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The role of ITS in noise mapping and noise action planning

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SUMMARY

For the production of strategic noise maps and noise action plans, as required under the European Noise Directive (END), improved assessment methods for environmental noise will be required. The EU project IMAGINE will provide improved methods for the assessment of noise impacts from railways, roads and aircraft, and industry. The project pays special attention to approaches to road traffic modeling, in particular, to improved accuracy in modelling the current traffic situation and methods to assess of the effects of a range of mitigating measures, for instance when considering Intelligent Transport Systems (ITS). This paper gives the initial results of the IMAGINE work package on road traffic modeling, and presents examples of case studies where the effects of ITS measures on noise were assessed.

INTRODUCTION

BACKGROUND

Transport policy always has to find a balance between several aspects of traffic, such as traffic efficiency (accessibility, throughput, travel times), safety and environmental impacts. Unfortunately, what is good for accessibility is not necessarily good for safety or the environment, or vice versa. In congested areas, where the emphasis of transport policy is likely to be on traffic efficiency, this sometimes leads to dilemmas that are difficult to solve. For instance: policy makers would like to introduce traffic management measures such as opening an extra lane during peak hours, but they are confronted with environmental directives that stipulate that the effects on the environment (air quality, noise annoyance) need to be specified before any action can be taken. Such directives are the *Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management* (1) (and daughter directives) and *Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002, relating to the assessment and management of environmental noise* (the 'European Noise directive' (END), (2)).

As a result of these directives, and the need to find a balance between all the different effects of traffic, it has become more important to be able to assess, usually with the help of traffic models, (i) the noise impacts of current traffic flow patterns and (ii) the effects of measures to mitigate those effects. These days, Intelligent Transport Systems (ITS) are often named as a promising alternative to the more traditional policy measures to solve traffic problems (e.g. building new roads, improving and promoting public transport, providing sound barriers). This goes for solving congestion as well as for solving environmental problems: policy makers have discovered the potential of ITS measures, such as lowering of the speed limits or adapting traffic signals, to improve air quality or reduce noise levels.

This paper discusses the consequences of the END and the harmonised noise models that have been developed to support the practice of noise mapping and noise action planning in the EU. It addresses the question of how traffic models can be used in such a way that accurate noise maps are produced, which may be comparable across cities and regions. Furthermore, it is important to be able to model ITS measures, and to provide estimates of the expected order of magnitude of effects of ITS measures on noise levels. Several case studies illustrate current practice and possible improvements.

THE EUROPEAN NOISE DIRECTIVE

For the production of strategic noise maps, as required under the END, improved assessment methods for environmental noise will be required. Noise from any major noise source, be it major roads, railways, airports or industrial activities in agglomerations, needs to be included in the noise mapping. Figure 1 gives an example of a noise map, showing noise contours along urban roads in the town of Delft, in The Netherlands.

National, regional and local authorities in the EU will not only be obliged to provide noise maps, they will also be asked to prepare a noise action plan with measures to reduce noise levels when limits are exceeded (thresholds are determined by the Member States). More information on the END can be found on the EU website (3).

Figure 1: Example of a noise map (source: URBIS model (4)).

THE IMAGINE PROJECT

IMAGINE (*Improved Methods for the Assessment of the Generic Impact of Noise in the Environment*), an EU-6th Framework project (5), will expand on the noise calculation methods for road and rail developed in the HARMONOISE project (*Harmonised, Accurate and Reliable Methods for the EU directive on the assessment and management of environmental noise*; EU-5th Framework Programme (6)). IMAGINE will develop similar methodologies for aircraft and industrial noise, and provide the link between HARMONOISE and the practical implementation of the END. The calculation methods differentiate between source models (for road, rail, air and industry) and a propagation model, which is basically the same for all sources. The HARMONOISE methods will eventually replace the noise calculation methods that are in use in the Member States now. In order to ensure high credibility and quality results, guidelines on how to use the harmonised noise models are being developed, as well as databases with default data (e.g. shares of fuel types, or tyre types, in different member states), with instructions on how to deal with situations deviating from the normal.

