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Noise action planning in agglomerations

Reduction potentials based on the example of Hamburg

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Noise action planning in agglomerations

Reduction potentials based on the example of Hamburg

by

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Abstract

According to the environmental noise directive 2002/49/EG noise maps had to be prepared for major roads, major railways, major airports and agglomerations with more the 250.000 persons until 06/30/2007. Based on this results action plans had to be developed. Numerous agglomerations hadn't been able to deliver the noise maps in time, and had to interpret the term "strategic" also in the case of action planning.

The determination of annoyed people according to the environmental noise directive is carried out by calculation. The road traffic is calculated according to the German calculation method VBUS. This calculation method is not designed to indicate the effect of all measures taken for action planning. Therefore, not all measures have an effect of the calculated noise values by VBUS. Some measures are underestimated or cannot be estimated at all by VBUS.

The purpose of this project is to identify a cost and time effective solution for agglomerations to estimate the effect of noise mitigation measures on road traffic noise as realistic as possible.

Kurzbeschreibung

Entsprechend der Richtlinie 2002/49/EG waren bis zum 30.06.2007 Hauptverkehrswege, Großflughäfen sowie Ballungsräume mit mehr als 250.000 Einwohnern zu kartieren und anschließend daran ggfs. Aktionspläne aufzustellen. Zahlreiche Ballungsräume waren jedoch nicht in der Lage, die Lärmkarten termingerecht zu erstellen. Viele Ballungsräume waren somit gezwungen, den Begriff „strategisch“ auch im Zusammenhang mit der Aktionsplanung etwas weiter auszulegen.

Bei der Umgebungslärmrichtlinie erfolgt die Bestimmung der Lärmbelastung mit Hilfe von Rechenmodellen. Der Straßenverkehr wird nach der Vorläufigen Berechnungsmethode für den Umgebungslärm an Straßen (VBUS) berechnet. Diese Vorschrift ist jedoch nicht vollständig in der Lage, die bei der Aktionsplanung ergriffenen Maßnahmen abzubilden. Zudem gibt es eine Reihe von Maßnahmen (etwa im Verkehrsmanagement), deren Wirkungen mit der VBUS gar nicht eingeschätzt werden können.

Das Ziel dieses Vorhabens ist es, für die Aktionsplanung zum Straßenverkehrslärm in großen Ballungsräumen eine vom Kosten- und Zeitaufwand her vertretbare Lösung zu finden, welche die Lärmminderungseffekte so realitätsnah wie derzeit möglich abzubilden vermag.

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1 Introduction

A practicable means of implementing an action plan for reduction of road traffic noise in complex agglomerations is outlined (in the short period of time available), based on Hamburg as model agglomeration. Synergies of various traffic and environmental protection concepts are considered on the basis of the 2008 Strategic Noise Action Plan for Hamburg /1/. The approaches specified in the action plan result from evaluation of planning instruments in Hamburg that are of significance for noise reduction. Their conclusions concerning the reduction of noise exposure can in principle be applied to other cities. This transferability is enabled by the two-stage model selected in Hamburg in drawing up the noise action plan. Detailed elaboration of specific noise reduction measures at a city district level is preceded by a strategic noise action plan for the city as a whole. This offers the advantage of initial formulation of basic approaches to noise reduction at a superordinate level, and thus definition of the framework for subsequent noise action planning in city districts. This principle distinguishes the Noise Action Plan for Hamburg from other similar plans, emphasizes its strategic orientation and therefore predestines it for application in other large cities.

The procedure involves, in particular, appropriate investigative methods and emission models (here: TraNECaM). The influences of the noise-reduction measures of the Strategic Noise Action Plan for Hamburg on the modal split as well as the implicit spatial shifting of traffic are evaluated on the basis of expert knowledge.

The resulting changes in relevant traffic parameters are subsequently converted into significant traffic emission parameters.

The approach thus has two components:

Appropriate calculation models

Calculation models have initially to be employed that represent action plan measures as realistically as possible.

The TraNECaM noise emission calculation model, which was developed in the 1990s, enables considerably more detailed calculation than the conventional RLS-90 and VBUS models, and takes account of technical advances in motor vehicles. The database of the TraNECaM model, which was originally developed on behalf of the German Federal Environment Agency (Umweltbundesamt, UBA) /2/, is more broadly designed in terms of road and vehicle categories than that of conventional models. TraNECaM was later expanded and updated with the financial support of the European Commission and the Norwegian Pollution Control Authority. The model was used in Norway for nationwide quantification of the effects of reduction measures that could be applied for attainment of political reduction targets.

Synergies

The development of appropriate noise-reduction measures and their execution require co-ordination and reconcilement with all relevant plans. Many existing plans that have been adopted by the Government ("Senate") of the Free and Hanseatic City of Hamburg contain measures that, besides their actual objective, also have an impact on the noise situation. It therefore makes sense to identify such measures and to assess them in terms of their significance for noise. The incorporation of existing plans in strategies for noise reduction and the development of integrated noise reduction measures ensure acceptance and compatibility of the noise action plan in the city, without giving rise to significant additional costs. As a rule, these measures have already been adopted by the Senate and furnished with the necessary funds, which markedly increases the chances of realization.

The individual procedural steps are described below.

2 Adoption and adaptation of the Hamburg calculation model

The Office for Immission Control and Industrial Plants of the Ministry for Urban Development and the Environment (BSU) of the City State of Hamburg has carried out noise mapping of the City of Hamburg in accordance with the EU Environmental Noise Directive. Due mainly to the enormous pressure of time, use has been made of general assumptions, in particular concerning road-specific emission data, during preparation of noise maps in accordance with the requirements of the Environmental Noise Directive.

Within the scope of the present research project, verification, refinement and supplementation of necessary input data were required in regard to the use of an emission model that is sensitive to all measure scenarios (here: TraNECaM).

This concerns the following tasks:

1. Extension of the road network under investigation
2. Determination of supplementary calculation parameters (for example, number of lanes, road surfaces and traffic lights)
3. Transfer of determined parameters to the acoustic model, taking account of multiple reflections on the basis of building-height and road-width categories
4. Agreement of traffic parameters with the responsible administrative authorities, and incorporation of necessary corrections resulting from such agreement

HafenCity has been disregarded within the scope of this project, since due to continuous construction activity a traffic analysis is not possible. The construction of a new inner-city district on such a scale also represents a special case that is not applicable to other large cities.

3 Analysis of relevant plans and concepts in Hamburg

This step is based on the 2008 Strategic Noise Action Plan for Hamburg /1/ and considers the following planning instruments and concepts that are of significance for noise related to road traffic (→ Annex 1):

- Guidelines to noise action planning in Hamburg
- Noise abatement concepts
- Climate protection concept
- Air pollution control plan
- Traffic development plan
- Urban development and regeneration
- Hazardous materials network
- Bicycle traffic strategy

The noise-reduction measures that have been identified within the scope of the Strategic Noise Action Plan for Hamburg are systematically reviewed and summarized in regard to their significance for noise:

Integrated plan of action

As a rule, individual measures are insufficient to achieve effective noise reduction on roads with heavy traffic. Concepts are therefore required that are composed of various measures and utilize different potentials. These include planning-, traffic- and design-related measures as well as technical, constructional and organizational measures. Application of precautionary measures at the source of noise is of primary importance.

Possible options for the reduction of road traffic noise are delineated in a three-stage process in the Strategic Noise Action Plan:

1. Development and description of possible noise reduction measures.
2. Comparison of these noise reduction options with existing plans as well as assessment of relevance and efficacy.
3. Conclusions concerning fields of action in which synergies are possible, or where action is required or conflicting objectives exist.

Assessment

The assessment of measures as to their significance for noise is of a qualitative nature (ranging from 'unimportant' to 'important' and 'very important').

Apart from significance, the acoustic efficacy of measures should also be assessed. This occurs with the attribute 'expedient' in the case of noise-reducing measures to 'uncertain' and 'counterproductive' for measures that thwart the objectives of noise reduction. Individual measures are evaluated on this basis.

Short- to medium-term recommendations for action

As a result of consolidation of the conceptual approaches of the noise action plan with already adopted plans and concepts, the need for action is determined from the acoustical point of view. The main conclusions and recommendations are summarized in a 12-point programme.

In the opinion of experts, the following reviews laid down in the plan of action can be completed within five years with regard to road traffic, within the framework of the review and possible revision of noise mapping required by the Environmental Noise Directive:

- Preparation of a speed concept for the city as a whole.
- Preparation of a concept for stabilization of traffic flow.
- Preparation of a Park & Ride (P & R) strategy for the Hamburg agglomeration for the reduction of commuter traffic
- Development of conceptual approaches for corporate mobility management with a pilot project.
- Preparation of a concept for the reduction of HDV traffic induced by port operations on the periphery of the port and in surrounding areas.
- Preparation of an HDV management concept
- Outline of a noise abatement programme for existing roads in the public easement register
- Development of conceptual specifications for urban land use planning.
- Preparation of a concept for the redesign of road space in line with noise-reduction considerations

Synergies with contiguous target areas

Noise action planning is a multidisciplinary task encompassing multifarious interaction with contiguous planning disciplines. Many noise-reduction measures also have an impact on traffic safety, the quality of traffic flow and road network capacity. Moreover, measures for traffic control and stabilization have an effect on immission of particulate matter and nitrogen oxide, which, as a result of new EU regulations, will attract increasing attention in the coming years. After all, noise is a decisive criterion in the choice of a place to live, and an important indicator for the general quality of life in a city.

Furthermore, many of the databases that are required for noise mapping and action planning are also utilized in other areas. This concerns, for example, traffic volumes and HDV shares thereof, the digital terrain model as well as building and population data.

A joint course of action thus enables a range of synergies:

- Joint data management and data preparation avoids unnecessary costs.
- Early agreement helps to recognize and preclude conflicts over objectives.
- A joint course of action enables the efficient use of personnel capacities and the allocation of financial resources.

It becomes clear from the above-mentioned points that noise action planning cannot be accomplished in the long term with classic departmentalized thinking. Efficient use of existing resources requires the linking of noise action planning with contiguous planning disciplines on a sustained basis. Tangible starting points are offered, for example, by the intended updating of traffic development planning, the air pollution control plan and efforts towards climate protection.

4 The impact of measures on the modal split and traffic parameters

Impact assessment is based on the plan of action for motor vehicle traffic, and the 12-point programme of the 2008 Strategic Noise Action Plan for Hamburg /1/ for the next five years that is derived from it.

In order to be able to draw conclusions on the efficacy of noise-reduction measures with the TraNECaM noise model, the approaches of the Strategic Noise Action Plan are reviewed with respect to the model parameters that are influenceable:

- road category,
- traffic volume,
- traffic composition and
- permissible speed.

In the case of road categories, motorways and major transport axes are considered in isolation from the remaining major road network. In principle, noise-reducing effects can also be apportioned to the total road network. For Hamburg, moreover, a distinction is made in the case of major transport axes between radial road links and ring roads (→ Annex 3).

The port presents a particular feature of the City of Hamburg that cannot be readily applied to other large cities. The effects in this respect are therefore disregarded.

Many of the noise-reduction measures in the Strategic Noise Action Plan are aimed at a reduction in traffic volume as well as a change in traffic composition. Apart from the shifting of journeys by car to environmentally-friendly modes of transport, the spatial shifting of noise-intensive HDV transportation is particularly important for achievement of the stated objectives. Due to their varied noise emission potential, a distinction has to be made in effect-based approaches between HDV transportation and car journeys. Through an adjustment in permissible maximum speed the possibility also exists to optimize the speeds actually driven from a technical point of view.

On considering the parameters that can be influenced in the model, it becomes clear that, on account of strong dependencies and existing interdependencies, a number of conceptual approaches contained in the Strategic Noise Action Plan have to be consolidated in effect-based approaches for representation in the model. [1] Consolidation therefore occurs with respect to the established objective and spatial reference in:

- Promotion of local public transport
- Corporate mobility management
- Promotion of bicycle traffic

[1] An important objective of the promotion of local public transport is a reduction in commuter traffic. Car users should be encouraged to switch to buses, trams and trains, for example by attractive Park & Ride facilities. Due to their traffic-reducing effect on major transport axes, the two approaches, which are presented independent of each other in the Strategic Noise Action Plan for Hamburg, can be consolidated.

- Spatial shifting of transportation
- Improvement of traffic flow

Further consolidation of effect-based approaches for promotion of local public transport, bicycle traffic and corporate mobility management into "promotion of environmentally-friendly modes of transport" initially appears to be useful, but proves, in view of the model parameters that can be influenced, not to serve the purpose intended. The corresponding effect-based approaches react together to changes, due to existing dependencies, but ultimately influence different model parameters.[2]

The traffic volumes used in the calculation model are based to a very great extent on traffic surveys carried out by the Traffic Office of the Ministry for Urban Development and the Environment (BSU) of the City State of Hamburg up to the year 2008, and form the basis for the 2008 analysis. A null forecast has not been drawn up and applied, since it is not necessary for the assessment of efficacy and can be conducted irrespective of the time horizon under consideration.

Furthermore, according to the Traffic Office of the BSU, car traffic in Hamburg will hardly change in the coming years. The situation is different with heavy duty traffic. Despite the planned extension of the port rail link and inland navigation a considerable increase in HDV traffic has to be expected. This will have a particular effect on traffic load on motorways. The reason for this assumption lies in the importance of Hamburg as a seaport and international freight transportation hub. The application of forecast heavy-duty traffic loads in the model would only represent a situation that is specific to Hamburg, and call into question the desired applicability of findings to other cities. At best, other seaports could profit from the knowledge gained, which, however, is not the objective of this study.

Data on the modal split is derived from the summary report "Mobilität in Deutschland" /3/ from 2004. The key figures for 2007 of the Hamburg Transport Association (Hamburger Verkehrsverbunds HVV) /4/ relate to this data, which it matches to the choice of transport mode in 2006 (→ Figure 1).

The following sections outline the extent to which conceptual approaches to noise reduction can influence traffic behaviour in Hamburg, as well as the changes that could result. At this point it should once more be emphasized that model-based consideration of the city as a whole is involved. The assumptions satisfy the demands of Hamburg and, due to their universality, ensure broad transferability to other cities. Nevertheless, it has to be examined in each individual case to what extent they correspond to local conditions.

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[2] For example, expansion of the Bike & Ride service has the objective of shifting car traffic to public modes of transport. Relief would mainly occur on major transport axes and in commuter traffic. The promotion of bicycle traffic that accompanies expansion of the B & R service is mainly aimed, however, at shifting the choice of transport mode from cars to bicycles for distances of up to 5 kilometres. The traffic situation on major transport axes would thus change only insignificantly.

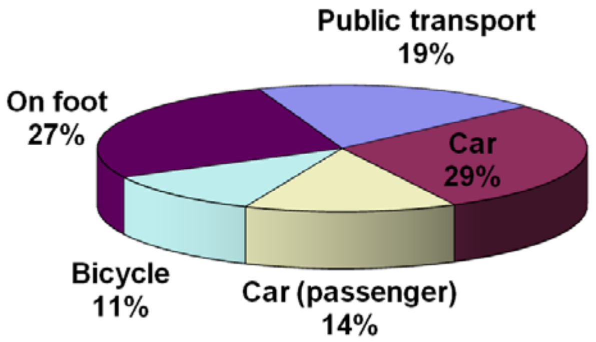

Fig. 1: Modal Split in the HVV service area in 2006 /4/

4.1 Promotion of local public transport

The effect-based approach for promotion of local public transport embraces conceptual approaches for expansion of local public transport, Park & Ride and Bike & Ride facilities as well as parking management. All four approaches have the objective of shifting the choice of transport mode from the car to local public transport, and have their main effect in the model on car traffic on major transport axes. Measures for a modal shift of commuter car journeys are also reflected in corporate mobility management (→ Section 4.2), and are considered in the summary of impact assessments at the end of the chapter. The following sections outline the considerations upon which this assessment is based.

