Danmarks Tekniske Universitet

RobustRailS Mini Conference August 27, 2015

Robustness in Railway Transport

August 27, 2015
DTU Transport

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Two perspectives

1) Train and system performance


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Nye forsinkelser for tog på Vestfyn

Fejlen ved et sporskifte i Tommerup er rettet, men det har skabt forsinkelser.

Det kører ikke for DSB og Banedanmark i disse uger. (Foto: DSB - pressefoto © DSB)

2) Passenger experience


Samfund 7. maj 2015 - kl. 11:44 Opdateret 7. maj 2015 - kl. 12:10

40 Kommentarer | 11 Del | 1 Del | Mail

DSB til forsinkede passagerer: Nyd udsigten

Fortsat problemer med togdriften over Fyn

Af: Claus Jessen @cljessen1

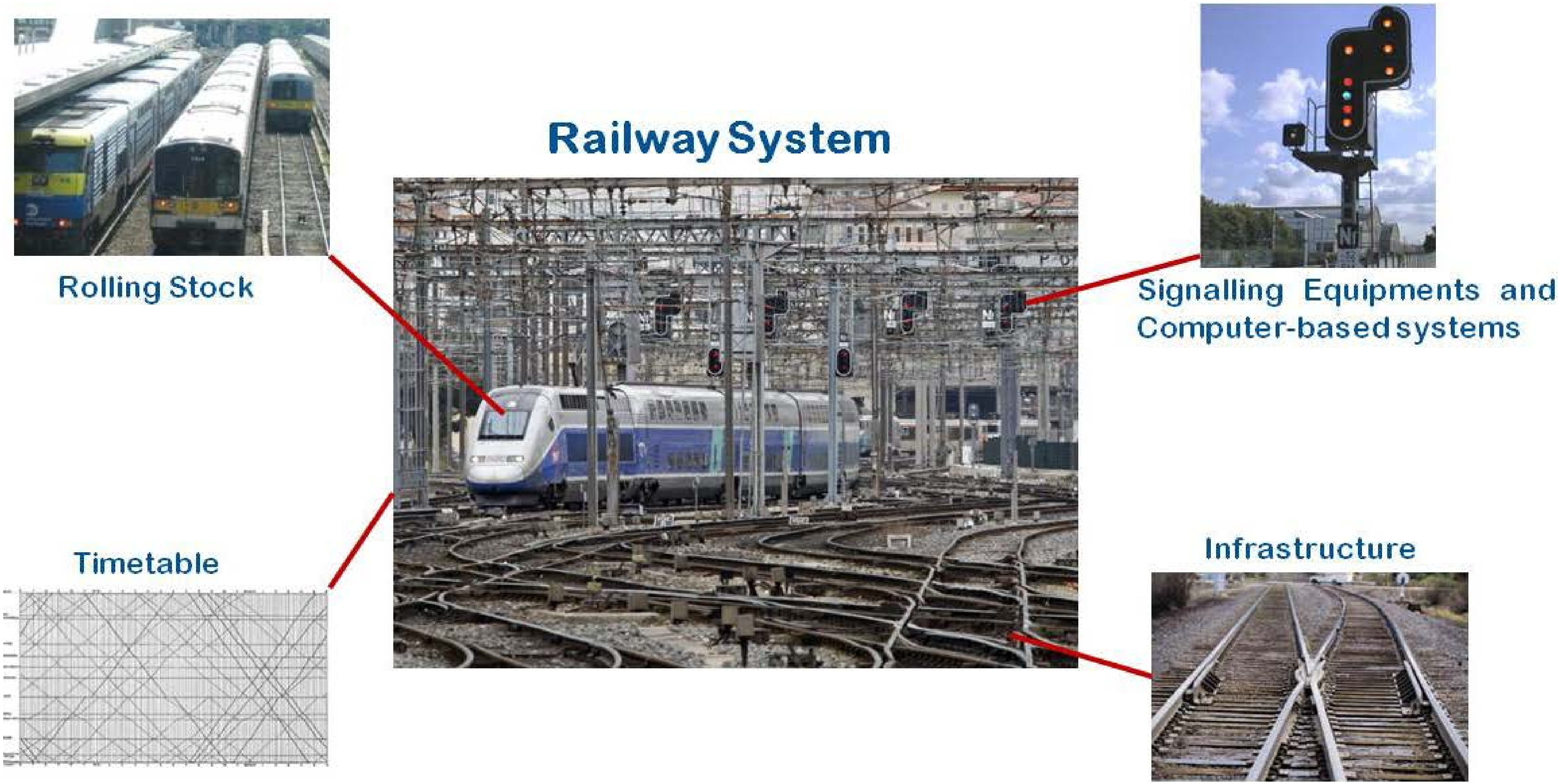
Nyd udsigten til denne betonmur, opfordrer DSB. Foto: Claus Jessen

Robustness in railway transport

How robust the system is in order to avoid

- Delays
- Cancelled trains

The overall performance of the railway system and its components



Matrix of explanations

- Probability distribution for events

	Infrastructure	Traffic Control	Rolling stock	Operations	Passager flows	Other factors
Links						
Nodes						
Stations/platforms						

