Selection of Technologies to Integrate Urban and Suburban Public Rail Transport

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22nd Metros & Railways Technology Meeting

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Selection of Technologies to Integrate Urban and Suburban Public Rail Transport

Purpose of this Presentation

- not addressing primarily urban transport operators or engineers, but rather addressing city planners and decision takers, who will have to decide on transport technology and design issues
- initially show and discuss on a broad scale means of public transport and define their characteristics and limits in order to have a common basis on definitions of technologies and their capacities
- specializing afterwards on rail-bound systems and modern technological options for improved integration

Outline of Presentation

- 1 The Problem
- 2 Requirement
- 3 Definition and dissipation of systems
- 4 The S-Bahn model
- 5 Conclusion
- 6 Recommendations
- 7 Requirements from a lender's point of view

The Problem

- Considering the players involved and their interests
- long term sustainable decisions on

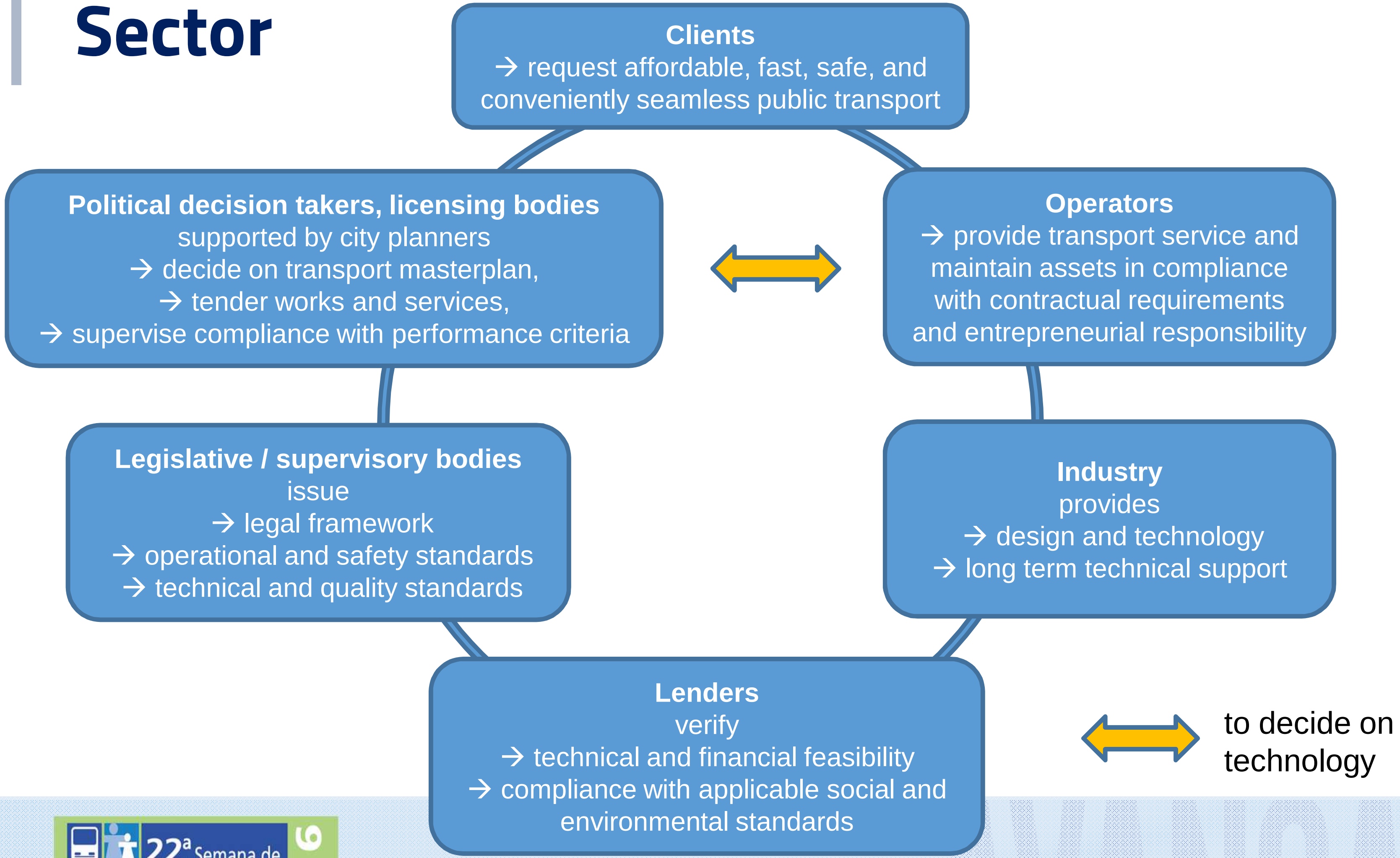
    technology

    integration of systems and

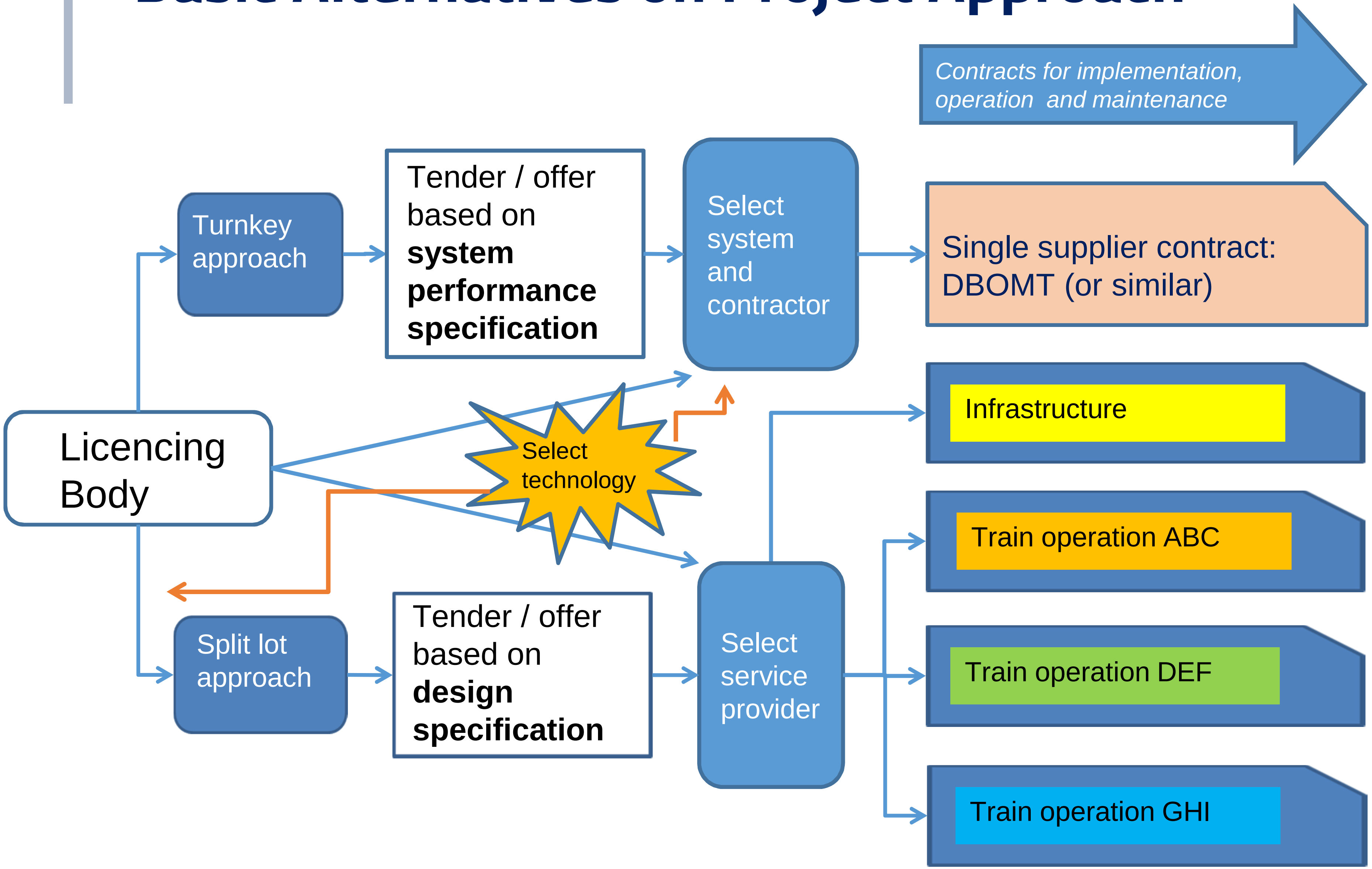
    project approach

are sometimes difficult to take

The "Players" in the Public Transport Sector



Basic Alternatives on Project Approach



Some Problems: Selected Technologies are often not Appropriate in the long-term

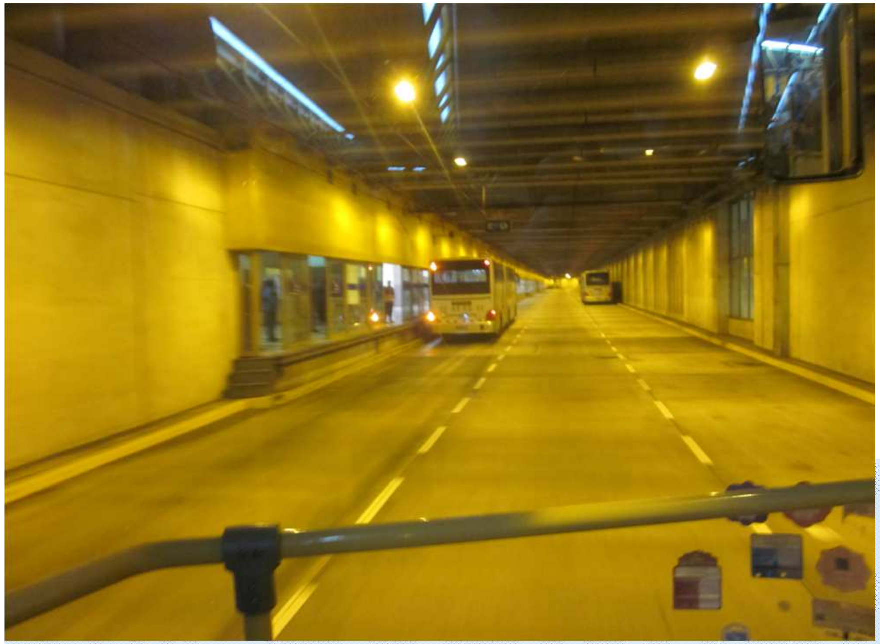
Different means of transport without proper integration increase door to door transport time

- BRT (Bus Rapid Transit System)
  - little or no integration with other technologies possible
  - requires large cross sections in otherwise scarce and expensive urban space (up to four lanes)
  - high wear of material, low riding comfort

and last not least:

