Speeding Up Public Transport

- A Practical Approach -

Dipl.-Wirtsch.-Ing. Rainer Schneider

Department director at Hamburg-Consult, a subsidiary of the Hamburger Hochbahn AG, the public transport operator in Hamburg (buses, underground, ferries).

It is a pleasure to me to get the opportunity at the ETC to bring one topic to discussion that is in the focus of many city councils and transport operators all over Europe, namely how to improve efficiency and attractiveness by making public transport faster.

The Problem:

The problems public transport operators have to solve is:

- Early or late arrivals/departures
- Time loss at stops
- Time loss on the route

However, operators are normally lacking data to realize how big the problems really are. In addition, the basis for the assessment of strategies is not existing. For this reason,

- Unsatisfied passengers, and
- inefficient operation of drivers and vehicles

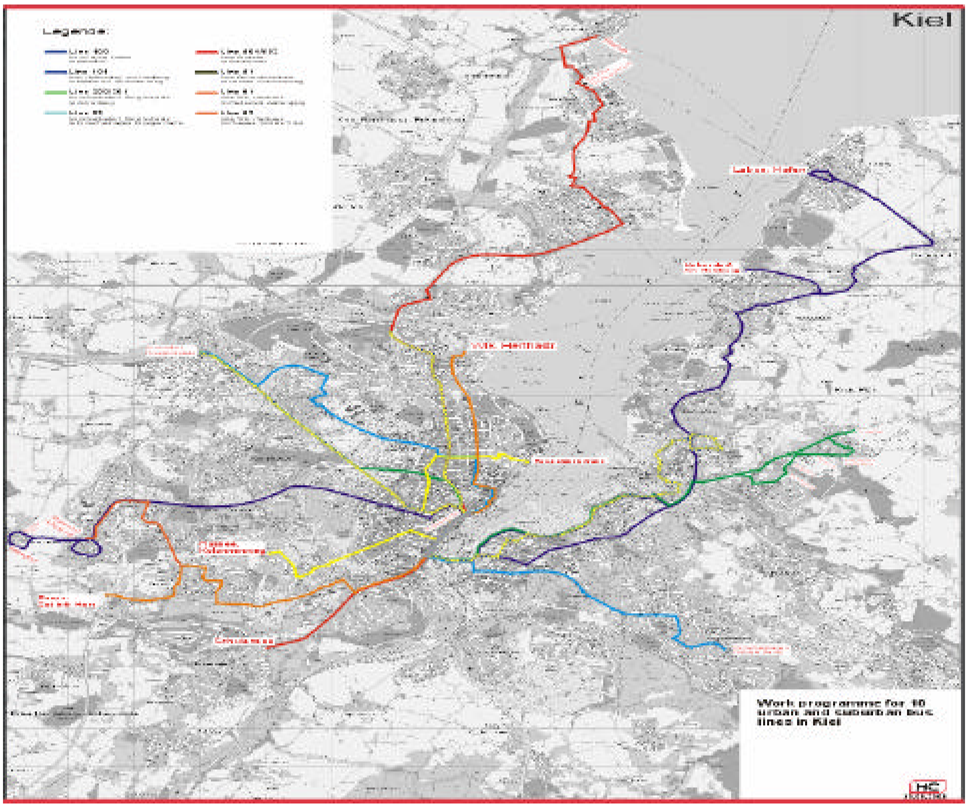
are very frequent.

The problems of operators we want to talk about here are unreliable time tables leading to unsatisfied drivers because of shorter breaks and additional capacity needed, both resulting in increasing costs. They also affect passengers and their mode decision. These unreliabilities occur when busses leave stops too early or too late, or when they get into time problems between the stops.

The Project:

The approach was developed and applied In the city and area of Kiel, capital of the German state Schleswig-Holstein with 250.000 inhabitants in the very north of Germany at the Baltic Sea. The objective of the project was to analyse ten urban and regional bus lines (see map below) with respect to potentials to make them faster. The project included the following topics:

- Data acquisition and interpretation
- Malfunction analysis
- Development of a catalogue of measures
- Evaluation of measures in reference to benefits and costs
- Recommendation.



The points of interest were time periods Monday to Friday focusing on peak hours 6 - 9, 11 - 14, 16 - 19.

Data Acquisition:

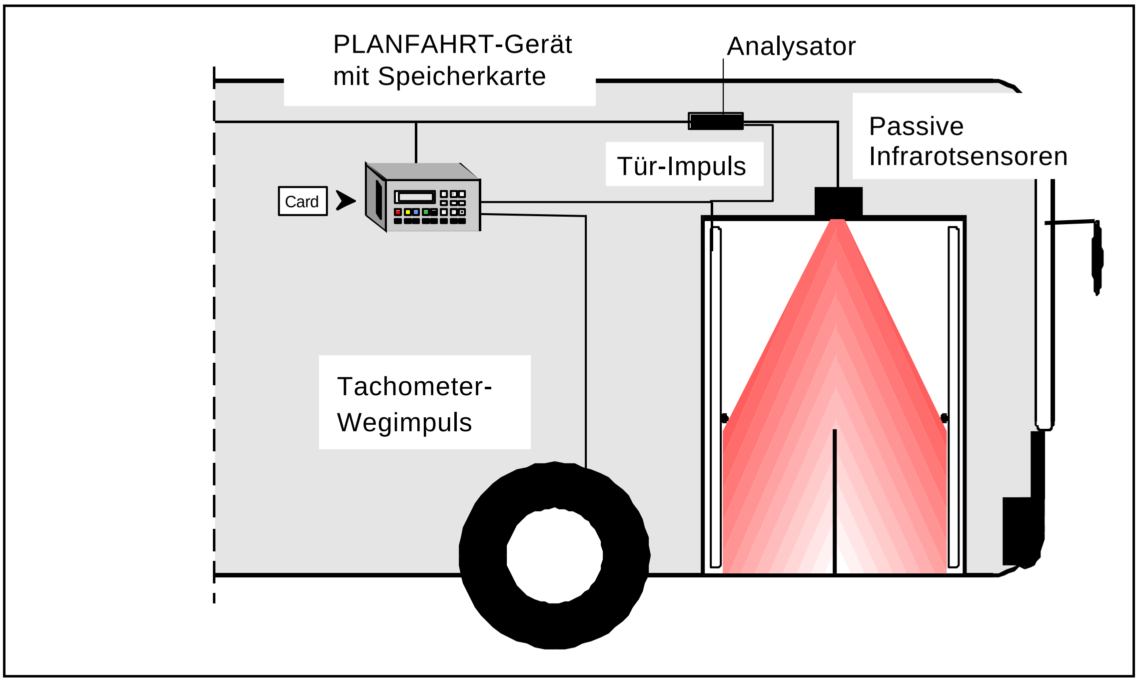
The core of the project was to collect reliable data. For this reason two vehicles – one 12 m and one 18 m long bus – were equipped with an automatic measuring and counting system to detect:

- Boardings/Alightings [number of passengers]
- Distance [meter]
- Status of door [opened, closed]
- Time [seconds]
- Line

- Course
- Direction
- Stop.

The hardware-instruments to measure distances, speed etc. were provided by the company INIT in Karlsruhe, the passenger counting system from the company Iris in Berlin. The software to evaluate and validate data and to project them to longer time periods (one week, one year etc.) is called Planfahrt. It was developed by Hamburg-Consult in close relation to the operator Hamburger Hochbahn.

The principle of the automatic data collection system is shown below.



The data evaluation program PLANFAHRT provides the following information:

- Travel times and speeds,
- Schedule deviation
- Times of door opening
- Duration of regular stops
- Delays and standing times in areas of intersection (with or without traffic lights) and
- on routes
- Boardings and alightings with vehicle occupancy.

The Planfahrt software also includes a module to recommend users which journeys should be recorded to get reliable data from a statistical point of view. This, however, is a serious problem since only a few busses are equipped and the time period to get results is always too short. In our case, we had two busses and half a year to collect data. However, considering the traditional approach using human resources with stopwatch, this procedure here seems to be more convincing.

The number of trips recorded (successfully) is listed in the following table.

Line	Direction	Number of measured courses
11	Pilauer Straße – Wik Kanal	35
11	Wik Kanal - Pillauer Straße	35
12	Pilauer Straße – Rungholtplatz	26
12	Rungholtplatz – Pilauer Straße	26
32	Rungholtplatz – Krooger Kamp	71
32	Krooger Kamp – Rungholtplatz	87
51	Kolonnenweg – Reventloubrücke	105
51	Reventloubrücke – Kolonnenweg	105
61	Aalborgring – Herthastraße	10
61	Herthastraße – Aalborgring	17
62	Schiefe Horn – Herthastraße	43
62	Herthastraße – Schiefe Horn	54
100	Roskilder Weg- Laboe Hafen	23
100	Laboe Hafen – Roskilder Weg	21
101	Roskilder Weg - Am Heidberg	29
101	Am Heidberg – Roskilder Weg	30
200	Rungholtplatz –Schönberg Strand	34
200	Schönberg Strand – Rungholtplatz	25
501	Flintbek Parkplatz – Olympiazentrum	24
501	Olympiazentrum – Flintbek Parkplatz	24

Just to give an impression of the sample: We had ten lines in total, two directions, and between 21 and 105 runs recorded. This is just time enough for three round trips per day to get data on a long line. It takes 84 minutes on the longest line (31 km one direction) to get from one end to the other by bus.

The average speed of the lines lies between 15 and 30 km/h. The slowest line 51 is an inner city short line forming something like half a circle. Since most of Kiel's travel relations are between city center and outside, the line crosses a lot of high density urban roads.

Data interpretation: Line Properties

Line	Operator	Direction	Line length [km]	Number of stops	Travel time [min]	Average speed [km/h]
11	KVG	Pillauer Straße - Wik Kanal	14,5	34	49	17,8
11	KVG	Wik Kanal - Pillauer Straße	14,4	34	49	17,6
12	KVG	Pillauer Straße - Rungholtplatz	16,0	36	53	18,2
12	KVG	Rungholtplatz - Pillauer Straße	15,9	35	54	17,7
32	KVG	Rungholtplatz - Krooger Kamp	17,0	35	49	20,9
32	KVG	Krooger Kamp - Rungholtplatz	17,1	34	52	19,7
51	KVG	Kolonnenweg - Reventloubrücke	8,9	20	34	15,6
51	KVG	Reventloubrücke – Kolonnenweg	8,7	20	34	15,4
61	KVG	Aalborgring - Herthastraße	16,3	40	48	20,4
61	KVG	Herthastraße - Aalborgring	16,5	41	50	19,8
62	KVG	Schiefe Horn - Herthastraße	14,4	34	43	20,1
62	KVG	Herthastraße - Schiefe Horn	14,6	35	45	19,4
100	KVG	Roskilder Weg - Laboe Hafen	28,2	50	70	24,2
100	KVG	Laboe Hafen - Roskilder Weg	28,0	49	71	23,7
101	KVG	Roskilder Weg - Am Heidberg	23,3	42	61	22,9
101	KVG	Am Heidberg - Roskilder Weg	23,4	41	62	22,6
200	VKP	Rungholtplatz - Schönberger Strand	39,3	57	83	28,4
200	VKP	Schönberger Strand - Rungholtplatz	39,5	56	86	27,5
501	KVG/AK	Flintbek Parkpl. - Olympiazentrum	31,6	50	84	22,6
501	KVG/AK	Olympiazentrum - Flintbek Parkpl.	27,2	50	68	24,0

The Approach:

The results are the basis for potentials to make busses faster. These potentials can be taken from

- early arrivals/departures
- standing at stops with closed doors
- opened doors without boarding and alighting
- delays at intersections without or with traffic light
- delays between intersections and stops.

