A COMBINED APPROACH FOR TRAFFIC RELATED NOISE AND AIR QUALITY: IMPROVING THE ENVIRONMENT OF CITIES IN THE NETHERLANDS

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ABSTRACT

EU guidelines and national laws set operative limits to both air quality and noise in urban areas. These limits are frequently exceeded in the urban agglomeration formed by the cities Amsterdam, Rotterdam, The Hague and Utrecht in the Netherlands (called 'the Randstad').

Conformance to these guidelines forces local authorities to create action plans that tackle the bottlenecks which result from the very dense network of roads in this region. Such plans require modeling of the air quality in order to calculate future scenarios. In our experience, local authorities are sometimes reluctant to do so because of the discrepancies that are often encountered between measured and modeled air quality.

However, in our opinion, this drawback is outweighed by a substantial advantage of modeling: by taking both noise and air quality aspects into account during the preliminary stages of urban planning, one can achieve a more optimal spatial planning. The result is a more sustainable urban development because the limited space can be used more efficiently and people can live a more healthy and pleasant life.

In this article, we present a number of cases where such a combined modeling approach has been applied. For one of these projects, we developed a tailor-made model for a bus station in the center of a city. We discuss the bottlenecks encountered and show how the combined modeling of the acoustical situation and air quality helped in finding a better location for the station, resulting in less nuisances to the community.

1 - INTRODUCTION

Living in a densely populated country like the Netherlands combined with a high need for transportation leads to a conflict situation for environmental aspects like air pollution and noise exposure. EU guidelines and national laws set operative limits to both air quality and noise in the urban areas. The principal objective of the environmental policy in the Netherlands is to achieve and maintain an acceptable level of environmental quality in the Netherlands. In particular it is aimed at ensuring the health and well-being of people and the preservation of animals, plants and goods.

In June 2001, the European air quality directive *1999/30/EC* [1] has been implemented in the Netherlands, leading to the publication of a Dutch air quality decree, the so called *Besluit Luchtkwaliteit* [2]. This Dutch air quality decree forces the municipalities to measure or calculate the local air pollution. The air quality decree sets limit for concentration of sulphur compounds, nitrogen oxides, particulate matter, benzene and carbon monoxide. In the Netherlands, the limit values which are being exceeded are mainly those for particulate matter and nitrogen dioxide.

An area frequently suffering from noise and air pollution problems is the so called *Randstad*, the urban agglomeration formed by the cities in the Western part of the Netherlands. Most of the time, these problems are caused by traffic. As a result of the air quality decree, municipalities have to remediate their air pollution issues before 2010. They have to make an air quality action plan, to solve existing bottlenecks and to prevent creation of new problem locations. Threshold values established by the national government are used to check plans during the trajectory to 2010. The air quality decree states that air quality should be taken into account with every new planning decision made by local, regional and national government. The legal framework that results eventually in action plans and possible measures that have to be accounted for by the authorities will be further highlighted in chapter 2.

Stringent planning requirements can be used to keep the effects of noise and air pollution under control, for example by maintaining sufficient physical space between the pollution source and the recipient. Special considerations can be given to the location of industrial sites and the routing of traffic near urban areas. One planning approach used by municipalities to protect urban and natural areas from pollution is based on the use of general indicative zoning standards. However, in some cases it is necessary to focus on measures in greater detail to assess the effectiveness of certain spatial planning. Consequently, application of a less coarse approach than indicative zoning is advisable.

The models that are applied for calculations will be described in chapter 3. In this article we present a number of cases where a combined modeling approach for both air and noise has been applied. This combined approach is described in chapter 4. Examples of projects for which we developed such a tailor-made model will be highlighted in chapter 5. We discuss the bottlenecks encountered and show how the combined modeling of the acoustical situation and air quality helped in finding a better location for the station, resulting in less nuisances to the community. We will end up in chapter 6 with our vision toward the use of modeling for both air and noise disturbance situations and the way to approach future problems.

2 - LEGAL FRAMEWORK

2.1 - Air quality

Since June 2001 the European air quality directive has been implemented in the Netherlands by the publication of the Dutch air quality decree. In this decree the local, regional and national authorities have different roles. The national government makes action plans and report to the European Community. Regional authorities act as an intermediary. Municipalities have to measure, calculate and report about this to the national, via the regional, government. There is no strict method on how to calculate, as long as a certain degree of accuracy is reached [2].

In the Netherlands problems with exceeding limits are mainly obvious for nitrogen dioxide (NO_2) and particulate matters (PM_{10}). The other chemicals like sulphur dioxide (SO_2) carbon monoxide (CO) and benzene are normally not an issue.

