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EFFECTS OF PRE-SIGNALS AT AN ISOLATED INTERSECTION: SIMULATION RESULTS

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Agenda

1. The operation of pre-signals
2. Building the simulation model
3. Model calibration and validation
4. Results and discussion

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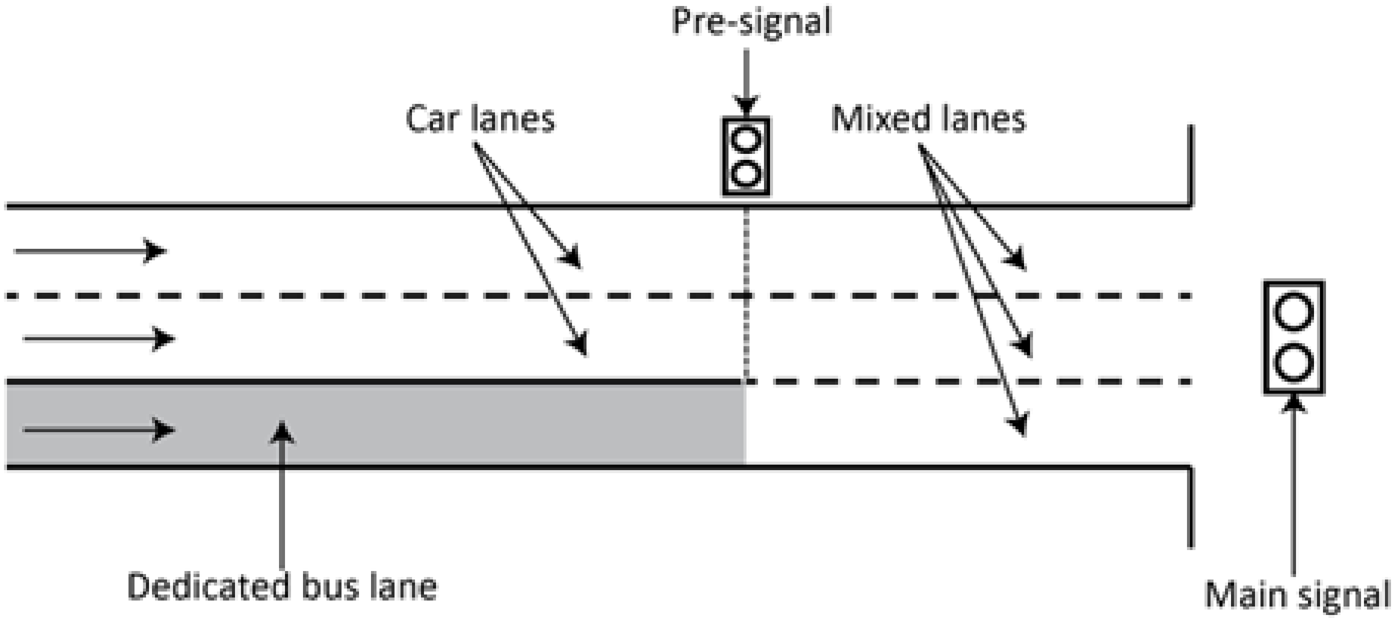
The operation of pre-signals

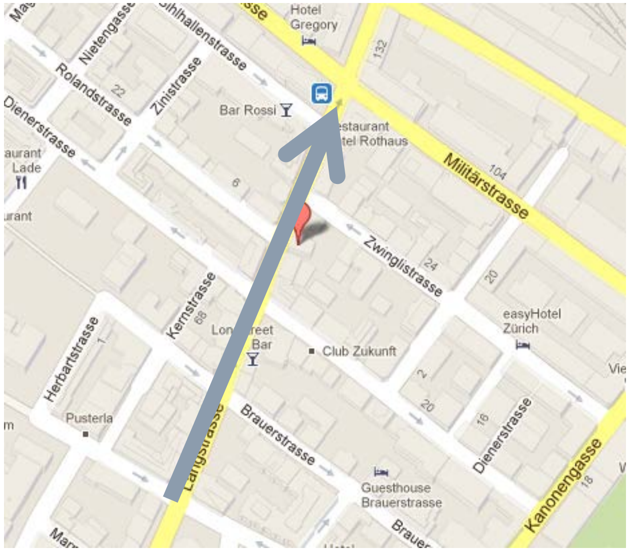
- Pre-signal: a signal in front of the main signal

