KVU OSLO-NAVET

A toolbox for achieving a high-quality PT-network

Ferdigstilt:	8. juni 2015
Prosjekt:	KVU Oslo-Navet
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Vedlegg til:	Delrapport 3

Sammendrag:
Dette notatet gir innspill til arbeidet med rolledeling mellom de kollektive driftsartene. Det er basert på en presentasjon som Axel Kuehn holdt på KVU Oslo-Navets verksted i juni 2014.

Introduction

Axel Kuehn and Bernt Nielsen have been asked in early 2014 by Jernbaneverket to accompany the KVU Oslo-Navet as independent experts.

As part of their activities they have delivered a number of reports and presentations which are summarised in their final statement of 29th April 2015 ("Anbefalinger fra Kuehn og Nielsen").

One of the presentations by Axel Kuehn, to which Bernt Nielsen has contributed, has been "**A toolbox for achieving a high-quality PT-network**".

To allow proper integration into the KVU documentation it has been decided to convert the ppt-file into a proper report format which is presented herewith. The wording and "bullet-point style" of the presentation has been left more or less unchanged.

The idea of the "toolbox" was to give an overview based on international examples of the different roles which PT-modes can have in integrated PT-networks.

There is to acknowledge a certain planning philosophy which includes:

- **Using PT-modes in a complimentary way (no competition in same corridor),**
- **Approaching different PT-modes in an unbiased way (no good or bad modes, just wrongly or not optimally applied modes?),**
- **Aiming for a more efficient network (less or better used operational costs),**
- **Accepting that a network is dependent on quality interchanges.**

To avoid misunderstandings it is clearly to be stated that the overview of different tools as given here does not aim for using all tools together in one network.

And certainly some tools may be more applicable for the Oslo network, others less…

PT-modes in the toolbox

The following modes have been covered in the toolbox:

- Long distance trains
- Regional trains
- Local trains
- Metro
- Light Rail and TramTrain
- Tramway
- HQ bus / busway
- (Bus)

Long distance trains

Classic use:

- Long distance connections into one main railway station (main hub), all interchanges take place there.

Other use:

- Establishing sub-urban stop to allow smart interchanges while taking pressure from main hub station,
- Separating long distance train station from regional/local train station.

Sub-urban stops for long distance trains

Three examples are presented:

- **Munich-Pasing**
- **Hamburg-Harburg**
- **Berlin-Spandau**
- **Stockholm-Flemingsberg**

Munich-Pasing

This station serves as a sub-urban hub station in the West of Munich.

Long distance and regional trains approaching or leaving Munich main station stop here (ICE, IC, RE).

Stuttgart Hbf	Di, 28.10.14	ab	06:56	2:17	0	ICE	45,00 EUR
München Hbf	Di, 28.10.14	an	09:13				→Zur Buchung

Bahnhof/Haltestelle	Datum	Zeit		Gleis	Produkte
Stuttgart Hbf	Di, 28.10.14	ab	06:56	16	ICE 699
Ulm Hbf		ab	07:56	2	
Günzburg		ab	08:11	2	
Augsburg Hbf		ab	08:42	3	
München-Pasing				9	
München Hbf	Di, 28.10.14	an	09:13	22	

Timetable excerpt ICE Stuttgart-Munich

Source: DB

Pasing station offers numerous interchange options in the Munich network (eg 5 S-train lines, 1 tramway line...) and takes pressure from Munich main station.

Pasing station within the Munich rail network

Source: MVV

Hamburg-Harburg

Harburg is a sub-urban hub station in the South of Hamburg.

Long distance and regional trains approaching or leaving Hamburg main station stop here (ICE, IC, RE).

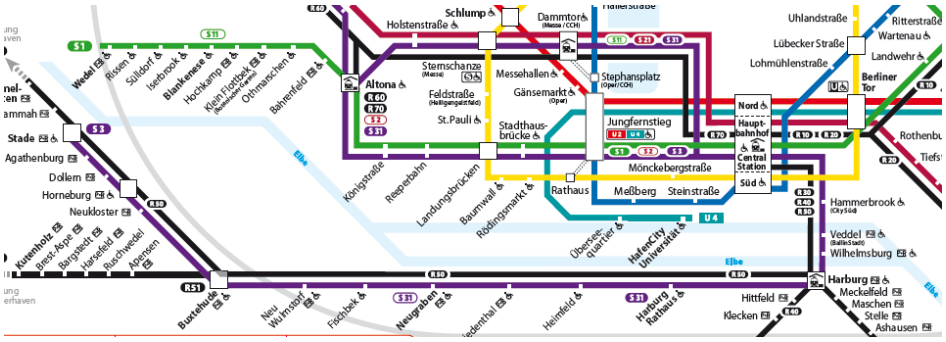
Hannover Hbf	Mo, 27.10.14	ab	15:36 +0	1:17	0	ICE	46,00
Hamburg Hbf	Mo, 27.10.14	an	16:53 +0				→ Z

Bahnhof/Haltestelle	Datum	Zeit		Gleis	Produkte
Hannover Hbf	Mo, 27.10.14	ab	15:36 +0	8 D-G	ICE 588
Hamburg-Harburg				1	
Hamburg Hbf	Mo, 27.10.14	an	16:53 +0	8	

Timetable excerpt ICE Hanover-Hamburg

Source: DB

The station offers interchange options in the Hamburg network (eg 1 S-train line, various regional train lines...).



Harburg station within the Hamburg rail network

Source: HVV

Berlin Spandau

Spandau acts as a sub-urban hub station in the West of Berlin.

The same principles as for Munich or Hamburg apply.

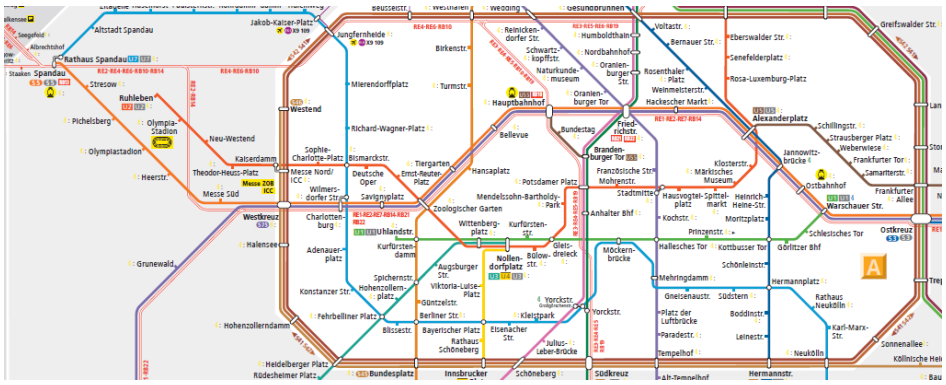
Braunschweig Hbf	Mo, 27.10.14	ab	15:59 +0	1:26	0	ICE	58,00 EUR → Zur Bu
Berlin Hbf	Mo, 27.10.14	an	17:25 +0				

Bahnhof/Haltestelle	Datum	Zeit		Gleis	Produkte
Braunschweig Hbf	Mo, 27.10.14	ab	15:59 +0	7	ICE 370
Wolfsburg Hbf		ab	16:17 +0	5	
Berlin-Spandau				5	
Berlin Hbf	Mo, 27.10.14	an	17:25 +0	11	

Timetable excerpt ICE Braunschweig-Berlin

Source: DB

Interchange options exist into the Berlin network (eg 1 S-train and one metro line, various regional train lines...).



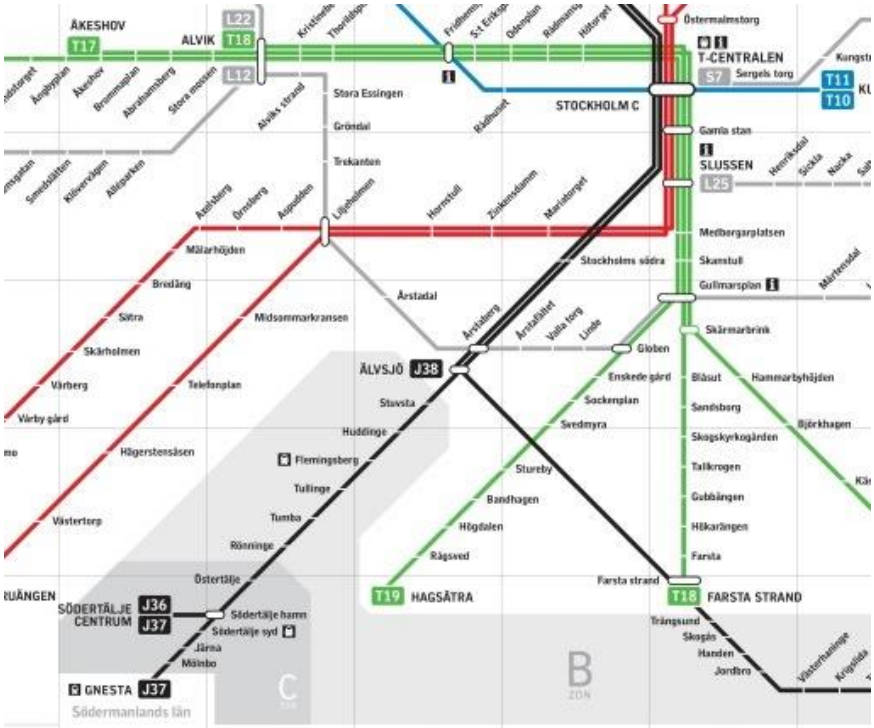
Spandau station within the Berlin rail network

Source: VBB

Stockholm-Flemingsberg

Flemingsberg is a sub-urban hub station in the South of Stockholm.

