Quantifying public transport reliability in Zurich

Nelson Carrasco

IVT
ETH
Zürich

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Institut für Verkehrsplanung und Transportsysteme
Institute for Transport Planning and Systems

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Presentation outline

- Performance and reliability in Public Transport (PT)
- The multiple dimensions of reliability
- Some definitions
- Why is reliability in Public Transport important?
- Measuring reliability and performance metrics
- Case study – Line 31 in Zurich
- Data availability and first insights
- Reliability analysis – Travel time and speed, Punctuality, Regularity
- Conclusions and future research

Performance and reliability in Public Transport (PT)

- In the past, estimating performance measures was difficult and expensive due to the lack of data (and partially methods)
- Today, Automatic Vehicle Location Systems (AVLS) have overcome this difficulty by providing rich and extensive data
- Traditionally performance has focused on attributes of service supply (e.g. capacity, passenger loads, frequency, etc.)
- However, a number of studies have focused on the demand side (passenger's point of view) [1],[2],[3]

The multiple dimensions of reliability

- Synonyms of reliability: dependability, accuracy, constancy, fidelity, security
- Users experience reliability mostly through punctuality (time at stop) and consistency of their travel time
- PT operators tend to focus on features of the system such as schedule adherence, headway regularity, % of trips on time, etc.

Some definitions

- *Reliability*: “one minus the probability of failure” [4]. However, in PT systems failure is complex and hard to define.

- *Travel time reliability*: consistency or dependability in travel times, measured from day to day for the same trip.

- *PT service reliability*: can be understood in different ways:

  > “variability in performance measured over time” [5]

  > “variability of service attributes and its effects on traveler behavior and on transport agency performance” [6]

  > “schedule adherence and keeping schedule related delays to a minimum” [7]

- *Frequency of service* (Veh./h) vs. *Headway* (time between Veh.)

Why is reliability in Public Transport important?

- The characteristics of a PT systems and its level of service reliability influence mode choice
- Studies have shown reliability to be considered more important than average travel time and costs (work & non-work trips) [6]
- Unreliable services are more “expensive” for operators…
- … as well as less attractive for users, leading to decreased ridership by unsatisfied users
- Improvements in PT service reliability have the potential of enhancing the mobility of PT users and induce car users to switch mode
- Reliability influences travel behaviour

Measuring reliability (1)

- PT service measures are the set of aggregate metrics used to characterize overall service, measure performance and evaluate service delivery [6]

- Service measures are required to compare planned (promised) and actual (delivered) service

- They are basically summaries of individual trips at different levels of aggregation over a specific period of time

- Performance measures should aid planners and the PT industry:
  - Identify and understand reliability problems
  - Identify and measure improvements
  - Relate improvements to strategies
  - Modify strategies, methods and design to further improve reliability

Measuring reliability (2)

- Early studies focused mainly on the shape of the probability distribution for schedule deviation, or with evaluating service reliability (running times, its variation, headway regularity, etc.)

- As reviewed and summarized in [6], contemporary methods to analyse performance in the PT industry can be classified in two types:

  > Parametric (such as stochastic frontiers and econometric models)

  > Non-parametric (like Data Envelopment Analysis and analysis through indicators)

- This work seeks to assess service reliability by performing route and stop level analysis of running times, schedule deviations and headway regularity, as well as estimating measures of their variation.

Performance metrics

- Summary of performance measures and indicators included in this study:

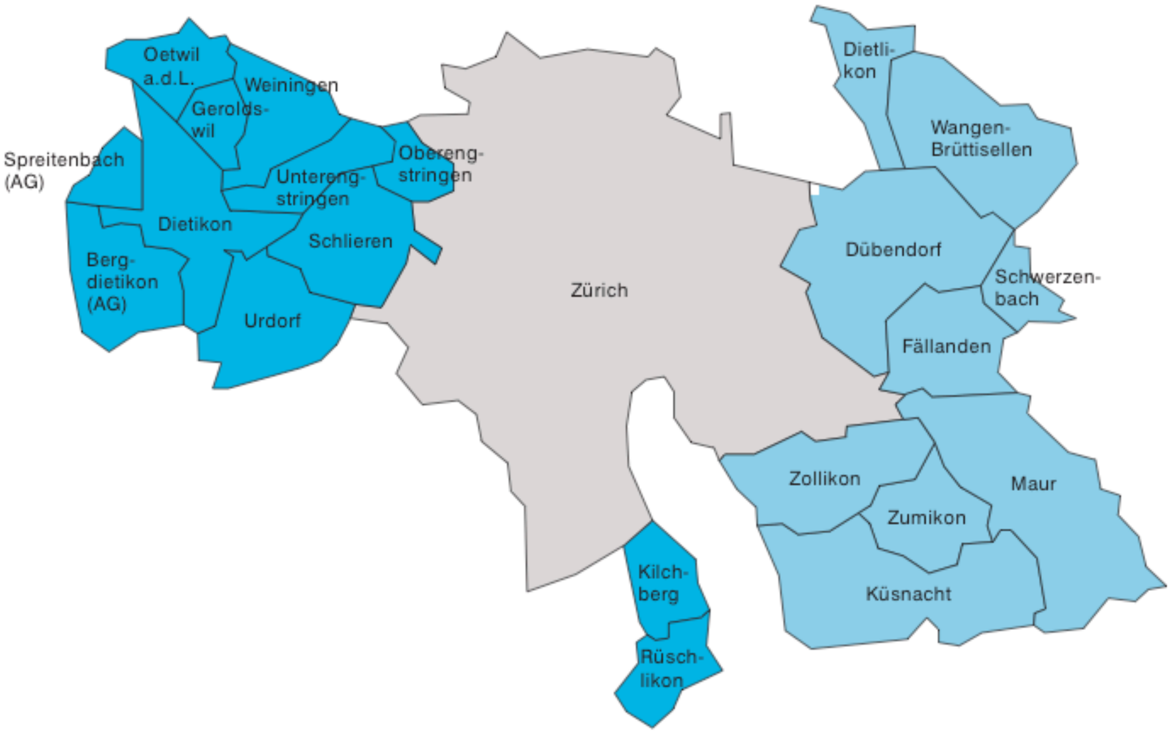
Travel time	Speed	Punctuality	Regularity
Mean distribution for all trips	Mean distribution for all trips	Schedule deviation frequency distribution at route level	Actual headway frequency distribution at route and stop level
Percentiles 5 and 95	Percentiles 5 and 95	Mean schedule deviation at stop level	Mean actual headway at stop level
		On-time performance (% of departures on time)	Coefficient of variation (CV) of actual headways at stop level
		Std. dev, from scheduled departures at stop level	
		Coefficient of variation of schedule deviation at stop level	

Case study – Line 31 in Zurich (1)

PT Operator: Verkehrsbetriebe Zurich (VBZ)

