The Dutch Road Noise Mitigation Program

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ABSTRACT

In July 2012 a new law on noise pollution along major roads entered into force in the Netherlands. This law contains three important elements of new noise legislation:

a) the introduction of noise production limits;
b) the stimulation of source related noise measures;
c) the reduction of situations with high noise exposure.

The first two elements deal with the prevention of new high noise levels occurring after introduction of the law. The third element concerns the reduction of noise for existing situations that already experience high levels of road noise from major roads in the Netherlands. To deal with the third element the Dutch National Road Authority developed the Dutch "Road Noise Mitigation Program" with a total budget of 275 million Euros. This program consists of three projects in which noise mitigation measures (noise reducing pavements, noise barriers, noise insulation of houses) will be taken along all major roads in The Netherlands. This paper deals with the first pilot project MJPG 1 of the program and discusses the first's results. In this project the Dutch cost benefit analysis method is used as a decision tool for designing noise measures.

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1. INTRODUCTION

In July 2012 a new law on road traffic noise was introduced in the Netherlands. This law "Wet Milieubeheer" (1) replaces parts of the existing law on noise "Wet geluidhinder" (2). The new law contains three key elements. The first element is the introduction of so called noise production limits along major roads and railways. The second element is the promotion of the use of source related noise measures like reduction of vehicle and tyre noise and noise reducing pavements. The third element is the reduction of existing high noise levels.

In this paper the first two elements are described in a global way in the chapter two. This is necessary to understand the working of the system and methods that are also applied in the working process of the third element. The third element is the main subject of this paper and is described in detail in chapter 3. Whereas the first two elements are related to the prevention of traffic noise exceeding limit values, the third element is related to the reduction of traffic noise at locations where the noise from major roads and railways is already exceeding limit values.

To deal with the excessive noise on these last locations, a national program of noise mitigation was introduced by the Dutch Government. This program is called "MeerJaren Programma Geluidsanering (MJPG)" (3), and is best translated in English as "Long Term Noise Mitigation Program". This program concerns road traffic noise as well as railway traffic noise. This paper solely concentrates on the road traffic noise part of the program which consists of three projects, each covering different parts of the major roads in the Netherlands.

The first pilot project (MJPG 1) covers regions in the north and south of the Netherlands and started in July 2012 and will finish in 2016. The other 2 projects covering the middle, eastern and western parts of the Netherlands started in the beginning of 2014 and will finish in 2018. The goal of the total program is to realise the noise mitigation measures by 2022.

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2. PREVENTION OF ROAD TRAFFIC NOISE

2.1 Noise Production Limits

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. 1).

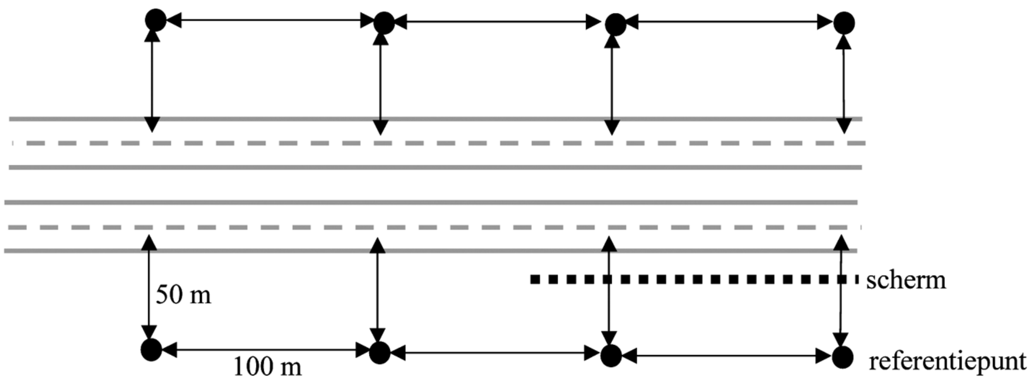

Figure 1 – Position of NPL points

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.

