Transport
Technologie -
Consult
Karlsruhe GmbH

Network optimisation with dynamic modelling: the case study of Karlsruhe

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Shareholders

Majority shareholder with 51 %

PTV Transport Consult GmbH, a firm of the PTV Group, active worldwide in Software development, Consulting and Research in transportation and transport planning

Majority shareholder with 49 %

Albtal-Verkehrs-Gesellschaft mbH (AVG), the AVG is the operator of the regional Tram-Train and railway in the Karlsruhe area, partly on its own network, partly on the DB-Infrastructure with a 500 kilometre network

PTV GROUP the mind of movement

AVG Bewegt alle.

VBK Bewegt alle.

KVV

TTK 20 years of expertise in Public Transport

- Founded in 1996
- Head office in Karlsruhe
- Branch in Lyon
- 30 employees
- Turnover 2015 : 2,6 Million Euros
- Firm fields:
  - Infrastructure
  - Transport Planning, Operation and Vehicle

Core competences

Direct access to the operator experience and the AVG's infrastructure

Large spectrum linked to expert engineers

International expertise in design and construction of tramway, Tram-Train, suburban railway and BRT

Wide knowledge of the French Public Transport market

Know-how exchange between France and Germany as well as other countries

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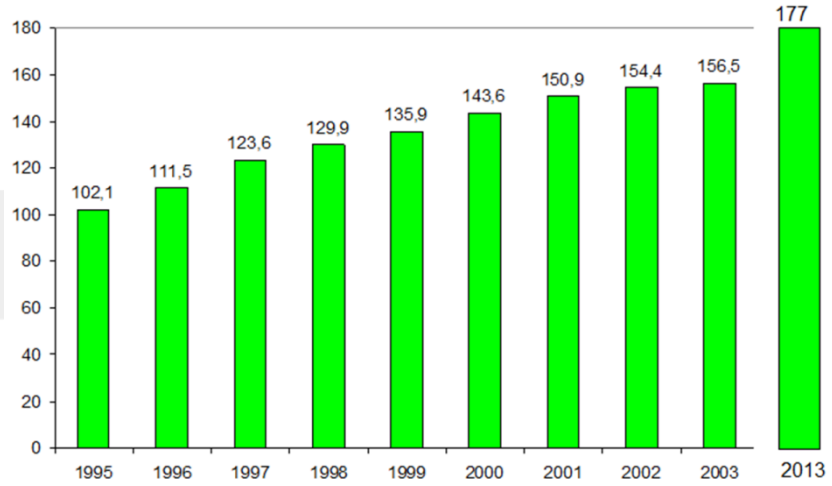
The Karlsruhe Model



Passengers growth

Main facts

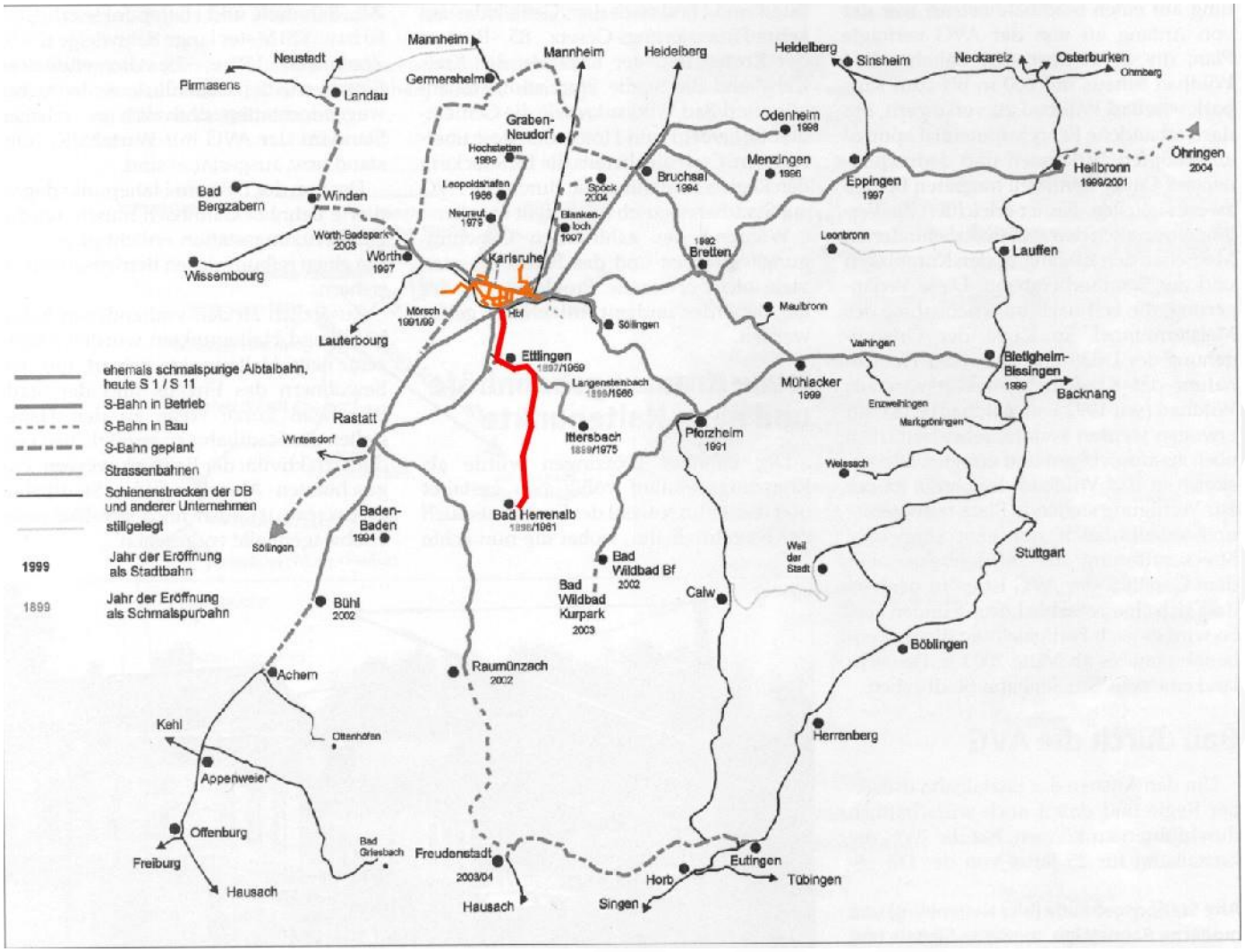
- Inhabitants: 1,3 Mio.
- Surface: 3.550 km²
- 120 cities and local authorities
- 21 operators
- 210 railway and bus lines
- 180 Mio. passengers / year
- Shareholder: 7 cities and administrative districts

Principles

- Direct lines between the suburbs and the city center
- As fast as trains outside the city and as flexible as trams in the city
- Connection between railway and tramway networks
- High frequencies each day from 5 am to 1 am
- Modern vehicle fleet
- Attractive fares

