Measure title: **Traffic Monitoring and Traffic signals**

City: **Malmo** *Project:* **SMILE** *Measure number:* **12.2**

A Introduction

A1 Objectives

Installation of an adaptive traffic signal control system at 10 traffic signals in Malmö. Make use of the adaptive system to control traffic flow, lower emissions and give priority to public transport, cyclists and pedestrians.

This will lead to shorter travel times

The measure objective is

- **That this measure will lead to shorter travel time**

A2 Description

Change of 10 traffic signals in the central part of Malmö. By changing to a new system, with detectors and machines working after modern design principles, the traffic signal can adapt to the actual traffic situation instead of what has been pre-programmed. Furthermore all the traffic signals of this type can be connected with each other and therefore the whole system will work better with less stops and queues. The measure will also include experiments to give priority to buses, pedestrians and cyclists and try to optimise the lowest level of exhaust emissions possible.

The measure will be implemented by the following tasks;
Project planning
Simulation
Groundwork
Installation
Optimising system
System operational

B Measure implementation

B1 Innovative aspects

Innovative Aspects:

- New physical infrastructure solutions

The innovative aspect of the measure is:

- **New physical infrastructure solutions, regionally** – Adaptive traffic signal control is an established way to control traffic, but there is little experience of it in Scandinavia (see report from the CIVITAS-project Trendsetter: Further improvements for a Scandinavian SPOT urban traffic signal control system).
  The Scandinavian way of traffic control is quite different from the philosophy used in the rest of Europe. In Sweden, “group“- and LHOVRA-technique are used. The “group-technique” means that each leg in the intersection forms a group and for each group, one

or more lanes form a stage. LHOVRA is a technique based on detectors 250-300meters from the stop line. The detectors ensure priority for certain traffic, for example large vehicles.

- Due to this there is a need to adjust the adaptive control systems to the Scandinavian way of traffic control. Due to organisation used for traffic control today in Malmö, the city has good possibilities to function as a demonstration site for adaptive traffic signal control in Scandinavia. Experiments show that there is a potential of 10-20% less emissions when using adaptive traffic signal control. The measure will demonstrate how you can use adaptive traffic signal control to lower emissions instead of, as traditionally, solve congestion problems

B2 Situation before CIVITAS

The traffic signals are old with a fix time-setting for on and off peak hours. The city has problems to meet the authorised levels of NO_2 by 2006 in several crossing (se also description below).

The congestion level is high during the morning and afternoon peak hours. During these periods, the traffic speed is low. The queues build up through two or three intersections.

B3 Actual implementation of the measure

The measure was implemented in the following stages:

Stage (task) 1: Project planning: In cooperation with the consultant, the number of detectors (114 detectors) was estimated as well as the number of stages in the program to ensure control over the Utopia/SPOT software. The key optimisation criteria for Utopia/SPOT are travel times and stops.

During the construction period, meetings with the drill contractor as well as the digging contractor were held every week, making sure that problems with existing cables and pipes were minimised.

Stage (task) 2: Simulation: Our supplier lost the consultant responsible for the computer simulation. We decided to wait to the evaluation.

Stage (task) 3: Groundwork: The work was done in two stages: the first stage was to drill and mount cable pipes and install the detector cable in the pipes, the second stage was to do sawing work for the new detectors and connect them. During stage 1, the drill contractor destroyed some water pipes.
In total, 4425 meters of cable and 2527 meters of pipe were installed, 82 connection-wells and 114 detectors were prepared.

Stage (task) 4: Installation: 114 detectors were installed and connected through the connection-wells to the signals. Ten signal-controllers were programmed, tested and started.

Stage (task) 5+6: Optimisation of the whole system started after summer 2008.

B4 Deviations from the original plan

The deviations from the original plan comprised:

- **Deviation 1 :** Task 3, groundwork, was slightly delayed during summer 2008 and as a result of that, the optimisation period was too short. The plan was to start the optimisation of the system in august 2008, but instead, the optimisation period started in november 2008. This is not a remarkable delay considered that this measure has been going on for four years. But the schedule has always been very pressed for the evaluation and with this delay, the optimisation period was too short. This affected the evaluation.

B5 Inter-relationships with other measures

The measure is not related to any other measures.

C Evaluation – methodology and results

C1 Introduction

The main concern of Civitas – Smile is to take measures to sustain a system of transportation more adapted to the environment. One way of doing this is to change the traffic signal system in several road junctions near Dalaplan in the south of Malmö. These junctions have earlier been coordinated with a fixed time plan to provide a green wave during the rush hours.