An important aspect of the practical implementation is the use of road traffic models and measurements in noise mapping and noise action planning. Work package 2 (Demand and traffic flow modelling) of IMAGINE is therefore dedicated to this subject. It deals specifically with approaches to traffic modelling for noise mapping and noise action planning. The objective is to provide guidelines and examples for an efficient link between traffic modelling (including the modelling of traffic demand and traffic management measures) on the one hand, and noise mapping and action planning on the other. To this end, the partners in the work package will develop practical solutions for problems that may arise, and recommendations for additional data collection will be given. The objective is not to provide a traffic model that everyone throughout the EU should use – instead, users should be able to use their own models, but in such a way that accuracy and comparability are ensured. The guidelines for the use of traffic modelling for road noise mapping and road noise action planning will be available in the second half of 2006, through the IMAGINE website.

Before entering into the specific needs of modelling ITS measures, the general problems that can be encountered when road traffic models are used to provide input for the road noise model will be presented.

LINKING TRAFFIC & NOISE MODELS

DATA NEEDS OF NOISE MODELS

The minimum amount of information needed to allow calculation of the sound power level of traffic on a certain road segment is the traffic volume and the average vehicle speed for each of the main vehicle categories. The accuracy and representativeness of the results will be further enhanced if distributions of vehicle speeds and acceleration values are included. The highest level of detail is to have the vehicle category, speed and acceleration for each vehicle at each road segment. To calculate the yearly averaged noise indicators L_{DEN} and L_{night} (as needed for the noise maps), these values should be known per day, evening and night period, and, if possible, for each separate road lane and driving direction.

In general, situations with low vehicle speeds and high acceleration values demand more detailed information (7). A theoretical modelling exercise showed that that for a motorway situation, using only the traffic volume and average speed results is sufficient. However, for urban traffic, the inclusion of a distribution of acceleration values is needed for an acceptably accurate result. As these data are not always available from traffic models, correction factors may have to be derived, for instance for the effects of accelerations of traffic on intersections.

With respect to the sensitivity of the noise source model for the various traffic parameters, it seems that the noise model is less sensitive to variations in the total vehicle volume than to the percentage of heavy motor vehicles and the average vehicle speed. Furthermore, the inclusion of distributions of vehicle speeds and/or accelerations may have a significant positive influence on the results, but the resolution of these distributions does not seem to be very important.

With the data needs of the noise model known, it is possible to assess the suitability of traffic models for use in noise mapping and noise action planning. Of particular interest for ITS is the fact that the noise model offers the possibility to incorporate data on speeds distributions and accelerations – parameters that many ITS measures influence.

SUITABILITY OF DIFFERENT TRAFFIC MODELS

In IMAGINE, the suitability for noise modelling was reviewed for four types of traffic models: static, dynamic, continuum and micro-simulation models (8). The conclusion was that there is no superior type of model to deliver input for traffic noise models. Depending on the study area (e.g. national, regional or agglomeration level), several traffic model types are capable to deliver the required output. Different models have different strengths and weaknesses, as illustrated by two tables from the review. Table 1 shows that micro-simulation models can produce data that is exactly what the noise model needs, but, as table 2 shows, it is not always practical to use this type of model, because a relatively large effort is needed to build, calibrate and run the model.

Table 1: Capability of traffic models to produce detailed output

	Static	Dynamic	Continuum	Micro-simulation
Traffic volumes	+	++	-	+/-
Speeds	+	+	++	++
Speed distributions	-	+	+	++
Acceleration	-	-	+	++
Traffic fleet influence	+/-	+/-	+/-	+

++ available and reliable
+ available; possibly not reliable
- not available

Table 2: Efforts involved in building, calibrating and maintaining the model

	Static	Dynamic	Continuum	Micro-simulation
Building the model	+	0	-	0
Calibrating the model	+	+	+	-
Maintaining the model	+	+	+	0

+ relatively small effort
0 neutral
- relatively large effort

Besides the characteristics of the output of different traffic models, and the efforts involved, there are other characteristics of the models that need to be considered, as they might have weak points that need attention, such as:

- problems associated with the use of traffic models in practice (which models can be used for different study areas, e.g. motorway networks vs. urban areas, do the models cover day, evening and night periods);
- problems associated with interfacing between traffic and noise models (e.g. spatial accuracy of road networks in traffic models, are lower level roads included, can data be easily exchanged between traffic and noise models);
- the quality of data for the traffic demand and assignment models, and how this relates to accuracy;
- the possibilities of modelling noise reducing measures.