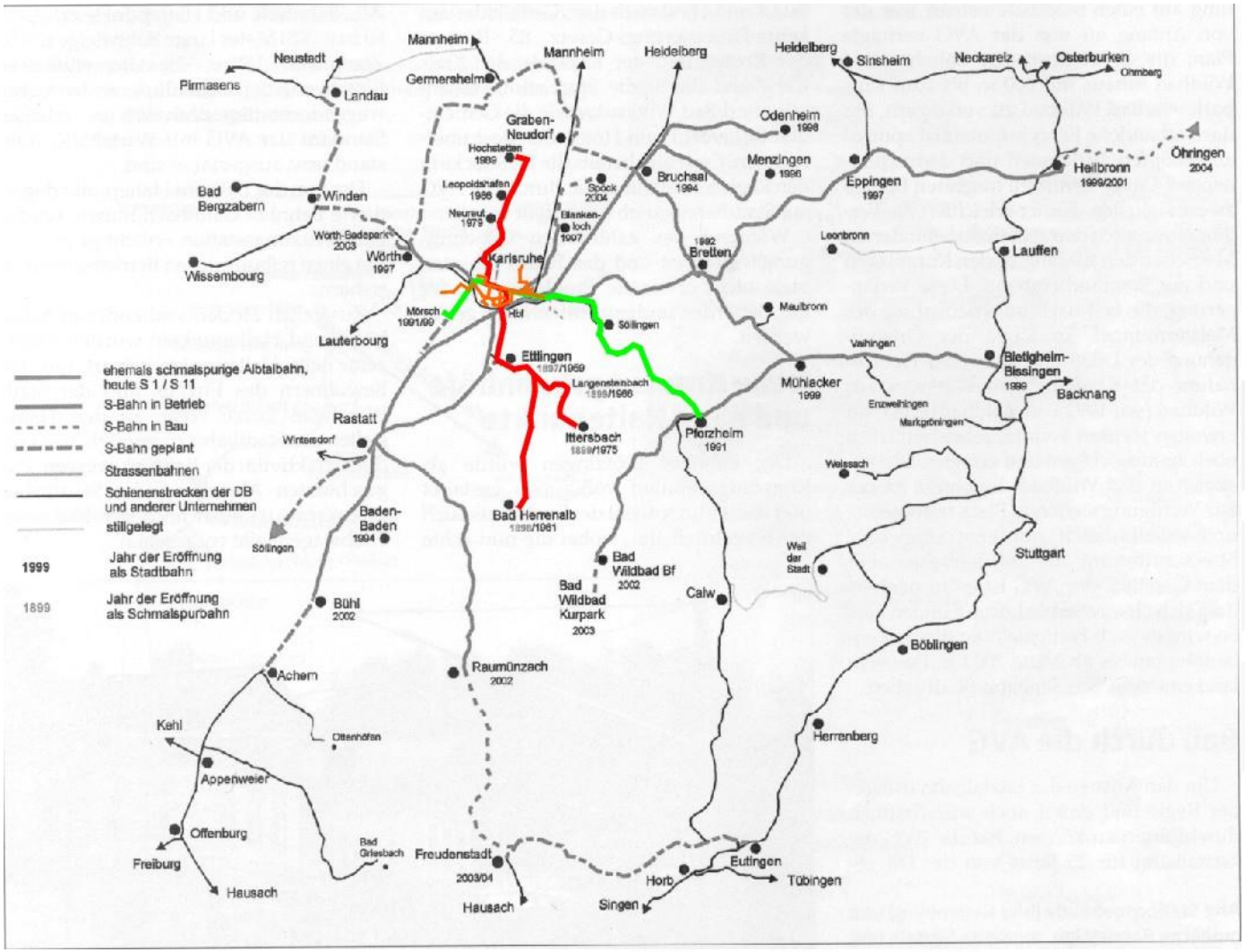
The Karlsruhe Model

Network development: 1961



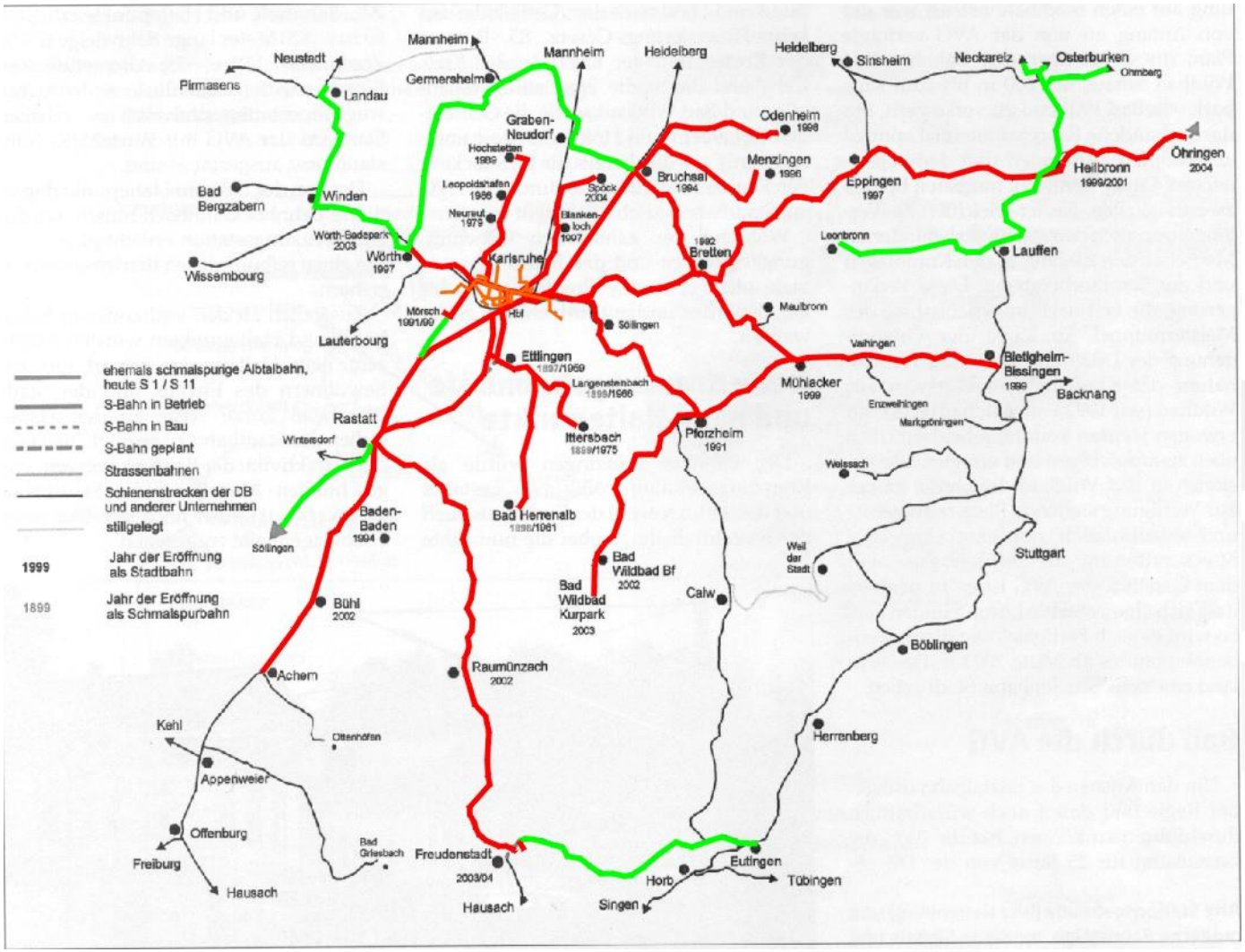
The Karlsruhe Model

Network development: 1991



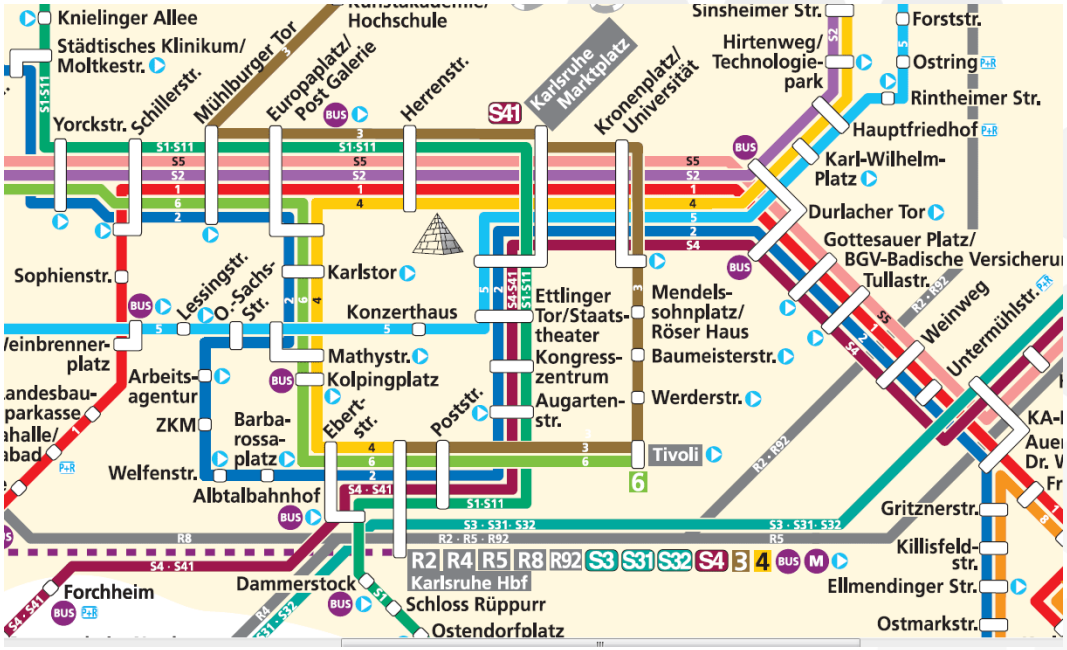
The Karlsruhe Model

Network development: since 2005



Origin of the „Kombilösung“

Due to the high tram and tram-trains traffic through the pedestrian area, it has been decided to build a tunnel in the city centre after a referendum at local level.



Karlsruhe Network in 2008

- 6 lines between Europaplatz and Marktplatz
  - (6*6)*2 = 62 tramways or trams-trains / hour
- 8 lines between Marktplatz and Kronenplatz
  - (6*7+4)*2 = 82 tramways or trams-trains / hour

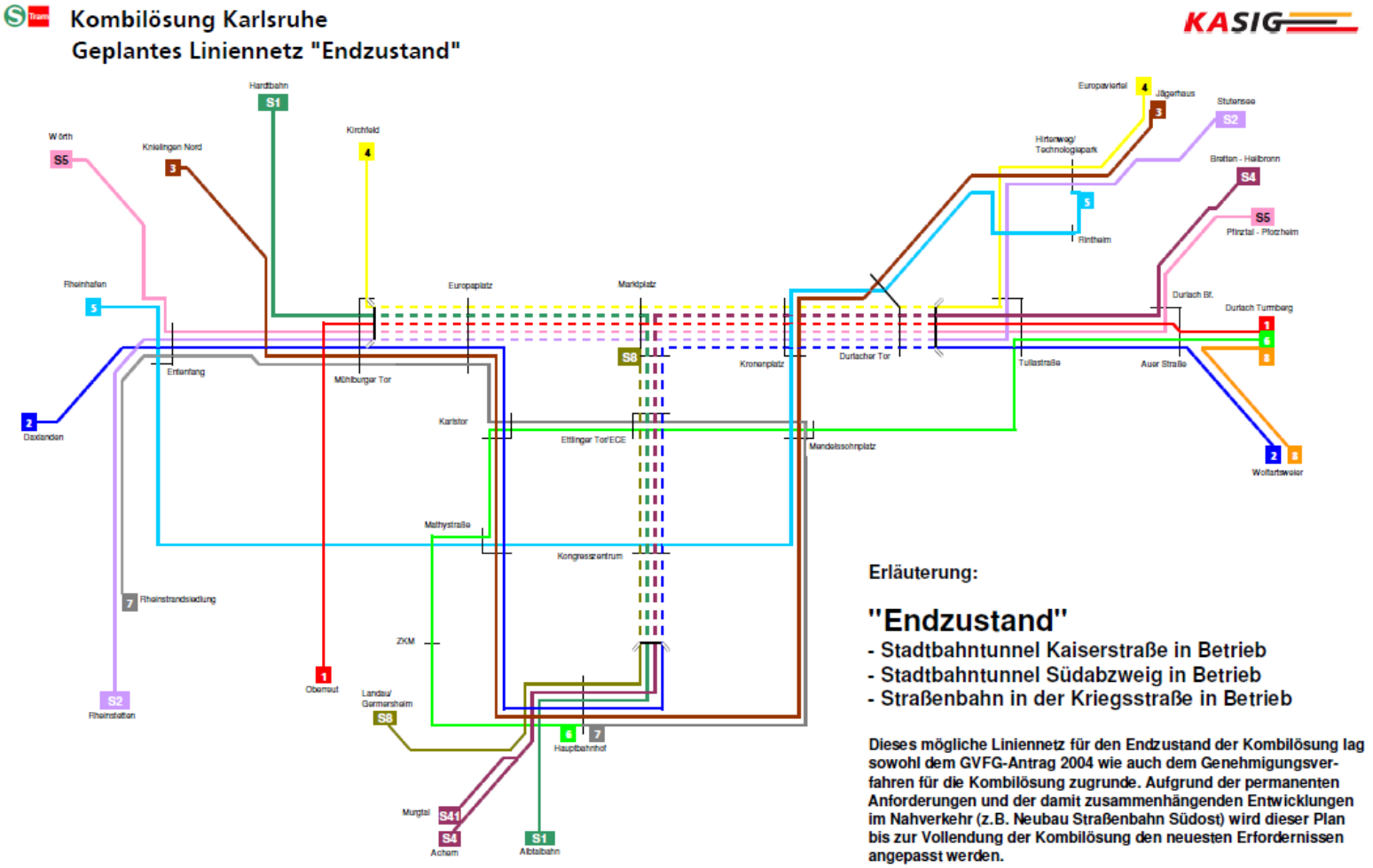