It offers interchange options in the Stockholm network (commuter train line, buses).



Flemingsberg station within the Stockholm PT-Network

Source: SL/SJ

Flemingsberg station

Source: Wikipedia

Separated hub for long distance and regional/local trains

Two examples are presented:

- Kassel Wilhelmshöhe / Kassel Hbf
- Lorraine TGV / Metz Gare

Kassel Wilhelmshöhe / Kassel Hbf

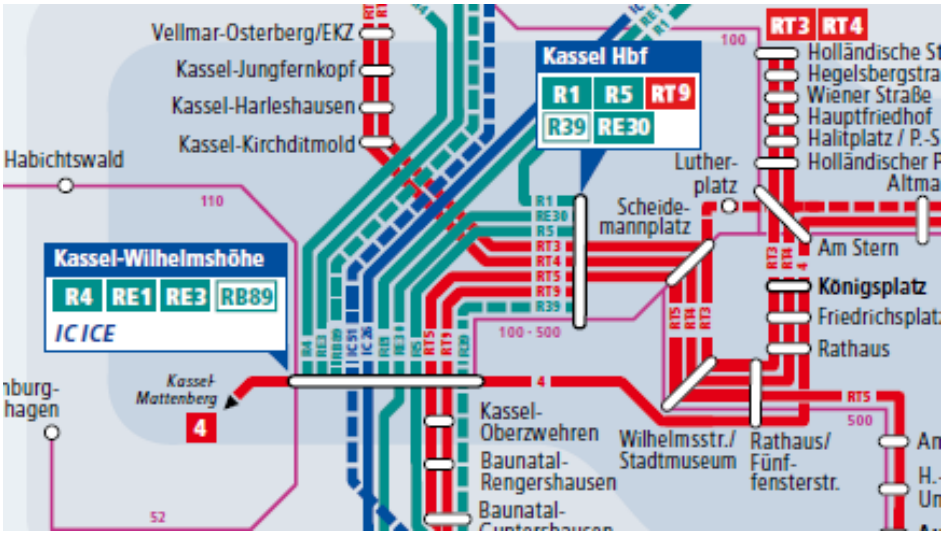
Kassel Wilhelmshöhe station was established as a new main station in regard of the Frankfurt-Hanover high-speed corridor – avoiding the terminus main station.

The old main station remains a hub for regional train services (including the Regiotram/TT network).

Aerial view of Kassel Wilhelmshöhe (left) and Kassel main station (right)

Source: Google Earth

Both stations are well connected to the urban and regional PT-network.



Excerpt of Kassel network map

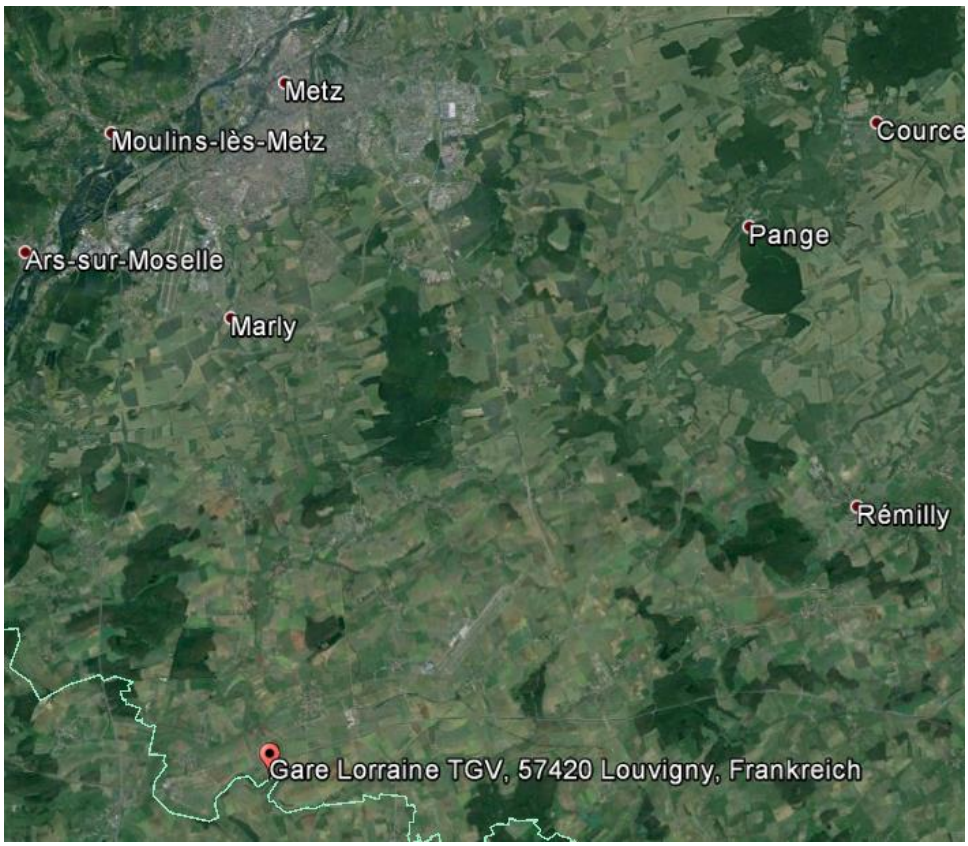
Source: NVV

Lorraine TGV / Metz Gare

Lorraine TGV serves as a stop in the Lorraine region for the Eastern TGV corridor.

Metz is about 25km away!

No train connection between TGV and Metz Gare – shuttle buses!



Location of Lorraine TGV and Metz stations

Source: Google Earth

Regional trains

Classic use:

- Regional trains using more than one stop in an agglomeration area and only hub stops in the wider region (express train characteristics).

Other use:

- Different, flexible operational patterns for agglomeration and (wider) region depending on local train scope/role

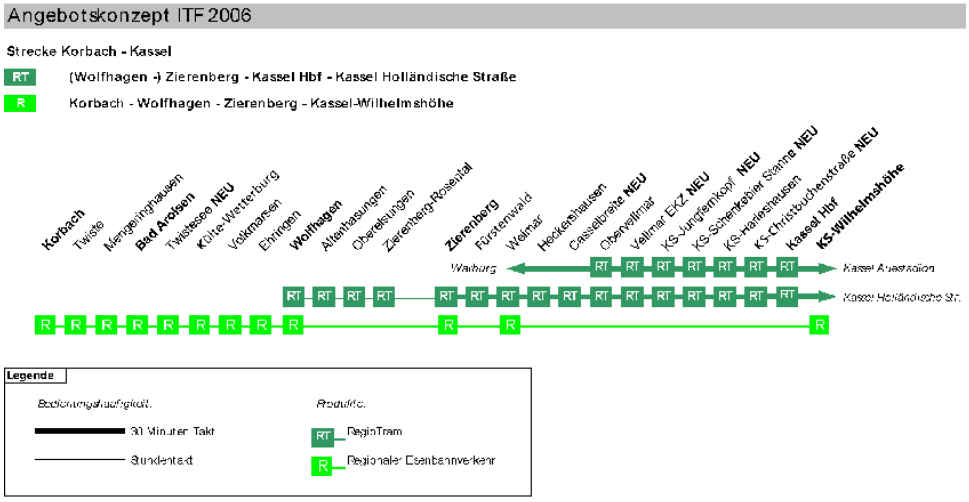
Flexible operational patterns depending on regional scope/role

One example is presented here:

Kassel NVV network

Regional express trains work as stopping trains in outer region and become express trains within the operation radius of the local (stopping) trains (here TTs).

Interchange connections are offered at hub stops.



Operational concept of interacting train products

Source: NVV

Local trains

Classic use:

- Sub-urban and or regional stopping services, slowest train category

Other use:

- Operation as a dedicated and possibly separated S-train network,
- Giving the local train / stopping train role to TramTrains.

Operation as a dedicated and possibly separated S-train network

Four examples are presented:

- Munich network
- Stuttgart network
- Hamburg network
- Leipzig/Halle network

Note: These and more examples, including non-German ones, have been described by Axel Kuehn in more depth within a separate S-Bahn report!

Munich network

Munich's S-train network is a classic example for the type of dedicated local train networks developed in various German agglos in the 1960/1970s.