A description of the mobility of vehicles and the consequence it has on the environment has been presented in a thesis by Lindelöf and Rasic [2006]. A considerable part of their thesis is devoted to describing the traffic situation in the area surrounding Dalaplan.

C1.1 Impacts and Indicators

Table of Indicators.

Nr.	INDICATOR Name	Possible DESCRIPTION	DATA /UNITS
3	Fuel Consumtion	Fuel used per vkm	Liters/10km
10	NO_x emissions	NO_x per vkm	G/vkm, derived
	HC emissions	HC per vkm	G/vkm, derived
	Stop time by vehicle type - peak	Total stop time per vehicle	Seconds per vehicle, quantitative, derived
	Stop time by vehicle type - off peak	Total stop time per vehicle	Seconds per vehicle, quantitative, derived
	Travel time by vehicle type - peak	Total travel time per vehicle	Seconds per vehicle, quantitative, derived
	Travel time by vehicle type - off peak	Total travel time per vehicle	Seconds per vehicle, quantitative, derived
23	Average vehicle speed - peak	Average vehicle speed over network	Km/hr, quantitative, derived
24	Average vehicle speed - off peak	Average vehicle speed over network	Km/hr, quantitative, derived

Detailed description of the indicator methodologies:

- **Indicator 3** (*Fuel Consumption by vehicle and kilometre*) –Data derived by using an instrumented car and drive through the intersections during peak hours.
- **Indicator 10** (*NOx emissions*) – Data derived by using an instrumented car and driving through the intersections during off peak hours.
- **Indicator** (*HC emissions*) – Data derived by using an instrumented car and driving through the intersections during off peak hours.
- **Indicator** (*Stop time by vehicle type* **-** *peak*) – Data derived by using an instrumented car and driving through the intersections during peak hours.

- **Indicator** (*Stop time by vehicle type - off peak*) – Data derived by using an instrumented car and driving through the intersections during off peak hours.
- **Indicator** (*Travel time by vehicle type - peak*) – Data derived by using an instrumented car and driving through the intersections during peak hours.
- **Indicator** (*Travel time by vehicle type - off peak*) – Data derived by using an instrumented car and driving through the intersections during off peak hours.
- **Indicator 23** (*Average Vehicle speed - peak*) – Data derived by using an instrumented car and driving through the intersections during peak hours.
- **Indicator 24** (*Average Vehicle speed - off peak)* – Data derived by using an instrumented car and driving through the intersections during off peak hours.

C2 Utopia/Spot

The system to be evaluated is called Utopia/Spot. It is a coordinated traffic signal system that reacts on the current traffic flows. Utopia/Spot is an adaptive traffic control system that computes optimal traffic signal time plans in real time. It has been developed in Italy and it has been used in approximately 20 cities around Europe. Public transportation was originally prioritised in Utopia/Spot which has been of great advantage.

The purpose of this evaluation is to describe the environmental consequences of the system. By using the VETO model, Hammarström and Karlsson [1987], it was possible to analyse changes in fuel consumptions and the exhaust emissions, with and without the Utopia/Spot system. The VETO model is designed to compute costs and exhaust emissions for different types of road vehicles, road standard, driving behaviour and observed driving patterns.

The evaluation of the system has been made by the Swedish Road Administration (SRA) Consulting Services. Authors of this report are Erik Fransson and Henrik Edwards. Additionaly Carsten Sachse, Jenny Eriksson and Maria Varedian where involved in the work.

C3 Routes

To evaluate the system, three (3) routes were chosen in the area. The selected routes were in principle the same as those in the LTH (Lund University, Faculty of Engineering) thesis, except for a few adjustments. Data was collected before the system was implemented, one day per route, Tue, Wed and Thu (Nov 18, 19 and 20, 2008. It was collected from rush hour traffic in the morning 07 - 09, lunch traffic 11 - 13 and in the afternoon rush hour 15 - 18 (times are approximate). All routes were driven in both directions. The data collection was repeated the following week, after the system had been implemented (Nov 25, 26 and 27, 2008).

In this report 8 of the 10 junctions with Utopia/Spot are included. Two evaluated routes contain three Spot-signal systems each and one route contains 4 Spot-signal systems. For more information about the routes, see Figure 1 and the text below. Latitude and longitude coordinate units are degrees in hours, minutes and fractional minutes.