The decree is focused on improving existing situations. Consequently, municipalities have to make an air quality action plan for existing bottlenecks. These plans have to be made if threshold values are exceeded. In this plan they have to indicate how they solve these problems, only for NO_2, before 2010, when they will be finished and what the effect and the costs of these measures will be. For PM_{10} the problem is not locally solvable, because problems are not only related to the Dutch situation, but also in the surrounding countries like Belgium and Germany. Because of this, municipalities have little control over PM_{10}. Therefore, the national government will make plans to reduce PM_{10}. But already it is clear that this will be a difficult task.

2.2 - Noise

Since the 70's the Noise Nuisance Act, *Wet Geluidhinder* [3], is implemented in the Netherlands. In this act limits are posed for mean daily values of noise load, the so called L_{Aeq} [dB(A)], which are based on yearly data of the amount of traffic. How to calculate these noise loads has been laid out in a strict method.

The Dutch policy is focused on noise abatement at the source. Source measures comply with the general environmental rule 'to prevent is better than to cure'. For present bottlenecks there is an extensive system of improving dwellings which is aided by the government. For future development plans there are strict regulations which allow certain noise loads on the outside of the dwelling. In addition there are also restrictions to the noise load inside the dwelling. For receiving a permit, which you need before you can build a dwelling, one has to carry out calculations to prove that the plan complies with these regulations.

Besides these measures related to the dwelling and the application of noise screens, the Dutch policy is focused on development of low-noise road surfaces. The application of these surfaces can assure a better acoustical environment for more people compared to measures that are taken to single buildings.

3 - MODELLING

3.1 - Air quality

Every year the Dutch government reports to the EU about the air quality for concentrations of particulate matter, nitrogen (di)oxides, sulphur dioxides and lead according to the guidelines 96/62/EC and 1999/30/EC [1]. These reports are initially set up by the local authorities. It appears from these reports that the threshold or limit values have been exceeded in 2002 for the compounds nitrogen oxide and particulate matter. At the end of 2004 the Netherlands will indicate in a plan what measures will be taken the coming years to improve the air quality and to reduce too high concentrations of compounds in air. The assessment of the impact of future measures can only be calculated through modeling. Depending on the level of detail different models can be used.

CAR II (Calculation of Air pollution from Road traffic) is a computer model [4] most local authorities use every year to calculate and report about the air quality around local roads and highways. These calculations are based upon last year's figures. Calculating the situation for

2010 is not (yet) possible, because future scenarios are not yet determined. In general municipalities use the *CAR II* model for calculating relatively simple situations. A limited number of parameters such as the daily number and category of cars, the type of road and the 'tree factor' serve as input for the model. The model can also serve as a tool for a quick scan of a new situation. An important limitation of this model is the distance (30 m) to the source, in which calculations are reliable. Because of this, a wish for a more detailed focus using a therefore more appropriate model arises.

For situations in which more detailed calculations are needed for, we use micro scale prognostic flow and dispersion models like *WinMiskam* [5] and *Lasat* [6]. These models are applied for determination of air pollutant concentrations in built up areas like street canyons, multistoried parking houses, underground garages and bus stations. The input parameters necessary for input are rather more exhaustive as the relatively simple *CAR II* model. Information is needed about buildings, the aerodynamic roughness of the area between the buildings, and wind profile characteristics. Most important advantage of these models is the fact that the effect of obstacles, like screens and buildings can be accounted for. Also, one can direct a wind field in the model, related to the location of the plan, based on meteorological data, including the different dispersion classes.
By use of these models the impacts can be calculated for instance mitigation effects of air pollution by maintaining sufficient physical space and objects between the pollution source and the building area affected. Special attention can be given to the location of industrial sites and the routing of traffic near urban and building areas. In the near field of sources up to several 100 meters a rather accurate description of the dispersion in atmosphere can be found.

The following physical/chemical processes including time dependencies can be simulated:
- transport by mean wind field;
- dispersion in the atmosphere;
- sedimentation of heavy aerosols;
- (dry) deposition on the ground;
- washout of trace by rain and wet deposition;
- first order chemical reactions.

Chemical reactions are irrelevant for most compounds except for NO_x. The NO-NO_x conversion is implemented via empiric correlations. The calculation of high percentiles of NO_2 concentrations, necessary for the execution of EU directive 1999/30/EC can be derived from available values of lower percentiles. Empiric statistical correlations between percentile values are used with acceptable accuracy for line sources [7].