The potentials to make public transport faster are derived from

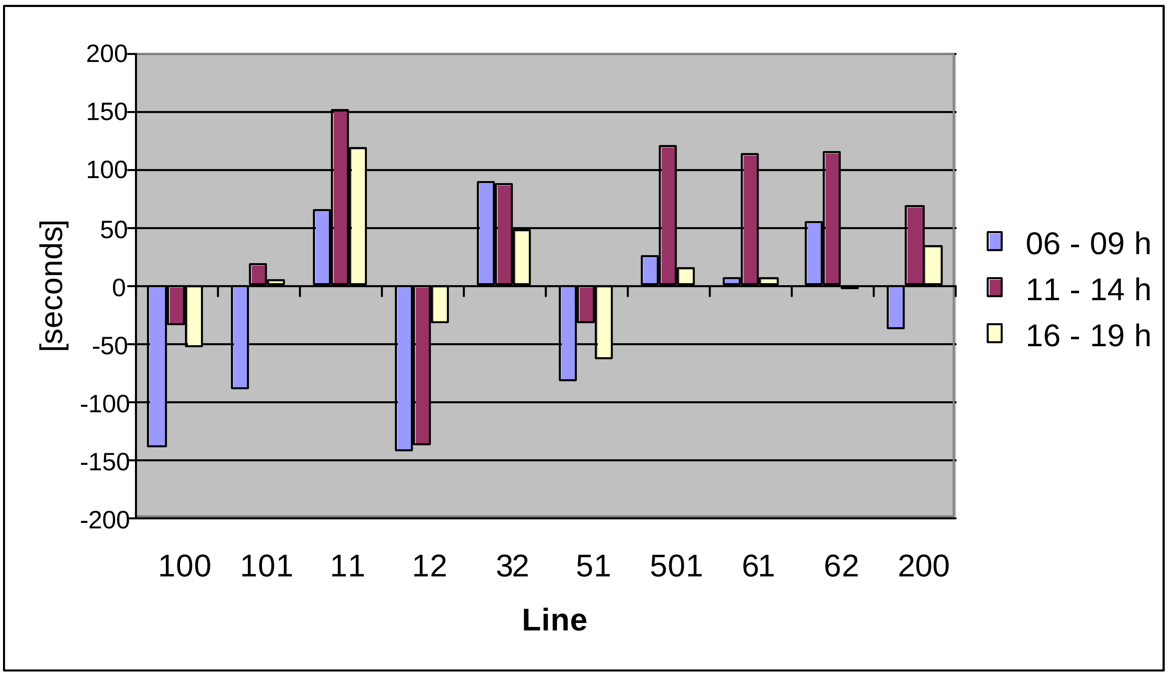
- *early arrivals / departures:* of course, not only the case has to be considered when busses are too early but also when they are late. Taking all three time periods morning peak, noon peak and afternoon peak, the minimum value of all departures can be considered as potential.
- *standing at stops with doors closed:* This can be traced back to several reasons: Bus is too early and waits for regular departure time, driver knows that the following sequence is shorter than fixed in the time table, or bus cannot leave stop due to cars blocking the bus or a red traffic light ahead. All in all, these problems can be solved by several measures.

- *opened door without boarding:* We analysed boarding and alighting behaviour in Kiel and we learned that two seconds per movement in or out seem to be enough. During peak periods it is even shorter, commuters are used to public transport. However, we classified only those processes with more than four seconds per movement - in or out - as potentials.
- *delays at intersections with our without traffic light:* The delay is a combination of breaking, standing accelerating. However, even an optimum traffic priority signal will not avoid delays. So only part of the measured delay was taken as potential. Furthermore, taking the average delays of the three time periods, the minimum value of these was regarded as potentials.
- *delays between intersections:* The reasons are heterogeneous, so measures were estimated to bring minimum benefit only. By the way, in Kiel problems between stops and intersections were of minor importance only.

To give you an impression on punctuality. First we thought it was enough to take a look at the line as a whole. But we learned soon that there is a pattern indicating that driving in direction to the city center needs more time than leaving the city center. This can be observed at any time of day. This was a strong indication that there are hidden reserves. In the end, busses arrive at the final stop in time.

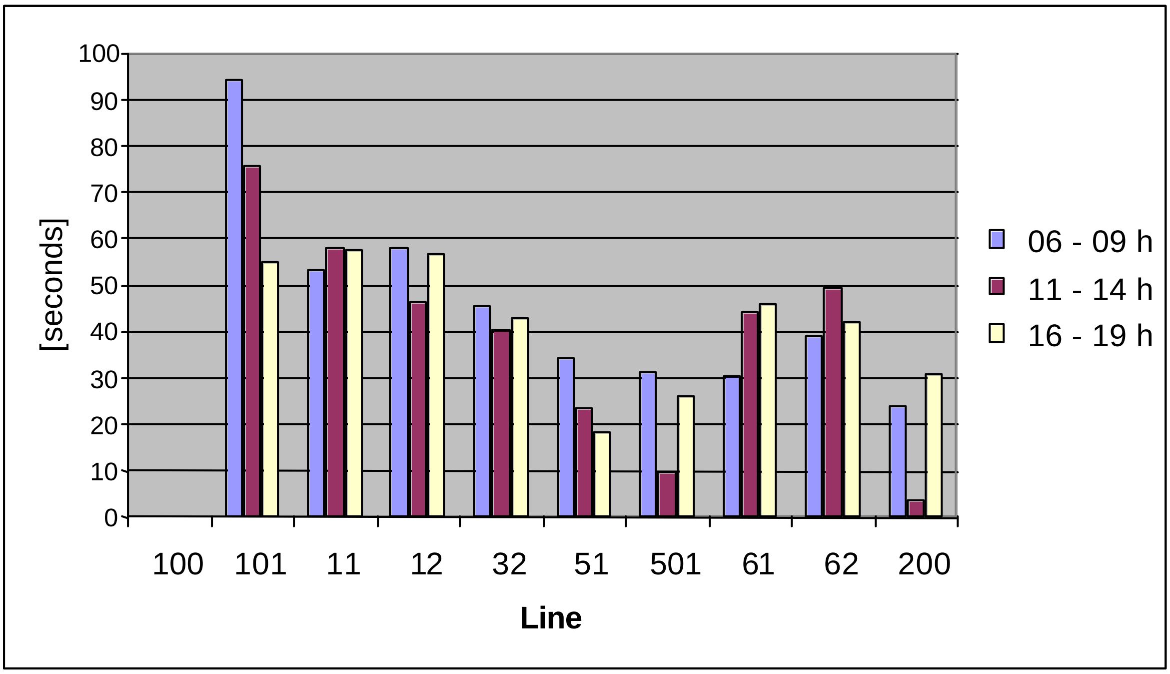
On the other hand, it does not make sense to take a look at punctuality stop by stop. So the lines were separated into four different homogeneous traffic areas: City center, inner city, suburbs, outward area. In addition, direction was taken into consideration; e.g. from city center to suburbs.

The following picture shows early arrivals and delays for bus trips from city center in direction to inner city (average values for one-way journeys).

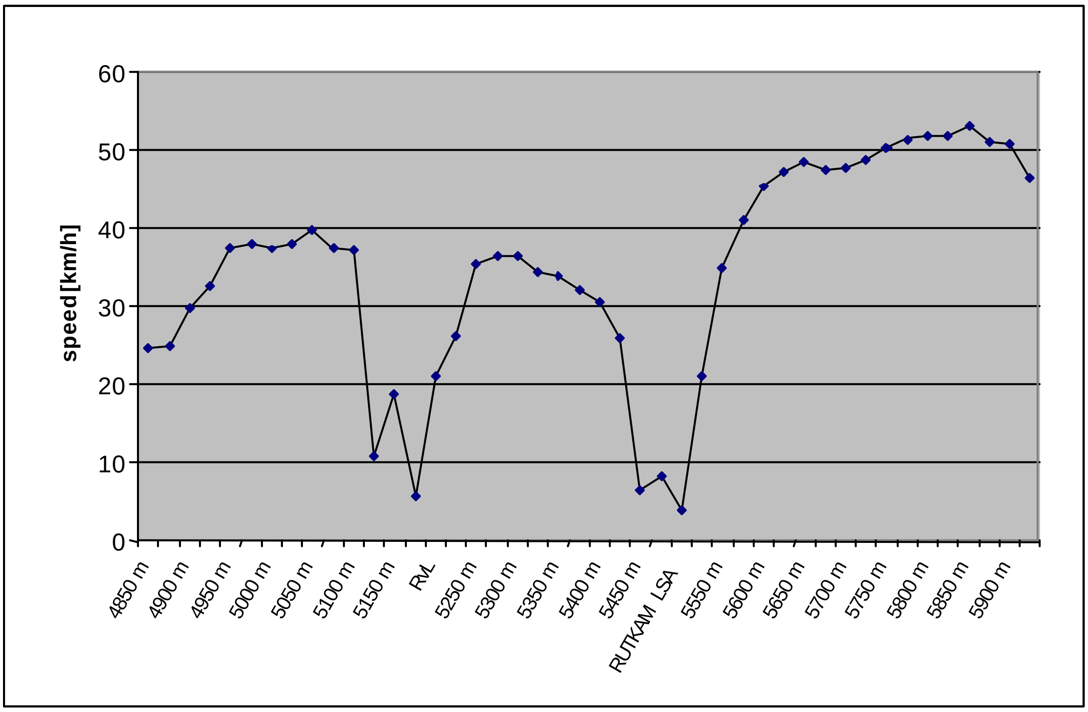


It can be seen that throughout the day some lines need less, some need more time than fixed in the time table.

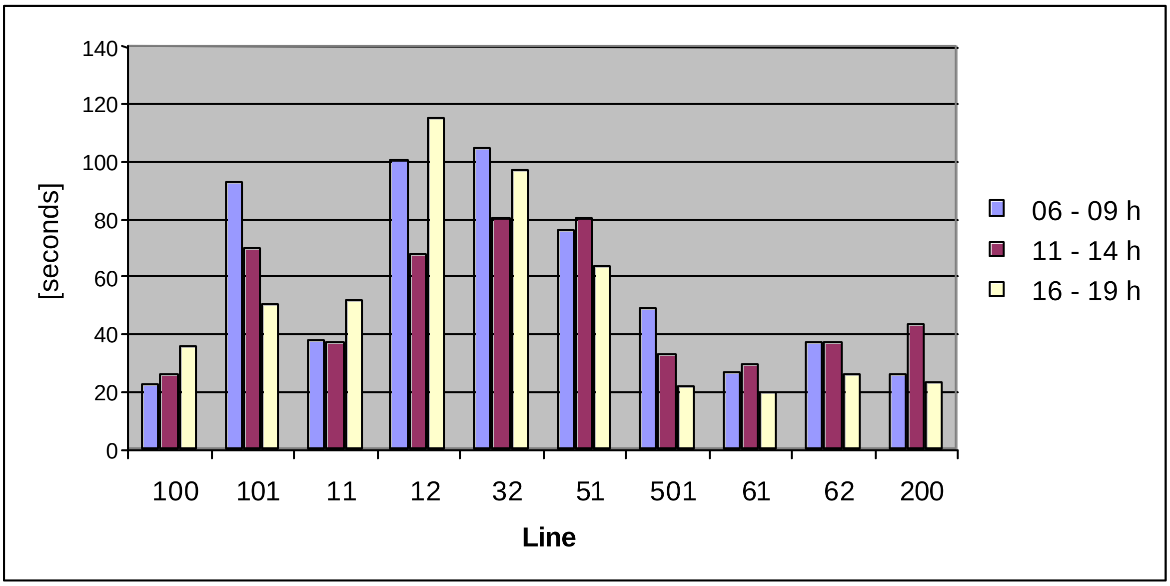
Another source for speeding up public transport is time loss at stops with doors closed. However, the differences between the lines are significant. And the reasons are very different. The next picture indicates the sums of average time loss per line and direction.



The dependency between distance and average speed can be taken from the following graph. The data are average values from all successful courses. The accuracy of the detection system is one meter / one second. It can clearly be seen low speed at traffic lights and at stops. Since busses do not stop always here, the value is only next to zero.



