Environmental Impact Assessment and Cost Benefit Analysis 
applied on Motorway A27 (NL)

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ABSTRACT
The Motorway A27 from Breda to Utrecht in the Netherlands will be reconstructed over a length of 45 kilometers. More lanes will be added to accommodate for future traffic growth until the year 2033. The works consists of adding 2 or more lanes to the Motorway that now consists of 2x2 lanes. The reconstruction also includes building 3 new bridges crossing main rivers and canals in the Netherlands.

The Dutch Road Authority is responsible for this reconstruction and the mandatory Environmental Impact Assessment on Noise as well as complying with the Environmental Law on Noise (1). A consortium of contractors (FLOW 27) of which Anteagroup is the main contractor carried out the surveys for all environmental aspects including traffic noise. As part of this survey a Cost Benefit Analysis was performed using the Dutch CBA method. The CBA method was used to determine whether or not noise mitigation measures (noise barriers and noise reducing pavements) should be taken based on their cost effectiveness.

The results of the survey are presented in terms of effects on noise annoyed people living in the urban areas around the Motorway.

Keywords: Traffic Noise, EIA, Cost Benefit Analysis, Noise Measures

1. INTRODUCTION
The reconstruction of the A27 Motorway is one of the largest projects of its kind in the Netherlands. The A27 is an important North – South route in the Dutch highway Network. Together with highway A2 it forms the heart of the network in the centre of the Netherlands on the North South route. Traffic from the southern parts of the Netherlands use the A27 or the A2 to travel to and from Utrecht and from there to other parts of the Netherlands. Both highways were having difficulties coping with the ever increasing volumes of traffic in the last 10 years. In recent years the capacity of the A2 was increased by adding more lanes to the existing 2 by 2 lane route. This project was finished before 2012.

The capacity of the A27 however was only marginally increased by adding “spitsstroken” (tidal lanes that are only open during rush hours) over a relatively small part of the highway. This proved to be insufficient as the traffic kept growing and congestion still occurred on a large scale. It was decided that a more robust solution was needed to deal with those problems so a large scale reconstruction was planned. A reconstruction of the highway over 45 km and laying in the heart of the Netherlands is bound to have consequences for the environment.

Whereas the A2 was reconstructed under old Dutch noise law (2), the A27 projects has to comply with the new Environmental Law on Noise (1) from 2012. Under the new Environmental Law a full scale Environmental Impact Assessment is mandatory and as part of that a survey into the effects of traffic noise on the noise annoyance of people in the neighborhood of the highway.

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2. THE PROJECT

2.1 Description of the project

The Ministry of Infrastructures and Environment wants to solve the heavy traffic congestion on highway A27 between the “Houten” junction and the “Hooipolder” interchange by widening (adding more traffic lanes) the highway. The project is situated in the area of three provinces and ten municipalities. It crosses three major rivers: River Maas, Waal and Lek and a major shipping canal the Amsterdam – Rijn canal. In figure 1 an overview is given of the project, the municipalities involved and the river crossings.

For the realization of the project a consortium was formed by four companies: Anteagroup, Movares, Goudappel Coffeng and Tauw. Collaboration between engineering firms is not new, but the way in which the firms are working together as part of this project is new. Each firm brings in its own specialization.

Anteagroup Nederland provides the pre-design for the “infrastructure planning study” on legal and environmental effects and procedures. This study describes the effects of the reconstruction of the 45 kilometers of National Highway. The objective of the project is to improve the flow of traffic, to reduce traffic jams, to reduce cut-through traffic, to generate more traffic capacity, and to integrate the landscape into the road design. To achieve this objective extra traffic lanes and “rush hour” lanes will be realized. At different parts of the project the highway will be extended from 2x2 lanes to 2x3 or 2x4 traffic lanes. Also the maximum speed will be increased from 120km/h to 130km/h. Several junctions (14) and overpasses (around 50) need to be modified and at the major rivers and canals three new bridges will be built next to the existing ones. By realizing the project the traffic growth until the year 2033 (from 92,000 in 2014 to 155,000 in 2033) will be accommodated for and traffic jams will be largely reduced.