Expansion of local public transport

The present HVV service area covers principal traffic flows within the Hamburg Metropolitan Region, and beyond that disposes of important transport connections in neighbouring rural districts. The existing finely-meshed city rail ("S"), underground ("U") and regional railway networks are supplemented with a network of bus routes, and offer considerable potential for a shift to public modes of transport.

According to data in the HVV Report 2007 /4/ passenger volume has noticeably increased in recent years, though with a declining trend. Compared with the previous year, the number of passengers increased by 2.9 % to 618 million in 2007. According to HVV, this increase is attributable to

- population growth in the Hamburg Metropolitan Region,
- an increase in the number of persons employed,
- an increase in the transportation of schoolchildren and trainees as well as
- a noticeable increase in occasional transportation for special events.

HVV expects growth of at least 0.5 to 1.0 per cent in the coming years. This takes into account passenger volume of the airport "S" link as well as the "U4" line to HafenCity Hamburg from 2011.

The Hamburg climate protection concept /5/ forecasts, on the basis of a 10 % cut in ticket prices, a potential shift of about 1.7 % from the car to public transport modes. Even when a cut in ticket prices is not a direct component of the plan of action of the Strategic Noise Action Plan for Hamburg, it nevertheless indicates the perceived scale of possible modal shift potentials for the Hamburg Metropolitan Region.

Park & Ride (P & R)

Within the framework of an overall integrative traffic system, Park & Ride (P & R) represents an important interface between local public transport services and private motorized transport. The aim is to encourage the motorist to switch to public transport and thereby to cut inner-city private traffic.

The service is primarily directed at road users for whom no attractive public transport service exists within walking distance of their home. They are offered free parking at a nearby, easily-reachable railway station. This is frequently required in the outlying dis-tricts of the city and surrounding areas, since, due to dispersed settlements, an eco-nomically viable, rural public transport shuttle service to "S" stations cannot be provided. Here, the car – but also the bicycle as means of initial transport (Bike & Ride) – as-sumes an important function.

In the present HVV service area there are 95 P & R facilities at "S" stations, which pro-vide around 15,000 parking spaces.[3] Of these, around 9,000 are available at 41 stations in the City of Hamburg, where average occupancy is 85 %. Potential sites for P & R facilities are, as a rule, HVV "S" stations and railway stations on regional routes in the surrounding area. Only in exceptional cases is P & R provided at bus stops /6/.

The provision of further P & R facilities leads, particularly in inner-city areas, to in-creased use of public transport services, and therefore represents special planning for feeder traffic with cars, which are used in increasingly-complex series of trip chains. Around 4,000 additional P & R parking spaces could be provided in the short to long term /6/.

An approximate estimation of the share of P & R users in HVV passenger volume, based on available figures, shows that with an average 85 % utilization of the 15,000 parking spaces and a car occupancy rate of 1.2 persons per vehicle, a P & R user share of around 1.0 % arises for the year 2004.[4] An additional 4,000 parking spaces would increase the share of P & R users in passenger volume, compared to 2004, by around 0.3 %. It has to be noted, however, that an increase in the number of parking spaces and the provision of new P & R facilities can also result in an increase in traffic volume on roads in the vicinity of such facilities, particularly in rush-hour periods.

Bike & Ride (B & R)

The combination of a bicycle with public transport enables bicycle use far beyond the distance of everyday journeys. In areas with a less dense public transport network (for example, city suburbs and outlying areas as well as the area surrounding urban agglomerations) the bicycle

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[3] The number of car parking spaces in 2004 corresponds coincidentally with the number of bicycle parking spaces at HVV "S" railway stations in 2006.

[4] According to HVV, passenger volume in 2004 amounted to 537.6 million.

allows cost-efficient expansion of the catchment area of stations and stops, reduces car journeys and enables public transport services to exploit customer potential /7/.

B & R facilities allow the parking of bicycles at stations and stops for initial and onward transport. In 2006 there were around 15,000 bicycle parking spaces at "S" stations in Hamburg. Regular surveys carried out by the BSU and district authorities provide information on the capacity utilization and quality of existing facilities /8/. Utilization of facilities during recent years is displayed in Table 1. Evaluation still shows a large number of unauthorized parkers, which indicates both the poor quality of parking equipment and further demand for parking places.

Table 1: Utilization of existing B & R facilities at "S" stations and stops in Hamburg /8/

Year	No. of facilities	Utilization
2002	128	81 %
2003	129	68 %
2004	130	67 %
2006	130	80 %
2008	130	96 %

Quantification of the share of B & R users in HVV passenger volume is not available, so that only rough estimates are possible. On the basis of available figures, and the assumption that 80 % of the existing 15,000 parking spaces are utilized on average once a day, the result is a B & R user share of around 0.7 % of the around 600 million HVV passengers in 2006.[5] Potential additional B & R users through the provision of new parking spaces is therefore likely to be well below 1 %, and is taken into account in the total of all approaches for promotion of local public transport.

Parking management

The management of limited parking space is part of comprehensive parking management and an important tool for control of parking demand. It serves long-term influence on the traffic situation and thereby also on the noise situation. The type and form of parking supply has, among other things, a considerable influence on the choice of transport mode, and thus ultimately on the quality of transportation. Parking management generally commences where the balance between parking supply and demand is uneven. This is particularly the case in inner-city locations. A shortage of parking for private motorized traffic can reduce the volume of traffic on access roads and open up vacant space to alternative uses, such as bicycle parking facilities, when accompanied by improvement in public transport services and infrastructure in the particular area /9/.

A general assessment of potential modal shift from cars to public transport as a result of parking management is hardly possible. Noticeable effects on traffic volume on the major road

[5] At the time of preparation of the report passenger figures for 2008 were not available.

network could be expected in Hamburg, for example, only with a marked cutback[6] in the around 30,000 parking spaces within the first ring road. Precise plans on this scale are not under discussion at a city-wide level. An unequivocal assessment of the effect is therefore not possible. The shift potentials that are indeed recognized are partly reflected in the overall promotion of local public transport. More realistic approaches for the reduction of traffic noise through parking management arise initially in the still-pending second stage of the noise action plan in city districts.

Soft policies

An important part of public transport promotion is the provision of information and appropriate image-building campaigns, so-called soft policies. Since their effect is difficult to quantify within the scope of this project, they are regarded as part of other approaches and thereby flow into the assessment.

Summarized impact assessment of public transport promotion

It is assumed for model calculations that promotion of local public transport mainly results in a reduction in commuter traffic on major transport axes. These assumptions combine the increase in the use of local public transport forecast by HVV with the potentials of expansion of P & R and B & R facilities, parking management and corporate mobility management. Separate impact assessment for individual conceptual approaches is very difficult, since the growth in local public transport envisaged by HVV already takes account of shift potentials from other conceptual approaches that it does not explicitly reveal. Summarized impact assessment accordingly takes up forecast HVV customer growth of 0.5 to 1.0 per cent and assumes that this is generated to a very great extent by a shift from cars. A generally applied additional 0.5 % takes account of disregarded potentials in forecast growth and corresponds with the shift potentials described in individual sections.

Related to the road network represented in the model, the following conservative approach has been chosen:

- Major transport axes ("magistrals" - major transport axes that radiate outward from the centre of the city - and ring roads): -1.5 %
- Remaining road network: -0.5 %population growth in the Hamburg Metropolitan Region

[6] A cutback in the supply of parking spaces could lead in the short term to an increase in the unauthorized parking of vehicles or the shifting of vehicles to neighbouring city areas. A noticeable increase in parking charges would initially be accompanied by a change in user group in favour of well-off users. In the long term, in both cases a shift to other modes of transport could be expected. The prerequisite for successful parking management is consistent monitoring of the parking area. In the model it is assumed that as far as effect is concerned a cutback in supply is to be equated with an increase in parking charges.

4.2 Corporate mobility management

The objective of corporate mobility management is the shifting of journeys by car to low-emission, environmentally-friendly modes of transport, as well as an increase in the rate of car occupancy through the formation of car pools. From a noise reduction point of view, enterprises suitable for mobility management are those located in noise-sensitive areas that have a large proportion of employees with very early or very late shift changes (for example, industrial enterprises, logistics companies and hospitals). The avoidance of night-time private motorized traffic to and from such locations offers considerable noise reduction effects.

Measures for implementation of corporate mobility management largely go hand-in-hand with the promotion of environmentally-friendly modes of transport, and are reflected in the methods of impact assessment referred to in the following:

- Financial incentives for the use of public transport; for example, company-paid tickets (→ Section 4.1)
- Creation of attractive and secure on-site bicycle parking (→ Section 4.3)
- Image-building campaigns and corporate information on switching to environmentally-friendly modes of transport (→ Section 4.1)
- Dismantling of car parking spaces, or imposition of charges for their use (→ Section 4.1)

An independent estimation of the effect of corporate mobility management is difficult, since modal shifts, as initially described, have varied spatial reference and address different modes of transport. For impact assessment of the Strategic Noise Action Plan it is therefore assumed that corresponding measures of corporate mobility management are already considered in approaches for the promotion of public transport and bicycle traffic.

4.3 Promotion of bicycle traffic

Besides the expansion of local public transport, the promotion of bicycle traffic is an important component of the promotion of environmentally-friendly modes of transport. An accompanying possible shift from cars to bicycles can contribute to a long-term and sustainable reduction in noise exposure. According to the report "Mobilität in Deutschland" /3/, 60 % of all journeys undertaken in Germany are shorter than 5 kilometres and can therefore be made by bicycle. It follows that the modal shift potential lies with car journeys within this distance. Traffic load on major transport axes will change only marginally as a result of the promotion of bicycle traffic. The most noticeable effects of a shift are therefore to be expected on the remaining major road network as well as on the secondary road network. According to expert groups, around 30 % of car journeys of less than 5 kilometres can be substituted by the bicycle, so that a shift potential of about 18 % can be assumed in respect of this distance range.

The bicycle traffic strategy for Hamburg lays down the objective of increasing the share of bicycle traffic in the modal split through measures specified therein by around 18 % up to 2015. Related to the modal split for Hamburg displayed in Figure 1, this implies an increase of around 7 % compared to 2006. Assuming that a large proportion of substitutable car journeys are to be found on the secondary road network, which is not represented, the following relief can be expected:

- Major transport axes (overall): -2.0 %,
  of which magistrals -0.5 % and ring roads -1.5 %
- Other major roads: -5.0 %

It should be noted that promotion of bicycle traffic, particularly in the inner-city area, can also result in a shift from public transport to bicycles. This is difficult to calculate, however, and is therefore not considered.

4.4 Spatial shifting of traffic

Conceptual approaches to the spatial shifting of traffic apply to a very great extent to HDV traffic, which gives rise to markedly higher noise exposure per vehicle than car traffic, [7] and is therefore of particular significance for impact assessment.

Hamburg, as a seaport and international transportation hub, plays a particular role in freight transport. At least half of container transportation in Hamburg port takes place by road. Inland waterways and rail share the remaining 50 % more or less equally. This shows that an efficient traffic infrastructure is indispensable for the handling of freight transport in Hamburg. The conceptual approaches of the Strategic Noise Action Plan outlined below take account of this fact and distinguish between Hamburg-specific noise reduction potentials and general assumptions.

Bundling of transportation, traffic-management measures and traffic restrictions

The bundling of transportation through traffic-management measures and traffic restrictions aims at shifting traffic to comparatively insensitive major transport axes and motorways. If shifts within the secondary road network are avoided through consistent implementation, noise-sensitive, densely-populated roads in the secondary network will be noticeably relieved.

Hamburg already has experience with regulation of HDV traffic on major roads. For a section of Stresemannstraße, which is a federal road and part of a magistral, the outside lane is closed to HDVs (excluding local HVV buses), combined with a general 30 km/h speed limit for all vehicles. Bans on HDV through traffic on major transport axes are, however, the exception, and they are actually contrary to the declared objective of shifting (and bundling) transportation to insensitive routes. They will have their greatest effect on the secondary road network, which, however, is not part of this model and will become relevant only within the scope of the second stage of the noise action plan in the city districts.

The effect of a bundling of transportation on the road network represented in the model is assessed as follows:

- Motorways: +1.0 % HDV traffic
- Major transport axes (magistrals and ring roads): +2.0 % HDV traffic
- Other major roads: -3.0 % HDV traffic

[7] The noise emissions of an HDV are roughly equivalent to the emissions of 10 – 20 cars.

Strengthening of other modes of transport

The shifting of HDV transportation to other modes of transport can make an important contribution to the reduction of road traffic volume. It should be borne in mind that the modal shift from road to rail also involves the shifting of noise sources. The Strategic Noise Action Plan for Hamburg takes a stand in this respect and indicates methods for effective reduction of noise on rail routes. In the model under consideration, however, rail traffic noise is not examined.

Due to the growth in freight transport, Hamburg assumes in its modernization and development programme for the port rail link /10/ a doubling of the number of daily freight trains by 2015. Statements on the potential modal shift from road to rail are not made. It is mentioned, however, that in different sections of the port rail link its capacity will be exceeded, which implies corresponding expansion.

A general assessment of the potential modal shift from road to rail is provided by a report prepared by Transcare in 2006 /11/. With implementation of appropriate measures for structural improvement the report expects a general shift potential of 4.1 %.

The possibility for shifting road transportation to inland and shuttle vessels is in many places not available. Even when a number of German cities lie on navigable waterways and dispose of an inland port, where a modal shift is possible in principle, Hamburg represents a special case, due to its size, the location of the port in the city and its importance in international shipping. The objective of a long-term increase in the share of inland navigation from 1.3 % to 5 %, as laid down in the Hamburg climate protection concept, /12/ is not easily transferable to other cities, and within the scope of impact assessment is only of minor importance.

Model-based examination is therefore directed to a great extent at envisaged potential shifts from road to rail, and arrives at a cautious estimate of around 2 %. In the model this reduction is applied to all HDV transportation on motorways and major radial transport axes.

Freight transport logistics

The setting up of freight transport centres has the objective of achieving a bundling of transport flows. The reduction in the number of HDV tours with the same transport performance, which is expected from such bundling, makes such freight transport centres attractive for many cities /13/.

Model calculations for Berlin show that relocation of logistics companies in freight transport centres on the outskirts of Berlin would result – assuming co-operation between hauliers – in a reduction in haulier mileage in city and regional transportation of around 13 %. Related to regional commercial transport, this implies a decline in mileage of around 1.8 %. Overall transport would decrease by 0.6 % /13/. At the same time, it has to be borne in mind that urban transport declines as a result of bundling in freight transport centres, while traffic loads on roads in surrounding areas increase /14/. Should hauliers not co-operate in freight transport centres, an increase in overall mileage is to be expected in both the urban area and the surrounding area, with the result that a traffic-reducing effect is only to be expected in long-distance haulage /13/.

Assuming co-operation among hauliers in the freight transport centres for the purpose of model-based examination, the following assumptions can be made related to HDV traffic:

- Motorways: +1.0 %
- Major transport axes and other major roads: -1.0 %

New road links

Relief of the existing road network through the construction of new road links can lead to a substantial reduction in noise exposure, assuming that noise can be largely avoided on the new roadway. Hamburg currently plans a number of road network extensions, whose main aim is relief of the existing road network from steadily increasing HDV traffic.

The A 252, in particular, the so-called port link road, will be very important for trans-European freight transport, since it will provide a link between the A 7 to the west and the A1 to the east of Hamburg. Through the port link road, HDV traffic, which at present mainly uses the inner-city major transport axes to the north of the River Elbe, will be shifted to the southern area of Hamburg. Since the route of the port link road has not yet been finally decided, an assessment of its likely effects is at present virtually impossible.

A further important road link is the Finkenwerder bypass in the south-west of Hamburg, which is intended to relieve the district of HDV traffic to and from the local Airbus plant. The planned route has nevertheless not been considered in the network model, since construction of the bypass would result in merely a local reduction in noise exposure. For the city as a whole, and for the major road network considered in the model, the Finkenwerder bypass is only of minor significance. An exemplary impact assessment has been dispensed with.