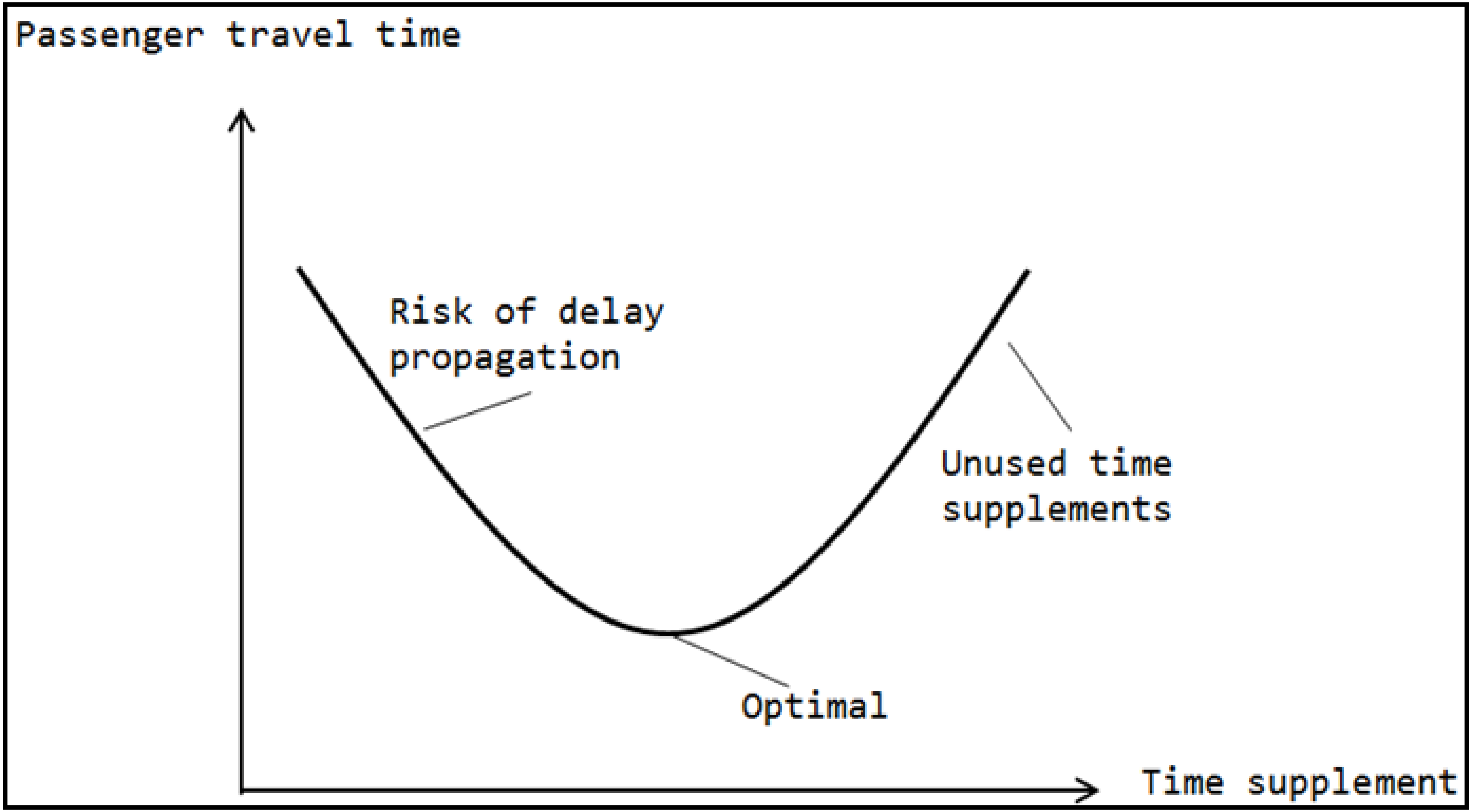
Railway Robustness definition?

- A common definition of robustness is the ability of a timetable to absorb smaller delays with or without light dispatching measures, given the state of the railway components

- Can be achieved with:
  - Running and dwell time supplements
  - Buffer times

- Efficiency – the balance between supplements and short travel times
  - Minimize the average travel time of the passengers