2.2 Stimulating the use of source related noise measures

The introduction of the new law facilitates the promotion of the use of source related noise measures in three different ways. First of all the law requires the use of a "minimal acoustic quality" of road surface (being single layer porous asphalt) for major roads in the case of newly built roads and when existing roads are being resurfaced in case of maintenance. Secondly the new law gives the Road Administration the option for a generic lowering of all NPL based on lower emission values for tyres and vehicles that are the results of EU regulations. In this scenario, lower emission levels of tyres and vehicles benefit people living along major roads rather than giving the Road Administration more room for traffic growth.

Thirdly the system of NPL is in itself an incentive for the use of source related noise measures. By applying these noise source measures, in case minor physical reconstructions to the road (like more lanes) are taken, complicated procedures can be prevented if the NPL are not exceeded.

2.3 Noise mitigation program

Whereas new situations of excessive noise are restricted by the NPL, the existing situations with high noise levels were not solved with the introduction of the NPL. At the moment of introduction of the law a great number of houses already experienced high noise levels from traffic noise above 60 and 65 dB(A). Noise limit values of 60 and 65 dB(A) were set for existing houses along existing major roads as a level above which, for specific categories of buildings, noise measures should be investigated. This survey of investigating the possible noise measures for existing roads culminated in the Dutch Road Traffic Noise Mitigation Program.

3. ROAD NOISE MITIGATION PROGRAM

3.1 Total program

In 2011 (updated in March 2012) a general survey (4) was held to estimate the total budget in Euros that was needed for the noise mitigation program. The survey concluded that the scope of the total program consists of 2,5 km^2 double layer porous asphalt, 24,3 km of noise barriers and 1390 houses that needed noise insulation. The total budget needed for these measures was estimated at € 275 million. The Road Administration consulted the market and concluded that the size of the program was too big for one project and divided the total program into 3 separate projects. The first (pilot) project MJPG 1 containing the regions "Noord Nederland, IJsselmeergebied, Limburg, Noord-Brabant and Zeeland" (see figure 2) started in July 2012 and will finish in 2016. The second and third project containing the other regions in the Netherlands started in 2014 and will finish in 2018.

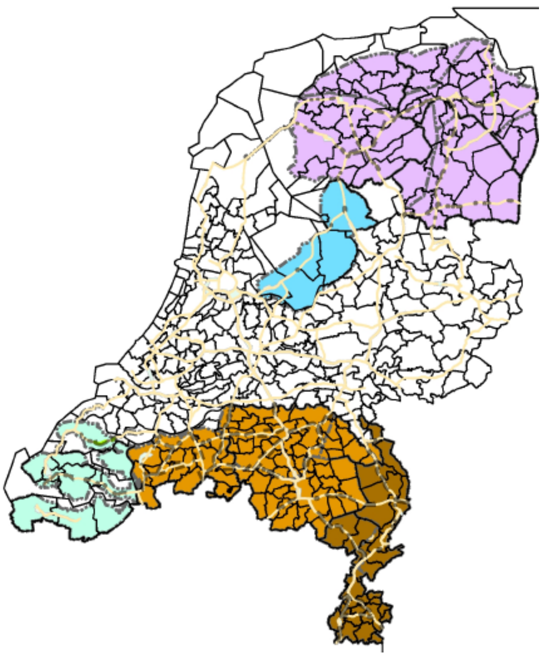

Figure 2 – Regions included in MJPG 1

3.2 Project MJPG 1

Project MJPG 1 is carried out by a consortium of three major engineering companies in the Netherlands "AnteaGroup", "Witteveen & Bos" and "RoyalHaskoningDHV". The consortium is led by the AnteaGroup Netherlands which is the main contractor. The total budget for the noise abatement measures of this project is estimated at € 69 million. Figure 2 shows the regions that are part of the scope of the project.