4.5 Improvement of traffic flow

Stabilization

A steady flow of traffic contributes audibly to a reduction in noise exposure, since the number and intensity of particularly-disturbing braking and acceleration procedures decrease. Co-ordination of traffic lights between intersections can make a considerable contribution towards stabilization of traffic flow and hence the reduction of noise emissions. It should be borne in mind that consistent operation of "green waves" is frequently accompanied by an increase in average driving speed. Noise reduction as a result of a reduction in braking and acceleration procedures can therefore be accompanied by an increase in noise exposure through increased driving speed. The introduction of traffic- and speed-related traffic light controls can provide a remedy in this respect, particularly in the evening and at night. Stabilization of traffic flow is closely connected with the speed concept, and they are consolidated in the model as far as their impact is concerned.

Speed concept

As a rule, the higher the driven speed the louder the noise produced by the vehicle. At the same time, the major road network must satisfy the mobility demands of different road users and meet the needs of commercial and local transport. Furthermore, there is the risk that traffic on major roads will switch to parallel minor roads, where available. With speed concepts, the road network as a whole has always to be considered.

Consolidated approach

Stabilization potentials are mainly seen on major transport axes in north-west (B 431, B 4/5 and B 433) and south Hamburg (B 73 and B 75) as well as on ring roads 1 and 2 (→ Annex 3). Actual driving speed can be matched to permissible speed through appropriate traffic-light co-ordination.

The permissible maximum speeds displayed in Table 2 represent initial deliberations for preparation of a speed concept for the city as a whole, in line with the 12-point programme in the 2008 Strategic Noise Action Plan for Hamburg. These deliberations envisage a general reduction in the maximum speed for cars on motorways in Hamburg to the permissible maximum of 80 km/h that presently exists on certain motorways sections. The permissible maximum speed for HDVs will be correspondingly reduced to 60 km/h. Cars and HDVs on major transport axes should be restricted to a maximum speed of 50 km/h. On all other major roads the permissible maximum speed for cars and HDVs is 40 km/h in the model.

Table 2: Permissible maximum speeds in the speed concept

Road category	Vehicle	Permissible maximum speed [km/h]
Motorways	Car	80
	HDV	60
Major transport axes	Car	50
	HDV	50
Other major roads	Car	40
	HDV	40

4.6 Summary of impact assessments

An assessment of the effects of measures on the modal split and speeds, related to the respective road category, is displayed in Annex 4. The results are summarized in Table 3:

Table 3: Assessment of the effects of measures on the modal split and speeds

Strategy	Motorways	Magistrals	Ring roads	Others
Promotion of public transport	-	DTV cars -1.5 %	DTV cars -1.5 %	DTV cars -0.5 %
Promotion of bicycle traffic	-	DTV cars -0.5 %	DTV cars -1.5 %	DTV cars -5.0 %
Spatial shifting of traffic	-	DTV HDVs -1.0 %	DTV HDVs +1.0 %	DTV HDV -4.0 %
Total	-	DTV cars -2,0 % DTV HDVs -1,0 %	DTV cars -3,0 % DTV HDVs +1.0 %	DTV cars -5,5 % DTV HDVs -4,0 %

Improvement of traffic flow	Cars: 80 km/h HDVs: 60 km/h	50 km/h	50 km/h	40 km/h

The above compilation makes clear that the greatest potentials are envisaged in the consistent implementation of a speed concept, and that here an optimistic position is represented compared to the rather conservatively assessed strategies of traffic avoidance and traffic shifting.

5 Modelling of road traffic emissions

5.1 Input data measure scenario

Validation of the measure scenario takes place on the basis of assessments of the impact of measures on the modal split and traffic parameters for Hamburg, as detailed in Annex 4 and Table 3.

Consideration of noise reduction through reconstruction of road surfaces in a city-wide context is not possible due to the lack of an official reconstruction concept for the city as a whole. Instead, representation of the noise reduction effect of road surface reconstruction in an exemplary area should takes place. For this purpose, an area is selected that on the one hand is manageable, and on the other hand is of sufficient size and manifests the influence of magistrals and ring roads (→ Figure 2):

General map | Area map

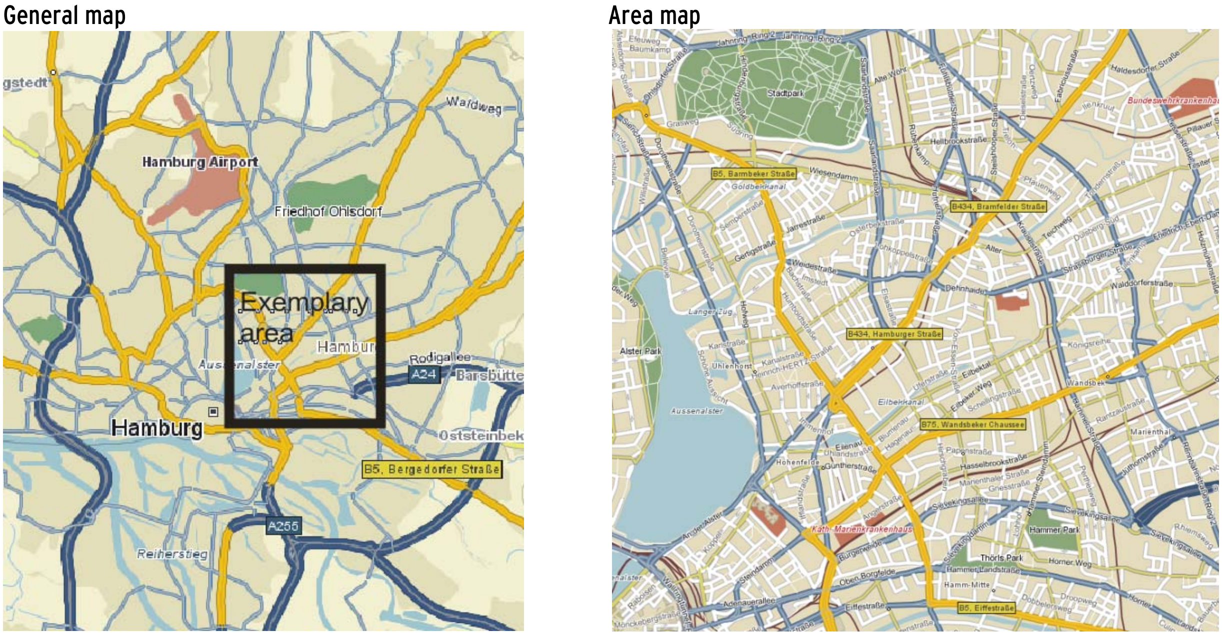

Fig. 2: Exemplary area

With a forecast horizon of 5 years, and based on the premiss of an average life span of 15 years for asphalt, replacement of around one-third of road surfaces is assumed (→ Figure 3).

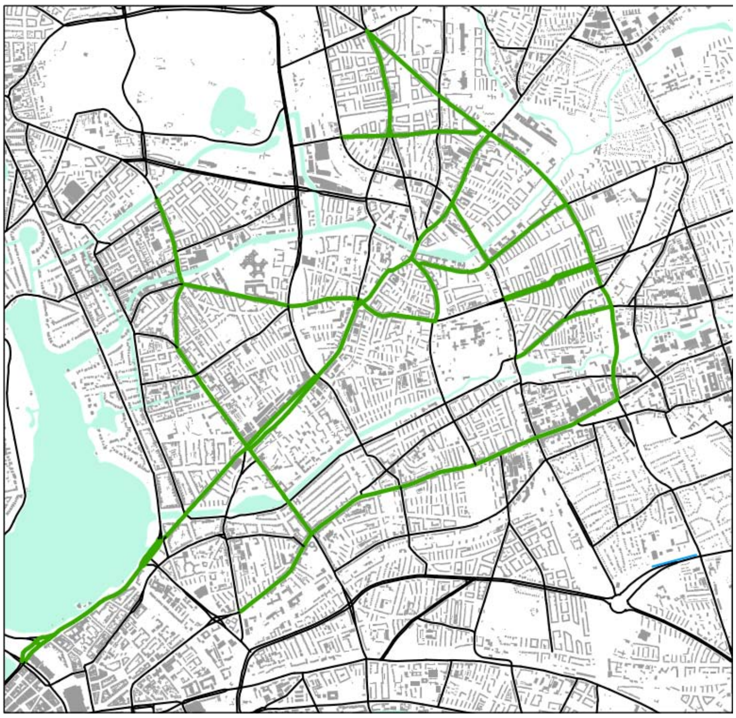

Fig. 3: Road sections with assumed reconstruction using low-noise road surfaces (shown in green)

5.2 Model description

Threshold values and other statutory requirements necessitate determination of exposure to noise and air-pollutants at least for urban areas. This generally takes place by means of calculation models. In the case of noise exposure through road traffic these are the Guidelines for Noise Abatement on Roads (Richtlinien für den Larmschutz an Straßen - RLS-90) and preliminary calculation methods for determination of road-related environmental noise (VBUS). RLS-90 was developed for the purpose of demarcation of legal entitlement to noise protection in the case of road construction. The detail and specificity of the section dealing with noise propagation has been improved on a number of occasions in the past. This is not the case, however, with the section on emission calculation. The emission calculation formulae in RLS-90 are still based on noise measurements carried out in the early 1980s, and they have not been adapted to the latest developments in technology.

This is less problematical for demarcation of legal entitlement in connection with the transgression of limit values, since emission calculation, as a rule, is designed in such a way they that it describes the worst case, and thus disposes of a safety margin in terms of its preciseness in the interest of those exposed to noise. This approach is disadvantageous, however, for determination of the effects of measures within the scope of action plans, since the effect in worst case observations is not described in accordance with actual conditions. On the other hand, there are a number of measures whose effects cannot at all be assessed with legal calculation models. These include, for example, measures aimed at improved traffic flow.

For this reason the TraNECam emission model /2/ is used for calculation of emissions, which offers much more detailed and more measure-sensitive calculations than RLS-90 or VBUS.

The emission factors used in the model are based on driving patterns with a resolution of 1 second, which are representative of the respective road and vehicle categories and were obtained from extensive measurements of driving behaviour in real traffic conditions for development of the Handbook of Emission Factors for Road Transport (Handbuch Emissionsfaktoren für Straßenfahrzeuge /15/), and for improvement of measuring methods and test cycles for determination of pollutant emissions of vehicles within the scope of type approval. Further marginal conditions and influencing factors, such as the influence of road surfaces, were derived from noise measurements on vehicles in statistical spot checks in real traffic conditions on behalf of the Federal Environment Agency and the Federal Road Research Institute (BASt). The model was validated within the scope of two EU projects (/16/ and /17/).

The vehicle categories are cars and light commercial vehicles (up to 3,500 kg permissible total mass) as well as heavy-duty vehicles (depending, in the case of cars, on engine displacement and propulsion system (otto/diesel), with light commercial vehicles on propulsion system, and in the case of HDVs on total mass), and additionally split during type approval into different noise limit categories depending on vehicle age. This way, emissions in practical operation can be realistically modelled. The basic category of this splitting is designated the 'vehicle layer'. As a consequence of this course of action, different fleet compositions and emissions arise, in each case depending on reference year. At the same time, there is the possibility to consider future vehicles with lower emissions in scenarios.

In order to determine emissions on a more source-specific basis, tyre/road noise and propulsion noise are calculated separately and added up to total noise, enabling precise determination of the effect of source-related measures (road surface, tyres, engine and powertrain).

The propulsion noise of a vehicle layer is modelled as a function of engine speed and engine load (→ Figure 4), and rolling noise as a function of tyres, road surface and speed (→ Figure 5). The influence of tyres is a parameter that is assigned to the vehicle layer.

The basis of calculations is maximum pass-by levels at a height of 1.2 metres and a distance of 7. 5 metres to the vehicle, which are then converted into hourly contributions of an HDV to continuous sound pressure level at a distance of 25 metres and a height of 4 metres.

If one applies this model approach to different driving cycles, which have been measured in real traffic conditions, it becomes apparent that the specific contribution of a vehicle to continuous sound pressure level increases, in the case of a car, not only with average speed but also with relative standard deviation of the speed curve, that is, with increasing cycle dynamics.

In the case of an HDV, a completely different picture emerges. Above an average speed of 40 km/h a qualitative connection arises similar to that with cars, but below 40 km/h specific emissions also increase with a constant speed curve with declining average speed (→ Figure 6).

The calculation method RLS-90 / VBUS differs with regard to vehicle categories for cars and HDVs. Their specific emissions (LCar, LHDV) are also dependent on speed, but rather on the permissible maximum speed of a given road. The corresponding functions are displayed in (→ Figure 7).

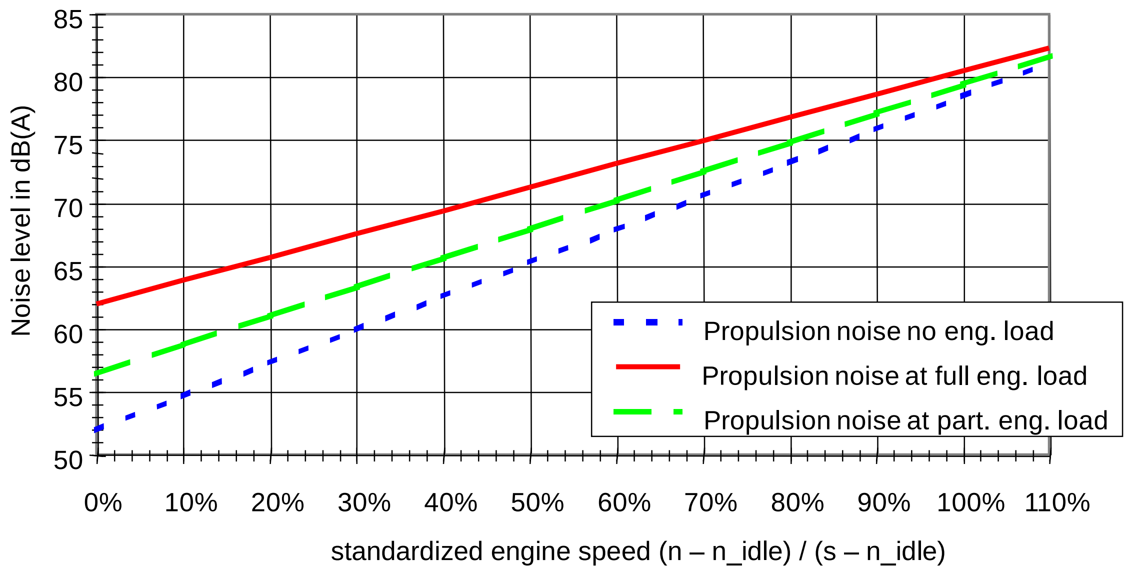

Fig. 4: Dependence of propulsion noise level on standardized engine speed and engine load

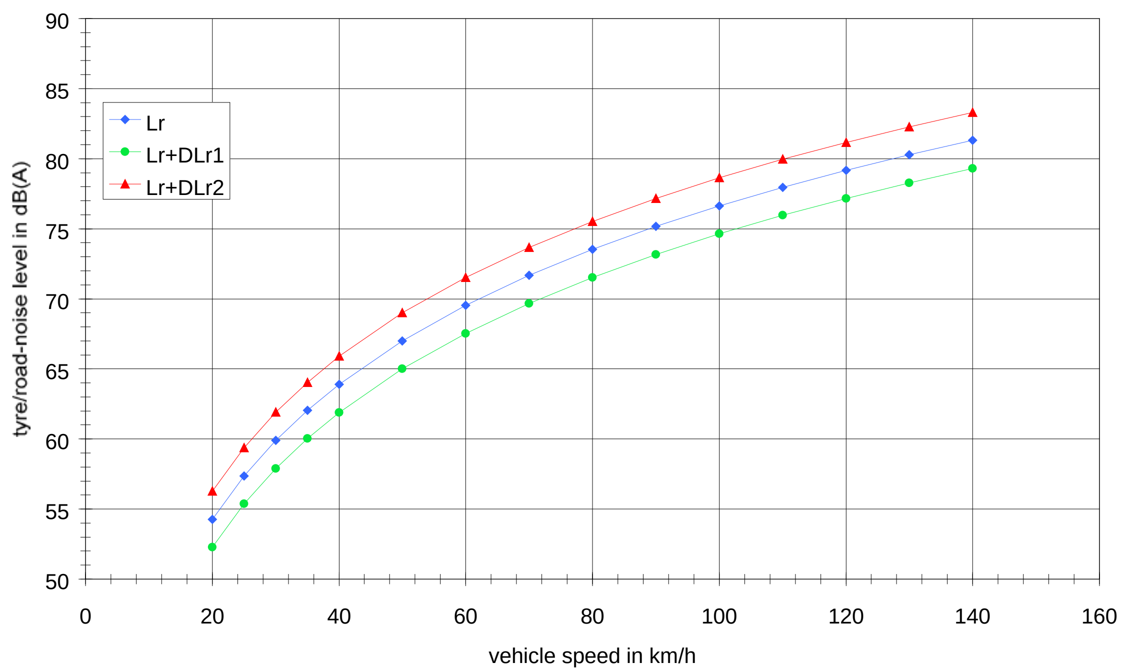

Fig. 5: Dependence of rolling noise level on speed. The influence of different road surfaces is considered by means of surface-specific adjustments that vary between cars and HDVs.

