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NOISE IN SINGAPORE AND A CITY NOISE STRATEGY

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1. INTRODUCTION

ERM has recently completed a 15 month, $US 250,000 study for the Singapore Government on transportation noise. Surprisingly, environmental noise is a relatively new issue in Singapore and the study has far reaching consequences for how it is addressed in the future.

Whilst it is recognised that differences between Asian cities and London will necessitate some differences in approach to noise management, many of the issues that arise are common. Furthermore, there are insights that can be gained from observing a city taking a fresh look at noise management.

This paper first gives an overview of the Singapore study, and then uses examples from its findings and from experience in Hong Kong, along with current UK national policies, to discuss the main elements of a London noise strategy.

2. SOME FINDINGS OF THE SINGAPORE STUDY

2.1 Introduction

The Singapore government set us the following main study objectives:

- to establish Singapore's 'noise profile';
- to compare the noise profile with that of similar cities;
- to review noise standards and planning guidelines;
- to review noise mitigation measures; and
- to recommend a noise abatement strategy.

The study covered the whole of Singapore, an area roughly 40 km by 20 km with a population of 4 million living mainly in high rise public housing blocks. The scope was limited to noise from expressways, major arterial roads, and from the Mass Rapid Transit (MRT) and Light Rail Transit (LRT) rail networks. Furthermore, it was only to address residential buildings fronting these transport corridors. In this way the terms of reference were intended to focus the study on the main areas of noise impacts. With hindsight it was observed that the omission of lesser roads probably meant the study missed major portions of the population's noise exposure where building set-backs were small. Also, the emphasis on quantifying railway noise proved to be unnecessary, and was probably based on a history of complaints of noise from this source, whilst the study showed light railways are a very minor source of noise exposure compared to roads.

2.2 The Noise Profile

The 'noise profile' proved to be an inspired choice of term, and required investigation of noise across the following dimensions; spatial, temporal (time of day and day of week) and vertical (up building facades). Dominant sources of peaks in road traffic noise (L_{Amax}) were also investigated.

The Ministry of Environment required the noise profile to be quantified entirely by direct noise measurement rather than by prediction. This was against ERM's recommendations, in view of European experience, primarily because a measured noise map would not allow forecasts of noise exposure under different strategy options.

The resultant noise survey required careful planning, took over two months to complete, and produced over 19,000 measurements made at two or three floor heights in 450 buildings. Most measurements were attended samples taken over 15 minute periods during the day and at night. Measurements during the day deliberately avoided peak traffic periods when noise levels could be dynamic and unpredictable. The temporal noise patterns of the various road/railway corridors surveyed were established by several days of continuous monitoring at 19 'core monitoring stations'. The relevant temporal pattern was then applied to all sampling sites along the corresponding corridor in order to estimate L_{Aeq}, day, night, peak hour etc, as required. Peak hour L_{Aeq} was of particular interest as a peak hour facade level of L_{Aeq} 67 dB is the current planning noise standard in Singapore. Various other noise metrics were recorded, including L_{Amax}, for which the observed noise sources at night were also noted for analysis with regards to sleep disturbance.

Estimates were made of the population exposed to noise at each monitoring site to allow overall population exposure to be forecast.

Some of the key findings of the noise profile survey are as follows.

- For expressways 70% of people living in buildings fronting the road have noise levels above $L_{Aeq,\ peak\ hour}$ 67 dB.
- For major arterial roads of 48% people living in buildings fronting the road have noise levels above $L_{Aeq,\ peak\ hour}$ 67 dB.
- MRT and LRT alignments generally follow main roads and their noise was not significant above road traffic noise which was above $L_{Aeq,\ peak\ hour}$ 67 dB for about 25% of people.
- Night-time $L_{Aeq,\ 2300\text{-}0700\ hours}$ noise levels were on average 6-7 dB lower than daytime $L_{Aeq,\ 0700\text{-}1900\ hours}$ and evening $L_{Aeq,\ 1900\text{-}2300\ hours}$ levels.
- The vertical noise profile is varied, but often shows the highest levels at mid-height floors.
- The sources of night-time peak noise events (L_{Amax}) are mainly motorcycles (50-60%) and heavy vehicles (30%).

The noise profile was compared with noise exposure information from Hong Kong, Taiwan Japan and other countries, but due to inconsistencies in the quantification methods it was not possible to draw meaningful results - a problem that should be overcome in Europe by harmonised methods for noise mapping.