- using renewable energy requires special and more expensive technology

Example BRT Lima

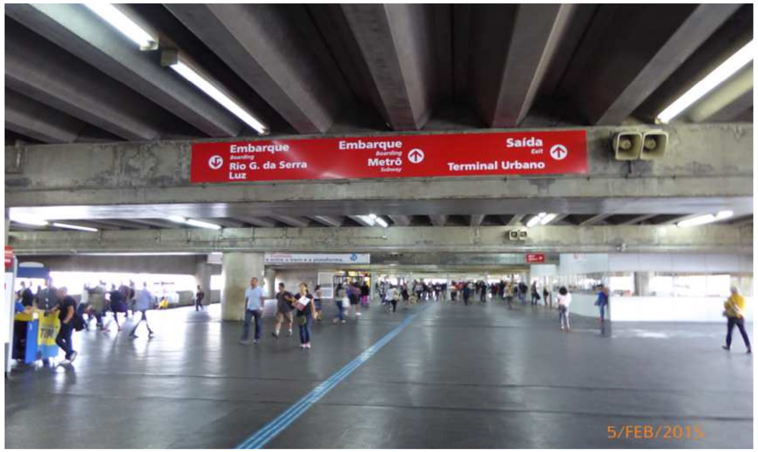


Some Problems: Selected Technologies are often not Appropriate in the long-term

- guided (rail-bound) systems are often not compatible with each other

- existing railway infrastructure:
  - often not integrated into network planning,
  - often not considered during selection of technology, however
  - may be used and integrated in the long term through step by step upgrading, thus, reducing initial investments

Complicated and Long Access and Interchange Routings



Requirement

When defining the transport masterplan and selecting the transport technology more emphasis should be laid on long-term integrated transport system by

→ avoiding the need of transfers between systems,

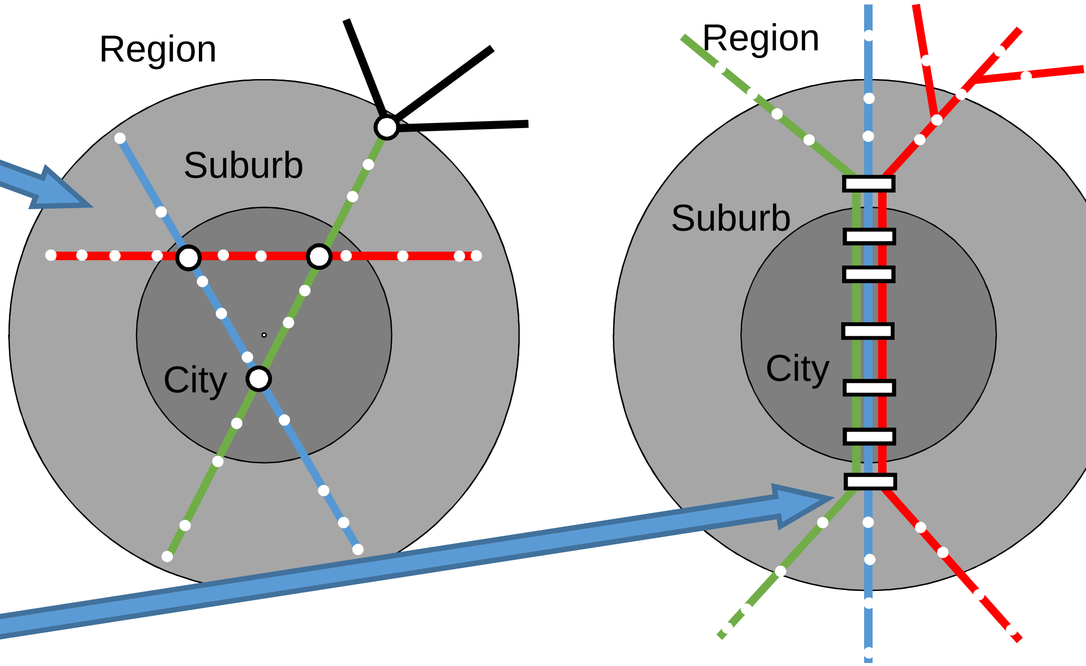
→ reducing times lost for access to stations and transfers inside the system,

