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# COMBINATION OF A TRAFFIC SIMULATION MODEL WITH AN AIR EMISSSION SIMULATION MODEL

Summary report

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# 1. The Purpose

## 1.1. The Challenge

The challenge of this project was to reduce the air emissions of road-traffic pollutants.

Road traffic is a major contributor to the emission of air pollutants (almost 75% of all CO, almost 50 % of all NOx emissions and almost 20 % of all $CO_2$ emissions in the Walloon Region[1]). These emissions are mainly related to the level of fuel consumption of this sector. Consequently, the challenge to reduce emissions is accompanied by a challenge to reduce energy consumption in this sector.

The reality however is that energy consumption is rising steadily. Between 1990 and 1997, the level of energy consumption in the transport sector in the Walloon Region increased by 13% while the overall level of energy consumption for the regions "only" increased by 3%[2].

This major increase in energy consumption and its corresponding emissions increases even more the seriousness of the negative consequences of road traffic (greenhouse effect, public health, degradation of public spaces, costs for communities, etc.). As far as health is concerned, a recent study estimates that 6% of all deaths in the countries analysed (France, Switzerland and Austria) are attributable to air pollution and half of them to pollution caused by road traffic[3].

Furthermore, Belgium made a commitment at the Kyoto Summit to reduce greenhouse gas emissions. Road traffic is a major contributor to this. It is therefore necessary for action to be taken in this sector.

In light of these facts, the research teams (*Institut Wallon* and The Transportation Research Group-GRT) decided to undertake a project whose challenge was to reduce the air emissions of road traffic.

## 1.2. The Aim

The aim of the project was to improve the evaluation and localisation of the quantity of pollutants produced by road traffic by combining this type of model with a traffic simulation model.

In order to address the problem of air emissions, it is first necessary to be able to estimate and localise them with some precision. For greenhouse gases, the localisation of emissions does not make any sense, for local pollution, however, it is relevant.

The combination of the traffic and emission models makes this double estimation and localisation possible.

The research teams therefore decided to follow this method, which is quite original, as usually these two types of models are applied separately.

## 1.3. The Objective

The objective of the project is to develop a combined traffic and air emissions simulation model in a test zone.

The basic research of this project was particularly attractive. However, the validation of the approach through its concrete application to a test-zone was necessary and useful.

The development of the combined model and its application to the town of Namur was the objective of the three-year project.

In our opinion, the validation had both a scientific value within the framework of the research project itself, but it also provided the possibility to align a basic research project with the realities of the field and thus to open the project to «civil society».

[1] *Institut Wallon*, 1997
[2] *Institut Wallon*, 1997
[3] Study published in the journal « The Lancet » and quoted by the Belgian Newspaper « Le Soir » on 1 September 2000.

# 2. The Actions and the Results

## 2.1. The Actions

### 2.1.1. The Actions undertaken

Different steps were necessary to meet the objective of the project. As a first step, the main focus of the work involved researching and adapting traffic simulation and air emission models. The combination of the models and the research for sources of relevant data to refine and gauge the models continued throughout the project.

The hypotheses and results were then compared by both a User's Group (made up of experts in the field) and through participation at an international conference on this topic. Finally, the choice of simulations to be studied and the comparative analysis of the results led us to revise and refine the combined model.

The analysis of these results was only possible through the creation of a software programme which could compare and synthesise the data making it easier to read. With this same objective in mind, the results were transferred to a system of maps that could present the statistical results in an «image» making the data more reader friendly and easier to interpret.

### 2.1.2. The Methods

The aim was to study the feasibility of combining a traffic simulation model with an air emissions simulation model, to create that combined model and to apply it to a test zone.

This proposal involved several steps as described below.

The first step was to undertake a survey of the emission simulation models available on the European market or described in literature in general.

On the basis of this analysis, the model, whose input characteristics guided the level of precision's of traffic, the simulation model was chosen. In fact, presently, traffic simulation models can be much more accurate than emission models. A choice had to be made between a traffic model whose level of accuracy corresponded to the level of details provided by the emission models. Furthermore, by avoiding the development of the details of the model, it was possible to apply the model to larger zones without having to substantially increase the collection of required data.