Origin of the „Kombilösung“

Overview of the future tunnels

- an east-west tunnel (2.5 km) under the pedestrian area (Kaiserstraße)
- a north-south tunnel (0,9 km) towards the main station (Ettlinger Straße)
- an east-west new tram track (Kriegstraße)

The future network

Planned network with the „Kombilösung“



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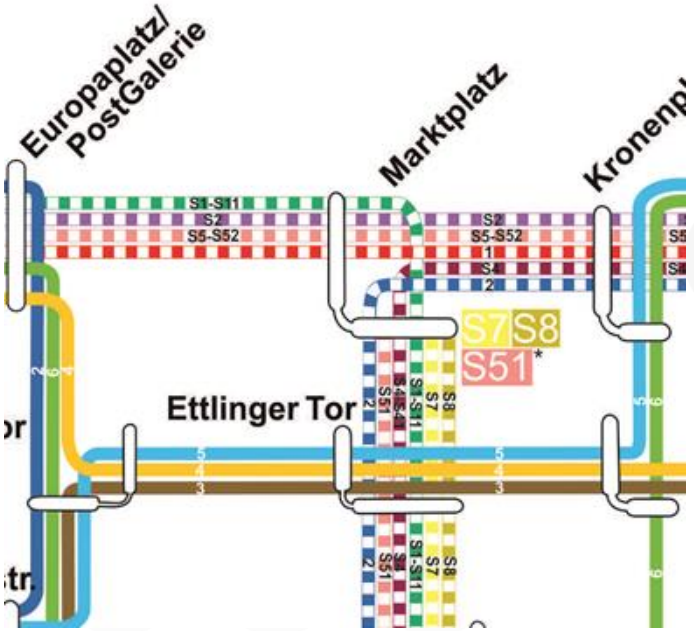
Comparison of the planned network with a new network

Planned network

- 5 lines between Europaplatz and Marktplatz (east-west tunnel)
- 6 lines between Marktplatz and Kronenplatz (east-west tunnel)
- 4 lines between Marktplatz and Hauptbahnhof (north-south tunnel)
- 2 lines on the new east-west track