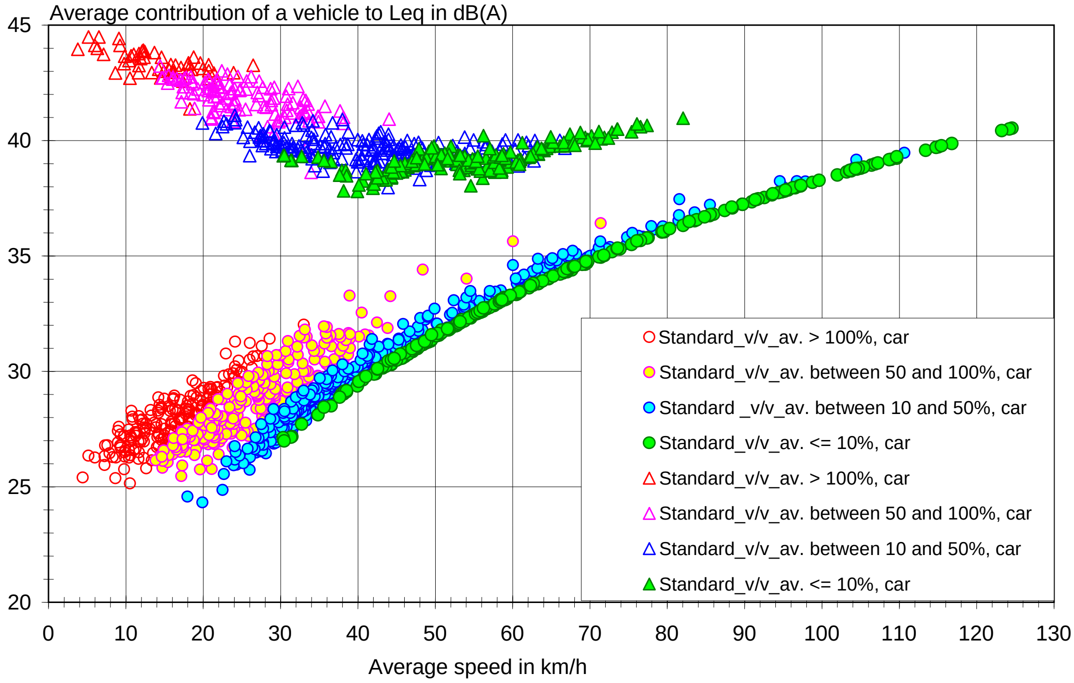

Fig. 6: Dependency of specific emissions of a car and an HDV with a permissible total mass of less than 7,500 kg on average speed and relative average deviation (standard deviation/average) of the speed curve. Each point represents a driving cycle that has been measured in real traffic conditions. The road surface is SMA 0/11.

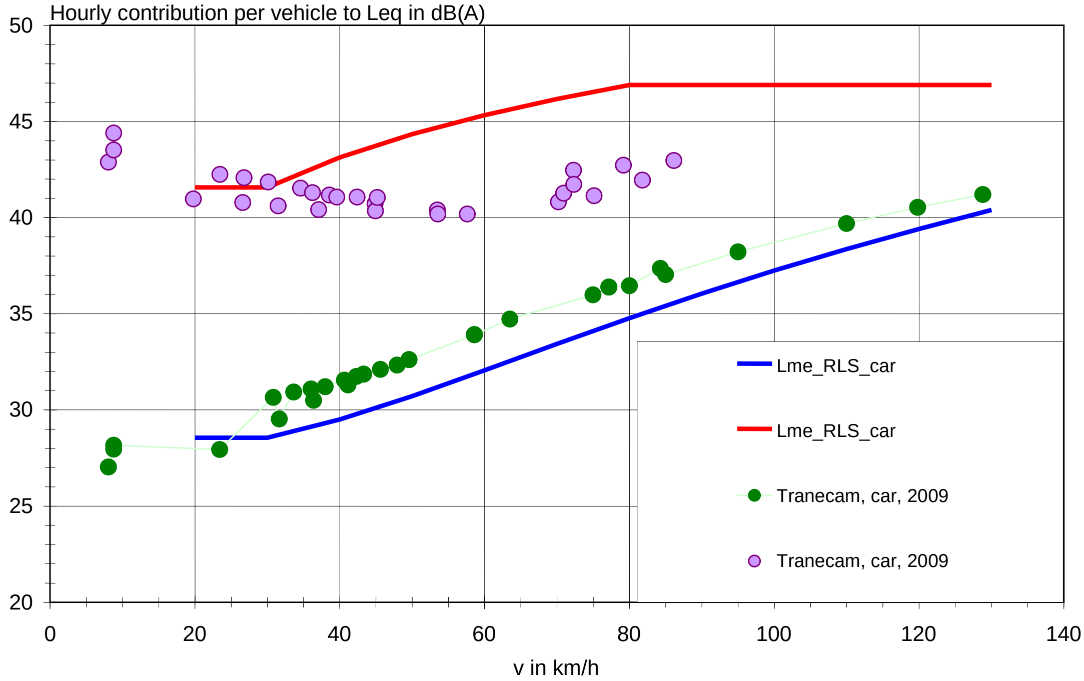

Fig. 7: Comparison of specific emissions of RLS-90 / VBUS and TraNECaM for melted asphalt

TraNECaM contains an all-embracing classification of road categories and traffic conditions, from the residential street with a maximum speed of 30 km/h to a motorway without a speed limit, and from flowing traffic to stop-and-go traffic. In

Figure 7, corresponding specific emissions of TraNECaM model are also plotted for the purpose of comparison; here, however, speed represents the average speed of underlying cycles. With cars there is a similar curve over speed, whereby TraNECaM values are 1 to 2 dB higher than RLS-90 values, due to the fact that tyres in the meantime have become on average much louder. This has occurred because the average maximum speed of the vehicle fleet has increased, and tyres have been correspondingly adapted in terms of dimension and speed index. In the case of HDVs, only with a 30 km/h speed limit is there concurrence; at higher speeds TraNECaM values are up to 5 dB lower. This reflects the fact that noise emissions of HDVs have in fact declined in the last three decades.

This can be particularly well demonstrated through comparison of present-day specific emissions of the TraNECaM model with those of 1980 (→ Figure 8).

The influence of different road surfaces on noise emissions is considered in RLS-90 / VBUS by means of adjustments to total noise (cf. VBUS, Table 3). These are dependent on permissible maximum speed, but independent of the HDV share. The application of noise-reducing surfaces is limited to roads with permissible maximum speed in excess of 60 km/h.

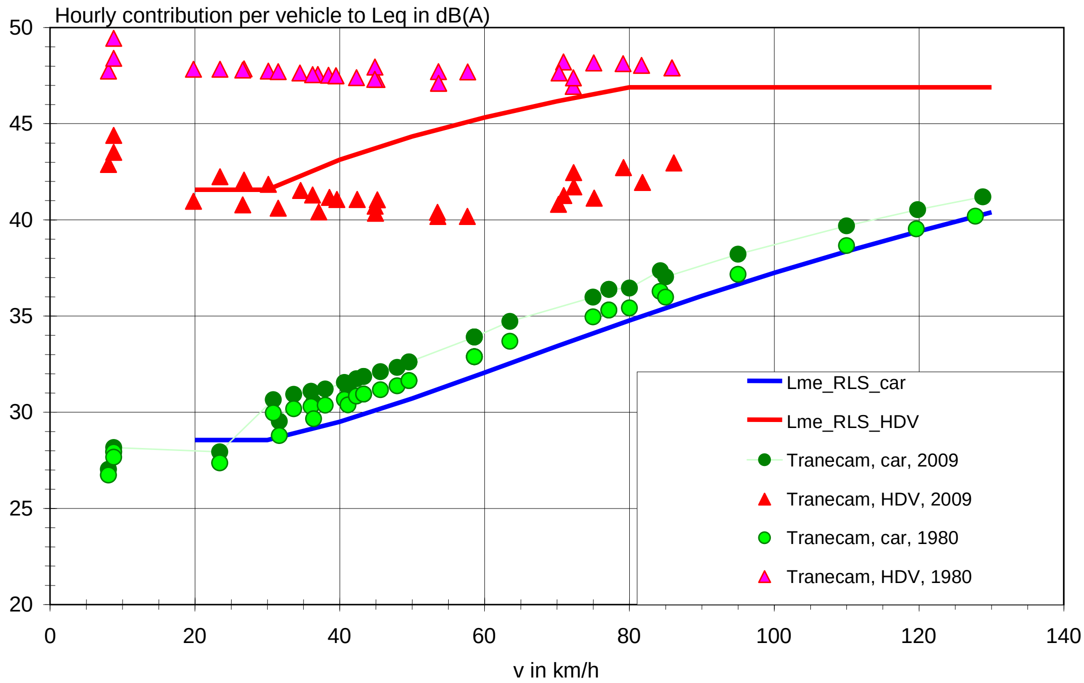

Fig. 8: Comparison of specific emissions of RLS-90 / VBUS with TraNECaM for melted asphalt, and for TraNECaM for different reference years and melted asphalt road surface

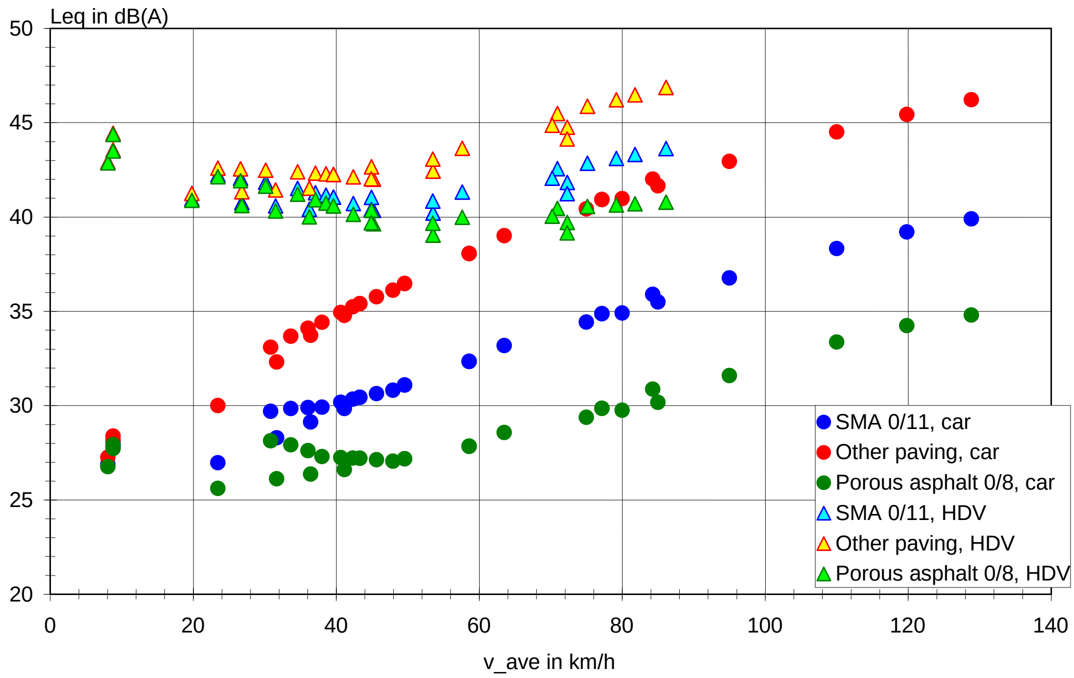

Fig. 9: Influence of road surface on specific emissions in TraNECaM

In TraNECaM, the influence of road surfaces is taken into account by means of adjustments to rolling noise that vary between cars and HDVs. Depending on speed, the varied effect on total noise is thereby directly and continuously accounted for (→ Figure 9). Leaps at category borders can thus be avoided.

In TraNECaM, daily traffic volumes (DTV) are apportioned to hourly values with the aid of daily traffic load distribution curves, which vary between cars and HDVs. Varied traffic situations and thus also specific emissions are allocated to a given road depending on hourly traffic load. Figure 10 illustrates this with the example of another major road from the Hamburg road network.

The model can therefore also take into account that reductions in speed are all the more effective the lower the traffic load. Figure 11 shows the example of a motorway with relatively low traffic load, where average speed is independent of time of day. The status quo has a permissible maximum speed of 120 km/h, which has been reduced for the forecast to 80 km/h for cars and 60 km/h for HDVs. For the status quo, the model takes into account an average car speed of 120 km/h, and for the forecast, in the absence of speed control, an average speed of 95 km/h. The reductive effect is more or less independent of time of day.