In an EIA study all the environmental aspects of the project are considered. This paper focusses on the impact on noise.

![Figure 1 – Overview of the project](image.jpg)
2.2 Description of the surroundings

The surroundings of the highway A27 can be characterized as a typical Dutch river landscape. The landscape is flat apart from local elevations for the dykes at the river and canal crossings.

In the vicinity of the highway A27 and the connecting roads there are 10 municipalities which have numerous residential areas laying within the influence of the highway. Besides the residential areas also a lot of single houses are situated near the highway. These 10 municipalities have a total of some 250,000 inhabitants. So potentially a lot of people are already exposed to traffic noise from the A27 and will be in the future. Also new residential areas are developed in the same time as the highway will be reconstructed. All the potential noise exposed people as well as the new developments are included in the analysis.

Besides the residential areas there are 5 large nature or ecological worth full areas along the A27. The diverse habitats in these areas were investigated and the effect of noise in these areas was also analyzed. In this paper however the focus will lay on the effects of noise on people.

2.3 Existing noise mitigation measures

As the highway is an existing noise source falling under the old Law on noise (1979) there are already 14 existing noise barriers along the A27 over a total length of 8.1 km with varying heights from 2 to 5 meter. Also over approximately 75% of the highway a road surface of single layer porous asphalt is already applied to reduce the noise. Whether new noise barriers or noise reducing pavements are needed is part of the outcome of the acoustic survey (see chapter 4).

3. THE DUTCH LEGAL SYSTEM ON NOISE

3.1 Environmental Law in general

The reconstruction of the A27 and the effects on the environment in general are dealt with in the Environmental Law. This law deals with all environmental aspects like effects on water, nature, air quality, landscape and noise. Under this law it is mandatory to perform a full scale Environmental Impact Assessments for all aspects mentioned before and to perform a detailed acoustic survey into the effects. Besides rules for the EIA (chapter 7) the law contains further rules and regulations on environmental aspects and limit values for different aspects.

In 2012 this Law has been updated with a new chapter on Noise (chapter 11). In paragraph 3.2 detailed information about the legal system and the limit values on traffic noise are given.

3.2 Noise Production Limits

Under the new chapter 11 of the Environmental Law the system of Noise Production Limits was introduced. The aim of introducing the noise production limits (NPL) is to restrict the increase of traffic noise caused by the yearly growth of traffic volume. Under the "old" Law on Noise the traffic volume and along with it the traffic noise could grow unlimited if no physical changes were made to the road itself. This "gap" in the existing Law on Noise in the Netherlands was recognised by politicians in the early years of the 21st century. In July 2012 this gap was finally repaired and NPL were introduced. The NPL are monitoring points along all major roads in the Netherlands at 50m distance on both sides from the road every 100m (see fig. 2). The NPL’s are not actually present in the field but monitoring points in a calculation model.

At each point the traffic noise was calculated based on the traffic volume at introduction of the new law in 2012. The calculated noise level result with addition of 1.5 dB(A) is the NPL for each individual point. The 1.5 dB(A) addition is necessary to accommodate for a certain amount of growth in traffic volume at introduction of the law, otherwise the limits would be exceeded soon after introduction due to traffic growth. The Road Administration has to monitor yearly the development of the traffic volume and the traffic noise levels in the NPL-points to guard the limit values. If the calculated traffic noise level is expected to exceed the NPL in the next year, the Road Administration is legally obliged to take preventive noise reduction measures like noise reducing pavement or noise barriers. In this way the dwellings along all major roads are protected against rising noise levels from increasing traffic volumes.
For the realisation of new roads or the reconstruction of existing roads, like the A27, a 3 step approach is used to determine whether or not the project complies with the system of NPL’s. In Annex 1 a flow chart of this approach is presented.