Timetable supplements

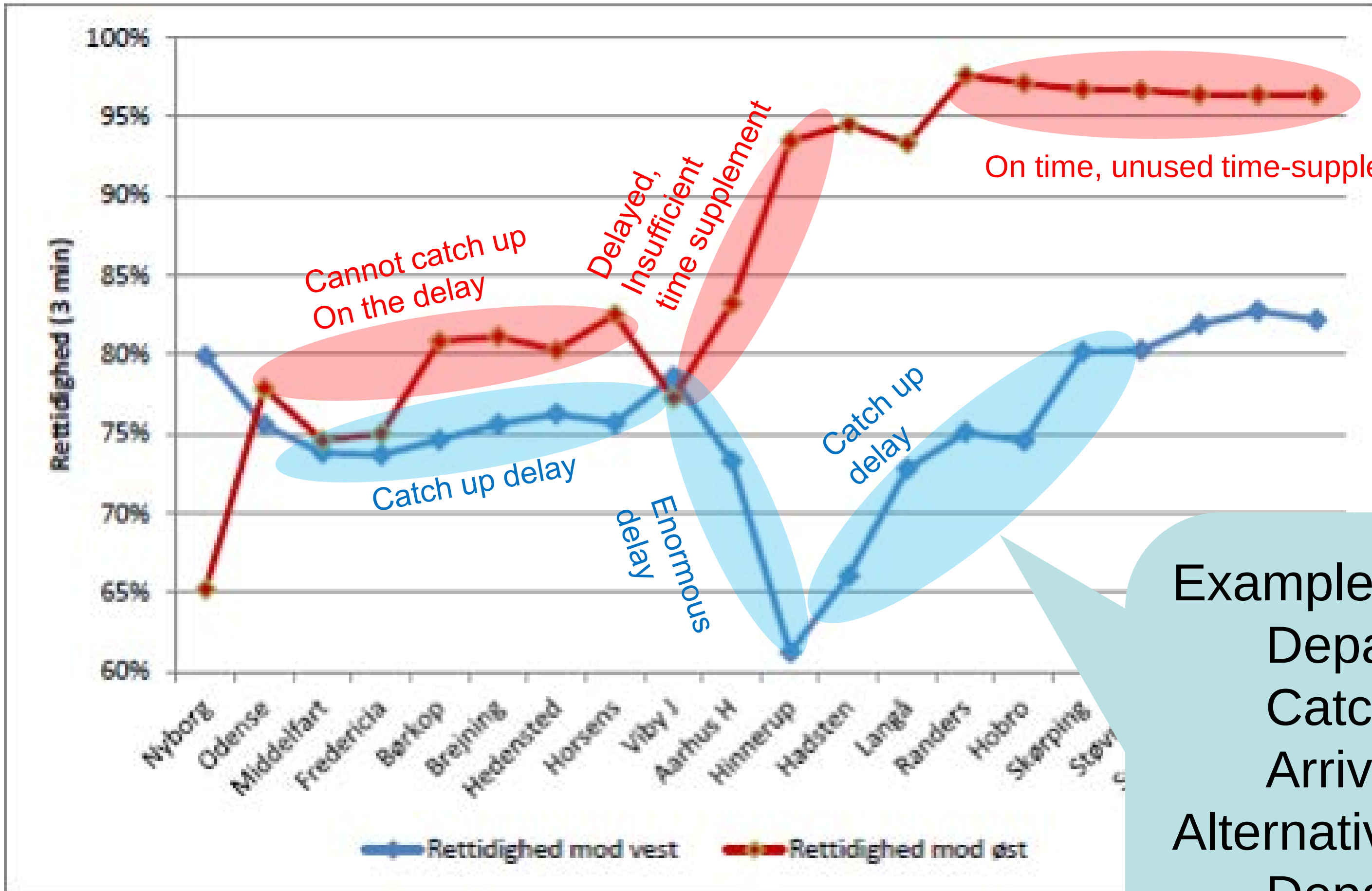


Optimal allocation of time supplement in schedules

Speed interval [km/h]	Time supplements used by IM Rail Net Denmark [%]	UIC recommendations [%]
0-75	3	3
76-100	4	3
101-120	5	3
121-140	7	3
141-160	9	4
161-180	11	5
181-200	13	5
201-250	13	6
251-300	13	7

Tabel 2: Køreplanstillæg brugt af Banedanmark og UIC forslag

Example of simulation of robustness



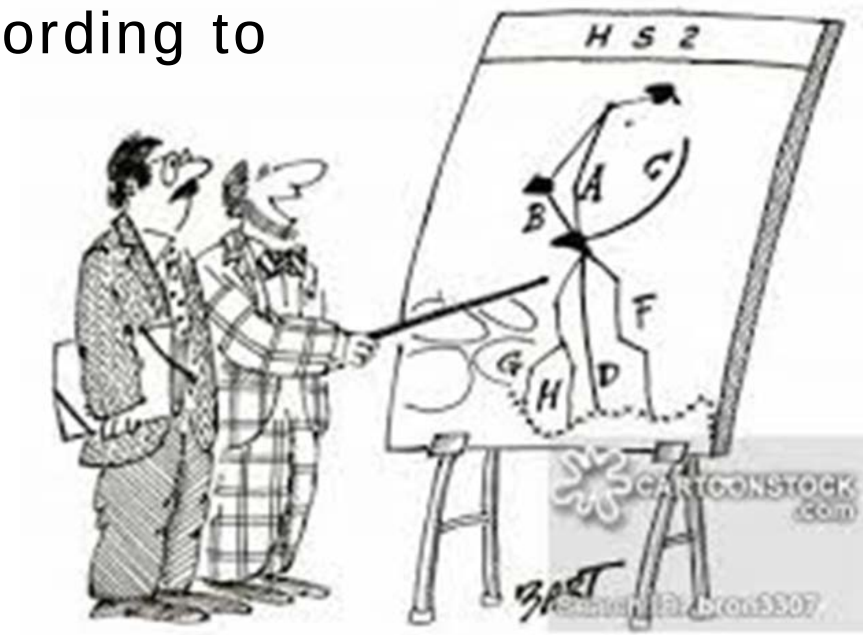
Figur 14. Rettidighed for linje 11 fordelt på retninger i basissituationen

Example
- Depart 10 min too late
- Catch up 5 min
- Arrive 5 min too late

Alternative
- Depart on time
- 5 min. faster time-table
- Arrive on time

Railway Robustness indicators (WP3.1)

- Can robustness indicators be used in early planning phases and mathematical models instead of simulation which is time consuming to set up?
  - Semantics of robustness indicators: when is a timetable robust according to an indicator?