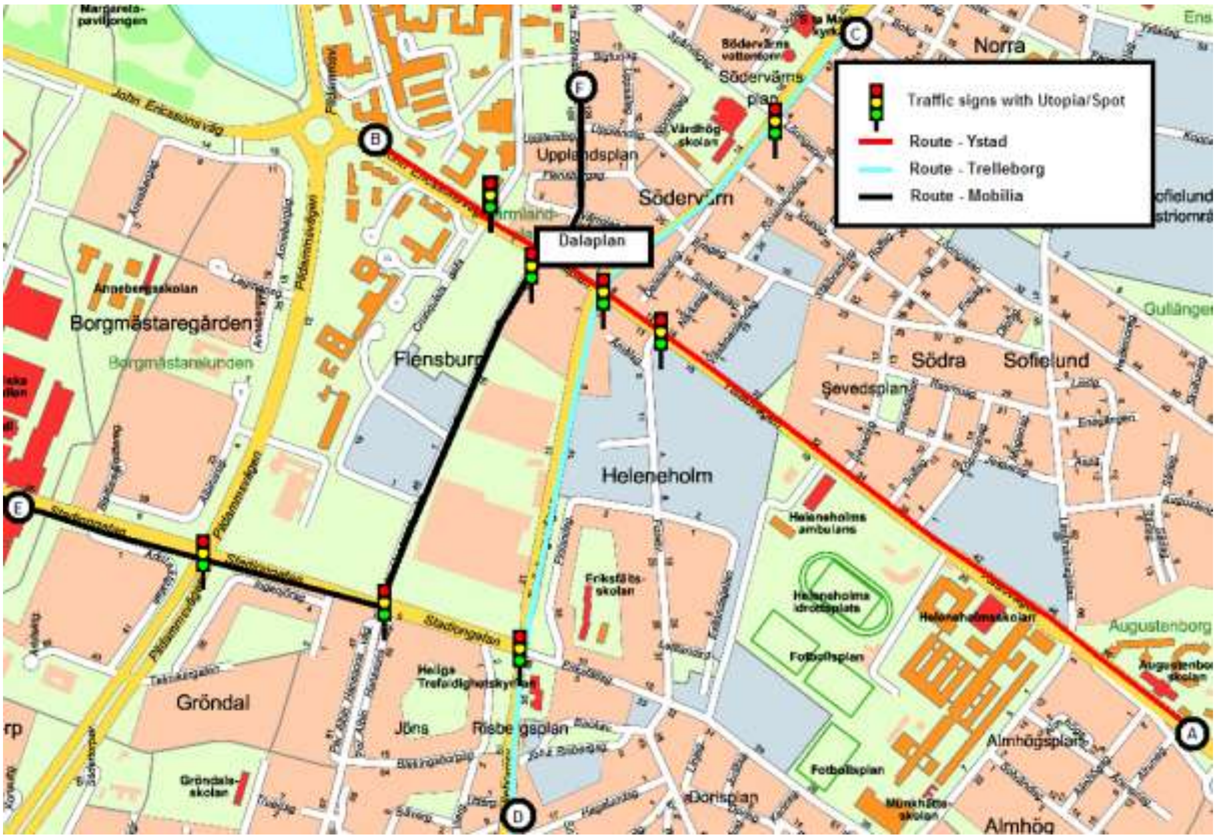

Figure 1. Evaluation routes in Malmö.

C3.1 Route – Ystad (red)

Description: From S. Grängesbergsgatan to Pildammsvägen (A to B, direction 1).
Length: Approximately 1.6 km.
Includes 4 traffic signals with Utopia/Spot.
Data was collected on Nov 20 and Nov 27 (before and after Spot-installation).
Coordinates A: (5534.846, 1259.432)
Coordinates B: (5535.183, 1300.372)

C3.2 Route – Trelleborg (green)

Description: From north of Spårvägsgatan to south of Stadiongatan (C to D, direction 1).
Length: Approximately 1,6 km.
Includes 3 traffic signals with Utopia/Spot.
Data was collected on Nov 19 and Nov 26 (before and after Spot-installation)
Coordinates C: (5535.298, 1300.771)
Coordinates D: (5534.542, 1300.289)

C3.3 Route – Mobilia (blue)

Description: From east of Pildammsvägen to Sigtunagatan (E to F, direction 1).
Length: Approximately 1.6 km.
Includes 3 traffic signals with Utopia/Spot.
Data was collected on Nov 18 and Nov 25 (before and after Spot-installation)
Coordinates E: (5534.672, 1301.416)
Coordinates F: (5535.159, 1300.120)

C4 Method - Chase car

In this evaluation study, the data collection was executed by Franzén Transport & Machine Consultation. The method used is called Chase car with shifting target. It was made by using an instrumented car from LTH to follow a selected target-vehicle during each drive. Should the target depart from the route during the drive, another target was immediately selected.