Project MJPG 1 is an integrated project containing the following activities:

- building the acoustical calculation models for the different sections of major roads;
- calculating and analysing the noise levels on individual houses along the sections;
- developing noise mitigation measures and performing cost benefit analysis on the noise measures using the Dutch CBA method;
- communication with stakeholders (municipalities, general public) about the proposed noise measures;
- design and cost calculation of the noise measures;
- legal advise;
- project management (risk- and quality management, planning, budget control)

The first step in the project is to establish the number of houses that are part of the program. The houses involved are divided into 3 categories:

- Category 1 "BSV": the houses built before 1986 that are remaining from the former noise mitigation program (started in 1986) and still experience a noise level of 60 dB(A) and higher and where until now no noise mitigation measures were taken;
- Category 2 "NoMo": the houses indicated in the policy document "Nota Mobiliteit" (5) published in 2004 with a noise level of 65 dB(A) and higher. This policy document stated the intention of the Ministry to reduce the traffic noise of all houses with a noise level above 65 dB(A) by using noise mitigation measures;
- Category 3 "GGG": the houses with a noise level of 55 dB(A) and more, which experienced an increase in noise level of at least 5 dB(A) in the period 1986 - 2012.

The second step is to develop noise mitigation measures for the houses involved in the program. These possible noise measures consist of noise reducing pavement, noise barriers , and noise insulation of the houses or a combination of these three measures. To investigate the cost effectiveness of these measures the Dutch cost benefit analyses method is used. The features of this method are highlighted in paragraph 3.3.

3.3 Dutch cost benefit analysis method

The Dutch cost benefit analysis method is part of the new law on noise which means that the use of this method is mandatory for the major roads. The method was developed from 2005 onwards and was used in practice under the old law on noise in many acoustical surveys in the period 2005 - 2012. In these years the method was improved several times based on the experiences in practice.

The method is described in detail in the Dutch publication "Kader Doelmatigheidscriterium Geluidsmaatregelen" (6) 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 the 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.

For example a noise barrier of 2 meter height will cost 93 points for each meter length, more detailed information can be found in Annex 1. The (combination of) noise measures to reduce the noise at a group of houses costs "noise measure points" and if the budget of "reduction points" is exceeded the measure will no longer be cost effective. The system deliberately uses "points" instead of "Euro's" to avoid discussion over actual costs which might fluctuate under influence of economic market conditions.

The budget of available "reduction points" per house increases if the noise level is higher. The graph in figure 3 shows the working of this system. The "reduction points" under the new law from 2012 are indicated in red (in blue the points under the old law are shown).

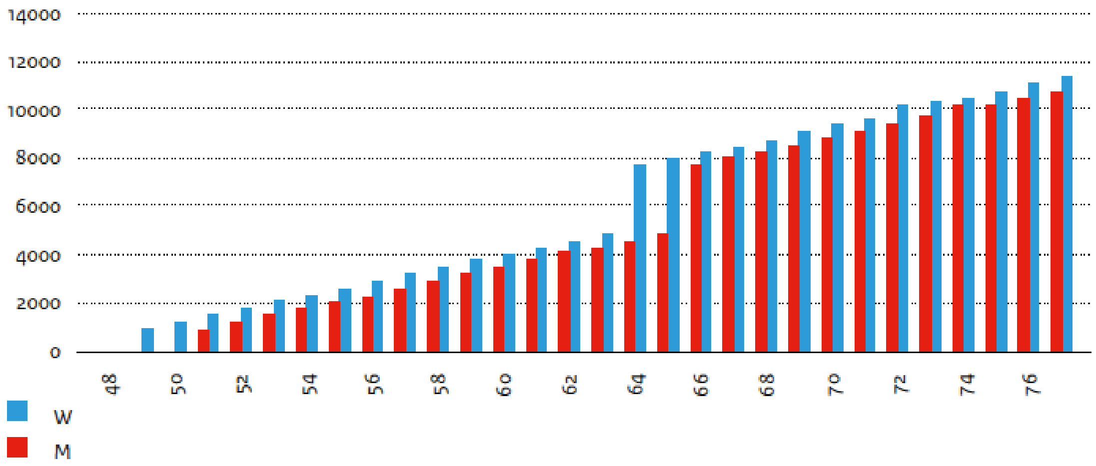

Figure 3 – Graph reduction points

The working of the graph is simple, the height of the noise level on the x-axis determines the number of reduction points on the y-axis. Using the graph it can be determined that one house with a noise level of 65 dB(A) will give 5000 reduction points, 2 houses with 65 dB(A) will give 10.000 points and 1 house with 65 dB(A) and 1 house with 66 dB(A) will give 12.800 points (see also table 1 in Annex 1).