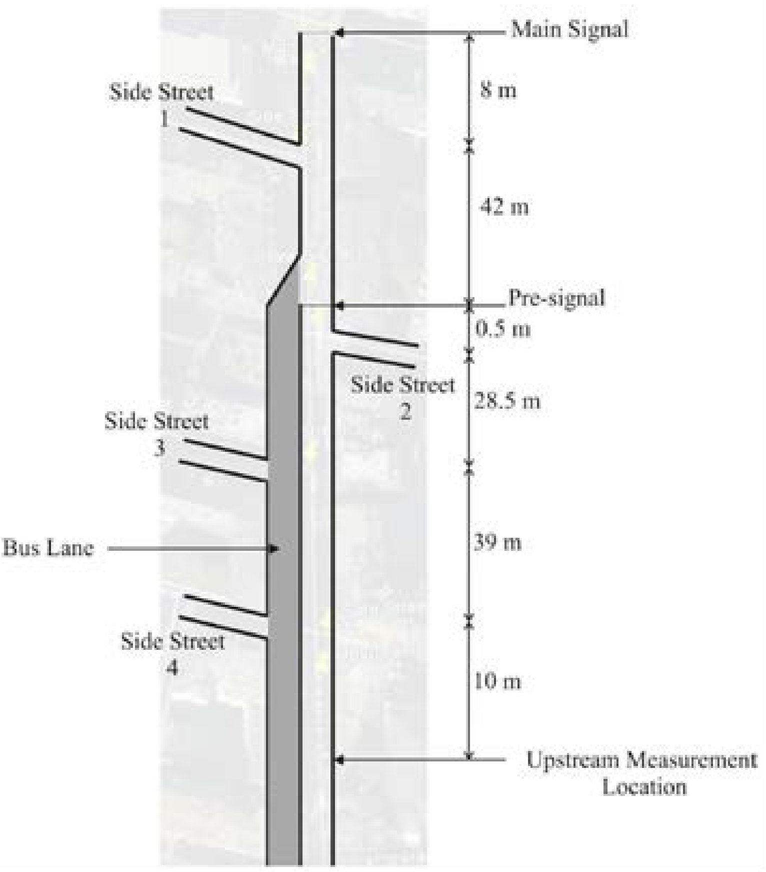


Examples of pre-signals

SVT

- In German signal guideline handbook
- In London
- On Langstrasse, Zurich





Goals of the research

- Build the simulation model...but WHY???

1. Visual insights: observe the effects directly to help understanding

2. The effect of red-signal duration when a bus arrives on total system delay

3. Foundation for the arterial case and network case

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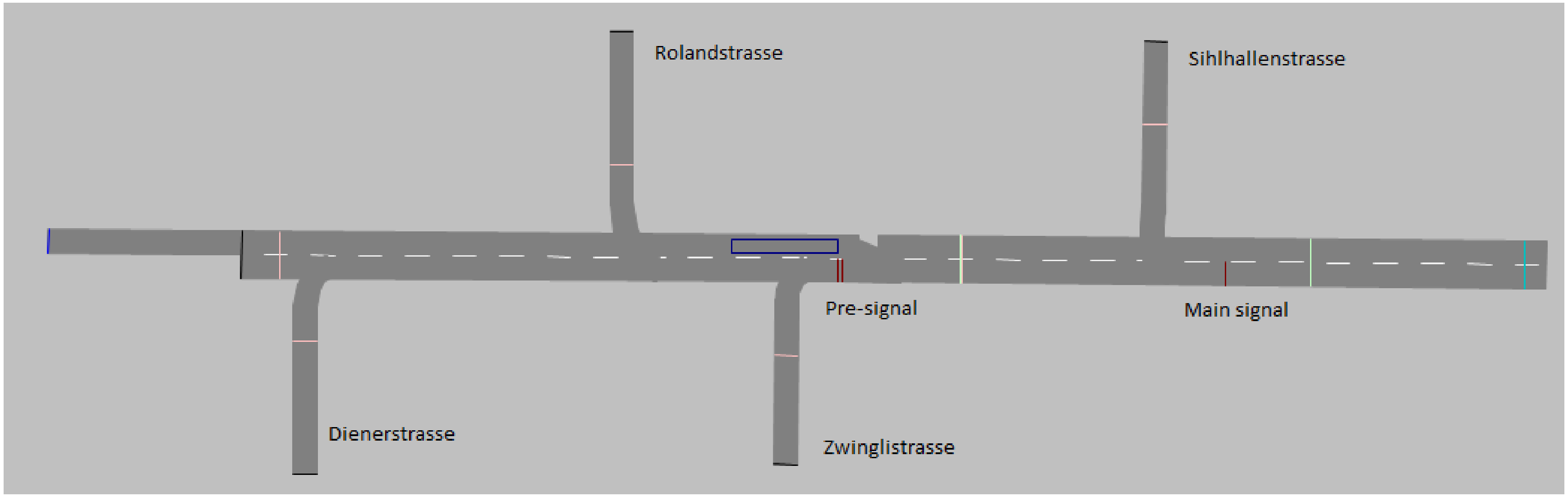
Step 1: Geometry