These aspects are also discussed in the review. Many of the weak points can be explained by the fact that until now, traffic models were developed specifically to implement transportation policies. The application of these models for environmental policies is possible but usually requires adaptations to the models and/or their input – which means extra effort. Furthermore, there is no guarantee that suitable traffic models exist in every region or agglomeration that is obliged to produce a noise map. The IMAGINE project aims to prepare traffic and noise modellers for when they will have to work with the new calculations methods.

MODELLING ITS MEASURES

What specific problems will modellers encounter when modelling ITS measures? Traffic is the result of many choices that travellers make: the choice to go somewhere, with a certain mode of transport, at a certain time, following a certain route and driving with a certain behaviour. Measures can have effect on any of these choices. A characteristic of many ITS measures, e.g. advanced driver assistance systems (ADAS) is that they influence, directly, driver (and vehicle) behaviour. That means that it must be possible to incorporate these changes in the traffic model, if one wants to assess the effects of the measure. Micro-simulation models are best suited to model ITS measures (though several traffic management measures influencing route choice can also be modelled in dynamic assignment models). Different driver-vehicle combinations can be distinguished and given their own specific characteristics (e.g. a vehicle is equipped with adaptive cruise control or not, a driver is likely to follow a speed advice or not). However, especially in the case of ADAS, this is not standard practice yet; much of the data that is needed is only available from pilot studies. Assumptions must be made to generalise the findings of pilot studies for a wider application of the measure, and often the simulation models will need to be adapted to include specific measures. When that has been achieved, the output data has to be processed into input data for the noise model, not a standard procedure yet either. This shows that the reliability of assessment of the (acoustic) performance of such measures relies fundamentally on the accuracy and flexibility of the supporting traffic models. With the help of a few case studies we will show how ITS measures can be modelled and what order of magnitude of effects can be expected.

CASE STUDIES

IMPACT OF TRAFFIC DEMAND STRATEGIES IN LEICESTER, UK ON NOISE EMISSIONS

In order to assess the magnitude of impact on noise emissions of a variety of Traffic Demand Management Strategies (TDMS) in Leicester, UK, a total of six scenarios were modelled as part of the HEAVEN project (9) using a combination of the static-assignment model TRIPS (10), and the Airviro Air-Quality Management System (11). The Leicester HEAVEN system itself constitutes a Decision Support System (DSS), combining air-quality and noise predictions using on-line traffic data, alongside libraries of pre-generated results, to allow network engineers to better assess the effects of their policies. Noise modelling in HEAVEN was limited to use of the UK interim calculation procedures (12, 13).

The TDMS scenarios analysed were:

- A base case scenario for the year 2001 (deemed “01base”) using the TRIPS model for traffic flows in the AM and PM peaks. Flows for other hours were scaled from peak values using hourly profiles developed by Leicester Area Traffic Control engineers, based on automatic count information, in accordance with Tool 3 for traffic flows from WG-AEN’s *Good Practice Guide* (14).
- A reduction in heavy goods vehicles (over 3.5 tonnes) from 100% to 0%, deemed scenario 2, or “01Base-NoHGVs”;
- A 20% reduction in vehicle speeds across the network, deemed scenario “01Base Speed-20”;
- The impact of the introduction of park-and-ride on five key radials at the periphery of the city, in the year 2005, deemed scenario “Park-and-Ride 2005”. The basis for this scenario was Leicester City Council’s Air Quality Management Strategy (AQMS) for 2005.

Often pollution control engineers estimate changes in noise levels created by reductions in traffic flows and speeds without considering the capacity effects of those changes on the network capacity. Therefore a further two scenarios were also studied, based on scenarios “01Base-NoHGVs” and “01Base Speed-20”, but also including the effects of reassignment in the TRIPS model. These are referred to as scenario’s “NoHGV” and “Speed-20” respectively.

Changes in noise levels due to TDMS

The analysis scenarios produced roadside $L_{Aeq,1h}$ or $L_{A10,1h}$ levels at a distance of 10m from the kerb. No attempt was made to include complex propagation effects (topography, meteorology etc.), as would be required for noise mapping. Concentration was focused solely on changes in noise emission due to traffic parameters. General analysis of traffic model output for the two speed reduction scenarios showed an increase in vehicle journey time of 9.2% and 8.9% respectively for the am- and pm-peak periods over the 2001 base case. Allowing redistribution of traffic in the “01Base Speed -20” scenario increased flows on some minor roads where vehicles attempted to avoid congestion bottlenecks. For scenario “01Base NoHGV”, the lowering of flow volumes gave a 28% improvement in network travel time during both peaks. However, in scenario “NoHGV”, lighter vehicles did not take advantage of the absence of HGV traffic, with no further increase in speeds. The general pattern of noise emissions in the demonstration area, as modelled using the TRIPS 2001 base network, is shown in Figure 2.