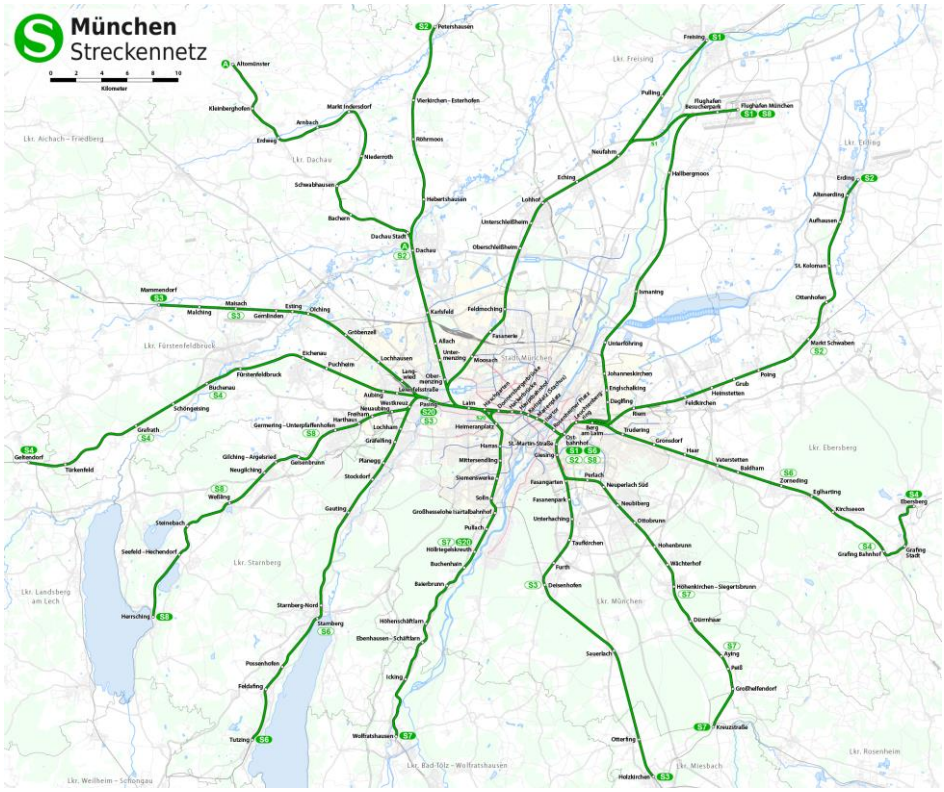
It is based on diametrical lines serving the city centre by a core tunnel while the tangential scope is limite.

The S-Bahn network is well connected/integrated with the local PT-network.

Network: 442km

S-Bahn Munich "DB-branding"

Source: DB



Munich S-Bahn network map

Source: Wikipedia

Munich S-Bahn impressions

Source: Axel Kuehn

Stuttgart network

Stuttgart's S-train network is another classic "German S-Bahn" example.

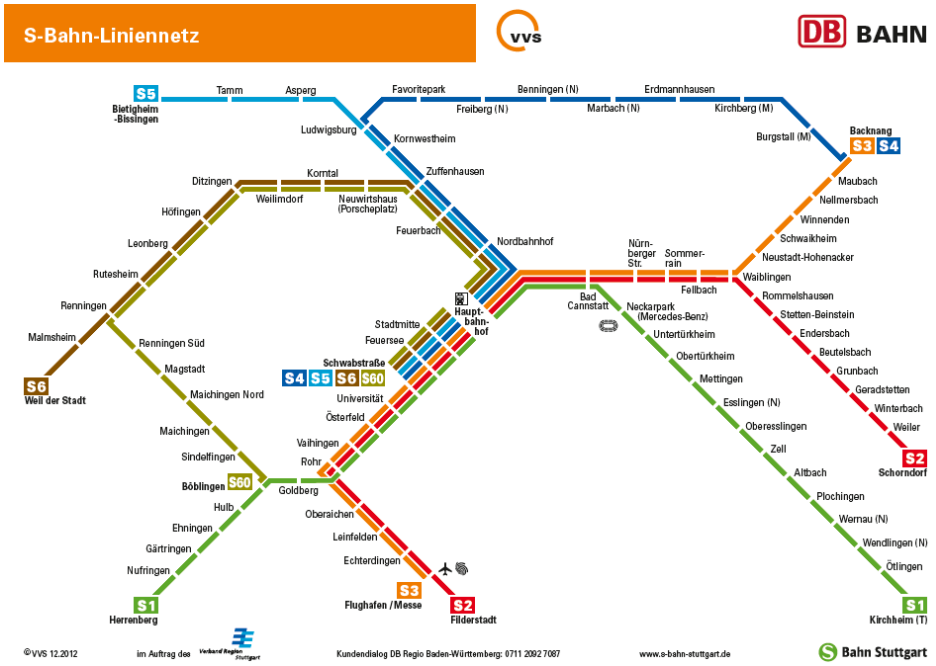
Originally based purely on diametrical operation, tangential connections have been added in recent years (S60, S4 extension Marbach-Backnang).

Also here the S-Bahn system is well connected with local PT-network.

Network: 215km

S-Bahn Stuttgart “DB-branding”

Source: DB



Stuttgart S-Bahn network map

Source: VVS

Stuttgart S-Bahn impressions

Source: Axel Kuehn

Hamburg network

Hamburg represents another “German S-Bahn” example.

Similar to Berlin and different to eg Munich or Stuttgart the Hamburg network is much older - established already in 1907 as a “fast urban rail network” and due to its

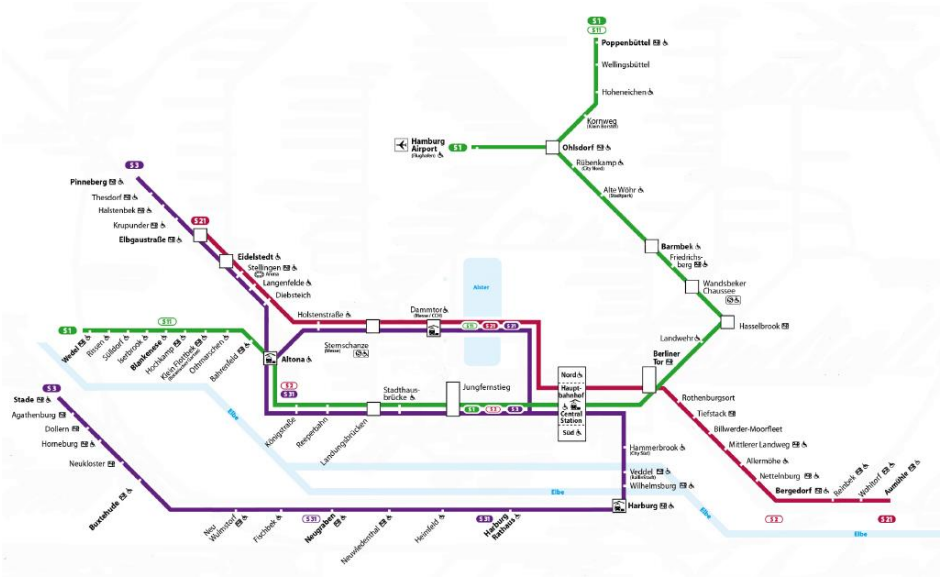
power supply system based on the use of separate, dedicated infrastructure.

It's function is much more urban than regional – only one line (S3) leaving city limits.

Network: 146km

S-Bahn Hamburg "DB-branding"

Source: DB



Hamburg S-Bahn network map

Source: DB

Leipzig/Halle "Mitteldeutschland" network

The S-Bahn Leipzig (or Mitteldeutschland, as it touches actually 4 German states!) is the newest S-train network in Germany.

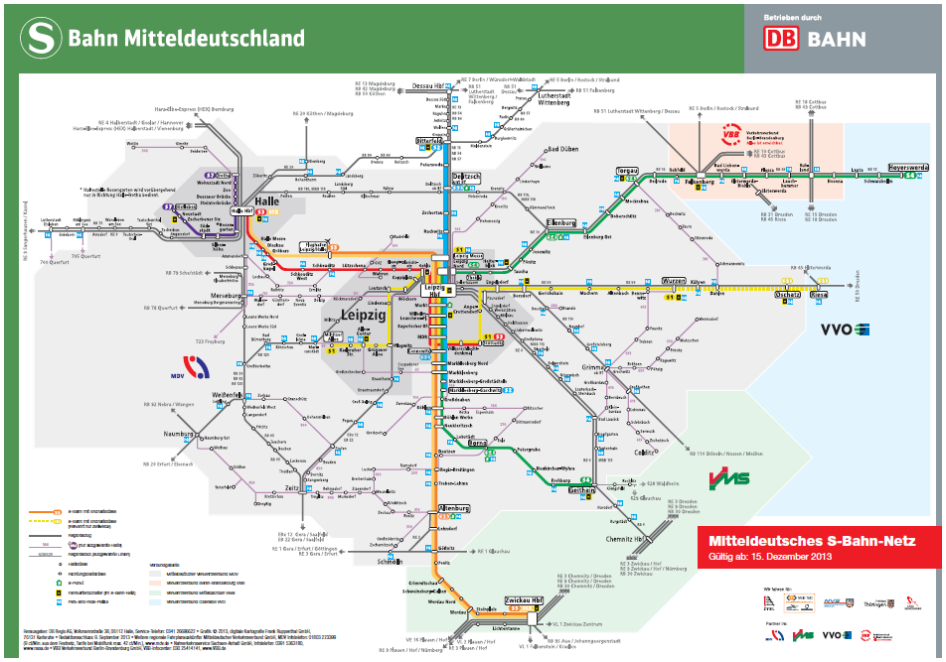
Inaugurated in 2013, it is based on a new city tunnel in Leipzig which allowed a new, diametrical network layout.

This scheme definitely owns a very regional scope.

