Global emission estimation by using probe vehicles

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Abstract

Air pollution is becoming a more and more important aspect for transportation, particularly car emission in urban area.
The objective of this paper is to evaluate the global emission of a transport network based on probe car and sensor data. Probe vehicles allow an accurate estimation of the emission at different points in the network and these results could be extrapolated to the whole network by using traffic sensor data.
To begin, data emission which can be extracted from probe car must be tested. Therefore, the first task is an evaluation of the differences between the simulated vehicle emission (provided by using the microsimulator; AIMSUN) and estimation of vehicle emission from a sample of simulated vehicles representing the population of probe vehicles.
The aim of the second part of this study is to determine the optimal penetration rate of probe vehicles. Then, the global emission and its accuracy could be determined.
This methodology shows that using probe car gives good estimation of the real data emission (90-95 %). Furthermore, depending of the network configuration a penetration rate of 10-15 % of probe car is enough to obtain satisfactory results of the global emission data.

Keys-words*: Probe vehicles, environmental aspect, vehicle emission, global emission, Microsimulation.*

1 - Introduction

Air pollution is becoming a more and more important aspect for transportation, particularly car emission in urban area. Using probe vehicles could allow evaluating the global urban emission by extrapolation. In order to know the confidence of these extrapolate values, analysis must be done by using a traffic simulator, AIMSUN NG.
The microsimulator AIMSUN NG developed by the Polytechnical University of Catalunya in Spain allows evaluating different physic characteristics as pollutant emission. By splitting vehicle in two categories (rates depending of the study), it allows extracting global and sample values as output.