VBZ Züri Linie

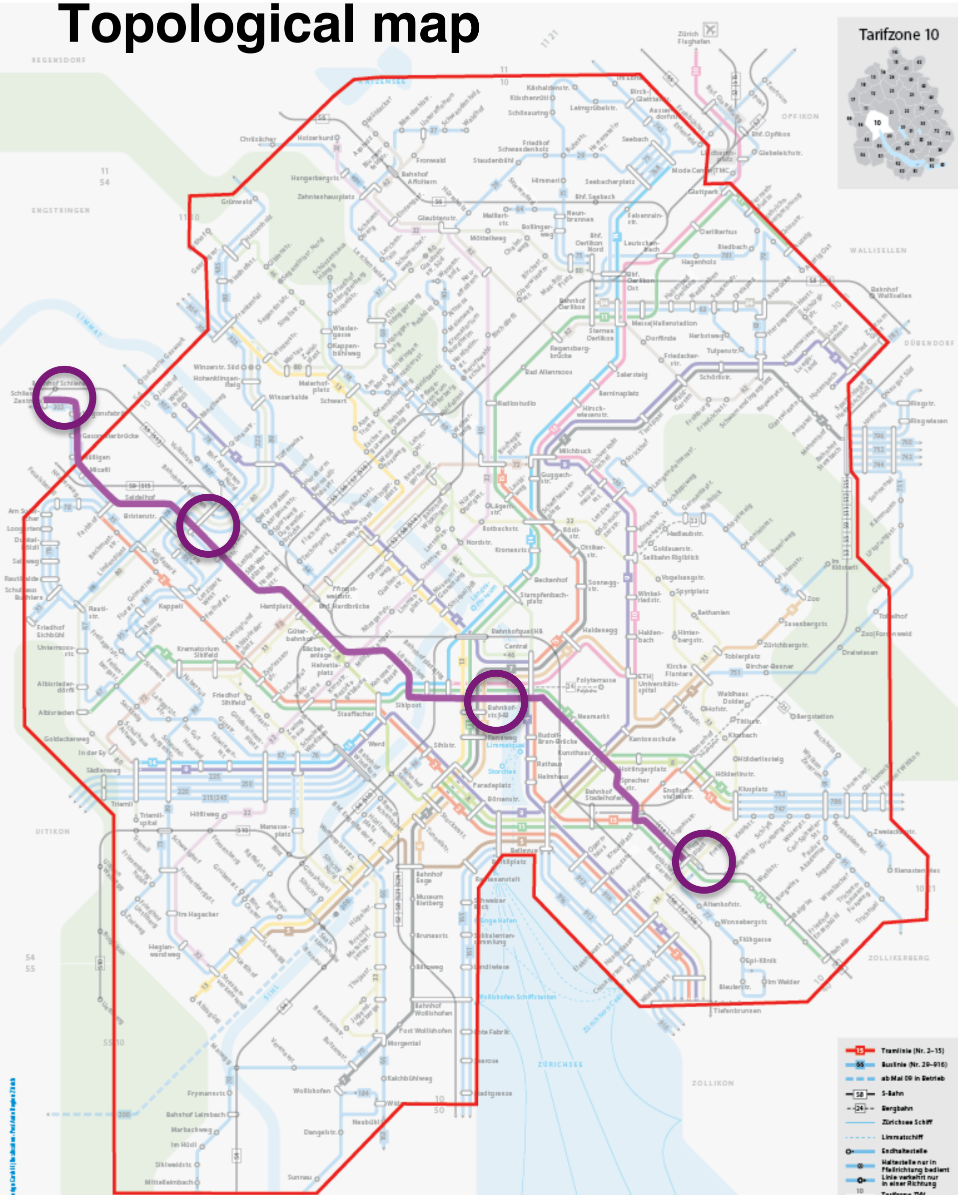
Market area



- VBZ provides service for 22 communes including Zurich
- About 318 mio passengers in 2010
- Total line length: >500 Km
- Night bus network: >190 Km
- Operates 325 trams and 245 buses, of which 178 are low floor (>70%)
- Operating cost coverage of around 64%

Case study – Line 31 in Zurich (2)

Topological map



VBZ Züri Linie

- Around 20’000 pax/day
- 12.4 mio pax/year
- 22 Km (round trip)
- 90 min (round trip)
- 27 stations
- Average distance between stations: 414 m
- Provides connection to four major stations

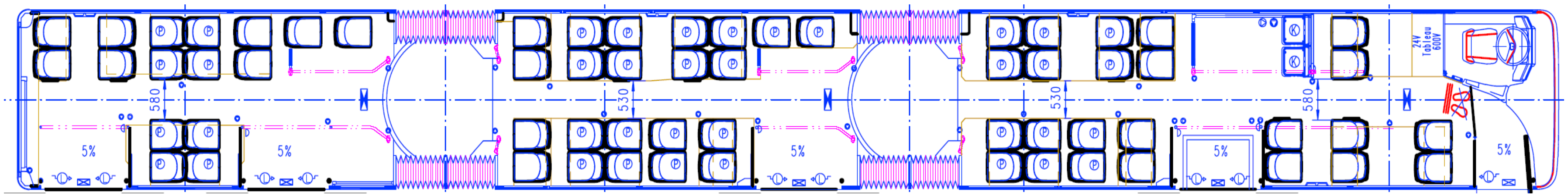
Case study – Line 31 in Zurich (3)

Vehicle

VBZ Züri Linie

Capacity

- 25 m long
- 60 seats (5 doors)
- standing room for 108 (4 pass. / m2)
- Technical max. capacity 202 passengers



Data availability and first insights (1)

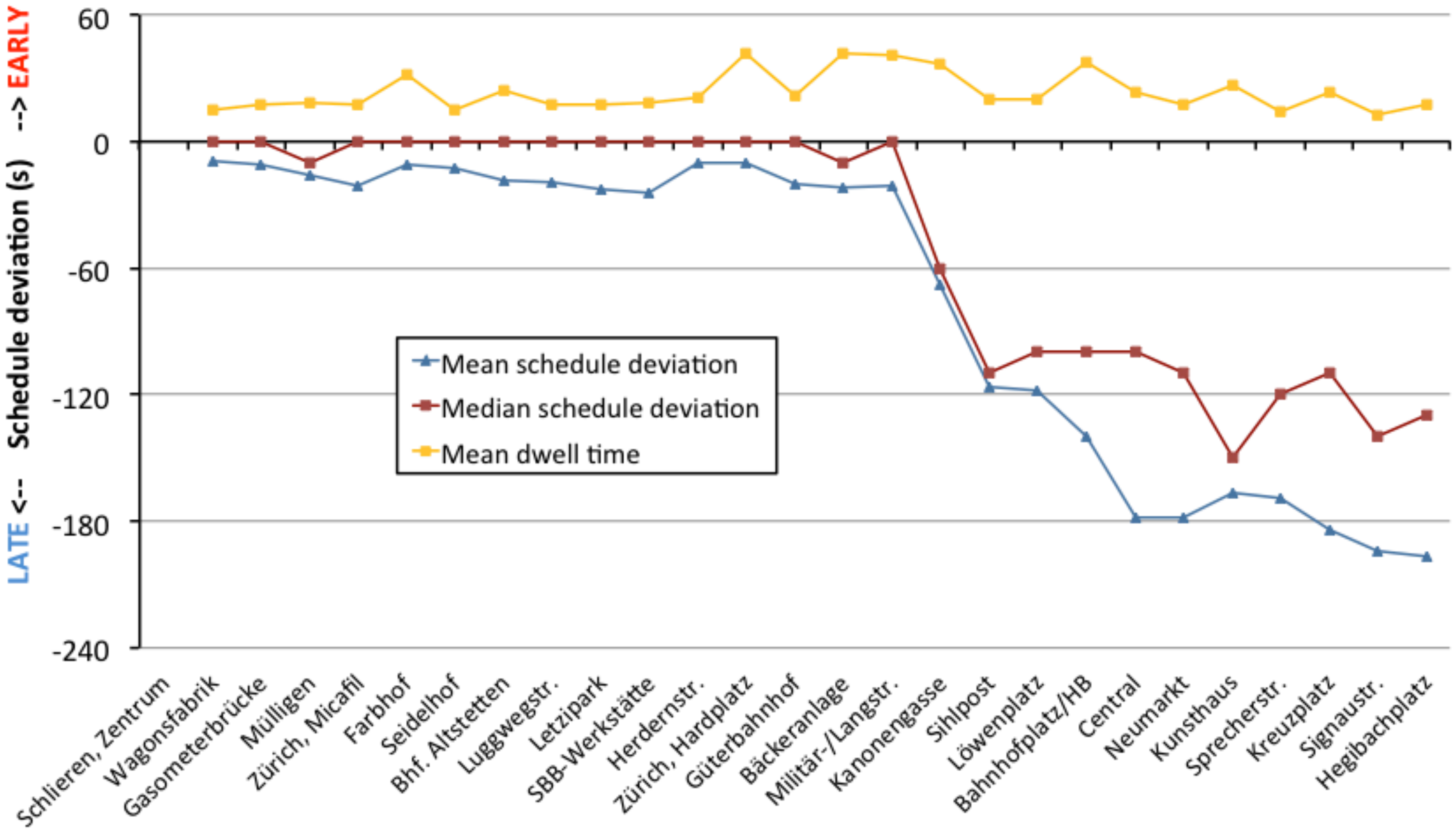
- Three sources of data were used in this study:
  1. Set of observations taken during rush hours of two week days
  2. Set of spread sheets with aggregate information and basic statistical measures on schedule deviation, vehicle speed records between stops, and aggregate vehicle travel time
  3. Original AVL records were made available by the VBZ in the form of a relational database containing detailed stop-level operational data