"Let's build all possible variants and see which one turns out to be the cheapest to run!"

How do we measure railway robustness?

- Microscopic simulation of the operation
  - Requires a detailed infrastructure model
- (Potential) robustness indicators
  - Capacity consumption (UIC 406)
    - Measure capacity consumption on railway lines by compressing train paths
    - Expression of the available buffer time between consecutive trains
  - Heterogeneity indices
    - Measure the distribution of trains on line sections and at stations
    - Indirectly indicate the robustness of a timetable by measuring the spread of buffer times
  - Complexity indices
    - Evaluate the complexity of infrastructure and the timetable in increasing detail (depending on indicator)
    - Increasing complexity = increasing risk of delays

How do we measure robustness?

- Robustness indicators (continued)
  - Train path fix points and risk profiles
    - Fix points are points in the timetable where a train path is dependent on another train path
      - E.g. scheduled crossings and overtakings, level junctions and transition, terminal and transfer stations
    - Risk profile can be created for a train or a group of trains as the amount of time supplements between fix points
    - Indicator of the timetable's ability to absorb delays on the different sections

- Others

Robustness Indicators

	Initial delays		Time supp.		Buffer times		PTT	Applicable	Input
Indicator	Size	Dist(s)	Size	Dist(s)	Size	Dist(t)			
UIC 406					(•)			L	TT
Heterogenity						•		L & S	TT
Infra. complexity					(•)			S	I (P)
TT complexity	•	•			•	•		L & S	TT D
Fix points			•	•				L & S	P
WTTE	•	•	•	•	•	•	•	A	TT D
Simulation	•	•	•	•	•	•	(•)	A	TT D
Max-Plus	•	•	•	•	•	•		A	TT D

Size: size of, *Dist:* distribution of, *s:* distance, *t:* time

L: lines, *S:* stations, *A:* lines and stations aggregated

TT: timetable, *I:* infrastructure, *P:* plan of operation, *D:* delay,

PTT: passenger travel times, *WTTE:* weighted travel time extension

Some references

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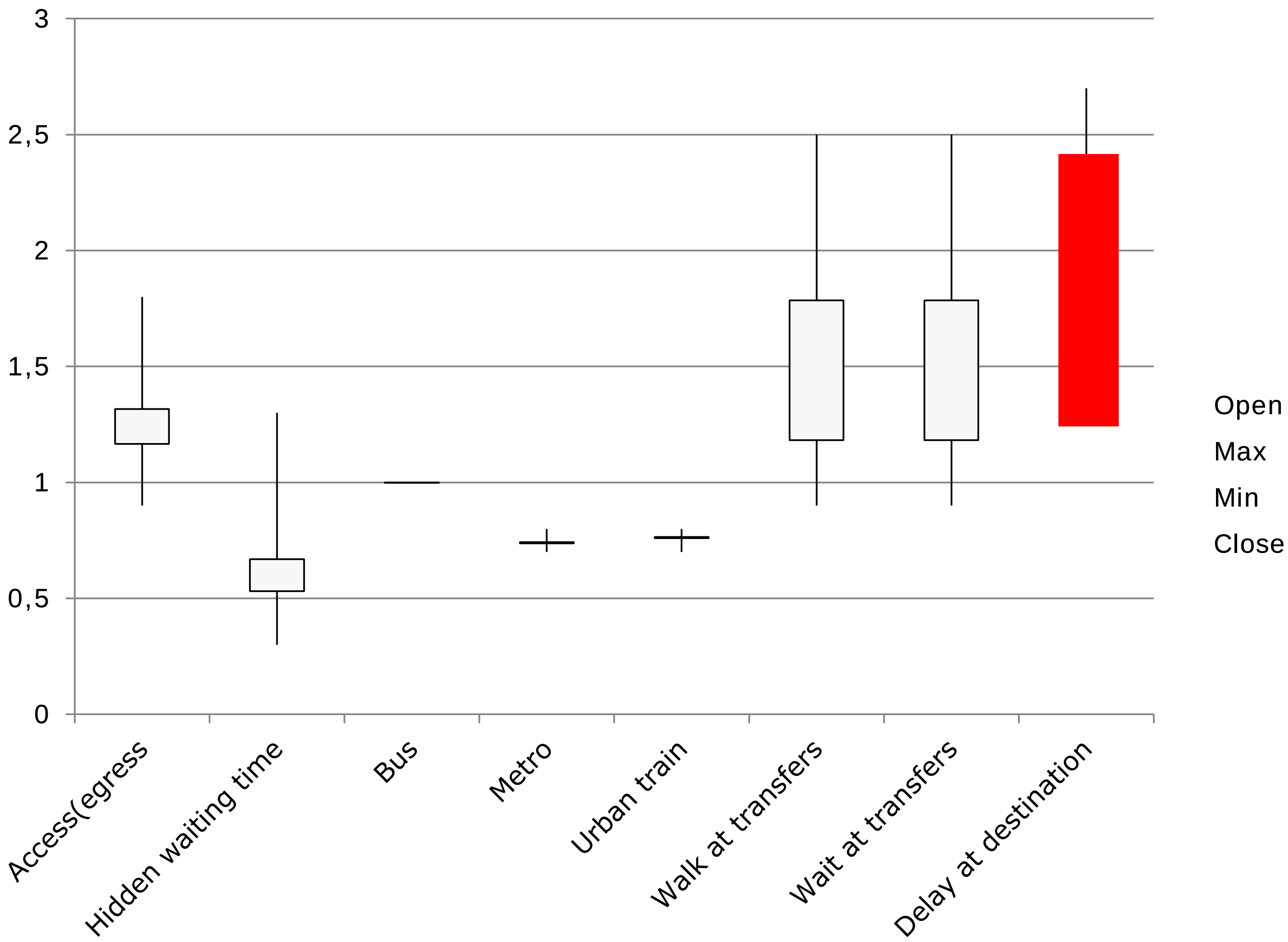
  COMPRAIL. 2014
- Landex, A. & Jensen L.W.
  Measures for track complexity and robustness of operation at stations.
  Journal of Rail Transport Planning & Management. 2013
- Jensen L.W. & Landex, A. **Measuring Robustness of Timetables at Stations using a Probability Distribution.**
  RailCopenhagen. 2013