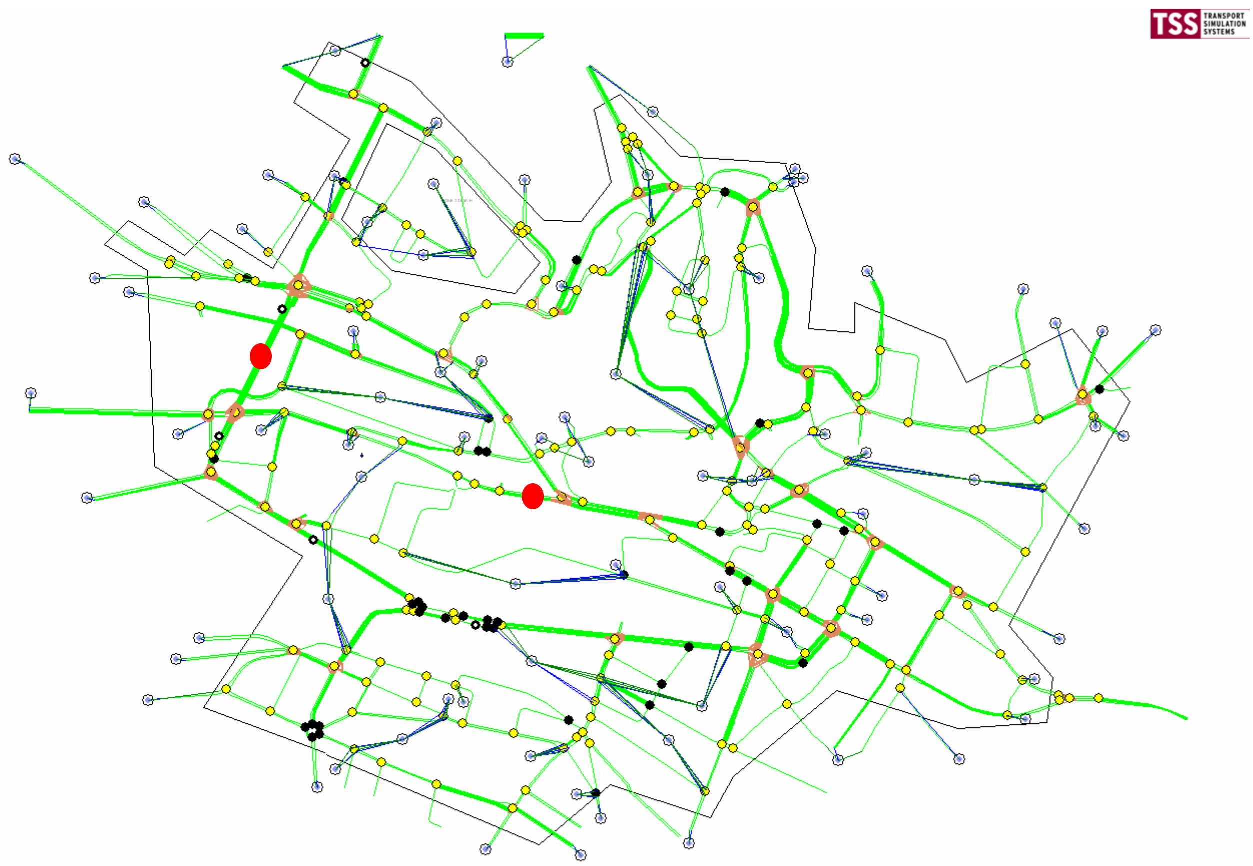
2 - Objectives

The objective of this study is to determine the optimal penetration rate of probe vehicles in the network for a must representative evaluation of the global emission. Then, depending of this rate, the global emission and the accuracy given by the sample will be determined.

3 – Network

The study presented in this article is based on the Lausanne city centre's network (Switzerland). This is a 2 km x 2 km (4 Km^2) perimeter area representing a dense network where all the roads have been considerate (except dead ends or without possible transit roads). Congestion during evening rush hours can be considered as moderate even if, some arterials are over loaded (particularly on the city centre exits and entrances).

The following figure represents the modelled network in green. Junctions are represented by circles and the perimeter's limits are in black.



The different characteristics of the network are summarised in the following table.

Sections	1'351	Nodes	241
Polysection	524	Traffic light	49
OD Matrix size	80 * 80	Simulation time	19h00 – 20h00

In AIMSUN, there is a special distinction between a section and a polysection. The latter one is a combination of sections. In this network, polysections are formed by an average of four sections. This represents dense network with short distance between junctions.
The network has been modelled with all the horizontal and vertical signalisation and fixed traffic light.

4 – Demand

The original matrix for the network has been provided with the help of the macroscopic EMME/2 software. It is a static one hour matrix for the evening peak period.
Two different matrices have been used to represent different traffic conditions. The first matrix with 14’800 vehicles / hour during the simulation represents heavy traffic condition with an average of 20 vehicles / km in the whole network. Second traffic condition represents a lighter utilisation of the network with 11’500 vehicles / hour and 10 vehicles / km.

To represent probe vehicle, two categories of cars have been created by splitting the original matrix in groups depending of the percentage of floating cars. Several proportions of probe vehicle have been tested (75 %, 50 %, 20 %, 10 %, 5 %, 2 %, 0.5 %, and 0.1 %). The microsimulator provides information for the whole car fleet and for the probe vehicle. By this way, data from the probe vehicle can be compared to the global reference emission data.

5 – Emissions

AIMSUN calculates the emission product by the different vehicle in the network. It takes into account acceleration, deceleration and car speed of each users of the network.

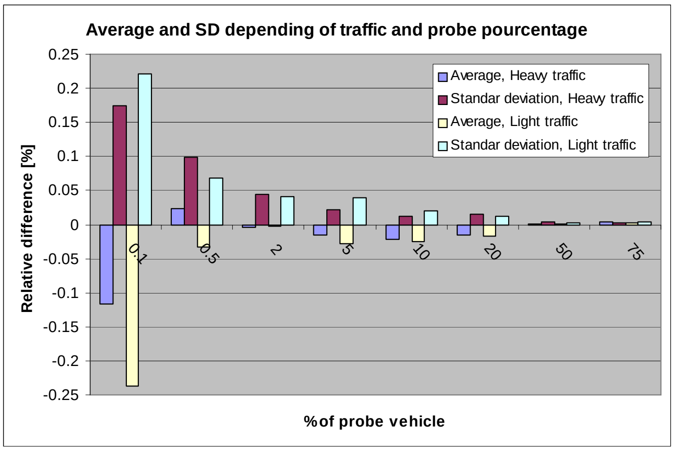
Depending of the behaviour of the car in the network, data used for this study for CO emission are:

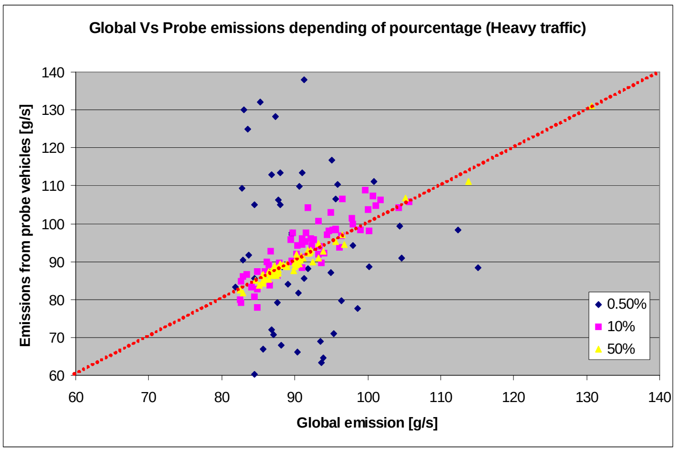
Emission rates for cars (g/s)	CO
Idling emission rate (g/s)	0.06
Accelerating emission rate (g/s)	0.377
Decelerating emission rate (g/s)	0.072
Cruising emission rate (g/s) :	
10 (km/h)	0.06
20	0.091
30	0.13
40	0.129
50	0.09
60	0.11

6 – Results

The outputs have been analysed to extract the global values but also link analysis.

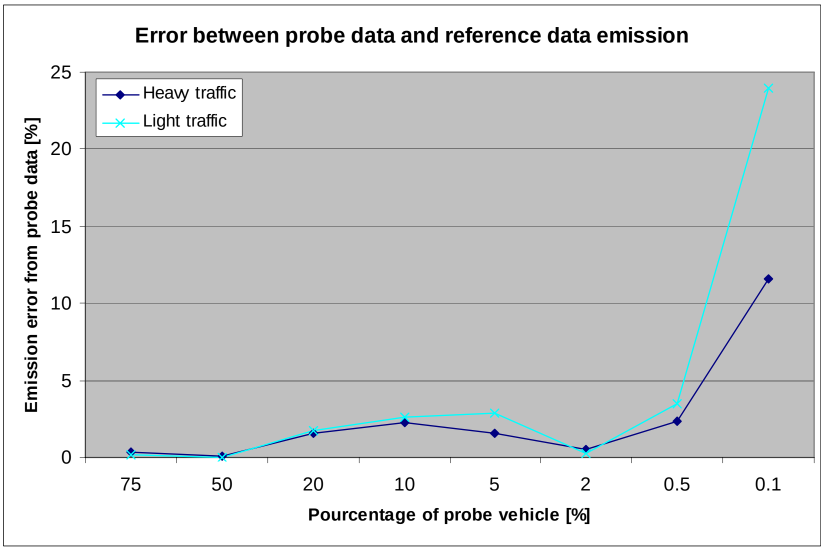
In the global results, the whole network and cars are considerate.
The following graphics show the difference of the mean and standard deviation depending of the rate value and traffic conditions.





Lower is the percentage of probe vehicle; less is the accuracy of the sample data comparing to the reference values (global emission).

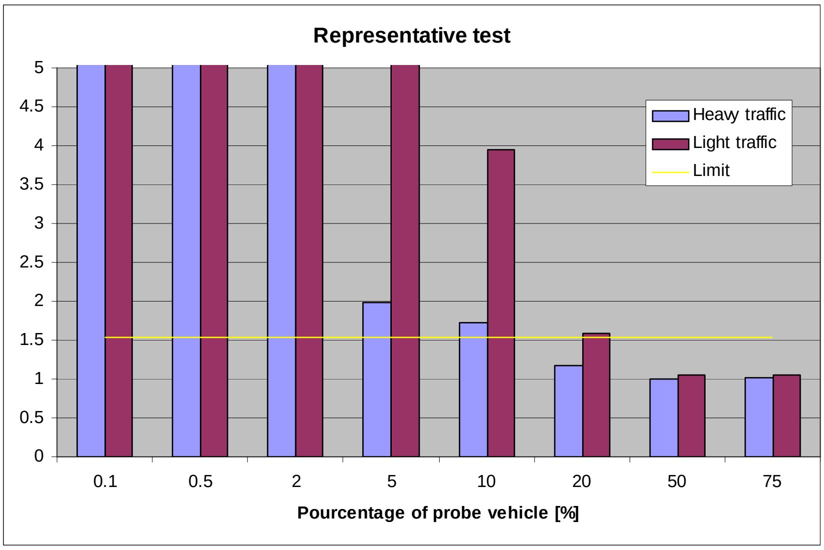
Depending of the number of probe vehicle, the error between what is measured by the sample and the observed value is the following.