Variable	Description	Variable	Description
[Id]	Primary record key	[Stop_Seq_No]	Sequence of stop in pattern
[Date]	Calendar day of planned arrival	[Service_Date]	Operational day of scheduled trip
[Block_Id]	Block identifier	[Planned_Arrival]	Planned at stop in seconds after midnight
[Trip_Id]	Trip identifier	[Planned_Departure]	Planned at stop in seconds after midnight
[Route_Id]	Route identifier (e.g. 31)	[Actual_Arrival]	Measured at stop in seconds after midnight
[Pattern_Id]	Sequence of stops for a trip	[Actual_Departure]	Measured at stop in seconds after midnight
[Direction]	Direction of trip (1 or 2)	[Day_Type_Id]	Day type identifier
[Stop_Id]	Stop identifier	[Month_Part]	Calendar Month
		[Year_Part]	Calendar year

Data availability and first insights (2)

- First insight from line observations (first data set)

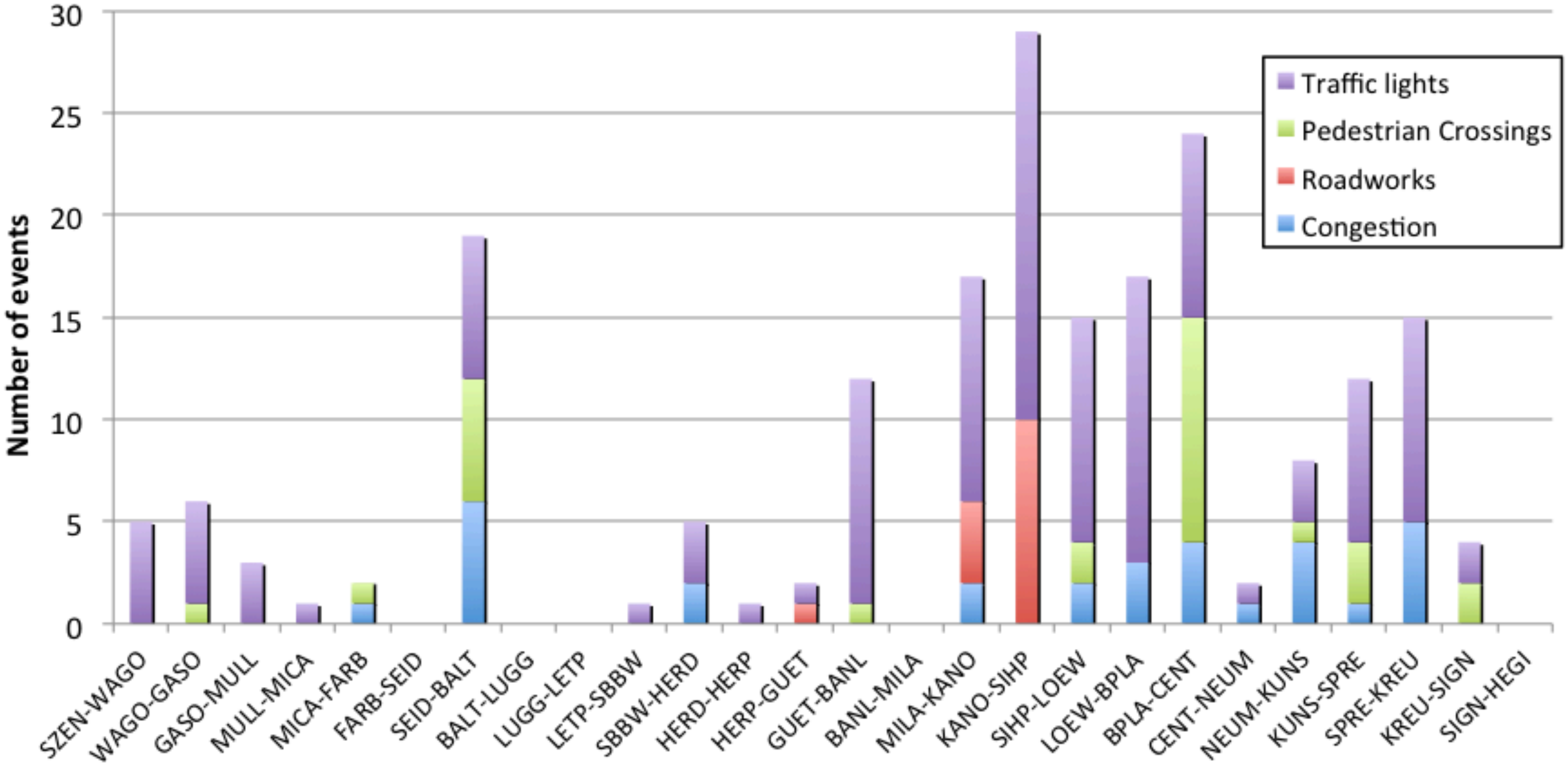
Schedule deviation at stops and dwell time for all observations



Data availability and first insights (3)

- First insight from line observations (first data set)

