



# KVU OSLO- NAVET

## S-Bahn features

A description of international understanding

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**Prosjekt:** KVU Oslo-Navet

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**Vedlegg til:** Hovedrapporten

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### Sammendrag:

Dette notatet er den utenlandske eksperten Axel Kuehns beskrivelse av S-bane og hvordan S-banesystemene skiller seg fra togsystemene internasjonalt.

## Executive summary

Axel Kuehn, as a part of his ongoing commission as an international expert for the Oslo Navet KVVU project, has been asked to contribute a description in regard of the international understanding of what S-Bahn operation distinguishes from standard train operation in agglomerations.

The expert's main findings are summarised below:

1. It is important to understand that “S-Bahn” is not a new PT-mode but a handy name for a dedicated commuter railway operation in agglomeration areas (similar to the use of eg “Flytoget” for dedicated airport services).
2. S-Bahn operation is not just a German phenomenon but something to be found in various European countries (also in Scandinavia). While the German term “S-Bahn” has been used as kind of a synonym within the KVVU-project, it is worth mentioning that similar operational features can be found in a variety of European countries under different names:
  - ⇒ Germany: S-Bahn (big variety of systems)
  - ⇒ Austria: S-Bahn (Vienna)
  - ⇒ Switzerland: S-Bahn (Zürich, Basel, several more)
  - ⇒ France: RER (Paris)
  - ⇒ Spain: Cercanias (Madrid, several more)
  - ⇒ Denmark: S-tog (Copenhagen)
  - ⇒ Sweden: Pendeltåg (Stockholm)
3. The majority of nowadays systems of the S-Bahn genre are operating jointly with other railway traffic. Segregation from other railway traffic, if existing at all, is limited to core and dedicated infrastructure as eg city-tunnels. In other sections of the network railway corridors may have been extended (eg from 2 to 4 tracks) to mitigate capacity limitations.
4. Technical layouts which hinder co-operation between S-Bahn and other railway traffic (specific power supply features, conductor rails, differing voltages) are by no means a requirement for those services but much more a historical feature surviving in few systems from pre-WW2 times. Such features are not found in any S-Bahn system created since the 1960s.
5. S-Bahn features are usually not just of technical nature but often linked to a variety of issues:
  - ⇒ rail infrastructure (dedicated infrastructure at least for core parts of the network, city-tunnels depending on local layout of main railway stations),
  - ⇒ rolling stock (dedicated rolling stock, often EMUs),
  - ⇒ operational patterns (eg fixed frequencies, also depending on more urban or regional characteristics),
  - ⇒ operational adaptability (eg differing frequencies for peak/off-peak times and different sections of a line, different train length by coupling of train-sets...),
  - ⇒ branding (easy to identify and to distinguish from other rail services),

- ⇒ fare integration (more “at home” in the local respectively agglomeration fare system than in the “national” railway fare structure),
  - ⇒ specific organisational structures involving PTAs or other bodies with tendering responsibility to ensure proper integration in agglomerations’ PT-networks.
6. S-Bahn is not a fixed definition but can include different features even within single networks (there is some flexibility given...).
  7. S-Bahn like systems may be but are not required to be treated as separate rail systems with regard to tendering and operator choice, they may also exist within classic “state railway” environments.
  8. Important is, however, in order to give S-Bahn-like operation the highest success opportunities in agglomeration areas, that those who require the offer (= the agglomeration) are able to influence (to decide) the layout of services and to ensure proper integration in the PTA’s other PT-offers.

## Introduction

Axel Kuehn, as a part of his ongoing commission as an international expert for the Oslo Navet KVVU project, has been asked to contribute a description in regard of the international understanding of what S-Bahn operation distinguishes from standard train operation in agglomerations.

While the German term “S-Bahn” has been used as kind of a synonym within the KVVU-project and forms a dedicated part of the K3 scenario, it is worth mentioning that similar operational features can be found in a variety of European countries under different names:

Germany:	S-Bahn (Berlin, Hamburg, Munich, Rhein-Ruhr/Cologne, Frankfurt/Rhein-Main, Stuttgart, Hanover, Dresden, Rhein-Neckar, Leipzig ... (Bremen, Rostock, Nuremberg, Karlsruhe, Freiburg not covered))
Austria:	S-Bahn (Vienna)
Switzerland:	S-Bahn (Zürich, Basel, (others not covered))
France:	RER (Paris)
Spain:	Cercanias (Madrid, Cadiz, (others not covered))
Denmark:	S-tog (Copenhagen)
Sweden:	Pendeltåg (Stockholm)

The following chapters give a short description of the different “S-Bahn” systems and highlight common or differing features.

## S-Bahn (Germany, Austria, Switzerland)

Germany has a long S-Bahn tradition dating back to 1907 (Hamburg) and 1924 (Berlin) but the big breakthrough took place in the 1970s when several bigger agglomerations received revamped commuter rail systems (Frankfurt, Munich, Stuttgart...). However, even very recently new S-Bahn-schemes came into existence (Rhein-Neckar, Leipzig).

The term S-Bahn was first used in Berlin from the late 1920s – the Hamburg system was called S-Bahn from 1934. There exists some confusion of what the S was standing for in the early days – it appears to be for “Stadtschnellbahn” (fast urban railway) and not “Stadtbahn” or “Schnellbahn”.

Typical for S-Bahn services have been from the early days the specific branding as a dedicated system (besides other railway systems but not to be seen as another mode!), the use of dedicated infrastructure at least in the core parts of the network and the use of dedicated rolling stock (often EMU trains).

The two oldest S-Bahn systems in Hamburg and Berlin are different from a technical perspective, being based on DC-electrification while railway electrification in Germany is generally based on AC.

Some German agglomerations (eg Karlsruhe, Freiburg) use the term S-Bahn for regional TramTrain respectively railway services without fulfilling the standard definitions.

The only Austrian S-Bahn system in Vienna received this name officially as late as 2005, before it was called “Schnellbahn” even if the term S-Bahn seems to have been used occasionally since the 1960s.

In Switzerland the term S-Bahn is now widely used in a number of agglomerations but not all of them are “true S-Bahn systems” in the core sense. The Zurich S-Bahn can be seen as such. It started in 1990 but there have been preliminary services with S-Bahn features from the 1960s.

### Berlin

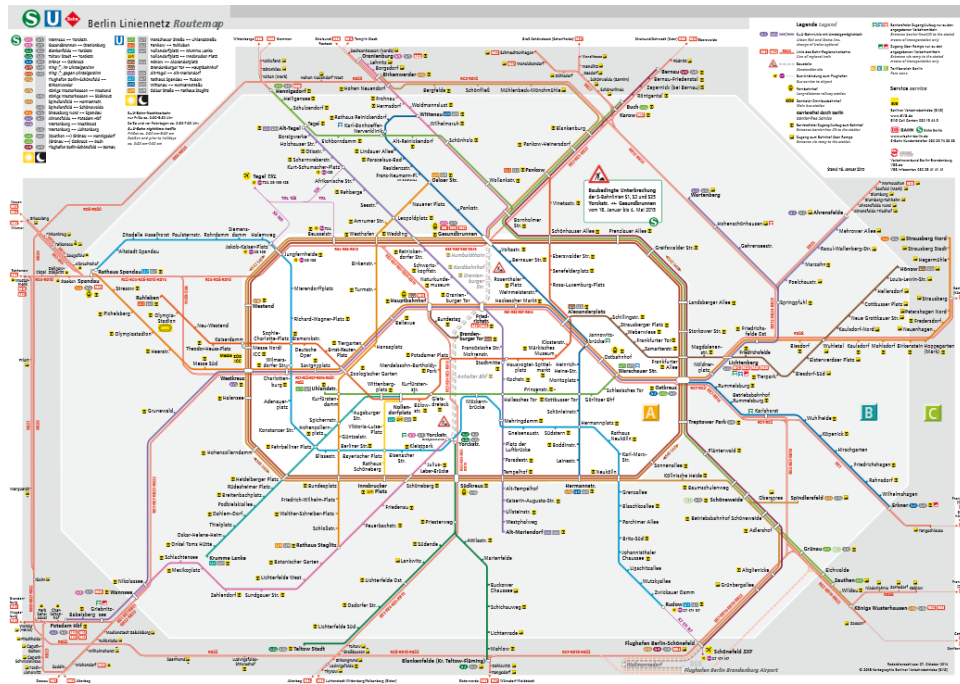
The Berlin S-Bahn, as mentioned above, can be seen as the “grand mother” of German S-Bahn systems.

The network covers a total of 331km with 166 stops which is operated with 15 lines.

The network consists basically of 4 components:

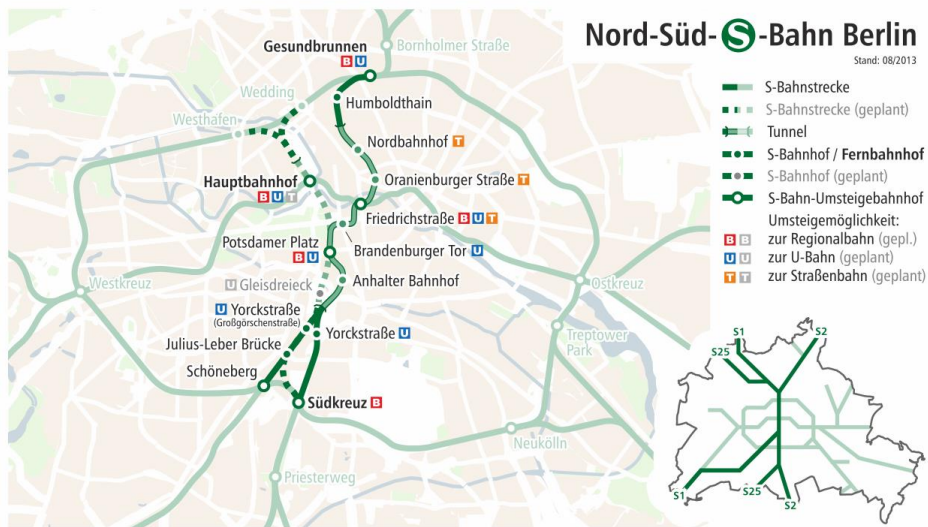
- ⇒ An East-West overground corridor through the central areas of Berlin,
- ⇒ A North-South underground corridor through the central areas of Berlin, which will be doubled in the future in order to connect to the new main railway station,
- ⇒ An S-Bahn ring with four node-stops in all compass directions (Ostkreuz, Westkreuz, Gesundbrunnen and Südkreuz),
- ⇒ Sub-urban / regional branches starting from the ring respectively the ring nodes.

The S-Bahn track system is more or less completely independent from the “standard” rail network. Power supply is 750V DC by conductor rails. Exceptions are a few sections in outer areas where “mixed” infrastructure with both 15kV AC overhead power supply and 750V DC conductor rail is in use and stops are used by both S-Bahn vehicles and other passenger trains.



Berlin S-Bahn / Rail network

(Source: VBB)



Nord-Süd-S-Bahn Berlin (existing and planned)

(Source: Wikipedia / CellarDoor85 (Robert Aehnelt))

The S-Bahn system is operated with special EMU vehicles of 36.8m length and 3m width, so-called “quarter trains”, which are used in four compositions:

- ⇒ Single vehicle (“Viertelzug”),
- ⇒ Two vehicles coupled (“Halbzug”),
- ⇒ Three vehicles coupled (“Dreiviertelzug”),
- ⇒ Four vehicles coupled (“Vollzug”), 147m trains, maximum length.



S-Bahn Berlin vehicle and system logo

(Source: Axel Kuehn)



S-Bahn Berlin train in Friedrichstraße station

(Source: Axel Kuehn)

The longest line by kms is S8 with 56km (70min travel time), longest line by travel time is S5 with 49km (96min travel time).

The operational patterns include principally for all lines the maximum line (total length, about 50km) and two reduced line lengths of about 25-30 and 10-15km length.

Frequencies per line are up to 20min (peak hours and ring 10min) which means for joint sections a maximum headway of about 3min.

During the period when Berlin was a divided city and the surrounding region was part of the GDR, the network was operated by DR (Deutsche Reichsbahn = GDR state railway). After the erection of the Berlin wall two separate networks were created but DR remained responsible also for the West-Berlin network. As a result of major struggles (strike, boycott...) the West-Berlin PT-operator BVG became responsible for the S-Bahn in the west part in 1983. After re-unification the joint network was operated from mid-1990, until 1993 still by DR and BVG. After the merger of DB and DR in 1993 DB became responsible.

From 1<sup>st</sup> January 1995 the newly established S-Bahn Berlin GmbH became responsible which is a 100% DB (DB Regio) subsidiary.

S-Bahn Berlin homepage

(Source: <http://www.s-bahn-berlin.de/>)

Current operation is covered by a contract from 2004 lasting until 2017. Attempts to tender the S-Bahn operation have so far failed for a variety of reasons.

The S-Bahn is operated under the regime of the Berlin-Brandenburg PTA (VBB, Verkehrsverbund Berlin-Brandenburg) which came into existence in 1999 and is fully integrated in the overall fare system. VBB owns also the tender responsibility for S-Bahn services.

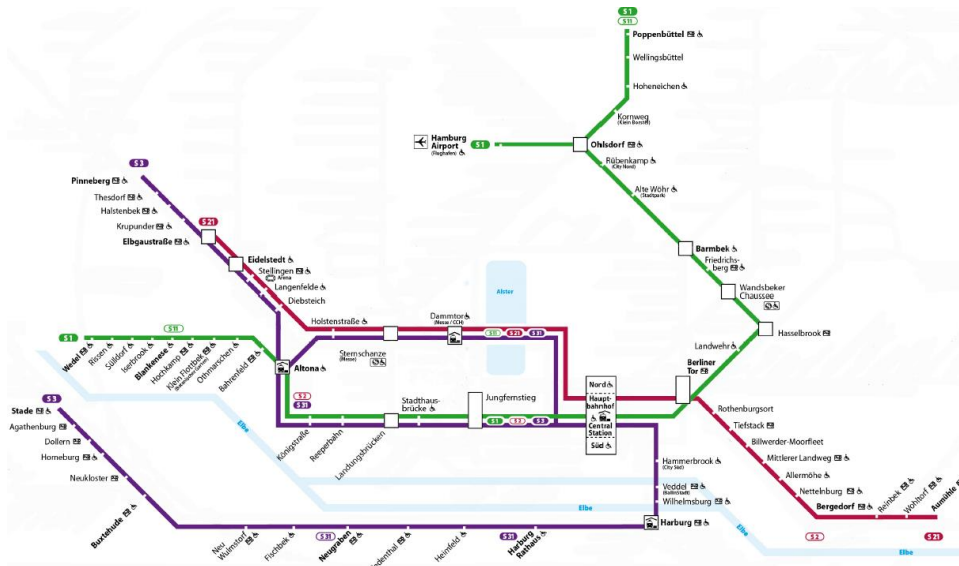
## Hamburg

Even if not named S-Bahn until 1934 the origins of the sub-urban railway system in Hamburg date back even further than the Berlin system.

Together with Berlin the Hamburg system is the only German S-Bahn system which is operated with DC power supply and thus principally independent from other railway traffic. The network of 147km and 68 stations is operated with 6 lines (4 lines + 2 peak hour lines).

Two corridors serve the city centre and offer kind of a ring infrastructure and serve the two main railway stations Hauptbahnhof and Altona. The second, Southern corridor was established in steps between 1975 and 1981.



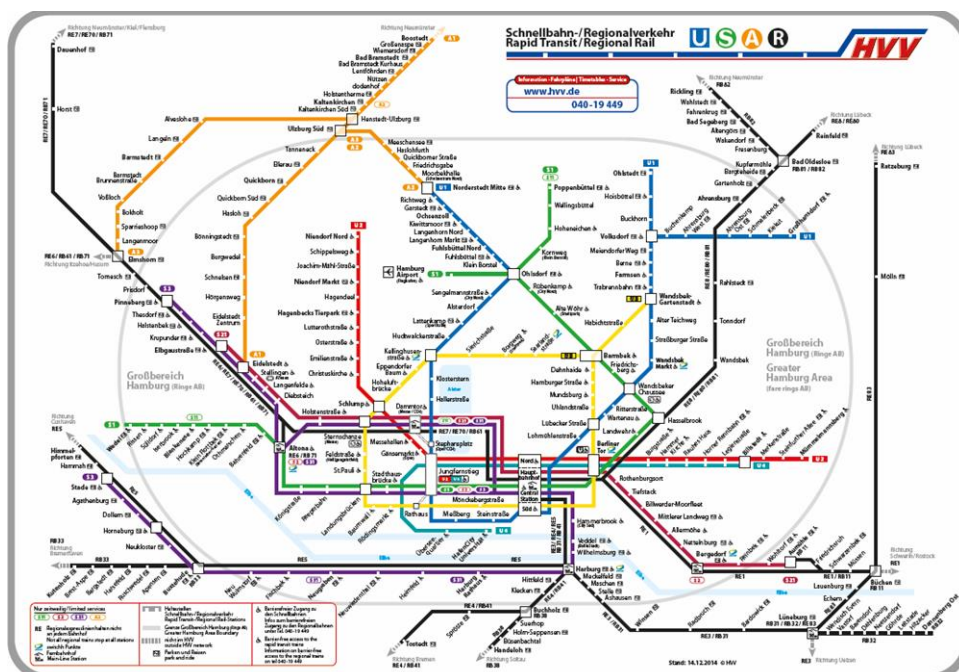


Hamburg S-Bahn network

(Source: S-Bahn Hamburg)

Line S3 to Stade is to be seen as a special one as here the S-Bahn operates for about 30km between Neugraben and Stade on standard DB-infrastructure with AC overhead power supply and using dual-mode rolling stock (since 2007). This line with 75km length and 100min travel time is also the longest line in the Hamburg network. Other lines are much shorter and range from about 30-40km.