To obtain error below 5 %, you must use at least around 2 % of probe vehicle.

This accuracy has been calculated for the total emission data, but a test has to be done to evaluate if the sample represents statistically the global data.

The test of representatively (Homogeneity of variance) show us the minimum rate of probe vehicle needed to obtain relevant information about the total emission data.

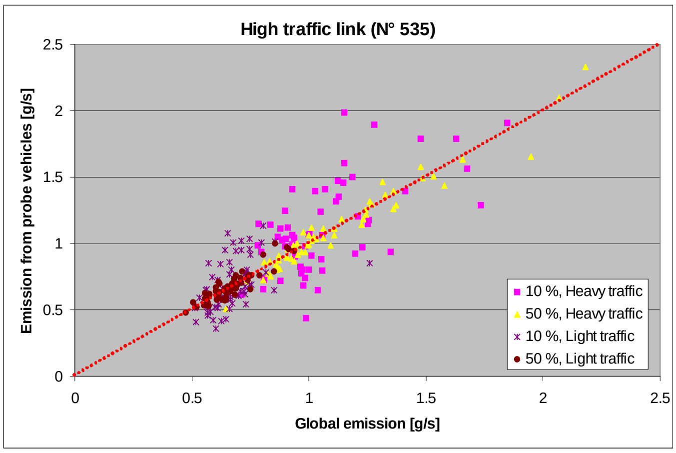


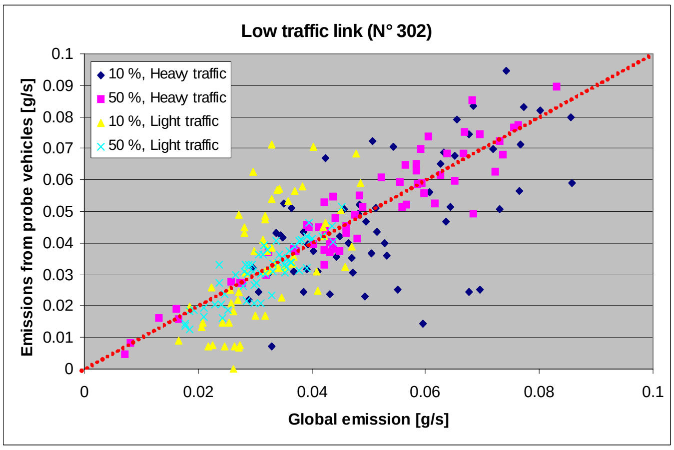
This minimum percentage of probe vehicle is between 10 % and 15 % in heavy traffic conditions and between 20 % and 25 % for lighter traffic conditions

To complete the study, values for 2 links have been extracted to see the difference whether you are interesting at local emissions data instated of global values.
The links chosen to be analysed (see red point in the perimeter area map) are different in term of utilisation. The first one (left one, N° 535) is a heavy traffic link (density around 18 veh/km) and the other one (N° 302) is less used (density: 6 veh/km).
These two links have been tested in the two traffic condition presented in “Demand”.

Like previously, mean and standard deviation have been analysed, a representatively test (Homogeneity of variance) has been done and the error have been evaluated.

Probe-global points graph shows the accuracy of the sample data depending of its size.





Minimum number of probe vehicle obtained with the homogeneous of variance's test to represent the global emission of one link from sample data (depending of the link and global traffic condition):

		Link traffic condition	
		High	Low
Global traffic condition	Heavy	30%	40%
	Light	40%	60%

This table shows that higher is the flow on one link, smaller is the number of probe vehicle needed for a good link between data from floating car and global data.
The case of light traffic condition and low link flow could be considerate as an extreme situation and of course the percentage could be decreasing depending of the accuracy needed (Cf. the graph of the probe-global points)

7 – Further researches and Conclusion

This study provides encouraging results. Nevertheless, more research has to be done to improve its. More statistical test will be performing to better understand the proportional needed for practical application depending of the network configuration.
This methodology shows that using probe car gives good estimation of the real data emission (90-95 %). Furthermore, depending of the network configuration a penetration rate of 10-15 % of probe car is enough to obtain satisfactory results of the global emission data. The study gives more information for low traffic condition and evaluates the minimum of probe vehicle in this case.

8 – References

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