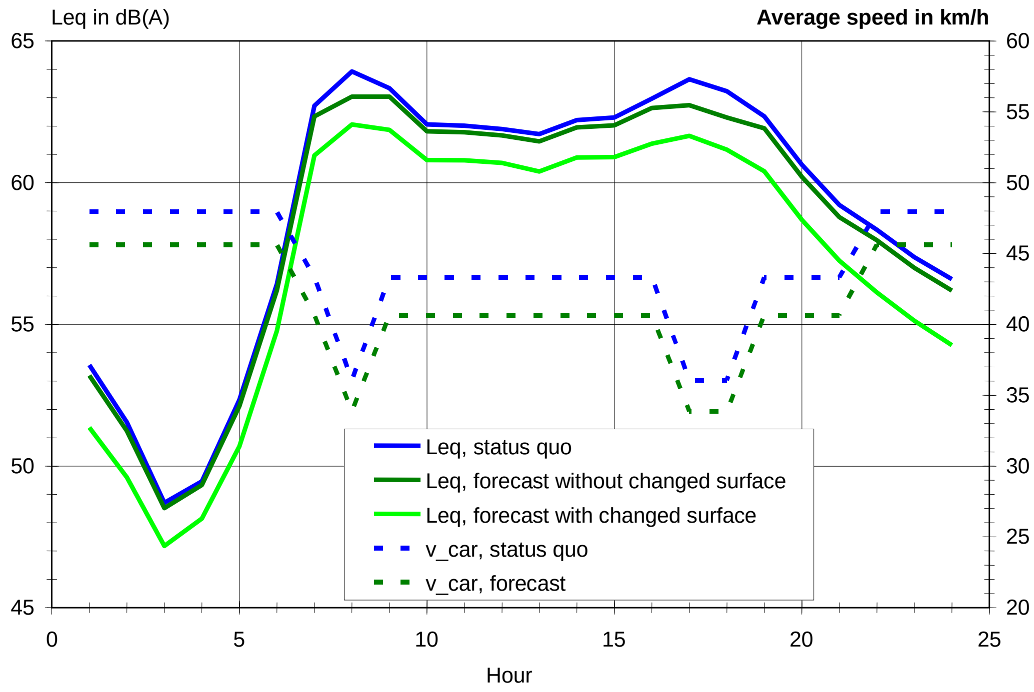

Fig. 10: Daily traffic load distribution curves of continuous sound pressure level on the example of another major road with 2 lanes with a DTV of 18,639 vehicles

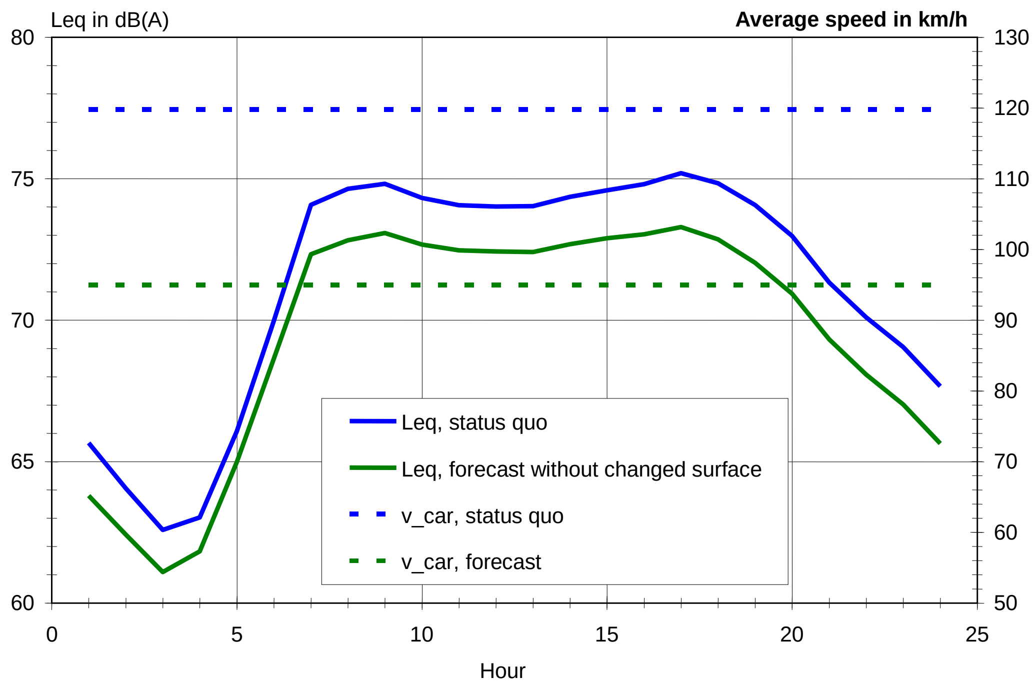

Fig. 11: Daily traffic load distribution curves of continuous sound pressure level on the example of a 6-lane motorway with a DTV of 41,000 vehicles

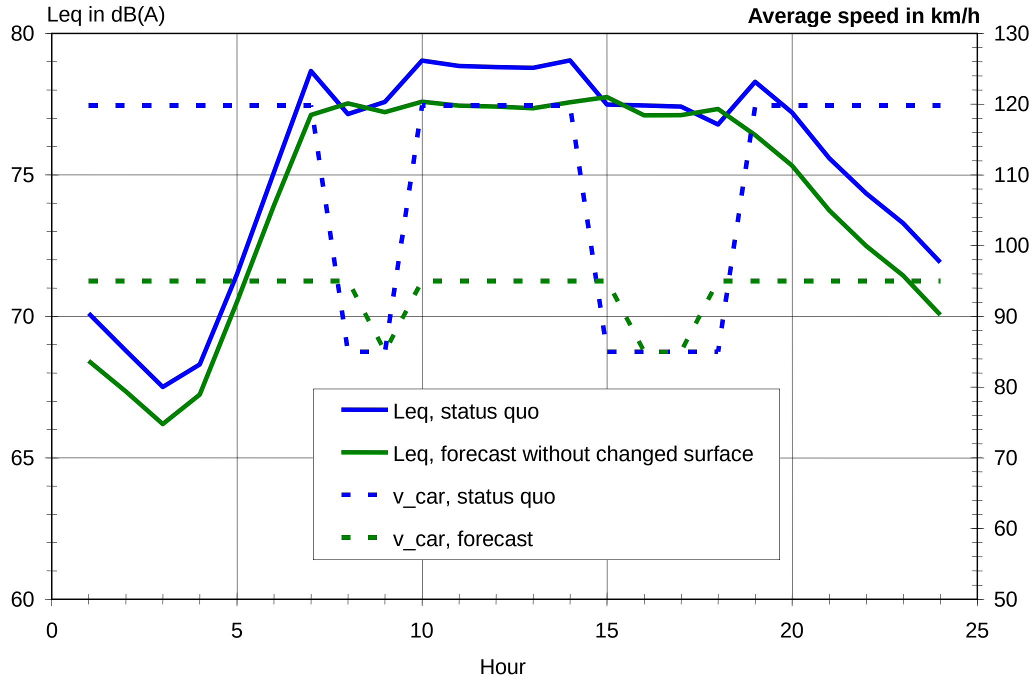

Fig. 12: Daily traffic load distribution curves of continuous sound pressure level on the example of a 6-lane motorway with a DTV of 106,000 vehicles

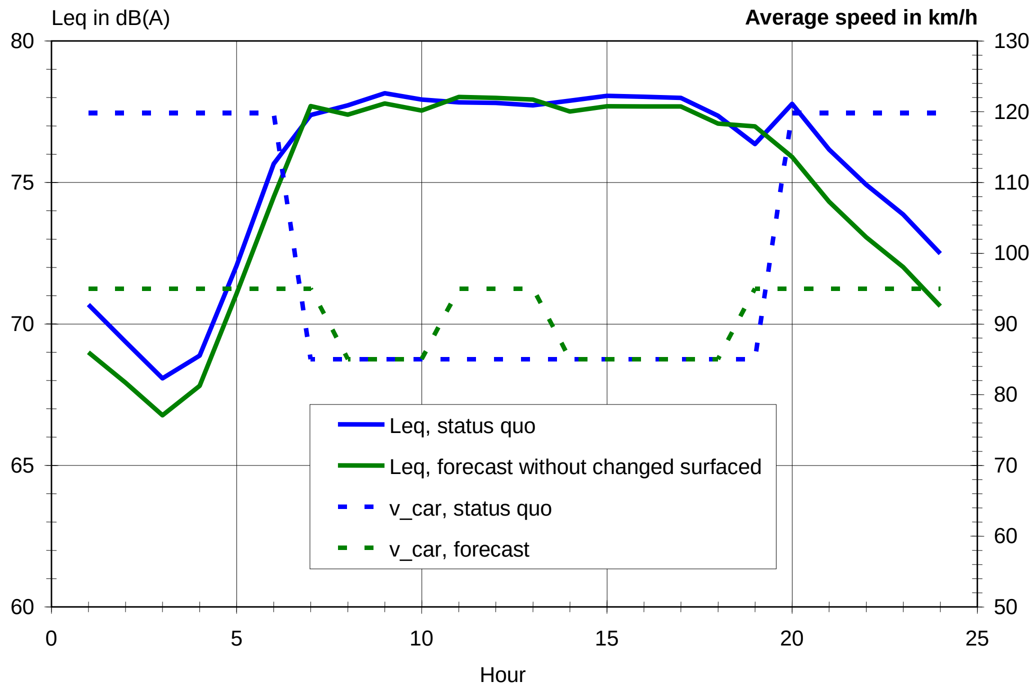

Fig. 13: Daily traffic load distribution curves of continuous sound pressure level on the example of a 6-lane motorway with a DTV of 121,000 vehicles

Figure 12 shows the same scenario, but for a motorway with markedly higher traffic load per lane, so that at peak hours sharp drops in speed occur. The reductive effect is available in this case only outside peak hours.

Figure 13 shows a still higher traffic load per lane, with the effect that the reduction is practically non-existent between 7 a.m. and 7 p.m.

These correlations generally remain unconsidered in other models (also in RLS-90 / VBUS).

Differentiation of traffic load for the assessment periods of day, evening and night is, however, also provided for in RLS-90 / VBUS (Cf. also VBUS, Table 2), where, in contrast to TraNECaM, there is no adaptation of driving speeds and traffic situations. The effects of measures that influence traffic flow can therefore not be determined with VBUS.

With TraNECaM this is indeed possible. When corresponding driving patterns are available, the effect can be determined in great detail with the aid of the road traffic noise model RoTraNoMo; for example, with traffic control measures aimed at stabilization of traffic flow.

RoTraNoMo determines the noise emission of individual vehicles with a resolution of 1 second, or, when required, with higher resolution. RoTraNoMo was developed within the scope of an EU research project with the objective of expanding the results of microscopic traffic simulation models to include noise emission. RoTraNoMo results for the measures described above can then be aggregated and implemented in the TraNECaM model. Moreover, TraNECaM provides the quantitative contributions of individual vehicle categories, so that the effects of bans on vehicles (both spatial and temporal) can be determined.

A programme description is to be found in Annex 2.

5.3 Procedure

Determination of noise emissions takes place on the basis of datasets provided for Hamburg (→ Chapter 2).

The TraNECaM model requires parameters that supplement those of the emission models RLS-90 / VBUS. Parameters that are not available in the Hamburg dataset are supplemented and allocated as follows:

Road category

In the course of preparation of proposals for reduction measures, roads in the input dataset are categorized as follows:

- Motorways
- Magistrals (major radial transport axes)
- Ring roads (major circular roads)
- Other major roads

These serve together with permissible maximum speeds as basis for apportionment to road categories in accordance with TraNECaM (→ Table 4).

Road surface

Road surfaces are adopted with classification from the Hamburg dataset:

- Asphalt (or stone mastic asphalt (SMA) 0/11)
- Even paving
- Other paving

In addition, replacement of the surface of certain roads in the exemplary area with a quieter surface is planned. This concerns 248 roads with asphalt surfaces and 19 roads with uneven paving. TraNECaM contains a table with adjustments for tyre/road noise, differentiated according to cars and light commercial vehicles on the one hand and heavy-duty vehicles (HDVs and buses) on the other hand. As a result, depending on the speed level of a road, different reduction effects arise for total noise (low in the case of low speeds and high shares of HDVs, and high in the case of high speeds and low shares of HDVs), which have been validated by pass-by measurements /17/.

On the basis of this table, the following reductions in tyre/road noise have been applied for replacement of a road surface:

- Existing surface SMA 0/11:
  - Cars & light commercial vehicles 3 dB(A)
  - Heavy-duty vehicles 3 dB(A)
- Existing surface uneven paving:
  - Cars & light commercial vehicles 9 dB(A)
  - Heavy-duty vehicles 7 dB(A)

HDV shares

HDV shares in the Hamburg dataset lie between 0 and 68 per cent. In the model, an HDV is understood to be a vehicle with a permissible total mass in excess of 3,500 kg. Light commercial vehicles with a permissible total mass of up to 3,500 kg are separated internally from remaining cars with default values from traffic censuses.

On the basis of DTV, the model distributes cars, light commercial and heavy-duty vehicles with separate specific daily traffic load distribution curves over the 24 hours of a day. The daily traffic load distribution curves stem from traffic censuses carried out on behalf of the Federal Ministry of Transport for use in the Handbook of Emission Factors for Road Transport, and are regarded as applicable to Hamburg.

Permissible maximum speed

The maximum speeds listed in the Hamburg dataset lie between 20 km/h und 120 km/h, and they are incorporated into the calculation model with the dataset classification. For this, the adjustments described in Chapter 2 had to be applied.

The City of Hamburg already has a number of roads on which different speed limits apply according to time of day. For forecast scenarios, different maximum speeds are allotted for cars and light commercial vehicles (hereafter: cars) on the one hand, and heavy-duty vehicles (hereafter: HDV) on the other hand. The model is therefore broadened to the extent that separate speed limits can be allotted for the vehicle categories described above on the one hand, and for the assessment periods of day and night on the other hand.

Road categories

The TraNECaM model makes use of the following road categories:

Table 4: TraNECaM road categories
Note: IDSKM is the model's internal indicator for allocation of emission factors. The permissible speed in built-up areas/city centre is 50 km/h.

IDSKM	Road category
10	Motorway, without speed limit
11	Motorway, speed limit 120 km/h
12	Motorway, speed limit 100 km/h
13	Motorway, speed limit 80 km/h
14	Motorway, speed limit 60 km/h
2	Outside built-up areas, speed limit 100 km/h
3	Outside built-up areas, speed limit 80/90 km/h
4	Outside built-up areas, speed limit 70 km/h
5	Built-up areas, major road, speed limit > 50 km/h
6	Built-up areas, major road, speed limit 50 km/h, right of way
7	Built-up areas, major road, speed limit 50 km/h, traffic-light controlled
8	Built-up areas, city centre
21	Built-up areas, thorough road, speed limit 30 km/h
22	Built-up areas, thorough road, speed limit 20 km/h
9	Built-up areas, residential road, speed limit 50 km/h
19	Built-up areas, residential road, speed limit 30 km/h
20	Built-up areas, residential road, speed limit 20 km/h

The measure scenarios also envisage a speed limit of 40 km/h on other major roads. The model is therefore supplemented with a corresponding road category, not only for major roads (IDSKM = 24) but also for residential roads (IDSKM = 23). Related emission data is obtained through energetic averaging of the values for a 30 km/h a 50 km/h speed limit.

Allocation to TraNECaM category occurs on the basis of permissible maximum speeds:

- Category "Motorway":
  70 and 80 km/h to IDSKM class 13 as well as
  50 and 60 km/h to IDSKM class 14
- Category "Magistral":
  100 km/h to IDSKM class 2,

80 km/h to IDSKM class 3,
60 and 70 km/h to IDSKM class 5,
50 km/h to IDSKM class 7 and
30 km/h to IDSKM class 21

- Category "Ring road":
  60 and 70 km/h to IDSKM class 5,
  50 km/h to IDSKM class 7 and
  30 km/h to IDSKM class 21
- Category "Other major roads":
  Allocation to IDSKM is the same as in the case of magistrals.

Direction and location/function

The TraNECaM model covers, in addition, the parameters of "direction" and location/function, which influence the choice of daily traffic load distribution curves.

In the case of "direction" the following distinction is made:

- Both directions
- Into town
- Out of town

Since no information is available in this respect, all roads are entered as "both directions".

In the case of "location/function" the following distinction is made:

- Inner city core, tangential and ring roads
- Inner city periphery, roads radiating outward from one point
- Suburban area, access roads, roads linking city districts
- Motorway

The indicators (see Table 4) are allocated correspondingly to ring roads, magistrals and motorways. The remaining major roads are categorized as suburban roads, access roads and roads linking city districts.

Calculations are then made with hourly resolution. The subsumption of hourly values into L_{Day}, $L_{Evening}$ and L_{Night} takes places in accordance with the calculation methods (VBUS) of the Environmental Noise Directive.

5.4 Data interface

The results are transferred by means of an interface – defined in the course of this project – to sound propagation software for calculation of sound immissions in the area under investigation.

In order to be able to carry out the changes described in the previous section within the time available, the following action is taken:

The input data is read into a separate database, whose tables are linked with the TraNECaM database. The tables with input data are first read into a mirror table, into which necessary indicators and calculation results are also read. The required allocation of parameters is effected by retrieval tailored to the respective calculation variant.

Input data as well as emission parameters are transferred to the data interface to sound propagation software:

- Leq_D – L_{Day} for all vehicles,
- Leq_E – $L_{Evening}$ for all vehicles, and
- Leq_N – L_{Night} for all vehicles.