Another dual mode case is the A1 line of Altona-Kaltenkirchen-Neumünster (AKN) railway which is principally operating DMU services on unelectrified infrastructure in the North-West of Hamburg. Some trains are extended to Hamburg main stations on S-Bahn infrastructure.



Hamburg S-Bahn / Metro / Rail network

(Source: HVV)

Compared to other S-Bahn networks, the Hamburg one owns much more urban characteristics and the Stade branch is actually the only one leaving the Hamburg city limits. Besides the Stade extension, the airport branch is one of the more recent extensions opened in 2008.

Until 2002 some regional railway lines operated with standard rolling stock (loco-hauled trains) had also been named as S-Bahn lines but since then the branding has been “cleaned”.

The operation scheme is based on a 10min frequency on all lines but outside peak hours the outer sections of lines are reduced to a 20min frequency. The Stade branch (S3) is operate in a 20min frequency during peak hours and hourly outside off-peak.

The Hamburg S-Bahn system uses EMU rolling stock of 65m length (three units) which is used as a short train (“Kurzzug”) or as a standard train (“Vollzug”) with six units respectively long train (“Langzug”) with nine units.



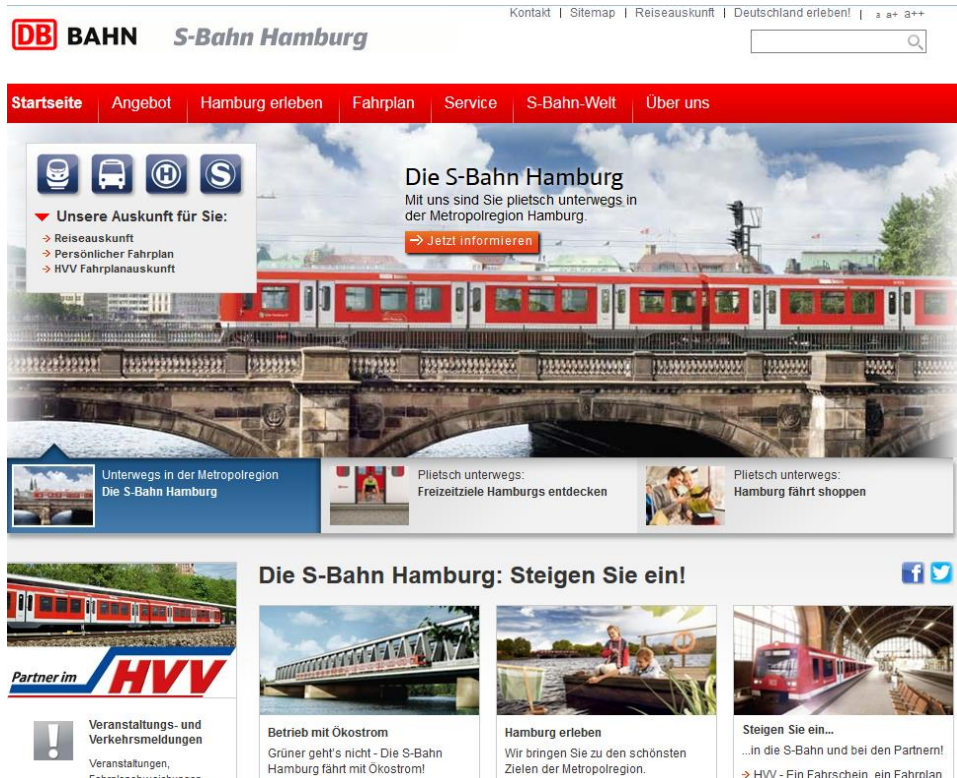
S-Bahn Hamburg train in Hamburg main station

(Source: Wikipedia/Clic)

Although designwise rather similar to other S-Bahn EMUs used in Germany the vehicles are specific Hamburg ones with regard to their 1200V DC requirement, even more with regard to dual mode layout which will become a rather standard feature for the next generation in regard of further extensions raising similar needs as the Stade branch.

The Hamburg PTA, the Hamburger Verkehrs-Verbund (HVV), was established in 1965 and is recognised as the oldest PTA world-wide. S-Bahn Hamburg has been (via the DB as its mother organisation) integral partner from the beginning. This means certainly full tarif integration within the HVV area. It should be noted that HVV until 1996 was a so-called “operators PTA” (“Unternehmensverbund”) which meant that the main operators (eg DB) were co-deciding the PTA-policy. The organisational layout was changed then and the “new” HVV is now an independent public organisation with the free city of Hamburg being main shareholder and as such able to act as a contract partner for tendering processes.

The current operations contract between the free city (state) of Hamburg (respectively HVV) and S-Bahn Hamburg GmbH (a 100% subsidiary of DB) terminates in 2018. As a result of a tender process, S-Bahn Hamburg GmbH was assigned with another 15 year contract. Due to the specific rolling stock requirements paired with a rather short contract period participation in the recent tender was rather low and there was only one competing bid. To heal the basic problem, the new contract foresees that DB/S-Bahn Hamburg will sell the rolling stock (which is currently in their ownership) to the free city of Hamburg after the current contract period if another operator would become preferred bidder. This would allow principally a tender just for operations.



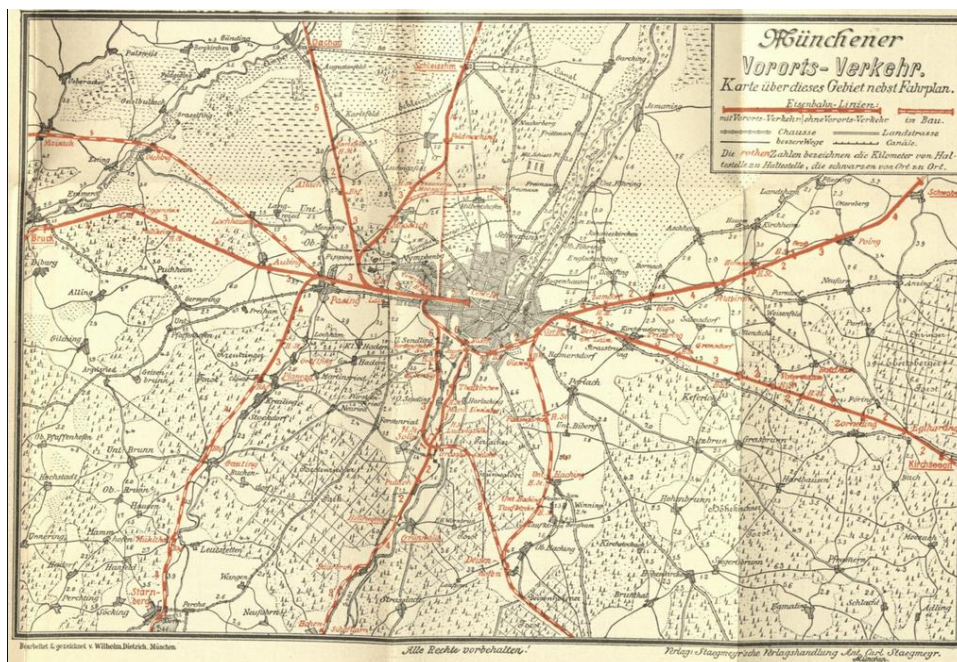
S-Bahn Hamburg homepage

(Source: S-Bahn Hamburg)

## Munich

The Munich S-Bahn system originates from the late 1960s when progress in the public transport system in Munich was boosted by the 1972 Olympic Summer Games.

Plans for connecting Munich main station and Ostbahnhof by a direct link through the city have, however, been discussed as early as 1900!



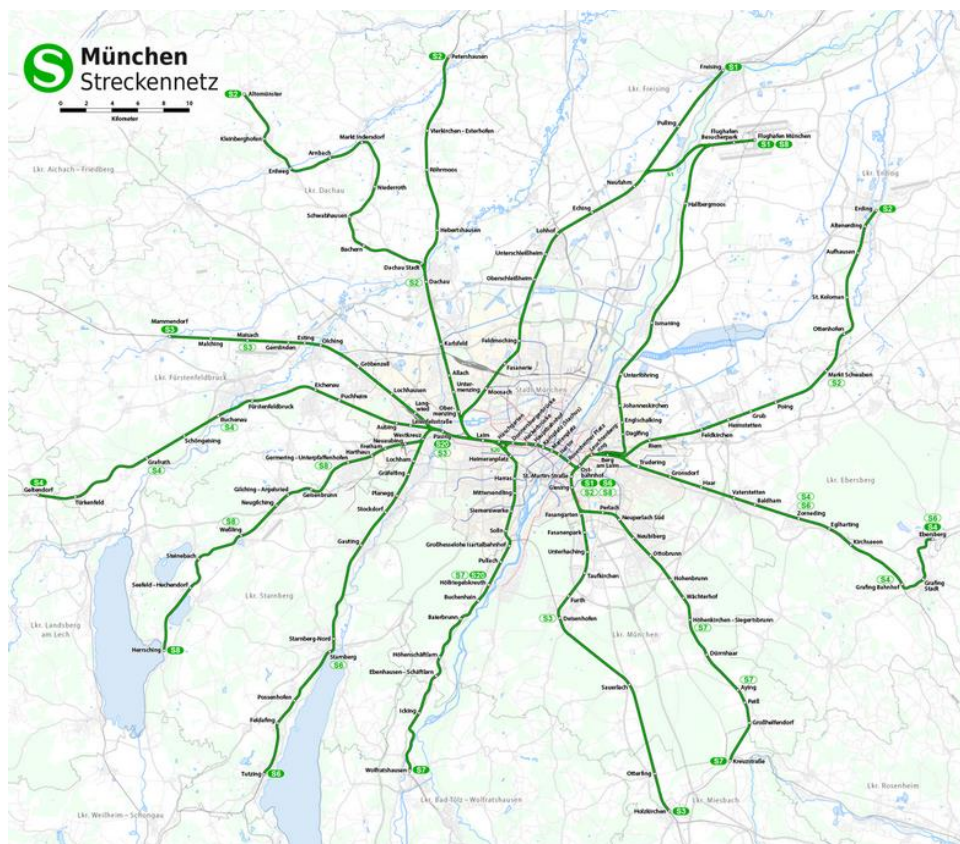
Munich suburban railway network 1898

(Source: Wikipedia / Bayrische Staatsbibliothek)

The layout of the railway network appears as what could be called the classic starting point for an S-Bahn project – at least for cities owning a terminus main station.

Shortly before WW II plans became more concrete when connected to plans for reshaping Munich and establishing a new main railway station. The scheme was already then presented as S-Bahn. A few hundred meters of “test tunnel” had been built until the project was stopped in 1941. This section was much later re-used for metro purposes.

The project was taken up again in the 1950s and the final decision dates from 1965. The project included the underground corridor through the city and the integration of 7 sub-urban railway branches in the West and 5 in the East. After the 1966 decision for the Olympic Games the planning and construction process required acceleration and some measures were postponed.



Munich S-Bahn network

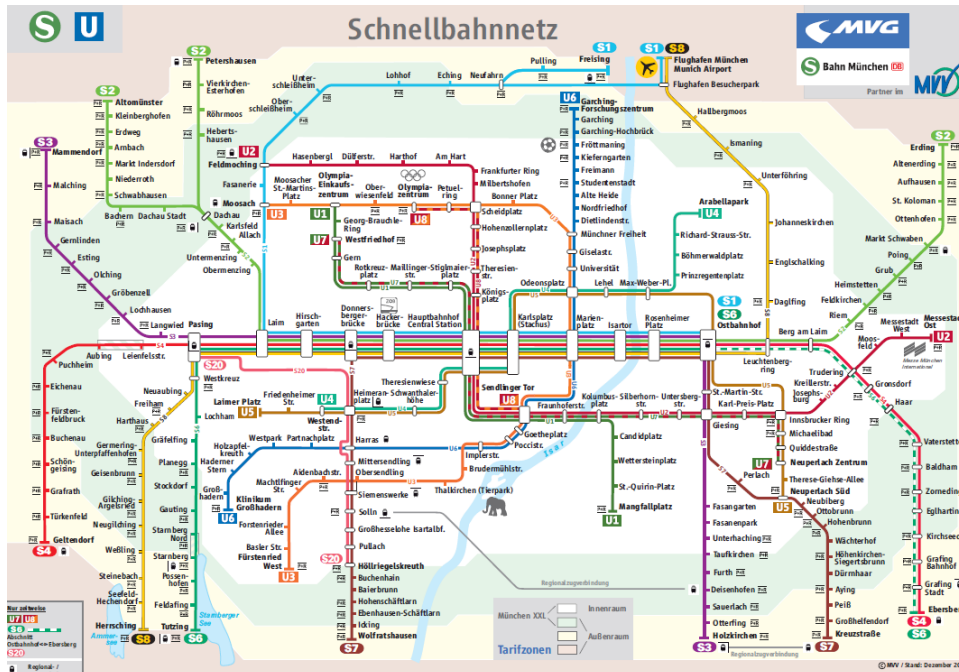
(Source: Wikipedia / Maximilian Dörrbecker)

The total network today consists of 434km tracks and 150 stations which are operated with 8 lines. This makes the Munich S-Bahn network the second biggest S-Bahn system in Germany behind the Rhein-Ruhr system.

Most S-Bahn lines use the so-called “Stammstrecke” (core corridor) between Pasing and Ostbahnhof via main station of 11km length. The sub-urban radial corridors in the West and the East are in a range from 30-40km which results in total line lengths of up to 80km.

Different to the Berlin and Hamburg systems the Munich S-Bahn like all later systems in Germany was approached as a standard railway scheme using 15kV AC overhead electrification. This means also that exclusive S-Bahn infrastructure is less a requirement and concentrates on core parts of the network respectively infrastructure along long-distance corridors while in other parts of the network operation is mixed with other passenger and cargo trains.

The network is well integrated within the Munich PTA with the more urban metro system established about the same time. The fare system of MVV includes all PT-offers in the PTA-area. However, it should be noted that MVV doesn't have the tender responsibility for S-Bahn services! Due to the different set-up of responsibilities in the federal German states, in Bavaria the responsible state organisation BEG (Bayrische Eisenbahn-Gesellschaft) deals with all tendering of rail services.



Munich S-Bahn and Metro network (“Schnellbahnnetz”)

(Source: MVV)

A second East-West corridor is currently in the planning phase (“2. Stammstrecke”).



Munich S-Bahn and metro network with second core corridor

(Source: Wikipedia / Maximilian Dörrbecker)

Operation is based on a 20min frequency per line which is increased on some sections to 10min during peak hours. Several lines own a 20/40min pattern which is created by stopping one service per hour earlier.

The Munich S-Bahn scheme uses standard EMU rolling stock which is used also by other German S-Bahn systems, first of the 420 series, now mainly of the 423 series as the newest generation. Single vehicles (4 units) are 67m long and are used as short trains (“Kurzzug”) mainly for weekend services. The standard composition (“Vollzug”) consists of two short trains (8 units), the maximum composition (“Langzug”) consists of three short trains (12 units).

S-Bahn München has been operated continuously since the opening in 1972 by DB respectively their subsidiaries (DB Regio / S-Bahn München GmbH).



S-Bahn Munich homepage (excerpt)

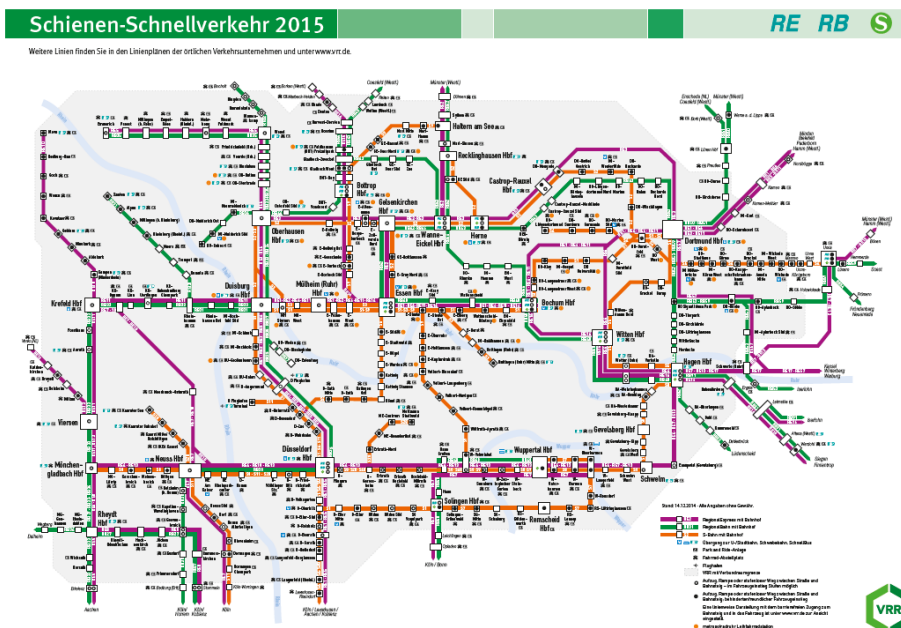
(Source: S-Bahn München)

The current contract terminates in 2017 and the Bayrische Eisenbahngesellschaft (BEG) as the state organisation responsible for tendering has just started the European tender process for operation from 2018. The big issue for this tender process will again be the handling of the rolling stock question even if the Munich systems requires more standard vehicles than Berlin or Hamburg.