i.e.

→ providing seamless transport as far as possible.

Definition and Dissoziation of Means of Public Transport

- mainly inner-city:
  - BRT
  - Tram
  - LRT
  - Metro



- combined solution: connecting city with suburbs and region:
  - S-Bahn
  - →bundle !

A) Rail-bound “Island” (Independent) Systems

- Tramways
  - within road or with separate right of way,
  - max. width of vehicle-envelop and max. length of train defined by road legislation (e.g. <2,65m x 75m in Germany),
  - speed and frequency limited by road traffic,
  - nowadays normally low floor,
- Light Rail (LRT)
  - high-floor vehicles with high platforms,
  - mainly separate right of way,
  - vehicle envelop and length of train independent from road legislation,
  - signalling priority at road interchanges
- Metro
  - entirely separate right of way
  - highest capacity

Examples

Tramway

LRT

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Examples

Metro

S-Bahn

B) Rail-bound Systems Compatible with Existing Railway Infrastructure → S-Bahn

- Suburban Commuter Express (→ S-Bahn)
  - compatible with railways
  - sharing infrastructure with existing railways outside of city, i.e. suburban lines, depots, workshops, power supply system,
- S-Bahn (only)
- → CPTM in Sao Paulo, Trem Supervia in Rio de Janeiro
- S-Bahn = Metro: own tunnels in down town like Metro,
- → Hamburg, Frankfurt, Munich, Paris
- S-Bahn = Metro = LRT = Tram → Karlsruhe, Kassel,

C) Other „guided“ Systems

- special technologies:
  - rubber-tyred metro (Paris, Mexico City, Santiago)
- proprietary technologies
  - Monorails
  - also VLT Carioca

Shortcomings:
→ not standardized
→ rather limited supplier competition in case of spare part supply and extensions
→ only justifiable in case of specific circumstances or requirements

D) Road-bound Transport Systems (buses)

- Road-bound, i.e. buses (BS), including articulated buses, double deck buses, etc.
  - generally easiest and fastest to implement in existing road infrastructure on a step by step basis
  - most flexible to accommodate changing requirements or new lines, however, sharing right of way with (congested) roads

- in big cities competitive only if on special separate lanes (BRT)
  - high capacity lines require large cross-sections (up to 4 lanes)

- rolling stock and infrastructure subject to relative high wear

- operation normally based on fossil fuel energy

Synopsis of Systems and Performance Indicators

Type of system	Maximum capacity per unit	Maximum length of unit	Length of platform (*)	Width of vehicle	Width of Infrastruture	Minimum Distance between stations	Maximum frequency	Commercial speed	Maximum speed	Capacity
	[Pax/unit]	[m]	[m]	[m]	[m]	[m]	[units/hr Dir]	[km/h]	[km/h]	[Pax/hr Dir]
BRT	180	25	< (2x) 45 = 90	< 2,55	> 12	500	60	< 22	60	< 10,800
BRT (with flyovers)	180	25	< (3x) 45 = 135	< 2,55	> 14	500	120	< 30	60	< 21,600
Tram	700	75	< 80	< 2,65	6	500	20	< 25	80	< 15,000
LRT = Tram (with separate right of way)	1000	100	< 105	> 2,65	8	500	30	< 30	80	< 32,000
Metro	1500	8x22	< 180	< 3,1	9	1000	40	< 35	90	< 60,000
S-Bahn	1500	3x70	< 215	< 3,1	9	1000	40	< 60	140	< 60,000

railbound

European Cities (Transport Associations) with Different Means of Public Transport