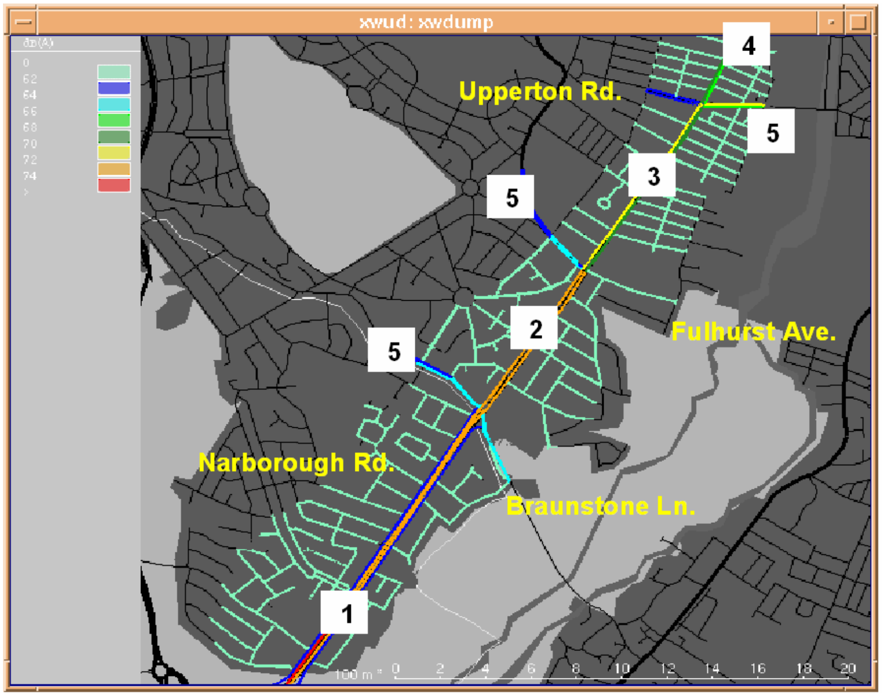
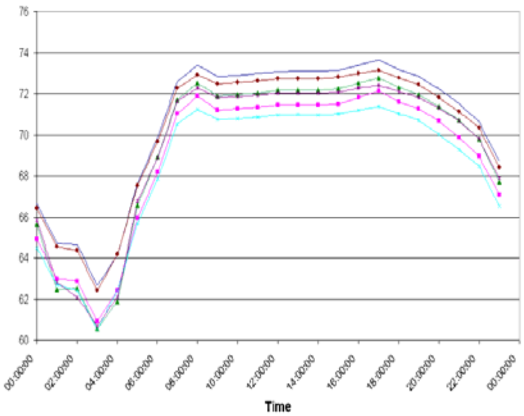


Figure 2: Average daytime $L_{A10,1\text{-}hour}$ levels calculated using TRIPS 2001 base network.

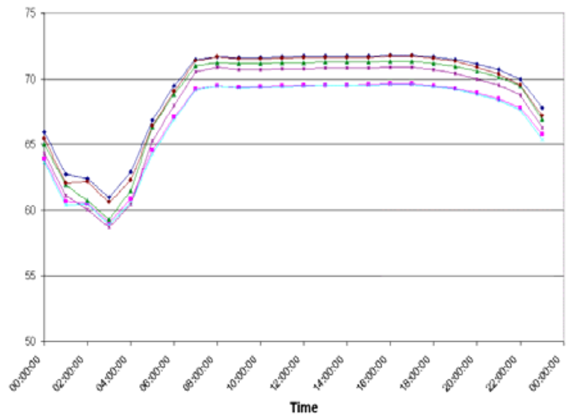
Figures 3a-d show the temporal variations in noise emission results ($L_{Aeq,\ 1h}$) from the TDMS analysis for link sections (1, 2, 3 and 5). Note Figure 2d. is based on an energy-average composite picture for all secondary roads in the study network. Analysis of these profiles show that roadside $L_{Aeq,\ 1\text{-}hour}$ levels are approximately 10 to 15 dB(A) lower at night than during the day, with the quietest hours between 0200 to 0500, when traffic flows are lowest.