- Vehicle origins
- Buses



Step 2: Traffic demand

- Traffic flow

	main road	side street 1	side street 2	side street 3	side street 4
data set 1	288.1	28.9	10.6	29.7	13.6
data set 2	346.8	39.5	2.6	7.2	3.3

- Buses (every 450 seconds)
- Large vehicles: trucks and vans of various sizes
- Desired speed and acceleration

Step 3: Signals

- According to average signal length values because the signals are adaptive

Cycle length	Red signal	Green signal	Red pre-signal with bus arriving	Pre-signal off set
52	30	22	12	7

- Main signal: VisSig

- Pre-signal: VisVap

Pre-signal with VisVap

- Constructed with two separate signals
- Normal signal (7 seconds off set)
- Actuated signal (with detection of buses)

VISSIM Simulation

- simulation video clip

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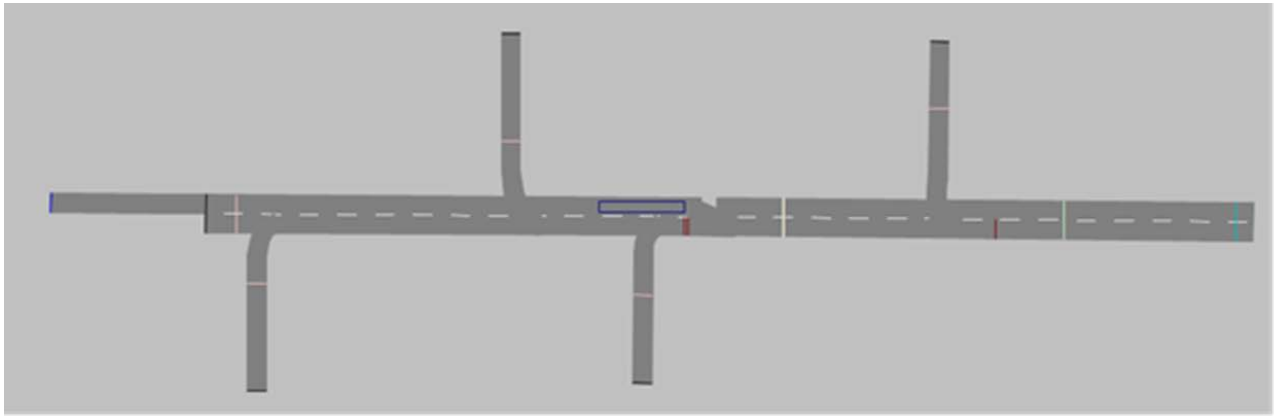
Model calibration

- Computed results are 6 pairs of travel time



Measurement	Vehicle Count	Average travel time (s)	Total travel time (s)
Upstream to PS	302	30.5	9209.2
Side street 4 to PS	21	41.9	880.5
Side street 3 to PS	27	42.1	1137.5
Side street 2 to PS	15	19.1	286.7
PS to MS	363	6.2	2265.9
Side street 1 to MS	28	38.1	1065.8

Model calibration

- We want to calibrate and validate against delay data calculated from empirical measurement

	Cycles	Average delay PS	Average delay MS	Total delay
Data set 1	bus not present	35.0	6.3	41.2
	bus present	36.2	6.4	42.6
Data set 2	bus not present	16.8	5.9	22.7
	bus present	8.2	6.4	14.6

- How do we do this?