City	Population	Number of operating transport companies	Number of lines	Total length of lines	Length of rail lines	Length of S-Bahn lines	Urban area covered	Daily passengers	Share of S-Bahn
	[mio]			[km]	[km]	[km]	[km²]	[mio]	[%]
Berlin	6	44	1,079	32.000	4,562	556	30.546	3.7	33
Frankfurt	5	54			1,450	303	14.000	2.5	30
Hamburg	3.4	30	716	20.317	1,217	238	8.628	2.3	35
Karlsruhe	1.3	21	251	3.232	932	663	3.550	0.6	60
München	2.7	45	345	5.832	691	509	5.470	2.3	55
Paris	12.4		1,454	25.141	1,827	1,525	17.174	11.8	15

Example S-Bahn Frankfurt (Rhein-Main) (operated by DB-Regio)

length of network 303 km, operated at 15kV / 16,6 Hz (like DB)

9 S-Bahn lines crossing down town city tunnel with

- headway of 2 minutes

and

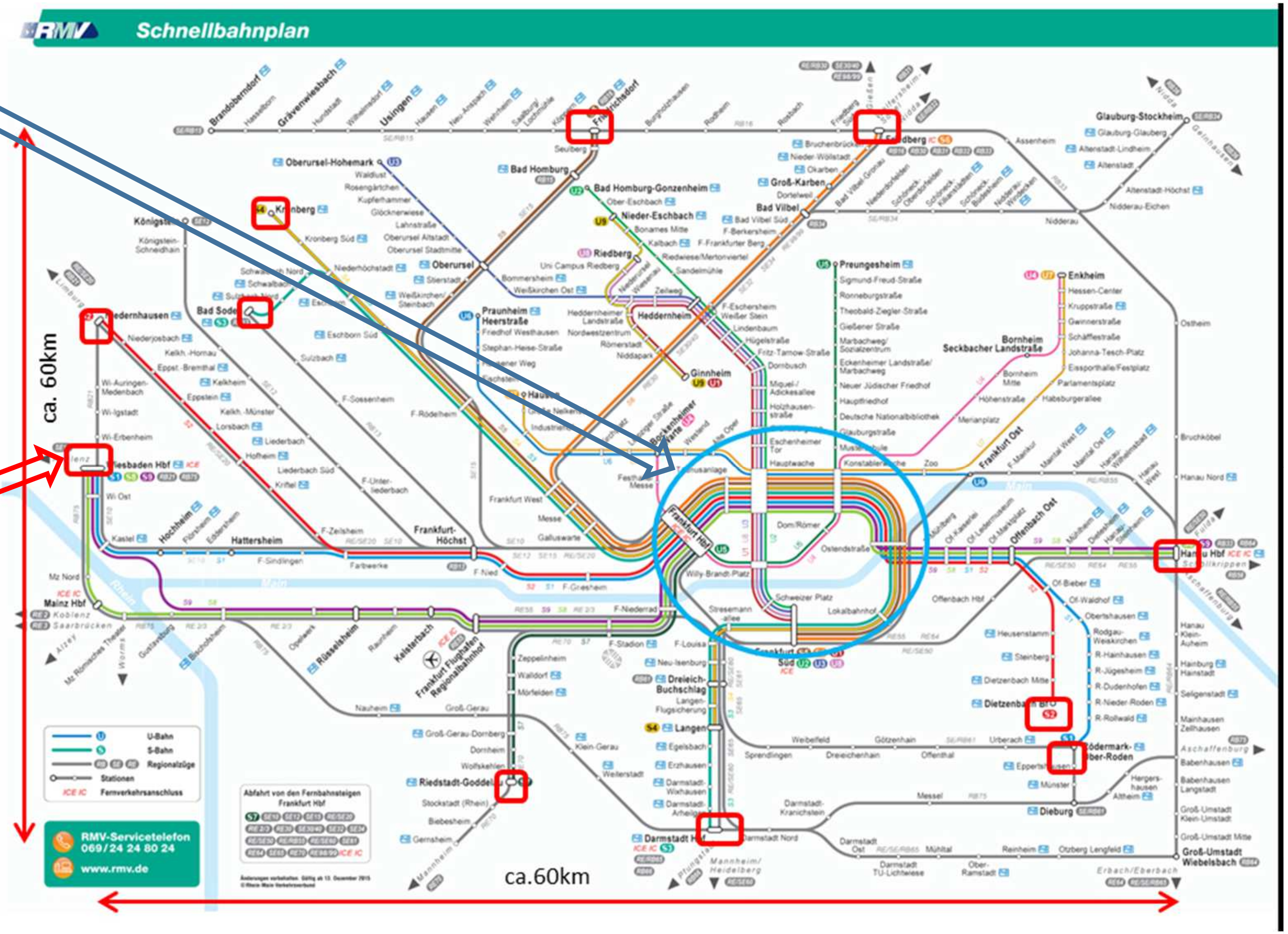
- station to station distance of ca. 1km