The most effective strategy to reduce noise emissions was found to be the complete removal of HGVs from the area considered. This leads to an approximate reduction in daytime $L_{Aeq,\ 1\text{-}hour}$ levels of ≈ 2.7 dB(A). At night the reduction is higher, being up to 3.1 dB(A). Obviously, the strategy of removing all HGVs from the roads is unrealistic. It must also be mentioned that the TRIPS modelled HGV flows (≈10%) for Narborough Road are generally greater than the HGV proportions observed during an on-street monitoring campaign during summer 2002 (≈6% HGVs). Therefore, it is suggested that the effectiveness of the HGV removal scenarios has been slightly over-estimated. The reduction of speeds by 20% is a less effective strategy, with corresponding reductions in roadside $L_{Aeq,\ 1\text{-}hour}$ levels for the studies of Narborough Road being of the order of ≈0.4 dB(A). Indeed, when using the UK CoRTN procedure, reducing speeds below ≈25 km/h in the model gives no benefit. This is because of the assumption of increased congestion levels at lower speeds increasing the calculated $L_{Aeq,\ 1\text{-}hour}$ levels. Some specific sections near junctions on the secondary links and on Narborough Road actually show increases in roadside noise level of the order up to 1.0 dB(A) when the speed decrease is applied, as speeds move away from the minimum for emissions at 20-40km/h.

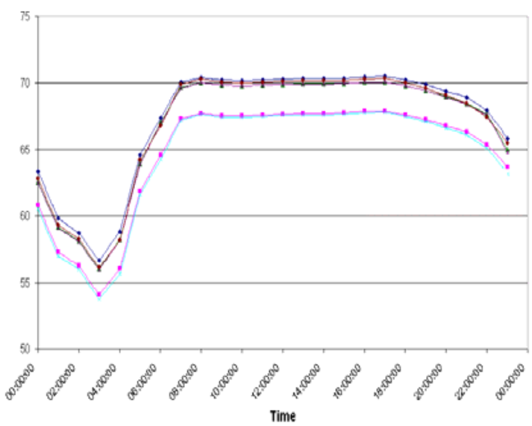
The most realistic scenario, i.e. “Park-and-Ride 2005” shows the least improvement in noise levels over the base case. Daytime noise levels for the park and ride scheme are within 0.2 dB(A) of the base case. Such a small variation in levels would be completely unnoticeable to a human. Greater benefits of ≈ 0.5 dB(A) are predicted fro the evening/night time levels, through the reduction of vehicle flows along Narborough Road. This scenario begs a more detailed repeat analysis, including better profiling of the 24-hour flows used and better modelling of reallocation of traffic from cars to buses, especially during the peak hours, in order to more accurately assess the changes in noise levels.



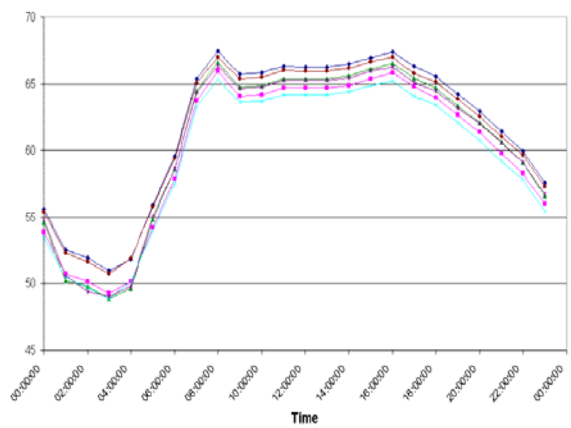
a) Narborough Road between M1 and Braunstone Ln. (Fig2. section 1)



b) Narborough Road between Braunstone Ln. and Fullhurst Ave. Fig.2 section 2)



c) Narborough Road between Fullhurst Ave and Upperton Rd. (Fig2. section 3)



d) Secondary Roads (Energy average Fig2. sections 5)

Key:

- 01 Base
- No HGVs
- Speed -20%
- 01 Base No HGVs
- 01 Base Speed -20%
- 2005 Park and Ride

Figures 3a-d: Diurnal profiles of roadside $L_{Aeq, 1h}$ levels

The effect of ignoring the network capacity effects when modelling the scenarios is complex for the “NoHGVs”case. With no HGVs, traffic flows along Narborough Road reduce, allowing drivers to potentially travel at higher speeds. However, this potential is restricted on the sections of the Narborough Road closer to the city centre where either road width is reduced, or the flow levels are higher. This means that ignoring capacity effects leads to an over-prediction of the benefits on the stretches of Narborough Road further from the City Centre. Some redistribution of traffic occurs complicating the situation further. Either of the speed reduction scenarios, impacts the throughput of traffic, leading to lower overall daily flows. However, there is potential for redistribution of traffic on alternative links. The changes in noise levels between the "Speed-20" and the "01Base-Speed-20" scenarios reflect the combination of drops in noise level due to reductions in flow and speed, but countered by an increase on some links due to redistribution of traffic.