Network: 430km

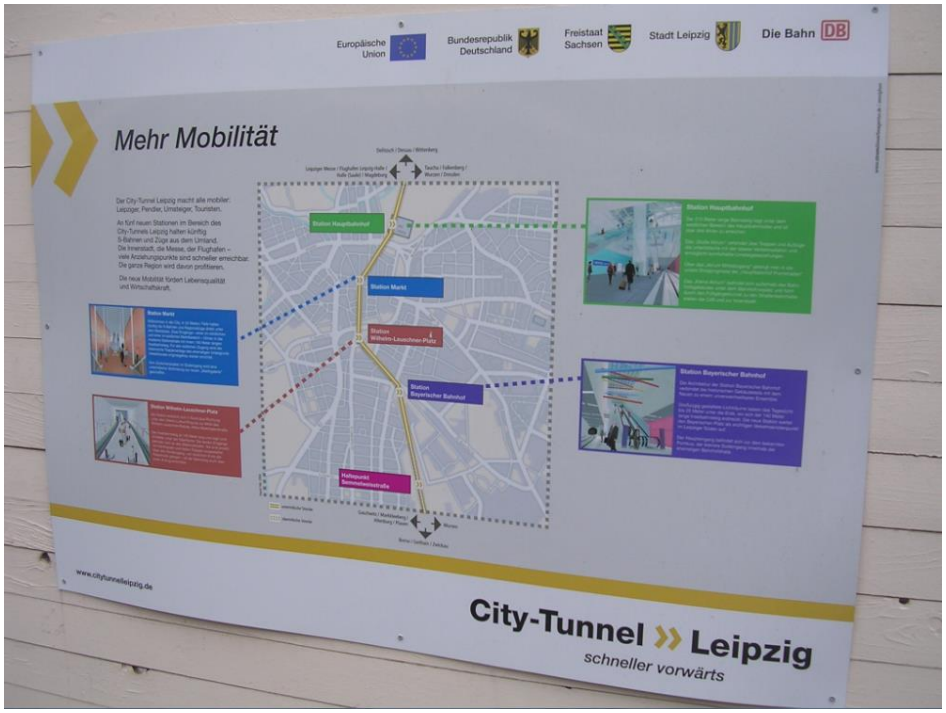
S-Bahn Mitteldeutschland "DB-branding"

Source: DB



S-Bahn Mitteldeutschland network map

Source: DB



City-tunnel Leipzig – the core of the scheme

Source: Axel Kuehn

Giving the local train / stopping train role to TramTrains

Four examples are presented:

- Karlsruhe network
- Kassel network
- L'Ouest Lyonnais network
- Nantes – Chateaubriant corridor

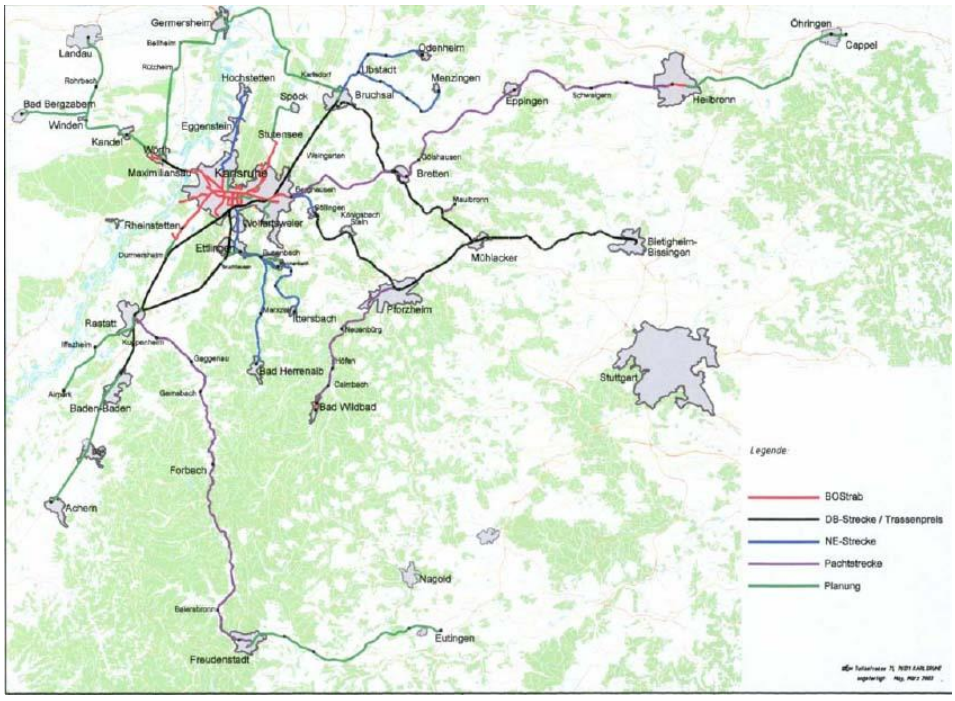
Karlsruhe network

Karlsruhe is to be seen as the mother of German style "TramTrains" – connecting regional railways directly with the city centre.

The regional network consists of more than 600km, the longest lines are up to 140km!

TTs have replaced classic stopping trains – in some corridors even regional express services.

Problem is the city centre where too many "trains" (75m!) have resulted in the need for a 2km underground section!



Karlsruhe TramTrain network

Source: AVG

Karlsruhe TramTrain impressions

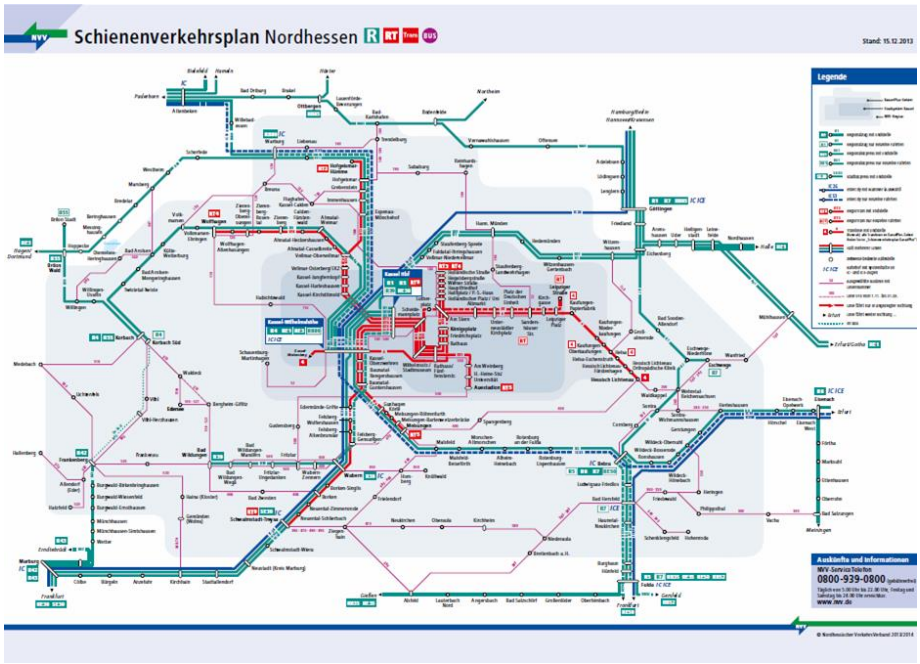
Source: Axel Kuehn

Kassel network

Kassel is the third German style "TramTrain" – connecting regional railways directly with the city centre.

Compared to Karlsruhe the operational scope is different:

- 25-40km distance from centre,
- more tramway operating on railway and less railway on tramway…
- Classic railway services have kept a serious role, especially for the wider region!



NVV regional network map

Source: NVV

Kassel TramTrain and regional railway impressions

Source: Axel Kuehn

L'Ouest Lyonnais network

This scheme is used as an example for French style "TramTrain".

Three rural railway branches (Sain Bel, Brignais, Lozanne), a total of 55km network, are operated by SNCF with TT-vehicles, but not connected to the urban tramway.

Opening is scheduled between 2011 and 2015 in several stages.

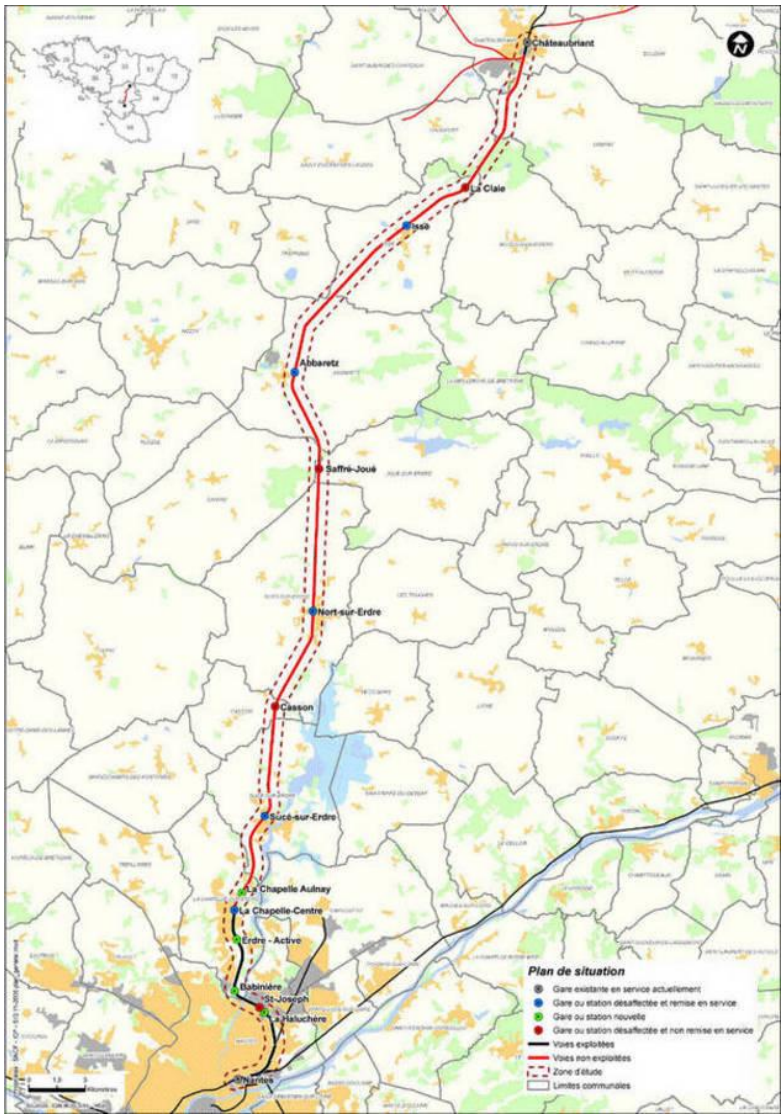
L'Ouest Lyonnais network

Source: Projet ferroviaire Ouest Lyonnais (project website)

L'Ouest Lyonnais TramTrain impressions

Source: Axel Kuehn

Nantes – Chateaubriant corridor



Nantes-Chateaubriant corridor

Source: Reouverture Nantes-Chateaubriant (project website)

This project covers the re-opening of a 64km railway closed in 1980 - operation started 2/2014.

