### 3. Interoperability and intermodality of vehicles



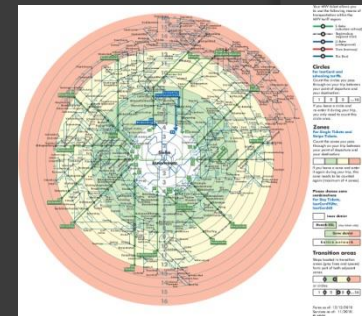
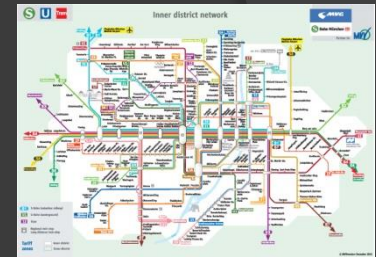
# 5. Other smart transport solutions

## ○ Munich

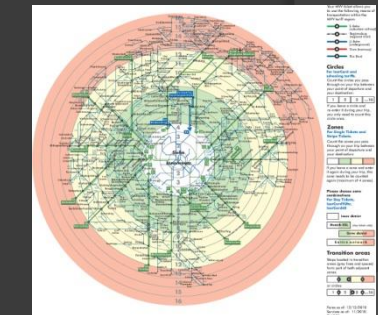
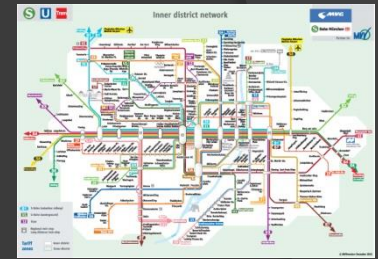
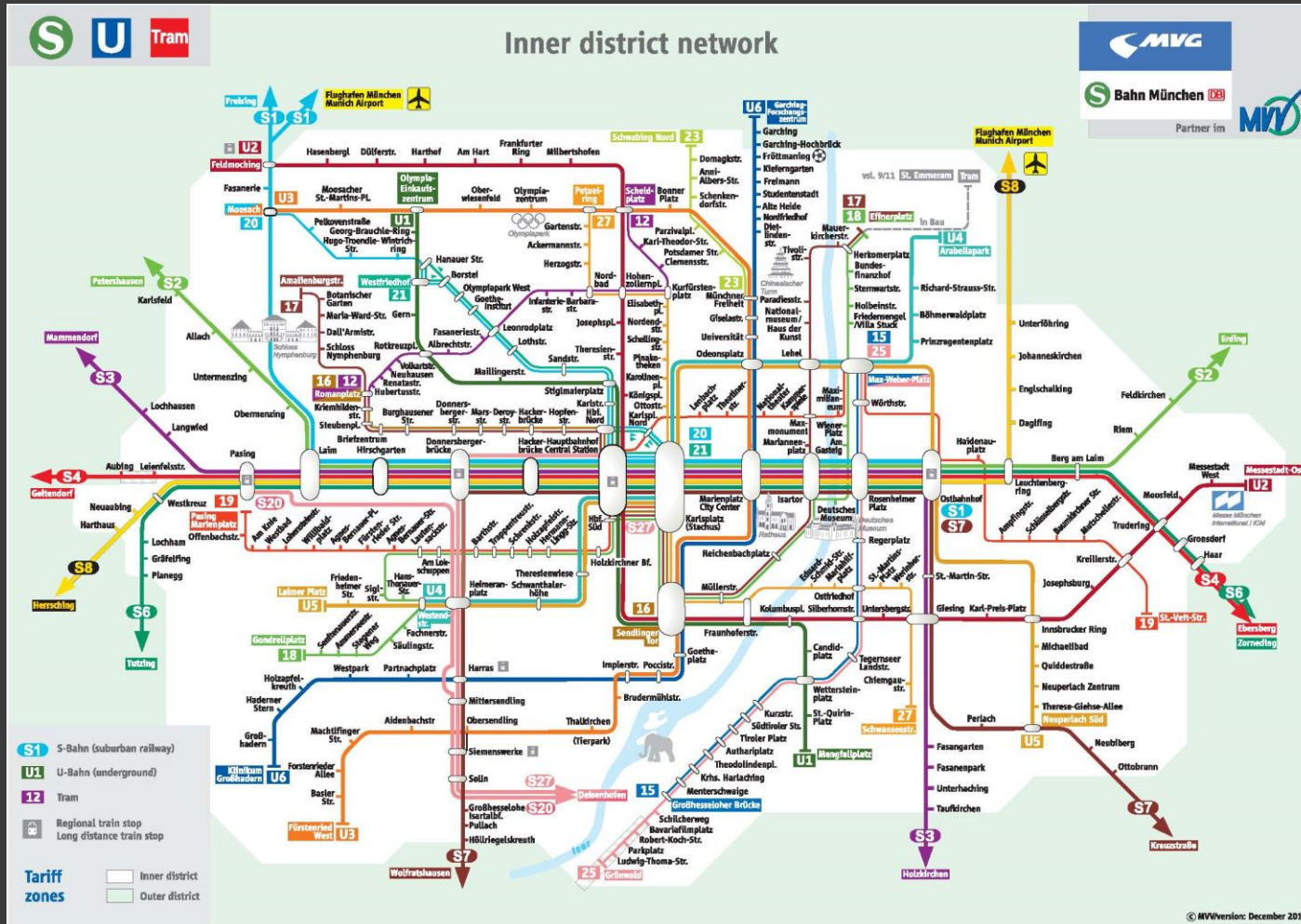
- International and long distance trains (CNL, EN) usually arrive in the morning and leave at night
  - make one day sightseeings possible
  - luggage storage rooms
  - Fresh and Ride
- Railway network and fare system of Munich (MVV)
  - lines
  - another S-Bahn tunnel (Express S-Bahn system)
  - zonal fare collection (two types, border points)
  - boarding and alighting at frequent stops