The next illustration shows delays in front of traffic lights. All lines are affected, but with big differences, and all over the day. It seemed very strange that there are differences between lines using the same routes at least partly. The reason for this was that although priority measures had been implemented at traffic lights and in busses, the communication between vehicle and traffic light does not work properly in some cases.

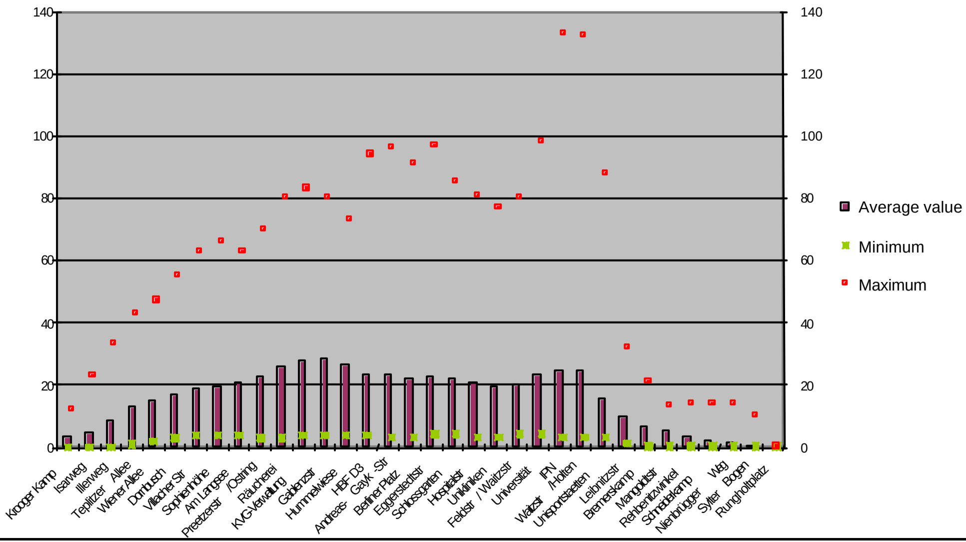


Parallel to the automatic detection of the movement an automatic passenger counting system was in operation. This makes sense because passenger numbers are essential to detect reasons for delays at stops **and** to evaluate possible benefits of certain measures to make public transport faster.

In the picture below, the average occupation, the maximum and minimum occupation can be seen. By the way, the maximum occupation is a helpful hint for capacity planning, minimum capacity is a gate for adapting offer and demand. But this is not our focus here.

Data Interpretation: Occupation Line 32

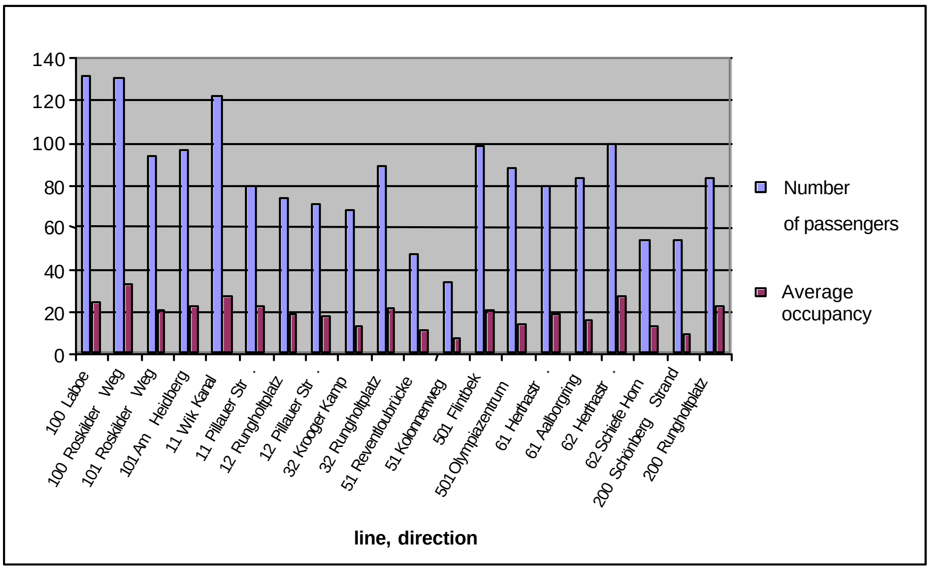
Average values for 89 runs covering three time-periods morning, noon and afternoon peak



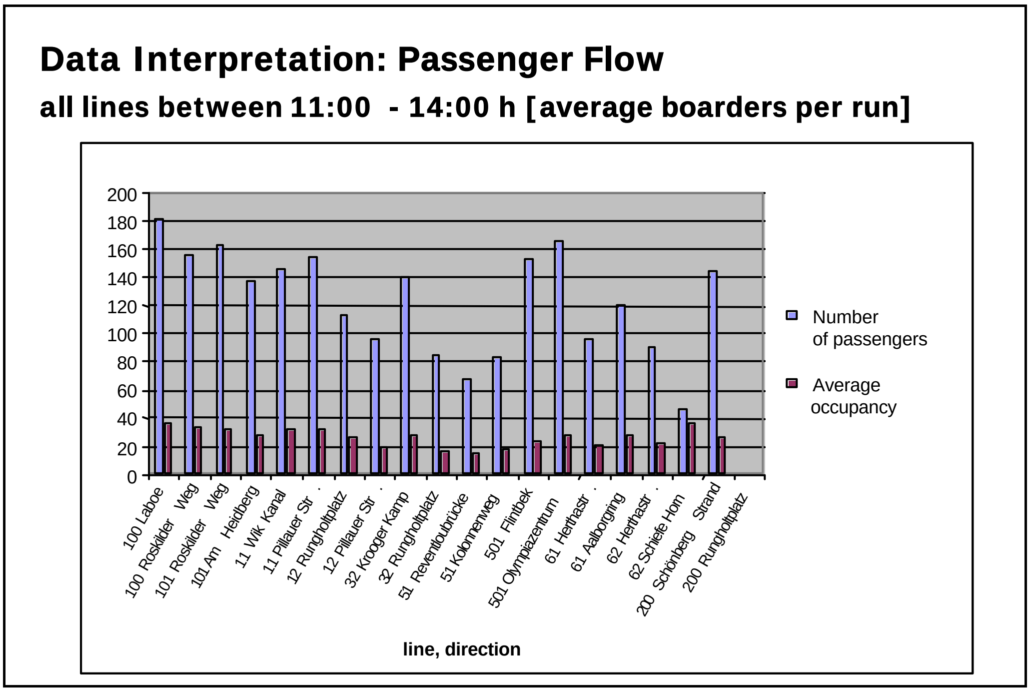
The next picture shows the number of passengers boarding. Of course: The longer the lines, the higher the columns of passengers boarding. So the average occupation is a better indication.

Data Interpretation: Passenger Flow

all lines between 6:00 - 9:00 h [average boarders per run]



Comparing the previous and the following picture, it is obvious that the differences between morning peak and noon peak are not significant. This makes it a bit easier for operators to realise economic and cost effective offer.



The Measures:

Up to now we were talking about potentials to make public transport faster at stops and at intersections. In addition, we were dealing with passenger numbers to learn more about reasons for delays and to assess certain measures. However, we didn't define measures yet. That' s why we are going to deal with the question <u>how</u> to realise these potentials in a real urban environment now.

Measures at stops are:

- Conversion / Marks
- Taking away of bus bays to ease the integration in flowing traffic
- Equipment
- Positioning of ticket machines and customer information to speed up boarding and alighting
- Adjusting time schedule
- Reducing of stop-times, e.g. by avoiding stops with closed doors.

At intersections we can

- check and improve existing priority signals
- or we can implement new priority signalling programs.

On the route between stops and intersections

- infrastructure measures as well as
- human measures

can contribute to successful implementation.

The Assessment:

Almost all cities and public transport operators have one thing in common: lack of money. So the key question is not to think about possible measures but how to form an optimum set of measures.

The first approach is to look at the costs. There are measures that are very cheap, e.g. changing the time table in cases where busses are always too early. Other measures are very expensive, first of all infrastructural measures.

The following table brings together possible measures and costs.

Allocation of Costs to Measures

Possible measures	Cost inclusion
Speeding up without infrastructure measures	Adopting schedule: no costs
Measures at Stops	Costs to remove bus bays, marks, stop equipment, etc.
Measures at Intersections	Costs for testing already existing or for implementing new priority signals
Measures on routes	Construction costs; Supervision

The second approach is to look at the benefits of measures. And here we have two different views that are feasible and necessary:

First the operator's interest to reduce capacity (vehicles, drivers) without changing quality of offer. And the drivers' and trade union's view to extend breaks at the final stop.

Second the passengers' point of view simply saying that benefit and travel time reduction strongly belong together. And therefore the number of passengers that are affected by a measure influences benefit as well.

Allocation of Benefits to Measures

Benefit criteria / Possible measures	Running time reduction	Number of passenger
Speeding up without infrastructure measures	Reducing early arrivals/departures	Vehicle occupancy after leaving stop
Measures at stops	Shortened stop time at stops in seconds	Vehicle occupancy after leaving stop
Measures at intersections	Minimum potential at intersection in seconds	Average vehicle occupancy at intersection
Measures on routes	Minimum potential on route part in seconds	Average vehicle occupancy between stops

These two approaches have to be brought together in a common assessment scheme. And it has to be guaranteed that measures of any kind can be compared to each other.

All in all, we identified more than 1,000 single measures of several kinds. We allocated costs and benefits to each measure. To bring all measures together and make them comparable, we had to transfer benefit, measured interests of seconds [travel time reductions], in benefit points.

The following table gives an impression of the assessing traffic light measures.

Example Traffic Lights with high Priority

Lines	Traffic Light	Measure detail	Min. running time reduc-tion [sec]	Average passenger number	Costs [€]	B-C-Indi-cator
61,62	51 Wulfsbrook	Check: too less time to turn left, approach signal needed	14	100	1.800	244
100,101	71 Sternstr.	Public transport priority implemented, success control necessary	12	87	1.800	193
100,101	32 Schülperbaum	Public transport priority implemented, success control necessary	9	120	1.800	183
100,101	159 Metzstr.	Public transport priority implemented, success control necessary	14	78	1.800	173
11,12,100	508 Wischhofstr.	To verify public transp. priority, if need optimisation effect	11	133	10.200	43
12,51,62, 200,501	7 Berliner Platz	To check Priority and coordination with TL 6 and PTL 181, if need optimisation effect	11	142	10.200	43
32,61,62	48 Hospitalstr.	To verify public. transp. priority, request is not transmitted if necessary optimisation effect	12	103	10.200	43
61,62,501	13 Rondeel	To verify public transp. priority	11	120	10.200	43
11,12,32, 100,101,501	44 Kehdenstr	To check priority an coordination with TL 6 and PTL 181 check, if need optimisation effect	10	195	10.700	41

Bringing together costs and benefits and ranking them according to a benefit-cost-ratio shows the sequence of measures to be implemented. At the top we see measures with high benefit and low costs.

Another example is the reduction of door-opening duration at stops.

Evaluation: Shortened Door-opening-time

Line	Direction	Station	Min. running time reduction	Average number of passenger	Benefit-Points in total
11	Wik, Kanal	KVG/Werftstr	4	48	10
100	Roskilder Weg	KVG/Werftstr	4	40	10
200	Rungholtplatz	Holstenbrücke	5	25	9
12	Pillauer Str.	KVG/Werftstr	3	34	8
12	Rungholtplatz	Gablenzstr	3	36	8
200	Rungholtplatz	Schoenkirch. Str.	3	31	8
12	Pillauer Str.	Gr. Ziegelstr	3	26	6
32	Rungholtplatz	Gablenzstr	4	28	6
51	Reventloubruecke	Kirchofsallee	4	26	6
200	Schönberger Stra.	Holstenbrücke	5	20	6
200	Schönberger Stra..	KVG/Werftstr.	4	27	6
11	Wik, Kanal	Gablenzstr	2	51	5
100	Roskilder Weg	Gr. Ziegelstr	1	41	5
100	Roskilder Weg	Gablenzstr	2	41	5

The measure is simply to make the time table tighter in order to reduce travel time. The costs are next to nothing an they can be neglected here. So only benefit points without costs have to be considered in the assessment. By the way, in 4 out of 14 cases the stop KVG/Werftstraße was detected as potential stop to reduce waiting time. This stop is close to the city center but without major importance for ordinary passengers. But it is the stop to change drivers, and this is a time-consuming procedure.