Propagation calculations take place pursuant to Directive 2002/49/EC /18/ in accordance with VBUS /19/.

6 Measure validation and model comparison

Determination of the number of people exposed to road traffic noise, on the example of Hamburg, takes place on the basis of the measure-sensitive TraNECaM noise emission model (→ Chapter 5), and of subsequent calculation of propagation in accordance with VBUS in an exemplary area:

5. **Analysis:** The number of people affected (in the exemplary area) is determined as reference for the initial position without measures (→ Chapter 2).
6. **Measures:** The measures are described on the basis of the assessment of their effect on the modal split and speed on the example of Hamburg (→ Chapter 4, Table 3). Traffic-related measures for the reduction of private motorized traffic, and of HDV traffic in particular, are considered in combination with consistent and extensive implementation of measures for reducing permissible maximum speed.
7. **Road surfaces:** In a further calculation variant, based on the exemplary area, the additional effect of replacement of road surfaces is established (→ Sections 5.1 and 5.3).

For localization of noise hot spots recourse is made to the LKZ noise indicator method (LärmKennZiffer-Methode (LKZ)) (a method of environmental noise index evaluation), according to Bönnighausen/Popp /20/. For this purpose, the number of inhabitants affected by noise above a certain threshold value (here: L_{Night} >= 55 dB(A)) is multiplied by the degree by which the threshold value is exceeded. Representation is effected with the help of an ha grid (100 m x 100 m).

The exposure situation for Hamburg is compared in the analysis with the situation with measures (without reconstruction of road surfaces) (→ Figure 14), the darker the colour the higher the exposure (ascending gradation from green to purple).

The following Figure 15 shows exposure reductions in the exemplary area with implementation of measures, compared to the analysis (LKZ difference: road surfaces/measures), as well as the additional effect of selective replacement of road surfaces (LKZ difference: road surfaces/measures), the darker the colour green the greater the LKZ reduction.

Exposure – analysis
(→ Annex 5)

Exposure – measures
(→ Annex 6)

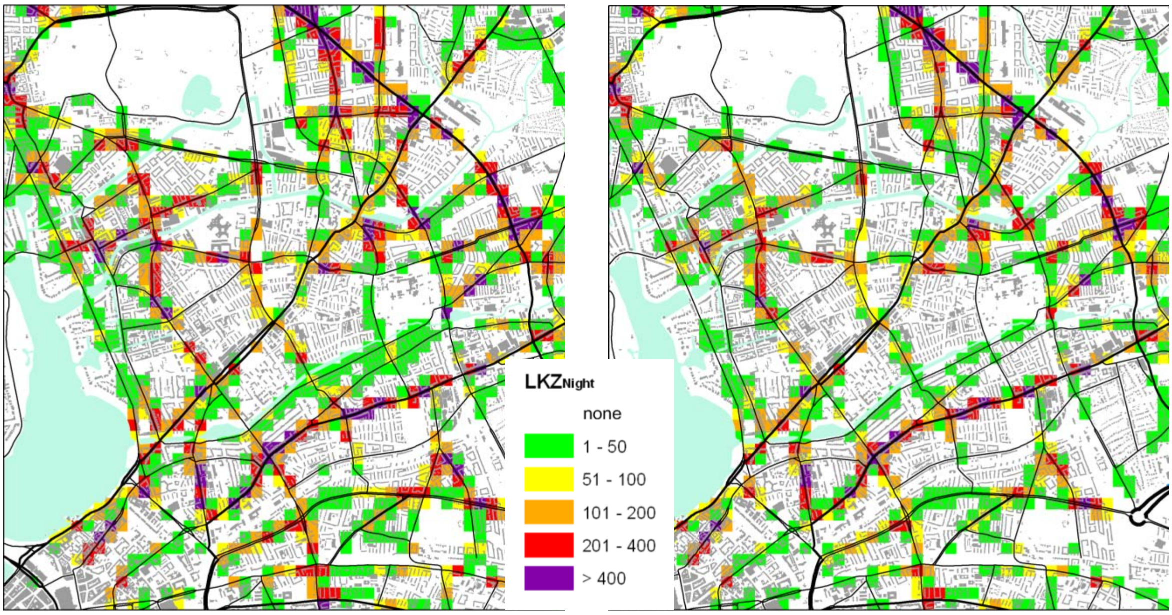

Fig. 14: Results of effect-based analysis (TraNECaM) without replacement of road surfaces

Reduction exposure – measures/analysis
(→ Annex 7)

Reduction exposure – road surfaces/measures
(→ Annex 8)

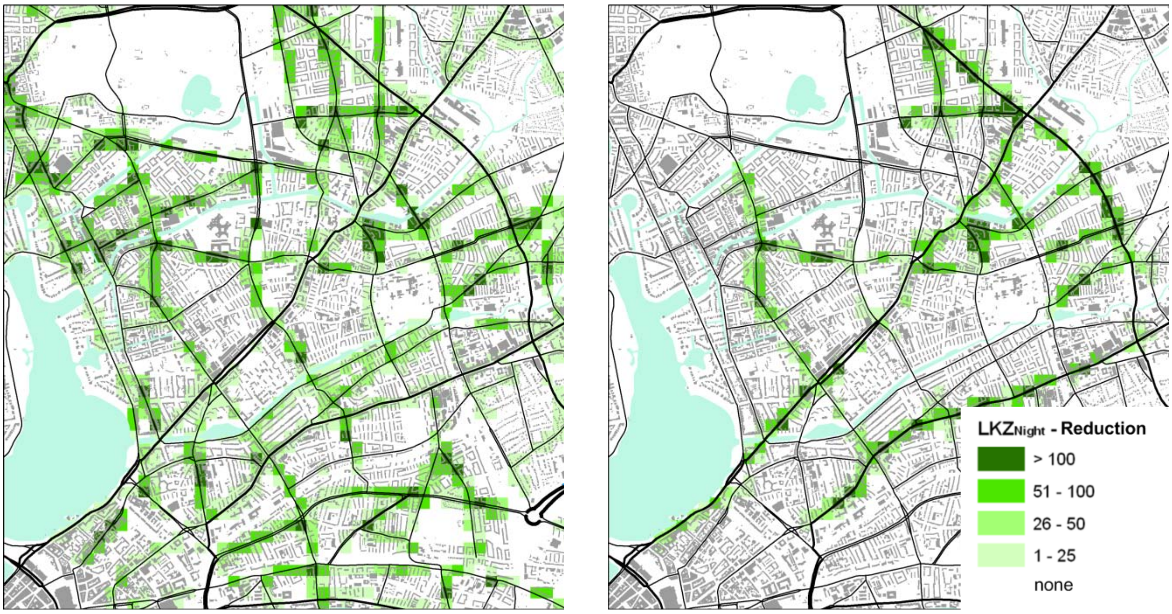

Fig. 15: Reduction exposure according to TraNECaM

In Figure 16, reduction potentials for Hamburg are shown with the aid of an exemplary area and statistical investigation by the measure-sensitive noise emission model TraNECaM for different threshold values. Here, the numbers of people affected has been set at 100 % in order to highlight declines from the respective threshold values.

It becomes clear that

... already with the aid of measures related to the modal split and speed, reductions of almost 15 % can be achieved in the number of persons affected by noise at night at a rating level > 50 dB(A).

... in the case of higher exposure, even higher potentials can be identified for reductions in the number of persons affected: Reductions of almost 20 % in the number of persons affected by noise at night arise in respect of the rating level > 55 dB(A), which, according to the German Advisory Council on the Environment (SRU), /21/ represents the potential health hazard threshold.

... related to the rating level > 60 dB(A), reductions of even 35 % arise in the number of persons affected by noise at night.

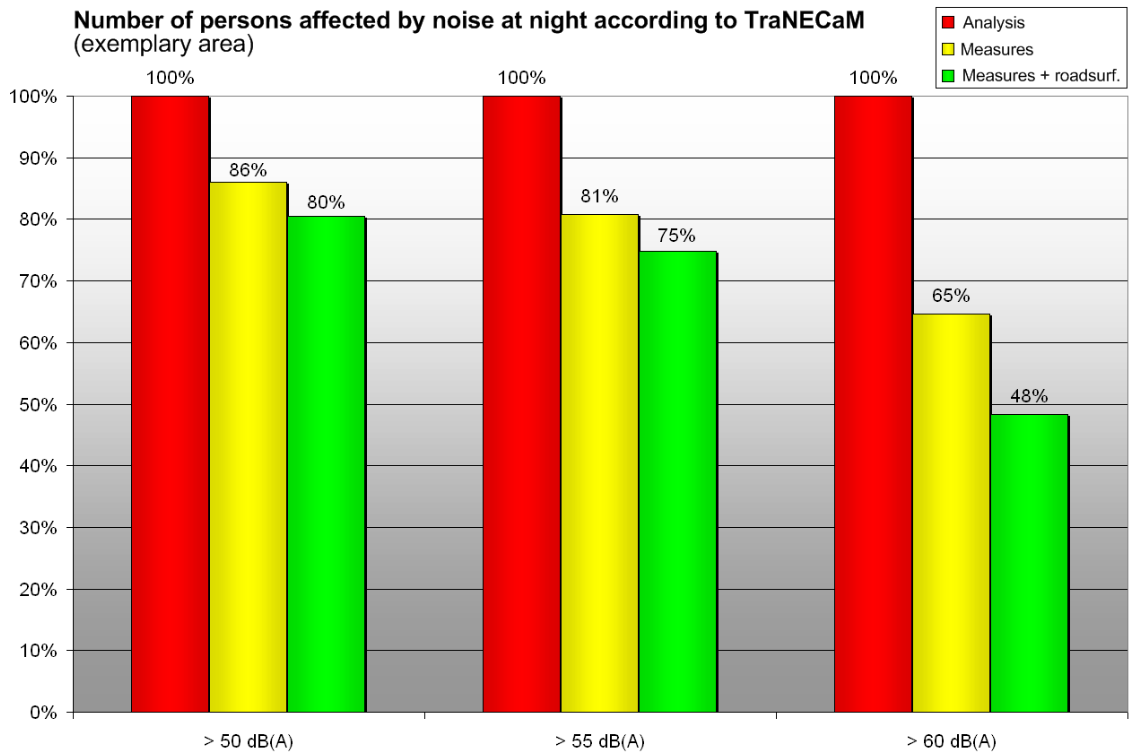

Fig. 16: Reduction in the number of persons affected by noise at night in the exemplary area in Hamburg (calculation with TraNECaM)

Moreover, the concept of reconstruction with low-noise road surfaces (→ Figure 3) can be effective, particularly in the case of very high noise exposure:

- The effect of low-noise road surfaces becomes apparent in the area under investigation with the number of persons affected at noise levels > 50 dB(A) and > 55 dB(A) at night through reduction of a further 6 %. The numbers affected at levels > 50 dB(A) at night can therefore be reduced by 20 % and those > 55 dB(A) at night by 25 %.
- For very high noise exposure > 60 dB(A) at night, a further reduction of more than 15 % in the number of persons affected, to a total of less than half, can be achieved through low-noise road surfaces.

In order to represent the disparity of statistical surveys with the measure-sensitive noise emission model TraNECaM and those of the conventional emission models VBUS and RLS-90, a calculation is made of reduction potentials of envisaged measures for the exemplary area that are representable in the respective models (→ Figure 17).

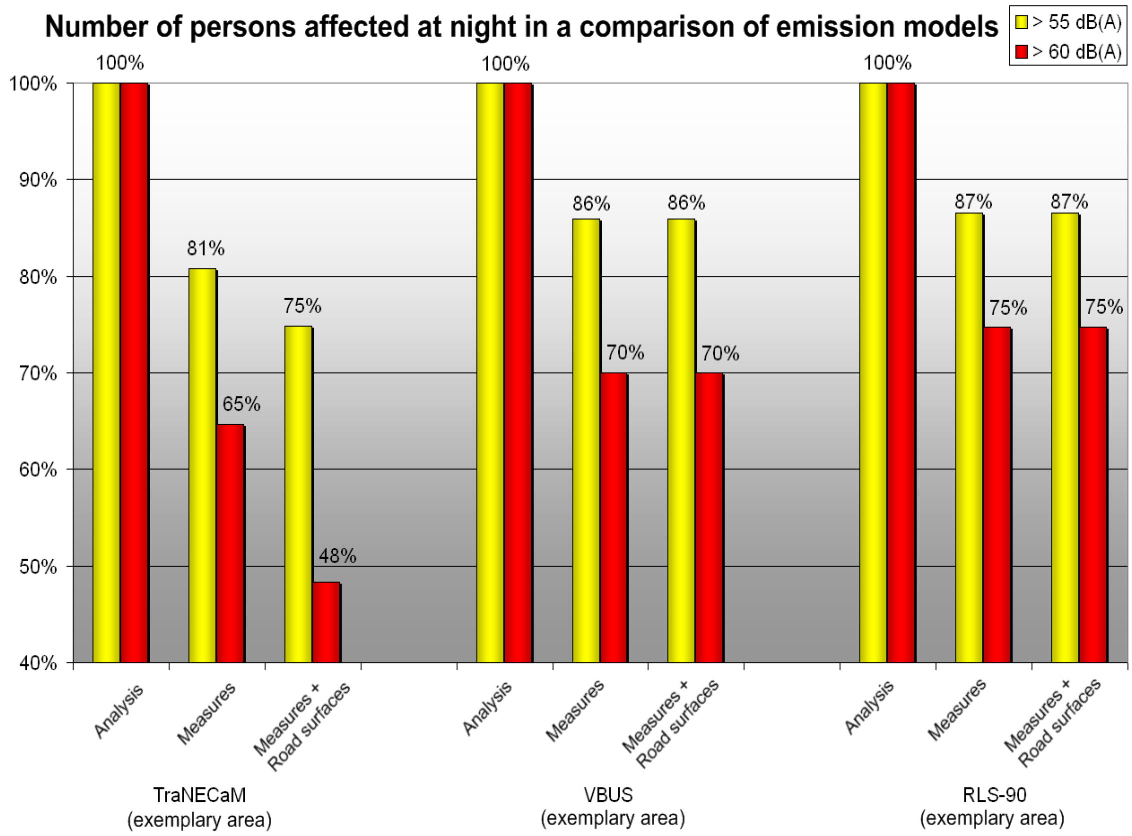

Fig. 17: Reduction in the number of persons affected at night in a comparison of emission models

The main results are as follows:

- The effect of low-noise road surfaces at permissible maximum speeds is not representable in the emission models VBUS and RLS-90.
- The effect of measures that influence traffic flow (for example, stabilization of traffic flow) is not representable in the emission models VBUS and RLS-90.
- Vehicle fleet composition is carried out with TraNECaM for the respective base year. The emission models VBUS und RLS-90 carry out calculations with a vehicle fleet that no longer corresponds with present circumstances.
- Due to similar model approaches, reduction effects on numbers of persons affected by noise at night in calculations with the emission models RLS-90 and VBUS are, as expected, also similar. On account of adjustments for traffic light systems in the RLS-90 model, higher absolute rating levels arise and thus a lower relative reduction in the numbers affected by the envisaged measures at higher noise levels (above 60 dB(A) at night).
- Lower reduction effects are representable with the emissions models RLS-90 and VBUS compared to TraNECaM. The reduction effects with RLS-90 and VBUS, for instance, amount with exposure above 55 dB(A) to about 15 %, with TraNECaM, on the other hand, to 20 %. In the case of exposure above 60 dB(A) at night, reduction effects amount to 25 % with RLS-90, 30 % with VBUS 30 % but 35 % with TraNECaM.
- Furthermore, it becomes clear that additional replacement with low-noise road surfaces, in particular at very high exposure levels, can result in marked success in reduction of the number of persons affected, an effect that is not always represented in conventional models.