New developed network

- Among another study with Prof. Dr. Ralf Borndörfer Berlin and PTV-TC
- Study of several optimised network solutions for the time after opening of the tram tunnel under construction



Tool

Major Strengths		Typical Use
Forecasting key line parameters (journey times, headways), without details, to get results quickly.	**SPREADSHEET TOOL**	**Upstream strategic stage** Journey times Rolling stock evaluation
Assessing journey times and potential timetables, (not taking into account "real-life" variability)	**FBS** *Statistical tool*	**Preliminary stage** Journey times Theoretical train diagram Rolling stock evaluation Timetables
Detailed testing of various operational or infrastructure choices on network performance (journey times, delays, reliability, line robustness).	**OPENTRACK** *Dynamic tool*	**Feasibility studies** Journey times Functioning of turn around Realistic train diagram Regularity analysis Capacity study Simulation of incidents
Combining LRT testing with junctions analysis impacts on traffic and on the LRT network of low, medium and high level of priority at some junctions.	**OPENTRACK & VISSIM**	**Deepening stage** Study of traffic light cycle Interaction car/LRT Road crossing capacity Realistic train diagram Consideration of all modes

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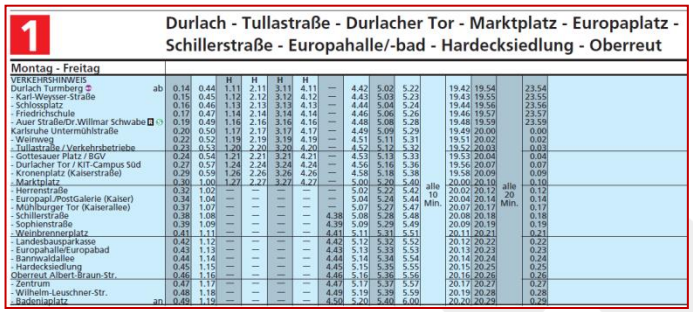
Creation of the infrastructure

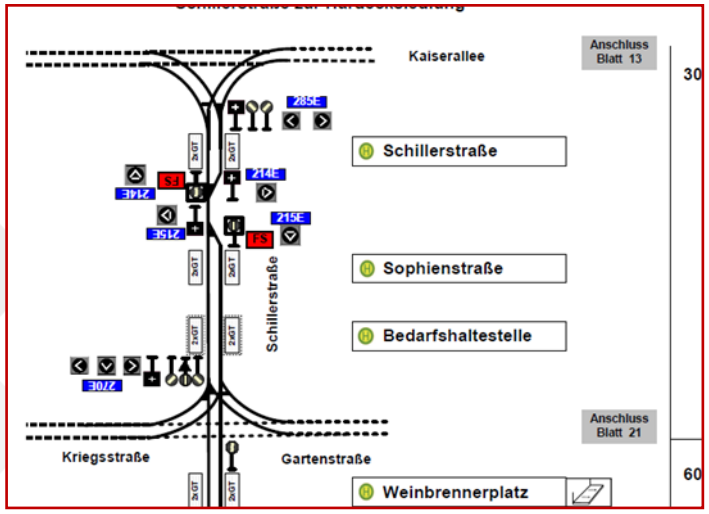
Different data

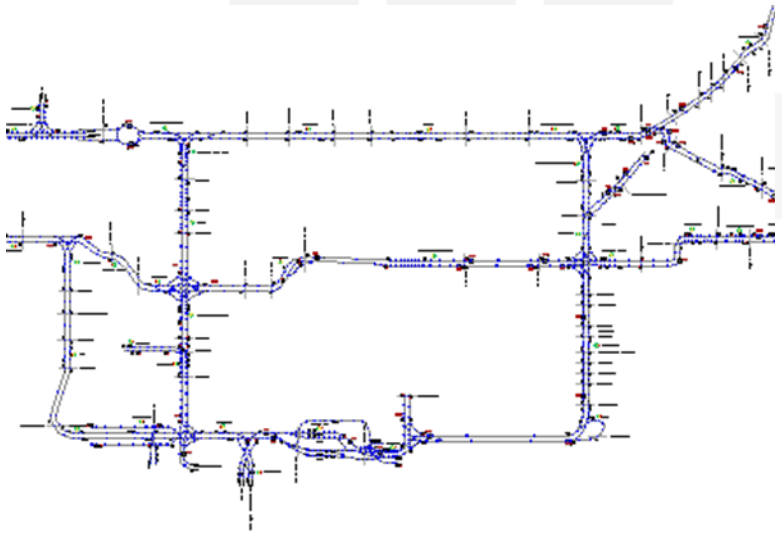
- Aerial view
- Track plan
- Speed limits
- Signals location
- Stations, etc.