### Rhein-Ruhr / Rhein-Sieg (Cologne/Rheinland)

The Rhein-Ruhr and Rhein-Sieg S-Bahn schemes are partly overlapping and therefore handled together here.

Like for some other S-Bahn schemes emerging in the 1970s (eg Stuttgart) the origins of the Rhein-Ruhr system are dating back to the 1930 when a so-called “Ruhrschnellverkehr” was established, partly on dedicated tracks but operated still with loco-hauled trains. DB had even developed a specific steam locomotive for these services.



Rhein Ruhr S-Bahn / Rail network

(Source: VRR)

## Linienetzplan S-Bahn Köln



Cologne S-Bahn network

(Source: DB)

When the first S-Bahn lines were opened in 1967 the Rhein-Ruhr scheme was the first German scheme using standard DB power supply / electrification (15kV AC).

Different to most other S-Bahn systems in Germany it is not based on any new city-tunnels but on existing respectively extended surface infrastructures. This is clearly a result of non-existence of big terminus railway stations in this area – all main stations allow “through running” of trains.

Serving such a big region with several centres it is also much more a multi-polar scheme, patterns which are only to some extent visible in other German schemes.

The Rhein Ruhr network of 676km and 124 stations is served by 11 lines, the Rhein-Sieg scheme (now called S-Bahn Cologne, future Rheinland) adds 239km, 65 stations and another 6 lines. Both Düsseldorf and Cologne airports are served by S-Bahn services.

Several long lines are operated: Line S1 Dortmund-Solingen with 97km, S9 Haltern-Wuppertal with 90kms, Line S8 Hagen-Mönchengladbach 80km.

**Alle Zugfahrpläne auf einen Blick:**

RegionalExpress (RE)	RegionalBahn (RB)	<b>S-Bahn</b>
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Foto: Deutsche Bahn AG

Hier finden Sie alle Fahrpläne der im VRR fahrenden S-Bahn-Linien.

- S 1: Solingen Hbf - Hilden - Düsseldorf Hbf - D-Flughafen - Duisburg - Mülheim - Essen - Bochum - Dortmund
- S 2: Dortmund - Castrop-Rauxel - Herne - Recklinghausen - Essen - Duisburg
- S 3: Oberhausen - Mülheim - Essen - Hattingen
- S 4: Dortmund-Lütgendortmund - DO-Dorstfeld - Do-Stadthaus - Unna
- S 5: Dortmund - Witten - Wetter - Hagen
- S 6: Essen - Ratingen Ost - Düsseldorf - Langenfeld - Leverkusen - Köln
- S 7: Solingen - Remscheid - Wuppertal
- S 8: Hagen - Wuppertal - Düsseldorf - Neuss - Mönchengladbach
- S 9: Haltern - GE-Buer Nord - Gladbeck - Bottrop - Essen - E-Steele - Velbert - Langenberg - Wuppertal
- S 11: Düsseldorf Flughafen - Düsseldorf Hbf - Neuss - Dormagen - Köln - Bergisch-Gladbach
- S 28: Kaarster See - Neuss - Düsseldorf - Erkrath Nord - Mettmann Stadtwald
- S 68: Langenfeld - Düsseldorf - Erkrath - Wuppertal-Vohwinkel

S-Bahn timetables offered on VRR website

(Source: VRR)



Regiobahn Kaarst-Mettmann vehicle (Talent DMU)

(Source: Axel Kuehn)



Classed as S-Bahn services are also some regional rail services as the S28 from Kaarst to Mettmann (future Wuppertal) which are operated with DMU vehicles.

As a result of the wide-spread network it has never been possible to operate with one dedicated vehicle type. From the early days in 1967 until nowadays electric, loco hauled trains have been in use for some lines while others have been operated with EMUs. Series 420 EMUs as developed for the Munich system have been introduced from 1972 and are still in use. Also the newer series 423 and 422, the latter developed from series 423 and specifically used in the Rhein-Ruhr area are in use.

Maximum train length is reached with two coupled EMU-sets (about 140m). Platform heights are both 96cm and 76cm. 96cm has been the target height for the system for decades but has never been reached for 100% of all stops. More recently 76cm has been announced as the new standard but there exists no plan or schedule yet for changing infrastructure.

Operation is based with few exceptions on a 20 min frequency on weekdays during the day respectively a 30min frequency on weekday evenings and weekends.

The network(s) are fully integrated in the two PTAs Verkehrsverbund Rhein-Ruhr (VRR) and Verkehrsverbund Rhein-Sieg (VRS) which both are also responsible for tendering operations. Within the VRR area several operators are active for specific lines – besides DB these are ABELLIO and TRANSDEV. However, the big majority of the S-Bahn services is operated by DB Regio.



Series 423 train entering Cologne main station

(Source: Axel Kuehn)

A screenshot of the S-Bahn Köln homepage. The page features the DB logo and the slogan 'DEUTSCHLAND ERLEBEN!'. There is a search bar and navigation tabs for 'Startseite', 'Regionen', 'Freizeit Tipps', and 'Fahrziel Natur'. The main content area is titled 'S-Bahn Köln' and includes a search filter for 'Ausflugsziele' (outing destinations) with options for 'Wo' (Region) and 'Was' (Interests). Below this, there are three columns of text and images: 'Wir verbinden Köln' (We connect Cologne), 'Das Unternehmen' (The company), and 'Abo&amp;Mehr in NRW' (Subscription &amp; more in NRW). Each column has a 'mehr' (more) link.

S-Bahn Cologne homepage

(Source: DB Regio)

## Frankfurt / Rhein-Main

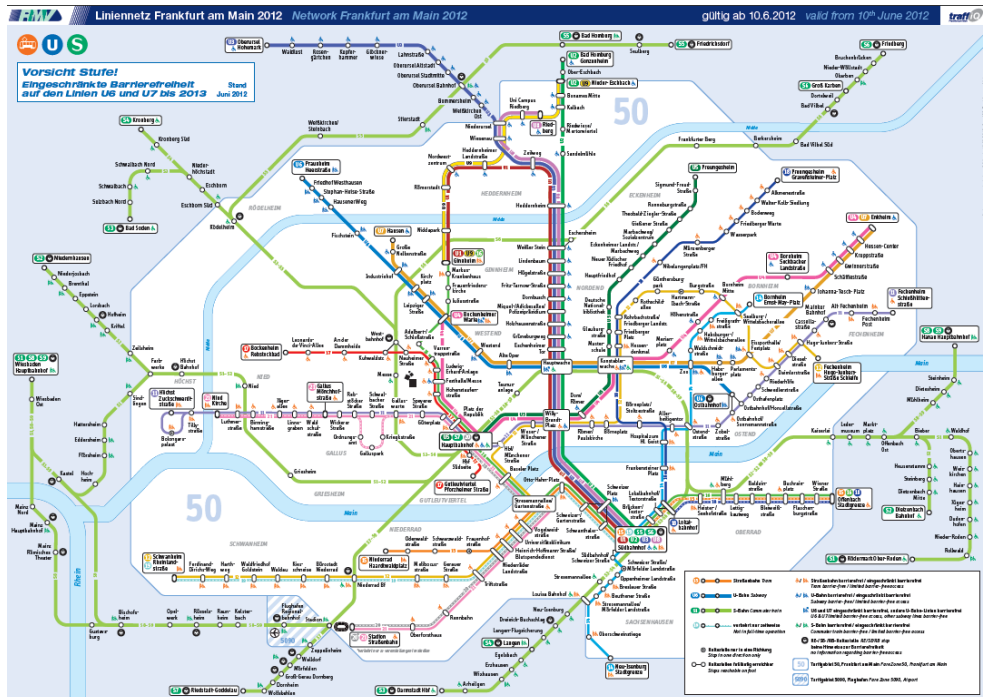
The Frankfurt S-Bahn system originates from the 1960s and was implemented in several steps between 1978 and 1992.

Similar preconditions as discussed for Munich: a terminus main station and following from this a core tunnel corridor through the city. A difference is the splitting of the tunnel in the East in two branches: further East towards Offenbach and South in direction of Darmstadt. The city-tunnel in Offenbach is a second core tunnel corridor (3.7km), the airport tunnel a third one (2.2km).



Frankfurt / Rhein-Main S-Bahn network

(Source: Wikipedia /Daniel Erler)



Rhein Main S-Bahn, metro and tramway network

(Source: RMV)

Frankfurt was the first city serving its airport by S-Bahn; since the opening of the “long distance” train station in 1999 the airport has also become an ICE-hub.

The network of 303km and 111 stations is operated with 9 S-Bahn lines. The longest lines are S1 and S8 with 72 respectively 70km length and travel times of 87 respectively 84 minutes.

S-Bahn services are well integrated with other PT-offers in the agglomeration (metro, tramway/light rail, other rail services) within the regional PTA (Rhein-Main Verkehrs-Verbund / RMV).

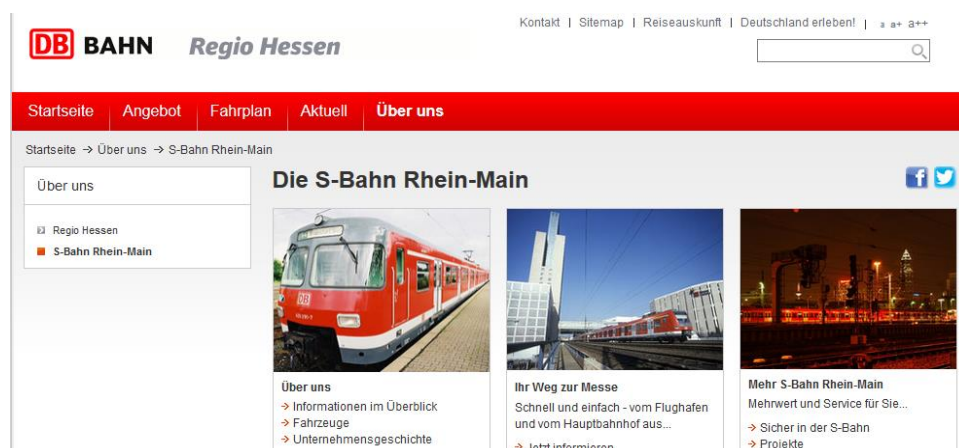
When the S-Bahn scheme was inaugurated in 1978, several other rail services have been classed as S-services. When RMV was established in 1995, the policy changed and today only “real” S-Bahn services are branded as S-Bahn. Many of such “historic” cases have been anyway converted in the meantime.

Operation is based on a 15min frequency during peak hours and 30min frequency off-peak.

When S-Bahn operation started in the 1970s the Rhein-Main system was using similar rolling stock as Munich (Series 420 EMUs). Those have been replaced now largely by series 423 vehicles and as part of the new operating contract new series 430 vehicles will be supplied by DB. The train compositions used in the Frankfurt area are similar to Munich (“Kurzzug”, “Vollzug”, “Langzug”).

Before RMV’s establishment, Frankfurt had an “operator’s PTA” similar to the “old HVV” described above. Different to the Munich situation described above, RMV has also the tender responsibility for rail services within it’s area as the Hessian state has handed the responsibility over to a few big PTAs.

RMV did tender the S-Bahn operation a few years ago and the current contract with DB Regio dates from 2014. The tender was covering three network parts which were tendered separately. The response was rather low and there was only one competing bid in the final round for one of the parts. The rolling stock issue was handled by an extended contract duration of 22 years for one (major) network part involving new rolling stock, other network parts have a duration of 15 years (re-designed / modernised rolling stock).



S-Bahn Rhein-Main homepage

(Source: DB Regio)

## Stuttgart

Even if Stuttgart is usually mentioned as the third new S-Bahn systems in Germany in the 1970s after Munich and Stuttgart, the origins date back to the 1930s when two sub-urban corridors have been extended to four tracks to give space for dedicated sub-urban operation using already at that time EMU rolling stock. Also first ideas for a city tunnel date back to this time - the starting conditions with the main railway terminus station being again similar as in Munich or Frankfurt.





S-Bahn Stuttgart station

(Source: Axel Kuehn)

The operational scheme is based since 1996 on a 60/30/15min frequency on all lines with a 15min offer during peak hours (except the tangential services with 30min). Peak hour definition has been widened in this regard.

Rolling stock is similar to the Munich and Frankfurt systems: originally series 420 EMUs, now series 423. Also the train compositions used are identical (“Kurzzug”, “Vollzug”, “Langzug”).

The organisational set-up for the S-Bahn in Stuttgart is different to most other cases in Germany. While there exists since 1996 a state organisation for the tendering of railway services (Nahverkehrsgesellschaft Baden-Württemberg / NVBW), such is not responsible for S-Bahn Stuttgart but for all other rail services in the region. The Stuttgart region owns since 1973 a specific political body, the so-called Verband Region Stuttgart (VRS) which deals with a number of issues of regional importance, as eg regional planning, strategic land-use planning, economical development support and PT-issues of regional importance. The S-Bahn as a core part of the regional PT-network is therefore under direct regional influence.

The regional PTA, the VerkehrsVerbund Stuttgart (VVS) is a “mixed PTA” which means that both PT-operators and local/regional bodies (as eg VRS) are responsible on the same level. It is therefore more a classic PTA for fare integration and less a PTA suited for tendering responsibility.

VRS started in 2005 a tendering process for S-Bahn Stuttgart for the period from 2013-2028. Out of originally 4 competitors only one bidder stayed to the end of the tender process: DB Regio

The private competitors gave two major reasons for withdrawing: a) they faced big problems with establishing a maintenance facility as negotiations with DB to share the existing Plochingen facility failed and b) they saw the Stuttgart 21 project as a threat in regard of schedules and impacting on operation.



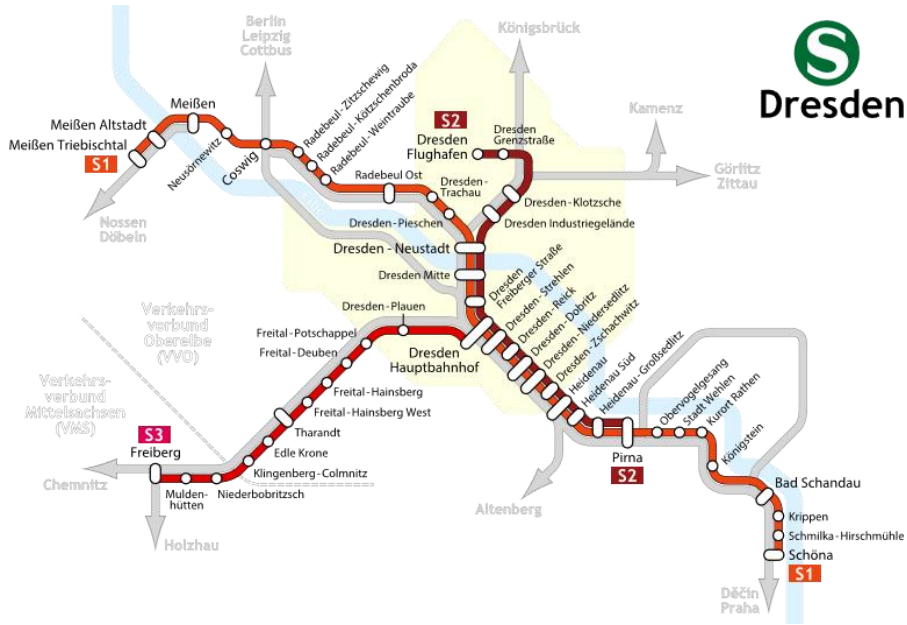
S-Bahn Stuttgart homepage (excerpt)

(Source: S-Bahn Stuttgart)

## Dresden

The term S-Bahn is used for the Dresden network since 1992. It is one of the smaller German networks with 128kms and 47 stations – operated with 3 lines. The scheme uses existing railway corridors with S-Bahn services passing through Dresden’s two main railway stations. The airport connection is part of the network.

The core corridor between Dresden-Neustadt and Pirna has been extended to 4 tracks to allow the maximum frequency achieved by overlapping of lines S1 and S2. The longest line is S1 with 78km – the backbone of the system in the Elbe valley.



Dresden S-Bahn network

(Source: Wikipedia / Maximilian Dörrbecker)

Operation is based on a maximum frequency of 30min, some outer sections are operated with a 60min frequency. Some sections of S2 and S3 are only operated on weekdays.