Emission sources of any number can be defined in form of point, line, area or volume sources. Most of the parameters necessary for the dispersion simulation, especially emission rates, source locations, exchange rates, and deposition rates can be specified in form of time series.
In the near field of the sources the dispersion calculations can be carried out with increased spatial resolution.

Up till now most authorities use the less comprehensive *CAR II* model. However as action plans for air quality require more detail, last period a slight shift towards these detailed models is noticed.

3.2 - Noise

This difference in detail one can also see with modeling noise situations. In the Netherlands the government has set up a calculation and measurement guideline, *het Reken- en Meetvoorschrift Wegverkeerslawaai* [8]. In this guideline two methods have been put down. First one uses the so called *SRM 1* (standard calculation method 1), which is a simple method, with limited input parameters, comparable with *CAR II*. This method is sufficient for distinguishing bottlenecks, but for example the effect of height differences or noise screens can not be accounted for. If this is the case, one can use the *SRM 2* (standard calculation method 2), which is a more detailed method, in which three-dimensional representations of the surroundings are made, comparable with *WinMiskam* and *Lasat*.

So far, the most import difference in modeling noise or air pollution is that for air pollution there only is a limit made for the accuracy of the calculations. For noise modeling the government has laid-out a strict method how to calculate. For noise there are a number of computer models to use, which are developed according to the mentioned *SRM 1* and *SRM 2*. For air pollution the number of available computer models in the Netherlands is rather limited.

4 - COMBINED APPROACH NOISE AND AIR BY MODELLING

Due to differences between (lower) measured and (higher) calculated concentrations, municipalities are sometimes reluctant to using calculations. Besides the already mentioned advantage when considering future situations, calculations also have an advantage regarding the meteorological data [9]. When measuring traffic related pollution, results depend highly on the meteorological situation during the measurement. If the wind direction is very different from the normal situation, measurements can not be relied on. By calculations, one can take into account the mean meteorological data of several years. In the field of noise conducting calculations is already a common practice.

Because the contribution of traffic is clearly visible for both noise and air pollution, a combined approach has advantages above solutions which are only directed to one problem. With traffic related pollution, you can make use of the same set of input data, when tackling these problems. For both noise and air, it is preferred to start in early stages of the planning process, in which you can still alternate plans.

The problem approach first has to be focused on source solutions, if these are not effective enough, one looks at transfer solutions and finally one uses destination solutions. In our experience for solving noise problems in spatial planning, municipalities more often use source solutions compared to solving air related problems by source solutions. The local influence on source solution is rather limited. For example, a local municipality has no influence on the application of soot filters on trucks, but they can introduce soot filters to their own city busses. Consequently, local authorities use transfer solutions for solving problems. Examples show that transfer solutions which are set up for solving noise problems, can also have a positive effect on air pollution [10]/[11]/[12].

5 – EXAMPLES

5.1 – Relocation bus station

For the municipality of a middle-sized city in the northwestern part of the Netherlands, we completed a project, for the relocation of a bus station [10]/[11]. In the existing situation the bus station was located next to a transit route, with on one side the railway and on the other side dwellings. The ground plan of the station was very long drawn. This location led to some unpleasant situations relating to noise and air quality, but also traffic safety. Because of this the municipality was looking for a new location. They found a possible, more concentrated, location on a former parking space, with fewer dwellings nearby. Limiting condition for the relocation was the fact that noise and air quality in the new situation should not lead to exceeding the current limits.
For both the existing as well as for the future location we developed a computer model for calculation of the noise loads and the air quality concentrations. For the air quality we used *Lasat*, in which the distinguishing marks of the surrounding can be accounted for. The subjoined figures report the concentrations NO_2 for the present and the future situation.

The figures show that, when realising the relocation, an improvement could be expected for the area in the vicinity of the present location. For the area close to the future location the local situation will worsen, but the threshold values are not exceeded and in total less people are impeded.