Like the Lyon example, also this scheme is not connected to the urban tramway, the line terminates in the main railway station.

The scheme is operated by SNCF with TT-vehicles; one major reason for this concept was to allow easier handling of level crossings and better urban integration of rural stops.

Visualisation of TT-stop in Nantes main station

Source: Reouverture Nantes-Chateaubriant (project website)

Metros

Classic use:

- Radial/diametrical lines connecting high density (high demand) areas to city centres

Other use:

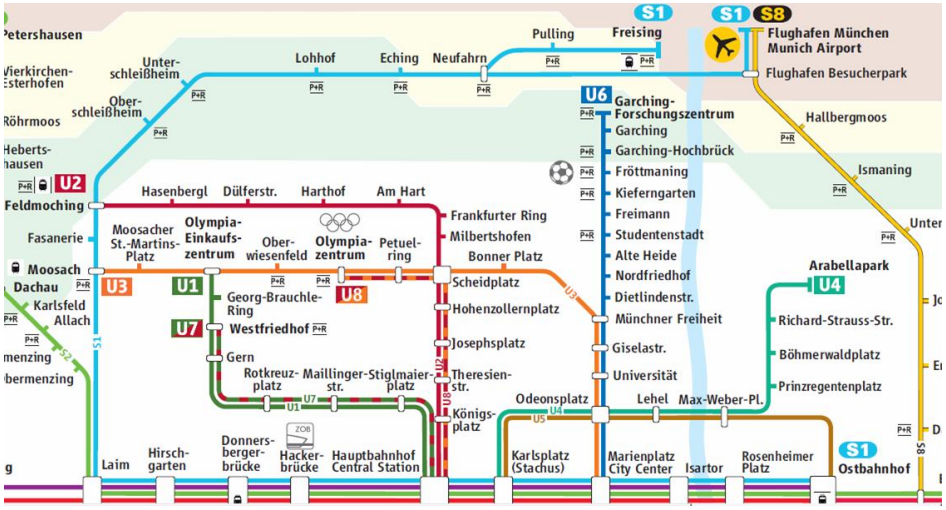
- Using metros as feeders to/between railway hubs

Metros with a feeder role

It should be understood that such function is kind of an “add-on role” – on top of the classic function. Munich is presented as an example.

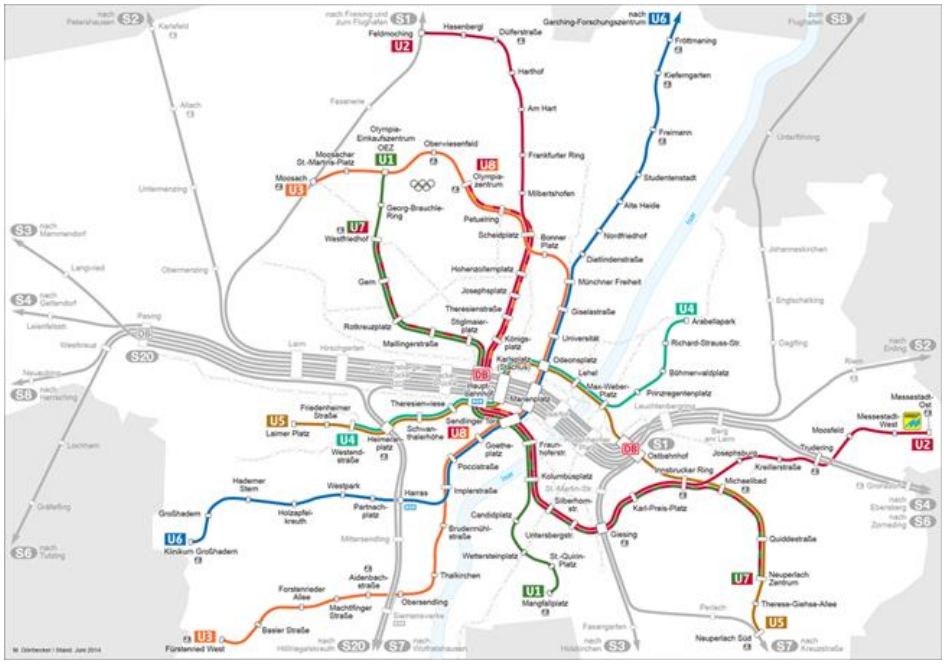
Munich network

Metro lines U2 and U3 have been extended to Feldmoching and Moosach railway stations which gives sub-urban interchange options to/from the airport S-train service and regional trains.



Munich S-Bahn and metro network

Source: MVV



Munich S-Bahn and metro network

Source: Wikipedia / Maximilian Dörrbecker

Light Rail

Classic use:

- Dominatingly segregated urban or sub-urban alignments allowing for longer train length ("upgraded tramway")

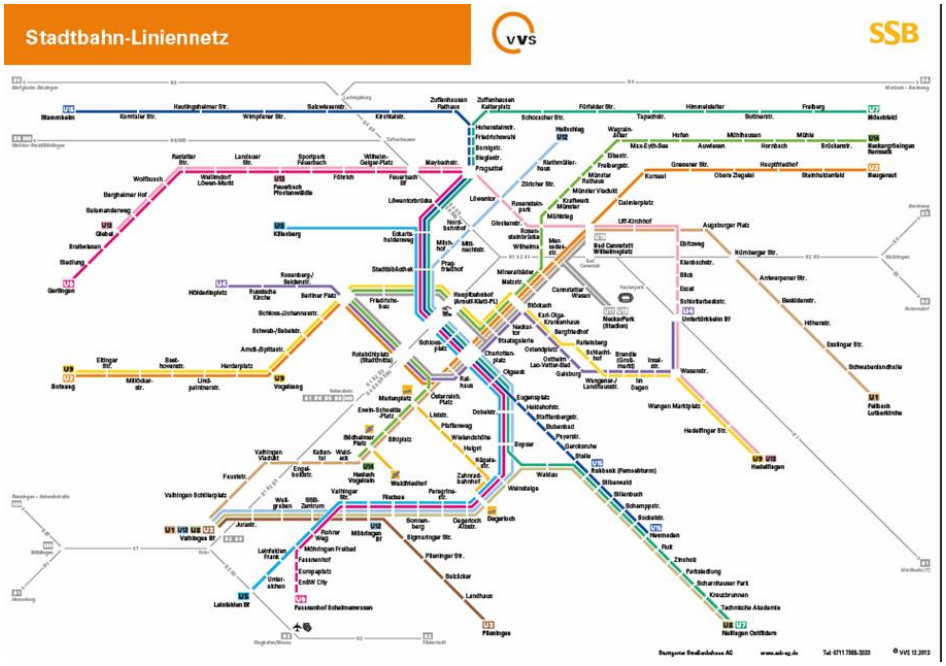
Other use:

- Light rail underground in city centre ("light metro"),
- Light rail upgraded to TramTrain (operation on railway infrastructure),
- Light rail used as tangential feeders to/between railway and metro hubs.

Light Rail underground in city centre

The two German cases of Stuttgart and hanover are presented.

Stuttgart network



Stuttgart light rail network

Source: VVS/SSB

Historically a narrow gauge tramway, the Stuttgart network has been upgraded to light rail since the 1980s and extended considerably.

Nearly completely separated, the high-floor system runs underground in the city centre.