In the same way noise abatement measures will cost points. For example: a noise barrier with a height of 3 meters will cost 133 points per meter length (see table 2 in Annex 1). Thus a simple noise barrier with a length of 100 meters and a height of 3 meter will cost 13.300 points. In this example the 2 houses with a noise level of 65 and 66 dB(A) will produce a budget of 12.800 point, which is not enough to "buy" a noise barrier with a length of 100 meter and a height of 3 meter. So, according to the method, this barrier is not an effective noise measure. This follows from rule number 2 of the method which states that the "noise measure points" needed for the noise measure (13.300) may not exceed the budget of available "reduction points" (12.800).

The most important rule in the method is rule number 1, which regulates that the noise measure that will be applied is designed in such a way that the noise level on the houses is decreased (as far as possible) to the preferred noise limit value of 60 dB(A) and no further. If the preferred noise limit value is reached within the budget the measure is considered effective and a survey into higher noise barriers is not needed even if there is budget left. For noise barriers, or noise barriers in combination with noise reducing pavement, an additional rule was introduced ordering that the noise reduction, from (the combination) of measures, for at least 1 house in the group should be no less than 5 dB(A).

Rule 3 of the method is a rule to prevent that irrational noise measures should be applied in case the available budget of reduction points is relatively high. One can imagine that in a large residential area with many houses with high noise levels the budget of reduction points may be quite large (some millions!). Rule 3 regulates that the addition of an extra noise measure (for example 1 meter extra height of a noise barrier) should still give a relevant contribution to the noise reduction of the houses involved. If an alternative noise measure leads to 95% of the noise reduction of the alternative that uses the total budget of reduction points, the 95% alternative will be considered as the most effective one.

When more than one (combination of) measures is possible within the budget and requires more or less the same number of points, the most effective measure will be the one with the highest noise reduction index. The noise reduction index (1) is determined by adding up the number of houses with the same noise reduction in a cluster multiplied with their noise reduction.

$$NRI = \sum_{i=1}^{n} (Hi * NRi) \tag{1}$$

NRI = Noise Reduction Index
H = Number of houses with the same noise reduction in a cluster
NR= Noise Reduction in dB(A)

3.4 Designing optimized noise measures using the method

The working of the method is demonstrated in the next example. In the situation shown in figure 4, first of all according to rule 1, the number of houses that don't comply with their noise limit value is determined. In the figure these houses are marked red. As rule 1 states that no (further) measures are needed if the preferred noise limit value is reached, the green houses don't need noise abatement measures, so they don't contribute to the budget of reduction points.