Data collected by LTH's measurement vehicle were observations of time, speed and position was made with a frequency of 5 times per second. Raw data was processed with LTH's program Estva before carrying out the analysis with the Veto model. Estva is a method and software developed at LTH for statistical estimation and correction of collected speeds and accelerations from instrumented vehicles, see Bratt and Ericsson [1999]. For evaluating the effects in terms of fuel consumption and exhaust emissions the Veto model was used. The vehicle input data for Veto were engine maps and other data, on the one hand for a Volvo 940, and on the other for a Renault Kangoo.

Before simulating the estva-adjusted driving profiles with Veto, we had to retrieve the appropriate part of the collected data using the logged coordinates from the GPS-system. With these data, it was possible to extract the driving profile parts from the estva program output corresponding to the start/end coordinates for the routes provided in the route descriptions above.

When analysing and discussing the results, it is important to keep in mind that the Spot/Utopia-system does not provide an optimal signal control from day one. On the contrary, it often takes weeks or months for an adaptive system like this to provide a good result.

Of importance is also the fact that parts of the Spot-system were out of order in the after-period. The Ystad-route was affected on Tue Nov 25, 07:00-09:00. The system did not work as it should at traffic signal Ystadvägen/Fogdievägen. More serious is the fact that all routes were affected Wed Nov 26, 07:00-09:00 when a traffic signal at Dalaplan did not work according to the algorithms.

C5 Measured results – Basic data

C5.1 Veto data

As presented in Table 1 travel time data is separated into *before* and *after* the implementation of the Utopia/Spot system. All routes have been driven at least 30 times in the *before* situation and 30 times in the *after* situation in each direction.

Between 07:00 and 10:00 in the morning the travel times increased in both directions on all routes except Mobilia, direction 2. During the lunch hours, between 11:00 and 13:00 the travel times also increased on all routes except Ystad, direction 1. When it comes to the afternoon traffic between 15:00 and 18:00, there are mostly increasing travel times except for direction 2 on the Trelleborg route and on the Ystad route. The pattern is obvious, travel times have increased after the implementation of the system.

Table 1. Observed travel times.

Time	Location		Direction 1			Direction 2		
			Time (sec)	Stand. dev	Repe-titions	Time (sec)	Stand. dev	Repe-titions
07 - 09	Mobilia	Before	205.43	37.34	10	217.07	49.14	10
		After	216.45	40.88	10	212.93	54.84	10
	Trelleborg	Before	165.75	26.67	10	161.33	18.46	10
		After	173.07	32.43	10	191.94	25.28	10
	Ystad	Before	206.71	42.48	10	210.64	51.57	10
		After	214.96	67.26	11	217.14	25.62	11
11 - 13	Mobilia	Before	245.10	35.94	10	204.16	41.71	10
		After	253.30	67.46	10	234.25	41.45	10
	Trelleborg	Before	186.62	25.24	10	184.43	19.62	10
		After	209.82	38.20	10	202.10	47.52	10
	Ystad	Before	203.58	20.08	11	201.95	21.67	11
		After	189.08	25.24	11	210.72	37.06	11
15 - 18	Mobilia	Before	252.42	51.68	13	236.53	51.84	13
		After	403.52	117.66	11	242.38	35.66	11
	Trelleborg	Before	202.09	41.93	11	240.63	57.53	11
		After	203.42	40.56	12	227.21	35.78	12
	Ystad	Before	229.82	25.45	14	244.42	40.88	14
		After	232.38	60.46	13	332.12	88.79	13

Similar conclusions can be drawn by studying Table 2. This table shows the total stop time of the routes. As seen in Table 2, 11 out of the 18 analysed cases (9 period pairs and 2 directions) have increased total stop times.