The screenshot shows the DB S-Bahn Dresden homepage. At the top, there is a navigation bar with 'Startseite', 'Regionen', 'Freizeit Tipps', and 'Fahrziel Natur'. Below this is a large image of a family enjoying a train ride. The main content area features a 'S-Bahn Dresden' section with the headline 'Wir bewegen Sie schnell und günstig durch Dresden und die Region!'. Below the headline, there is a brief description of the service and three promotional boxes: 'Fahrkarten & Abo', 'Kinderzug der S-Bahn Dresden', and 'Seien Sie immer top informiert!'. The footer contains a search bar and social media icons.

S-Bahn Dresden homepage

(Source: DB)

The Dresden S-Bahn system is completely based on loco-hauled double decker trains.

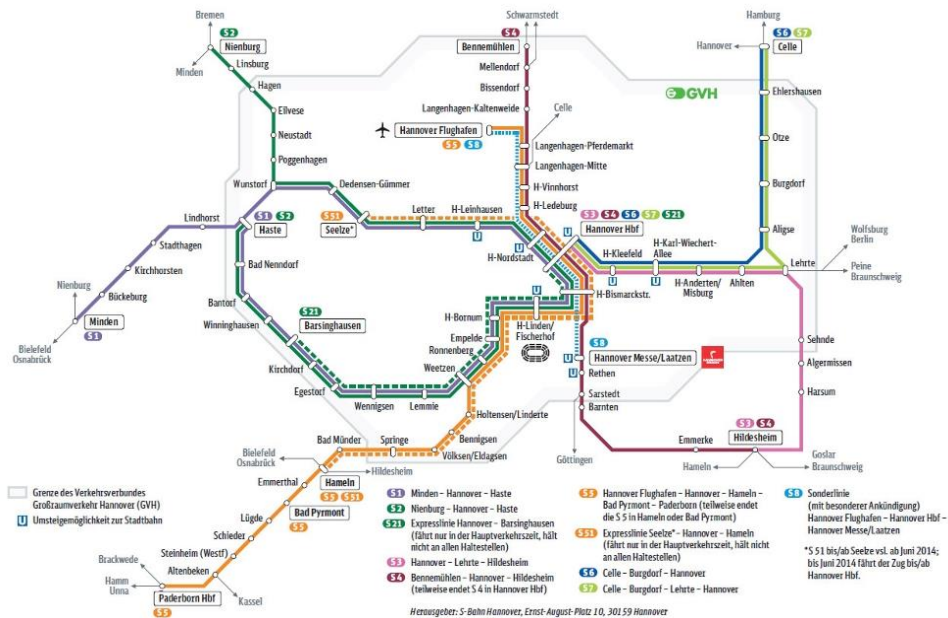
The Dresden scheme is fully integrated in the regional PTA Verkehrsverbund Oberelbe (VVO) acting as the service unit of the so-called Zweckverband Verkehrsverbund Oberelbe (ZVOE) which is formally the responsible organisation for the tendering of railway services.

The current operational contract with DB Regio dates from 2010 based on a tender procedure in 2008. It durates until 2020 with an option for 4 more years.

## Hanover

Discussions in regard of establishing an improved commuter rail network for the Hanover region date back to the 1960s but it needed the decision for EXPO 2000 to speed up decisions. The initial contract for implementing the scheme was signed then in 1990. Four lines have been opened in time for the EXPO event.

Today's network consists of 385kms with 74 stations which is operated with 9 (10) lines. One of the lines serves the newly created airport link – for special occasions (trade fair) a direct line from the airport to the exhibition area is offered.



Hanover S-Bahn network

(Source: DB)

Similar to the Rhein-Ruhr conditions this S-Bahn system is not based on a city-tunnel – all trains are just passing through Hanover main station and using existing railway corridors. At least for some corridors it s easily visible that the Hanover S-Bahn scheme is a much more regional system than other S-Bahn schemes.

The distance Hanover-Paderborn is roughly 120km and the S-Bahn requires a travel time of 108 minutes! Minden is about 80km away, Nienburg about 50km.

This regional feature is also reflected by the maximum frequency used: 30min

Differences are also reflected by the rolling stock in use: Series 424 and 425 EMUs, developed for S-Bahn Hanover. A significant difference of the series 424 is the lower floor height which allows level access fom standard 76cm platforms while the older S-Bahn schemes have been based upon higher 90cm platforms and thus causing problems for stations/platforms used by other passenger trains.

Rather unique in Germany is the organisational set-up in Hanover, even if some similarities with Stuttgart exist. The Region Hanover is a new political body created in 2001 which has replaced the former classic structure of city and county of

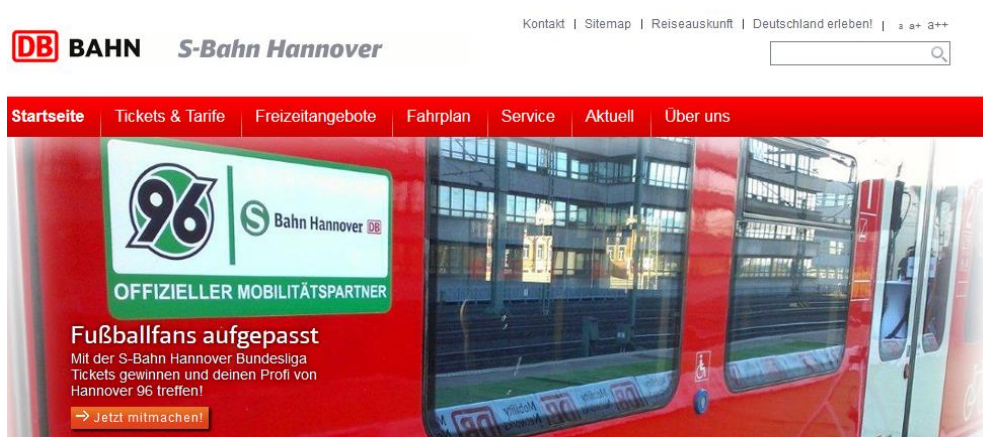
Hanover. It ensures integrated approaches for a variety of issues including public transport planning. It owns tendering responsibility for railway services within its area and is together with the Braunschweig region the only region in Lower Saxony which is not handled by the state organisation Landes-Nahverkehrs-Gesellschaft (LNVG).

The local PTA Großraumverband Hannover (GVH) is to be seen as a “mixed PTA” formed by local PT-operators and Region Hanover as the public body. It’s responsibility is more classic fare integration.



Lower Saxony organisations with tendering responsibility for rail services

(Source: LNVG)



S-Bahn Hannover homepage

(Source: S-Bahn Hannover)



The current operating contract for DB Regio dates from 2012 and durates until 2020. It was the first integral tender for the whole network. Due to the regional characteristics the tendering process involved Region Hanover, LNVG and the responsible organisation in the neighbouring state of Northrhine-Westphalia (Zweckverband Nahverkehr Westfalen-Lippe).

## Rhein-Neckar

The Rhein-Neckar S-Bahn scheme opened in 2003 meant the second last bigger German agglomeration receiving it's S-Bahn. Due to the difficult framework conditions -serving three german states- negotiation took several decades.



Rhein Neckar S-Bahn network

(Source: DB)

With a network of 370kms and 96 stations it is one of the bigger German systems operated with 7 lines. Characteristics are rather regional – clearly visible from line lengths reaching even 200km (!) with line S1. Similar to the Rhein-Ruhr, Rhein-Sieg, Dresden or Hanover schemes the network is based on existing respectively extended railway corridors. Even if no city-tunnel was required, infrastructure measures formed an important part and included eg a new bridge across the Rhine river and a new central railway station in Ludwigshafen.



S-Bahn Rhein-Neckar station Ludwigshafen-Mitte

(Source: Axel Kuehn)



S-Bahn Rhein-Neckar station Heidelberg-Kirchheim

(Source: Axel Kuehn)

Operation is based on a 60min frequency of all lines which result in a 15min frequency for the core section between Schifferstadt and Heidelberg (4 lines) and 30min frequencies on other sections. The complex network structure involves, however, a lot of influence from other railway services and makes dogmatic fixed frequencies difficult to achieve.

S-Bahn Rhein-Neckar uses exclusively EMUs of series 425 which is rather similar to series 424 used in Hanover. This means also that the complete network is based on 76cm platforms.

The network stretches across three different PTAs:

- ⇒ Verkehrsverbund Rhein-Neckar (VRN),
- ⇒ Saar Verkehrs-Verbund (SVV),
- ⇒ Karlsruher Verkehrs-Verbund (KVV).

Special fare offers enable travels across PTA borders.

Tendering responsibility for the network is shared by four partners:

- ⇒ State of Baden-Württemberg (Nahverkehrsgesellschaft B-W (NVBW)),
- ⇒ State of Rheinland-Pfalz (Zweckverband SPNV Rheinland-Pfalz Süd),
- ⇒ Verkehrsverbund Rhein-Neckar (only for the Hessian part!),
- ⇒ State of Saarland.

The first tender period stretched from 2003 to 2015. As a result of a new tender procedure DB Regio received in early 2015 the assignment for another 17 years of operation from 2016.



S-Bahn Rhein-Neckar homepage

(Source: DB)

### Leipzig/Halle (Mitteldeutschland)

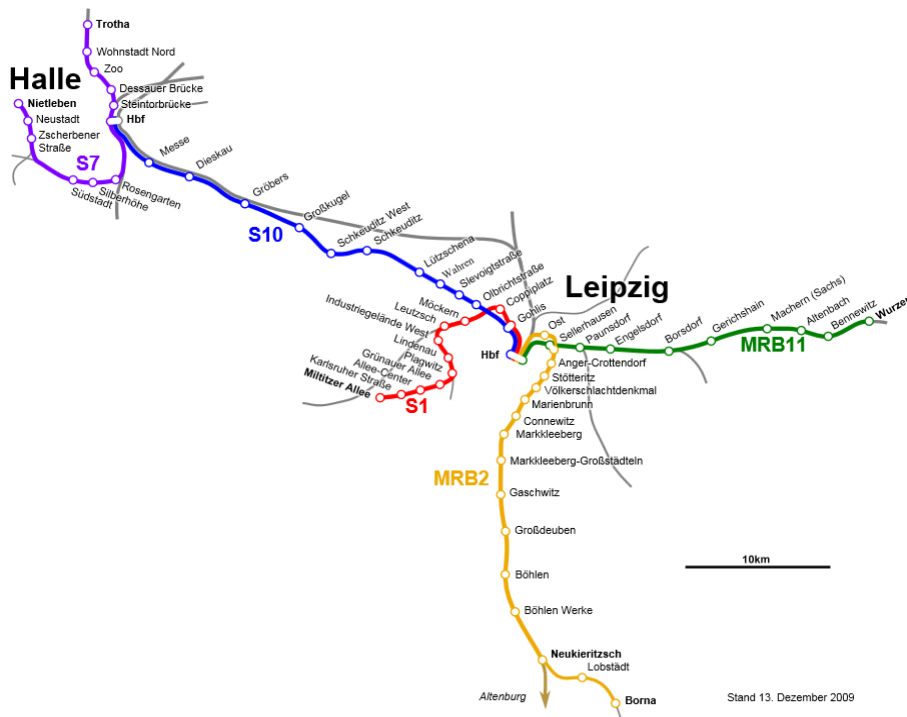
Both Leipzig and Halle received S-Bahn like systems already during GDR-times (1969). When the two networks were joined in 2004 the resulting scheme was called S-Bahn Leipzig/Halle. The network at this time was still based on existing railway corridors and especially the Leipzig main station with its terminus configuration (similar to the starting conditions for Munich, Frankfurt and Stuttgart schemes). A major and more recent step, however, was the implementation of the city tunnel in Leipzig which allowed for the first time through running services and reaching the city centre of Leipzig (for both S-Bahn and other trains). The completely reshaped and expanded network was opened in late 2013 and is now called S-Bahn Mitteldeutschland.



City-Tunnel-Leipzig

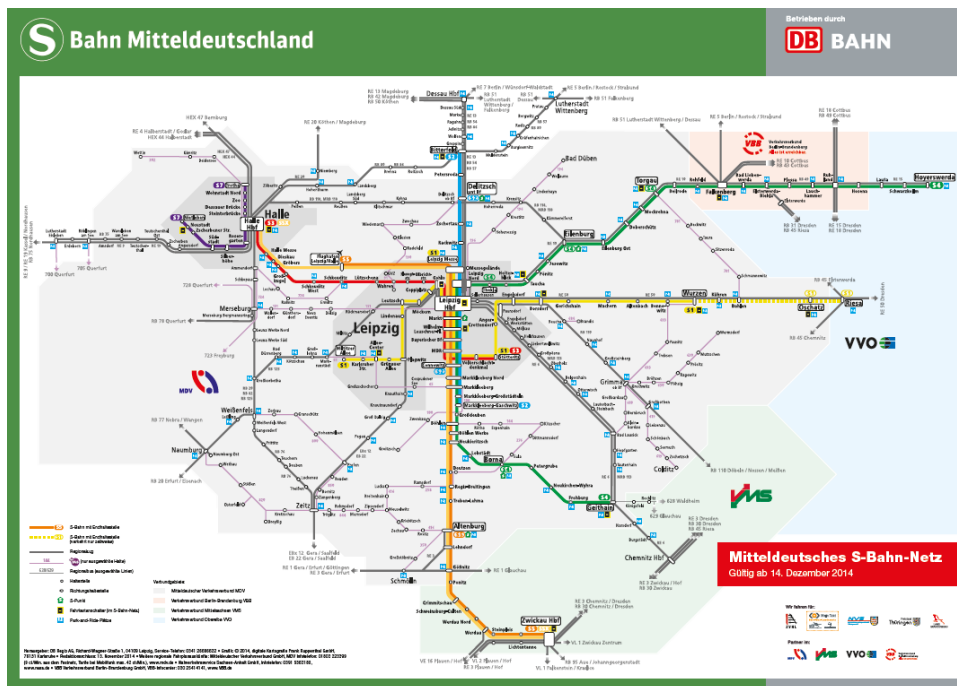
(Source: Wikipedia / Maximilian Dörrbecker – Axel Kuehn)

With a network of 430km and 105 stations it is principally the third biggest S-Bahn network in Germany behind Rhein-Ruhr and Munich. It is operated with 7 lines.



Leipzig/Halle S-Bahn network 2009

(Source: Wikipedia / Michael Kümmling)



Leipzig/Halle S-Bahn network 2013

(Source: DB)

Like the Rhein-Neckar or Hannover S-Bahn schemes the Mitteldeutschland scheme owns very regional patterns: the distance Leipzig – Hoyerswerda being for example about 150km! The network serves railway infrastructure in four German states: Saxonia, Thuringia, Brandenburg and Saxony-Anhalt. And is integrated respectively in touch with a variety of PTAs: Mitteldeutscher Verkehrsverbund (Leipzig/Halle, MDV), Verkehrsverbund Berlin-Brandenburg (VBB), Verkehrs-Verbund Oberelbe (VVO) and Verkehrsverbund Mittelsachsen (VMS).

Operation is based on a maximum frequency per line of 30min respectively 60min which creates currently in the overlapping core section a 10/20min frequency. Further enhancement is envisaged but depending on some infrastructure measures giving more capacity in outer sections. For line S1 within the city limits a frequency of 15min is envisaged for the future.

The city-tunnel is currently used by 11 S-Bahn trains per hour and direction (+ other trains).

Rolling stock for the Mitteldeutschland scheme is rather new for German S-Bahn schemes: TALENT 2 EMUs (DB series 442), partly in a 4 unit (72m) and 3 unit (56m) configuration. Different to most other S-Bahn rolling stock is the maximum speed of 160km/h.

Like other more recent S-Bahn schemes the Mitteldeutschland rolling stock is based on 76cm platforms.

As indicated, the scheme uses rail infrastructure in 4 different states which means that tendering responsibility is also shared by these states and their respective organisations (similar to the Rhein-Neckar scheme). The European tender process was started in 2008 and resulted in S-Bahn Mitteldeutschland GmbH (now merged into DB Regio) being announced as the successful bidder in 2010. The contract period stretches from 2013 to 2025.