The model was then applied to a test zone (Namur) in relation to two aspects : traffic and air emissions caused by road traffic. For this test, it was necessary to gather all the data required for the two models for this zone. (road infrastructures, characteristics of this infrastructure, the origin-destination matrix, traffic census, etc. the vehicle park, age, cylinder capacity, types, etc.)

### 2.1.3. The materials and the sources of information

#### 2.1.3.1. Related to the «air emissions» aspects

The **choice of pollutants** to be recorded and the types of emissions to be considered were determined by national and international records of road traffic emissions. The pollutants which were studied in this work were:

- The major pollutants divided between those responsible for acid pollution - such as sulphur dioxide et the nitrogen oxides; those responsible for photochemical pollution (ozone precursors) - such as the volatile organic compounds and carbon monoxide and finally the greenhouse effect gases - such as carbon dioxide and nitrous oxide.
- Fine diesel particles (PM) et dioxines (Diox) which have adverse effect on health, in particular related to the occurrence of cancer.

As far as the review of models and studies on the theme of air emissions and road traffic is concerned, the *Institut Wallon* chose the **CORINAIR/COPERT method**[4] from the models at its disposal for several reasons:

- It is the result of the work of a European group of experts on transport, each member of which has real experience in the subject matter. To a certain extent, it is the intersection of European studies undertaken by specialists. The development of COPERT is funded by the European Environmental Agency within the framework of the activities of the European Topic Centre on Air Emissions;
- It proposes advanced systems of classification (vehicles and roads) allowing an exact approach to the problem. Similarly, the estimation of the emission factors and that of the specific consumption is particularly elaborate;
- The first version used (COPERT II) dates from April 1997 [**B 23**] and the new version (COPERT III) from July 1999 [**B 24**]. Both the technology of the vehicles and the on-going changes in regulations make it necessary to use an up-to-date method.
- It provides clear details on the validity of each of the parameters it proposes and underlines their weaknesses;
- It is a European model and thus includes the range of different European roads therefore offering a coherent methodology to all EU Member States. This cohesion is an essential factor for the combined publication of statistics on emissions and for the comparison of statistics with other methods.
- Finally, the parameters necessary to calculate the emissions (temperature, average speed) are relatively easily available.

This model has become known as the «hot emissions» model, i.e. once the engine has reached its running temperature.

However, a percentage of emissions significant on short journeys occurs when the engine is still «cold». The formulae used to **calculate the cold suremissions**, i.e. when the car is departing, are presented in M. JOUMARD de l'INRETS[5], as the formulae used in COPERT do not suit a dynamic simulation model.

### 2.1.3.2. Related to the « traffic model » aspects

PACSIM, a dynamic traffic simulation model, is the model used for the different simulations. This model - which was developed by the Transportation Research Group (TRG), partly within the framework of the DRIVE 1 Programme of the European Commission and partly within the framework of the «Transport and Mobility» Impetus Programme of the Belgian Federal Office for Scientific, Technical and Cultural Affairs (SSTC) - simulates traffic in urban areas .

For this reason, particular attention has been paid to the application of the model to crossroads.

The dynamic nature of PACSIM makes it possible to study the evolution of traffic flow over time through different intersections (or roads) that are part of the model. For example, we can analyse the congestion of certain intersections during rush-hour. This dynamic characteristic is possible through an «events-driven » simulation. This means that the passing of time is accompanied by events (accidents, traffic flow, etc.), which result in an action or a series of actions. The model will deal with these actions and will simulate the change in the traffic resulting from these events.

PACSIM also includes a behavioural aspect which makes it possible to simulate the way in which users choose their type of transport or the route they will take or even how they react to the information that they receive. In this respect, it should be noted that PACSIM is not based on the assumption that every user knows the road network perfectly well. On the contrary, the idea is

[4] Computer Programme to Calculate Emissions from Road Transport

[5] Institut National de Recherche sur les Transports et leur Sécurité (Belgian National Insitute of Research on Transport and Road Safety)

introduced of a network where the user has an incomplete knowledge of the network depending on which areas he is used to passing through.

A significant percentage of journeys are made using public transport. So as to remember this fact, PACSIM includes a multi-modality aspect. Buses, along with cars, are included in the model and the interdependence between private vehicles and public transport is taken into consideration. Finally, Information Systems are also included in the model. This means that the effects resulting from the dissemination of information (such as announcing accidents or road works) via media as varied as variable message boards or radio broadcasting systems are included in the model.

