Risk management for transportation noise

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INTRODUCTION

Road transport, railway transport and aircraft operations are sources of substantial noise in urban areas and around airports. The noise levels due to road transport are increasing due to the growth in the number of both cars and freight vehicles. This growth trades off the technological achievements in motor and tire noise emissions. In addition, freight vehicles are less insulated. Road transport noise both in developed and developing countries makes it difficult to communicate when walking through a busy street. Noise due to railway transport stems from the friction between wheels and tracks. Railway noise sources include traction noise, rolling and squeal noise, and aerodynamic noise. Aircraft takeoffs are known to produce intense noise including vibration and rattle and the landings produce substantial noise in long flight corridors as well as when reverse thrust is applied. In general, larger and heavier aircraft produce more noise than lighter aircraft.

Environmental noise from transport is a global problem. There is a direct relationship between the level of development in a country and the degree noise impacting on its people. As a society develops, it increases its level of urbanization and industrialization and the extent of its transportation system. Each of these developments brings an increase in noise levels and related burden of disease. With no or weak intervention, the noise impact on communities will escalate (Figure 1). If governments implement only weak noise policies and regulations they will not be able to prevent a continuous increase in noise and its associated health effects.

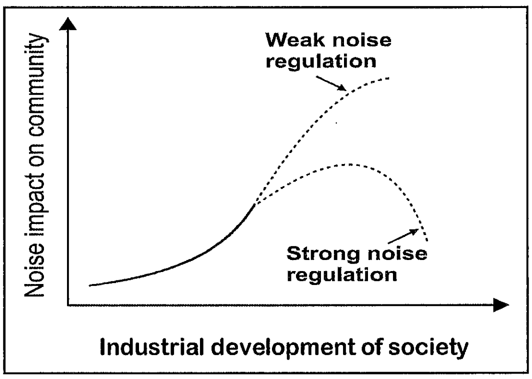

Figure 1: Relationship between noise impact and development

NOISE RISK MANAGEMENT

The goal of noise risk management is to achieve and maintain low noise exposures such that human health (including well-being) is protected. The specific objectives of noise risk management are to develop criteria for maximum permitted noise exposure levels and to promote noise assessment and control as part of environmental health programs (WHO 1999, 2009). In achieving this goal a number of environmental management principles can be applied which include the:

- precautionary principle
- polluter pays principle
- prevention principle (WHO 1999).

The foundation for transport noise risk management is the government policy framework. Without an adequate policy framework, adequate legislation and adequate implementation and enforcement it is impossible to maintain a successful noise management program. A policy framework refers to transport, energy, planning, urban and regional development, land use planning and environmental policies. The goals are more readily achieved if the interconnected government policies are compatible, and if issues, which crosscut different areas of government policy are coordinated. An example for an integrated policy framework is the Environmental Noise Directive of the European Parliament and of the Council (EU, 2002).

POLICY PROCESS AND STAGES IN NOISE MANAGEMENT

A general model for environmental noise risk management is depicted in Figure 2. The process outlined in Figure 2 can start with the development of noise standards or guidelines. Noise standards and model outputs or measurements may be considered in devising noise control tactics aimed at achieving the noise standards. Control tactics need to be enforced, and if the standards are achieved, they need continued enforcement. If the standards are not achieved after a reasonable period of time, the noise control tactics may need to be revised.

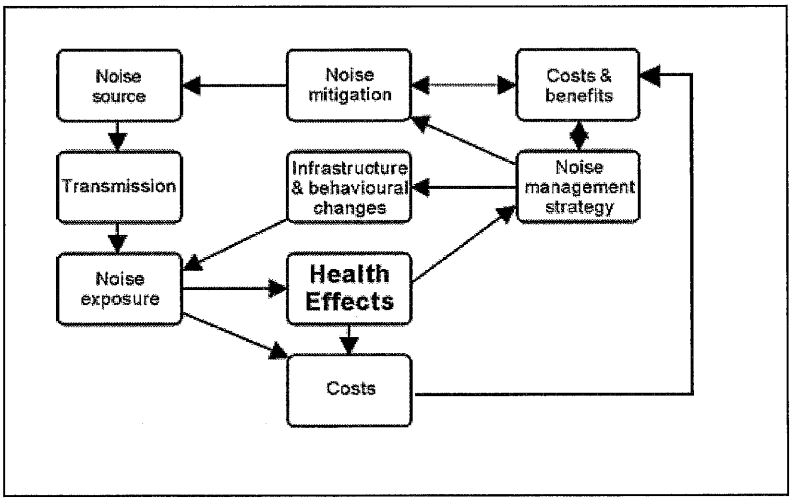

Figure 2: Model of policy process for community noise (adapted from WHO 1999)

National noise standards can usually be based on consideration of international guidelines, such as the Guidelines for Community Noise and the Night Noise Guidelines of the WHO (WHO, 1999; 2009). National criteria documents are also relevant if they base on exposure-response relations for the effects of noise on human health. National standards take into account the technological, social, economic and political factors within the country. Noise standards periodically change after reviews as conditions in a country change in the course of time, and with improved scientific understanding of the relationship between noise and the health of the population.