Estimation of passenger preferences - What matters?

- Travel time
  - Punctuality and travel time variability
  - Use of the travel time
- Many other factors
  - Frequency, information, cost, terminal

Danish Value of Time studies (extract of 12 surveys compared to bus)



Passenger delays equal train delays?

- Trains tend to be more delayed during peak hour (larger capacity utilization)
- Peak hour delays normally affects more passengers per train

- Delays tends to accumulate during a train run, i.e. more and more delayed e.g. when approaching Copenhagen in the morning peak
- Passenger are hit by the delay when they exit the train. Whether the train is on-time during the run matters less, if it is delayed at the destination

- If a connection is missed, then the passenger delay is much larger than the train delay

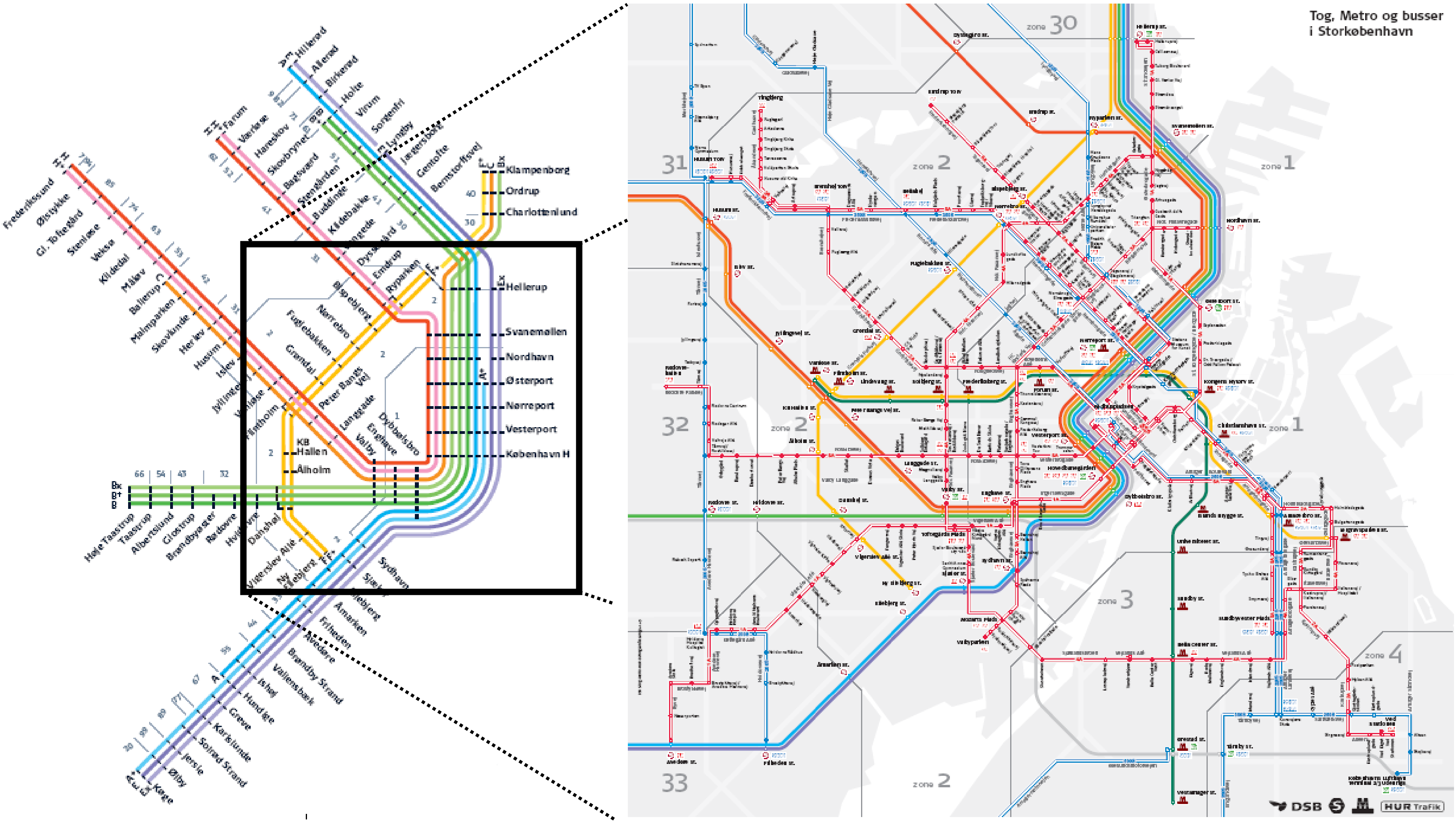
Are delays of this train affecting more passengers?