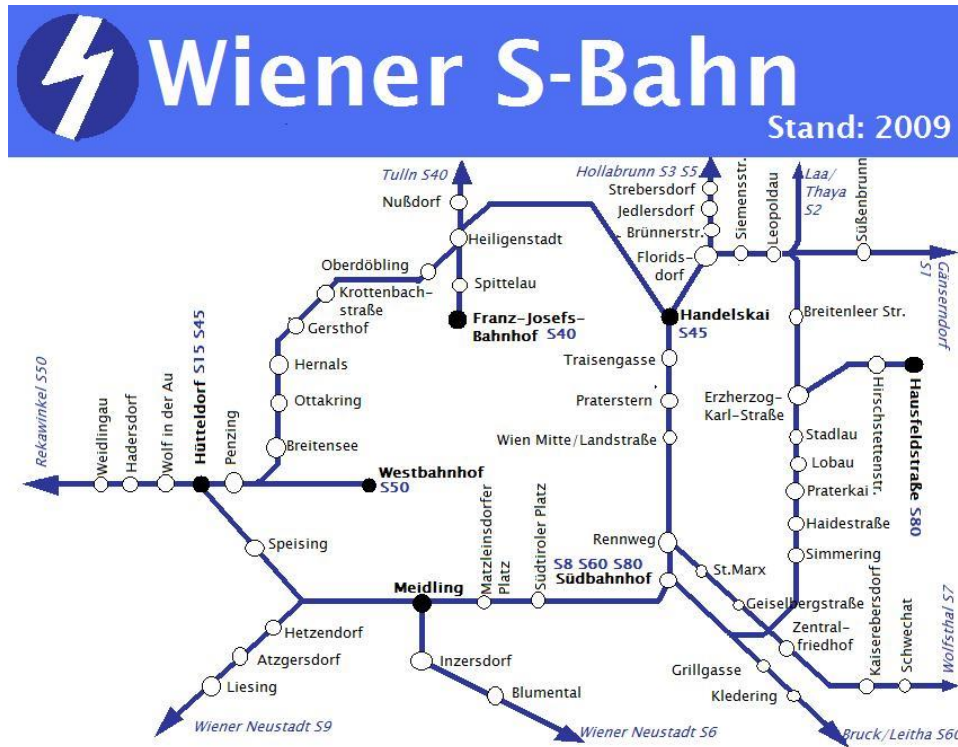
S-Bahn Leipzig homepage

(Source: DB)

## Vienna

Even if existing as a sub-urban rail scheme for many more years the term S-Bahn has not been introduced officially before 2005. Before the term “Schnellbahn” (“fast railway”) has been dominating. It came into use in 1959 for the corridor Wien-Floridsdorf – Wien-Praterstern – Wien-Hauptzollamt (today Wien-Mitte) which from 1962 was fully electrified which is the reason why 1962 is seen as the starting year for Vienna’s Schnellbahn/S-Bahn.

The core corridor of the Vienna S-Bahn network is today the 13km long section from Meidling to Floridsdorf which is used by the majority of S-Bahn lines. All stations within this section (formerly 9, with the new main station now 10) are functioning as interchange nodes to both urban/regional PT and long distance trains. The section was used by about 640 trains per day and had about 270000 passengers – these numbers will likely grow with the new main station.



Vienna S-Bahn network 2009

(Source: Wikipedia)

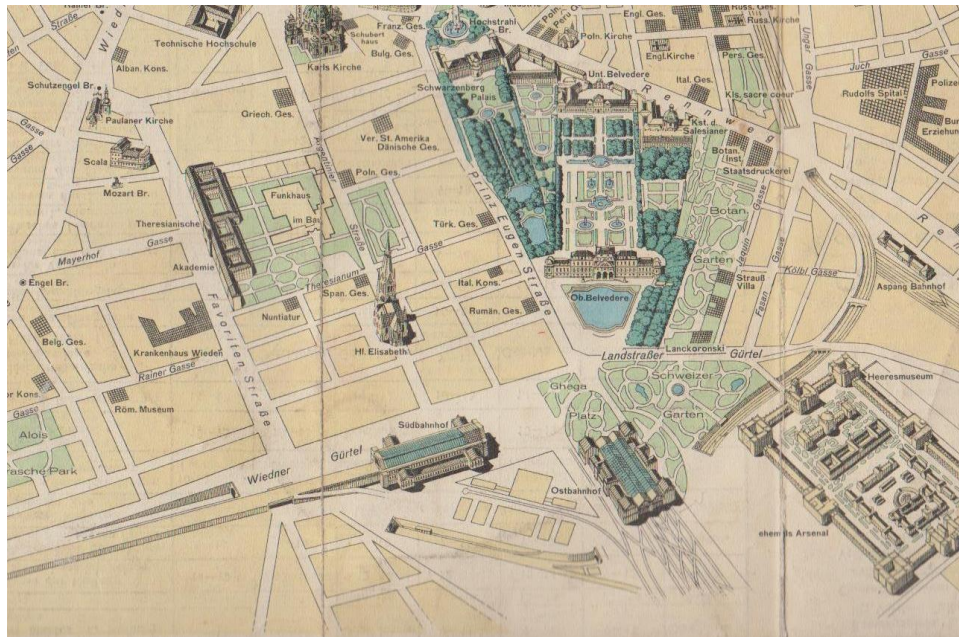
A major change for the Vienna railway node has been the now nearly completed introduction of a new main railway station (“Wien Hauptbahnhof”) within this section. While Vienna like many other bigger cities had historically been dependent on terminus layouts for its main stations, the new main station, which has replaced the former Südbahnhof, allows through-running from principally all directions which is a big improvement for long-distance trains but has also had impact for the S-Bahn scheme.

The historic “Südbahnhof” was actually a combination of “Südbahnhof” and “Ostbahnhof” – two directly neighbouring terminus stations.



Vienna “Südbahnhof” and “Ostbahnhof” (in foreground; seen from South-East)

(Source: Wikipedia / Herbert Ortner)



“Südbahnhof” and “Ostbahnhof” Vienna 1937

(Source: Wikipedia / historic city map)



New main station Vienna (seen from South-West)

(Source: Wikipedia / FrontOffice)

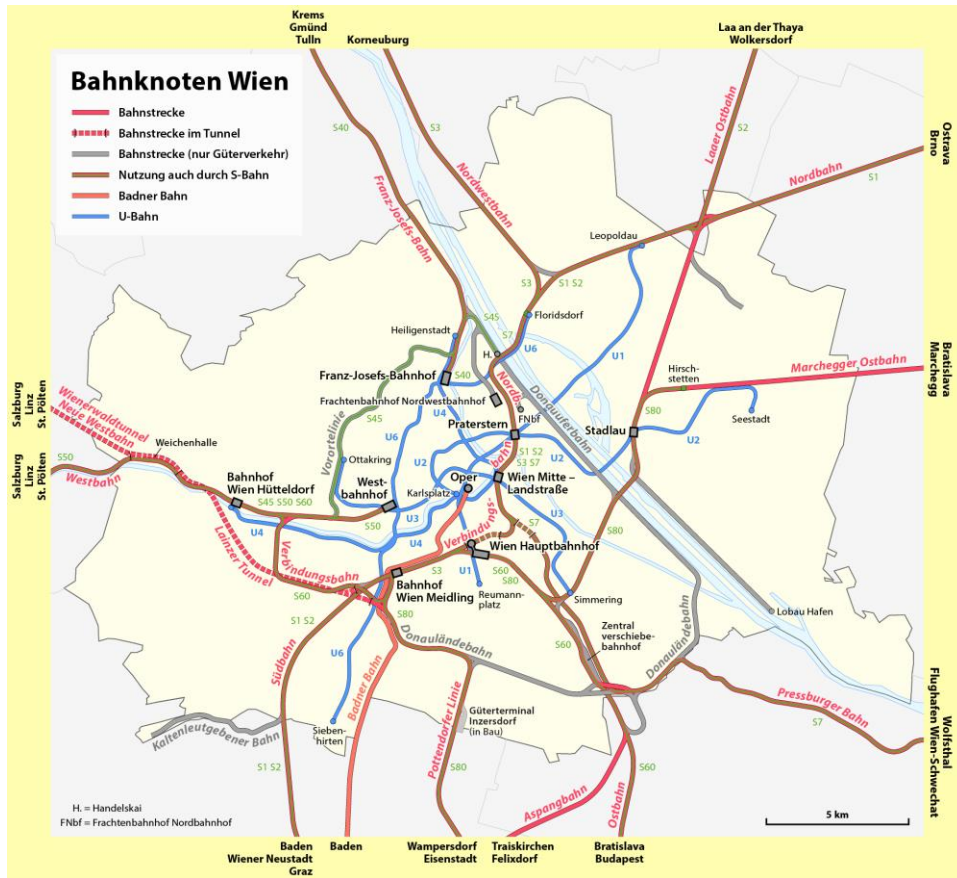
The only remainings of the former Südbahnhof station and track layout are the underground S-Bahn tracks and platforms in the old connecting tunnel which survived as the new/renamed “Quartier Belvedere” stop.

The new main station allowed also a simplification of the S-Bahn network which is today operated with 9 lines. All lines which are operated through the core corridor receive single numbers (S1, S2,...) while other S-Bahn lines which offer tangential or radial services in other parts of the network (eg into Westbahnhof or Franz-Josef Bahnhof) receive double numbers (S40, S45,...). The numbering system is principally clockwise, starting in the North-East but some changes have disturbed the structure.

The tangential line S45 is rather special – being a single track railway and re-opened in 1987. It is leading through some sub-urban quarters of Vienna but has become rather important in connection with the extension of the line from Heiligenstadt to

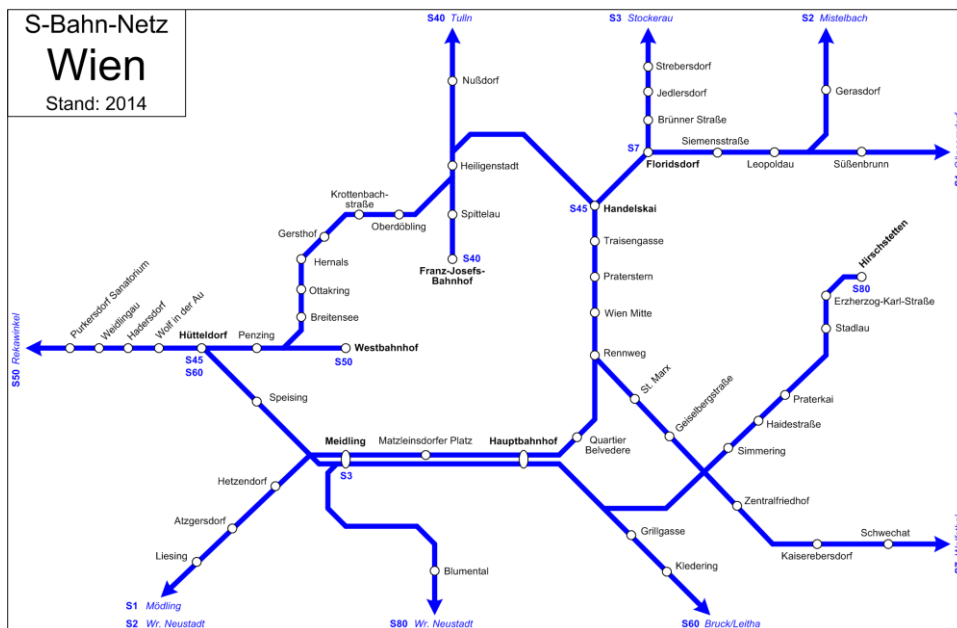
the Handelskai node and by Ottakring becoming another node with the extension of the metro.

Operation is based on a 30min frequency on core sections for most of the lines, outer sections are often served by an hourly frequency.



Vienna railway node with new main station

(Source: Wikipedia / Maximilian Dörrbecker)

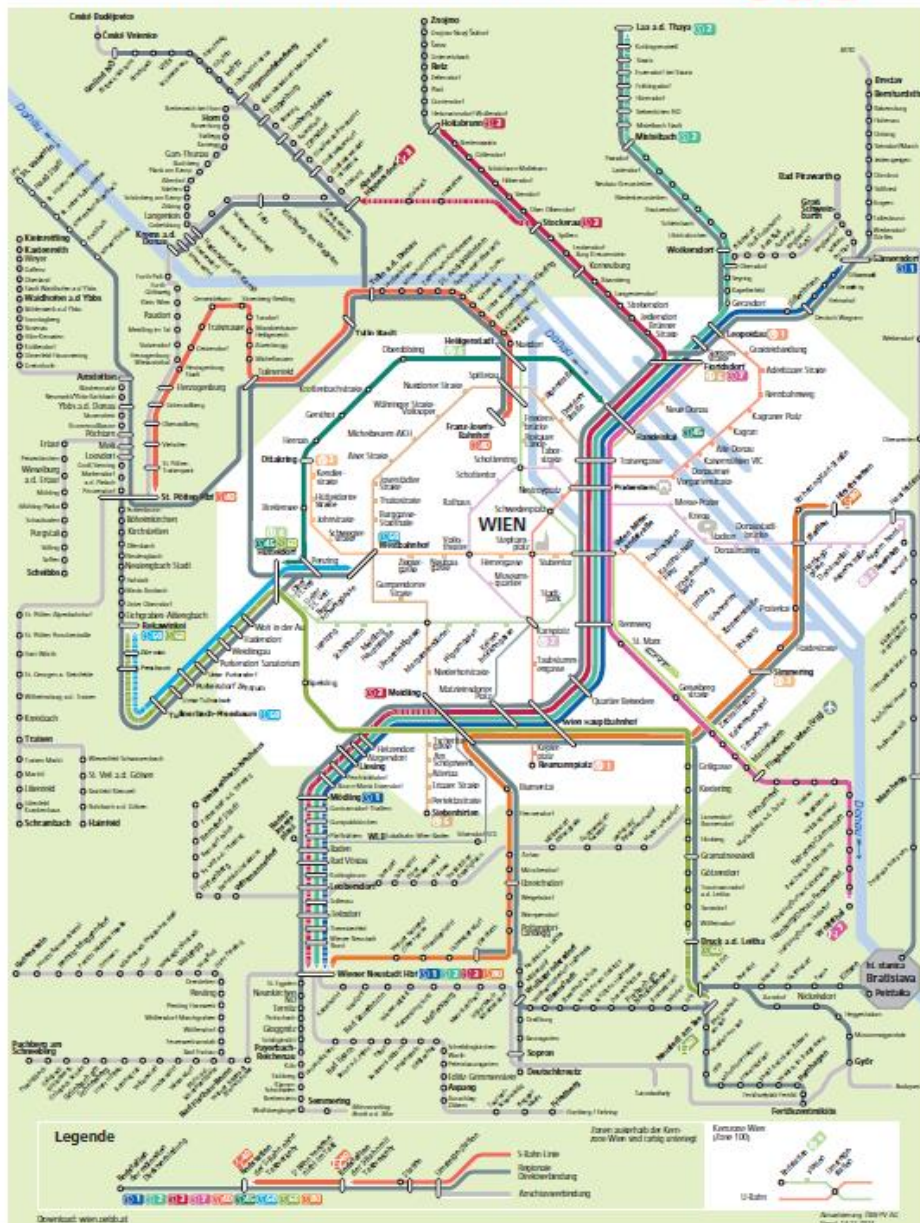


Vienna S-Bahn network 2014

(Source: Wikipedia / my friend)



# Nahverkehr Großraum Wien



Vienna S-Bahn / Rail network

(Source: ÖBB)

The Vienna-scheme is clearly a more regional scheme serving destinations up to 90km from Vienna centre. Line S2 for example has a length of about 126km.

Rolling stock is EMU based, originally using series 4020 vehicles (kind of a Austrian series 420). More recently Talent 2 rolling stock has come into use as series 4024 but showed out less suited for urban S-Bahn operation.

Lately ÖBB has ordered Siemens Desiro ML trains to replace the 4020 rolling stock from 2015 as so-called CITY JET. Single train sets for both 4020 and CITY JET are about 70m long and are used as coupled trains up to 140m length.



ÖBB series 4020 rolling stock

(Source: Wikipedia / Linie29)



Vienna S-Bahn logo

(Source: Wikipedia)

For the „Schnellbahn“ one did create originally a blue logo with a stylised „S“. It resembled the alignment of the core corridor and should symbolise speed. The original version was using an edged design, as the standard „round“ S was used until 1989 by the so-called “Stadtbahn Wien”.

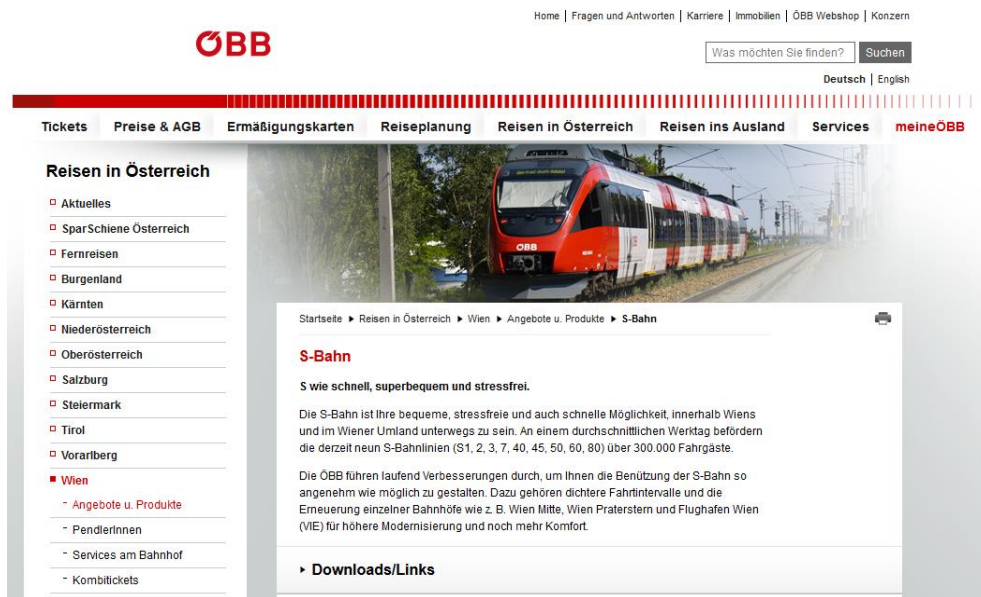
When the core corridor was re-opened in 1959 the fare system was –with only a few exceptions- still the standard railway one.