→ **similar to Metro**

connecting to

- 11 terminal stations in the region
- 100 intermediate stations
- with speeds up to 140km/h
- Station to station distance up to 10 km

→ **similar to regional express train**

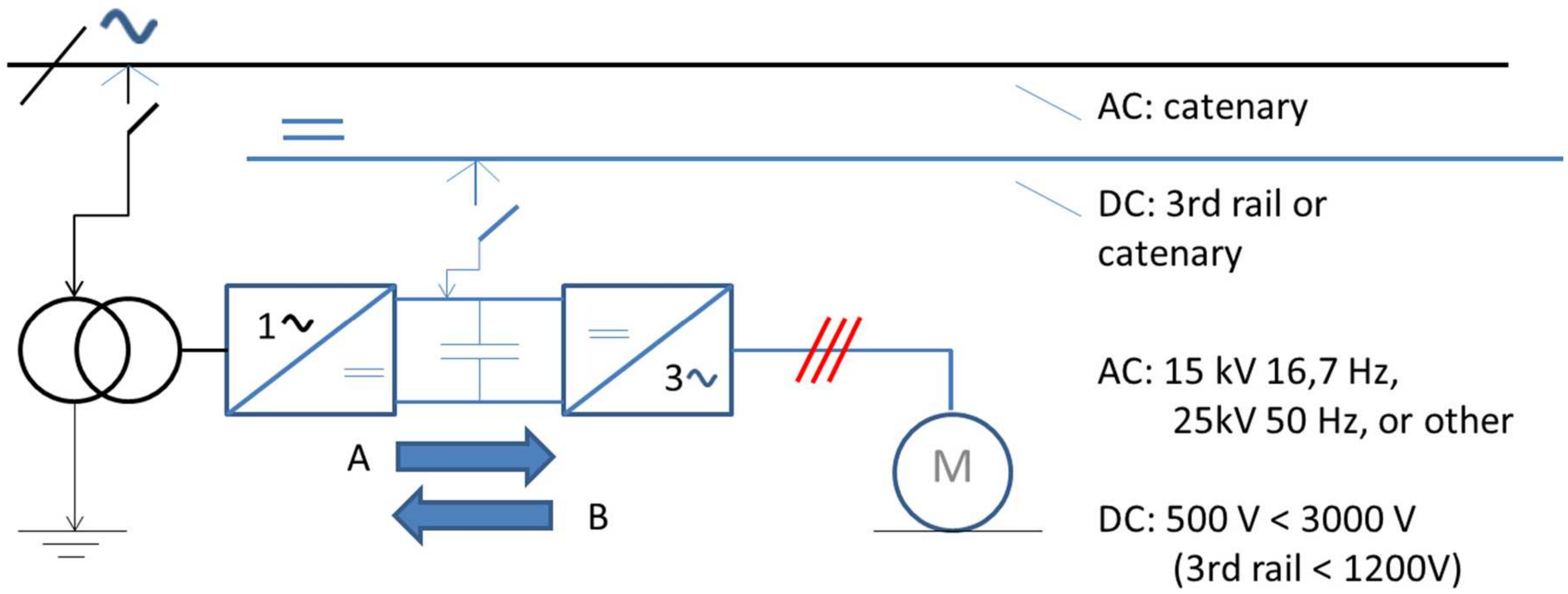


Frankfurt S-Bahn

using mainline track
in the region

in down town city tunnel:
cross platform interchange to
metro

3-phase Traction Technology (simplified)



Flow of Energy: AC

A) Acceleration: catenary → transformer → rectifier → inverter → traction motor

B) Regenerative Braking: catenary ← transformer ← inverter ← rectifier ← traction motor

Flow of Energy: DC

A) Acceleration: inverter → traction motor

B) Regenerative Braking rectifier ← traction motor

Example S-Bahn Karlsruhe (→„Karlsruhe Model“)
(operated by KVB and AVB using also DB track)