Figure 3 shows the various stages in the policy process and the policy player groups (stakeholders).

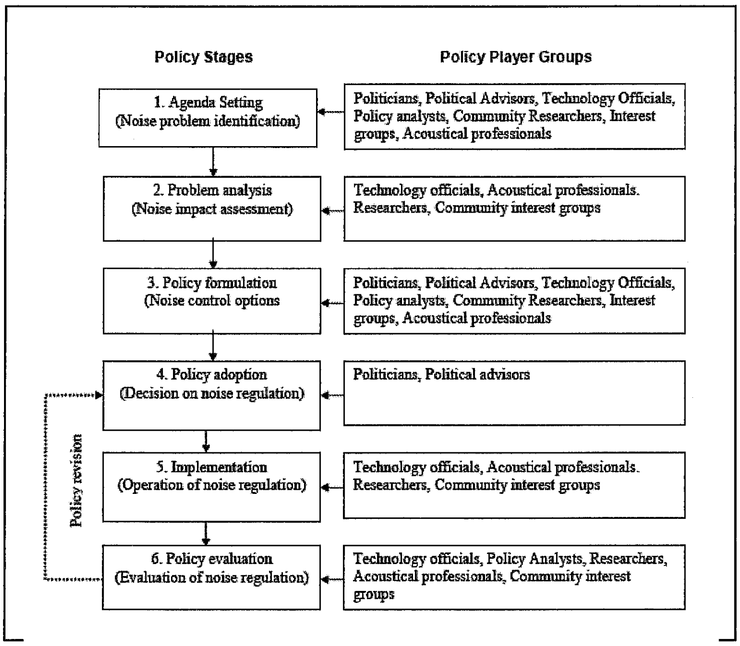

Figure 3: Policy stages and stakeholders (adapted from WHO 1999)

NOISE IMPACT ASSESSMENT

Noise impact assessment needs the assessment of noise exposure levels and the estimation of the potential impacts of noise exposure. Noise exposure monitoring can be used to assess whether noise levels at particular locations comply with the standards selected, but given the cost and need for temporal and geographical extent of monitoring, compliance has to be determined largely through noise exposure modeling and noise exposure mapping.

NOISE EXPOSURE MODELLING

Modeling is a powerful tool for the interpolation, prediction and optimization of control strategies. The accuracy of models available depends on many factors, including the accuracy of the source emissions data and details of the topography (for which a geographical information system may be used). For road noise parameters such as the number, type, the permitted speed of cars, and the type of road surface must be known. Similarly, for railway noise the number of trains per time unit, their speed, and the average length of noise events from a passing train are indispensable for noise exposure estimation. Aircraft noise parameters such as the number, type and speed of planes and the noise characteristics of takeoffs and landings must be known. Accurate forecasts of flight paths and variations in these are critical.

NOISE EXPOSURE MAPPING

A crucial component of a noise risk management is a reasonable quantitative knowledge of exposure (see Figure 2). Basic information about the exposed population is needed for noise exposure estimates from road traffic, trains and aircraft movements. These and other relevant factors can be used to calculate noise exposures, which can be used to develop and implement noise management plans and environmental impact assessments. Exposure should be mapped for all types of transport noise sources.

POLICY OPTIONS FOR SUSTAINABLE TRANSPORT AND NOISE REDUCTION

An integrated noise policy should include several control procedures: measures to limit the noise at the source; noise control within the sound transmission path, protection at the receiver's site, land use planning, education and raising public awareness. Ideally, countries should give priority to precautionary measures that prevent noise, but they must also implement measures to mitigate existing noise challenges and manage the growth of new ones. At-source measures that reduce overall emissions, traffic management and transport demand management measures are generally more cost-effective than noise exposure measures (noise barriers, building insulation) at the local level (Nijland et al. 2003; EC 2004; Larsen 2005; Ohm 2006; T&E 2011).