Table 2. Observed stop times

Time	Location		Direction 1			Direction 2		
			Stop (sec)	Stand. dev	Repe-titions	Stop (sec)	Stand. dev	Repe-titions
07 - 09	Mobilia	Before	29.34	20.35	10	51.37	40.17	10
		After	44.76	32.25	10	46.48	39.79	10
	Trelleborg	Before	23.13	23.76	10	25.09	15.56	10
		After	24.47	25.02	10	37.51	19.98	10
	Ystad	Before	36.35	24.73	10	45.07	26.77	10
		After	44.53	39.88	11	45.34	34.27	11
11 - 13	Mobilia	Before	69.73	29.73	10	37.02	29.56	10
		After	63.63	57.24	10	48.87	32.47	10
	Trelleborg	Before	33.12	24.46	10	31.22	14.61	10
		After	56.90	29.96	10	48.35	34.66	10
	Ystad	Before	43.19	15.44	11	40.25	13.22	11
		After	22.33	15.94	11	39.17	37.85	11
15 - 18	Mobilia	Before	60.08	38.87	13	56.86	37.85	13
		After	177.56	98.65	11	58.40	33.91	11
	Trelleborg	Before	44.27	31.41	11	72.15	45.06	11
		After	43.46	33.32	12	62.45	31.41	12
	Ystad	Before	58.97	20.05	14	55.07	23.77	14
		After	43.61	42.51	13	112.06	50.46	13

When looking at effects on traffic, speed plays an important role. The results in Table 3 show that the speeds have decreased in 13 of the 18 analysed cases.

Table 3. Observed speeds

Time	Location		Direction 1			Direction 2		
			Speed (km/h)	Stand. dev	Repe-titions	Speed (km/h)	Stand. dev	Repe-titions
07 - 09	Mobilia	Before	28.08	5.47	10	27.26	7.34	10
		After	26.72	4.98	10	27.87	7.30	10
	Trelleborg	Before	34.84	5.80	10	34.36	3.71	10
		After	33.86	6.53	10	29.02	3.86	10
	Ystad	Before	29.34	4.98	10	29.64	5.15	10
		After	27.82	6.67	11	28.12	3.57	11
11 - 13	Mobilia	Before	22.98	3.82	10	28.51	5.98	10
		After	23.33	5.31	10	24.68	4.41	10
	Trelleborg	Before	30.79	4.36	10	30.04	3.27	10
		After	27.91	5.64	10	28.72	7.47	10
	Ystad	Before	29.19	2.89	11	29.46	3.06	11
		After	31.64	4.24	11	28.68	4.73	11
15 - 18	Mobilia	Before	23.09	4.93	13	24.59	4.69	13
		After	14.96	4.64	11	23.54	3.81	11
	Trelleborg	Before	29.17	6.63	11	24.18	6.83	11
		After	28.89	6.05	12	24.71	3.74	12
	Ystad	Before	25.90	2.57	14	24.62	3.75	14
		After	26.79	6.20	13	19.27	5.18	13

On the matter of fuel consumption we found an increase in 10 of the 18 analysed cases, cf Table 4.

Table 4. Observed fuel consumption Volvo 940

Time	Location		Direction 1			Direction 2		
			Fuel (dm^3 /10km)	Stand. dev	Repe-titions	Fuel (dm^3 /10km)	Stand. dev	Repe-titions
07 - 09	Mobilia	Before	1.09	0.14	10	1.20	0.24	10
		After	1.12	0.19	10	1.20	0.24	10
	Trelleborg	Before	1.14	0.21	10	0.93	0.15	10
		After	1.14	0.21	10	1.03	0.16	10
	Ystad	Before	1.12	0.14	10	1.05	0.17	10
		After	1.19	0.28	11	1.09	0.13	11
11 - 13	Mobilia	Before	1.29	0.22	10	1.19	0.20	10
		After	1.25	0.19	10	1.36	0.21	10
	Trelleborg	Before	1.29	0.16	10	1.12	0.14	10
		After	1.29	0.24	10	1.19	0.26	10
	Ystad	Before	1.12	0.15	11	1.15	0.15	11
		After	1.10	0.14	11	1.12	0.14	11
15 - 18	Mobilia	Before	1.21	0.19	13	1.28	0.21	13
		After	1.59	0.27	11	1.35	0.13	11
	Trelleborg	Before	1.31	0.20	11	1.26	0.23	11
		After	1.26	0.23	12	1.16	0.18	12
	Ystad	Before	1.15	0.10	14	1.20	0.15	14
		After	1.19	0.20	13	1.46	0.31	13

In Table 5 the same corresponding results for the Renault Kangoo data, fuel consumption increased in 11 of the 18 cases.