Starting from 1961 tramway tickets have been accepted for the trains between Hauptzollamt and Floridsdorf. When the S-Bahn service (“Schnellbahn”) opened in 1962 tramway tickets became valid for the whole core corridor from Hauptzollamt to Meidling; however, only for the specific S-Bahn trains and the Vienna section of the Pressburg (Bratislava) railway. Further extensions of the unified “Vienna fare” followed. However, as other trains were using similar rolling stock, there was considerable confusion which lasted until the Vienna PTA (VOR, “Verkehrsverbund Ost-Region“) was created in 1984.

When the Vienna S-Bahn was integrated into the PTA only very limited changes became necessary as the „Vienna fare“ became integral part of the PTA-wide fare system. The S-Bahn can be used since both with VOR-tickets but ÖBB-tickets are also valid.

It is worth mentioning that ticket sale by conductors has been never practiced on trains within Vienna but more recently “self service” has also been introduced on more and more regional corridors within the VOR region.

The Vienna S-Bahn network is operated by the Austrian State Railway and services are paid directly by the state. Austria has so far refused to implement tendering in the railway sector.

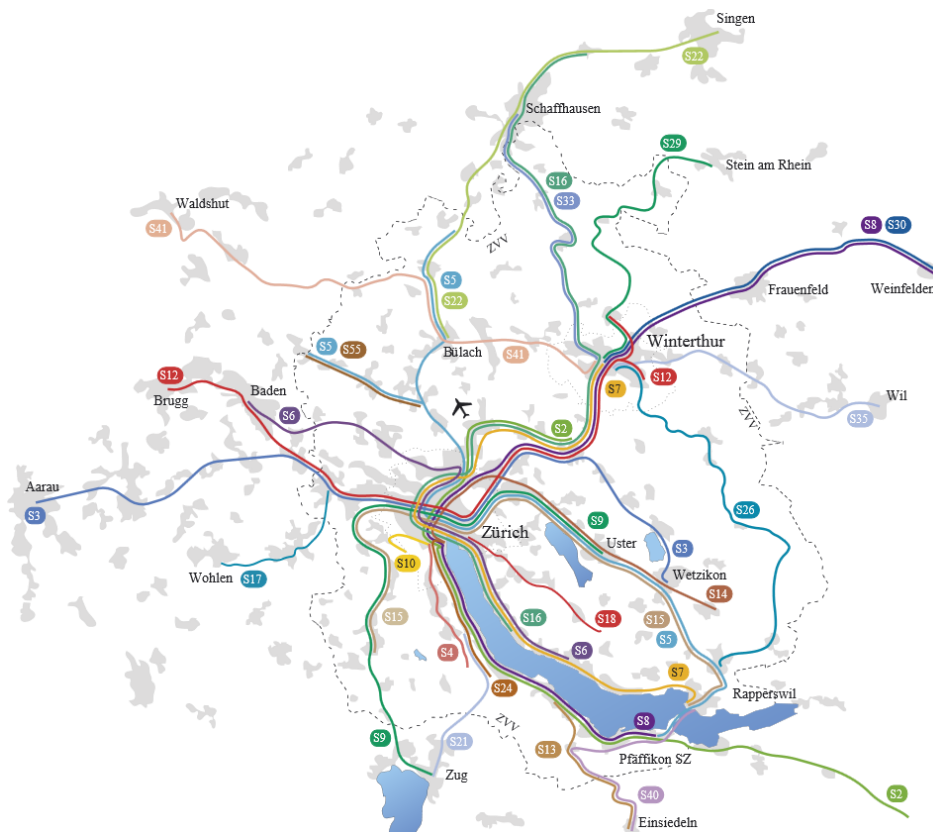


S-Bahn Vienna homepage

(Source: ÖBB)

## Zurich

S-Bahn Zurich has been introduced in 1990 as a network for the Zurich region ("Canton") and the neighbouring regions. It is to be seen as a pilot for further S-Bahn projects in Switzerland.

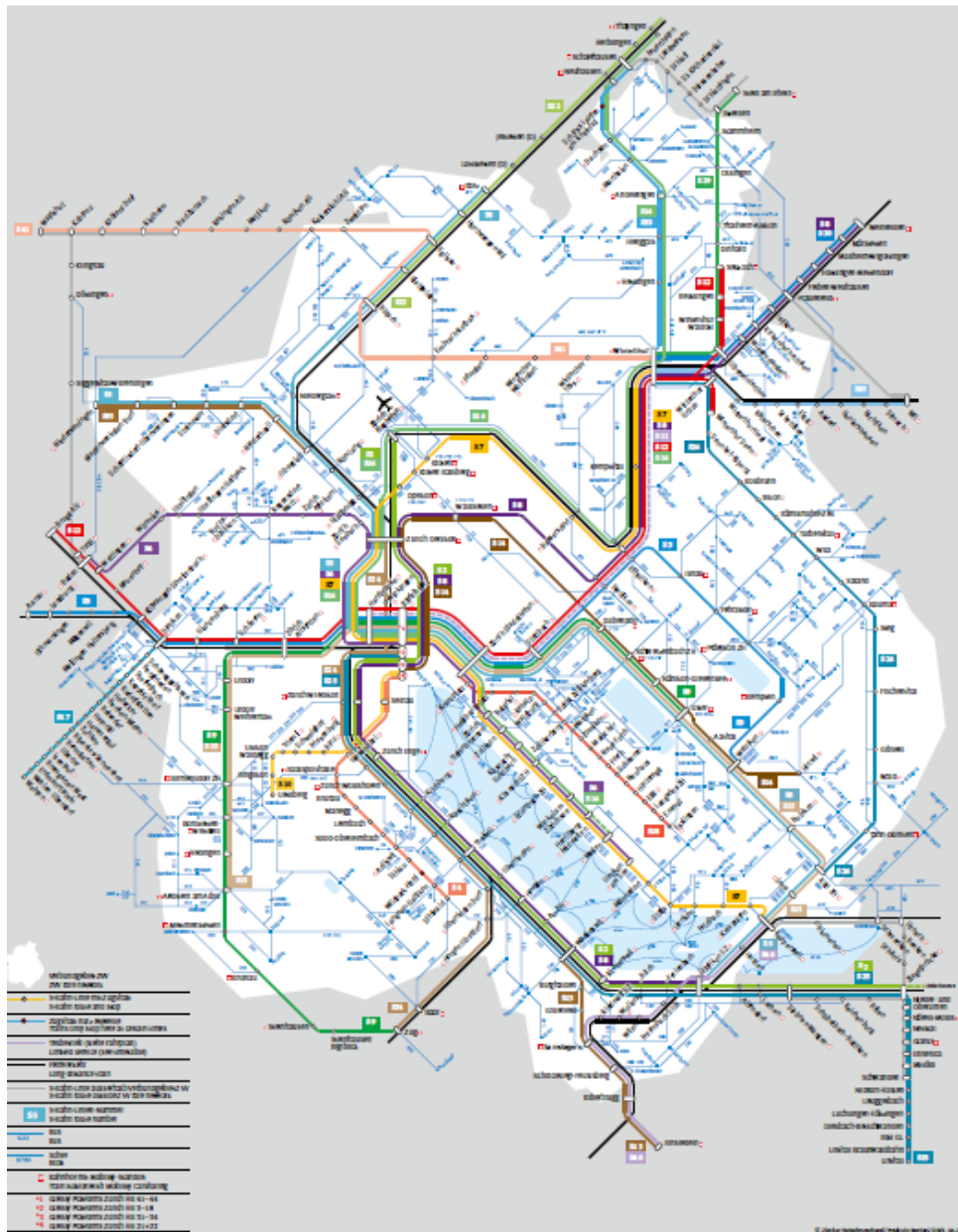


S-Bahn Zurich

(Source: Wikipedia / Lukas Haefliger)



# S-Bahnen, Busse und Schiffe S-Bahn trains, buses and boats



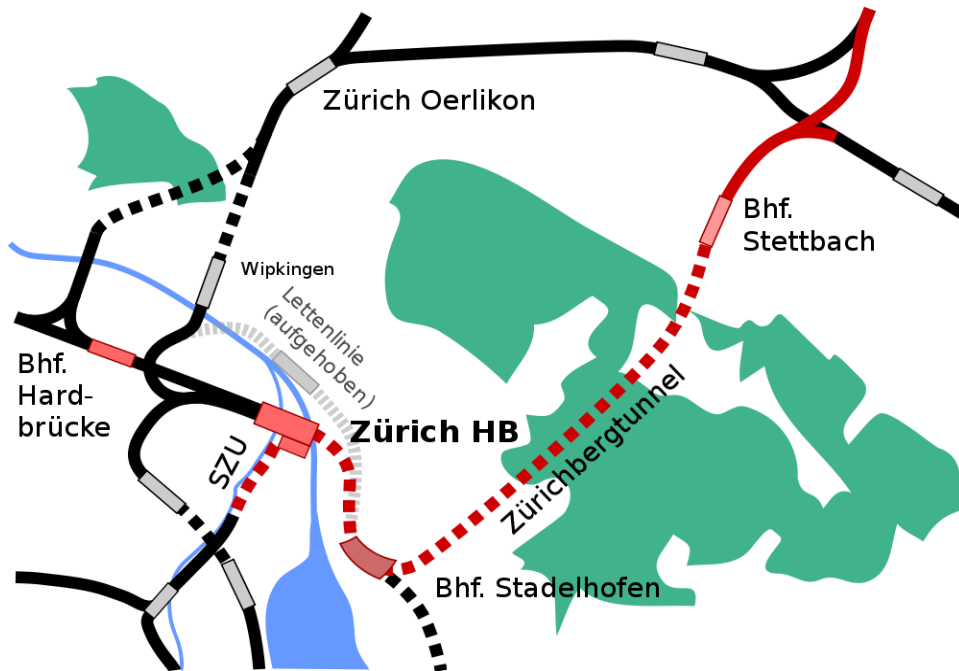
S-Bahn Zurich

(Source: ZVV)

The network consists today of 380km infrastructure with 171 stations and is operated with 28 lines. Daily passenger loads amount to about 400000 passengers (2010).

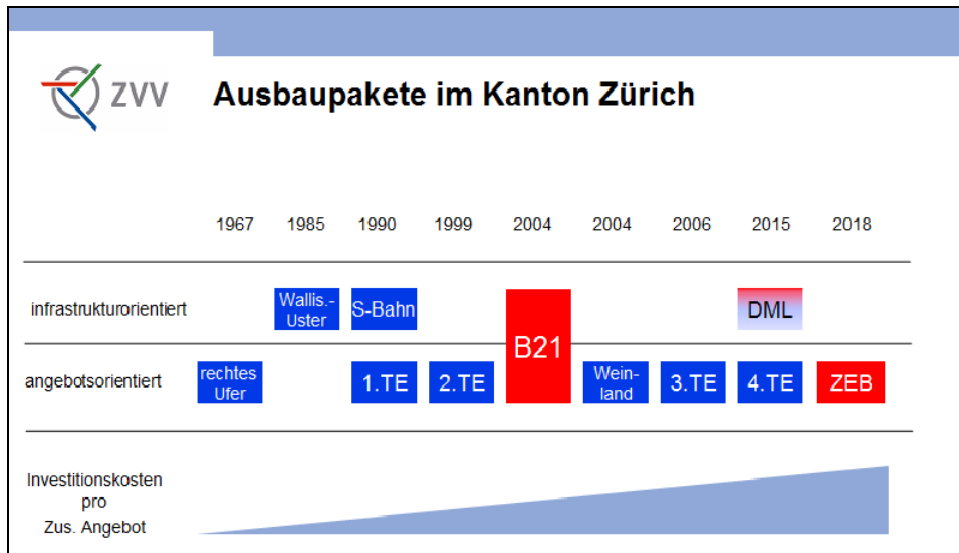
Some of the lines operated certainly before establishing the S-Bahn brand. The S-Bahn concept was also a reaction to public referendi in 1960 and 1973 which turned down plans for the development of an independent metro system and from 1978 cooperation between the Canton of Zurich and Swiss Railways started in view of the S-Bahn plans. Another public referendum in 1981 was positive for the S-Bahn and the development of the core network started.

Main infrastructure measures included a first four-track underground stop at Zurich main station (“Museumsstraße” stop), the creation of the Stadelhofen node station and the Zurichberg tunnel.



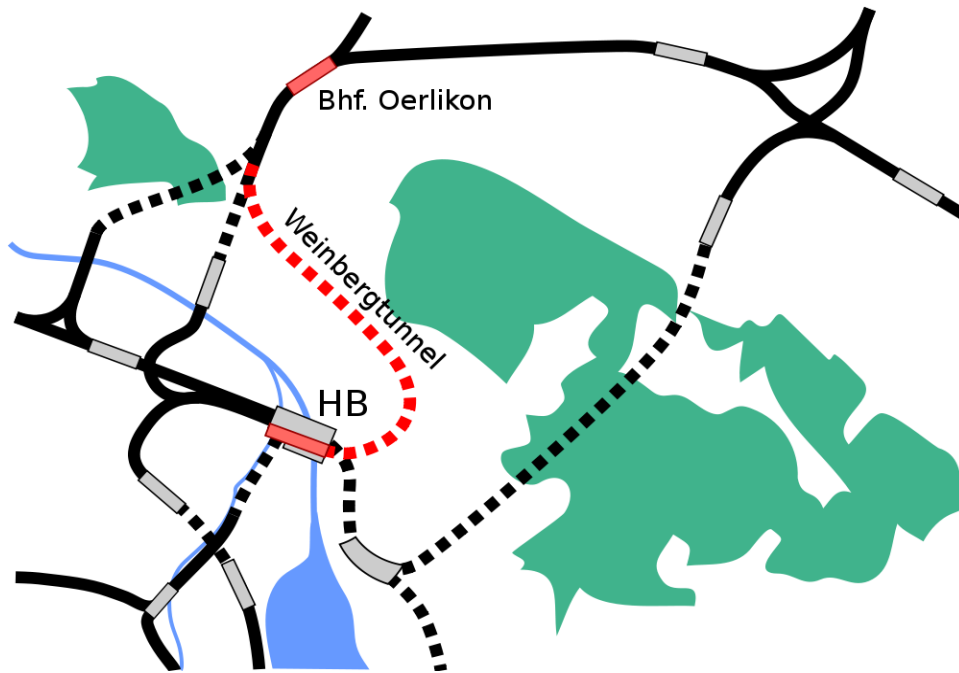
Initial package S-Bahn Zurich: first tunnel + underground stop at main station  
 (Source: Wikipedia / Lukas Haefliger)

The diagram below illustrates measures taken for S-Bahn Zurich (including some pre-work) both with regard to infrastructure and offer. It makes also clear that investment costs per additional offer have been ever increasing which means there are no “cheap measures” anymore to achieve further improvements!



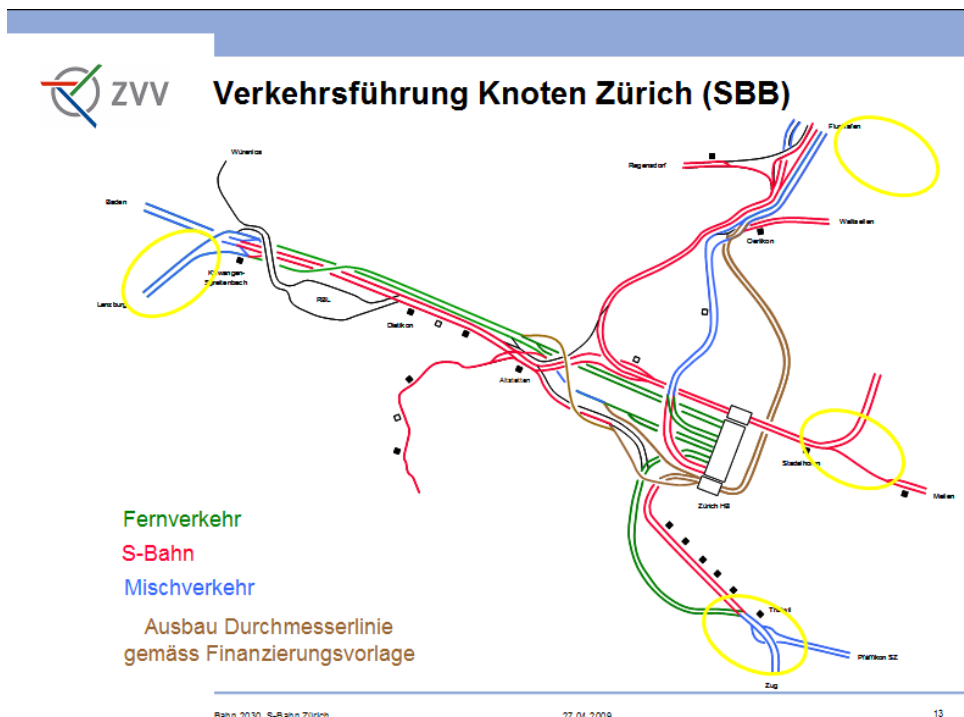
Investment packages – infrastructure and operation related  
 (Source: ZVV)

The 4th package included also a second underground stop under the Zurich main station (“Löwenstraße stop”) and the Weinbergtunnel-both completed in 2014.