The Potentials:

The overall potentials to reduce travel time from any kind of measures are fixed in the following table. The figures in seconds refer to one round trip per line.

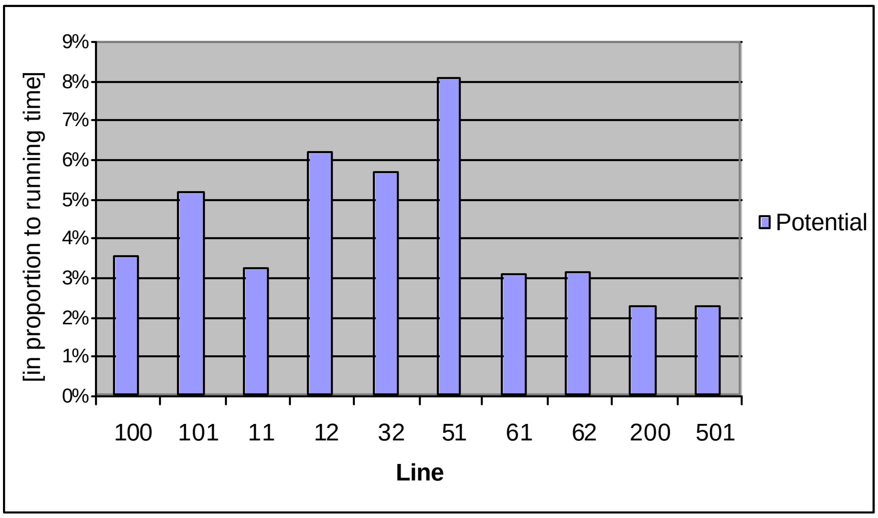
Evaluation: Potential
Basing on one round trip per line

Line	Schedule avoid early arrivals/ depart.[sec]	Physical measures at stops [sec]	Shortened door-opening time [sec]	Traffic Lights [sec]	Route [sec]	Total [sec]
100	124	0	12	178	0	**314**
101	65	9	5	292	3	**374**
11	0	4	9	180	0	**193**
12	127	14	24	226	5	**396**
32	13	10	8	312	0	**343**
51	33	0	4	289	4	**330**
61	4	5	6	152	16	**183**
62	41	13	2	101	8	**165**
200	135	0	51	37	0	**223**
501	0	1	44	152	8	**205**
Total	**542**	**56**	**165**	**1.919**	**44**	**2.726**

Taking one round trip per line as a basis, the travel time reduction can amount up to 6.5 minutes (line 12).

Taking into consideration travel time between final stops, the potentials can amount to 8 % of the travel time. The highest value occurs at line 51, a short line running exclusively in the city center.

Evaluation: Potential

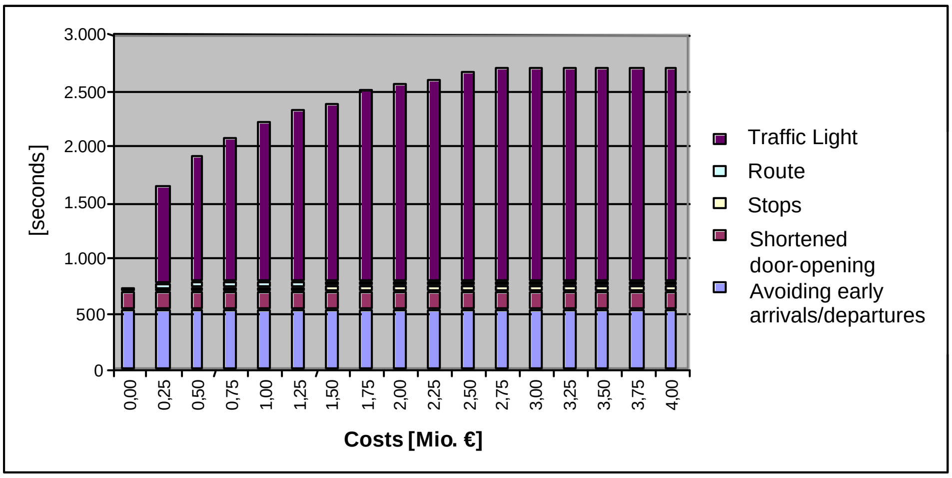


As we are talking about a practical approach here, it is important that the influence variables for the assessment scheme can be changed. E.g. if boarding and alighting can be realised within three seconds maximum, this can be implemented at once.

The Recommendation:

From the city council’s point of view, it is very interesting to get a guideline for typical questions like ‘How much travel time reduction can I achieve with € 1 million?’ The answer can be derived from the following picture.

Evaluation: Running-Time and Costs



From the operator’s point of view it is interesting to know how many vehicles can be reduced. This information can be gained from the table below.

Round Trip Efficiency

Line	Day	Time	Freq. [min]	Run. time now	Waiting time	Round trip time	Efficiency now	Vehc. now	Run. time new (S Potential)	Round trip duration	efficiency new	D vehc.
11/12	MF	HVZ/NVZ	15	201	54	255	78,8%	17	191	225	84,9%	-2
32	MF	HVZ/NVZ	30	99	21	120	82,5%	4	93	120	77,5%	0
51	MF	HVZ	10	68	12	80	85,0%	8	63	70	90,0%	-1
51	MF	NVZ	15	68	22	90	75,6%	6	63	75	84,0%	-1
61	MF	HVZ	20	98	22	120	81,7%	6	95	100	95,0%	-1
61	MF	NVZ	40	204	36	240	85,0%	6	198	240	82,5%	0
62	MF	HVZ	20	88	12	100	88,0%	5	85	100	85,0%	0
62	MF	NVZ	40	88	32	120	73,3%	3	85	120	70,8%	0
100	MF	NVZ	30	158	52	210	75,2%	7	153	180	85,0%	-1
100/101	MF	HVZ	20	264	56	320	82,5%	16	253	300	84,3%	-1
501	MF	HVZ	20	152	8	160	95,0%	8	149	160	93,1%	0
501	MF	NVZ	30	147	33	180	81,7%	6	144	180	80,0%	0

All in all, 5 from 64 vehicles in the peak hour (HVZ) can be reduced.

Following the idea of a realisation step-by-step, we recommended our client to behave as follows:

- 25 % of the potentials can be achieved by urgent measures - they cost next to nothing
- 40 % of the potentials can be won by immediate measures - by 7 % of the costs

- 25 % of the potentials are to be realised by middle term measures
- the rest of the potentials by subordinate measures - at almost two thirds of total costs.

The existing programme to make public transport faster in Kiel looks very different::
Line by line, starting outside. Our recommendation contributes to rearranging the existing programme.

To Sum Up:

We could prove that in a practical urban environment it is possible to speed up public transport at reasonable costs and to achieve higher efficiency and attractiveness. The study as prerequisite must form a reliable base and is not cheap. But looking at the potentials to gain, the costs for the study should be of minor importance only.

European Transport Conference 08/10/03

Speeding Up Public Transport

- A Practical Approach -

Dipl.-Wirtsch.-Ing. Rainer Schneider

The Problem

- Early arrivals/departures
- Time loss at stops
- Time loss on the route

- Lack of data to react

- Unsatisfied passengers
- No economical operation of drivers and vehicles

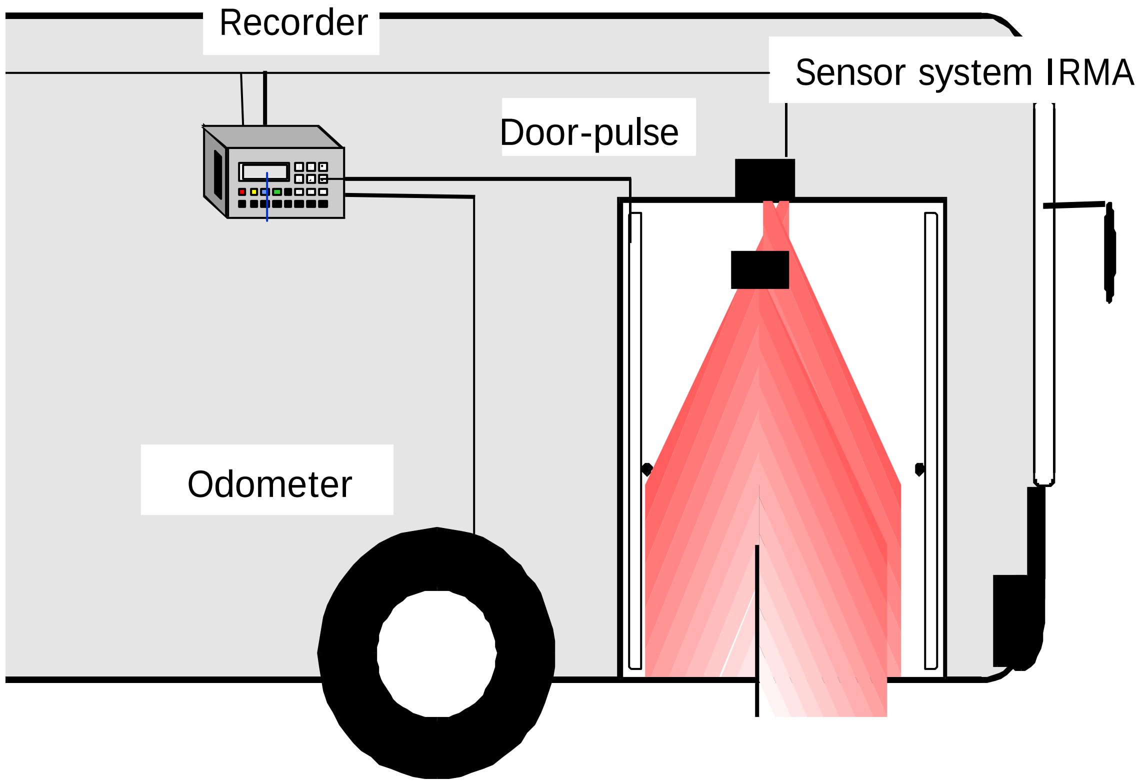
The Approach

Work programme for 10 urban and suburban bus lines in Kiel

- Data acquisition and interpretation
- Malfunction analysis
- Development of a catalogue of measures
- Evaluation of measures in reference to benefits and costs
- Recommendation

Automatic Data Collection

- Boardings/Alightings [number of passengers]
- Distance [meter]
- Status of door [opened, closed]
- Time [seconds]
- Line
- Course
- Direction
- Stop