Table 5. Observed fuel consumption Renault Kangoo

Time	Location		Direction 1			Direction 2		
			Fuel (dm^3 /10km)	Stand. dev	Repe-titions	Fuel (dm^3 /10km)	Stand. dev	Repe-titions
07 - 09	Mobilia	Before	0.88	0.08	10	0.96	0.13	10
		After	0.90	0.12	10	0.96	0.14	10
	Trelleborg	Before	0.97	0.14	10	0.78	0.10	10
		After	0.96	0.14	10	0.84	0.10	10
	Ystad	Before	0.91	0.08	10	0.85	0.10	10
		After	0.97	0.18	11	0.90	0.09	11
11 - 13	Mobilia	Before	1.00	0.13	10	0.95	0.13	10
		After	1.00	0.13	10	1.09	0.14	10
	Trelleborg	Before	1.04	0.11	10	0.90	0.10	10
		After	1.05	0.17	10	0.94	0.18	10
	Ystad	Before	0.92	0.09	11	0.90	0.08	11
		After	0.91	0.10	11	0.91	0.09	11
15 - 18	Mobilia	Before	0.95	0.12	13	1.01	0.13	13
		After	1.18	0.15	11	1.08	0.07	11
	Trelleborg	Before	1.07	0.12	11	1.00	0.15	11
		After	1.04	0.14	12	0.94	0.13	12
	Ystad	Before	0.94	0.07	14	0.95	0.10	14
		After	0.99	0.12	13	1.12	0.21	13

C5.2 Traffic flows

The city of Malmö has detected the traffic flows in the area at the time of the chase car during the first week of the evaluation, before the implementation of the Utopia/Spot system. Figure 2 shows three (3) points that were chosen for traffic detection, numbers 1 and 2 on route-Ystad and number 3 on route-Trelleborg. The traffic flow during two consecutive weeks is under normal circumstances (as for this period) quite the same, according to experience in Malmö

Figure 2 – Measure points

The traffic volumes are quite even on all 3 points detected around Dalaplan. The volume is approximately 10 000 vehicles per leg and per direction Monday to Friday. The traffic flow during the evaluated periods of time is presented in Table 6. In all 3 measure points direction 1 is targeting Dalaplan. In the morning, Trelleborgsvägen has a high traffic flow targeting Dalaplan. In the afternoon Ystadvägen, direction 1 has the highest traffic flow.

Table 6. Traffic flows

Time	Nr	Street	Vehicles / hour	
			Dir. 1	Dir. 2
07:00-09:00	1	John Ericssons väg	830	780
	2	Ystadvägen	723	883
	3	Trelleborgsvägen	1101	524
11:00-13:00	1	John Ericssons väg	614	667
	2	Ystadvägen	790	734
	3	Trelleborgsvägen	608	520
15:00-18:00	1	John Ericssons väg	854	885
	2	Ystadvägen	1036	880
	3	Trelleborgsvägen	766	905

C6 Statistical significance

According to Tables 1 – 3, travel times, stop times and speeds were influenced by the implementation. However, whether the differences between the before and after situations are significant needs to be tested.

C6.1 The Paired *t* Test

The basic null hypothesis is that there is not any difference in the results between the *before* and *after* situations. To study whether this hypothesis is valid we compare the pairwise differences in the results from the before and after situations by applying this *t* test. The basis for using this test is that the observations are normally distributed with unknown standard deviations and relatively small sample sizes. A suitable theory reference is Devore and Peck [1996].

The t statistic to test whether the means are different can be calculated as follows:

$$t = \frac{\overline{X}_1 - \overline{X}_2}{s_{\overline{X}_1 - \overline{X}_2}}$$

$$s_{\overline{X}_1 - \overline{X}_2} = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$$

Where:

$\overline{X}_i$ = Sample mean for *i* = *before=1, after=2*

s_i^2 = Sample variance for *i* = *before=1, after=2*

n_i = Sample size for *i* = *before=1, after=2*

C6.2 *t* distribution

In Tables 7 and 8 below we show the results from a double sided t-test in terms of the probality mass (in %) lying outside the range [-|t|, |t|] of the *t* distribution with degrees of freedoom equal to $n_{before} + n_{after} - 2$ (p-value). For the individual test to be significant at the 5 % - level the values in the cells of Tables 7 and 8 should be less than 5.0.