Conclusions

The HEAVEN TDMS analysis shows that for there to be any major, discernable benefits on roadside noise levels, then fairly robust solutions need to be considered, if the mitigation approaches are limited solely to manipulation of traffic flows through individual ITS measures. Such drastic measures as outright bans on vehicle movements might be considered unpalatable in policy terms, with the norm being composite measures comprising of more moderate strategies.

The HEAVEN analysis also highlights problems of the paucity of analysis possible when using a traditional static assignment model, with a number of basic assumptions on traffic parameters and diurnal profiles, coupled with an interim computation measure, to assess or develop noise action plans. The HARMONOISE/IMAGINE approach, alongside WG-AEN (14), will better specify the defaults to be used when data does not exist at the required level of detail, whilst also allowing refinements to be made in modeling where such data does exist.

EFFECTS OF LOWER SPEED LIMIT IN OVERSCHIE, NL

Another example of the current practice of using traffic models for traffic noise modelling is a quick scan study carried out by TNO for the Transport Research Centre of the Dutch Ministry of Transport (15). The aim of this study was to determine the optimal speed limit on motorways near bottlenecks from the point of view of traffic throughput, safety, noise, emissions, and user acceptance. Three different speed limits were considered: 80, 90 and 100 km/h, all with strict enforcement. They have been compared with a base case of 100 km/h without strict enforcement. The study was based on the positive effects obtained at the Overschie area in Rotterdam where the speed limit on a major motorway, the A13, was reduced from 100 km/h to 80 km/h. This measure resulted in significantly reduced noise and emission levels. Here, we will focus on the method used to determine the effects of different speed limits on noise.

A reduced speed limit will normally primarily influence average speeds. But, introducing strictly enforced speed limits will also alter speed distributions. Empirical data revealed that under strict enforcement, drivers tend to stick more closely to the speed limit than normally. This behaviour results in significantly narrower speed distributions. In order to determine the effects on noise of a reduced strictly enforced speed limit, we therefore needed information on resulting speeds and speed distributions when a reduced strictly enforced speed limit was applied. Since measurement data on speeds were only available for 80 km/h with strict enforcement and 100 km/h without strict enforcement, a micro-simulation model was used to model the effects of all three different strictly enforced speed limits on speeds and speed distributions. The model used for that aim was MIXIC, a micro-simulation model developed by TNO. With this model, the traffic flow on a single stretch of motorway can be simulated using detailed driver and vehicle models. For this particular application, we had to modify the driver model of MIXIC to incorporate the differences in driver behaviour under strict enforcement. This involved primarily changing the speed preferences of different driver types under different speed limits. Using MIXIC, simulations have been carried out for 100 km/h and 120 km/h without strict enforcement, and 80 km/h, 90 km/h and 100 km/h with strict enforcement. The resulting speed distributions are given in figure 4.