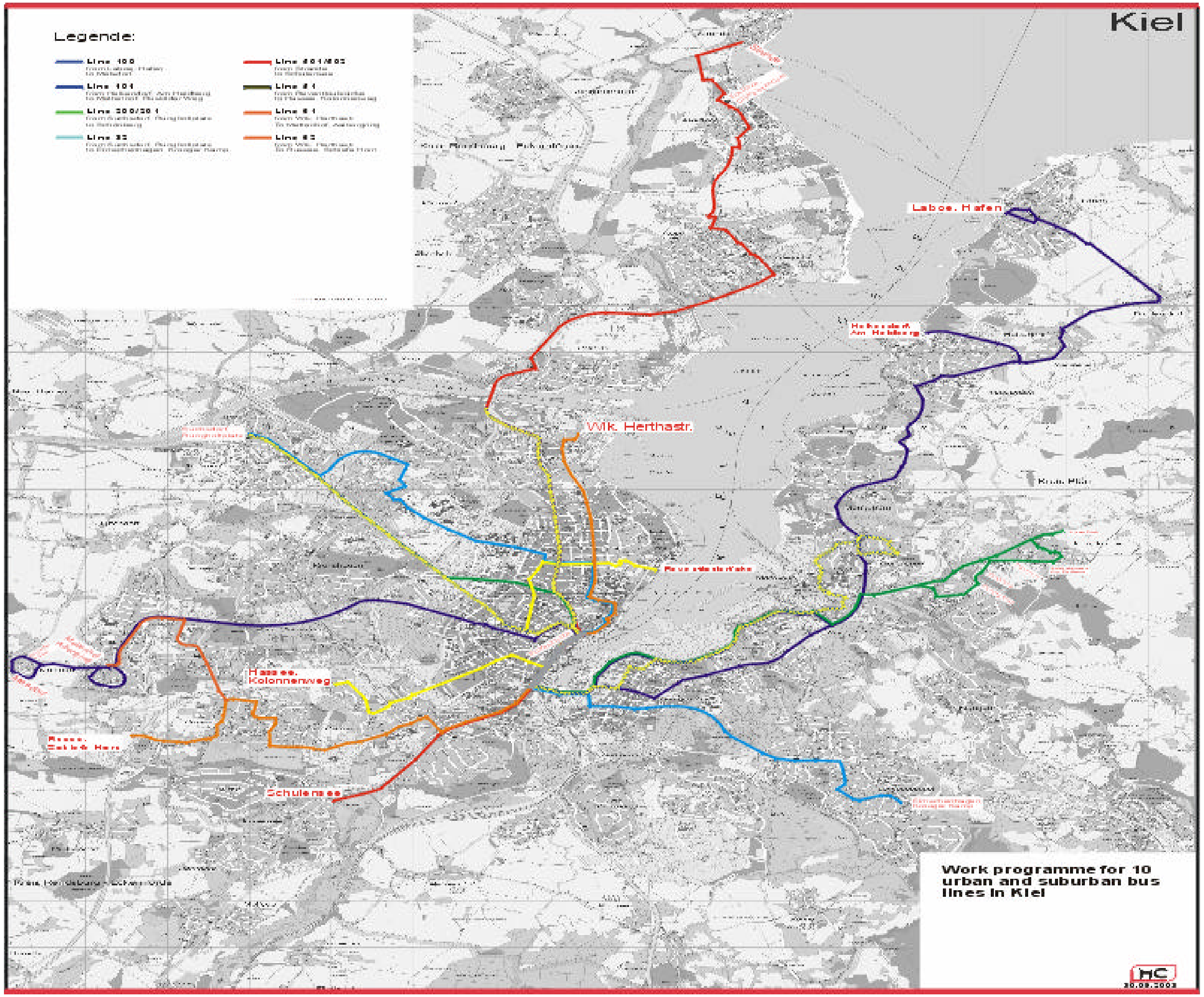
Evaluation of Data by the PLANFAHRT software:

- Travel times and speeds,
- Schedule deviation,
- Times of door opening,
- Duration of regular stops,
- Delays and standing times in areas of
    - intersection (with or without traffic lights) and on
    - routes,
- Boardings and alightings with vehicle occupancy

Data Acquisition: The Lines

Line	Direction	Number of measured courses
11	Pilauer Straße – Wik Kanal	35
11	Wik Kanal - Pillauer Straße	35
12	Pilauer Straße – Rungholtplatz	26
12	Rungholtplatz – Pilauer Straße	26
32	Rungholtplatz – Krooger Kamp	71
32	Krooger Kamp – Rungholtplatz	87
51	Kolonnenweg – Reventloubrücke	105
51	Reventloubrücke – Kolonnenweg	105
61	Aalborgring – Herthastraße	10
61	Herthastraße – Aalborgring	17
62	Schiefe Horn – Herthastraße	43
62	Herthastraße – Schiefe Horn	54
100	Roskilder Weg- Laboe Hafen	23
100	Laboe Hafen – Roskilder Weg	21
101	Roskilder Weg - Am Heidberg	29
101	Am Heidberg – Roskilder Weg	30
200	Rungholtplatz –Schönberg Strand	34
200	Schönberg Strand – Rungholtplatz	25
501	Flintbek Parkplatz – Olympiazentrum	24
501	Olympiazentrum – Flintbek Parkplatz	24

Bus Lines in Kiel



Data interpretation: Line Properties

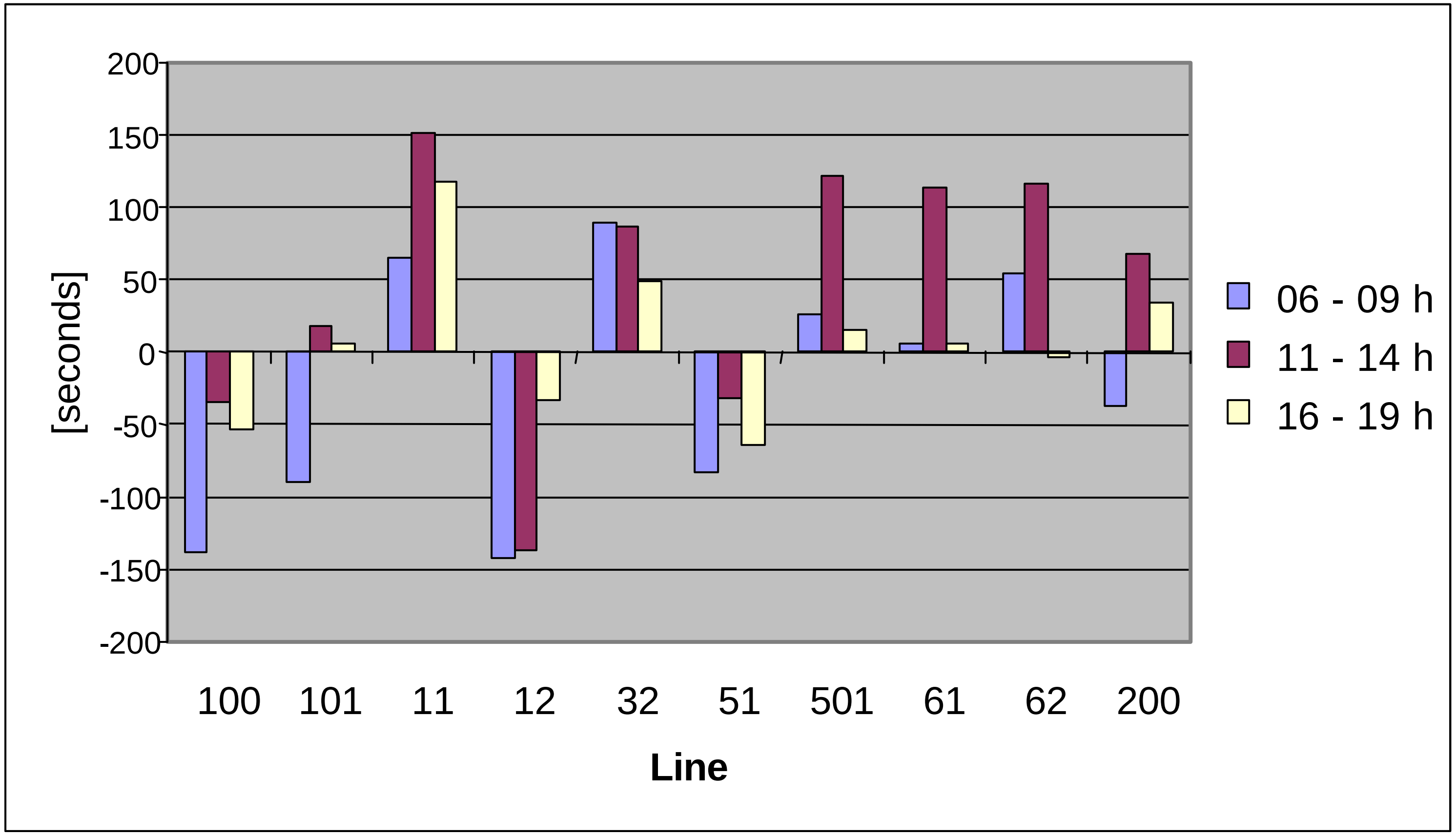
Line	Operator	Direction	Line length [km]	Number of stops	Travel time [min]	Average speed [km/h]
11	KVG	Pillauer Straße - Wik Kanal	14,5	34	49	17,8
11	KVG	Wik Kanal - Pillauer Straße	14,4	34	49	17,6
12	KVG	Pillauer Straße - Rungholtplatz	16,0	36	53	18,2
12	KVG	Rungholtplatz -Pillauer Straße	15,9	35	54	17,7
32	KVG	Rungholtplatz -Krooger Kamp	17,0	35	49	20,9
32	KVG	Krooger Kamp - Rungholtplatz	17,1	34	52	19,7
51	KVG	Kolonnenweg -Reventloubrücke	8,9	20	34	15,6
51	KVG	Reventloubrücke –Kolonnenweg	8,7	20	34	15,4
61	KVG	Aalborgring -Herthastraße	16,3	40	48	20,4
61	KVG	Herthastraße -Aalborgring	16,5	41	50	19,8
62	KVG	Schiefe Horn -Herthastraße	14,4	34	43	20,1
62	KVG	Herthastraße -Schiefe Horn	14,6	35	45	19,4
100	KVG	Roskilder Weg - Laboe Hafen	28,2	50	70	24,2
100	KVG	Laboe Hafen - Roskilder Weg	28,0	49	71	23,7
101	KVG	Roskilder Weg - Am Heidberg	23,3	42	61	22,9
101	KVG	Am Heidberg - Roskilder Weg	23,4	41	62	22,6
200	VKP	Rungholtplatz -Schönberger Strand	39,3	57	83	28,4
200	VKP	Schönberger Strand -Rungholtplatz	39,5	56	86	27,5
501	KVG/AK	Flintbek Parkpl. - Olympiazentrum	31,6	50	84	22,6
501	KVG/AK	Olympiazentrum -Flintbek Parkpl.	27,2	50	68	24,0

Data Interpretation: Potentials

- early arrivals/departures
- standing at stops with closed doors,
- opened doors without boarding and alighting,
- delays at intersections without or with traffic light,
- delays between intersections and stops.