Light rail works as kind of a light metro…

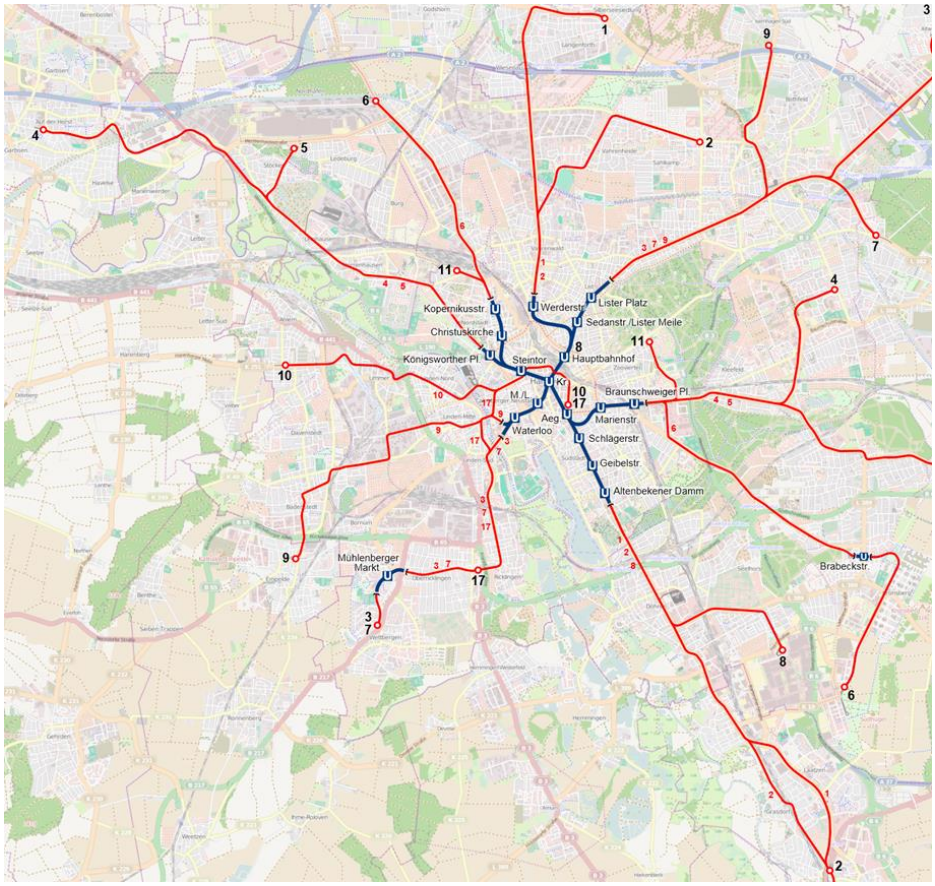
Stuttgart Light Rail impressions

Source: Axel Kuehn

Hanover network

Originally concepted as a real metro in the 1960s, the system was modified in the 1970s to a light rail system running under-ground in the city centre ("light metro").

Total: 196 stations
Underground: 19 stations



Hanover light rail network

Source: Wikipedia

Hanover light rail impressions

Source: Wikipedia

Light Rail upgraded to TramTrain

See examples in “Local trains” chapter.

Light Rail used as sub-urban tangential feeders

Three examples are presented:

- Madrid ML2 (Aravaca-Colonia Jardin)
- Paris T4 (Aulnay-Bondy)
- Stockholm Tvärbanan

Madrid Metro Ligero 2 and 3

Madrid owns no tramway or light rail system with a classic city-centre function. It has, however, introduced several light rail schemes with sub-urban functions.

Metro Ligero 2:

- 8.7km, 13 stops (3 underground), terminus stops linking to metro and commuter rail.

Metro Ligero 3:

13.7km, 14 stops (2 underground), terminus stops linking to metro.

Metro Ligero Madrid impressions

Source: Axel Kuehn

Madrid network map excerpt

Source: Metro Ligero Oeste

Madrid network map excerpt

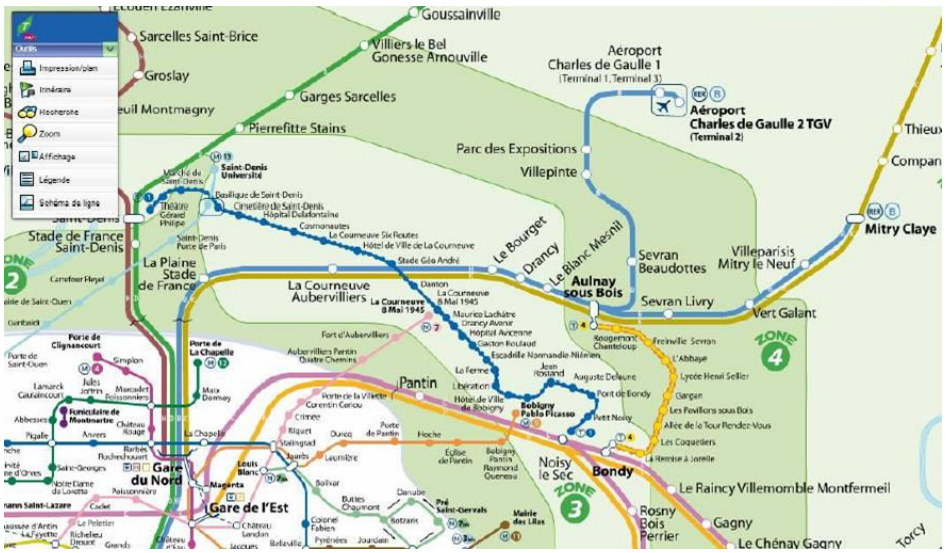
Source: Metro Ligero Oeste

Paris T4 (Aulnay – Bondy)

While several other tangential Paris tramway schemes are presented in chapter below, the T4 scheme as a tangential sub-urban service in Greater Paris is to be seen as a “light rail” case.

The scheme uses a historic railway corridor and acts as a TramTrain „shuttle“ between two RER-nodes (Paris commuter railway, see S-Bahn report). There is no physical connection to main line railways at either end (except to the depot) – TT-operation is completely separated (6min frequency).

The only 8km long corridor serves a population of 280,000 inhabitants!



Paris network map excerpt

Source: RATP

Aulnay – Bondy TramTrain impressions

Source: Axel Kuehn

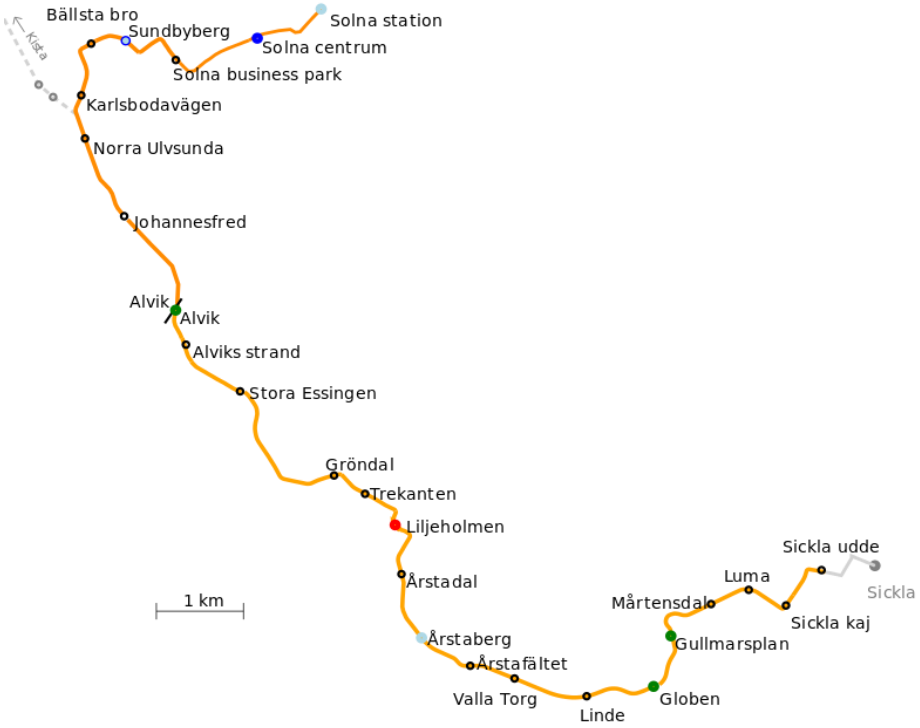
Stockholm Tvärbanan

Tvärbanan is a tangential light rail corridor in the West and South of Stockholm. It connects Metro line hubs and has been a tremendous success (> 100000 pass/day).

Tvärbanan impressions

Source: Wikipedia (left) / Rob van der Bijl (right)

The 4th extension process has already been started.



Tvärbanan corridor

Source: Wikipedia

Tramway

Classic use:

- More or less segregated urban or sub-urban alignments allowing for standard train length (30-45m), usually diametrical lines crossing the city centre.

  Attention: concentration on the classic scope is still state-of-the-art if the tramway is the highest quality mode in a network!

Other use:

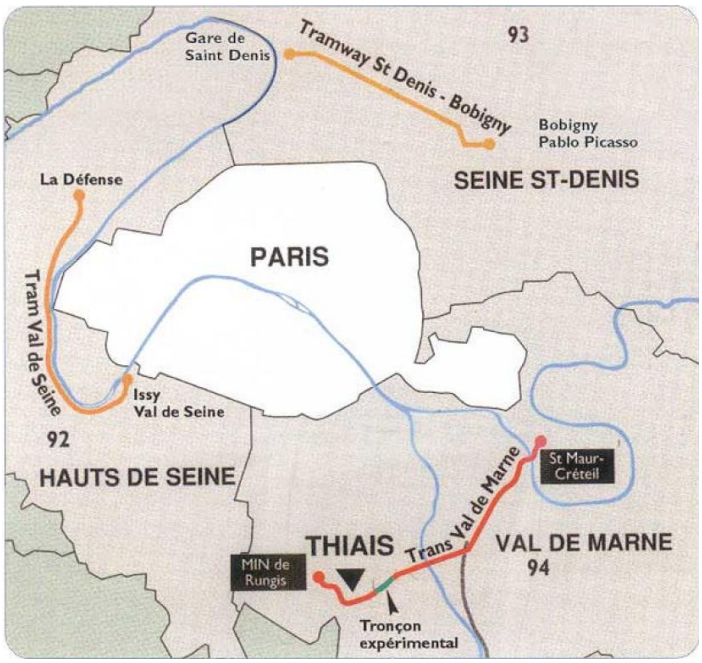
- Tramway alignments with a tangential and/or feeder/connector function

Tramway used as tangential feeders or connectors

Examples from 5 European cities / agglomerations are presented.