Are passengers delayed if this train is not on time?

Full scale calculations on the Copenhagen Urban Rail network

- 104 ”zones”, 80 trains
- 1.8 million inhabitants in Copenhagen,
- 330,000 trips made each day by the urban rail
- 42 main time intervals with 1-5 min. Launches
- 60,000 OD-elements (sparse matrix)
- 1,200 train runs per day
- Diachronic graph with 200,000 links and 120,000 nodes
- A calculation of an entire day takes between 10 and 20 minutes with 5 min. launches

Alternative route options?



Comparing train and passenger delays

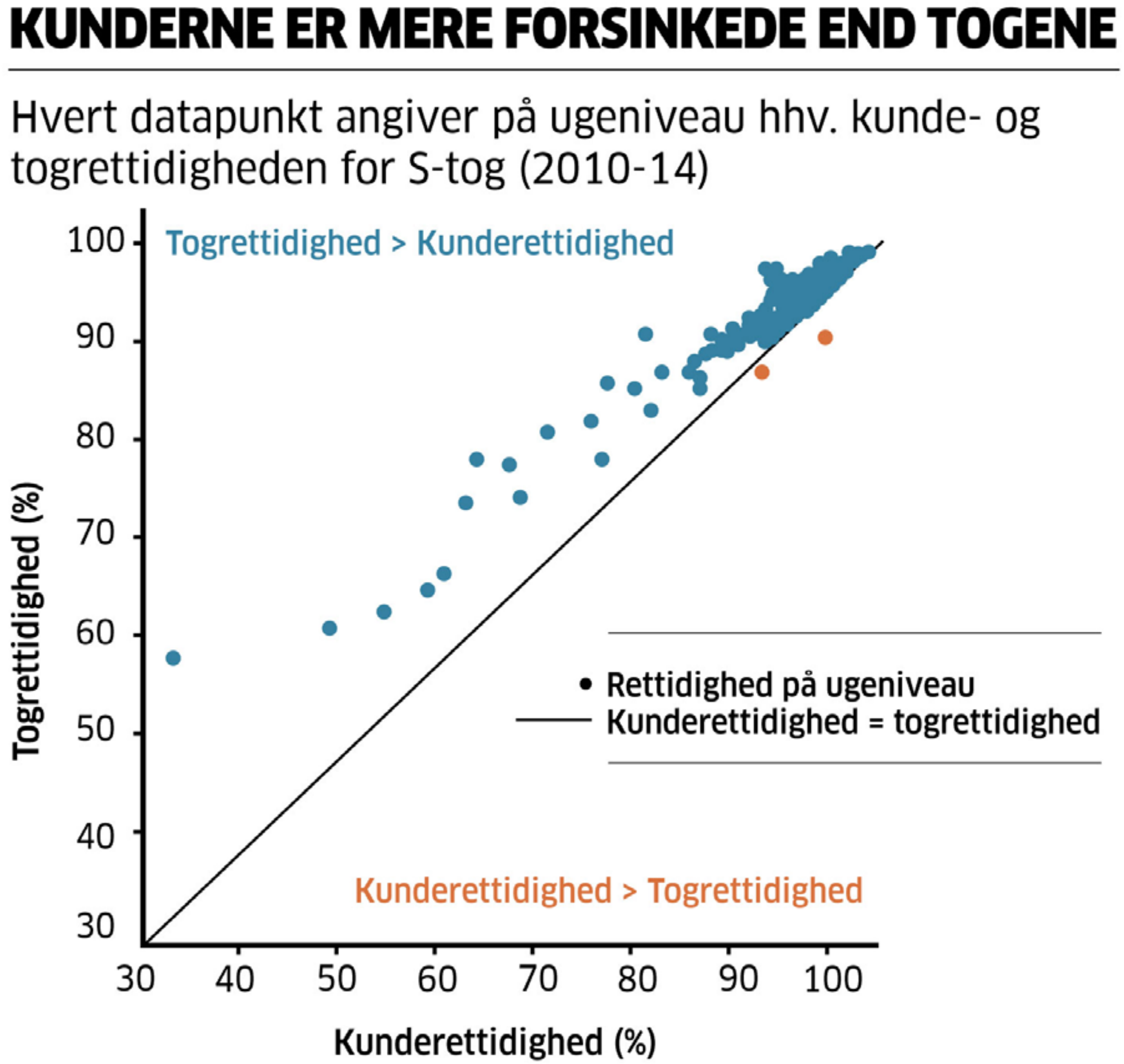
Thres-hold (sec)	Train regularity and punctuality	Morning		Day hours		Afternoon		Other hours		Total	
		99,6	**95,4**	94,5	**90,6**	99,3	**95,4**	98,6	**91,4**	97,6	**92,7**
	Base OD launches (min)	10	5	20	10	10	5	20	10	10/20	5/10
50	Regularity	100,0	100,0	100,0	100,0	100,0	100,0	98,1	98,1	99,7	99,7
	Punctuality (no delays)	**84,0**	**84,3**	**80,5**	**80,6**	**90,3**	**89,1**	**86,8**	**83,0**	**85,0**	**84,3**
	of this before time	15,7	14,1	17,3	15,3	22,5	19,3	25,5	22,6	19,6	17,3
	Average delay (min)	8,2	7,9	9,0	7,7	7,9	6,7	7,5	7,5	8,4	7,5
150	Regularity	100,0	100,0	100,0	100,0	100,0	100,0	98,1	98,1	99,7	99,7
	Punctuality (no delays)	**82,7**	**83,4**	**79,8**	**79,2**	**88,9**	**87,9**	**86,6**	**82,7**	**84,1**	**83,2**
	of this before time	15,3	13,9	16,8	14,9	22,4	19,1	24,8	22,6	19,2	17,0
	Average delay (min)	8,4	7,9	9,1	8,0	8,2	7,0	7,8	7,7	8,6	7,7
248	Regularity	100,0	100,0	100,0	100,0	100,0	100,0	98,1	98,1	99,7	99,7
	Punctuality (no delays)	**81,3**	**82,4**	**79,2**	**78,1**	**87,9**	**86,3**	**86,1**	**80,7**	**83,2**	**81,9**
	of this before time	14,9	13,7	16,5	14,7	22,1	18,9	24,7	22,5	18,9	16,8
	Average delay (min)	8,9	8,1	9,4	8,1	8,8	7,3	8,3	7,5	9,0	7,8
400	Regularity	100,0	100,0	100,0	100,0	100,0	100,0	98,1	98,1	99,7	99,7
	Punctuality (no delays)	**80,1**	**80,7**	**78,8**	**76,6**	**87,0**	**84,7**	**85,4**	**80,1**	**82,4**	**80,4**
	of this before time	14,6	13,4	16,2	14,5	22,0	18,5	24,2	22,2	18,6	16,5
	Average delay (min)	9,4	8,6	10,1	8,6	10,0	7,8	8,6	7,8		