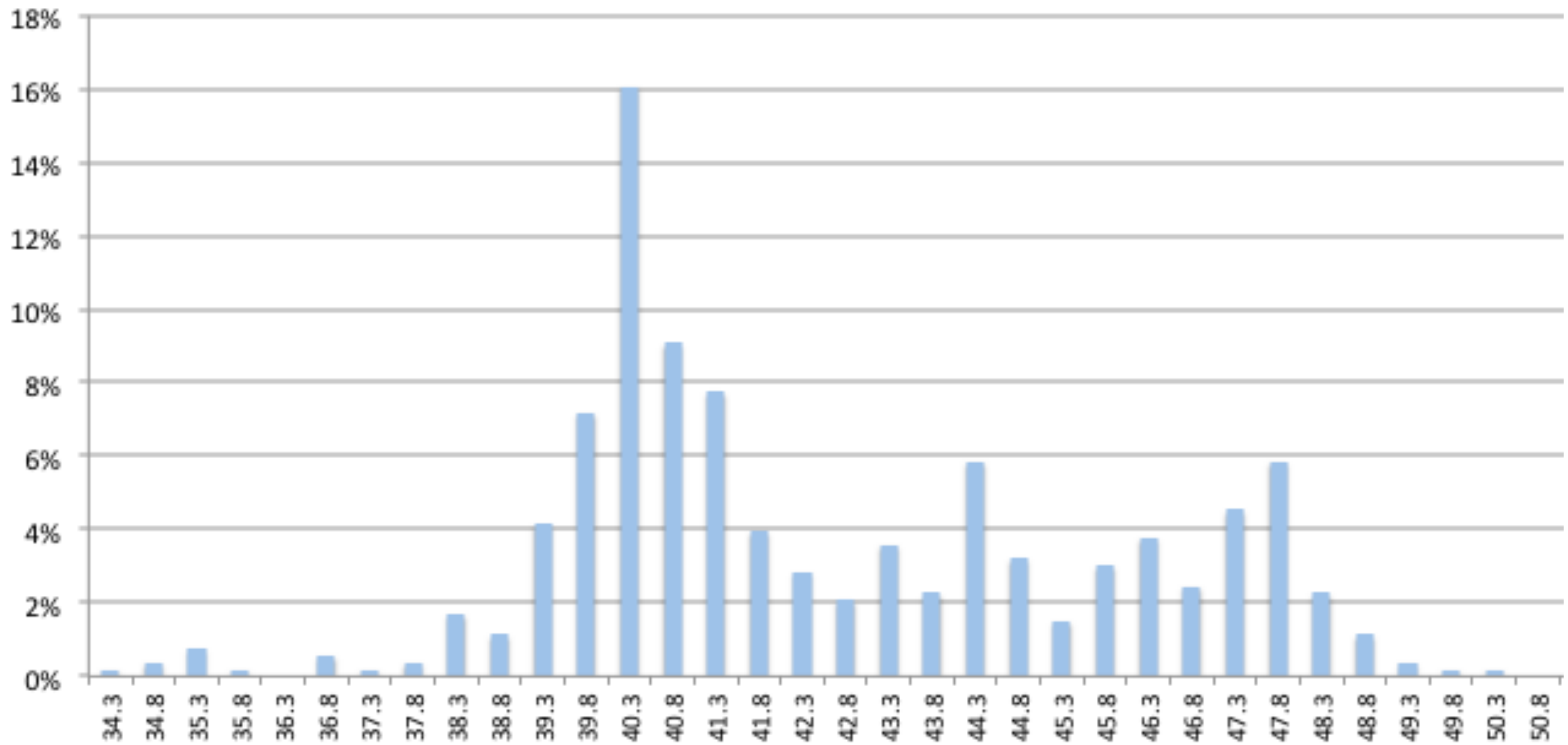
Perceived delay causing events between stops



Reliability analysis – Travel time and speed (1)

- Analysis from second data set

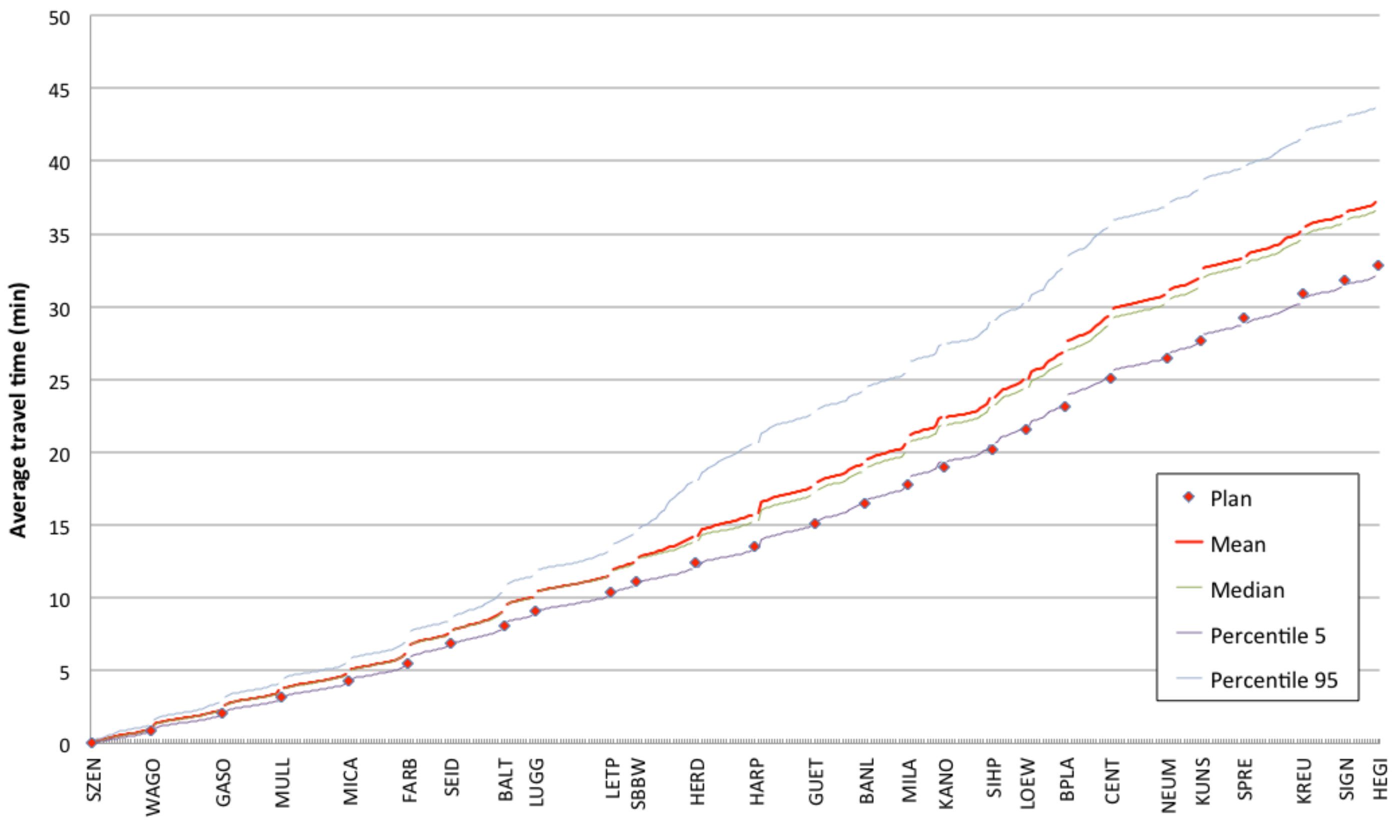
Travel time frequency distribution for all trips (Mo-Fr) in March 2011



Reliability analysis – Travel time and speed (2)