C6.2.1 Volvo 940

The effects are mostly not significant without any clear patterns in the data. However, there are some effects below the 5 % limit. Comparing with Tables 1 - 3 we find only negative effects, longer driving and stop times and lower speeds.

Table 7. t-test results based on Volvo 940 data for Veto (p-value = probability mass outside ratio |t|).

Time	Location	Time		Stop		Speed		Fuel		Nox		HC	
		% Dir. 1	% Dir. 2	% Dir. 1	% Dir. 2	% Dir. 1	% Dir. 2	% Dir. 1	% Dir. 2	% Dir. 1	% Dir. 2	% Dir. 1	% Dir. 2
07 - 09	Mobilia	52.3	83.3	21.7	78.7	57.1	83.5	74.4	100.0	69.0	76.7	43.0	80.3
	Trelleborg	59.8	**0.6**	90.4	13.8	73.9	**0.6**	99.6	17.8	96.9	88.7	79.9	92.1
	Ystad	74.9	71.9	57.5	98.4	55.8	43.8	42.1	64.4	44.3	65.2	76.1	88.4
11 - 13	Mobilia	73.8	13.0	76.8	40.5	88.1	12.6	71.0	7.1	70.4	6.6	30.8	6.2
	Trelleborg	12.6	28.9	6.8	16.7	21.7	61.5	97.6	46.1	41.4	65.7	76.6	13.0
	Ystad	13.8	51.8	**0.5**	93.0	11.7	66.3	69.3	63.7	85.6	65.3	34.3	29.7
15 - 18	Mobilia	**0.1**	73.9	**0.1**	91.7	**0.0**	56.9	**0.1**	35.6	61.8	8.7	**0.2**	36.1
	Trelleborg	92.9	51.9	95.3	55.9	90.6	83.0	61.6	24.3	43.8	52.4	61.4	53.2
	Ystad	86.9	**0.3**	24.7	**0.1**	65.8	**0.6**	60.5	**1.4**	8.1	13.8	70.6	6.0

C6.2.2 Renault Kangoo

Similar results are presented in Table 8. Only a few routes show a significant change after the implementation of the system.

Table 8. t-test results based on Renault Kangoo data for Veto (p-value = probability mass outside ratio |t|).

Time	Location	Time		Stop		Speed		Fuel		Nox		HC	
		% Dir. 1	% Dir. 2	% Dir. 1	% Dir. 2	% Dir. 1	% Dir. 2	% Dir. 1	% Dir. 2	% Dir. 1	% Dir. 2	% Dir. 1	% Dir. 2
07 - 09	Mobilia	53.7	86.1	21.7	78.7	56.9	85.4	67.2	93.4	58.1	90.9	32.3	85.8
	Trelleborg	58.8	**0.6**	90.4	13.8	72.6	**0.6**	88.5	16.2	56.1	17.9	85.6	9.2
	Ystad	73.8	72.3	57.5	98.4	55.9	44.4	35.2	28.5	26.9	76.7	36.3	39.4
11 - 13	Mobilia	73.8	12.3	76.8	40.5	86.7	12.1	96.4	**3.7**	57.1	**2.6**	75.6	**4.4**
	Trelleborg	12.6	29.1	6.8	16.7	21.7	61.7	90.4	52.1	33.3	43.0	5.8	12.5
	Ystad	15.2	50.6	**0.5**	93.0	12.9	65.2	79.9	82.2	88.7	63.3	**1.9**	18.5
15 - 18	Mobilia	**0.1**	74.8	**0.1**	91.7	**0.0**	55.1	**0.1**	15.9	**0.1**	34.0	**0.2**	81.1
	Trelleborg	93.9	51.3	95.3	55.9	91.7	82.3	62.3	28.5	37.2	33.0	76.3	16.8
	Ystad	88.8	**0.3**	24.7	**0.1**	63.5	**0.5**	20.6	**1.5**	40.4	**1.8**	58.1	**1.1**

C7 Summary of evaluation results

A significance level at 5 % means that even if the null hypothesis is true we would expect 5 % of test cases to turn out as significant, in our case that would be one case approximately. We have 3-4 cases satisfying the 5 % level in Tables 7 and 8, but they all, with a few exceptions, display a negative development: longer driving and stop times, lower speeds, higher fuel consumption and higher exhaust emissions.

Should many of the differences have turned out significant, we would have followed up these individual t-tests with a simultaneous test comprising all routes and time periods, but with so few individually significant results we skip this.