Data Interpretation: Early arrivals and Delays

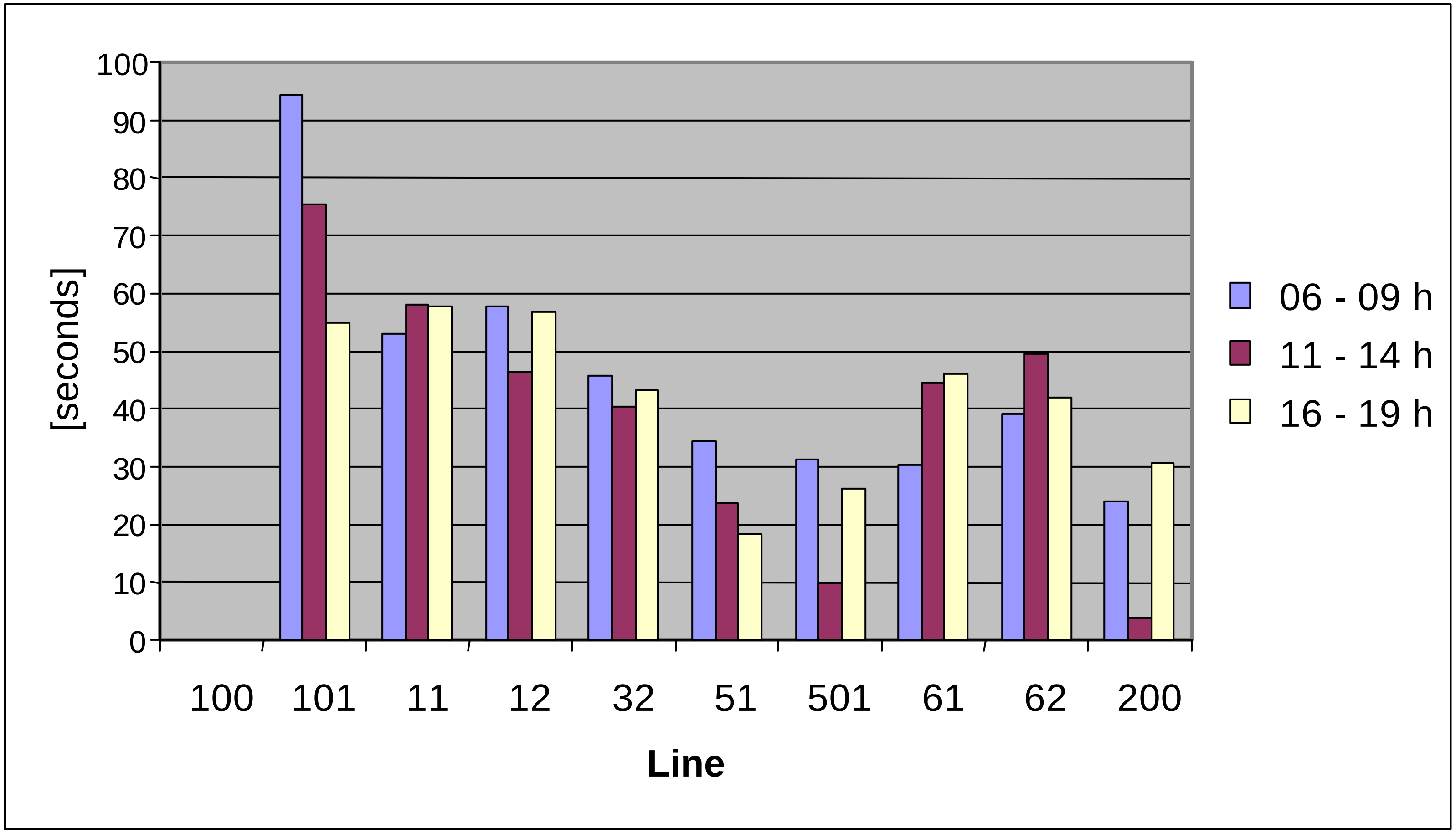
From city centre in direction to suburbs [average values for one-way journeys]



Data Interpretation: Standing at Stops

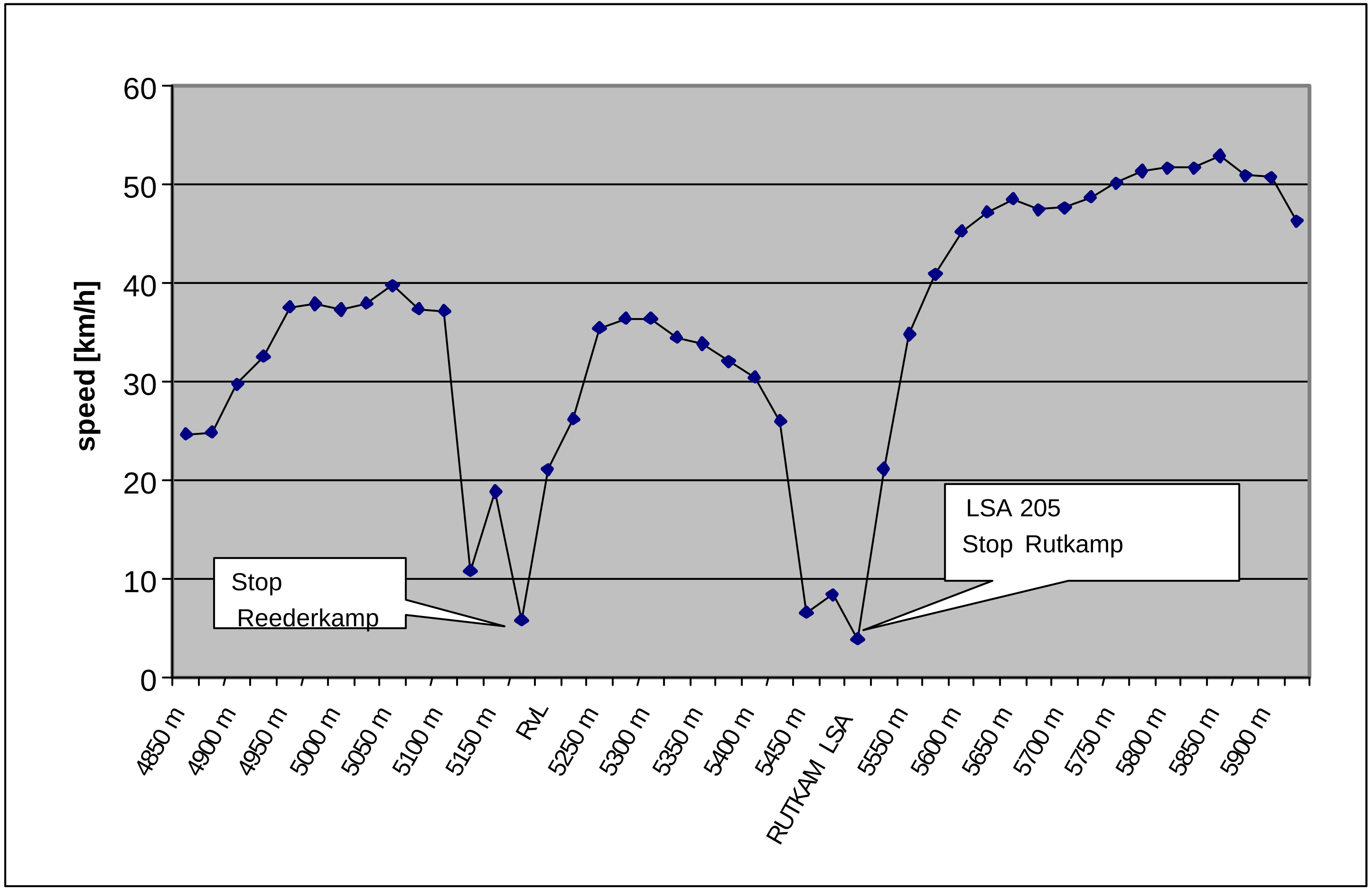
with Closed Doors in the City Centre

[average value for one-way journeys]



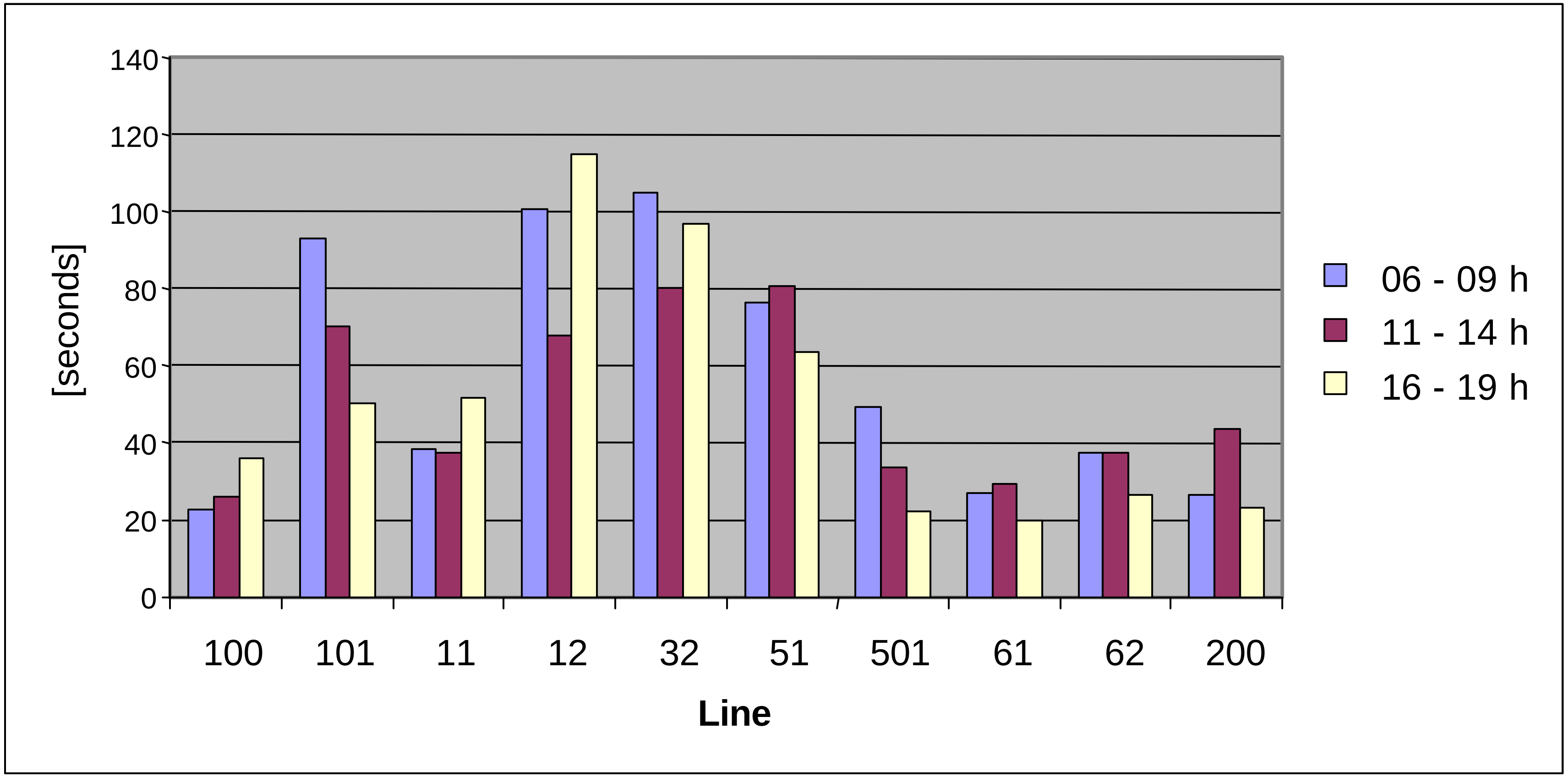
Data Interpretation: Speed Profile

Line 61



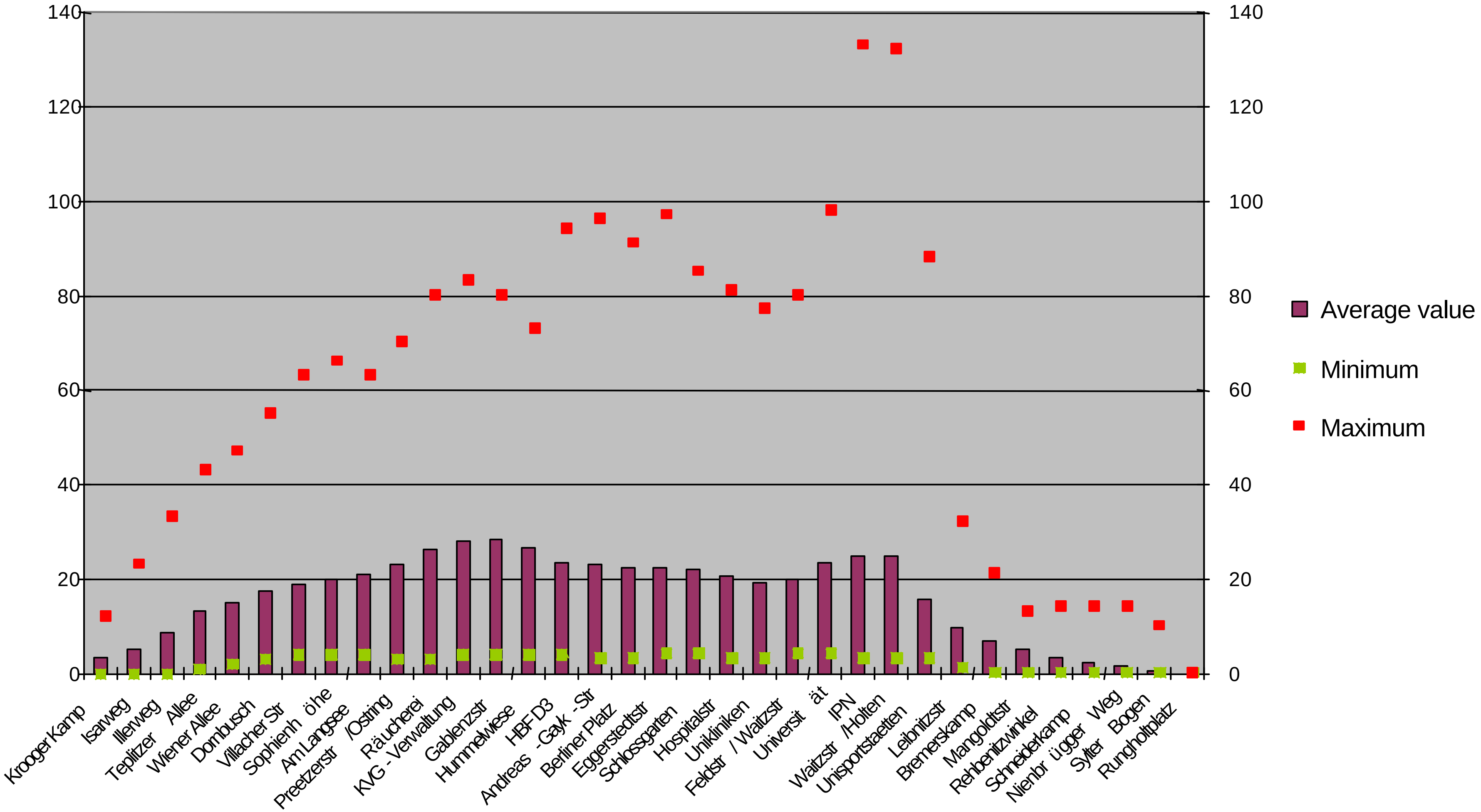
Data Interpretation: Delays at Traffic Lights