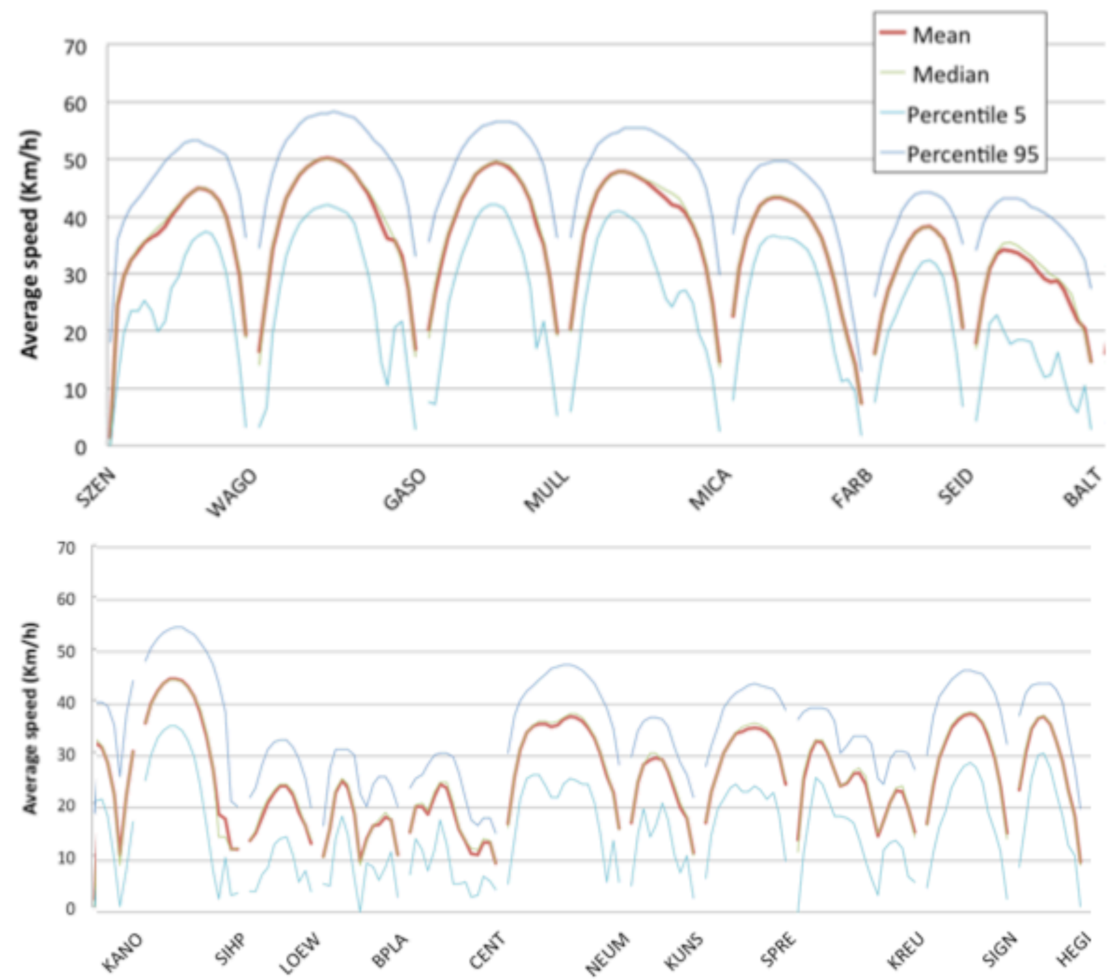
- Analysis from second data set

Average travel time distribution for all trips (Mo-Fr) in March 2011



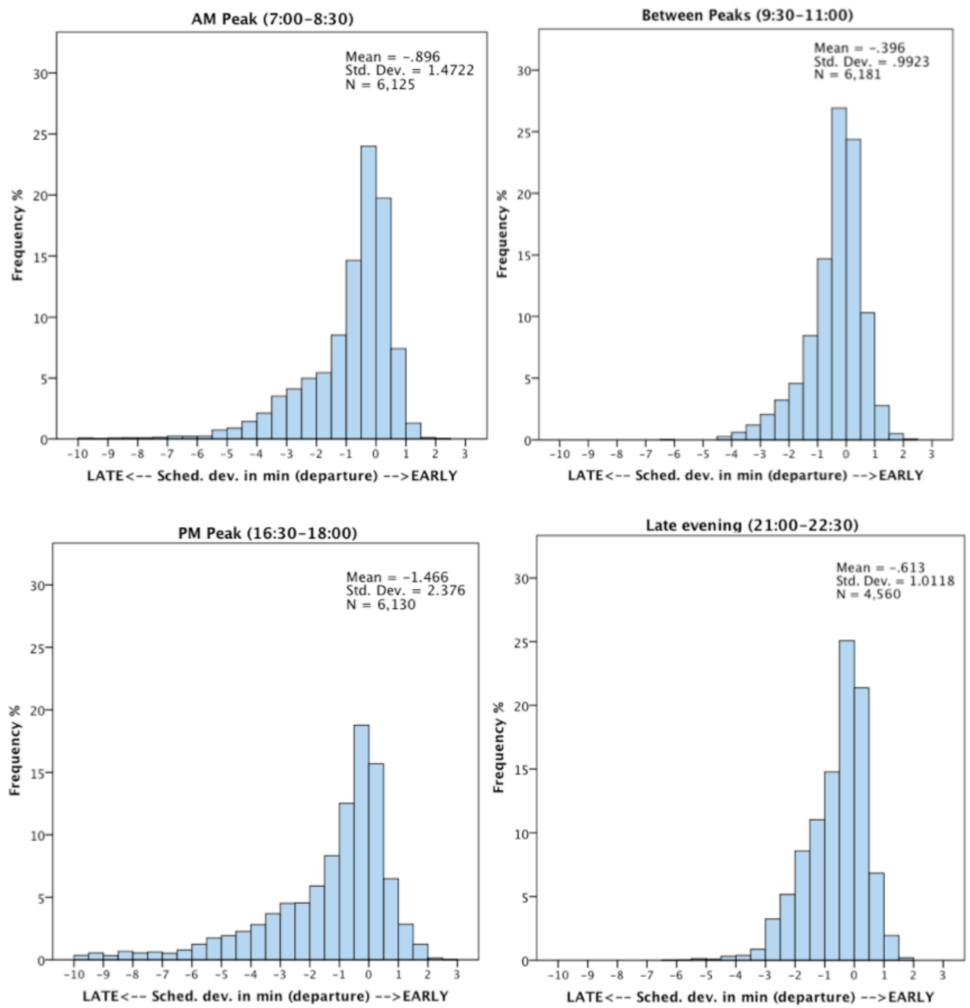
Reliability analysis – Travel time and speed (3)

Average speed distribution for all trips (First and last section of Line 31)

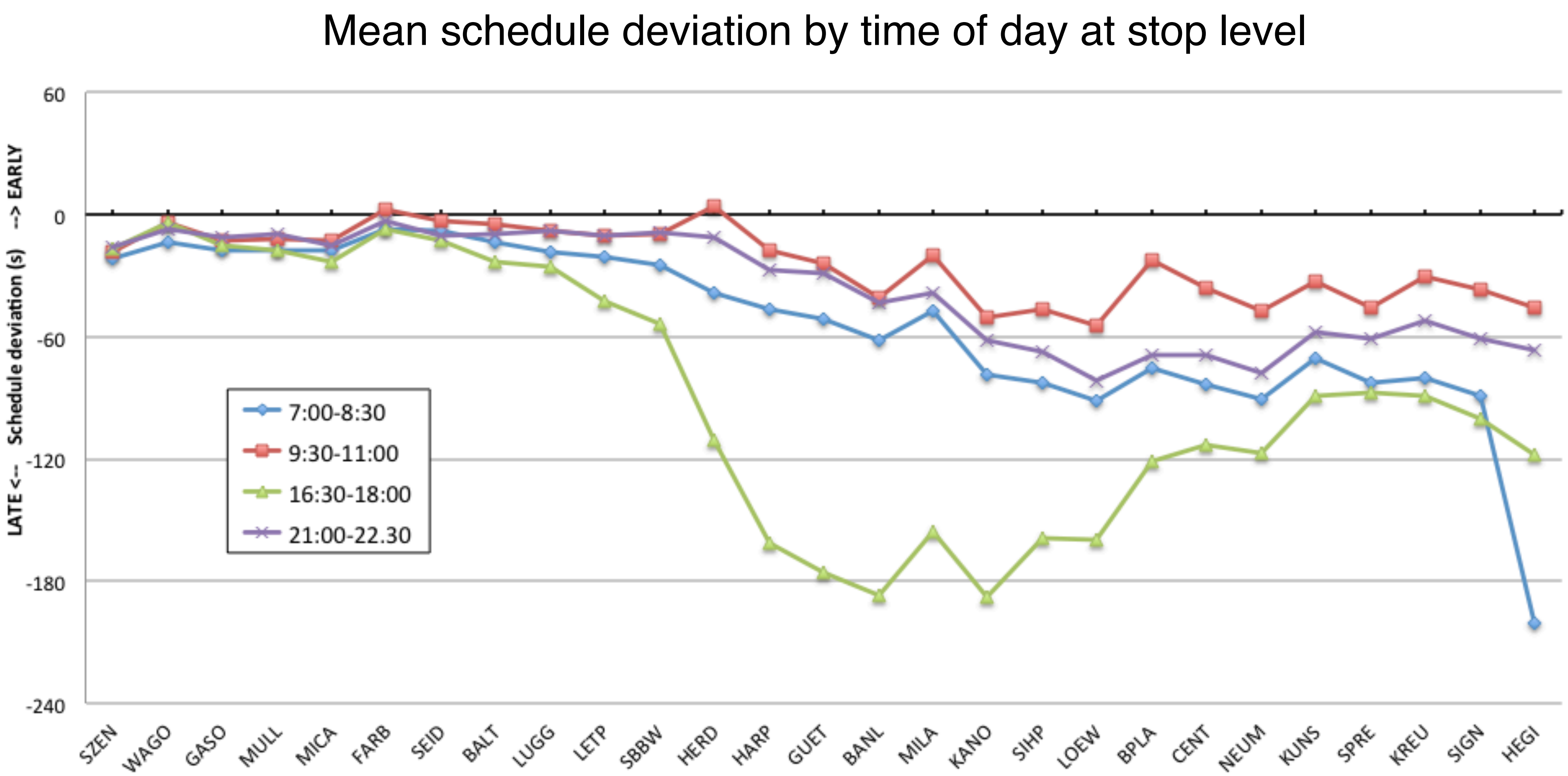


Reliability analysis – Punctuality (1)