Creation in OpenTrack

- Vehicles
- Lines
- Timetable



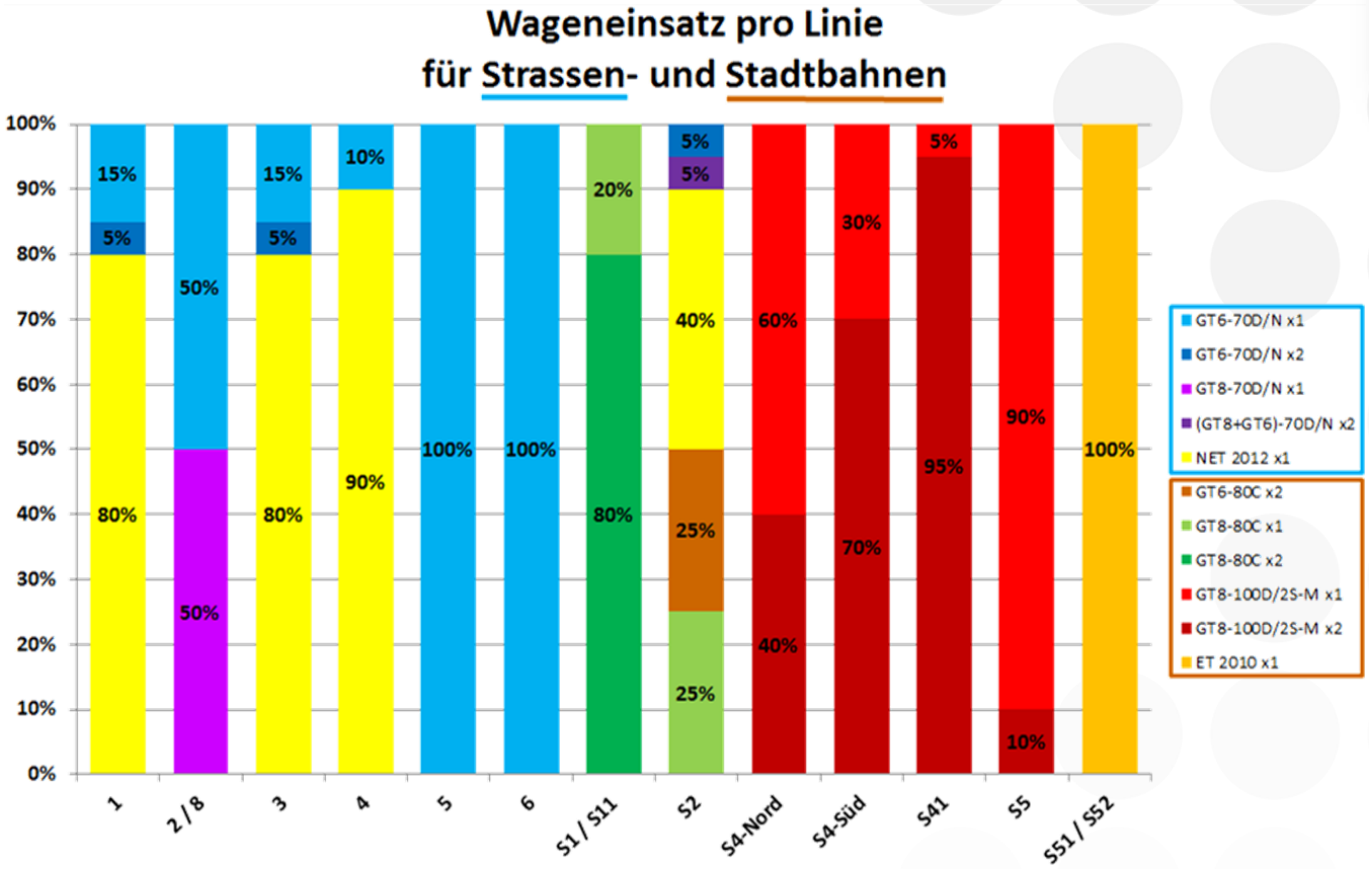




Creation of the infrastructure

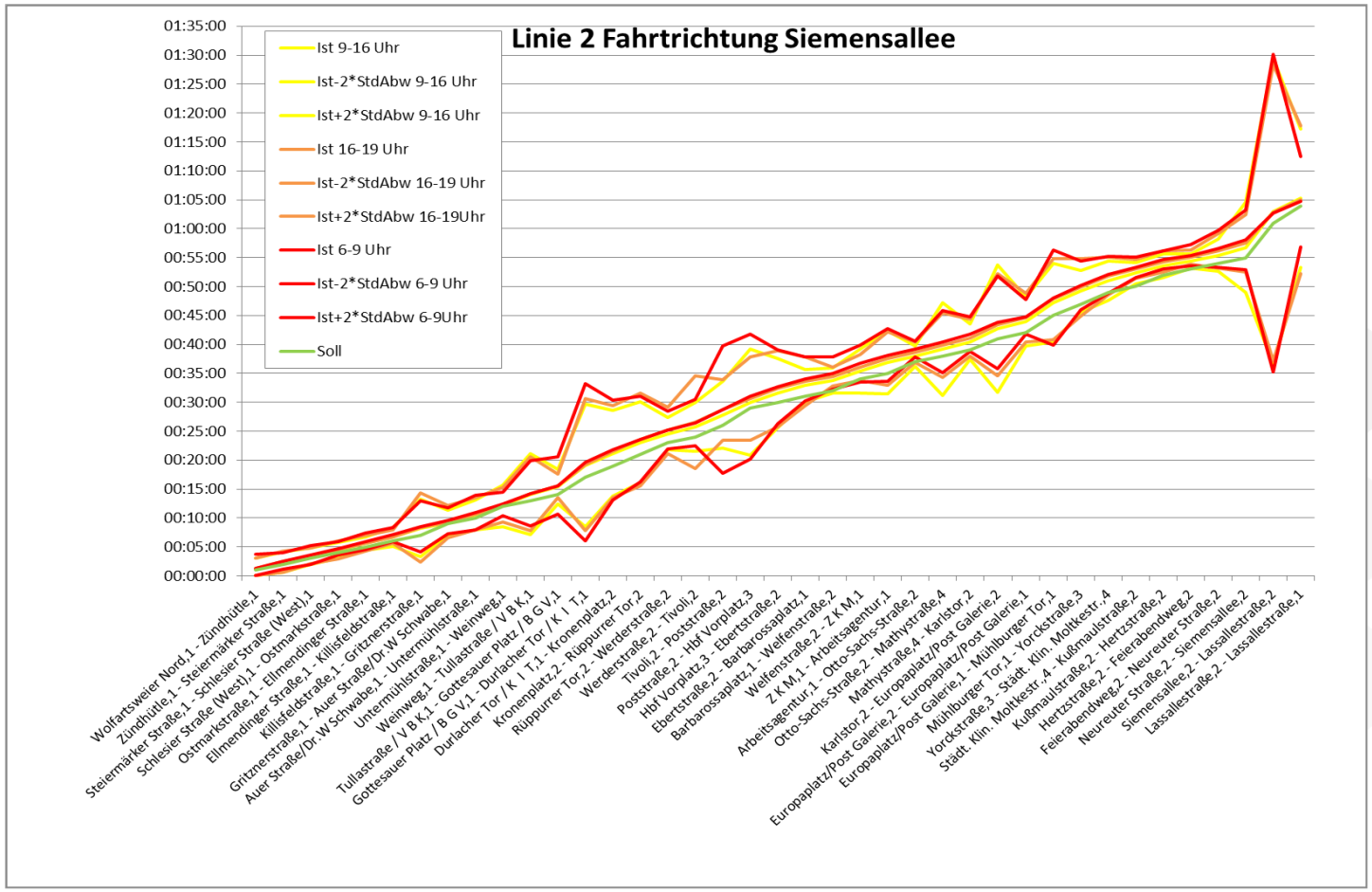
6 different vehicles

- A fleet of 3 different trams
- A fleet of 3 different trams-trains



Analysis of the actual operation data

Travel times and variation along the day



Analysis of the actual operation data

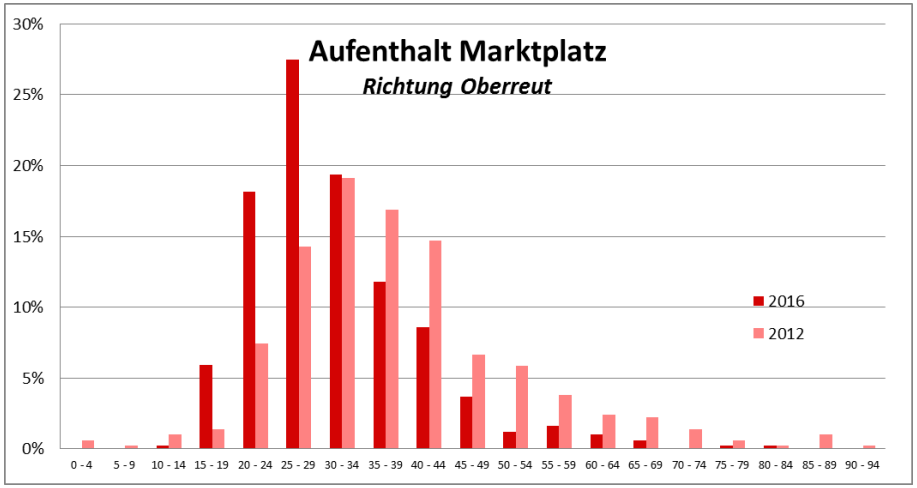
Dwell times distributions

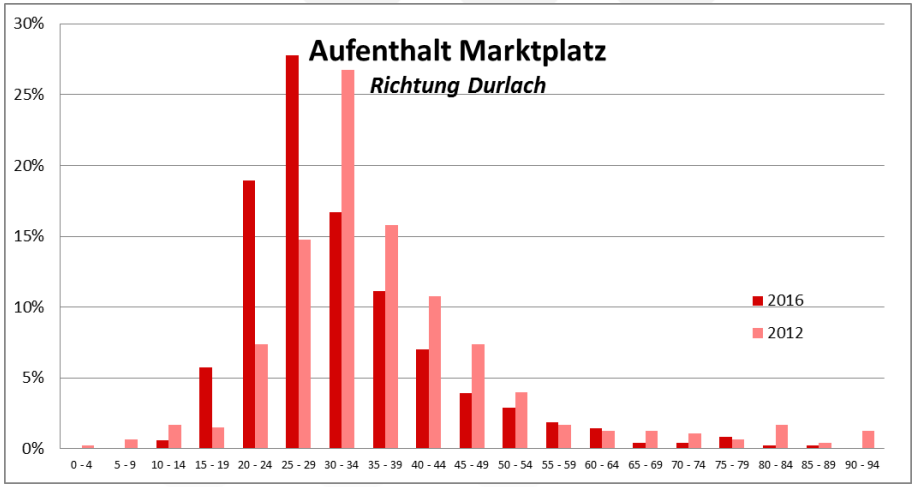
- Study for all the stations
- Definition of standard distributions, except for some specific stations as the main station

Delay at the departure

Delay at the arrival

Frequency at major stations





Dynamic parameters

Performance

- Each tram, in relation to their drivers, will have a specific behaviour in terms of speeds (some variation in the travel times).