4th package S-Bahn Zurich: additional Weinbergtunnel + underground stop at main station

(Source: Wikipedia / Lukas Haefliger)



Separated operation of longer distance trains and S-Bahn services

(Source: ZVV)

Core activities after the completion of B21 and the 4th package will concentrate on the most economical use of existing infrastructures which includes an operation frequency in the core network sections of 2min!



## Stossrichtungen für Weiterentwicklung S-Bahn Zürich nach 4. TE (1/3)

- Stammstrecken:
  - Konsequenter Betrieb der beiden Stammstrecken im 2-Minuten-Takt (**kürzere Zugfolgezeiten**) => wirtschaftliche Nutzung bestehender Infrastruktur



Future strategy targets after completion of 4th package

(Source: ZVV)

Operation is based on a 30min frequency for all lines which results on denser frequency on joint sections while at the same time more direct origin-destination links are offered than it would be the case with a single line in a denser frequency. This approach explains also why the number of lines in the Zurich network appears much higher than in other schemes.

The strong corridors within the ZVV-network are operated with loco-hauled double-decker trains while other, more regional branch lines are operated with smaller EMU rolling stock or even light rail vehicles.

For the future one aims for creating a two level S-Bahn network consisting of a more urban network based on single deck rolling stock and a regional network based on double-decker trains.



S-Bahn Zurich “double-decker” train

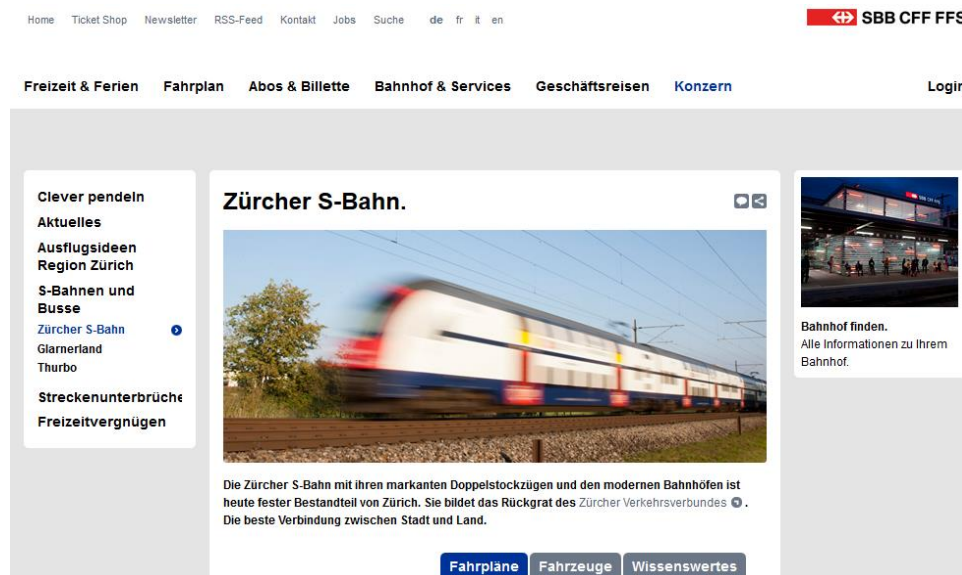
(Source: Axel Kuehn)



S-Bahn Zurich regional EMU

(Source: Axel Kuehn)

The S-Bahn scheme is an integral part of the urban and regional PT-network and the related fare system of the Zurich PTA (Zürcher Verkehrsverbund / ZVV). ZVV orders and finances the services while Swiss State Railways SBB is the main operator and responsible for infrastructure and rolling stock. In total six operators are involved for different services within the network which includes both high level main lines and more regional branch lines.



S-Bahn Zurich on SBB-website

(Source: SBB)

## Basle

The so-called Regio-S-Bahn Basel has been inaugurated in 1997. It is serving the tripartite agglomeration of Basle which covers parts of Switzerland, France and Germany.





S-Bahn Basel

(Source: SBB)

The 250km network with 72 stations is served by 5 lines of which 2 operate cross-border. Longest line is S3 with 105km.

There isn't a common basic frequency for all lines. The lines with the highest demand (S1 and S3) are operated with a 30min frequency on core sections while other lines and sections are operated with a 60min frequency. Two sections gain a 15min frequency by overlapping of lines. In peak hours additional trains or longer train compositions are in use. Besides demand there is a second influence factor and this is the responsibility for ordering being shared by three countries.

As Rolling stock have been used until 2005 older EMU vehicles of Swiss origin which have now been replaced by Stadler FLIRT types (series RABe 521 and/or RABe 522) which are suited for cross-border operation. As homologation is delayed for the operation in France, through-running of line S1 is currently not possible.



Regio-S-Bahn Basle train (Stadler Flirt)

(Source: Wikipedia / Wladyslaw)

The network is integrated in a variety of PTAs – the two main ones being the Tarifverbund Nordwestschweiz (TNW) and the Regio-Verkehrsverbund Lörrach (RVL).

Three operators are involved for different parts of the network:

- ⇒ SBB (S1 on Swiss side, S3, S9)
- ⇒ SBB GmbH (SBB subsidiary for operation in Germany; S5, S6)
- ⇒ SNCF/TER Alsace (S1 on French side)

S-Bahn Basle homepage (Swiss)


(Source: SBB)

Zweckverband  
REGIO S-Bahn

Aktuelles    Regio-S-Bahn    „Rote Linie“    ZRL    Presse


ÜBERSICHT    IMPRESSUM

# Regio - S - Bahn






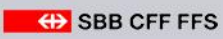
Eine trinationale Regio-S-Bahn wird Realität.

Aktuelle Fahrplantabellen für die Regio-S-Bahn-Linien S5 (Gartenbahn) und S6 (Wiesentalbahn) finden Sie unter:  
<http://www.sbb-deutschland.de/download.php>

Netzplan als PDF-Dokument  [mehr lesen](#)

Neue Stationen  
Moderne S-Bahn-Stationen.  
Stufenloser Einstieg in die S-Bahn-Triebwagen.  
Verknüpfung mit dem Straßenverkehr ...  
[mehr lesen](#)

Regio-S-Bahn  
GRÜN, ROT, BLAU,  
ORANGE... Bunte S-Bahn  
Linien bringen die Regio TriRhena zusammen. 1997  
Auftakt ...  
[mehr lesen](#)

Baden-Württemberg  Zweckverband REGIO S-Bahn  Die Bahn  

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S-Bahn Basle homepage (German)

(Source: ZV Regio-S-Bahn )

## RER (France)

The term RER stays for Réseau Express Régional, which means kind of a regional express network. Currently Paris / Ile-de-France is the only region / agglomeration owning a system with such features.

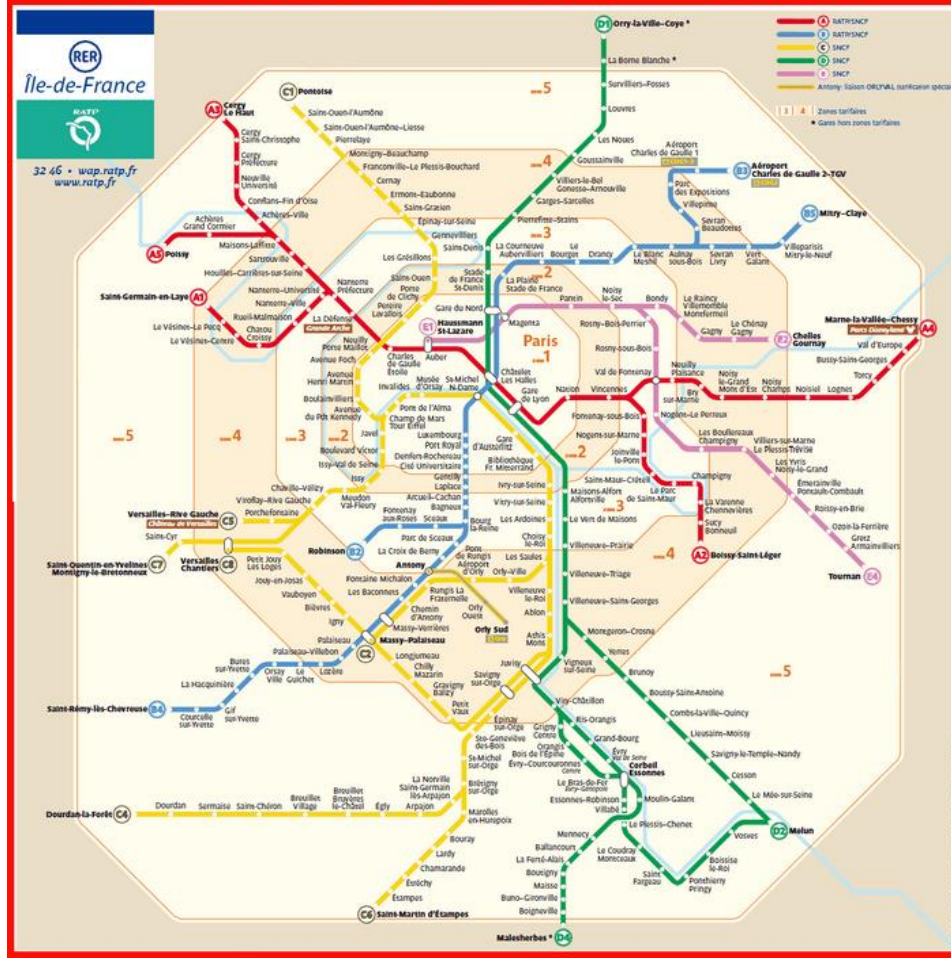
### Paris

As in other European cities also in Paris the origins of today's network date back to pre-war times. Different to most other networks the initiative was, however, not in the hands of the state railway SNCF but with the Paris metro company RATP, which took over in 1937 a disused SNCF-corridor in the South of Paris (today part of RER B). 1969 followed the take-over of another branch which is today part of RER A (East). Shortly after a new corridor to the new La Defense quarter in the West of Paris was opened (part of RER A West).

The true start of the RER came in 1977 when the two branches of RER A were linked in a new tunnel under the city and the Southern RER B branch was extended North to reach the Chatellet-Les Halles node served also by RER A.

At this stage SNCF noticed the "success potential" of the new service type and became engaged in further phases of the RER development. This explains why still today RER A and RER B are operated jointly by RATP and SNCF while RER C-E are operated by SNCF.

# PARIS RER MAP - 2013



RER Ile-de-France (Paris) network map 2013

(Source: RATP)

The network today consists of 587km with 257 stations which is operated with 5 lines. 4 of the 5 lines show diametrical characteristics, one (line E) is a radial service terminating in the centre. Regarding line length the five lines show quite some differences. While lines A and B with 108 and 80km are in a more standard range, lines C (opened 1979) and D (opened 1987) show with 187 respectively 197 km very regional characteristics.

Lines A and B show dual-mode characteristics as the RATP infrastructure has been electrified with 1500V DC while SNCF uses 25kV AC for their infrastructure (on these lines).

Rolling stock for these lines is owned by both RATP and SNCF. The vehicles in use are EMU-sets of 104m length (Z8100/Z8400 (SNCF) respectively MI79/MI84 (RATP) series) which have been delivered in the 1980s. RATP receives since 2010 new rolling stock of the MIO9 series to replace older rolling stock. The latter are double decker EMUs of 114m length which are either used as single vehicle ("short train") or with two vehicles coupled ("long train").

The MIO9 series uses extra-wide doors (2m!) which allows compensating the +55% passenger load without increasing stop times.

SNCF uses comparable rolling stock for their RER-lines (Z8800 series).



Vehicle of MI79 series at Saint-Rémy-lès-Chevreuse

(Source : Wikipedia)



Vehicle of MI09 series at Nanterre

(Source : Wikipedia / Kirikoude-Gonioul)



Vehicle of Z8800 series (SNCF)

(Source : Wikipedia / Spendeau)

Tendering and contracting body for public transport in the Ile-de-France region is the Syndicat des transports d'Île-de-France (STIF) which is controlled by elected political representatives from the different public bodies.



Area of STIF and political representation / control

(Source : STIF)

STIF organises, steers and controls all PT-projects in its area, defines the level of service, the fare structure and negotiates/signs all operations contracts for RER, other rail services, metro, tram, bus with SNCF, RATP and other operators. STIF has also taken over largely the responsibility for buying new rolling stock since 2000 (100% of costs for RATP, 50%/100% for SNCF depending on renewal/new).

Operating contracts are awarded for 4 years. However, one should understand that there is currently no real competition which could lead to a change of operator.

## Cercanias (Spain)

In Spain S-Bahn type services are branded as “Cercanias” using like in Germany a specific logo all across the country – some autonomous regions like Catalonia or Valencia use the term “Rodalies”.]

The Cercanias-brand has been introduced in the 1990s when the Spanish State Railway RENFE started to divide their rail services in different business areas.



Cercanias logo

(Source: Wikipedia / Renfe)

Today exist 15 systems in different parts of Spain – more are likely to follow when further high-speed corridors allow using old tracks for more local purposes.



RENFE-Cercanías overview map

(Source: Wikipedia / Matthias Dörrbecker)



RENFE-Cercanías general homepage

(Source: Renfe)

Two systems, Madrid and Cadiz are presented below in more detail.

## Madrid

The Madrid Cercanías-network is the biggest in Spain. It comprises 370km with 89 stations and is operated with 9 lines.



RENFE-Cercanías Madrid map

(Source: Renfe)

It is based on the connecting tunnel between the Northern (Chamartín) and Southern (Atocha) main railway stations which are both terminus stations. This tunnel was started already in the 1940s but not finished until 1967 (!). When the Cercanías-brand had been introduced in the 1990s RENFE started a big expansion program which resulted in major extensions.

In 2004 construction of a second tunnel connection between Atocha and Chamartín started and it was opened in 2008. It is used now by two Cercanías-lines while four lines stay in the old tunnel. With a different alignment in the central area, the new tunnel serves the new Sol-stop instead of the Recoletos-stop of the first tunnel.

One can note two types of services:

- ⇒ Radial/diametrical lines connecting suburbs to the centre,
- ⇒ Tangential services connecting suburbs.

Frequencies can be rather different across the network depending on the specific line, the demand within its corridor, peak/off-peak respectively weekday/weekend situations. The range of frequencies can vary from 5min to 2h. The central section sees a headway of 3-4 minutes by the overlap of several lines.

The Cercanías network is integrated in the overall fare system of the Madrid PTA “Consortio Regional de Transportes de Madrid”.

The system is operated with three types (generations) of rolling stock which are mainly EMUs. One type are push-pull double-decker trains.





RENFE Series 443 Cercanías Madrid

(Source: Wikipedia / Hugh Llewellyin)



RENFE Series 450 Cercanías Madrid

(Source: Wikipedia / Smiley.toerist)

With the RENFE / state railway background the Cercanías network is still in state hands while all other PT-services in the Madrid agglomeration are under control of the regional Madrid government. This has resulted in some struggles and “political” competition, eg with regard to the question who should link to the new terminal of Barajas-Airport – a discussion which delayed the whole project.



RENFE-Cercanías Madrid homepage

(Source: Renfe)

## Cadiz

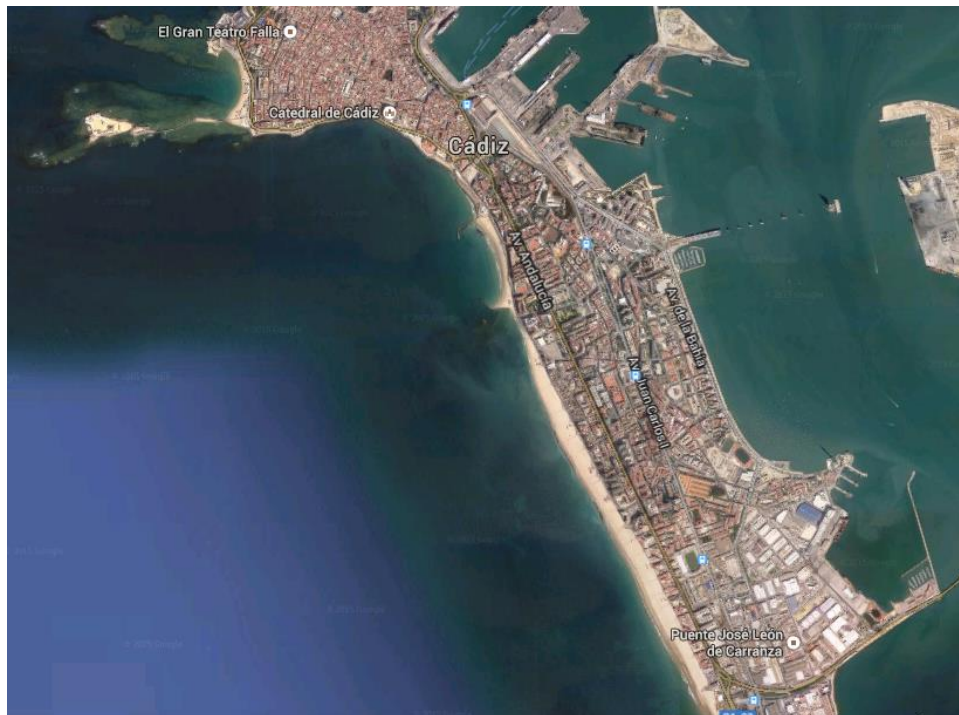
Cadiz is clearly one of the smallest Cercanias-networks in Spain – consisting nowadays of just one line of 61km between Jerez and Cadiz plus a small branch-line to serve the university area. A second line has been closed some years ago. The extension to Jerez Airport has been opened in 2011.