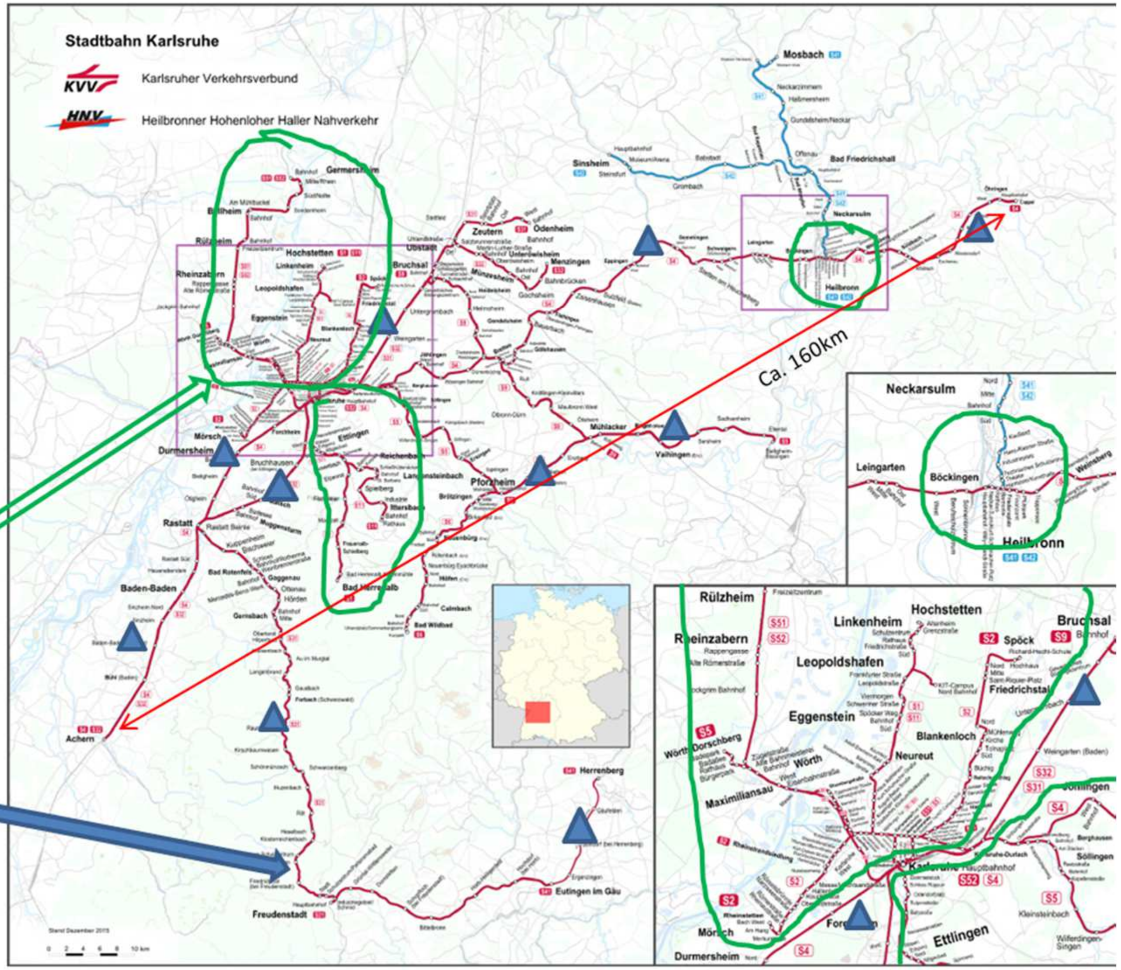
originally operated only as LRT in Karlsruhe and Albtal with 650/750V DC from catenary

since 1994 introduction of dual voltage trains (based on LRT rolling stock)

now largest S-Bahn network in Germany

ca. 200km LRT track
750 V DC / catenary

ca. 450km DB-track
15kV AC / catenary
(combined with long distance service)



Karlsruhe S-Bahn

cross platform connection to regional and long distance trains

own right of way on major apprach roads

entering DB-mainline

passing through pedestrian street down town

Example S-Bahn Hamburg (operated by subsidiary of DB AG)
- originally operated only with 1200V DC / third rail
- since 2007 extension by 31km under 15kV AC / catenary
- introducing dual-voltage trains (based on S-Bahn trains)