Dwell times distributions

- Each tram will stop with specific dwell times based on a distribution (which can change during the day).

Delay at the departure

- Each tram will enter in the model with a specific advance / delay.

Junctions

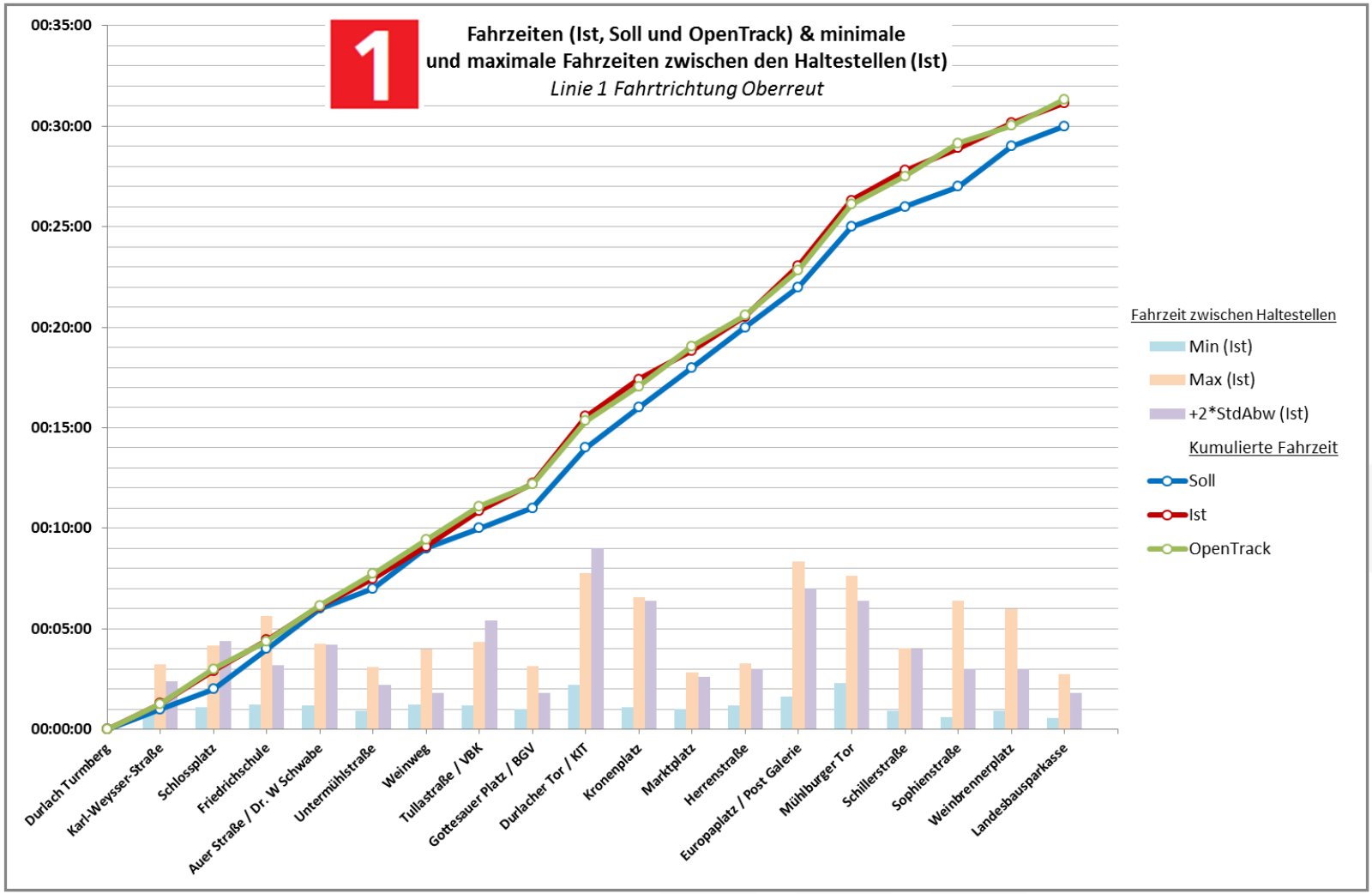
- Some junctions will be crossed with different levels of priority.

Delay amplification

- A delayed train will have a longer dwell time based on ist delay regarding the timetable.