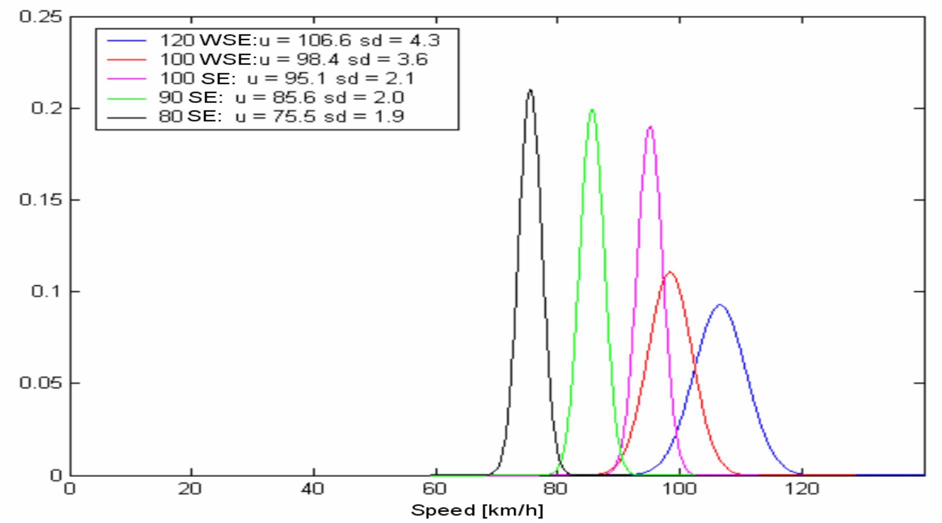


Figure 4: Speed distributions (WSE = without strict enforcement, SE = strictly enforced)

The next step was to estimate the effects on noise emission levels. Noise emission levels have been computed using the statutory calculation scheme SRM I (Standaard Rekenmethode I, see (16)). Using this scheme, noise emission levels had to be computed for three different vehicle types: light vehicles (primarily cars), medium-weighted vehicles (vans/small lorries) and heavy vehicles. The MIXIC output was used to compute average flows and mean speeds for these three vehicle types. This resulted in the noise emission levels as given in table 3. Due to the type of road surface modelled (pervious asphalt, ZOAB), only limited reductions in noise emission levels are obtained by lowering the speed limit. On normal asphalt, the effects are estimated to be approximately twice as large.

By combining microscopic traffic simulation modelling and the common Dutch noise calculation scheme, it could be concluded that from the three different speed limits, a strictly enforced speed limit of 80 km/h is the most effective. However, more generally we could conclude that introducing strictly enforced reduced speed limits is not a very effective measure to reduce noise emission levels, as the reductions achieved were small (compared to reductions that can be achieved by, for instance, the installation of noise screens, reducing noise emission levels by 10 dB(A), or using pervious asphalt, which reduces noise emission levels by approximately 3 dB(A).

Table 3: Noise emission levels (WSE = without strict enforcement, SE = strictly enforced)

	Light vehicles	Medium vehicles	Heavy vehicles	Total (combined)	Difference
100 WSE	86,7	75,5	73,7	87,2	
80 SE	**86,0**	**75,3**	**73,6**	**86,5**	**-0,7**
90 SE	86,3	75,4	73,6	86,9	-0,4
100 SE	86,6	75,5	73,7	87,2	-0,1

The findings above are strengthened further by recent work at the University of Leeds (17), studying the effects of the uptake of mandatory ISA (Intelligent Speed Adaptation) on both emissions (i.e. sound power levels) and roadside noise levels. This work was carried out using a version of the DRACULA micro-simulation model (18), with the HARMONOISE road source model (19). Variations in results due to the choice of modeling procedure (i.e. noise calculations using aggregate statistics from the micro-simulation model or using individual vehicle information) were found to be larger (>0.5dB) than the changes associated with 100% penetration of ISA (<0.3 dB).

Whilst these findings are preliminary, and suggest that ISA would have little impact on calculated L_{DEN} levels, required for the END, they were based on the study of peak and off-peak daytime flow levels. Further work is required on assessing whether ISA would be of benefit to reducing speeding and harsh acceleration (and hence noise levels and sleep disturbance) during nighttime periods.

DISCUSSION

This paper addressed the consequences the European Noise Directive has on traffic modelling, and what role ITS or, more specifically the modelling of ITS measures, may have in noise mapping and noise action planning. In the IMAGINE project, the data needs of the road noise model and the capability of different types of traffic models to produce the desired input for the noise model have been reviewed. A selection of the results have been presented here; the full reports can be found on the IMAGINE website (WP2). Future publications will also be published on the website and will include a report on strategies to improve traffic modelling for noise modelling, a report on additional data collection and, finally, the guidelines for the use of road traffic models and measurements in noise mapping and noise action planning. This should result in accurate noise maps that are comparable across regions and countries.

Because traffic models were not developed for environmental analyses, traffic modellers will face several problems when applying traffic models to provide input for the noise model (similar problems exist for air quality analyses). Most of these problems can be solved, but extra effort may be required.