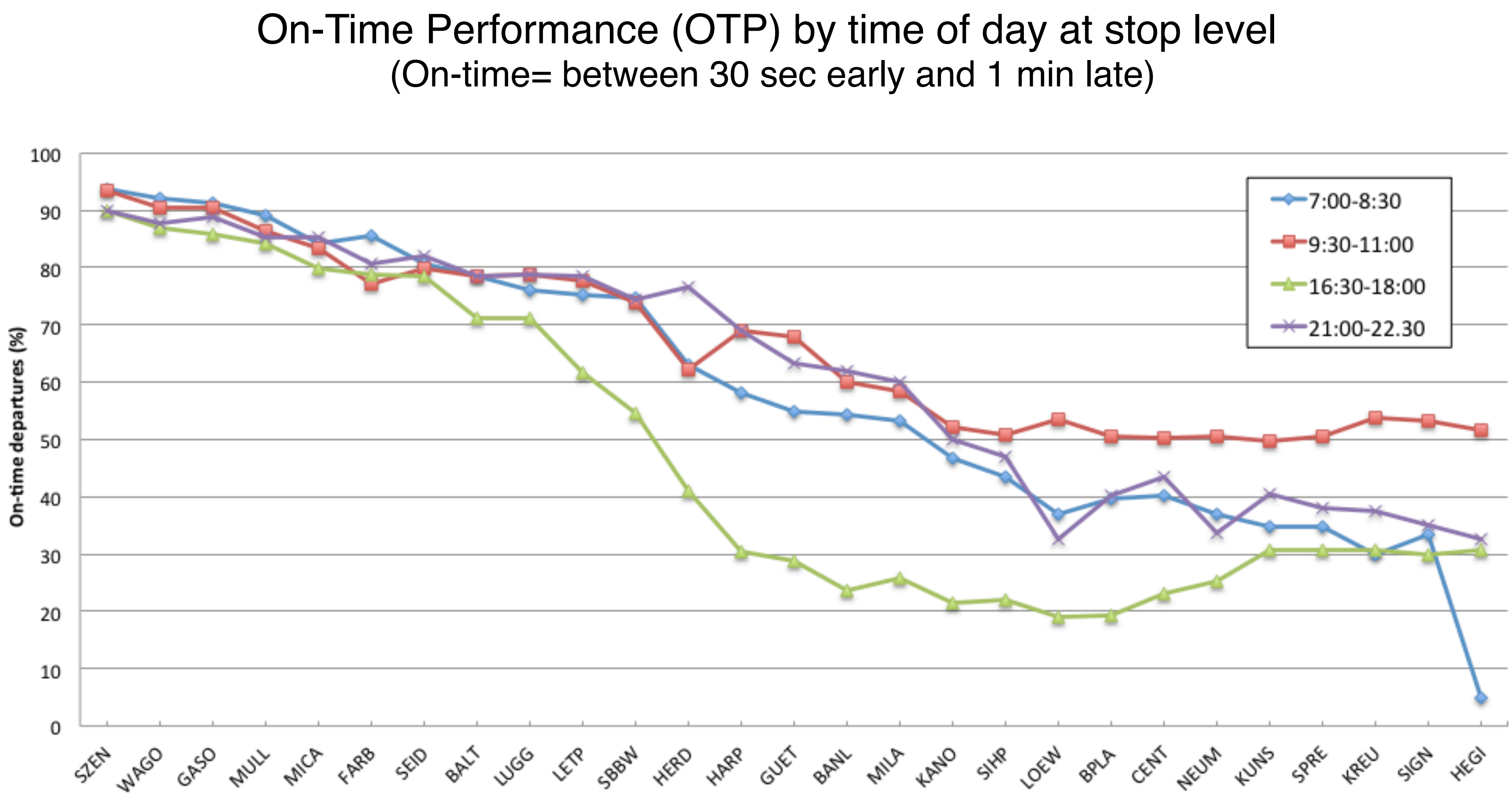
Schedule deviation distribution by time of day at route level



Reliability analysis – Punctuality (2)

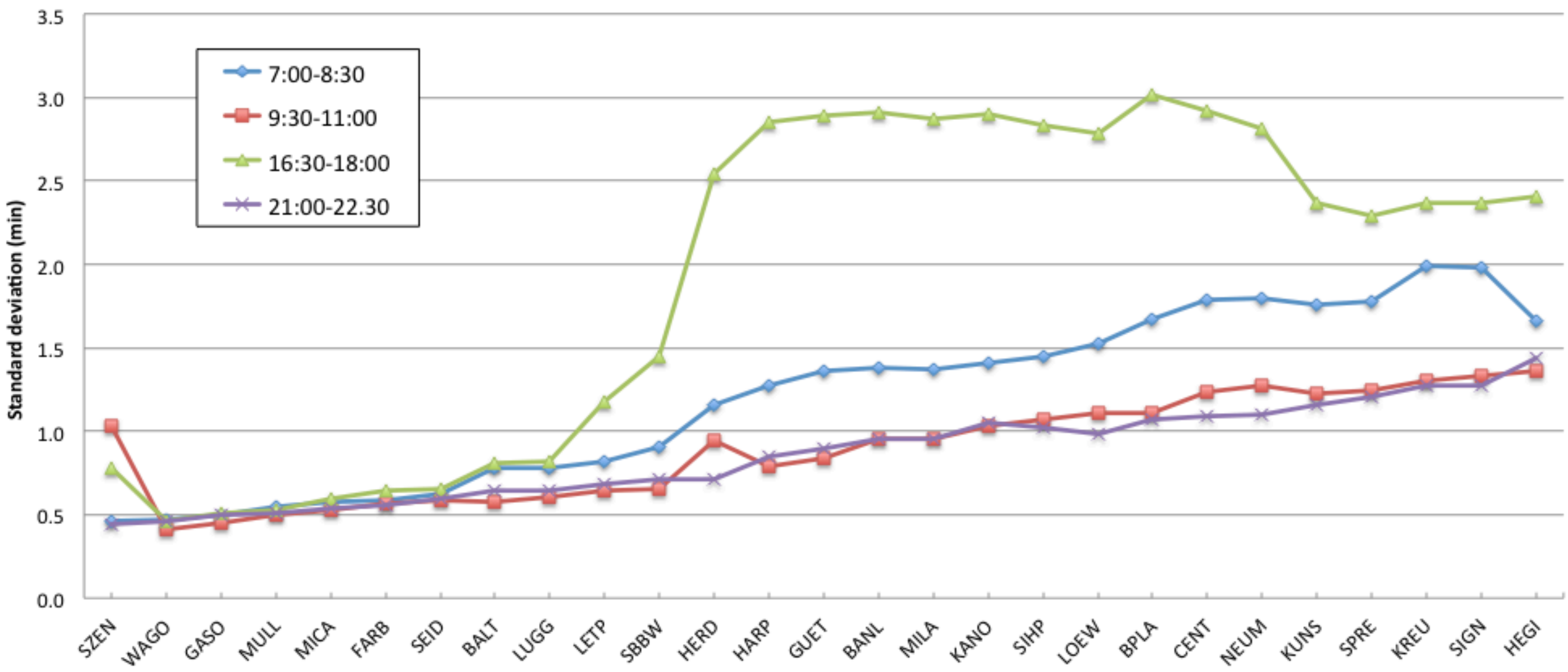


Reliability analysis – Punctuality (3)