Should the reader wish more information, he/she should consult the references [**B 4**], [**B 5**] et [**B 6**].

To supply this model with data, an origin-destination matrix was necessary and therefore we have used the most recent one available to us - that evaluated in 1992 by the company STRATEC within the framework of a study on road traffic in Namur [**B 26**].

### 2.1.4. Significant Points and Controversial Aspects concerning the choices made

#### 2.1.4.1. The Emission Model

There are many much debated points in relation to the choice of the emission model. Two types of models exist one that calculates emissions instantaneously and one by using an average speed. The COPERT model which was chosen is based on the second of these two approaches. There is no reason why formulae to calculate the instantaneous emissions cannot be added to the combined simulation model, as long as the data necessary for this calculation are available and does not require an exaggerated complication of the model (behaviour of the driver, position of the road, road gradient, etc.).

#### 2.1.4.2. The Combination of the two models

Before combining PACSIM with emission and suremission models, the model did not distinguish between private vehicles and only one category existed : «Private vehicles». Whereas, the emissions are calculated according to the kind of vehicle (the type of fuel, the cylinder capacity and the age of the vehicle). We decided to use the vehicle park of the Province of Namur, published by the National Statistics Office (INS) [**B 13**].

In order to introduce these vehicle related characteristics into the traffic simulation model, we have randomly attributed a type (fuel, cylinder capacity and age) to each vehicle in our input data while retaining the real distribution of the number of cars on the road of our test zone.

Another difficulty was to integrate cars leaving with a cold engine. The question was how to distinguish in our input data cars that are starting their journey with a cold engine from the others? We made the assumption that cars starting their journey from a place within the network had a cold engine whereas cars entering the network had an engine hot enough that it was not necessary for any possible suremissions to be taken into account.

In the first part of the study, we apply formulae from COPERT to calculate the air emissions on each link (street) of the model and we add the calculation of the emissions while stationary (traffic lights, traffic jams, etc.).

It became apparent, following discussions at the Study Day [**B 7**] and through the use of COPERT III, that COPERT formulae must be used over a longer period of time and over a greater distance than the crossing of a standard street.

Indeed, the COPERT Manual underlines that «In principle, the COPERT III Methodology can be applied for the calculation of traffic emission estimates at a relatively high aggregation, both temporally and spatially», i.e. on a yearly basis for a country. However, it has been shown that the methodology can also be used with a sufficient degree of certainty at a higher resolution too. i.e. for the compilation of urban emission inventories with a spatial resolution of 1x1 for one $km^2$ and a temporal resolution of one hour.

The model has since been adapted in the following way : we wait until the vehicle has travelled far enough that the COPERT formulae are applicable. Once the vehicle has driven this distance, we can evaluate the average speed of the vehicle. This speed takes into consideration the time the vehicle may be stationary. When the speed is calculated, we can evaluate the level of pollution of each pollutant. Finally, we redistribute the emissions on each arc crossed by the vehicle, according to the time necessary for it to cross.

We have performed simulations with different distances (1.5 km, 3 km et 5 km) Through the comparisons of different results, our study shows that there is not a significant difference between the calculated emissions irrespective of the distance taken into consideration.

Because of the combination with the COPERT III model, we chose to integrate the emissions once the distance equals 5 km.

Our procedure to evaluate the suremissions is similar to that used for the emissions. We simply wait until the vehicle has reached its destination to be able to evaluate its speed and its cold engine distance. Knowing the total distance driven and the ambient temperature (assuming that it is constant during the entire length of the simulation period), we then calculate the suremissions that we redistribute, no longer to each arc of the total distance, but to each arc of the cold engine distance – still according to the time necessary to cross the arc.

## 2.2. The results

### 2.2.1. The intermediary results

#### 2.2.1.1. The choice of the test zone

Namur was chosen as the test zone because of the specific characteristics of the combined model. Indeed, there was enough data on Namur available to the two groups that it was possible to undertake simulations straight away. Of course, in order to gauge the model, it was necessary to up-date certain data but this process is shorter and less expensive than having to acquire all the data necessary for the model (length, width, number of lanes, permitted speed limit, parking possibilities for each arc of the network and availability of an O/D matrix, division of the vehicle park, etc.)