In this paper we presented several case studies to illustrate how ITS measures can be evaluated and what impact they can be expected to have on noise levels. These case studies, from the HEAVEN project and the effects of a lower speed limit with strict enforcement on a motorway, showed that modelling ITS measures often requires adaptation of existing static assignment and micro-simulation packages, to enable the modelling of changes in driver and vehicle behaviour. The case studies also showed that the effects that can be expected from (current) ITS measures on noise seem to be small. Far more effective measures exist, such as noise screens pervious asphalt. However, in specific cases ITS measures may be effective in reducing peaks in noise levels, and therefore reduce noise annoyance and sleep disturbance. In some cases, ITS measures may be the only option. And as ITS measures will continue to evolve, and the EU Directives continue to require accurate noise mapping, research into the (modelling of) effects of ITS measures remains important.

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REFERENCES

(1) Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management. In Official Journal L 296, 21 November 1996, pp. 0055 – 0063.

(2) Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002, relating to the assessment and management of environmental noise. In: Official Journal of the European Communities. 18 July 2002.

(3) See http://europa.eu.int/comm/environment/noise/home.htm

(4) URBIS model, see http://www.tno.nl/ruimtegebruik_en_infrastructuur/kwaliteit_van_de_leefomge/leefomgeving_en_gezondhei/urbis/

(5) IMAGINE Project website at www.imagine-project.org.

(6) HARMONOISE Project website at www.harmonoise.org.

(7) B. Peeters (2004), Review of data needs for road noise source modelling. M+P Raadgevende Ingenieurs B.V., Vught, 2004, Imagine report number IMA2TR-040615-M+P10.

(8) Transport and Mobility Leuven, TNO, University of Ghent, University of Leeds. Review of the suitability of traffic models for noise modelling. Leuven, 2005, Imagine report number IMA02TR-050112-TML10.

(9) S. Harris, N. Hodges, H. Jenkins, J. Ellison, , M.C. Bell, P. Goodman, A. Namdeo and K. Häggkvist (2003). Demonstrator Leicester. Deliverable of WorkPackage 8.11 of the HEAVEN Project. EU 5th Framework, Information Society and Technology Programme, IST-1999-11244.

(10) Citilabs Europe. (2001). TRIPS (TRansport Improvement Planning System). Citilabs Europe. Wokingham, Surrey, UK. See http://www.citilabs.com.

(11) SMHI. (2002). Airviro user documentation, Airviro Air-Quality Management System, User's Guide Version 2.40.00. SMHI (Swedish Meteorological and Hydrological Institute), Norrköping, Sweden.

(12) P. Abbot, P. Nelson (2002). Converting the UK Traffic Noise Index, $L_{A10,\ 18h}$, to EU Noise Indices for Noise Mapping. Report PR/SE/451/02, prepared by TRL Ltd., Crowthorne, UK. for the Department of the Environment, Farming and Rural Affairs (DEFRA).

(13) DoT (Department of Transport – Welsh Office) (1998). Calculation of Road Traffic Noise. Her Majesty's Stationary Office (HMSO), London, UK.

(14) WG-AEN (2003). Position Paper Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Mapping Version 1. WG-AEN (European Commission Working Group on the Assessment of Exposure to Noise).

(15) I.J. Riemersma, N.L.J. Gense, I.R. Wilmink, H.H. Versteegt, J.H. Hogema, A.R.A. van der Horst, F. de Roo, I.M. Noordhoek, S.D. Teeuwisse, Y. de Kluizenaar & W. Passchier. Quickscan optimale snelheidslimiet op Nederlandse snelwegen. Delft, TNO, 12 May 2004, TNO-report (In Dutch; Quick scan optimal speed limit on Dutch motorways).

(16) Reken- en meetvoorschrift wegverkeerslawaai 2002. in: Staatscourant nr. 62, March 2002 (in Dutch).

(17) P. Goodman, I.R. Wilmink, M.C. Bell (undated) Effects of Mandatory Intellegent Speed Adaptation (ISA) on Noise Emissions. Unsubmitted paper in preparation.

(18) Liu, R. (2003). The DRACULA microscopic traffic simulation model. To appear in Kitamura, R., Kuwahara, M. and Schreckenberg, M. (eds) *Transport Simulation*, Springer.

(19) H. Jonnason, U. Sandberg, G. van Blokland, J. Ejsmont, G. Watts, M. Luminari (2004). Source Modelling of Road Vehicles (HARMONOISE WP 1.1). Deliverable 9 of the HARMONOISE Project, Document ID HAR11TR-041210-SP10. SP Swedish National Testing and Research institute, Borås, Sweden.