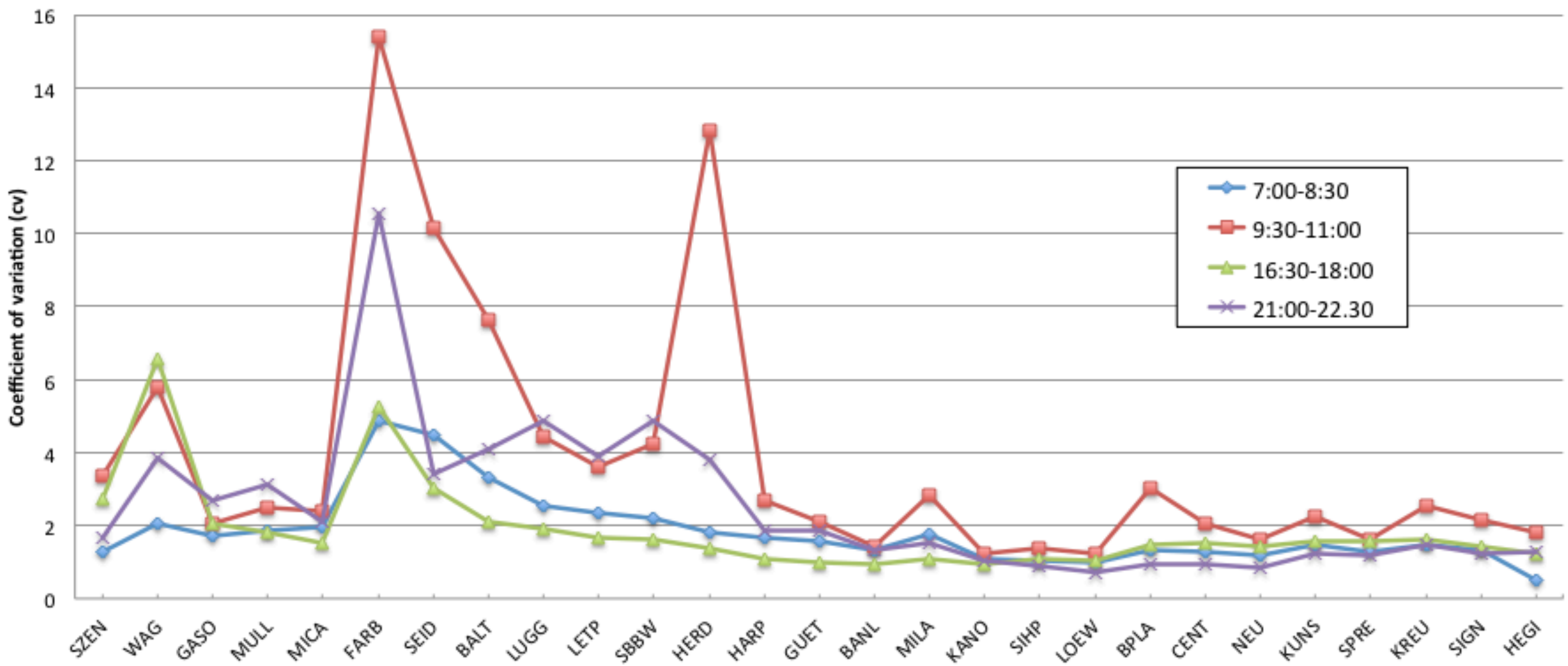
Reliability analysis – Punctuality (4)

Standard deviation from scheduled departure times per time of day at stop level



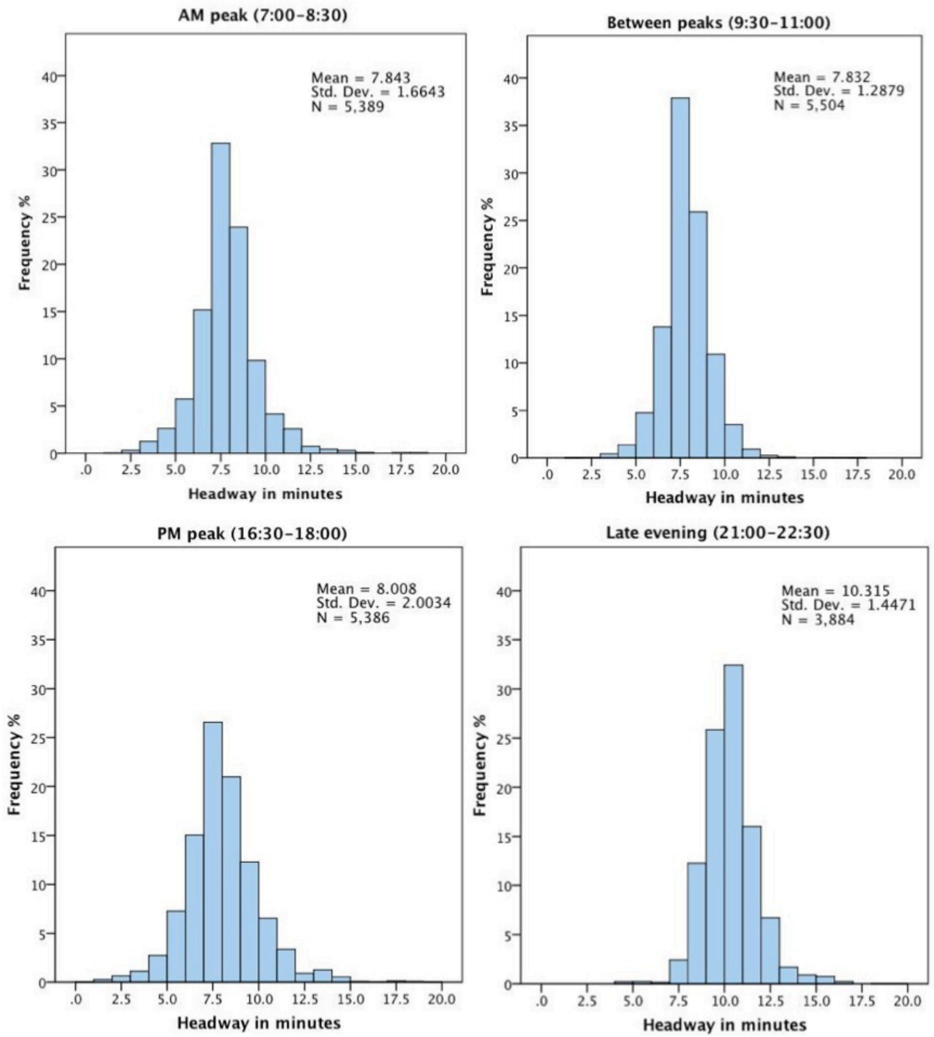
Reliability analysis – Punctuality (5)

Coeff. of variation (cv) of mean scheduled deviation per time of day at stop level