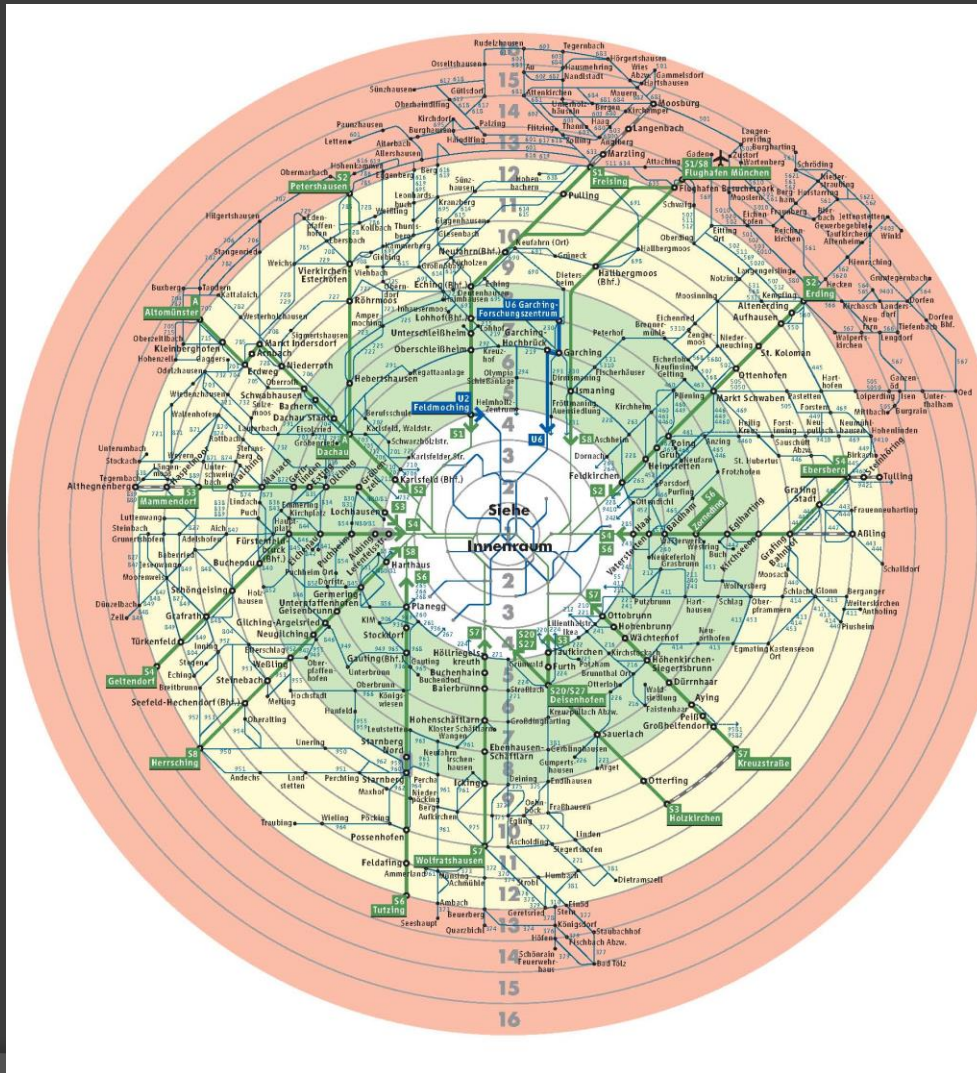
# 5. Other smart transport solutions



# 5. Other smart transport solutions



# 5. Other smart transport solutions



Your MVV ticket allows you to use the following means of transportation within the MVV tariff region:

- S-Bahn (suburban railway)
- Regionalzug (regional train)
- U-Bahn (underground)
- Tram (tramway)
- Bus (bus)

### Circles

**For IsarCard and schooling tariffs.**

Count the circles you pass through on your trip between your point of departure and your destination:



If you leave a circle and re-enter it during your trip, you only need to count this circle once.

### Zones

**For Single Tickets and Stripe Tickets.**

Count the zones you pass through on your trip between your point of departure and your destination:



If you leave a zone and enter it again during your trip, this zone needs to be counted again (maximum of 4 zones).