City Centre [average values for one-way journeys]



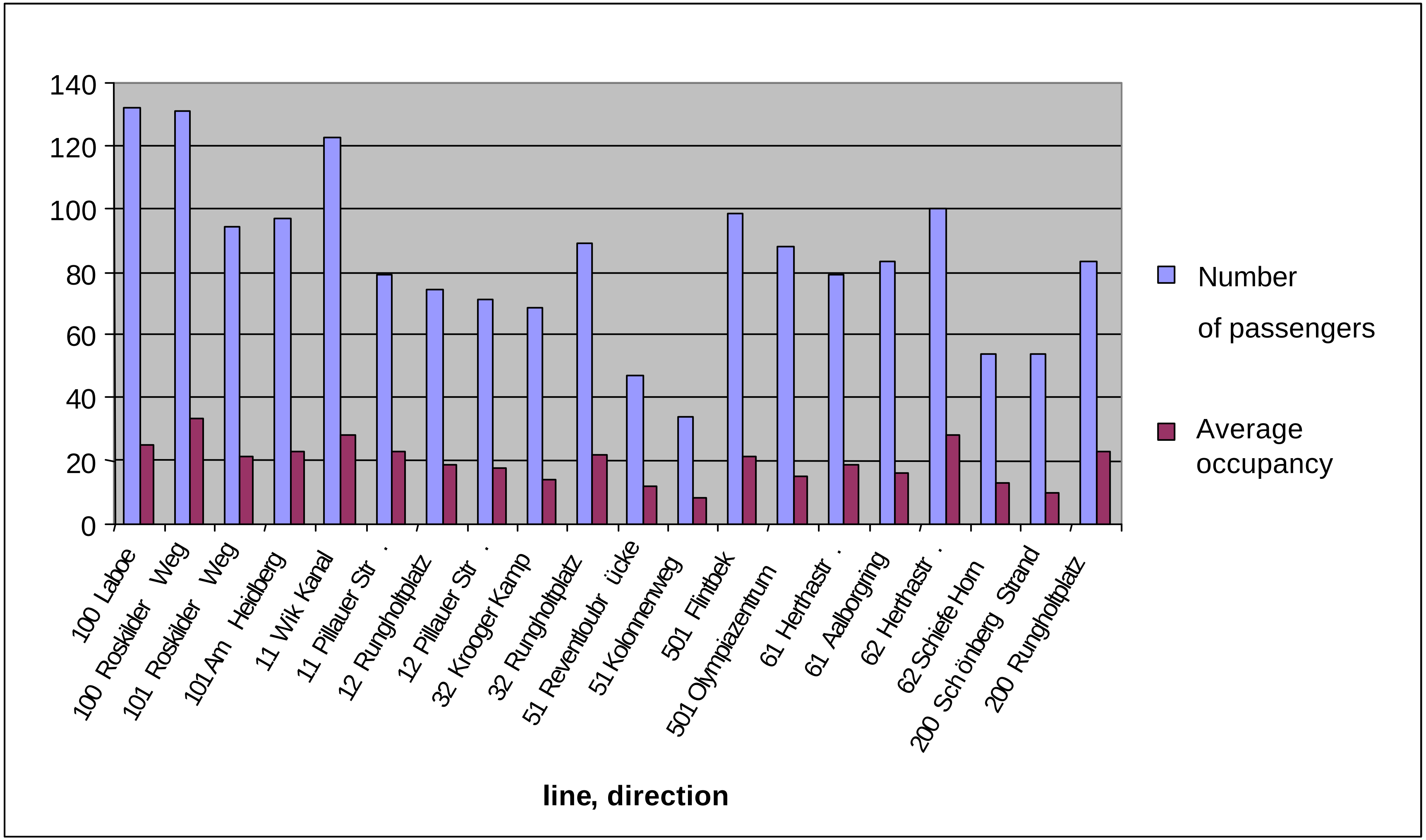
Data Interpretation: Occupation Line 32

Average values for 89 runs covering three time-periods morning, noon and afternoon peak



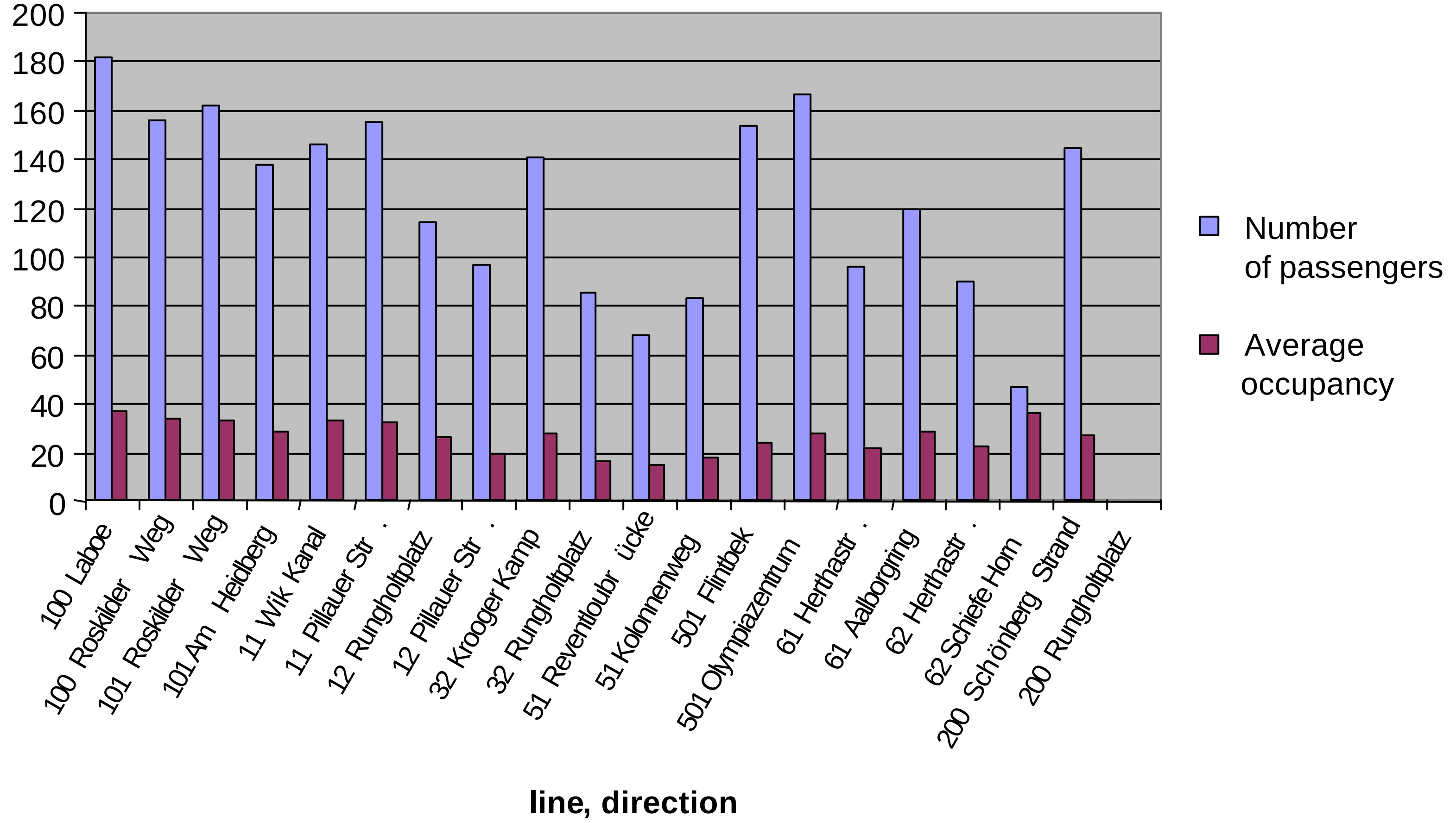
Data Interpretation: Passenger Flow

all lines between 6:00 - 9:00 h [average boarders per run]



Data Interpretation: Passenger Flow

all lines between 11:00 - 14:00 h [average boarders per run]



Catalogue of Measures: Stops

- Measures at bus stops
  - Conversion / Marks
    - Taking away of bus bays to ease the integration in flowing traffic
  - Equipment
    - Positioning of ticket machines and customer information to speed up boarding and alighting
  - Schedule
    - Reducing of stop-times, e.g. by avoiding stops with closed doors

Catalogue of Measures: Intersections

- Measures at Intersections
  - Functional Test of already implemented priority signals
  - Change fixed-time signal control to public transport priority signalling

Catalogue of Measures: Route

- Measures on the route
  - Constructive measures
    - Bus lanes
    - Separation of the traffic modes
  - Supervision and Controlling

Allocation of Costs to Measures

Possible measures	Cost inclusion
Speeding up without infrastructure measures	Adopting schedule: no costs
Measures at Stops	Costs to remove bus bays, marks, stop equipment, etc.
Measures at Intersections	Costs for testing already existing or for implementing new priority signals
Measures on routes	Construction costs; Supervision

Allocation of Benefits to Measures

Benefit criteria / Possible measures	Running time reduction	Number of passenger
Speeding up without infrastructure measures	Reducing early arrivals/departures	Vehicle occupancy after leaving stop
Measures at stops	Shortened stop time at stops in seconds	Vehicle occupancy after leaving stop
Measures at intersections	Minimum potential at intersection in seconds	Average vehicle occupancy at intersection
Measures on routes	Minimum potential on route part in seconds	Average vehicle occupancy between stops

Example Traffic Lights with high Priority

Lines	Traffic Light	Measure detail	Min. running time reduc-tion [sec]	Average passenger number	Costs [€]	B-C-Indi-cator
61,62	51 Wulfsbrook	Check: too less time to turn left, approach signal needed	14	100	1.800	244
100,101	71 Sternstr.	Public transport priority implemented, success control necessary	12	87	1.800	193
100,101	32 Schülperbaum	Public transport priority implemented, success control necessary	9	120	1.800	183
100,101	159 Metzstr.	Public transport priority implemented, success control necessary	14	78	1.800	173
11,12,100	508 Wischhofstr.	To verify public transp. priority, if need optimisation effect	11	133	10.200	43
12,51,62, 200,501	7 Berliner Platz	To check Priority and coordination with TL 6 and PTL 181, if need optimisation effect	11	142	10.200	43
32,61,62	48 Hospitalstr.	To verify public. transp. priority, request is not transmitted if necessary optimisation effect	12	103	10.200	43
61,62,501	13 Rondeel	To verify public transp. priority	11	120	10.200	43
11,12,32, 100,101,501	44 Kehdenstr	To check priority an coordination with TL 6 and PTL 181 check, if need optimisation effect	10	195	10.700	41