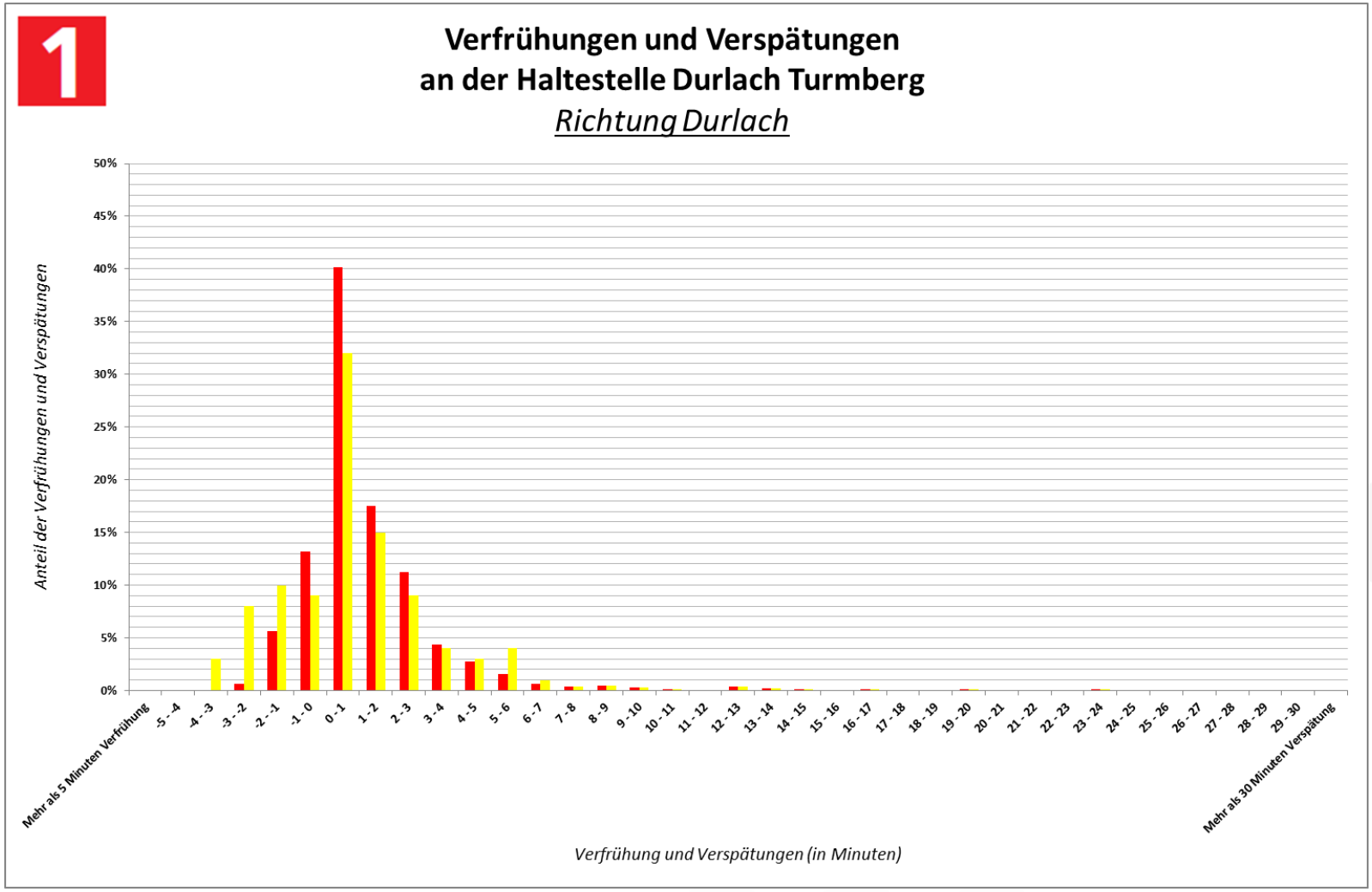
Calibration of the model

Average travel time : planned timetable, real data and OpenTrack data



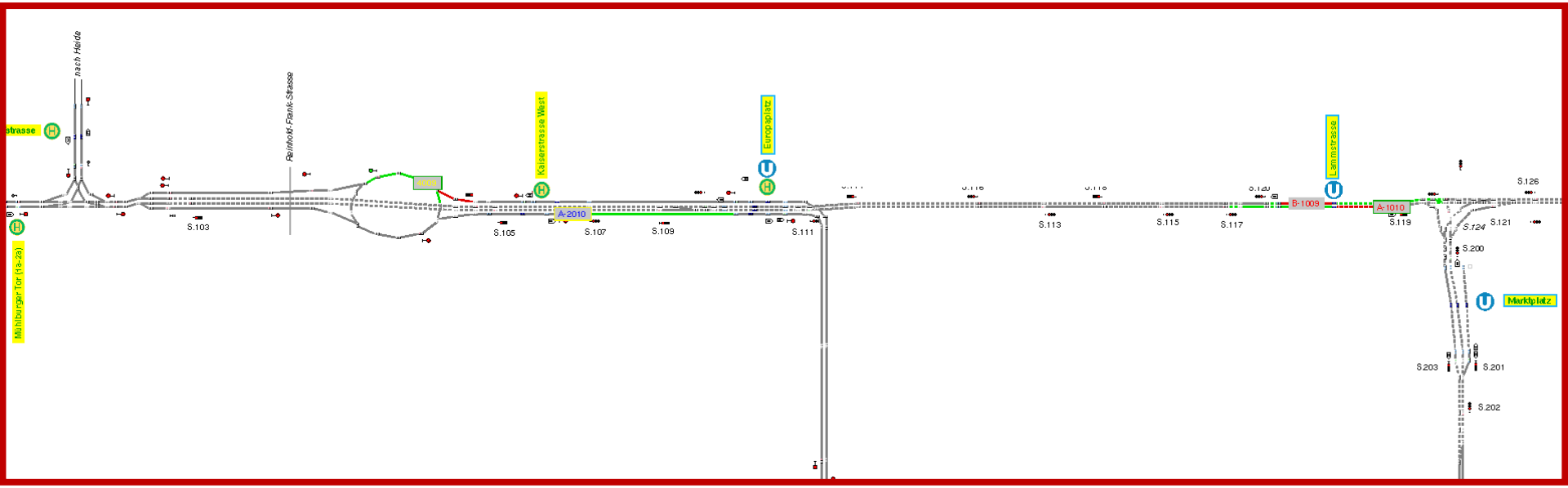
Calibration of the model

Example of distribution for arrivals ahead and behind schedule at a station

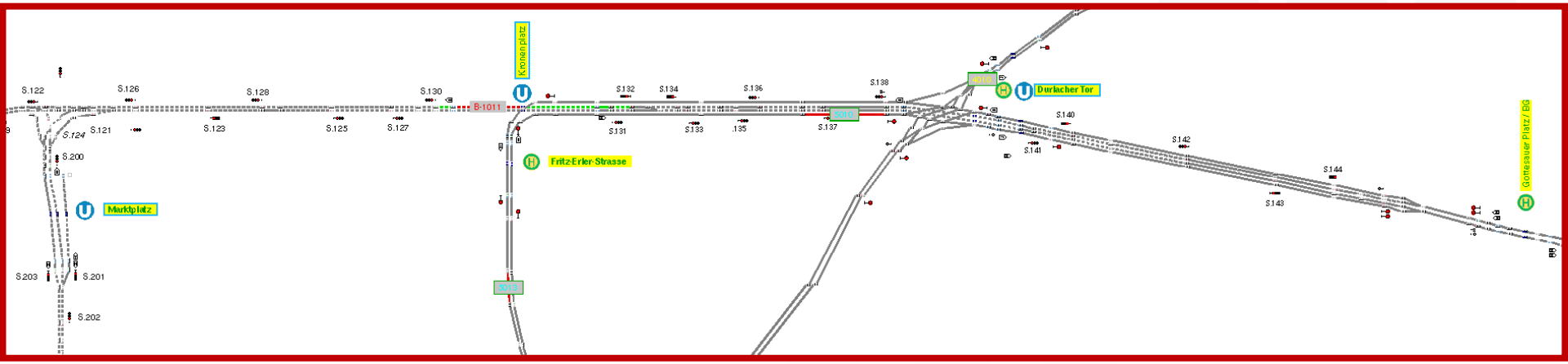


Update of the model

Mühlburger Tor <> Lammstraße / Marktplatz



Marktplatz <> Gottesauer Platz



Update of the model

New fleet on each line depending on the rolling stock available in the near future (2020-2021)

- New rolling stock for tram lines
- New rolling stock for tram-train lines

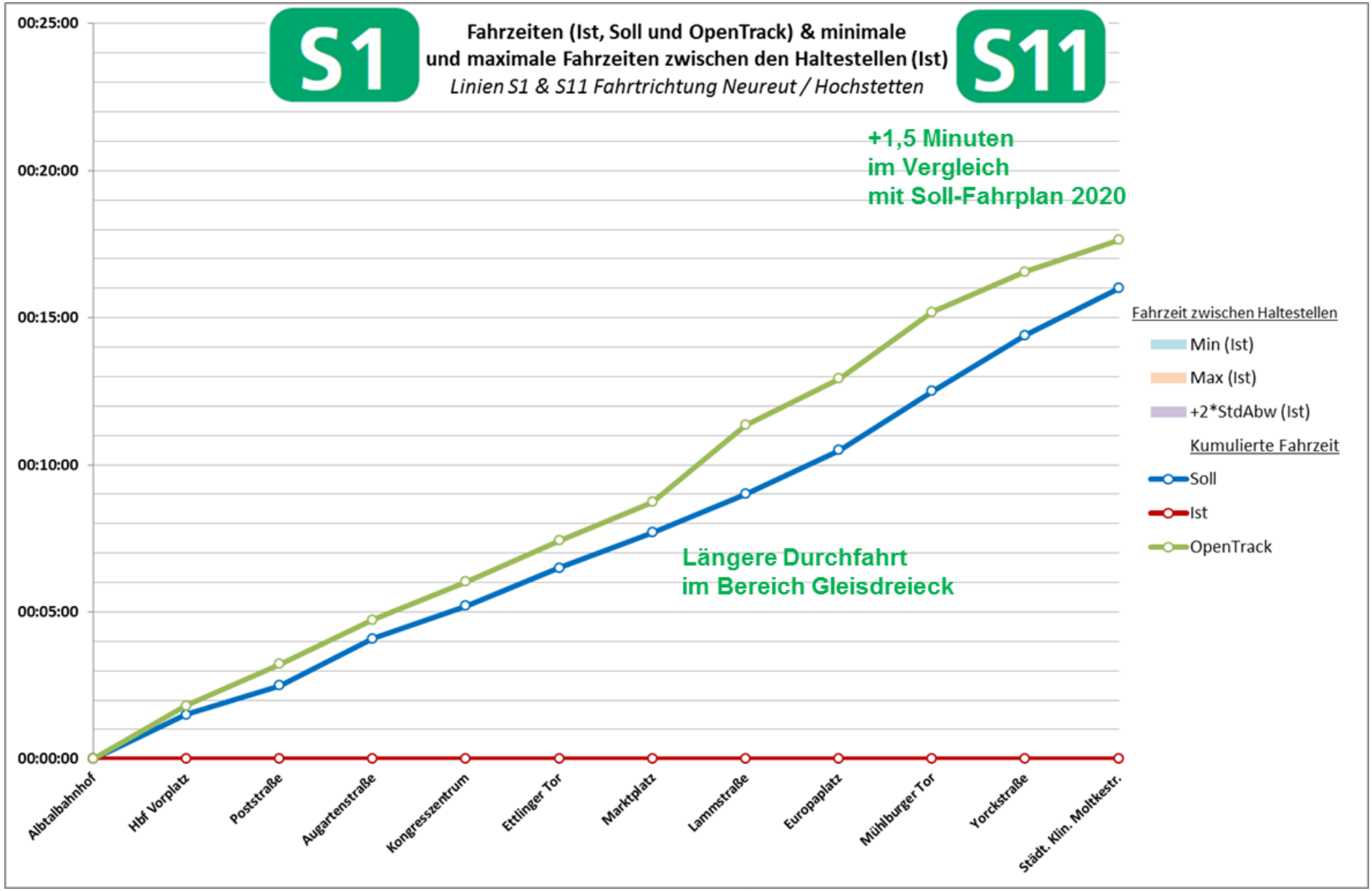
Assumption for dwell time distributions at some major stations