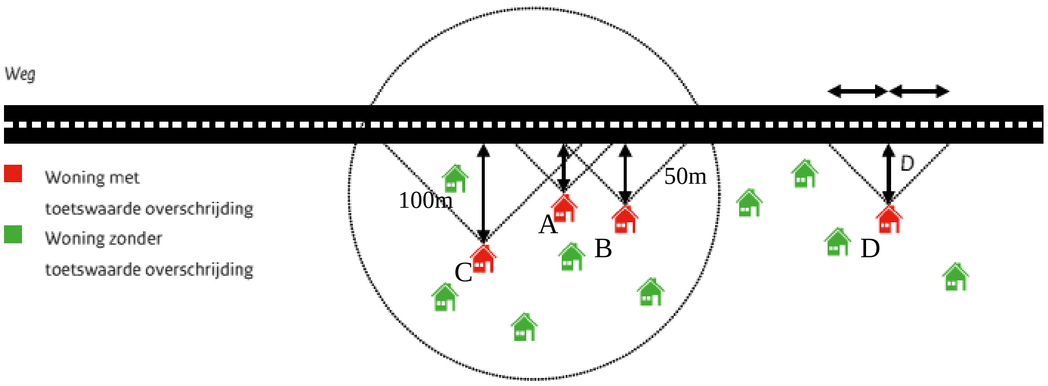

Figure 4 – Clustering the houses

To get a coherent set of noise measures, the buildings with a noise level that exceeds the noise limit value (here indicated in red), are clustered using the 1D view angle method (see Annex 2 for explanation). All buildings with overlapping view angles (A, B and C in figure 4) are combined into one cluster. In the situation above the buildings will be divided into 2 clusters. The clustering is performed to prevent that noise measures are developed that are irrational. The buildings in the 2 separate clusters are to far apart to form a logical group for one integrated noise measure (noise barrier or noise reducing pavement). In this example the buildings in cluster 1 (A, B and C) are each supposed to consist of 2 connected houses, so the total budget is calculated for the total number of houses. Building D in cluster 2 is just a single house. In table 1 the actual noise levels, the preferred noise limit values and the reduction points for the red houses in cluster 1 (encircled) and cluster 2 (single house) are given.

Table 1 – Noise levels & reduction points

Houses (#)	Actual noise level	Noise limit value	Reduction points
	Cluster 1		
Houses A (2)	66	60	15.600
Houses B (2)	65	60	10.000
Houses C (2)	63	60	8.800
total			34.400
	Cluster 2		
House D (1)	65	60	5.000
total			5.000

The road consists of 2x2 traffic lanes and the standard width for applying porous asphalt for this type of road is given in the method as 15 meter.

The possible alternatives for noise measures to consider for cluster 1 are:

1. Two layer porous asphalt (the method requires a minimum length of 500 meter related to maintenance requirements);
2. A noise barrier (the method requires a minimum height of 2 meters, below this height noise barriers are considered not effective).
3. A combination of two layer porous asphalt and a noise barrier.

The next step in the process is to design and optimize the measures for the alternatives above within the available budget. Ideally noise measures like porous asphalt and noise barriers are considered most effective if they cover the 2D view angle of the houses which they are designed for. The total length to cover based on this view angle would be 400 meter. As the minimum length of two layer porous asphalt (TLPA) is 500m, the first alternative consist of applying TLPA over the full length and width of the both lanes (500m x 15m). In table 2 the noise reduction in dB(A) and the costs in noise measure points are shown. The noise reduction is 3 dB(A) for each building and the measure costs 16.500 points. This is well within the budget but only for building C the preferred noise limit value is reached and there is still budget left. Although we comply with rule 2 (costs within the budget) we don't comply with rule 1, trying to reach the preferred noise limit values if there is still budget available.

In alternative 2 we are looking for a noise barrier instead of using the TLPA from alternative 1. The ideal length would be 400m (full 2D view angle covered). But with a minimum height required of 2m this alternative costs 37.200 points which exceeds the budget. Also with 2m height none of the buildings will have a noise reduction of 5 dB(A) (and this is required for at least one house). It is therefore not necessary to calculate this alternative in detail, but is it possible to optimise this alternative? Following the method from the other end we just look at a design for a logical solution that fits into the budget and the rules. If we limit the length of the noise barrier and increase the height (to deal with the 5 dB(A) requirement) a possible solution is a noise barrier of 250m and 3m height. This will cost 33.250 points and gives more noise reduction than alternative 1, but still the preferred noise limit values for A en B are not reached (see table 2). Increasing the height or length to reach the preferred noise limits values for A en B will cost more points and these are not available because the budget is spent.