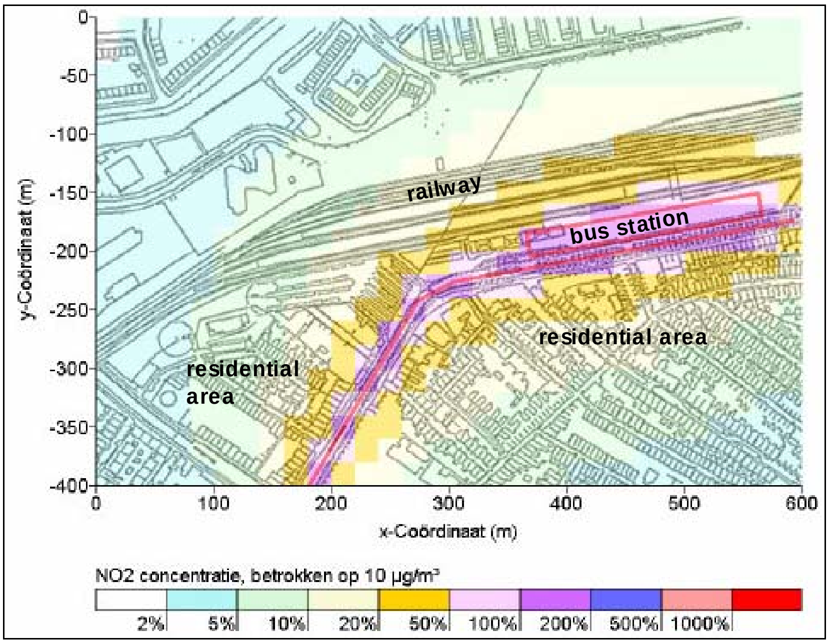

Figure 1. Present situation bus station

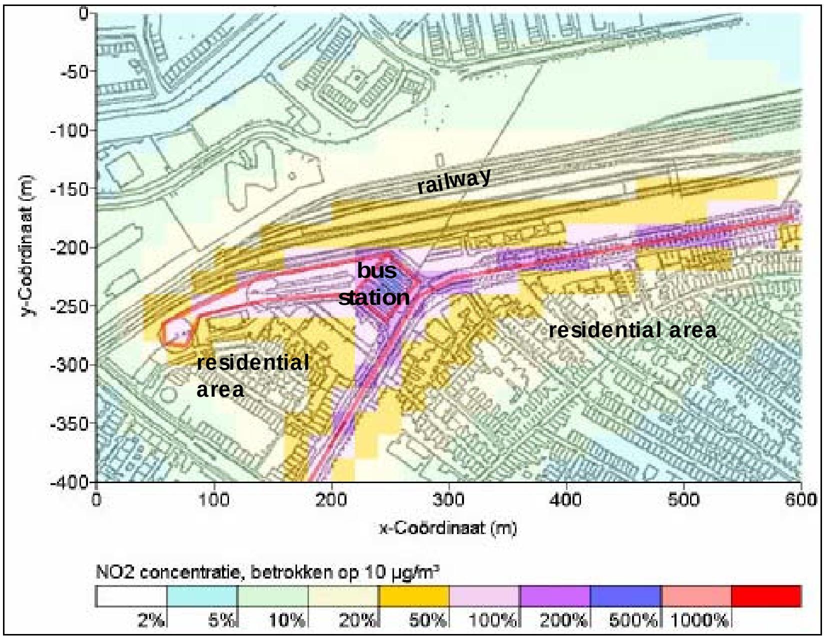

Figure 2. Future situation bus station

The calculations for noise have been made according to the *SRM 2* method. The same conclusion as already mentioned for air pollution, can also be made for noise. Different inhabitants are impeded, but in total the amount will be less than in the present situation. The results of the models clearly supported the authorities in their final choice for relocating the bus station.

5.2 - Extension of a caravan camp

For the municipality of Amstelveen which is a small town just south of Amsterdam research was carried out for the air quality near the local traverse of a highway, where a caravan camp is situated. As *CAR II* calculations pointed out earlier, this location is a bottleneck for air quality regarding nitrogen oxides and particulate matter. The direct motive for the calculations was the request of the caravan camp to expand.

As this caravan camp is situated close to a highway and next to another road, more detailed calculations were required, taking in consideration present buildings and noise screens [12].

From the results it appeared that actually no limits were exceeded and there was no need to be anxious for the current situation as well as for the future. It could be concluded that the noise screen had a positive impact on the level of particulate matter and nitrogen oxides. The effect of the screen could not be accounted for in the earlier made calculations with *CAR II*.
The figures below give an impression of the calculation results for nitrogen oxide (2004) and particulate mater (2014) with the micro scale prognostic flow and dispersion model *WinMiskam*.