RENFE-Cercanias Cadiz map

(Source: Renfe)

Interesting is the about 3.5km tunnel section in Cadiz which lets the Cercanias-corridor function in Cadiz like a metro section with 3 underground stops.



Railway tunnel in Cadiz

(Source: Google Earth)



Cercanias Cadiz EMU of series 440

(Source: Axel Kuehn)



Cercanias Cadiz station entrance

(Source: Axel Kuehn)



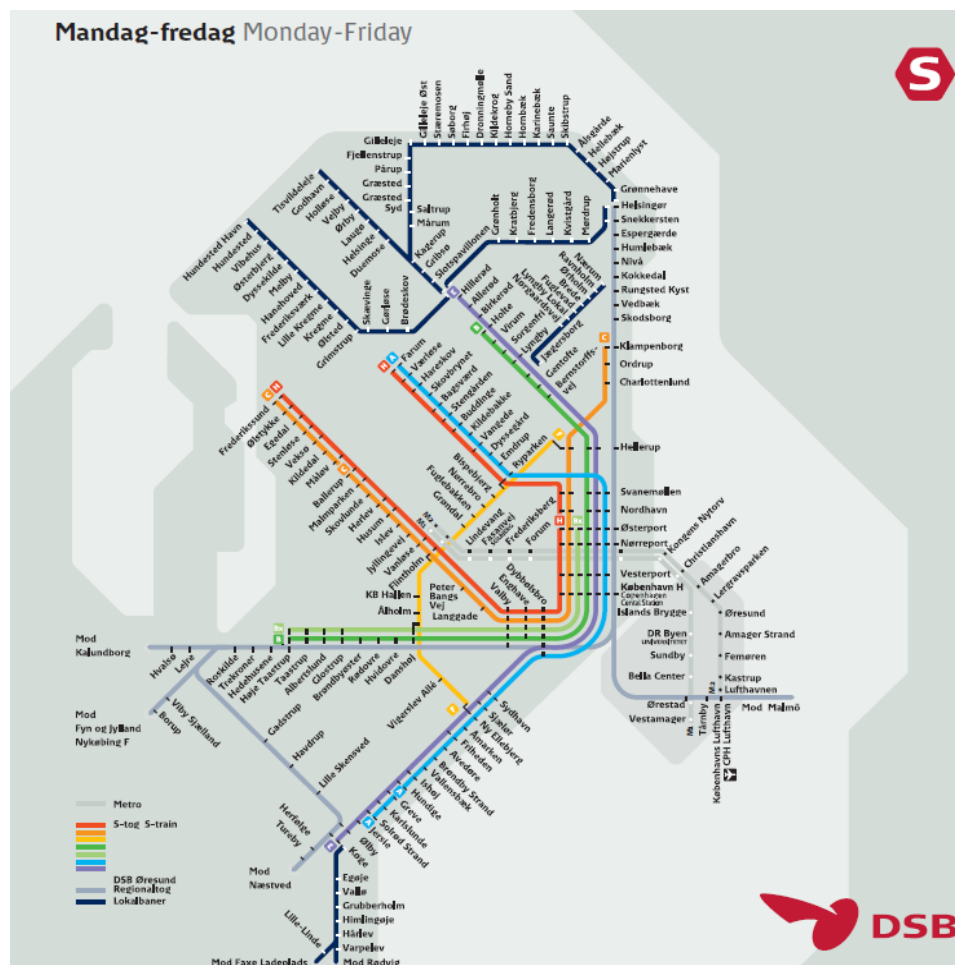
Cercanias Cadiz station entrance

(Source: Axel Kuehn)

## S-tog (Denmark) Copenhagen

The Copenhagen S-Tog system's history dates also back to before WW2. The first line from Klampenborg to Fredriksberg was opened in 1934 and was then the first electrified railway line in Denmark. The fact that it was electrified with 1650V AC gives it a “natural independence” from other rail traffic, especially as Denmark has chosen 25kV AC for its electrification plans.

Today's network of 170km and 84 stations is operated with 7 lines of which 6 pass through the core corridor including Copenhagen main station – the 7<sup>th</sup> line has a tangential function. It is completely separated even if running in parallel with other railway services.



S-tog network map

(Source: DSB)

The name S-tog was chosen by a public survey of a Copenhagen newspaper in 1934 and may have been influenced by the German S-Bahn term. However, the S seems not to indicate something specific as in Germany. One could say that the Copenhagen S-Tog system played the metro role in Copenhagen before “a real metro” finally came into existence in the 1990s.

The basic frequency for all lines except two is 10min during the day, 20min in evenings (weekdays). Line H operates with 20min frequency all day while the tangential line is operated with a 5min frequency in peak hours and 10mn in evenings.

Rolling stock in use are EMUs of which the majority are 8 unit sets of 84m length. Also in use are 4 unit sets of 42m length. Maximum speed is 120km/h.

Operator has been until 2013 DSB S-Tog A/S, now DSB has taken over after its subsidiary has been wound up. S-Tog has been operated since 1978 in one-man operation (no conductors).

S-Tog operation is integrated in MOVIA's fare system for the Copenhagen agglomeration (Zealand)



Copenhagen S-tog

(Source: Axel Kuehn)

## Pendeltåg (Sweden)

### Stockholm

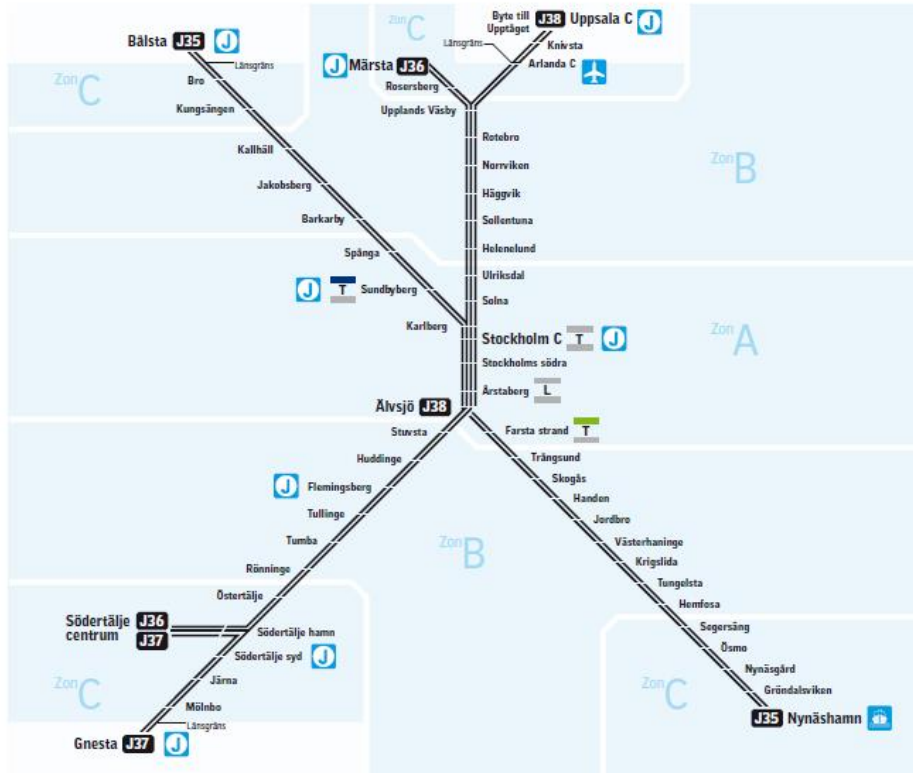
The origins of the Stockholm scheme date back to the 1960s when Statens Järnvägar (SJ) for cost reasons aimed for stepping out from urban rail transport. The conclusion of the city and region of Stockholm was to transfer related railway traffic to Storstockholms Lokaltrafik (SL). From that time level of service and fares haven been decided by SL while SJ still own and maintained the infrastructure and rolling stock (and supplied the staff).

The target of SL was to modernise the system and to bring it to kind of metro standards.

First new vehicles arrived in 1968 and the service was branded first as sub-urban trains (SL förortståg), later as local trains (SL lokaltåg). The term Pendeltåg was introduced early in the 1980s.

Today's network of 245km and 53 stations is operated with 4 lines of which J35 with 107km and 104min travel time is the longest.

While in the beginning the existing railway infrastructure has been used and shared with other passenger and freight trains, core parts of the network have been extended to 4 tracks and allow largely separated operation. However, problems still exist in the centre of the city around Stockholm main station which has big impacts on punctuality.



Pendeltåg network map

(Source: SL)

Operational patterns vary but most lines own a basic 30min frequency which may be increased in peak hours to 15min (or even 7.5min for specific sections).

Rolling stock in use comprises the older X10 and the more recent X60 type – both EMUs. X60 rolling stock is of 107m length and used either in single or double composition. Maximum speed is 160km/h.

Rolling stock is owned by SL and handed over to the operator which is assigned by tendering. Operator was until 2006 Citypendeln (a 90% KEOLIS subsidiary) then after a new tender process Stockholmståg (now a 100% SJ subsidiary).



Stockholm Pendeltåg (series X60) in today's critical "wasp-waist" section

(Source: Axel Kuehn)

The Citybanan project comprising a new, 6km tunnel for Pendeltåg operation has been established to solve the capacity issue in the core network. Construction started in 2009 – opening is envisaged for 2017. Two new tunnel stations will be established – Stockholm City more or less replacing today’s main station stop.



Citybanan alignment in Stockholm centre

(Source: Banverket)

## Common and differing features of “S-Bahn” systems

The European overview of S-Bahn and S-Bahn like systems in different European countries confirms first-of-all that “S-Bahn” is not a new PT-mode but a “handy name” for a dedicated commuter railway operation in agglomeration areas (similar to the use of eg “Flytoget” for dedicated airport services).

While the term S-Bahn is used as a brand name in German speaking countries, systems of similar characteristics exist in other European countries using other names (also in Scandinavia).

It becomes also obvious that the majority of nowadays systems of the S-Bahn genre are operating jointly with other railway traffic.

Segregation from other railway traffic, if existing at all, is limited to core and dedicated infrastructure as eg city-tunnels. In other sections of the network railway corridors may have been extended (eg from 2 to 4 tracks) to mitigate capacity limitations.

Technical layouts which hinder co-operation between S-Bahn and other railway traffic (specific power supply features, conductor rails, differing voltages) are by no means a requirement for those services but much more a historical feature surviving in few systems from pre-WW2 times. Such features are not found in any S-Bahn system created since the 1960s.

S-Bahn features are usually not just of technical nature but often linked to a variety of issues:

- ⇒ rail infrastructure (dedicated infrastructure at least for core parts of the network, city-tunnels depending on local layout of main railway stations),
- ⇒ rolling stock (dedicated rolling stock, often EMUs),
- ⇒ operational patterns (eg fixed frequencies, also depending on more urban or regional characteristics),
- ⇒ operational adaptability (eg differing frequencies for peak/off-peak times and different sections of a line, different train length by coupling of train-sets...)
- ⇒ branding (easy to identify and to distinguish from other rail services, specific logos...),
- ⇒ fare integration (more “at home” in the local respectively agglomeration fare system than in the “national” railway fare structure),
- ⇒ specific organisational structures involving PTAs and/or other bodies with tendering responsibility to ensure proper integration in agglomerations’ PT-networks.

S-Bahn is not a fixed definition but can include different features even within single networks (there is some flexibility given...).

S-Bahn like systems may be but are not required to be treated as separate rail systems with regard to tendering and operator choice, they may also exist within classic “state railway” environments.

Important is, however, in order to give S-Bahn operation the highest success opportunities in agglomeration areas, that those who require the offer (= the agglomeration) are able to influence (to decide) the layout of services and to ensure proper integration in the PTA’s other PT-offers.

A summary spreadsheet of the described cases follows below:



## Overview of S-Bahn type operations in Europe

Location	Country	Operational since	Brand name	Network size lines km stations	Longest line [km]	Rolling stock	Max. train length [m]	Infrastructure	Maximum frequency [min]	PTA integration	Responsible body	Tendering	Operator
Berlin	Germany	1920s	S-Bahn	15 331	166	56 EMU	147 separated	147 separated	20 VBB	VBB	(yes)	DB	
Hamburg	Germany	1907/1934	S-Bahn	6 147	68	75 EMU	195 separated	195 separated	10 HVV	HVV	(yes)	DB	
Munich	Germany	1972	S-Bahn	8 434	150	~80 EMU	201 partly separated	201 partly separated	20 (10) MVV	BEG	(yes)	DB	
Rhein-Ruhr	Germany	1967	S-Bahn	11 676	124	97 EMU/DMU	140 mixed/expanded infra	140 mixed/expanded infra	20 VRR	VRR	yes	DB+others	
Rhein-Sieg (Cologne)	Germany		S-Bahn	6 239	65	EMU	mixed/expanded infra	mixed/expanded infra	VRS	VRS	yes	DB	
Rhein-Main (Frankfurt)	Germany	1978	S-Bahn	9 303	111	72 EMU	201 partly separated	201 partly separated	15 RMV	RMV	yes	DB	
Stuttgart	Germany	1930s/1978	S-Bahn	7 215	83	71 EMU	201 partly separated	201 partly separated	15 VVS	Region Stuttgart	(yes)	DB	
Dresden	Germany	1992	S-Bahn	3 128	47	78 DD-trains	mixed/expanded infra	mixed/expanded infra	30 VVO	ZVOE (VVO)	yes	DB	
Hanover	Germany	1997	S-Bahn	9 385	74	~120 EMU	mixed/expanded infra	mixed/expanded infra	30 GVH	Region Hanover, LNVG, NVBW, ZV-SPNV RP-Süd, VRN, Saarland	yes	DB	
Rhein-Neckar	Germany	2003	S-Bahn	7 370	96	200 EMU	mixed/expanded infra	mixed/expanded infra	VRN, KVV, 60 SWV, MDV, VBB, 30 VVO, VMS	VRN, Saarland	yes	DB	
Leipzig-Halle	Germany	2013	S-Bahn	7 430	105	~150 EMU	mixed/expanded infra	mixed/expanded infra	30 VOR	ZVNL + others	yes	DB	
Vienna	Austria	1962	S-Bahn	9		126 EMU	140 mixed	140 mixed	30 ZVV		no	ÖBB	
Zurich	Switzerland	1990	S-Bahn	28 380	171	DD-trains/EMU	300 mixed/expanded infra	300 mixed/expanded infra	30 TNW, RVL, ...		no	SBB	
Basle	Switzerland	1997	S-Bahn	5 250	72	105 EMU	mixed	mixed	STIF	(STIF)	no	SBB / SNCF	
Paris	France	1977	RER	5 587	257	197 DD-EMU	228 partly separated	228 partly separated			(no)	SNCF	
Madrid	Spain	1990s	Cercanias	9 370	89	EMU/DD-trains	partly separated	partly separated			no	RENFE	
Cadiz	Spain	1990s	Cercanias	1 61	14	61 EMU	mixed	mixed			no	RENFE	
Copenhagen	Denmark	1934	S-Tog	7 170	84	EMU	84 separated	84 separated	10 MOVIA		no	DSB	
Stockholm	Sweden	1968/1980s	Pendeltåg	4 245	53	107 EMU	214 mixed/expanded infra	214 mixed/expanded infra	30 (15/7.5) SL	SL	yes	Stockholmståg (SJ)	

To avoid any misunderstanding – the purpose of this report was not to highlight any specific S-Bahn schemes which present most similarities with the Oslo situation or to prescribe any details of an envisaged Oslo application. The main aim was to show that specifically branded commuter rail offers exist throughout Europe in rather different configurations:

- ⇒ Some segregated – many others mixed with other rail traffic.
- ⇒ Some with more urban scope – others operating far out in the region.
- ⇒ Some with rather unified features – others with rather flexible approaches.

The variety of features shown, allows, however, to state that there is every chance to develop an “Oslo S-Bahn” under whatever name within the Norwegian framework conditions and fitting to the local needs. It is just necessary to pick the right tools from the toolbox.

Karlsruhe –April 28<sup>th</sup> 2015

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