7 Summary

The project indicates a reasonable approach to the planning of action on the reduction of road traffic noise in large urban conurbations (bearing in mind the limited time avail-able between conclusion of noise mapping and the preparation of action plans), which represents noise reduction effects as realistically as presently possible, taking into ac-count in the process the synergistic effect of different environment protection concepts:

Noise action planning is a multisectoral task

Noise action planning is a multidisciplinary task with multifarious interaction with contiguous planning disciplines. Many noise-reduction measures also have an impact on traffic safety, the quality of traffic flow and road network capacity. Moreover, measures for traffic control and stabilization have an effect on immission of particulate matter and nitrogen oxide, which, as a result of new EU regulations, will attract increasing attention in the coming years. After all, noise is a decisive criterion in the choice of a place to live, and an important indicator for the general quality of life in a city.

Furthermore, many of the databases that are required for noise mapping and action planning, such as the digital terrain model, building and population data as well as traffic volumes and HDV shares thereof, which are also utilized in other areas. A joint course of action

... avoids unnecessary costs for data management and data collection.

... helps, through early agreement, to recognize and avoid conflicts over objectives.

... enables efficient use of personnel capacities and allocation of financial resources.

Synergistic effect with other planning projects

It becomes clear from the above-mentioned points that noise action planning cannot be accomplished in the long term with classic departmentalized thinking. Efficient use of existing resources requires the linking of noise action planning with contiguous planning disciplines on a sustained basis. Examples of this are traffic development planning, the air pollution control plan and efforts towards climate protection.

Strategic approach

The development of appropriate noise-reduction measures and their execution require co-ordination and reconcilement with all relevant plans.

Hamburg has decided on strategic noise action planning at a city-wide level. Many existing plans that have been adopted by the Government ("Senate") of the City State of Hamburg contain measures that, apart from their actual objective, also have an impact on the noise situation. It therefore makes sense to identify such measures and to assess them in terms of their significance for noise. The incorporation of existing plans in strategies for noise reduction and the development of integrated noise reduction measures ensure acceptance and compatibility of the noise action plan in the city, without giving rise to significant additional costs. As a rule, these measures have already been adopted by the Senate and furnished with the necessary funds, which markedly increases the chances of realization.

The concept of the Strategic Noise Action Plan for Hamburg serves as basis for im-pact analysis and comprises the following approaches:

1. City-wide approach
    - Analysis of existing and planned noise reduction measures
    - Preparation of a plan of action for the "city as a whole"
    - Development of a long-term strategy (which can be supported by policy-makers)
    - Evaluation of identified measures on the basis of changes in the numbers of persons affected by noise and their public presentation
    - Consolidation of plan of action and long-term strategy into a city-wide action plan taking account of the results of evaluation of measures and public participation
2. District level

On the basis of the strategic city-wide approach, specific planning of measures takes place in a second stage at the district level.

Measure-sensitive models

In order to represent noise reduction effects as realistically as possible, the use of measure-sensitive emission models is indispensable for evaluation of measures.

Calculation of noise exposure through road traffic is carried out in accordance with the Guidelines for Noise Abatement on Roads (Richtlinien für den Lärmschutz an Straßen - RLS-90) and preliminary calculation methods for determination of road-related environmental noise (VBUS). RLS-90 was developed for the purpose of demarcation of legal entitlement to noise protection in the case of road construction and with major reconstruction work on existing roads. Emission calculations of RLS-90 are based in the main on noise measurements from the early 1980s, and have not been adapted to the prevailing composition of vehicle fleets. This is less problematical for demarcation of legal entitlement in connection with the transgression of limit values, since emission calculation, as a rule, is designed in such a way they that it describes the worst case, and thus disposes of a safety margin in terms of its preciseness in the interest of those exposed to noise. This approach is disadvantageous, however, for determination of the effects of measures within the scope of action plans, since the effect in worst case observations is not described in accordance with actual conditions. On the other hand, there are a number of measures whose effects cannot at all be assessed with legal calculation models. These include, for example, measures aimed at improved traffic flow.

Against this background, the measure-sensitive, noise emission model TraNECaM, which was developed in the 1990s on behalf of the Federal Environment Agency, enables considerably more detailed calculation than the conventional RLS-90 and VBUS calculation models, and takes account of technical advances in motor vehicles. The database of the model is more broadly designed in terms of road and vehicle categories than that of conventional models. A further basic difference com-pared to VBUS and RLS-90 is that TraNECaM calculates rolling and propulsion noise separately, thus enabling representation of measures relating not only to propulsion technology but also to tyres and roads.

Within the scope of this project, with the aid of so-called soft measures (that is, measures for the reduction of private motorized traffic and, in particular, HDV traffic, combined with consistent and extensive implementation of measures for reduction of permissible maximum speed) in the area of Hamburg under investigation marked reductions of almost 20 % could be achieved in the number of persons affected by noise at night, related to a noise rating level > 55 dB(A). Related to a very high rating level > 60 dB(A), the reduction in the numbers of persons affected at night was even 35 %.

Through reconstruction of individual roads with low-noise road surfaces a noticeable additional reduction in the number of persons affected by noise, in particular with very high noise exposure, could also be achieved in the inner-city area. The number of persons affected by noise in the selected exemplary area at a level above 60 dB(A) at night could be reduced by more than 50 %. This effect, as with the noise-reducing effect of stabilization of traffic flow, is, however, not representable with the emission models VBUS and RLS-90.

8 Annexes

Annex 1: Evaluated planning instruments

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Annex 4: Assessment of the effect of measures on the modal split and speeds

Annex 5: Exposure map (LKZ = number of persons affected x exceedance threshold value L_{night} >= 55 dB(A) in ha grids), analysis,
exemplary area, statistical survey with TraNECaM

Annex 6: Exposure map (LKZ = number of persons affected x exceedance threshold value L_{night} >= 55 dB(A) in ha grids), measure scenario,
exemplary area, statistical survey with TraNECaM

Annex 7: Difference map exposure (LKZ = number of persons affected x exceedance threshold value L_{night} >= 55 dB(A) in ha grids), measure scenario - analysis,
exemplary area, statistical survey with TraNECaM

Annex 8: Difference map exposure (LKZ = number of persons affected x exceedance threshold value L_{night} >= 55 dB(A) in ha grids),
additional effect of low-noise road surfaces – measure scenario,
exemplary area, statistical survey with TraNECaM

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Annex 1: Evaluated planning instruments

Noise abatement

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- Radverkehrsstrategie für Hamburg

Annex 2: Model description of TraNECaM/RoTraNoMo

Introduction

The exposure of the population to noise and air pollutants are caused predominantly by

- road traffic,
- rail traffic and
- air traffic.

Other important sources are industry and trade. In the case of noise, they now play only a minor role, while In the case of air pollutants they are mostly responsible for background pollution, since emission generally occurs at a great height and is extensively distributed through meteorological influences.

Among traffic-related sources, road traffic is of great significance, since, compared to the other two sources, it manifests no spatial limitation, at least in urban conurbations, and is present everywhere.

Threshold values and other statutory regulations meanwhile require determination of exposure to noise and air pollutants, at least in urban conurbations. This is generally carried out with calculation models. In the case of noise pollution from road traffic, for instance, the RLS-90 model is used. These calculation models comprise an emission module and a propagation module. With the emission module the concentration of noise or air pollutants in a given road is quantitatively determined; with the propagation module it is established to what extent such pollution enters the homes of those affected.

The depth of detail and accuracy of propagation modules have been enhanced on a number of occasions in the past. As far as emission calculation is concerned, this is the case to only a limited extent. Emission calculation formulae of the RLS-90, for example, are still based on noise measurements carried out in the early 1980s.

This is less problematical for demarcation of legal entitlements in connection with exceedance of limit values, since emission calculation is mostly designed in such a way that the worst case is described; that is, it disposes of a safety margin with respect to its accuracy.

This course of action is disadvantageous, however, for determination of the effects of measures within the scope of an action plan, since effect is often overestimated in considerations of worst case. In addition, there are a number of measures whose effects cannot at all be assessed with legal calculation models; these include, for example, traffic management measures.

The TraNECaM/RoTraNoMo noise model

Against this background, the TraNECaM noise model was developed in the 1990s, which enables much more detailed calculation and takes account of technical advances in motor vehicles. The design of the model database is considerably broader in terms of road and vehicles categories than conventional models.

Tyre/road noise and propulsion noise are separately calculated and added together to give total noise, in order to allow precise determination of the effect of source-related measures (road surface, tyres, engine and powertrain).

The emission factors applied in the model are based on representative driving patterns for the respective road category and vehicle category, which have been obtained from extensive measurements of driving behaviour in real traffic conditions. Further marginal conditions and influence parameters, such as the influence of road surfaces, are derived from noise measurements from statistical vehicle spot checks in real traffic conditions.

The model was originally developed on behalf of the German Federal Environment Agency. It was later expanded and updated with the financial support of the European Commission and the Norwegian Pollution Control Authority. It was utilized in Norway to quantify the nationwide effects of reduction measures that could be implemented for attainment of political reduction targets.

The model calculates continuous sound pressure level with hourly resolution, so that user-defined assessment periods can be evaluated. At the same time, it is taken into account that vehicles drive faster at night with lower traffic load and slower in peak hours than the daily average speed. It also provides the quantitative contributions of individual vehicle categories to total noise level, so that the effects of selective bans on vehicles (spatial as well as temporal) can be determined.

The effects of measures whose typical driving patterns are not included in the TraNECaM database, or for which an hourly resolution is insufficient, can be calculated with the preliminary road traffic noise model RoTraNoMo. This is the case, for example, with traffic management measures that are directed at stabilization of traffic flow. RoTraNoMo calculates the noise emission of individual vehicles with a resolution of 1 second, or, when required, also with higher resolution. RoTraNoMo was developed within the scope of an EU research project with the aim of extending the results of microscopic traffic simulation to include noise emission. RoTraNoMo results for the measures described in this report can be aggregated in such a way that these models can be implemented in the TraNECaM model.

The pollutant emission model MOBILEV/PHEM

The pollutant emission model MOBILEV is the counterpart to and forerunner of the noise emission model TraNECaM. It is based on the Handbook on Emission Factors of the Federal Environment Agency, and makes use of traffic statistics from the TREMOD model. TraNECaM and MOBILEV are compatible in terms of road and vehicles categories. MOBILEV also calculates with hourly resolution emissions of both regulated pollutants and unregulated pollutants such as nitrous oxide and ammonia, as well as CO2 emissions.

The effects of measures whose typical driving patterns are not included in the MOBILEV database can be calculated with the preliminary PHEM model. PHEM was developed at the Institute for Internal Combustion Engines and Thermodynamics at Graz University of Technology, and is used for calculation of the emission factors in the handbook.

Required input data

The accuracy of calculations depends on the quality of input data.

For TraNECaM/MOBILEV the following gradations arise:

- DTV, share of HDVs, road category, regulations governing junctions/crossroads and number of lanes are minimum requirements. The internal default values are applied inter alia for daily traffic load distribution curves, categorization of vehicles by size and emission level as well as for the share of delivery vans.
- Where daily traffic load distribution curves exist, these can be used for calculation purposes. More precise categorization of vehicles by size and emission level can be effected by analysis of licence plate detection.

Use of the RoTraNoMo/PHEM models requires speed curves with a resolution of at least 1 second as input data. Such data can stem from microscopic traffic simulations or from measurements with vehicles in traffic flow, whereby the latter provide greater accuracy.

TraNECaM/MOBILEV results can be passed on via interfaces to the propagation module of established calculation models for determination of pollutant concentrations or noise exposure levels.