144 km S-Bahn network serving 5 terminal stations

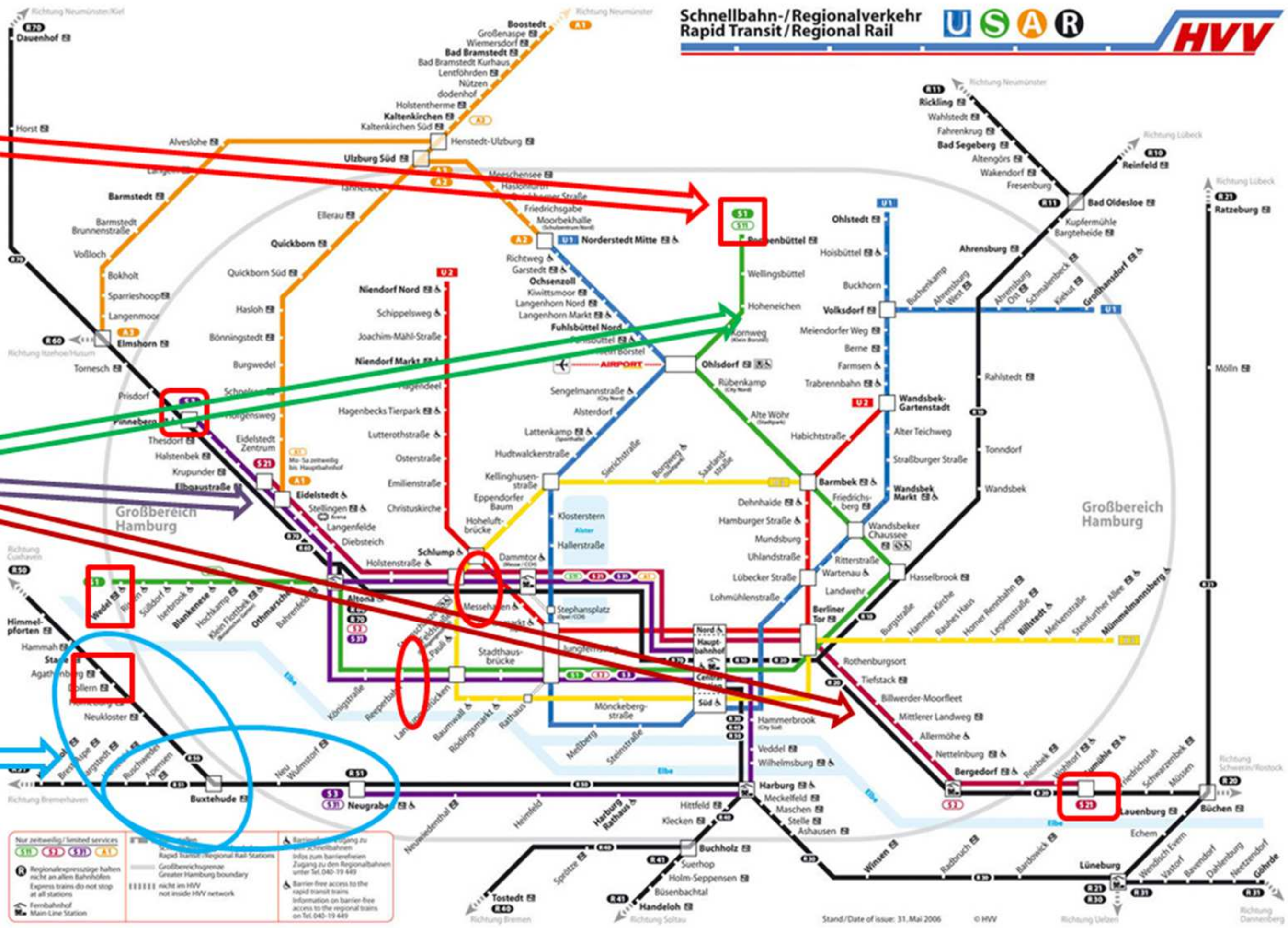
and

63 intermediate stations

113 km operated DC 1200V from third rail

31 km operated AC 15kV /16,7 Hz from catenary

2 cross city trunk corridors →



Hamburg S-Bahn

3rd rail operation in tunnel

pantograph lowered in down town

transition 3rd rail to catenary

pantograph lifted on main line

CONCLUSION

MODERN RAILWAY TECHNOLOGY

OFFERS A WIDE AND FLEXIBLE RANGE

TO SEAMLESSLY INTEGRATE SUBURBAN

AND URBAN RAIL SYSTEMS

Recommendations
Technical Aspects when Selecting Technology

Select long term sustainable technology

- Transport planers should take long-term future view on network design
- Integration of systems secure long-term attractivity to customers
- Compatibility of systems secures flexibility for future extensions or modifications
- Special and proprietary technologies should be limited to cases where very specific requirements are to be complied with

Recommendations
Environmental Aspects when Selecting Technology

- minimize impact in urban space and landscape
- minimize resettlement and negative social impacts
- improve safety, reduce accident rate
- use energy from renewable sources (wind, solar, hydro)
  → electric operation
- optimize energy-efficiency (e.g. operational program, signalling technology, regenerative braking)
- minimize dissipation of GHG, noise and vibration
- avoid later redesigns and changes

Additional Observations and Requirements from a Lender's Point of View

General

- Who is the borrower?
- Who is the implementing institution?

e.g.:

- State or Local government or Private (built/operate consortium)
- or other?

Special

- Technical feasibility? Long-term sustainability?
- Environmental and social impacts?
- Financial and economic viability?
- What type of project approach? Who is responsible for what?

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THANK YOU
FOR YOUR ATTENTION
AND
QUESTIONS

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3º Prêmio Tecnologia & Desenvolvimento Metroferroviários

ANP Trilhos CBTU Companhia Brasileira de Trens Urbanos