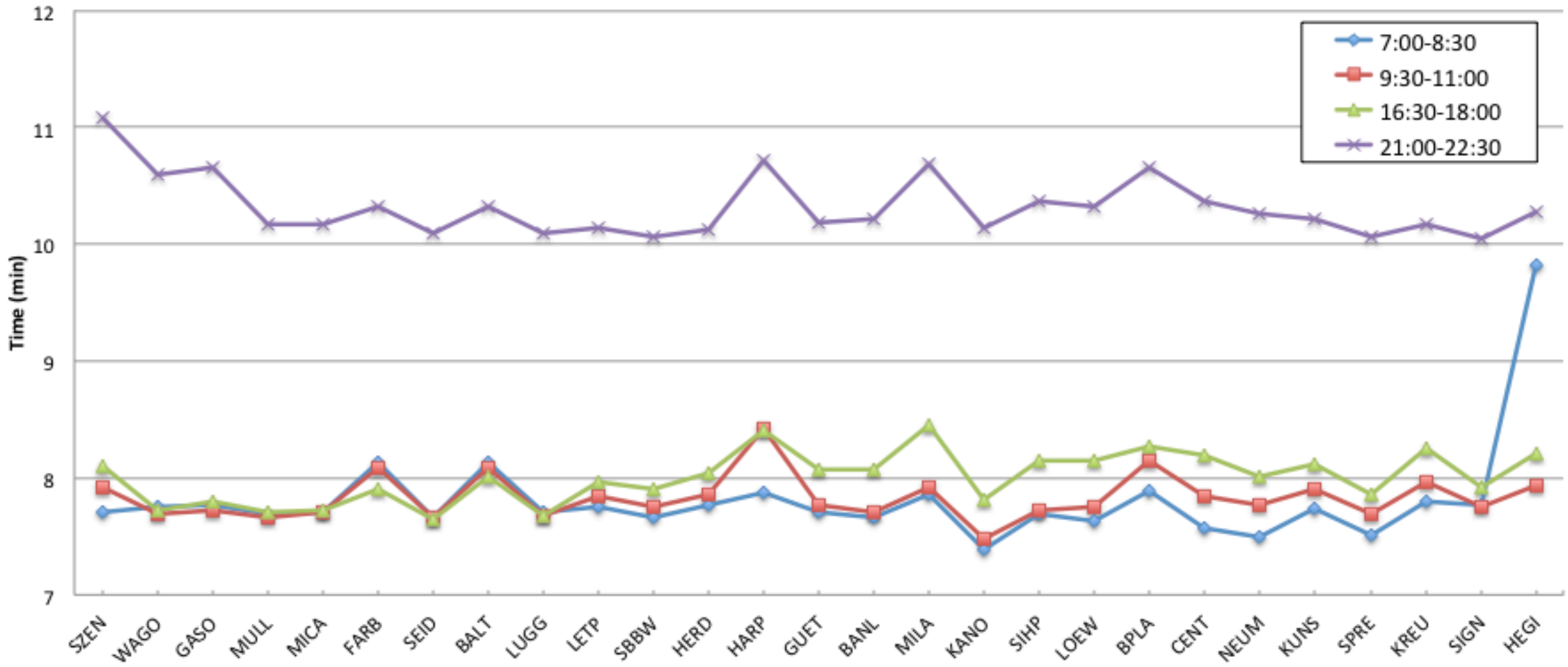
Reliability analysis – Regularity (1)

Actual headway distribution by time of day at route level



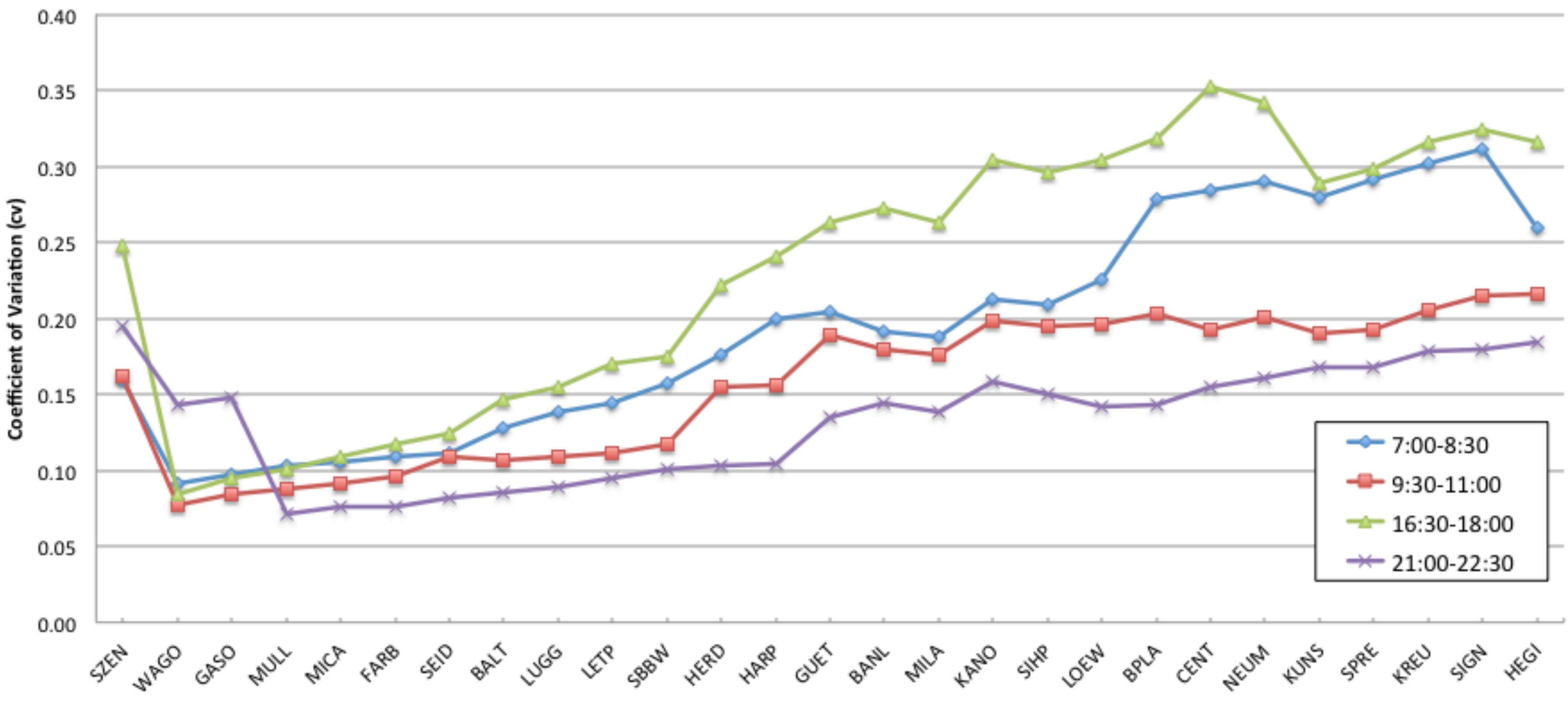
Reliability analysis – Regularity (2)

Mean actual headways per time of day at stop level



Reliability analysis – Regularity (3)

Coeff. of variation (cv) of actual headways per time of day at stop level



Conclusions

- Public transport agencies are increasingly realizing the benefits of collecting and analyzing operational data recorded by AVL systems, and using it to increase the quality of their service

- PM peak time profile describes the highest mean deviation from schedule, as well as the highest variation, ad the lowest on-time performance.

- The most critical section appears to be between Altstetten train station (BALT) and the tram node Central (CENT), after which the vehicles consistently recover time and reduce delay.

- Contrary to expectations, the best performing time profile was that between peak hours, and not during the late evening. In average it departs from stops around 24 seconds “late”, with a standard deviation of less than a minute.

Limitations and future research

- The three different data sources
- Available data was limited, as no passenger or driver (level of experience) data was made available.
- Selection of adequate indicators and measures that fit to the Zurich context, but are transferable and comparable to those in other places.
- Only one direction of one bus line in Zurich. More lines/modes. Analysis at route and network level.

Thank you for your attention!

For more information, please visit:

www.ivt.ethz.ch

Or email me at:

nelson.carrasco@ivt.baug.ethz.ch

References

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