Annex 3: Transport axes of the Hamburg agglomeration

Annex 4: Assessment of the effects of measures on the modal split and speeds

<table>
<tr><th rowspan="3">Approach</th><th rowspan="3">Concept component</th><th colspan="2" rowspan="2">Motorways</th><th colspan="4">Major transport axes</th><th colspan="2" rowspan="2">Other major roads</th></tr>
<tr><th colspan="2">Magistrals</th><th colspan="2">Ring roads</th></tr>
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<tr><td>Park & Ride</td></tr>
<tr><td>Bike & Ride</td></tr>
<tr><td>Parking management</td></tr>
<tr><td>Soft policies</td></tr>
<tr><td colspan="2">Corporate mobility management</td></tr>
<tr><td colspan="2">Promotion of bicycle traffic</td><td>-</td><td>-</td><td>-0.5%</td><td>-</td><td>-1.5%</td><td>-</td><td>-5.0%</td><td>-</td></tr>
<tr><td rowspan="6">Spatial shifting of transportation</td><td>Bundling of transportation</td><td rowspan="3">-</td><td rowspan="3">+1.0%</td><td rowspan="3">-</td><td rowspan="3">+2.0%</td><td rowspan="3">-</td><td rowspan="3">+2.0%</td><td rowspan="3">-</td><td rowspan="3">-3.0%</td></tr>
<tr><td>Traffic management measures</td></tr>
<tr><td>Bans on through traffic</td></tr>
<tr><td>Strengthening of transport modes</td><td>-</td><td>-2.0%</td><td>-</td><td>-2.0%</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Freight transport logistics</td><td>-</td><td>+1.0%</td><td>-</td><td>-1.0%</td><td>-</td><td>-1.0%</td><td>-</td><td>-1.0%</td></tr>
<tr><td>New road links</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
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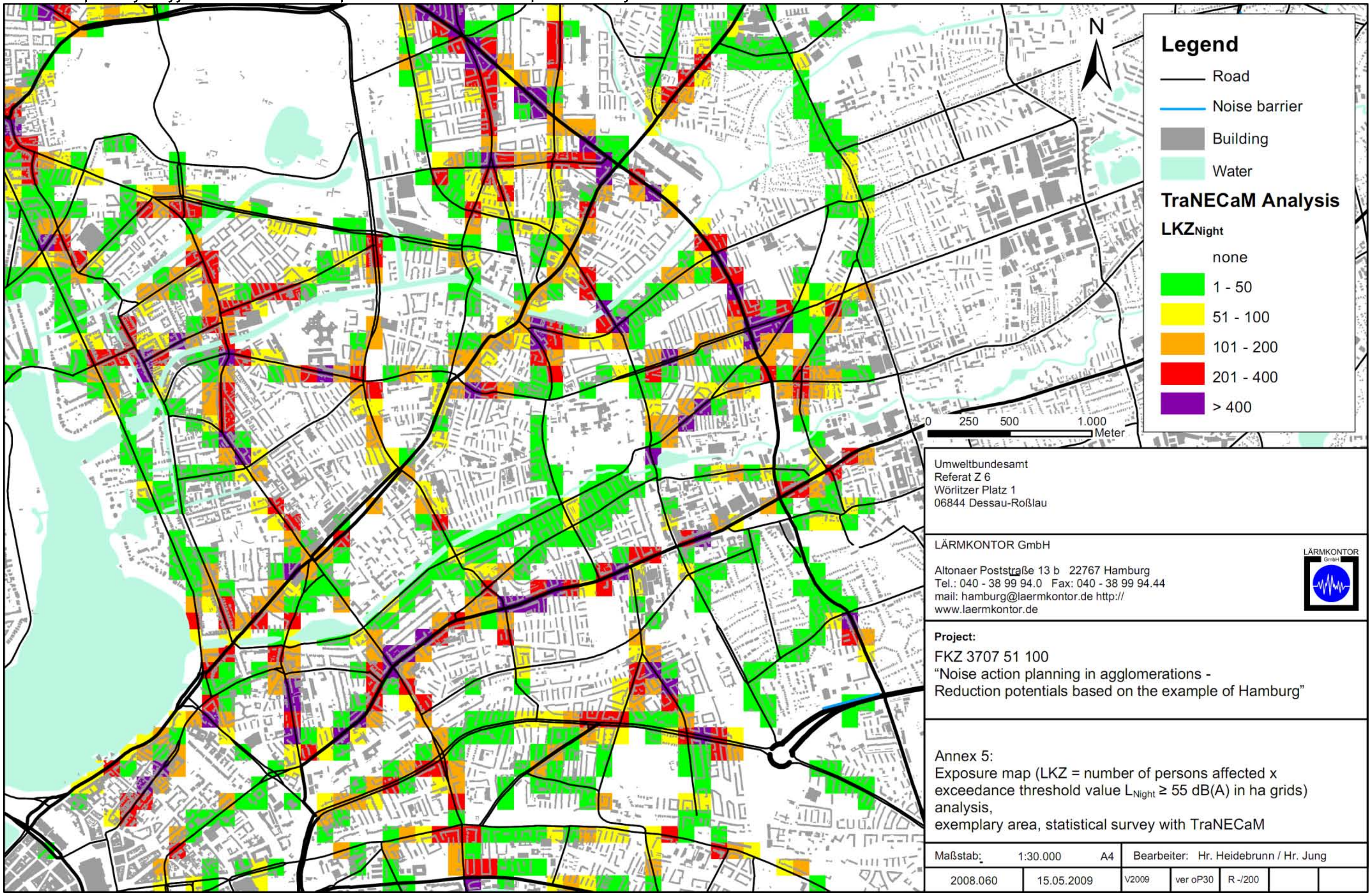
<tr><td colspan="10"></td></tr>
<tr><td rowspan="2">Improvement in traffic flow</td><td>Stabilization of traffic flow</td><td rowspan="2">80 km/h</td><td rowspan="2">60 km/h</td><td colspan="2" rowspan="2">50 km/h</td><td colspan="2" rowspan="2">50 km/h</td><td colspan="2" rowspan="2">40 km/h</td></tr>
<tr><td>Speed concept</td></tr>
</table>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Noise barrier
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TraNECaM Analysis
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101 - 200
201 - 400
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Umweltbundesamt
Referat Z 6
Wörlitzer Platz 1
06844 Dessau-Roßlau
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LÄRMKONTOR
Project:
FKZ 3707 51 100
“Noise action planning in agglomerations -
Reduction potentials based on the example of Hamburg”
Annex 5:
Exposure map (LKZ = number of persons affected x
exceedance threshold value LNight ≥ 55 dB(A) in ha grids)
analysis,
exemplary area, statistical survey with TraNECaM
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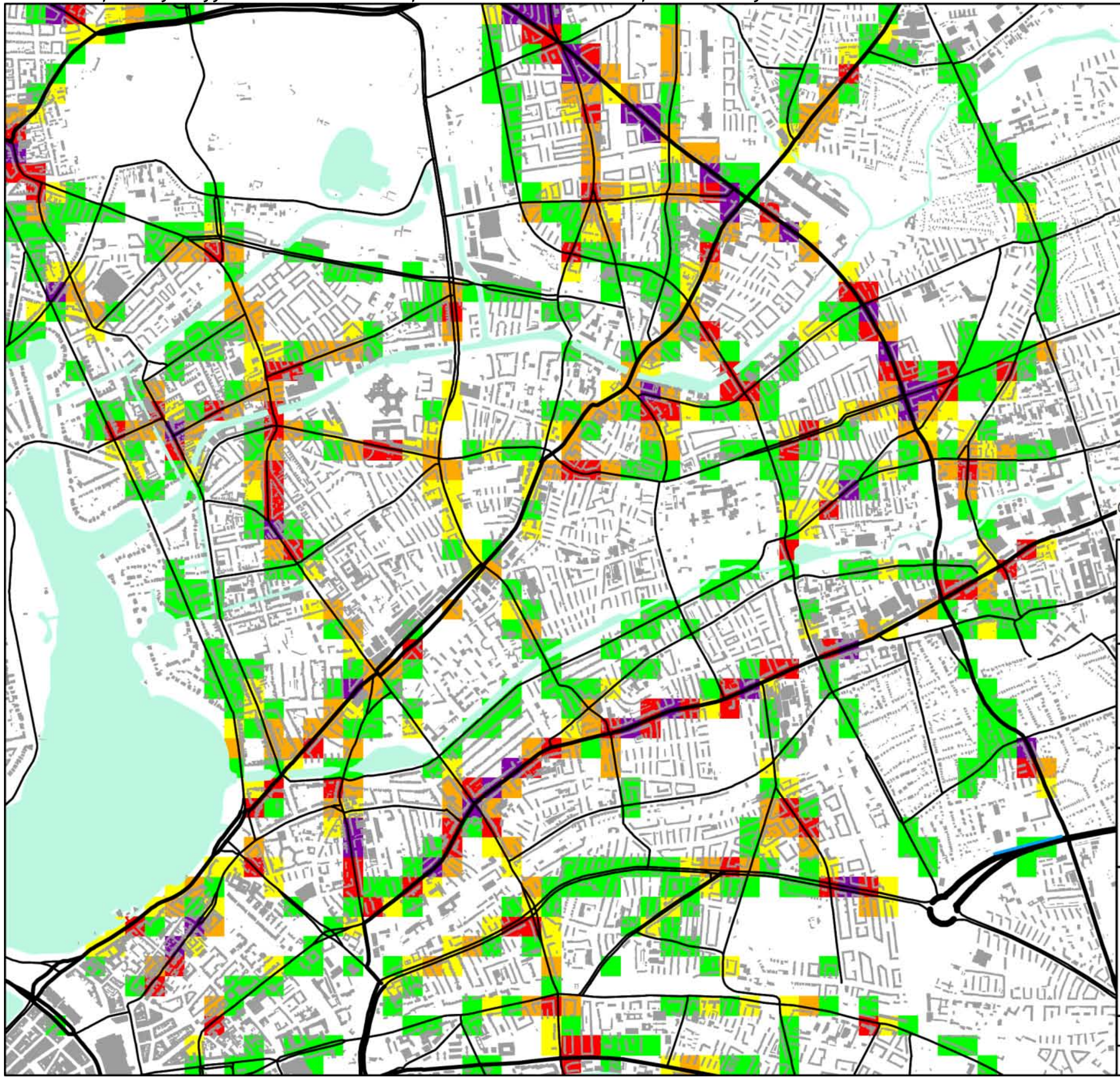

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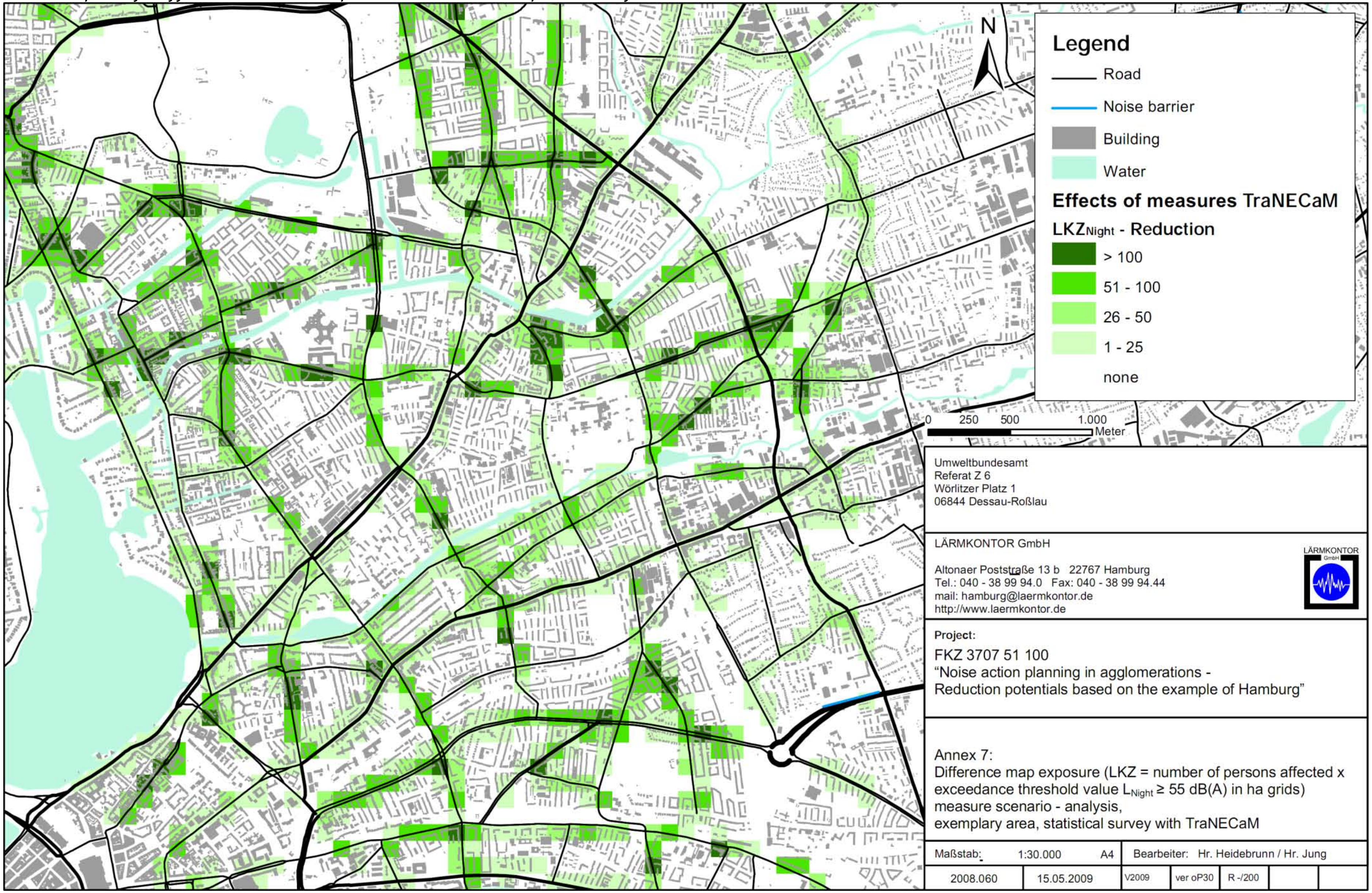
Project:

FKZ 3707 51 100
"Noise action planning in agglomerations -
Reduction potentials based on the example of Hamburg"

Annex 6:
Exposure map (LKZ = number of persons affected x exceedance threshold value $L_{Night} \geq 55$ dB(A) in ha grids)
measure scenario,
exemplary area, statistical survey with TraNECaM

Maßstab:	1:30.000	A4	Bearbeiter: Hr. Heidebrunn / Hr. Jung		
2008.060	15.05.2009	V2009	ver oP30	R -/200	


N
Legend
Road
Noise barrier
Building
Water
Effects of measures TraNECaM
LKZNight - Reduction
> 100
51 - 100
26 - 50
1 - 25
none
0 250 500 1.000
Meter
Umweltbundesamt
Referat Z 6
Wörlitzer Platz 1
06844 Dessau-Roßlau
LÄRMKONTOR GmbH
Altonaer Poststraße 13 b 22767 Hamburg
Tel.: 040 - 38 99 94.0 Fax: 040 - 38 99 94.44
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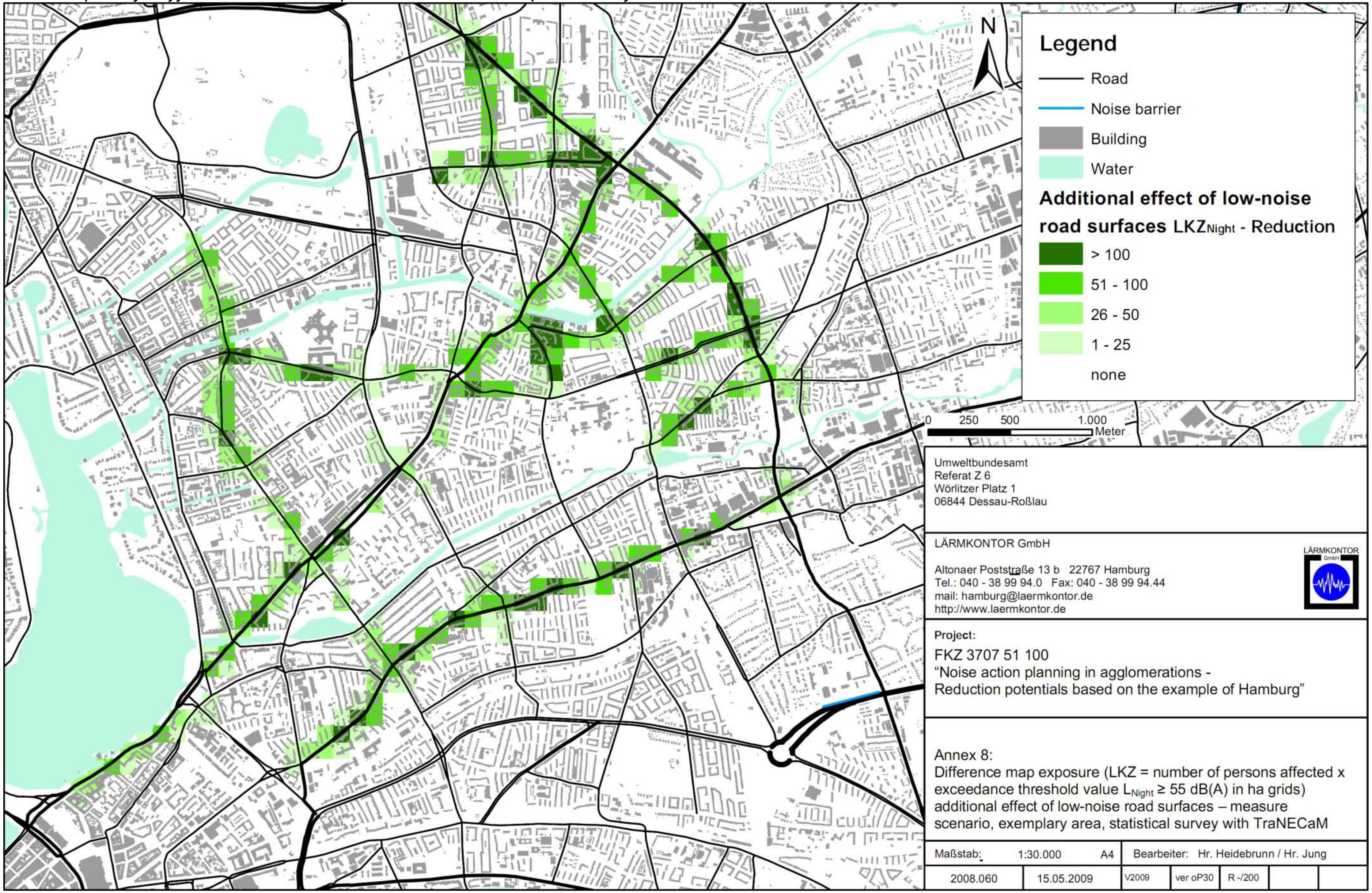
Project:
FKZ 3707 51 100
"Noise action planning in agglomerations -
Reduction potentials based on the example of Hamburg"
Annex 7:
Difference map exposure (LKZ = number of persons affected x
exceedance threshold value LNight ≥ 55 dB(A) in ha grids)
measure scenario - analysis,
exemplary area, statistical survey with TraNECaM
Maßstab: 1:30.000 A4
Bearbeiter: Hr. Heidebrunn / Hr. Jung
2008.060
15.05.2009
V2009
ver oP30
R -/200


N
Legend
Road
Noise barrier
Building
Water
Additional effect of low-noise road surfaces LKZNight - Reduction
> 100
51 - 100
26 - 50
1 - 25
none
0 250 500 1.000
Meter
Umweltbundesamt
Referat Z 6
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LÄRMKONTOR
Project:
FKZ 3707 51 100
"Noise action planning in agglomerations -
Reduction potentials based on the example of Hamburg"
Annex 8:
Difference map exposure (LKZ = number of persons affected x exceedance threshold value LNight ≥ 55 dB(A) in ha grids) additional effect of low-noise road surfaces – measure scenario, exemplary area, statistical survey with TraNECaM
Maßstab: 1:30.000 A4
Bearbeiter: Hr. Heidebrunn / Hr. Jung
2008.060
15.05.2009
V2009
ver oP30
R -/200