- Paris (T1-T3, T7)
- Bilbao tramway
- Zurich Glattalbahn
- Munich line 23
- Gothenburg “Kringen”

Paris



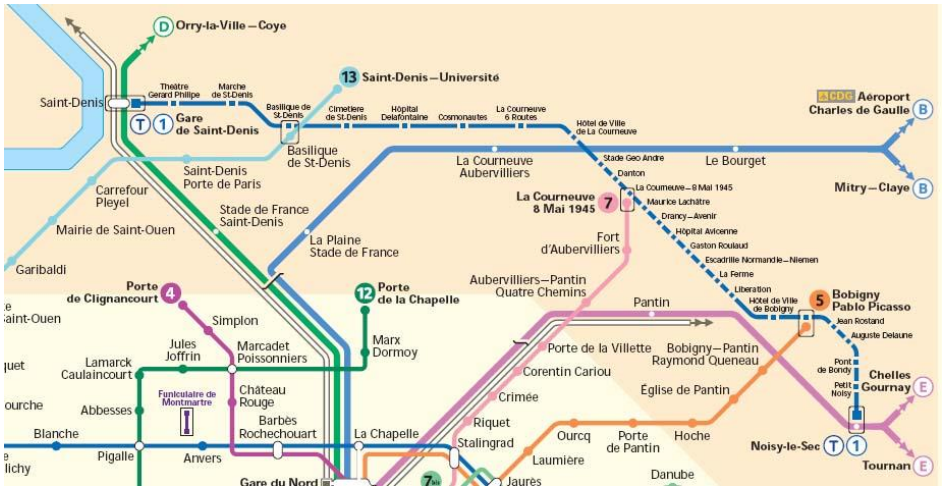
Tangential schemes in Paris agglo

Source: RATP

Paris has a tradition for high quality tangential services in the suburbs which are implemented either as tramways (T1, T2, …) or busways (TVM).

Paris T1

T1 is the first "Paris" tramway opened in 1992 between St.Denis and Bobigny in the North of Paris, extended in 2003 to Noisy-le-Sec. It offers various interchanges to RER and Metro.



Paris network map excerpt

Source: RATP

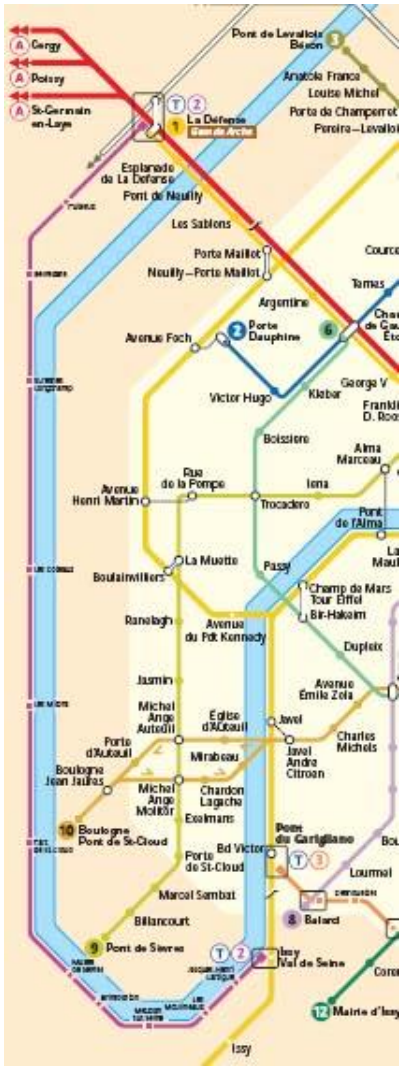
Paris T2

Formerly a railway line, the corridor from Ivry Val-de-Seine to the La Defense newtown in the West of Paris has been converted to tramway in 1997, in 2009 it was extended from Ivry to Porte de Versailles, in 2012 also beyond La Defense.

It offers various interchanges to RER, Metro and tramway.

Paris T2 impressions

Source: Axel Kuehn



Paris network map excerpt

Source: RATP

Paris T3

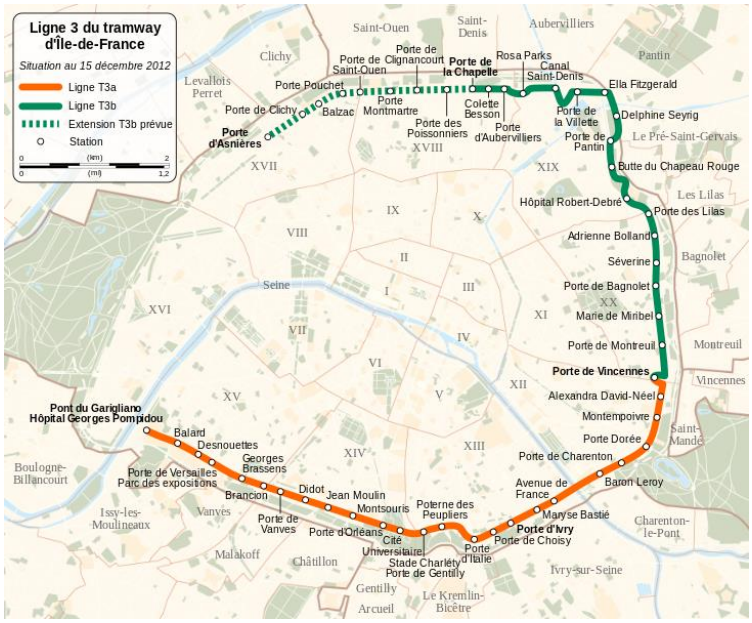
T3 should be seen as the first “urban tramway” in Paris as it is serving the boulevard ring. It has been opened in 2006 and extended in 2012.


Paris T3 impressions

Source: Axel Kuehn

With a length of currently 22.4km long it is operated as two lines: 3a and 3b

It offers interchange to 6 metro lines, 2 RER lines and the T2 tramway.



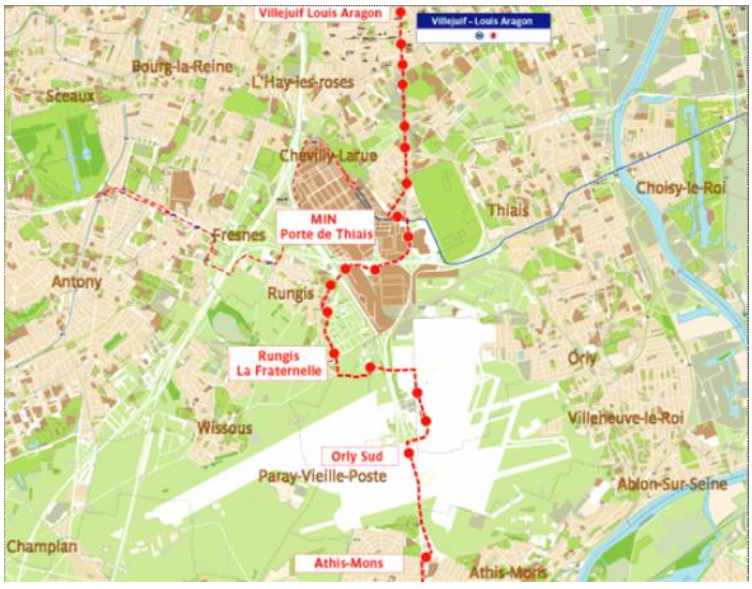
T3 map

Source: Wikipedia

Paris T7

T7 is the latest “Paris tramway” opened in 2013.

Currently 11.2 km long, it is extending Southwards from Metro 7 terminus Villejuif Louis Aragon and connecting to Orly Airport, TVM and RER.



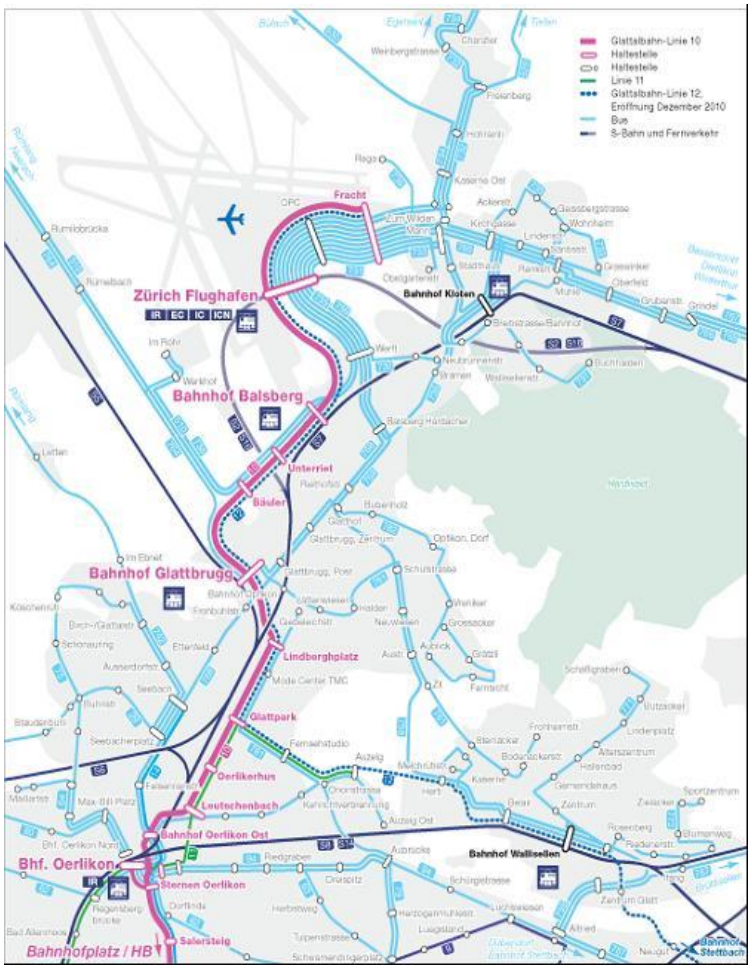
Paris T7 map

Source: RATP

Paris T7 impressions

Source: Wikipedia/Le Republicain

Zurich Glattalbahn



Glattalbahn network map

Source: VBG

This regional tramway is linking Zurich airport by light rail to Zurich main station, passing through business and develop-ment areas and offering various interchange options.