  Cycles with buses vs. cycles without buses

Model calibration

- Parameters for calibration: speed, acceleration, large vehicle ratio
- Calibration results with data set 1

	Average delay PS	Average delay MS	Total delay
Measured value	35.0	6.3	41.2
Simulation result	33.5	7.6	40.5

Validation results

SVT

- Validate the simulation model with data set 2
- Run with 10 random seeds

Normal mixed cycles	Up to pre-signal	Pre-signal to main signal	Total
Average travel time	30.4	11.9	40.2
Standard deviation	5.2	0.8	5.3

Without buses	Up to pre-signal	Pre-signal to main signal	Total
Average travel time	28.3	11.0	38.6
Standard deviation	4.1	0.8	4.1

Without signals	Up to pre-signal	Pre-signal to main signal	Total
Average travel time	10.3	5.7	15.4
Standard deviation	0.1	0.1	0.2

Validation results

SVT

- Results

	Average delay PS	Average delay MS	Total delay
Measured value	16.8	5.9	22.7
Simulation result	18.0	5.3	23.2
Standard deviation	4.0	0.8	4.1

- Measured values fall within the range of the simulation results

Conclusions about the simulation model

- The simulation is validated and correctly models the mechanism behind the operation of pre-signals
- The simulation is a good tool to provide direct visual insights
- The simulation must be used with caution when generating exact numerical results

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Red time duration at the presence of buses

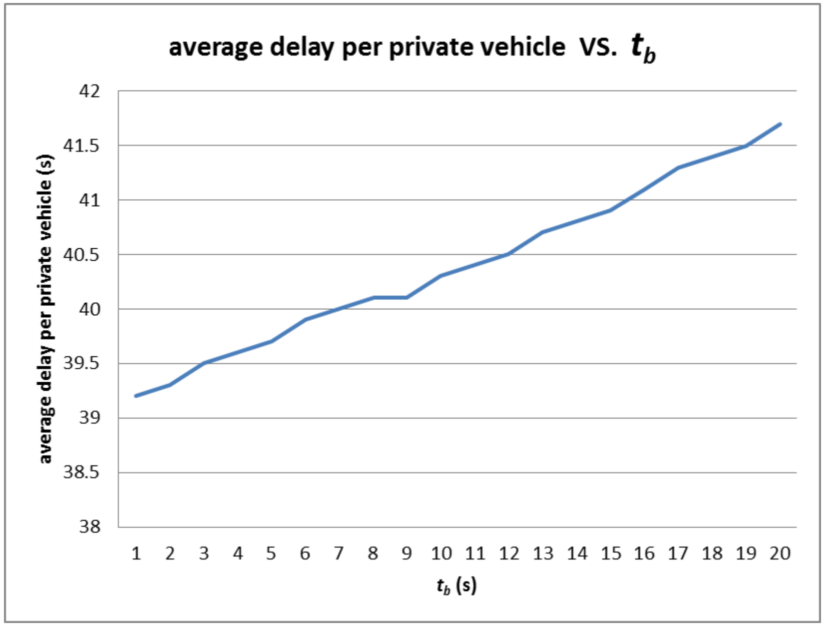
- Question:

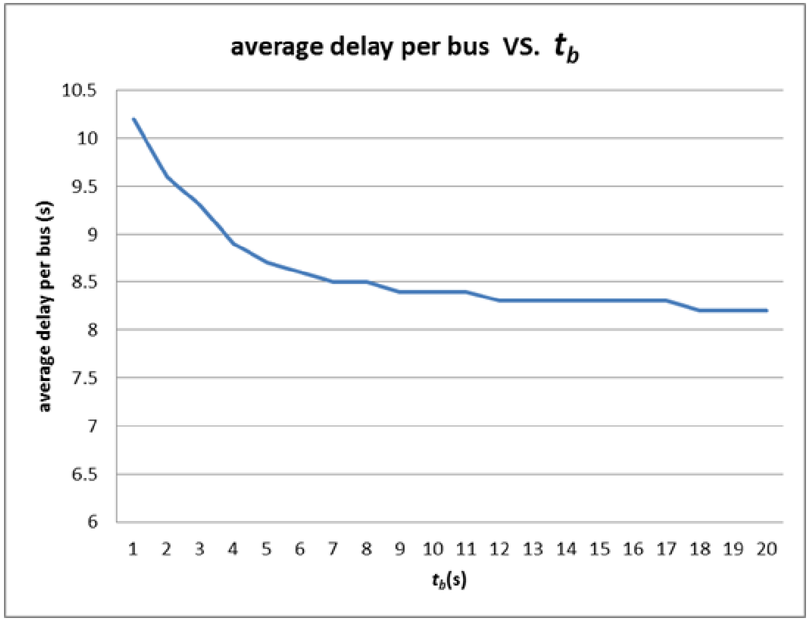
How does this red time duration (t_b)affect the vehicle delay, the bus delay and hence the total system delay?