Furthermore, The Town Council of Namur had undertaken a study of a «traffic plan» and it seemed interesting to see what impact the change in the traffic policy would have through a concrete example and not one imagined by us.

We used the most recent origins/destinations matrix (O/D) available to us, the model evaluated in 1992 by the company STRATEC within the framework of a study on road transport in Namur [**B 26**]. This 1992 matrix, including more than 40,000 journeys using private vehicles, was up-dated using the methodology described in **Error! Reference source not found.**and using the computer programme ATES developed by the TRG [**B 3**].

We carried out the simulation between 7.30 a.m. and 9.00 a.m. (the morning rush hour) divided into blocks of 15 minutes.

#### 2.2.1.2. The road network

The data concerning the infrastructure of the Namur road network dated back to 1990. For this reason, we had to up-date this data in order to validate and gauge our model. This up-dating was mainly concerned the town centre with changes in the direction of the traffic flow, the reduction in the number of lanes or the introduction of speed limits.

#### 2.2.1.3. Cartographic representation of the emissions

Based on the location of nodes in the network as perceived and analysed by the PACSIM model, we presented the Zone of Namur, to which the model had been applied, in the form of a map.

The results are processed «Arc View » which provides a direct representation of the level of pollutants simulated by PACSIM from a file exported from our ACCESS programme.

With this information it is now possible to compare for one simulation with different time periods or to compare different simulations in order to observe how these emissions are divided.

Because of the quality of the representation using maps it is possible to focus on specific zones or districts which can be the subject of a particular analysis.

### 2.2.1.4. Data retrieval and processing

The programme for the retrieval and treatment of the simulation data was developed using Microsoft ACCESS®. With this programme it is possible in a simulation to view the total emissions of each time block and their evolution over time. Furthermore, it is possible with the programme to the different simulations carried out compare two to two or three to three and to identify in this way the important elements for the analysis. The comparison can be done at several levels, the arc of the street, the street, the district or the whole town. Furthermore, it prepares the data to be transferred to the cartographic software programme which allows the whole network to which the model is applied to be visualised and to observe the variations in time and space of the emissions that have been calculated.

The parameters that have been analysed are : $CO_2$, $SO_2$, NOx, CO, Diox, NMVOC, $N_2O$, PM, LOAD, FLOW.

« FLOW » is a data field which provides information on the number of vehicles that have passed over the arcs during a chosen period of time. Thus, if a car travels over 10 arcs or 10 vehicles travel over 1 arc, the FLOW will still equal 10. The higher this figure, the heavier the traffic. We estimate it as the number of vehicles*links (v*l).

« LOAD » is a data field which provides information on the number of cars still on the arc at the end of the chosen period (one hour period). To a certain extent, it is an indication of the congestion of the roads, the higher it is, the less fluid the traffic. It is based on the number of vehicles.

### 2.2.1.5. The Pilot Simulation

As we have already underlined several times, we needed a situation which could be used as a basis for the gauging of our traffic model. This simulation, apart from the physical characteristics of the network of the town of Namur, (chosen as a test zone for the reasons mentioned above) includes different parameters with well defined values, which we will be able to influence through our different simulations.

This simulation, which shall be known as the *pilot simulation* was made both on the basis of speed limits in force at the time (1995) but also for certain streets, the speed commonly used which differs considerably from the speed limits (on the avenues forming the ring road of the town or on certain major intersections in the centre where the speed limit of 50 km/h is often exceeded). The ambient temperature is equivalent to the average temperature of 1999 (11.1°C). As our O/D matrix only includes journeys made by private cars and as there is no O/D matrix specifically for public transport, our basic situation does not take into consideration the division between the kinds of transport (car – bus).

The pilot simulation, whose main results will be presented in the next chapter, will be used as a basis for comparison with the test simulations that we are now going to describe.

During the analysis of the results, it became apparent that many vehicles were still present within the network at the end of the simulation (9.00 a.m.). We therefore ran the model during an additional one-hour period so that all vehicles reached their destination. Had we not taken this additional step, the resulting comparisons would have been incorrect. In fact, the decrease in emissions can be linked to the fact that the traffic is stationary (traffic jams). It is therefore useful to consider the total number of movements until the vehicle reaches its destination.

### 2.2.2. The final results

#### 2.2.2.1. Prospective Simulations

The simulations were carried out with a view to observing the effects and the influence of the modification of certain parameters of the pilot simulation on certain traffic management policies in Namur.