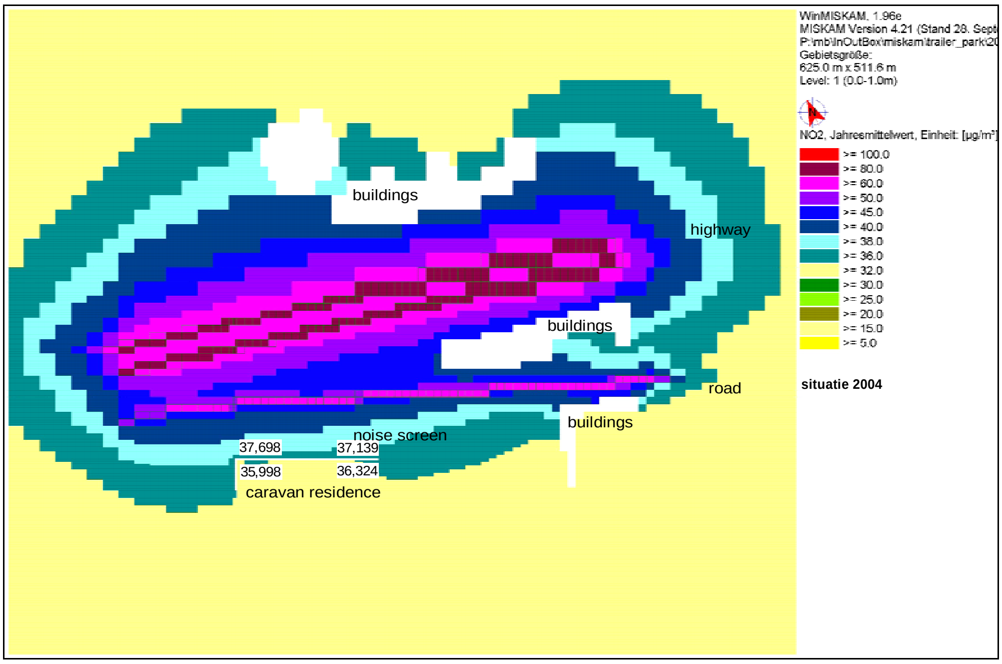

Figure 3. Yearly mean concentration NO_2 in 2004

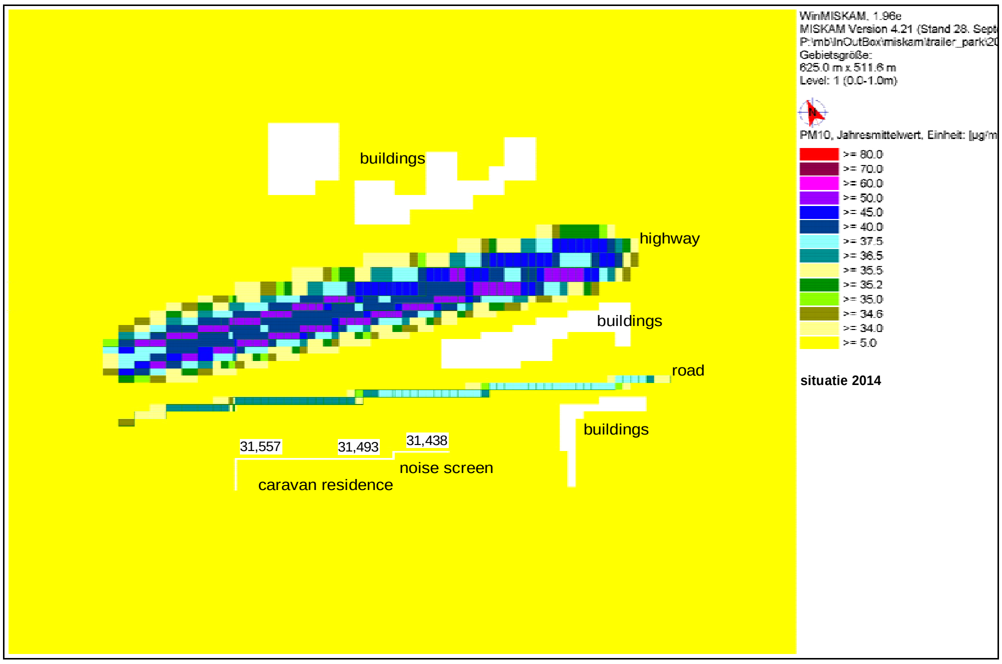

Figure 4. Yearly mean concentration PM_{10} in 2014

6 - CONCLUDING REMARKS

Improving the quality of cities is one of the policy spearheads of the Dutch Ministry of Housing, Spatial Planning and the Environment (Dutch abbreviation: *VROM*) [13]. The European Guidelines had certainly contributed and accelerated this. The last couple of years in the Netherlands there is a tendency towards innovative experiments in which solutions for environmental problems are sought. An important success factor seems to be the involvement of the different parties concerned, in the early stages of a project. In these projects the benefit of using prediction models for indicating the effect of future measures is clearly visible.

We believe that it is necessary to tackle different problems at one time, especially with noise and air pollution. Then, solutions which are better geared to one and another can be found. The examples in this article both found this opinion.

The use of computer models is an essential part in dealing effectively with future situations and attaining a good residential and ambient environmental quality in 2010 and beyond.

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