### Please choose zone combinations

**For Day Tickets, IsarCard 90hr, IsarCard 60**

- Inner district
- Munich XXL (day tickets only)
- Outer district
- Entire network

### Transition areas

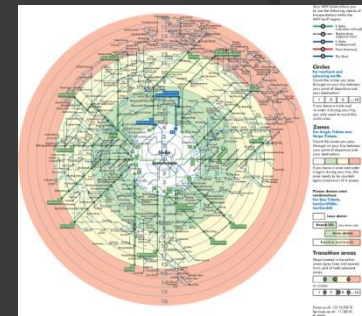
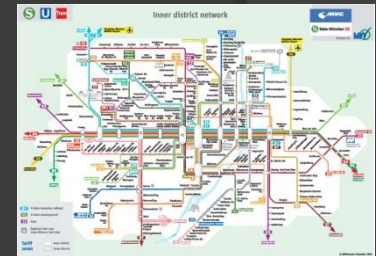
Stops located in transition areas (grey lines and spaces) form part of both adjacent zones



or circles.

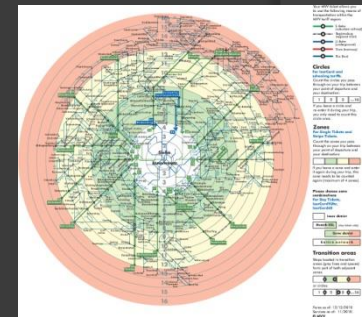
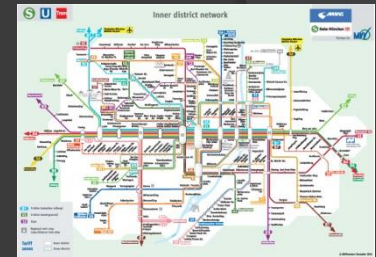


Fares as of: 12/12/2010  
Services as of: 11/2010  
© MVV

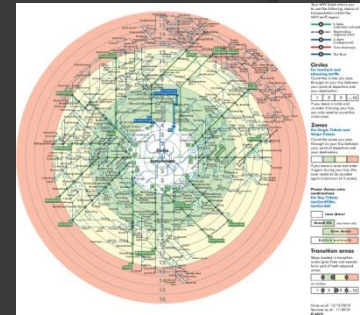
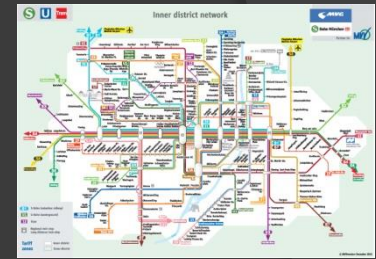




# 5. Other smart transport solutions



# 5. Other smart transport solutions



# 5. Other smart transport solutions

## ○ Berlin

### ■ Interesting facts of tram-, metro network and junctions

- differences between East- and West-Berlin

- long walking distances at junctions (intermodality?)