Alternative 3 is a combination of TLPA and a noise barrier. We learned from alternative 1 that with TLPA, building C has reached its preferred noise limit value, so no noise barrier is needed for this building. For the remaining two buildings a total cover over 2D view angle requires a length of 220 m, with a minimum height of 2m, the budget needed is 20.460 points. This exceeds the remaining budget of 17.900 (budget after applying TLPA). As in alternative 2 it is possible to optimize the length of the noise barrier. With a height of 2m a length of 190m is possible within the budget. In this alternative the preferred noise limit value on all buildings is reached (see table 2), also on at least one house the required minimum of 5 dB(A) noise reduction is reached for a noise barrier in combination with noise reducing pavement.

Although the number of points required is slightly higher in alternative 3, compared to alternative 2, the combination of measures in alternative 3 is the most cost effective one, as it remains within the budget, all houses reach their noise limit value and the total of noise reduced houses (Noise Reduction Index) is the highest (index of 28[2] compared to 24 for alternative 2 and 18 for alternative 1).

Table 2 – Noise measure alternative and effectiveness

Alternative	Measure(s)	Costs (pts.)	Noise reduction (dB(A))			Noise Reduction Index
			A	B	C	
1	TLPA 500m	16.500	3	3	3	18
2	NB l=250m h=3m	33.250	5	4	3	24
3	TLPA 500m &	16.500	3	3	3	
	NB l=190m h=2m	17.670	3	2	1	28
	Total	34.170	6	5	4	

Cluster 2 is much simpler because the budget of available reduction points is only 5000. This budget is not sufficient to "finance" any measure at all. TLPA requires a minimum length of 500m and will cost 17.600 points which is well above the budget. With a minimum height of 2m the maximum length possible for a noise barrier is 50m. As the house is 50m away from the road this will not lead to a significant noise reduction and certainly not to the required noise reduction of 5 dB(A). No further survey is needed.

[2] Noise reductions under the preferred noise limit value are not calculated in the NRI

This example shows how the method works and leads to cost effective noise measures. Non logical, insufficient and ineffective noise measures will be directly removed from the possible alternatives. In this way the actual costs of the noise measures will be less than without using the cost benefit method.

3.5 First results from the Zeeland region

The examples in 3.4 are fictitious situations, so the question rises; does the method also work in practice? This is highlighted using the first actual results from the Zeeland region of MJPG 1. The Zeeland region is the pilot region within the project because it is one of the smallest regions and in the planning this region was the first to be surveyed. In the beginning of 2014 the first results for Zeeland were available. The first results contained the objects with actual noise levels above their noise limit value and an initial clustering. In Zeeland only two major roads needed to be surveyed; the major road A58 from Bergen op Zoom to Vlissingen and the N59 from Bruinisse to Burgh-Haamstede.

In this paper only part of the results from the A58 are presented. The A58 was divided into 9 sections where houses with high noise levels are located, and formed logical groups to be included in one coherent noise calculation model. Each section of road contains several cluster of houses based on the clustering method from the CBA method. In figure 5 the clustering along a section of highway A58 near the city of Middelburg is shown.