1. The effect of the temperature. By considering the same hypothesis and the same network as in the pilot simulation, we simply tested the effects of a change of temperature in relation to the air emissions. For this, we chose the average temperatures of the warmest month (July with 19.5°C) and the coldest month (February with 2.8°C) of 1999.
2. The setting up of a 30 km/h zone in the centre of the town. We chose to limit the speed inside the town centre to 30 km/h and we assume that drivers would respect this limit. Indeed, this is achieved not only by placing appropriate road signs but also by narrowing the width of the roads, reducing the number of lanes and introducing different speed kerbs. Irrespective of the method used to reduce the speed limit, we made the assumption that it would be respected by drivers..
3. The use of public transport (bus). The O/D matrix of the basic situation only included journeys made by private vehicles. As far as we area aware, there is no matrix of journeys made by public transport for the town of Namur. The only test that we could carry out, with the current data, is to transfer part of the mode of transport figures (5%) from car to public transport (bus in the case of Namur) for the data available to us.
4. The new traffic plan. Namur Town Council recently adopted a new traffic plan whose first phases started during 2000. This traffic plan foresees in particular the removal of the possibility of crossing the town centre, the restructuring of some crossroads of the ring road (replacement of crossroads with roundabouts), the impossibility to drive in front of the railway station with the traffic being diverted behind the station where new roads with a higher capacity than those already existing will be built. From the proposed traffic plan, we have only taken into consideration the modifications of the infrastructure mentioned above and have simulated the situation with the existing O/D matrix. However, the traffic plan includes other hypotheses such as a transfer mode (with car parks in order to discourage traffic) or access checks outside the town which should result in a easier flow of traffic into the town. It is clear that, with these additional hypotheses, our results could be different but, due to a lack of data, we have not taken them into consideration.

#### 2.2.2.2. Comparison of pilot simulation between summer and winter.

We notice the effect of the ambient temperature on the emission of pollutants and in particular for the pollutants of which the cold-start emission rate is significant. For the emissions of CO, there is a decrease of 30% in summertime and an increase of 30% in winter time through a comparison with the pilot simulation.

#### 2.2.2.3. Speed Limit Reduction Simulation

For the emissions, there is a slight increase linked to the fact that the minimum level of emissions in the COPERT formulae used are observed at an average speed of 50 – 60 km/h. Whereas, in this simulation we are influencing a lower speed.

Inside the inner town centre, there is a considerable decrease in traffic and emissions. The commuters who usually cross the centre of the town to get to the other side of Namur, now avoid this route. We observe that the increase of emissions likely to result from a reduction in speed is compensated by a considerable decrease in traffic.

| | Pilot | 30 km/h Simulation | | Overall difference. |
|---|---|---|---|---|
| $CO_2$ (kg) | 1 319.8 | 968.0 | 73% | -352 |
| NOx (kg) | 7.9 | 5.2 | 65% | -2.7 |
| CO (kg) | 206.5 | 156.0 | 76% | -49.5 |
| FLOW (v*l) | 53 696 | 24 129 | 45% | -29 567 |

Table 1 : Evolution of $CO_2$ , NOx, CO and FLOW between CopIII-Tem et CopIII-30kmh, in the Inner town centre between 7.30 a.m. - 9.15 a.m.

We can see that the traffic which avoids the centre of town is diverted onto the outer streets, leading to increased congestion and thus leading to a substantial increase in emissions. Indeed, on the peripheral ring road, we note a 15% increase in traffic which results in proportional increases in emissions between 4% and 13%. There is therefore simply a redistribution of emissions with no reduction.

#### 2.2.2.4. The Traffic Plan Simulation

The traffic plan of Namur includes major changes in the infrastructure of the roads. The conversion of crossroads into roundabouts and the creation of new thoroughfares will considerably increase the number of links to be considered in our model. There will be an increase from 946 arcs in the pilot model to 1091 arcs in the model of the plan. This increase will have a direct influence on the «FLOW» parameter. It is therefore very risky to compare this parameter amongst the simulations that have been studied.

| | Pilot | Namur Plan Simul. | |
|---|---|---|---|
| $CO_2$ (kg) | 50 335.8 | 53 976.2 | 107% |
| NOx (kg) | 383.2 | 378.4 | 99% |
| CO (kg) | 5 693.6 | 5 879.6 | 103% |
| FLOW (v*l) | 568 545 | 732 851 | 129% |

Table 2 : Evolution of $CO_2$ , NOx, CO and FLOW between CopIII-Tem et CopIII-Plan, Namur 7.30 a.m. – 9.15a.m.