### ■ Metro network

- klein- und grossprofil

- the two types of profil are not interoperable (interoperability?)

- track connections exists

- different size (profil), polarity and physical contact to supply

### ■ Specialty of the fare system

- after 8 PM/weekends 1 extra person can travel for free with a monthly pass owner

- concert ticket functioning as a daily ticket





## 5. Other smart transport solutions



## 5. Other smart transport solutions

### ○ Copenhagen

- Several operators in city transport
  - buses - Movia
  - S-Tog - DSB
  - metro - Ansaldo STS (IC4 trains as well)
    - 2 lines, length of 21 kilometer (by 2018 new metro around the center with 2 lines)
    - no driver onboard (e.g. operational cost savings, like M4 would be in Budapest)
    - closed platform (passenger safety, faster loading)
  - no trams
  - work motivated bicycle transit mode share is 37%!
- the flow of information between participants going well
- under supervision of transport alliance



## 5. Other smart transport solutions



## 5. Other smart transport solutions





# 5. Other smart transport solutions



## 5. Other smart transport solutions



## 5. Other smart transport solutions

- Fitting guided transport modes to cityscape
  - For the last two decades, tram systems has dispersed widely, especially in France
    - the aim of these lines was not only the development of transport but also the renewal of city areas
    - rolling back of road traffic also helped this
  - Complex urban planning; tram as a signal cityscape element, a landmark
    - tram tracks and all supplements are designed to fit to the architectural conception
    - unique design, used in only one city

# Trams and cityscape



# Trams and cityscape



# Trams and cityscape



# Trams and cityscape



## 5. Other smart transport solutions

- ◎ Buffet car on a „tram”
  - Karlsruhe: some of special trams has very long travel time, so that introducing snack bars seemed to be reasonable
- ◎ Raised road lane instead of platform
  - On narrow streets no enough place for platforms
  - The road itself has been raised to ease getting on trams
- ◎ Special ferries
  - Strausberg: electric ferry (one pole is the overhead wire, the other one is the wire in the water)
  - Rendsburg: over (!) Nord-Ostsee-Kanal (Kiel Canal)
- ◎ Priorization
  - In Germany tramlines (tracks) are often labelled as railways – so that they have absolute priority





## 5. Other smart transport solutions



# 5. Other smart transport solutions



## 5. Other smart transport solutions



## 5. Other smart transport solutions



# 5. Other smart transport solutions



# 5. Other smart transport solutions



# 6. Bicycle solutions

## ○ Denmark

- guidance through an intersection
  - supported by pavement paintings
  - non-direct left turn
  - Hungarian practice
  - lead through a PT stop (pl. Andrassy road)
  - in the outskirts, lead under roundabouts
- detectors, traffic signs
  - modifying signal timing by bicycle detection
  - there is no button to push
  - green recall (to make cyclist move first)
  - e.g. Andrassy road (counting bikes automatically)



# 6. Bicycle solutions





# 6. Bicycle solutions



# 6. Bicycle solutions



# 6. Bicycle solutions



# 6. Bicycle solutions



# 6. Bicycle solutions



# 6. Bicycle solutions



# 6. Bicycle solutions



## 6. Bicycle solutions

- Some bike-sharing systems

The main difference to a simple bike-rental is that the bike doesn't have to be taken back to the rental point.

- Vienna, Citybike

- 50 stations
- first hour is free!

- Berlin and other German cities, Call a bike

- DB (state railway) operates a bike-sharing system
- 30 minutes for free
- iPhone and Android app

- Budapest, BUBI

- 74 station, 1000 bikes
- from 2014 spring





# 6. Bicycle solutions



# 6. Bicycle solutions



# 6. Bicycle solutions



## 6. Bicycle solutions

- Transport bikes by public transport vehicles
  - Copenhagen
    - by metro
  - Stuttgart
    - by cogwheel-railway on a single flat-wagon
  - United States
    - fixing bikes to the front of the buses



# 6. Bicycle solutions



## 6. Bicycle solutions



# 6. Bicycle solutions



**Thank you for your kind attention!**

28th November 2018.