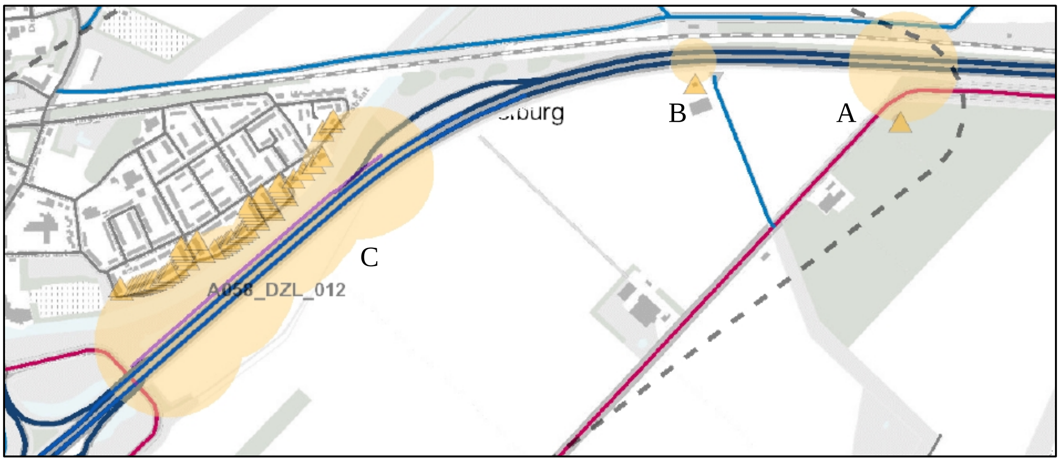

Figure 5 – Clustering A58 near Middelburg

For all clusters the budget of available reduction points was established and the process of designing optimized noise measures as described in 3.4 was followed. The results for three clusters A, B and C are highlighted. The clusters A and B are small clusters with just a single house. The triangles in figure 5 indicate the houses and the (overlapping) circles indicate the clusters.

First analysis of these clusters showed that for cluster A the actual noise level, after being calculated with the detailed calculation model, was already below 65 dB(A) which is the noise limit value for this house and so no further survey into noise measures was needed.

For cluster B the detailed calculations resulted in a noise level of 68 dB(A). This level is above the noise limit value of 65 dB(A) and measures were investigated. With a limited budget of 8.300 points no TLPA could be applied, as the required minimum of 500m for this measure costs 16.500 points which is above the budget. Next alternative could be a noise barrier, but it can easily be understood that a total coverage of the 2D view angle (160m) with a required minimum height of 2m is not possible (costs are 14.880 points). Reasoning the other way around, a noise barrier of 2m or 3m height fits within the budget respectively with a length of 85 or 60m. Both solutions are not cost effective as they don't deliver the minimum noise reduction of 5 dB(A). So the only solution left for this house is noise insulation.

Cluster C is a large cluster containing 60 houses with a noise level above the noise limit value. The total budget of reduction points available is 315.900. With a 2D view angle of 900m a maximum solution for this cluster could be 900m of TLPA combined with a noise barrier of 900m with a height of 7m. The CBA showed that this solution is an overkill for this location, because with a combination of TLPA and a noise barrier of 5m high all houses already meet their preferred noise limit value (rule

1). Additionally this latter solution already gives 95% of the total noise reduction of the maximum solution, so the additional 3m height only marginally contributes to the total NRI (rule 3).

Still the result showed that further optimization of the noise barrier as well as the TLPA was possible. With a height of 5m over the full length of 900m the actual noise levels dropped for some houses under the preferred noise limit value. According to rule 1 this is not necessary. The final and preferred solution is a combination of 700m of TLPA and a noise barrier with total length of 600m and varying heights of 2, 4 en 5 meters. The total actual costs based on standardized cost figures are estimated as follows:

- Alternative 1: 900m TLPA and 900m noise barrier 7m high € 3.580.000;
- Alternative 2: 900m TLPA and 900m noise barrier 5m high € 2.645.000;
- Alternative 3: 700m TLPA and 600m noise barrier (varying heights) € 1.381.000.

If these alternatives are compared on estimated actual costs it becomes clear that not only the "best fit" solution but also the alternative with the lowest estimated costs has the preference.

3.6 Next steps in the project

The alternatives for all clusters were developed in an integrated process. Meetings were held to discuss the possible alternatives within the margins of the CBA method and taking into account other aspects like technical engineering problems, aesthetics, design, traffic regulations etc. In these meetings experts from the Road Administration departments of road maintenance, communications, technical engineering & design and acoustics were present. All aspects of the alternatives were discussed and this resulted in the most preferable alternative for each cluster regarding the demands for all aspects.

The next step in the process will be to present these solutions for every cluster to the local stakeholders involved, like municipalities and general public. Because the integral analysis of the situation has already been done (including a cost benefit analysis) a good bases has been created for a strong presentation of the preferable alternative to the stakeholders. This will lead to less discussions regarding the alternatives as the motivation for the preferable alternative is solid and based on a statutory method.