In the first step (1A) the effects of the project are globally calculated for the situation after reconstruction. If the NPL values are exceeded the second step is performed. For those parts of the highway where NPL’s are exceeded, silent pavements is applied to comply with the NPL values (step 1B). For those parts of the highway where the noise levels comply with the NPL’s after step 1B no further survey is needed. For those parts of the highway where the noise levels still don’t comply with the NPL values a detailed survey is needed and performed (step 2). In this way the survey can be performed very efficiently because it is not necessary to investigate each part of the highway in detail.

In the detailed survey every individual house is taken up in the calculation model and the noise level of each single house is calculated. The calculated noise levels are compared with the noise limit values. For existing houses the limit value is the value calculated in the situation before the reconstruction, with a minimum of 50 dB and a maximum of 65 dB, so a kind of “stand still” principle is used. If the limit values on the houses are exceeded additional noise measures like noise barriers are investigated. At this stage a Cost Benefit Analysis is performed using the legal mandatory method.

### 3.3 Cost benefit analysis

Cost benefit analysis is included in the Environmental Law for noise and mandatory for noise measures. A detailed description of this method was already documented in the Internoise paper Melbourne (5) in 2014 and can be read there. In this paragraph only a short summary of the system is highlighted.

The method is legally regulated in detail in the Dutch publication "Kader Doelmatigheidscriteria Geluidsmaatregelen" (4) and is based on a system of so called "reduction points" and "noise measure points". The number of houses and their noise levels determine the number of reduction points that are available for a range of noise measures for that particular situation. From that total budget of reduction points for a group of houses, noise measures like noise reducing pavements and noise barriers can be "bought", up to the maximum level of the budget. The "costs" of the noise measures is determined by a standardised system of "noise measure points" that are related to the size of the noise measures.

In general the system generates more “reduction points” for houses as the noise level increases, in this way more noise mitigation measures are available for situations were higher noise levels are perceived and annoyance is higher. In the figure below the point system is illustrated. The red graph is based on the new environmental law. Typical is the “jump” at 65 dB as this is considered as a level were annoyance will increase heavily and is the maximum noise limit value.
For each group of houses both the number of available reduction points as well as the number of noise measure points is calculated and as long as the number of noise measure points (costs) does not exceed the number of noise reduction points (budget) the combination of noise measures is considered to be “cost effective” and will be applied on that location. In case there is more than one possible combination of noise measures the one with the highest noise reduction for the lowest budget will be applied.

3.4 Environmental Impact Assessment

The legal obligation to perform an Environmental Impact Assessment is regulated in Chapter 7 of the Environmental Law. Whether or not EIA is mandatory depends on the scale and the impact of the project. For a reconstruction of a road consisting of 2 by 2 traffic lanes or more an EIA is mandatory. Because the A27 is an existing highway with at least 2 by 2 traffic lanes the reconstruction has to comply with the rules from the Environmental Law and an EIA is necessary.

In the EIA all the effects of the environment are quantified by calculation where possible and otherwise qualitatively described. The method of describing the effect on different aspects is determined in the Environmental Law and in addition by the Dutch EIA commission who is advising the Ministry.

For the aspect of noise the regular way to describe the effect for the reconstruction of a highway is by calculating the effect in numbers of affected houses and (highly) annoyed people in range of noise levels starting from 50 dB up to 75 dB and higher at intervals of 5 dB. In the EIA the situation before the project is realized is compared with the situation after realization of the projects. To get a good comparison the situation without realization of the project is based on the same future year (2033) as the situation after realization of the project.