Trains

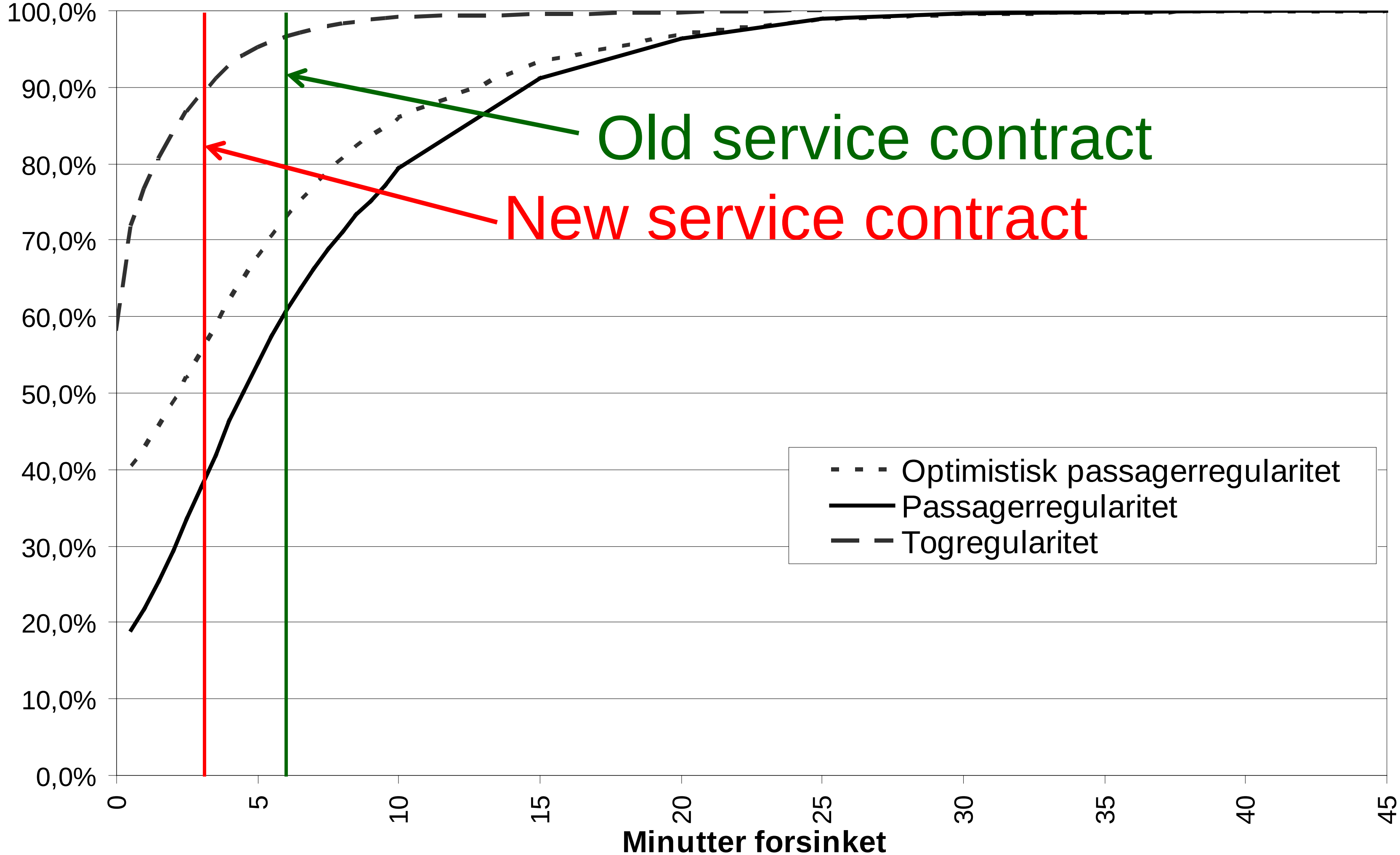
Passengers With fast information

Passengers

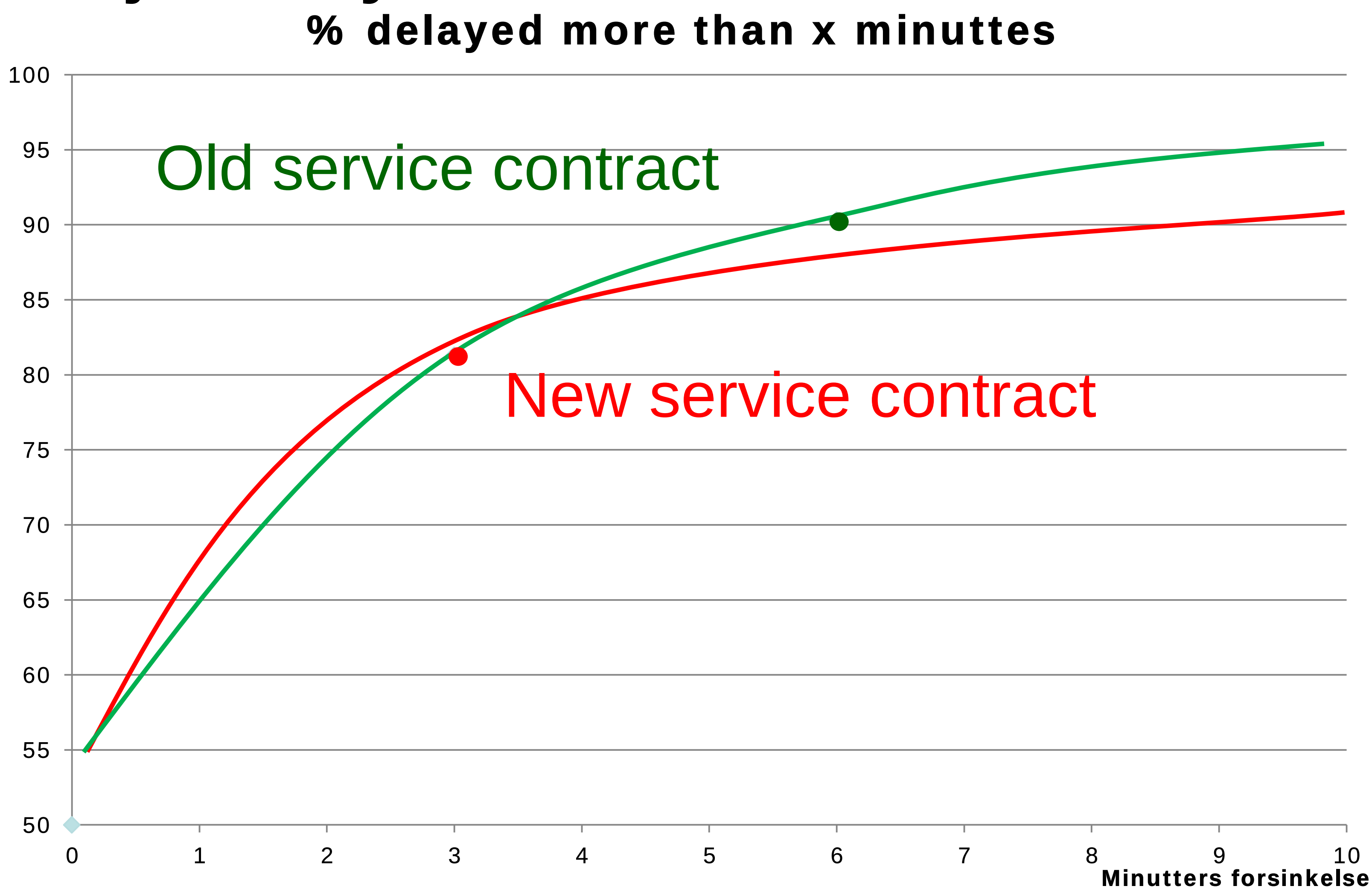
Punctuality and delays



Delays, examples of measurements



Measurements (KPI's) and service contract – Focus on sub-components in the journey



Questions?


PLATFORM
5
17·35
NEXT TRAIN
PARAPARAUMU
FREE RIDE
312
"PASSENGERS WAITING TO BOARD THE DELAYED SERVICE TO PARAPARAUMU, - PLEASE MAKE YOUR WAY TO PLATFORM 9 TO AWAIT BUSES, PRESENTLY DELAYED IN HEAVY TRAFFIC CONGESTION. — THANK YOU"

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