- Not possible in the analytical model to calculate total system delay with t_b

- t_b is varied between 1-20 seconds in 1 second increments in the simulation

Red time duration at the presence of buses





Red time duration at the presence of buses

- Total system delay with bus occupancy and t_b

Red signal (s)	occupancy	20		occupancy	40		occupancy	60		occupancy	80		occupancy	100	
	Total bus passenger delay (s)	Total car passenger delay (s)	Total system delay (s)	Total bus passenger delay (s)	Total car passenger delay (s)	Total system delay (s)	Total bus passenger delay (s)	Total car passenger delay (s)	Total system delay (s)	Total bus passenger delay (s)	Total car passenger delay (s)	Total system delay (s)	Total bus passenger delay (s)	Total car passenger delay (s)	Total system delay (s)
1	1836	15680	17516	3672	15680	19352	5508	15680	21188	7344	15680	23024	9180	15680	24860
2	1728	15720	17448	3456	15720	19176	5184	15720	20904	6912	15720	22632	8640	15720	24360
3	1674	15800	17474	3348	15800	19148	5022	15800	20822	6696	15800	22496	8370	15800	24170
4	1602	15840	17442	3204	15840	19044	4806	15840	20646	6408	15840	22248	8010	15840	23850
5	1566	15880	17446	3132	15880	19012	4698	15880	20578	6264	15880	22144	7830	15880	23710
6	1548	15960	17508	3096	15960	19056	4644	15960	20604	6192	15960	22152	7740	15960	23700
7	1530	16000	17530	3060	16000	19060	4590	16000	20590	6120	16000	22120	7650	16000	23650
8	1530	16040	17570	3060	16040	19100	4590	16040	20630	6120	16040	22160	7650	16040	23690
9	1512	16040	17552	3024	16040	19064	4536	16040	20576	6048	16040	22088	7560	16040	23600
10	1512	16120	17632	3024	16120	19144	4536	16120	20656	6048	16120	22168	7560	16120	23680
11	1512	16160	17672	3024	16160	19184	4536	16160	20696	6048	16160	22208	7560	16160	23720
12	1494	16200	17694	2988	16200	19188	4482	16200	20682	5976	16200	22176	7470	16200	23670
13	1494	16280	17774	2988	16280	19268	4482	16280	20762	5976	16280	22256	7470	16280	23750
14	1494	16320	17814	2988	16320	19308	4482	16320	20802	5976	16320	22296	7470	16320	23790
15	1494	16360	17854	2988	16360	19348	4482	16360	20842	5976	16360	22336	7470	16360	23830
16	1494	16440	17934	2988	16440	19428	4482	16440	20922	5976	16440	22416	7470	16440	23910
17	1494	16520	18014	2988	16520	19508	4482	16520	21002	5976	16520	22496	7470	16520	23990
18	1476	16560	18036	2952	16560	19512	4428	16560	20988	5904	16560	22464	7380	16560	23940
19	1476	16600	18076	2952	16600	19552	4428	16600	21028	5904	16600	22504	7380	16600	23980
20	1476	16680	18156	2952	16680	19632	4428	16680	21108	5904	16680	22584	7380	16680	24060

Red time duration at the presence of buses

- The range increases with increasing bus occupancy
- Red time duration normally should exceed 10 seconds
- When safety is guaranteed, t_b at Langstrasse should be shorter (currently 12 seconds)

Conclusions

- It is possible to use VISSIM to simulate the operation of pre-signals. This is the foundation for further work on arterial and network cases.
- Numerical results from the simulation have large variance and must be used with caution.
- The red time duration at the presence of buses should be within a range to minimize total system delay, which normally does not exceed 10 seconds.

Questions

Thank You