4. THE METHODS AND RESULTS

4.1 The methods used

The calculation of the effects on traffic noise are established by using a noise prediction model. In the Netherlands a standardized detailed calculation model is used based on a standard method (Standard Calculation Method II 2012). This is a 3D calculation model like many others that are used in different countries in EU. In future this method and accompanying model will be replaced by the CNOSSOS method and a model based on that method. The calculation model is built from the most recent input data that is available in the Netherlands. For the highway itself input data from the Dutch Road Administration is used from the so called “noise register”. The noise register contains the basic information on traffic volumes, average speed of the vehicles, road pavement and existing noise barriers. An example of the register from the A27 is shown in figure 4. The register also contains the NPL values in each point for the particular stretch of highway. This data is imported into the 3D model that is based on a Digital Terrain Data (x,y and z coordinates). In this way a basic model is built that

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2 Only if there are no technical or road safety objections, regarding noise barriers also objections from the view of landscape or architectural design are considered.
will function as a global model for the calculation on the NPL points in step 1A. Depending on the outcome of step 1A and 1B the model will be enriched with data of the surroundings like buildings to produce an detailed model for step 2 calculations. This step 2 model is used for calculating the noise levels on individual houses. If the noise limits on houses are exceeded the step 2 model is used to calculate the noise measures needed and to produce the noise calculation results needed for the Cost Benefit Analysis. Based on the results of the CBA noise mitigation measures (noise barriers and noise reducing pavements) are designed to reduce the effects of traffic noise.

For the EIA an acoustic survey is performed into the effects of the traffic noise from the highway on the surrounding municipalities and nature areas. The 3D noise calculation model is used to calculate the effects of the current situation and the new designed situation. To analyze the results and effects noise maps are produced. With a GIS application the total number of (highly) annoyed people and the number of m² of affected nature area are derived from the noise maps. The results (including noise maps) are reported in an acoustic report for the EIA (6).

4.2 Results from step 1A and 1B

In step 1A all existing noise barriers that cannot be replaced after reconstruction of the highway are excluded from the model. This is a fictional situation just to determine on which location the NPL values will be exceeded. The results give an indication for the locations where new noise barriers are needed and for locations where the existing noise barriers still fit into the design. The new situation leads to NPL’s being exceeded and additional noise measures are needed. In figure 5a the result of step 1A for the southern part of the highway 27 is presented. The red dots show the NPL points where the limit value is exceeded, the blue dots comply with the limit value.

In figure 5b an overview of the same location is presented after performing step 1B. In step 1B two layer porous asphalt (TLPA) is applied on the highway where this is technical possible and cost effective. On a few of the existing bridges there are technical restrictions to apply TLPA and on this locations NPL values are still exceeded. As can be seen in figure 5b at a lot of NPL’s the noise level is reduced by TLPA and the NPL values are no longer exceeded. For these locations the survey is finished. For the location where the red dots remain after applying TLPA a detailed step 2 survey is conducted (7).
The outcome of step 1A and step 1B is that the total number of houses with noise level that exceed the limit values, drops from app. 11,000 to 1,850. So it may be concluded that on these locations TLPA is a very effective noise measure. Due to the many residential areas and single houses along the highway enough measure points are available to make TLPA cost effective according to the legal method.

4.3 Results from step 2

Step 2 is only performed for locations where NPL’s and the noise levels on houses are still exceeded after step 1B. In step 1B 35.4 km of TLPA is applied on the north bound lanes and 51.2 km on the south bound lanes, including connecting lanes in the Gorichem, Everdingen and Hooipolder interchanges. Figure 6 shows the locations for the total project where additional calculations were made for new noise barriers. On these locations the noise limit values of single or groups of houses are exceeded. In many of these cases the exceedance is caused by existing noise barriers being removed because of the widening of the highway. Again using the CBA method as described before, new noise barriers were designed to replace the existing ones.

Because of the increase in traffic volume and the increase in average speed the noise levels are higher in the future situation, so more noise barriers are needed to bring back the noise levels on the houses to the present level or below. In total a length of approximately 11 km of noise barriers with a height varying from 2 to 6m will be newly build or replaced. This is 3 km more than the existing length of 8 km. Due to the application of TLPA the total kilometers of extra noise barriers as well as their height is relatively small regarding the total length of the project.

The new noise barriers are designed in an integrated engineering process at the same moment that the road design is made. This process ensures that realistic and technically possible noise barriers are developed and realized.