Evaluation: Shortened Door-opening-time

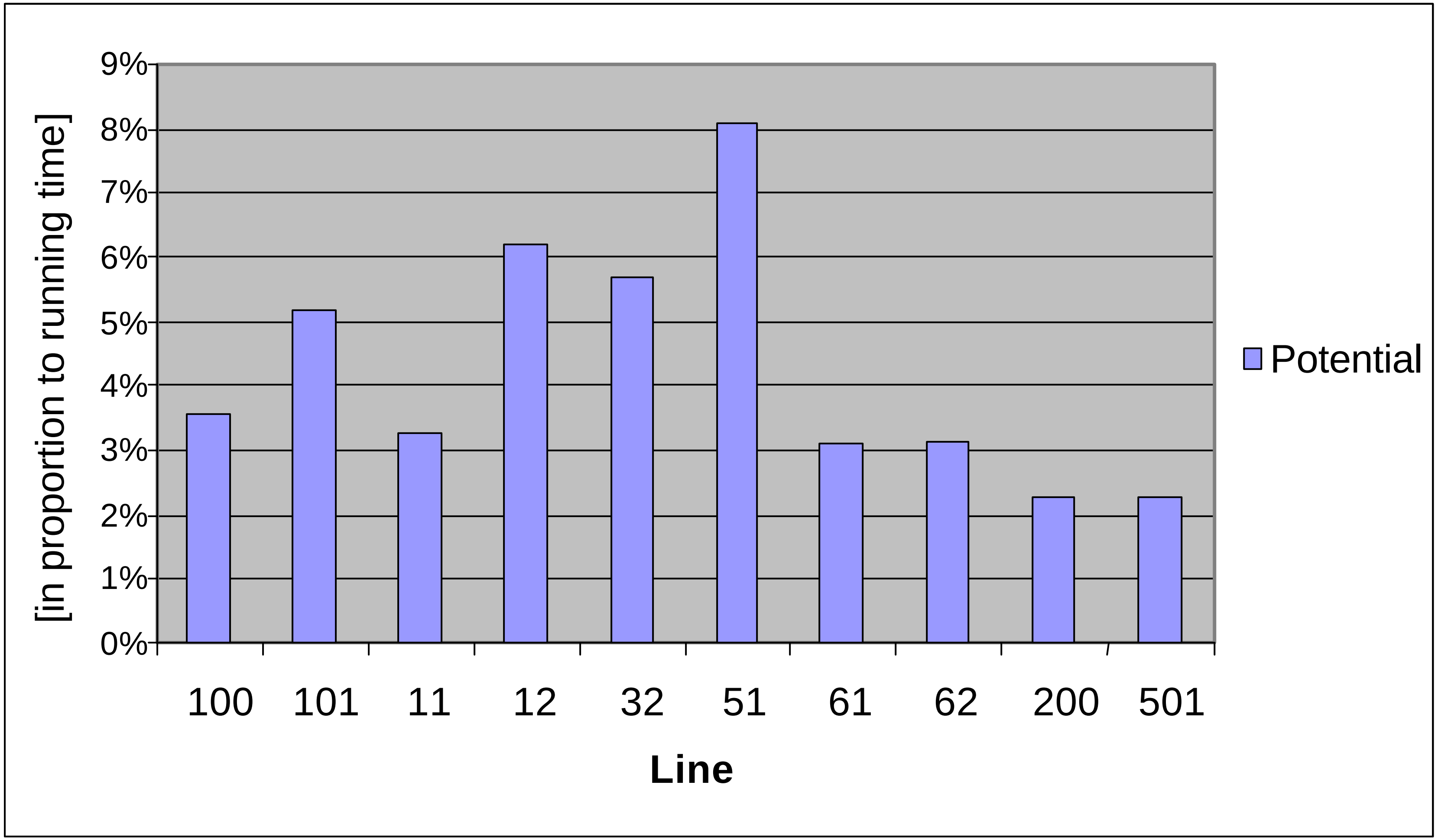
Line	Direction	Station	Min. running time reduction	Average number of passenger	Benefit-Points in total
11	Wik, Kanal	KVG/Werftstr	4	48	10
100	Roskilder Weg	KVG/Werftstr	4	40	10
200	Rungholtplatz	Holstenbrücke	5	25	9
12	Pillauer Str.	KVG/Werftstr	3	34	8
12	Rungholtplatz	Gablenzstr	3	36	8
200	Rungholtplatz	Schoenkirch. Str.	3	31	8
12	Pillauer Str.	Gr. Ziegelstr	3	26	6
32	Rungholtplatz	Gablenzstr	4	28	6
51	Reventloubruecke	Kirchofsallee	4	26	6
200	Schönberger Stra.	Holstenbrücke	5	20	6
200	Schönberger Stra..	KVG/Werftstr.	4	27	6
11	Wik, Kanal	Gablenzstr	2	51	5
100	Roskilder Weg	Gr. Ziegelstr	1	41	5
100	Roskilder Weg	Gablenzstr	2	41	5

Evaluation: Potential

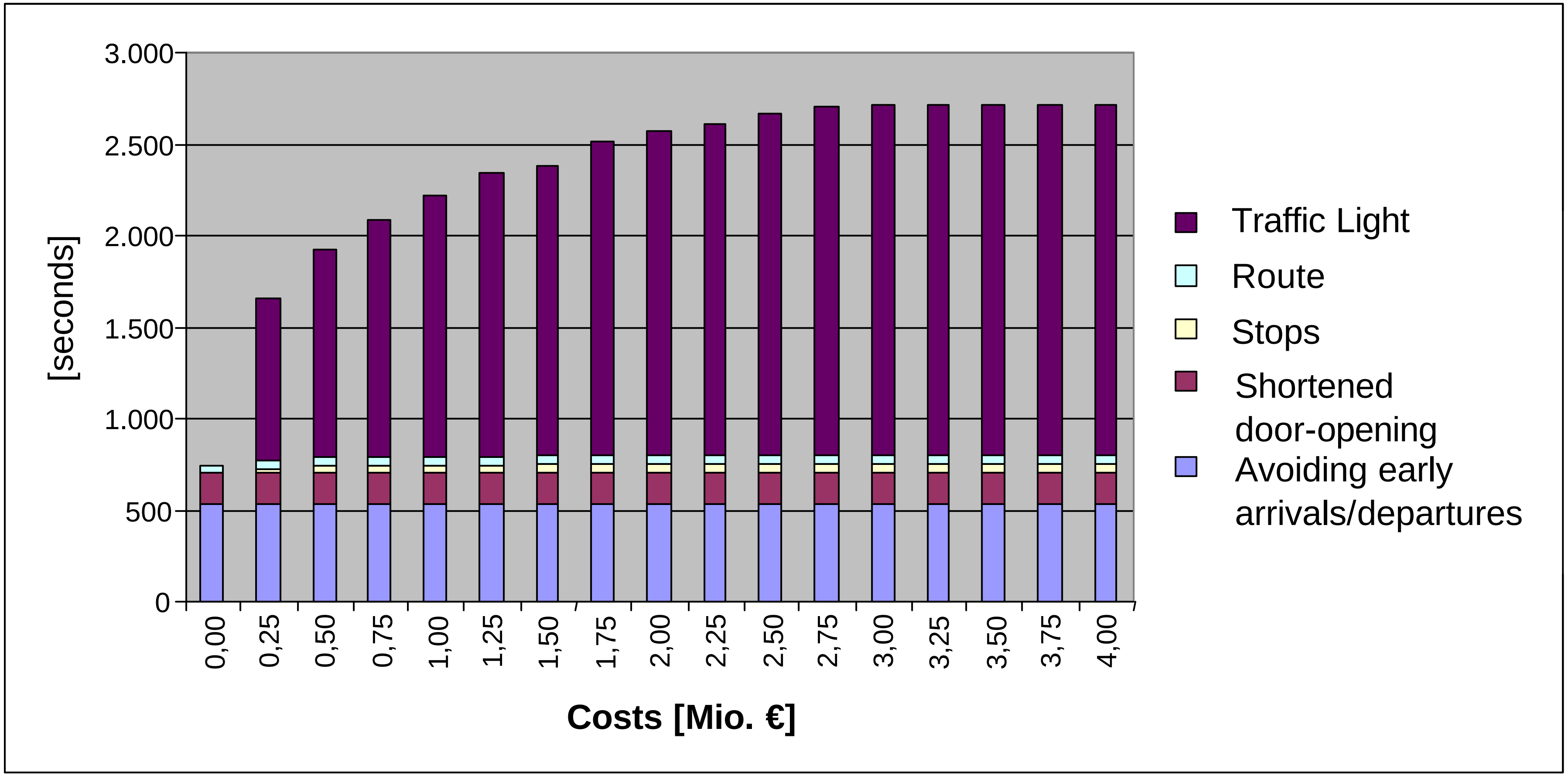
Basing on one round trip per line

Line	Schedule avoid early arrivals/ depart.[sec]	Physical measures at stops [sec]	Shortened door-opening time [sec]	Traffic Lights [sec]	Route [sec]	Total [sec]
100	124	0	12	178	0	**314**
101	65	9	5	292	3	**374**
11	0	4	9	180	0	**193**
12	127	14	24	226	5	**396**
32	13	10	8	312	0	**343**
51	33	0	4	289	4	**330**
61	4	5	6	152	16	**183**
62	41	13	2	101	8	**165**
200	135	0	51	37	0	**223**
501	0	1	44	152	8	**205**
Total	**542**	**56**	**165**	**1.919**	**44**	**2.726**

Evaluation: Potential



Evaluation: Running-Time and Costs



Round Trip Efficiency

Line	Day	Time	Freq. [min]	Run. time now	Waiting time	Round trip time	Efficiency now	Vehc. now	Run. time new (S Potential)	Round trip duration	efficiency-new	D vehc.
11/12	MF	HVZ/NVZ	15	201	54	255	78,8%	17	191	225	84,9%	-2
32	MF	HVZ/NVZ	30	99	21	120	82,5%	4	93	120	77,5%	0
51	MF	HVZ	10	68	12	80	85,0%	8	63	70	90,0%	-1
51	MF	NVZ	15	68	22	90	75,6%	6	63	75	84,0%	-1
61	MF	HVZ	20	98	22	120	81,7%	6	95	100	95,0%	-1
61	MF	NVZ	40	204	36	240	85,0%	6	198	240	82,5%	0
62	MF	HVZ	20	88	12	100	88,0%	5	85	100	85,0%	0
62	MF	NVZ	40	88	32	120	73,3%	3	85	120	70,8%	0
100	MF	NVZ	30	158	52	210	75,2%	7	153	180	85,0%	-1
100/101	MF	HVZ	20	264	56	320	82,5%	16	253	300	84,3%	-1
501	MF	HVZ	20	152	8	160	95,0%	8	149	160	93,1%	0
501	MF	NVZ	30	147	33	180	81,7%	6	144	180	80,0%	0

Recommendation for Realisation

Priority	Measure	Proportion potential	Proportion total costs
Urgent	Adopting Schedule	25 %	0 %
Immediate	Testing of existing implemented bus priority signalling (primary need)	40 %	7 %
Middle-term	Implementing bus priority signalling (secondary need)	25 %	30 %
Subordinated	Infrastructural measures	10 %	63 %

Thank you for your attention.

Dipl.-Wirtsch.-Ing. Rainer Schneider