4. CONCLUSIONS

4.1 Conclusion from first results of MJPG 1 project

The project MJPG 1 is the first pilot project within the "Dutch Road Noise Mitigation Program" and is well on its way. In all 5 regions the houses with noise levels above their noise limit value are determined and the process of designing and optimizing the noise measures for the clusters is partly ready. The use of CBA method in an integrated design process leads to optimised and cost effective noise abatement measures for the houses involved and in the Zeeland region the results are promising.

Next steps in the project will be to finish the integrated design process including cost benefit analysis for all regions and communicate the preferable alternatives with the stakeholders involved. In the same time the preferable (combination of) noise reduction measures are designed in more technical detail to deliver an estimation of the actual costs based on standardized cost figures. The next important milestone for the project is 1 July 2015, as on this date the estimation of total costs with an accuracy of 85% most be finished. This is necessary in order to check if the first MJPG pilot project with the use of the CBA method will stay within the estimated budget of € 69 million. Also it will give a prediction of costs for the other two projects in the program and a possible estimation of the total budget needed.

As stated earlier the first results in the Zeeland region are promising and lead to the following conclusions for use of the CBA method:

- Less survey is needed as incoherent or non logical alternatives are directly removed by using the method and need not be investigated in detail;
- Less costs are spent on detailed survey and investigating "oversized" noise measures as the method in itself already leads to the "best fit" solution of noise measures;
- The "best fit" solutions of noise measures lead to less costs compared with traditional methods of designing noise measures;
- The communication process with the stakeholders (municipalities and general public) is easier as the preferable alternative of noise measures is solidly based on a standardized integrated design process including CBA;

- The CBA method is embedded in the legal system of the new law on noise which gives it an strong position against objections made in legal procedures;
- The method contributes to the general use of source related noise measures, like noise reducing pavements, because these are always considered as first option in the process.

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ANNEX 1 : CBA Point system

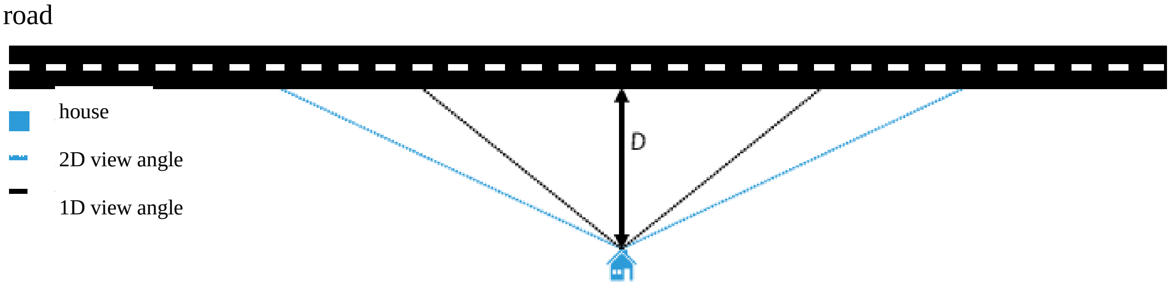
Table 1 : Calculation table for noise reduction points

Noise level (dB(A))	Reduction points
50	0
51	1.000
52	1.300
53	1.600
54	1.900
55	2.100
56	2.400
57	2.700
58	3.000
59	3.300
60	3.600
61	3.900
62	4.100
63	4.400
64	4.700
65	5.000
66	7.800
67	8.100
68	8.300
69	8.600
70	8.900
71	9.200
72	9.500
73	9.800
74	10.100
75	10.300
76	10.600
77	10.900

Table 2 : Calculation table noise measure points for noise barriers

Barrier Height (m)	Noise measure points (per meter length)
2	93
3	133
4	173
5	212
6	251
7	289
8	327

ANNEX 2 : Explanation of 1D and 2D view angles



In the CBA method the 1D view angles (black lines) are used to determine the coherent clusters. The 2D view angles (blue lines) are used to design noise measures like noise reducing pavements or noise barriers.