Mitigation measures for road traffic noise

Measures that tackle the basic sources of noise are technical measures to reduce noise emissions from vehicles, tires and road surfaces. At-source measures at the vehicle level, however, have the disadvantage that penetration of the vehicle fleet takes several years for tires and almost a decade for motor vehicles (den Boer & Schroten 2007).

Traffic management includes measures to reduce the number of vehicles on the road, measures to smoothen traffic flow by road bypasses, roundabouts and intelligent tuning of traffic lights, speed limits and nighttime bans on trucks and lorries. A smaller number of vehicles reduces not only noise but also air pollutant and greenhouse gas emissions. Less cars plying on the roads also improve road safety. Specific traffic management measures may reduce noise levels between 2 and 7 dBA (Berndtsen et al. 2005). Traffic management measures involve only limited investments and have a direct effect because they can easily be enforced. However, the costs associated with potential travel time losses may be significant.

Transport demand management can reduce the number of vehicles by promotion of public transport, encouraging cycling and walking, applying congestion charges and parking management. In order to influence travel behavior an integrated approach should be applied (SDC, 2009). Such an approach considers the future needs of a community; behavior and trip generation; opportunities to make cycling, walking and public transport the modes of choice; needs for housing, schools, health centers, employment; good urban design which maximizes sustainable transport; and stakeholder information and participation. Urban design should consider the following hierarchy; (1) Pedestrians, (2) Cyclists, (3) Public transport use, (4) Specialist service vehicles (emergency, waste, etc.), (5) Other motor traffic.

In smaller towns of up to 10,000 dwellings, the majority of journeys should be feasible on foot or by bicycle. For larger urban areas, walking and cycling may need to be implemented by public transport. Prerogatives for convenient walking and cycling include: Direct, continuous, and uninterrupted links which are not accessible to motor vehicles to shopping areas and community facilities; improved road safety by pedestrian walks, lighting etc.; secure bike storage and rental facilities.

Encouraging a reduction in car dependency is a key component of promoting sustainable transport that emits less noise, air pollutants and greenhouse gases. This can be promoted by completely, or partially, car-free sites; limitation of car spaces; charge for residential car parking; restriction of car access and parking; low car flow favouring design of roads and streets; preferential treatment for eco-friendly, low-noise cars and scooters; provision of alternative access to local taxi services, home delivery vehicles, and on-demand public transport provision; and frequent, reliable and easily accessible public transport.

If at-source measures are insufficient to comply with noise limits, noise barriers and insulation of dwellings can reduce the propagation of noise. On average, noise barriers reduce noise levels by 3-6 dBA, depending on their design and height (den Boer & Schroten 2007). Roadside noise barriers are only useful for protection of dwellings close to motorways and bypass roads in urban and non-urban areas. For dwellings located farther away from motorways and bypass roads or at higher elevations roadside noise barriers do not provide a solution.

The average cost of a noise barrier is around € 300 per m^2, depending on its construction and the materials used (den Boer & Schroten 2007).

Mitigation measures for railways noise

Possible solutions for railway noise mitigation include the lowering of radiation efficiency at wheels and rails; smooth wheels on smooth rails (optimized wheel design using damping rings, absorbers and optimized braking system – 4 -10 dBA - and track design via embedded rail systems, block and direct fastening systems - 5 dBA); rail grinding strategies (silent rail systems – 6 dBA, acoustical grinding – 10 -16 dBA); and appropriate maintenance of rails and wheels (Licitra 2006).

Mitigation measures for aircraft noise

In many countries, the noise emission of aircraft is now limited by ICAO Annex 16, Chapter 3, defining maximum permissible sound limits under certain measuring procedures (ICAO 1993). Aircraft following the norms of Chapter 3 represent the state-of-the-art of noise control of the 1970s. On 1 January 2006, a more stringent noise certification standard - Chapter 4 was introduced, for new aircraft designs. Chapter 4 aircraft are at least one third quieter than those currently certified to the Chapter 3 standard (IATA 2007).

Most developed countries determine their noise control requirements on the basis of effect-oriented and/or source-oriented principles (Gottlob 1995; Jansen 1998; ten Wolde 1998).