The key results are:

- **Key result 1** – The comparison between the before and after situations does not display significant changes in the evaluated effects: time, speed, fuel consumption and exhaust emissions.
- **Key result 2** – If anything, the limited individual significance comparison displays a negative impact from introducing the Spot/Utopia system.

There are a number of possible explanations for this result, of which some already are mentioned, namely:

a) During parts of the *after* evaluation period the Spot-systems were not fully operational

b) Experience says that it takes weeks or even months for the adaptive signal control system to reach the "optimal" control. One observation was that the cycle time had increased from 80 seconds to 130 seconds.

c) Technical problems may have been present, for example the communication between traffic detection devices and the Spot-system

d) Possibly the Spot-system could be setup for public transit priority setting (we don't have any evidence of this).

References

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C8 Achievement of quantifiable targets

This measure has no quantifiable targets. The objective is shorter travel times through these signals and as an effect of that increases in fuel consumption, but no actual target for this is presented. The evaluation shows no significant change in travel times. If anything, the limited individual significant comparison displays a negative impact from introducing the Spot/Utopia system.

No.	Target	Rating
1	**shorter travel time**	★
NA = Not Assessed ★ = Not achieved ★★= Achieved in full ★★★= Exceeded		

C9 Up-scaling of results

The results are not significant and somewhat point in the wrong direction. The SPOT-system was probably not working properly and optimally during the test period. Therefore there is no reason to up-scale the results at this point. It is better to wait until a proper after-study can be made and then draw conclusions concerning up-scaling.

C10 Appraisal of evaluation approach

Due to the time pressure for the SPOT-system to be trimmed and due to the fact that during the after-study parts of the SPOT-system was out of order, the data collected for the "after-period" were not the best available. But this is not an effect of the method chosen or the evaluation approach. We did the evaluation as late as possible during 2008.
It will be possible to repeat this after study when the system is working properly and when a few months of optimisation has passed – but this will not be included in the SMILE project.

D Lessons learned

D1 Barriers and drivers

D1.1 Barriers

- **Barrier 1** – Delay in optimisation could have affected the evaluation results as the optimisation period was too short to give this measure enough time to embed and function before collecting the after data on travel times and emissions
- **Barrier 2** – There is only one supplier of adaptive traffic signal control technology in Sweden which can affect the quality of work in absence of competition and comparative analysis of more suppliers
- **Barrier 3** – Apparent negative results of evaluation could potentially deter the implementation of this system elsewhere in Scandinavia despite its potential environmental and traffic management benefits

D1.2 Drivers

- **Driver 1** – Traffic control organisation in Malmo means the city has good possibilities to function as a demonstration site for adaptive traffic signal control in Scandinavia
- **Driver 2** – The traffic signals in Malmo are old with a fixed time setting for off peak hours and the Scandinavia way of traffic control is quite different from the European philosophy which make introducing adaptive traffic signal control ideal
- **Driver 3** – Adaptive traffic signal control system can help reduce traffic emissions by managing traffic flows effectively
- **Driver 4** – Adaptive traffic signal control system has been developed in approximately 20 cities in Europe which is good for lessons learning and sharing ideas and experiences
- **Driver 5** – Adaptive traffic signal control can adapt to the actual traffic situation and can work with signals of this type to reduce traffic stopping and traffic queues, reduce emissions and bring environmental benefits

D2 Participation of stakeholders

- **Stakeholder 1 –** Transport and traffic department of Malmö Stad Gatukontoret City of Malmö Street and Parks Department
- **Stakeholder 2** – Public transport users; about 90,000 people use public transport in Malmo every day and some travel in Dalaplan
- **Stakeholder 3** – Car drivers; every day about 25,000 vehicles travel in Dalaplan in Malmo

D3 Recommendations

- **Recommendation 1 –** To measure the success of adaptive traffic signal control and evaluate its results the system needs to be in place and running for some months; after surveys need to be repeated again to gain better and more reliable data and results of this system
- **Recommendation 2** – It is recommended to seek information from similar projects in Europe to learn from their experiences and apply their knowlwdge in Malmo
- **Recommendation 3** – It is recommended to establish the reasons why this measure has not reduced travel times rather than guess the possibilities in order to mitigate the problems and engage in a process of finding the most appropriate solutions to make this system achieve its potential to bring wider benefits

D4 Future activities relating to the measure

Further activities are not specified in the measure template; however recommendations can be seen as future activities.