We note that in Table 2 the increase in FLOW, as explained above and we observe a slight increase in the pollutants in general with the exception of NOx.

#### 2.2.2.5. Localised analysis (districts - streets)

| | Pilot | Namur Plan Simul. | | Difference |
|---|---|---|---|---|
| $CO_2$ (kg) | 1 319.8 | 1 091.7 | 83% | -228 |
| NOx (kg) | 7.9 | 6.9 | 87% | -1.1 |
| CO (kg) | 206.5 | 154.1 | 75% | -53 |
| FLOW (v*l) | 53 696 | 47 176 | 88% | -6 520 |

Table 3 : Evolution of $CO_2$ , NOx, CO and FLOW between CopIII-Tem et CopIII-Plan, in the inner town centre 7.30 a.m. - 9.15 a.m.

The reduction of FLOW is explained by the restructuring of the town centre. It was previously possible to cross the town by passing through the centre. The changes in the town no longer allow for this kind of transit because of the installation of one-way thoroughfares, bends in the road, etc. Of course, this decrease in FLOW results in a decrease of emissions.

| | **Pilot** | **Namur plan Simulation** | | **Difference** |
|---|---|---|---|---|
| $CO_2$ (kg) | 6 168.6 | 7 601.7 | 123% | +1 433 |
| NOx (kg) | 36.7 | 45.3 | 125% | +9.2 |
| CO (kg) | 752.7 | 914.9 | 122% | +162 |
| FLOW (v*l) | 145 807 | 276 150 | 189% | +130 343 |

Table 4 Evolution of $CO_2$ , NOx, CO and FLOW between CopIII-Tem et CopIII-Plan, on the ring road between 7.30 a.m. – 9.15 a.m.

The ring road of the town was the primary target for restructuring, we increase the number of links so that the ratio with the pilot simulation is doubled (103 to 221). This explains the large increase in FLOW.

Furthermore, as drivers are no longer permitted to cross the town through the centre, they must take the ring road. As a result the emissions increase significantly (from 22% to 25%), far greater than the decrease recorded inside the inner town centre (Table 3).

### 2.2.3. Comparison between the reduction in speed and the restructuring of thoroughfares

#### 2.2.3.1. Parameters ($CO_2$, NOx, CO)

| | **Pilot** | **30 km/h** | | **Plan** | |
|---|---|---|---|---|---|
| $CO_2$ (kg) | 50 335.8 | 53 575.4 | 106% | 53 976.2 | 107% |
| NOx (kg) | 383.2 | 387.2 | 101% | 378.4 | 99% |
| CO (kg) | 5 693.6 | 5 922.1 | 104% | 5 879.6 | 103% |
| FLOW (v*l) | 568 545 | 561 719 | 99% | 732 851 | 129% |

Table 5 : Evolution of $CO_2$ , CO, FLOW and NOx between the 3 simulations, Namur 7.30 a.m. – 9.15 a.m.

In general, in the Namur area, there is no significant difference between the two simulations that were studied as far as the emission of pollutants is concerned. We recall that the increased FLOW of the Plan simulation is mainly due to the increased number of arcs in the network model.

#### 2.2.3.2. Localised Analysis (districts – streets)

| | **Pilot** | **30 km/h** | | **Plan** | |
|---|---|---|---|---|---|
| $CO_2$ (kg) | 1 319.8 | 968.0 | 73% | 1 091.7 | 83% |
| NOx (kg) | 7.9 | 5.2 | 65% | 6.9 | 87% |
| CO (kg) | 206.5 | 156.0 | 76% | 154.1 | 75% |
| FLOW (v*l) | 53 696 | 24 129 | 45% | 47 176 | 88% |

Table 6 : Evolution of $CO_2$ , CO, FLOW and NOx between the 3 simulations, town-centre between 7.30 a.m. - 9.15 a.m.