The use of low noise aircraft may also be encouraged by setting noise-related charges (landing charges not only related to weight and capacity but also to noise emission). Examples of systems for noise-related financial charges are given in OECD (1991; see also OECD-ECMT 1995). Nighttime aircraft movements should be discouraged where they impact on residential communities. In Europe, there is a lot of debate among stakeholders about nighttime flight bans. Governments and aircraft carriers hold that nighttime flights are necessary while nongovernmental organizations claim that in spite of technological progress to reduce the noise from individual aircrafts people still suffer from the same or higher noise levels due to the increases in number and size of starting and landing aircraft (e.g. BANG 2004). Many of the Europe's leading business centers, including Berlin, Düsseldorf, Frankfurt, Hamburg, London-Heathrow, Munich, Zürich enjoy nighttime passenger curfews of 6-8 hours (HBA 2010). Of the approximately 300 US airports listed in the Boeing airports database, 73 are listed as having night-curfews (Boeing 2010). Airports without such regulations include Amsterdam, Barcelona, Madrid, Paris-CDG, and Tokyo.

PRECAUTIONARY MEASURES

With careful planning, exposure to noise can be avoided or reduced. A sufficient distance between residential areas and an airport will make noise exposure minimal although the realization of such a situation is not possible everywhere. Additional insulation of houses can help reduce noise exposure from airports. For new buildings standards or building codes should describe the position of houses and the ground plan of houses with respect to noise sources and also the required sound insulation of the façades.

Land use planning is a main tool of noise control. The necessary tools to be given to planners (and available to communities) include the calculation methods to predict the noise impacts; noise level limits for various zones depending on the type of buildings in these zones based on real or possible health impacts; and noise maps or noise inventories showing the existing noise situation.

Education and public awareness

Noise abatement policies can only be established if basic knowledge and background material is available and people and authorities are aware of noise as an environmental hazard and the necessity to avoid and control noise. It is, therefore, necessary to include noise in school curricula and establish scientific institutes in universities and similar institutions, working on acoustic and noise control.

Evaluation of control options

Unless legal constraints in a country prescribe a particular option, the evaluation of control options must take into account technical, financial, social, and health and environmental factors, as well as the speed with which they can be implemented, and their enforceability. Although considerable improvements in noise levels have been achieved in some developed countries, the financial costs have been high, and the resource demands of some of these approaches may make them initially unsuitable for developing countries and countries in transition. Planning to avoid transportation noise challenges is the long-term cheaper option as against fixing up problems once they occur. If developing countries put off considerations of transportation noise now because of other priorities, they will forego their current opportunities, and that will cost them dearly in the future.

There needs to be confidence that selected options are technically practical. A selected option must be able to be brought into operation, and maintain the expected level of performance in the long term with the resources available. The selected options must be financially viable in the long term. This may require comparative cost-benefit assessments of options. These assessments must include not only the capital costs of making an option operational, but also the costs of maintaining the expected level of performance in the long term.

The costs and benefits of each option should be assessed for social equity in relation to the potential for effects on people's way of life, community structures and cultural traditions. These may include disruption or displacement of residents, change of land-use, impacts on community, culture, and recreation. Some impacts can be managed, or resources or replacement uses can be substituted.

The costs and benefits of each option should be assessed for health and environmental factors. This may involve use of exposure-response relations, or risk assessment techniques.

Dealing with noise risks includes the acceptance of a risk. This is a dynamic process dependent on changing knowledge, attitudes, views, technical development, and costs of both studying the problem and implementing ameliorating solutions (Babisch 2002).

CONCLUSIONS ON NOISE RISK MANAGEMENT FOR TRANSPORTATION

Noise from transport – road, rail and aircraft – can have serious impacts on human health in terms of cardiovascular effects, annoyance, sleep disturbance, cognitive effects, physiological and, particularly in developing countries, physical effects. Current transport policies often compensate increasing use of vehicles by growing road building, which leads to urban sprawl. Such policies are unsustainable. Four different routes for policy options to achieve sustainable transport with less noise (and air pollution and greenhouse gas emissions) are discussed in this paper: At-source measures, traffic management, transport demand management and measures to hamper noise propagation. The most cost-effective options are the first three, which can provide more transport sustainability. The fourth option is most expensive, only partially effective, and does not contribute to transport sustainability.

Successful noise management should be based on the fundamental principles of precaution, the polluter pays and prevention. The noise abatement strategy typically starts with the development of noise standards or guidelines, identification, mapping and modeling of noise exposures in communities. The powerful instrument of modeling must be transparent, allow scenario testing by planners and the community, and need ideally be validated by some monitoring data.

Noise control should include measures to limit the noise at the source, control within the sound transmission path, protection at the receivers' site, land use planning, education and public awareness raising. With careful planning, exposure to noise can be avoided or reduced.

The control options should be evaluated while taking into account the joint technical, financial, social, health and environmental factors of concern. Risk-cost-benefit relationships as well as the cost-effectiveness of the measures must be considered in the perspective of each country's social and financial situation.

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