Figure 5a and b – Results step 1A and 1B

The new noise barriers are designed in an integrated engineering process at the same moment that the road design is made. This process ensures that realistic and technically possible noise barriers are developed and realized.
After the implementation of the noise measures as described above, two layer porous asphalt and noise barriers, a very effective noise reduction is reached for most of the houses along the A27. From the total of 1.850 houses with a noise level exceeding their limit value only 45 houses remain after the noise barriers are implemented. All the other houses comply with their legal limit value. The 45 remaining houses will get a survey on the need for noise insulation of the houses.

### 4.4 Results from the EIA

The results of the EIA (6) on noise using the step 2 model are presented in the table below (table 1). In the EIA the results of the (fictional) situation in 2033 without the reconstruction of the A27 are compared with the situation after the realization of the project. The situation without the project includes the existing noise measures like single layer porous asphalt and existing noise barriers. The situation with the project includes all the cost effective noise measures like two layer porous asphalt and new noise barriers. The number of annoyed people is calculated with the doses response equations from the Miedema method.
Table 1 – Results of EIA on noise

<table>
<thead>
<tr>
<th>Noise level (dB)</th>
<th>2033 without project</th>
<th>2033 with project</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 - 55</td>
<td>9.168</td>
<td>9.132 (-1%)</td>
</tr>
<tr>
<td>55 - 60</td>
<td>11.711</td>
<td>11.082 (-5%)</td>
</tr>
<tr>
<td>60 - 65</td>
<td>4.610</td>
<td>3.897 (-12%)</td>
</tr>
<tr>
<td>&gt; 65</td>
<td>960</td>
<td>843 (-7%)</td>
</tr>
<tr>
<td>Total &gt; 50</td>
<td>26.449</td>
<td>24.954 (-5%)</td>
</tr>
</tbody>
</table>

From table 1 the total result of the project can be analyzed. The total number of annoyed people experiencing a noise level of 50 dB decreases from 26.449 to 24.954, that is a decrease of 5%.

5. CONCLUSIONS

The following conclusions from the acoustic survey on the effect of traffic from the reconstruction of the A27 can be derived:

- The A27 is one of the largest infrastructure reconstruction projects in the Netherlands containing the realization of more traffic lanes, new bridges and overpasses and new interchanges.
- The traffic volume will grow from 92,000 in 2014 to 155,000 in 2033, speed will increase from 120km/h to 130km/h.
- The traffic noise will increase with approx. 2.5 to 3dB because of the growth in traffic volume, increasing speed and infrastructural reconstruction of the highway;
- If no noise measures are taken some 11,000 houses will exceed their noise limit values;
- After realization of cost effective noise measures like noise reducing pavement and noise barriers the number of houses exceeding their limit value drop to 45;
- The total number of annoyed people will decrease with 5% from 26.449 to 24.954

It may be concluded that despite the growth in traffic flow, the increase in speed and the infrastructural reconstruction the noise annoyance will decrease throughout the project environment. This is the result of the implementation of the cost effective noise mitigating measures like noise reducing pavement and noise barriers.
REFERENCES

5. N. Faber, Anteagroup, The Dutch Road noise mitigation program, Melbourne, 2014;
6. N. Faber, Kees-Jan Mensinga et al, Anteagroup, A27 Houten - Hooipolder, Deelrapport MER geluid, Oosterhout 2016;
ANNEX 1: FLOW CHART STEPS ACOUSTIC SURVEY

Step 1a: Compare project effect with limit value on NLP's

Step 1b: Step 1a including silent pavement.

Step 1c: determine locations where NLP values are still exceeded.

Locations for detailed survey

(Part of) project fits within the existing NLP values. No further detailed survey needed.

Step 2
Acoustic survey on individual houses.

Determine cost-effective noise measures

Step 3
Determine new NPL (values).

Legal registration of new NPL

Publication of new NPL's in Noise register.

= NPL value is not exceeded

= NPL value is exceeded