We note that, for the town centre, the simulation of the speed reduction at 30km/h results in a more significant reduction in emissions and the amount of traffic than the proposal to modify the structure of the thoroughfares. The latter is usually more troublesome to implement.

| | **Pilot** | **30 km/h** | | **Plan** | |
|---|---|---|---|---|---|
| $CO_2$ (kg) | 6 168.6 | 6 993.4 | 113% | 7 601.7 | 123% |
| NOx (kg) | 36.7 | 37.7 | 104% | 45.3 | 125% |
| CO (kg) | 752.7 | 824.8 | 110% | 917.9 | 122% |
| FLOW (v*l) | 145 807 | 167 915 | 115% | 276 150 | 189% |

Table 7 : Evolution of $CO_2$ , CO, FLOW and NOx between the 3 simulations, Ring-road 7.30 a.m. - 9.15 a.m.

Similarly, concerning the ring road, the diverting of traffic from passing through the town results in a far higher increase in emissions with the plan simulation than that with the 30 km/h simulation.

We can therefore estimate that in the two areas we have analysed, (making due allowance), the solution to impose a speed limit of 30 km/h in the centre will have a more favourable impact in the local area in question as far as the level of emissions is concerned rather that the traffic plan.

### 2.2.4. The interest of the results

What is most interesting about this project is that it has achieved its objective, to have a model which would be able to simulate journeys of vehicles in real time with real conditions and to extract information on the emissions that result from this.

All too often, people working with simulators are happy to provide information on traffic flow or the number of displacements but no data on the result related to the quantity of pollutant emissions are available.

As we have seen, a solution which can seem advantageous in relation to traffic can result in effects on emissions which have the opposite outcome. Therefore with a simple «computerised » change of traffic conditions of the zone to which the model is applied, the decision-makers will be able to have a tool at their disposal which will assist them in making a choice which considers both the « traffic » and the «air emissions».

# 3. Results and perspectives

## 3.1. Results of the project

### 3.1.1. Restrictions of the combined model

As a model is the formal and simplified representation of a phenomenon in the real world, its use implies making a certain number of choices and assumptions. For this reason we should take some precautions in relation to the results. In reality, it is illusory to believe that the results of the different test are absolute, nevertheless, it is reasonable to consider that they are representative of reality.

A first choice imposed by the availability of data was that of considering only private vehicle traffic. The other choices which we made during our study related to the network as well as the position of the origin or destination centroids. As far as the network is concerned, it is obvious that developing a model based on all the major and minor roads, lanes, etc of the Namur area would have implied a network that was far too complex. On the other hand, it is equally impossible to make each input depart from the exact place where it has started. As a result, we are forced to regroup the origins and the destinations and the destination of our input data into points which we call centroids. This simplification of the reality can explain certain differences between the results obtained by simulation and the traffic flow observed in reality. The fact of combining this first model (traffic model) with a second model (emission simulation model) can only result in a higher risk of less reliable results. Nevertheless, we know that each of the models in their own right is quite representative of the reality.

Consequently, we can state that although our results should not be considered an absolute truth, they represent a good indicator of the trends when we compare the two different scenarios.

### 3.1.2. Difficulties in Implementation

The main difficulty associated with the use of a model such as ours is the data collection necessary for it to work. In fact, it is relatively troublesome and costly to obtain the length, width, number of lanes, speed limits, the possibilities of parking for each arc in the network. for each region to which we would like to apply the model. Considering, in addition, the level of precision of our model, we need the description of all the crossroads (priority rules, traffic light phases, permitted manoeuvres, etc). If we wish to include public transport, we have to consider the times but also the routes taken by the public transport vehicles. In addition, we need to have an O/D matrix that is sufficiently recent and reliable and preferably multi-modal.

Furthermore, we also need to gather information on the vehicle park used in the zone where the model is applied so that the random distribution of the type of private vehicle corresponds to this. Also, if we wish to gauge the model in this new region, we need to have figures from several road traffic census.

### 3.1.3. Interest of the comparative predictions

The major interest of the combined traffic–emission model is that it will allow the relevant authorities, or consultancy companies, to foresee, within the restrictions and hypotheses of the model, the double impact of an active policy in relation to the traffic plan or the restructuring of the thoroughfares. The ability to compare several simulations in the same zone has the advantage of easily extending the range of possibilities without having to implement them.

Once the work of applying the model to the network has been done, the up-dating is relatively simple and the model can be operational for several years.

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