- Depending on the location of the new stations: station in or outside the tunnel
- Depending on the new network: new interchange points

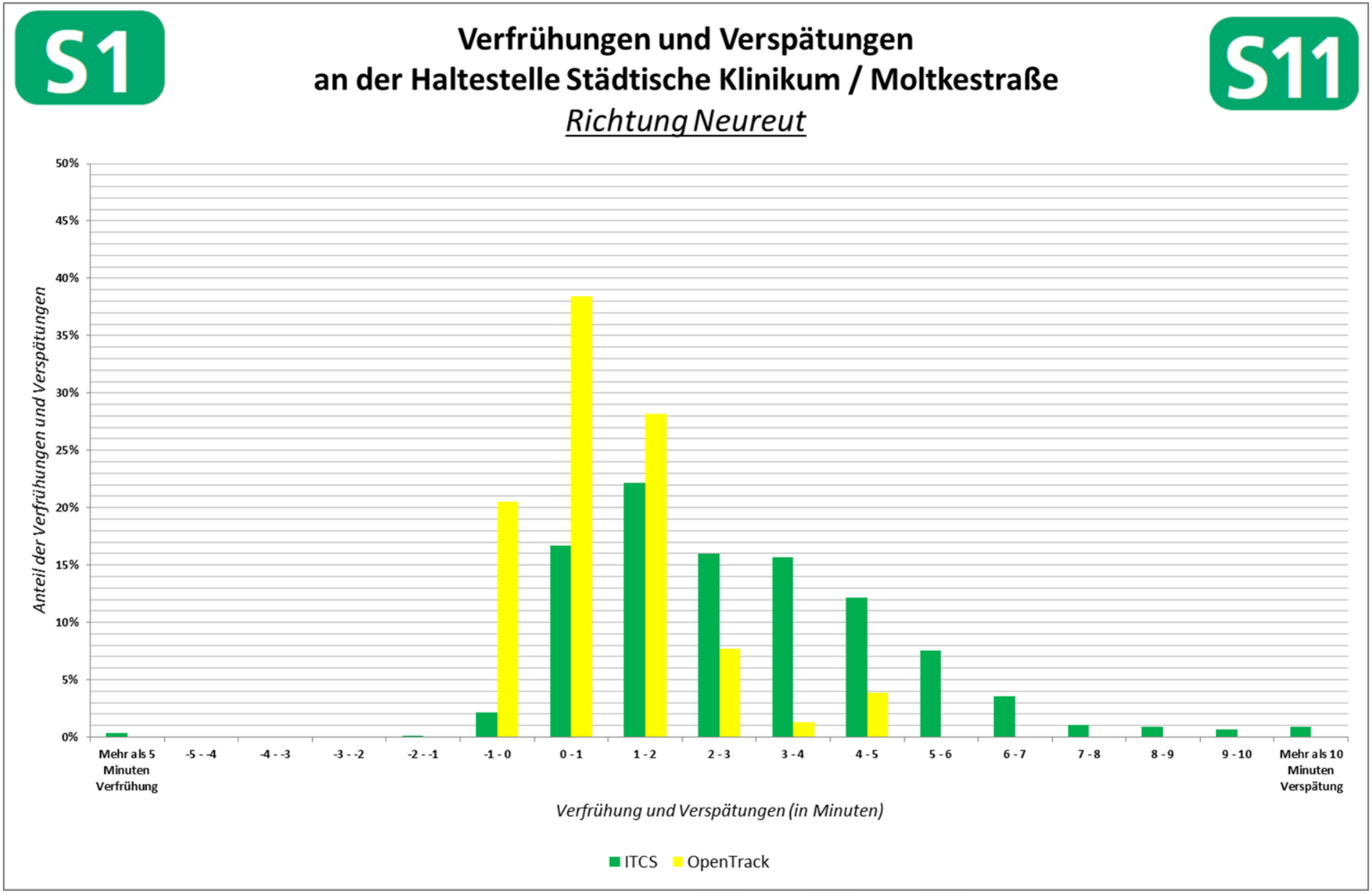
Assumption for the junctions

- Public Transport priority increased at some junctions due to the whole project

Results from the modelling: travel time analysis



Results from the modelling: ponctuality analysis



Results from the modelling

1. **Comparison of the travel times before and after the project**
2. **Comparison of the travel times planned and „simulated“**
   - on the east-west / west-east tunnel section
   - on the east-south / south-east tunnel section
   - on the west-south / south-west tunnel section

Beschriebung	Linie	Strecke			Fahrplan 2020 *(in Minuten)*	OpenTrack 2020 *(in Minuten)*	Zeit-Gewinn / -Verlust *(in Minuten)*
Tunnel Ost-West	1	Mühlburger Tor	<>	Gottesauer Platz / BGV	8,5	Confidential	
		Gottesauer Platz / BGV	<>	Mühlburger Tor	8,5		
	S2	Mühlburger Tor	<>	Gottesauer Platz / BGV	8,0		
		Gottesauer Platz / BGV	<>	Mühlburger Tor	8,5		
	S5	Mühlburger Tor	<>	Gottesauer Platz / BGV	8,0		
		Gottesauer Platz / BGV	<>	Mühlburger Tor	8,5		

Beschriebung	Linie	Strecke			Fahrplan 2020 *(in Minuten)*	OpenTrack 2020 *(in Minuten)*	Zeit-Gewinn / -Verlust *(in Minuten)*
Tunnel Ost-Süd	2	Augartenstraße	<>	Gottesauer Platz / BGV	9,0	Confidential	
		Gottesauer Platz / BGV	<>	Augartenstraße	9,0		
	S4	Augartenstraße	<>	Gottesauer Platz / BGV	9,0		
		Gottesauer Platz / BGV	<>	Augartenstraße	9,0		
Tunnel Süd-West	S1	Mühlburger Tor	<>	Augartenstraße	9,0		
		Augartenstraße	<>	Mühlburger Tor	8,5		

PROJECT PROGRESS

1. Calibration 
2. Integration in the model of the new network developed 
3. Modelling of the optimised network and analysis 
4. New scenarios? 

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Thank you
for your attention!

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