Main task is not offering an airport link from the centre of Zurich (train services are much faster!) – it is much more a feeder and connector role.

Bilbao tramway

The Bilbao tramway owned when opened in 2002 a length of just 4.95km and 12stops (average stop distance ≈ 410m). Its function is the one of a feeder tram serving touristic sites and connecting to several interchange nodes (6 trams per hour). With 19min travel time end to end the average speed is only 16km/h – speed is not the issue!

Function of the tramway (green) within the Bilbao network

Source: Enrique Urkijo Goitia, adapted

Bilbao riverfront before/after re-development

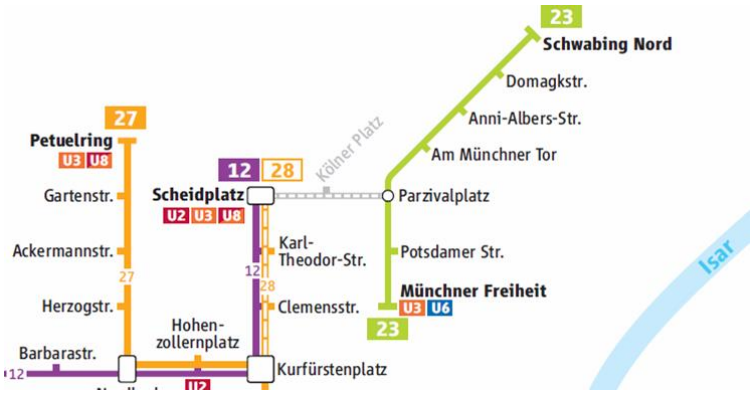
Source: Bilbao RIA2000

Bilbao tramway impressions

Source: Axel Kuehn

Munich Line 23

Munich's new tramway line 23 serves as a sub-urban "island" feeder connecting the Schwabing-Nord development area to the Münchner Freiheit metro stop. It was opened in 2009 – Munich's first new tramway line for many years.



Munich network map excerpt

Source: MVV

Munich network map excerpt

Source: MVV

Munich line 23 impressions

Source: Axel Kuehn

Gothenburg “Kringen”

So-called “Kringen” (established 2002 – 2015 in steps) is a new network feature for Gothenburg: offering now also tangential services beyond the “all lines through City centre” style.

Kringen “principle”

Source: Västtrafik, adapted

HQ bus / busway

Classic use:

- Radial or diametrical busway alignments leading into or through city centres

Other use:

- Busway alignments with a tangential and/or feeder/connector function

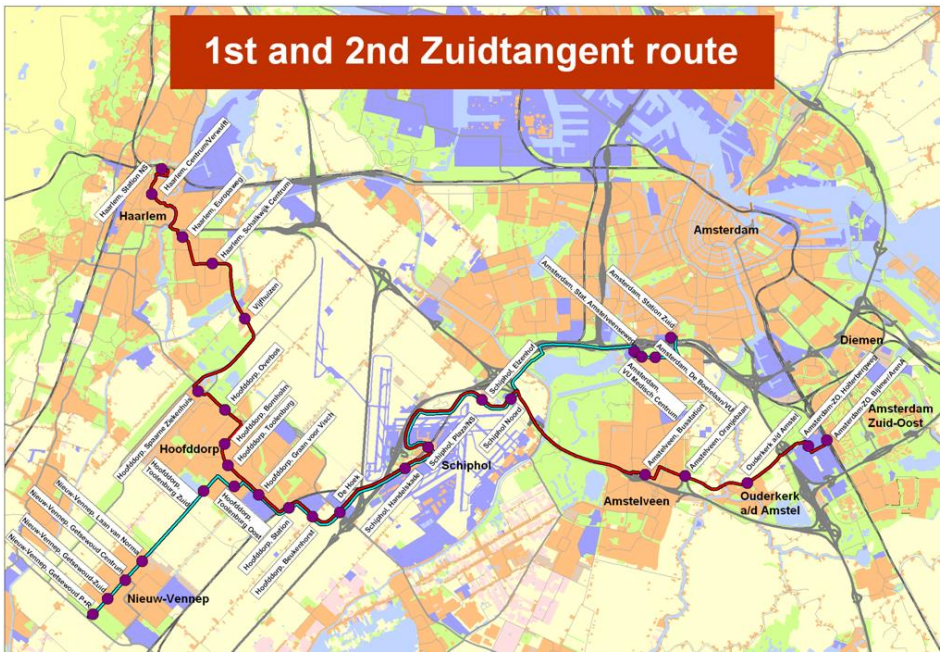
Busway alignments as tangential feeders or connectors

Three examples are presented:

- Amsterdam Zuidtangent
- Paris Trans-Val-de-Marne
- Helsinki Jokeri Line

Amsterdam Zuidtangent

Amsterdam Zuidtangent is a tangential busway system in the South of Amsterdam agglo. It links Haarlem via Hoofdorp with Schiphol Airport and further to Amstelveen and Amsterdam Zuid-Oost (football stadium, shopping centre etc).



Zuidtangent corridor

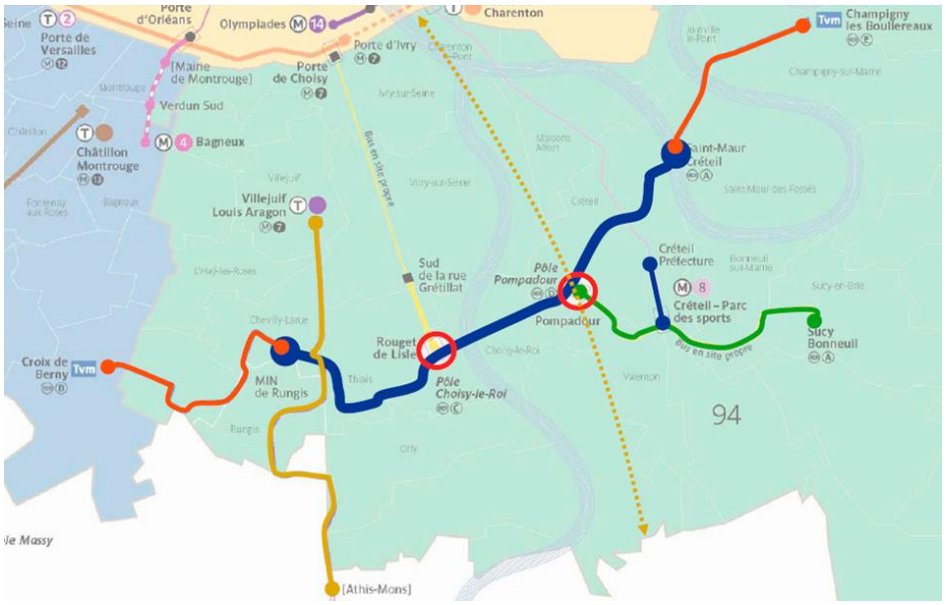
Source: Stadsregio Amsterdam

Zuidtangent impressions

Source: Axel Kuehn

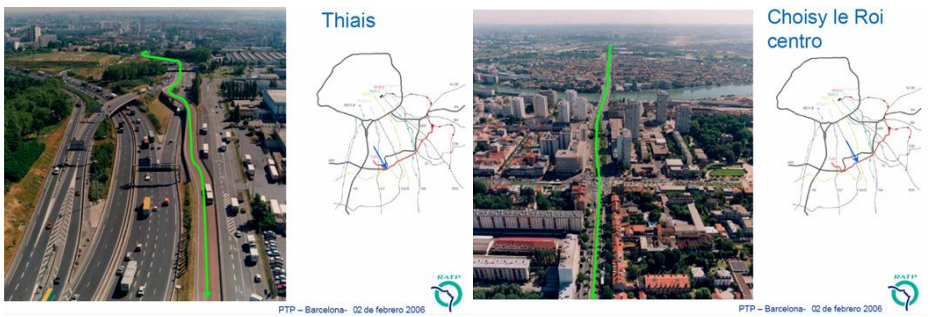
Paris Trans-Val-de-Marne (TVM)

TVM is a tangential busway system in the South of Paris. It offers several interchange options to RER-lines, lately also to tramway T7 (linking to Orly airport).



TVM corridor

Source: RATP



TVM impressions

Source: RATP

Helsinki Jokeri Line

The Jokeri Line is a tangential busway system in the North of Helsinki region. It is connecting radial rail lines.

Jokeri corridor

Source: Wikipedia

Bus

Standard bus features have not been integrated in the original presentation.

However, a separate report of the experts on bus terminal issues has highlighted a variety of international approaches in regard of bus network planning.

Conclusion and recommendation

As mentioned before, this collection of PT-cases is neither representing all “other uses” of the different PT-modes and it is certainly not covering all “best practice” cases which could be mentioned.

The author’s understanding was to present a “toolbox 1.0” without having a chance to cover everything. Further updates could/should be expected.

As pointed out, there was no aim to focus specifically on themes and cases which appeared of specific importance for Oslo. The original presentation was aiming to give an overview of options which should be evaluated further regarding their applicability for Oslo.

It is recommended to use this overview as a contribution to a “planning manual” for Oslo’s PT.

Axel Kuehn, Karlsruhe

8 June 2015