The observed prominence of motorcycle noise events at night lead to a separate study into motorcycle noise to investigate motorcycle noise emissions standards, and ways of improving their enforcement through improved roadside and test centre noise testing.
The study's final report includes the results of numerous analyses of the noise profile data but it has been recognised that the best way to maximise the value of the data would be to view it geographically through an interactive GIS database.

The noise profile proved to be vital in setting the scene for the remainder of the study into noise abatement options. For example, it diverted our focus away from the MRT and LRT, and it highlighted the potential limitations of noise barriers.

2.3 Noise and Planning Standards

Originally, the Ministry of Environment's $L_{Aeq,\ peak\ hour}$ 67 dB noise guideline was introduced for the purpose of regulating noise emissions from the first MRT railway commissioned in the late 1980's. Since then, it has been interpreted more widely to also apply to other sources of transport noise including road traffic and LRT noise. However, as the study progressed it was noted that the enforcement of the guideline for new transport infrastructure is largely an internal governmental process. For new housing noise protection is implied by rigorously applied planning set-back distance guidelines, which, in many cases, lead to exceedances of the noise guideline.

Enforcement in Hong Kong is very different. For some years the Environmental Protection Department has been making great efforts to ensure that a very high proportion of new residential development is in compliance with the external noise planning standard. There is in fact a statutory memorandum used to determine what percentage compliance must be achieved depending on the site characteristics (increasing to 95% for sites over 9 hectares). In 1998, an additional 10,000 flats (8% of all those that received planning approval that year) were in compliance with the local planning noise standard as a direct result of the Environmental Protection Department's (EPD) enforcement at the planning stage. The Hong Kong government has a clear strategy of planning for noise which, due to the rapid pace of re-development, appears to be steadily improving the situation.

In the UK new infrastructure is subject to close public scrutiny at the planning stage that generally results in a good standard of noise control. Compliance with PPG24 guidance for new housing is taken for granted (although it does allow for flexibility in particular situations). There is little doubt that 'good noise planning' is helping to control overall population noise exposure in the UK, but as the pace of re-development is relatively slow it has historically been overwhelmed by growth in traffic.

2.4 Mitigation Options and Abatement Plans

An extensive international review of noise mitigation measures was undertaken, not only to establish their acoustic benefits but also to record their dis-benefits and the situations in which they tend to be used in city environments. The measures were split into two categories, 'direct' ie at source, and 'indirect' ie at the receiver (or on the intervening land). This distinction is commonly used to reflect the responsibilities of different parties for the different places where noise mitigation can be located.

The review considered the costs (initial and ongoing), acoustic performance, limitations, and the timeframe of implementation for various mitigation measures, including the following.

Direct measures: demand management, underground roads, noise barriers and enclosures, porous asphalt road pavements, thin surfacings, noise emission reductions.

Indirect measures : building set-back, block design (flat layout, reduced aspect etc), block screening (by non-sensitive buildings), architectural features (eg balconies, acoustics 'fins'), and noise insulation.

There appears to be wide variations in the predominance of different noise mitigation measures in different countries, even within apparently similar urban settings. For example, noise barriers are used widely used in Hong Kong (with more than 27 km built by last year), but there are no noise barriers in Singapore. Hong Kong has probably the best examples of buildings designed for noise control in the world. It also has several complete covers over roads which are not seen elsewhere. The use of quiet road surfaces also varies. Resurfacing roads with quiet road surfaces has often acceptable disadvantaged, particularly with the advent on thin surfaces which appear to offer useful noise benefit whilst largely overcoming the maintenance and cost concerns of porous asphalt. The Singapore cost-benefits study suggested that an improvement in compliance with the local noise standard of about 25% could be achieved by resurfacing roads.

Approaches to noise insulation also vary between countries, and are of particular interest to a city noise strategy because noise insulation can offer an apparently complete solution where other measures fail. Singapore is considering applying environmental noise standards indoors. This would create an incentive for architects to develop external facade features to provide local screening to window openings, and importantly, great care would be taken to ensure that noise insulation is only permitted as a means of achieving compliance as a last resort when no other measures can be sufficiently effective.

The latter stages of the Singapore study involved extensive consultation with various government departments to develop a preferred list of mitigation measures to be pursued in a future noise strategy. Some of the issues debated are discussed in the next section.

3. ELEMENTS OF A LONDON NOISE STRATEGY

3.1 Introduction

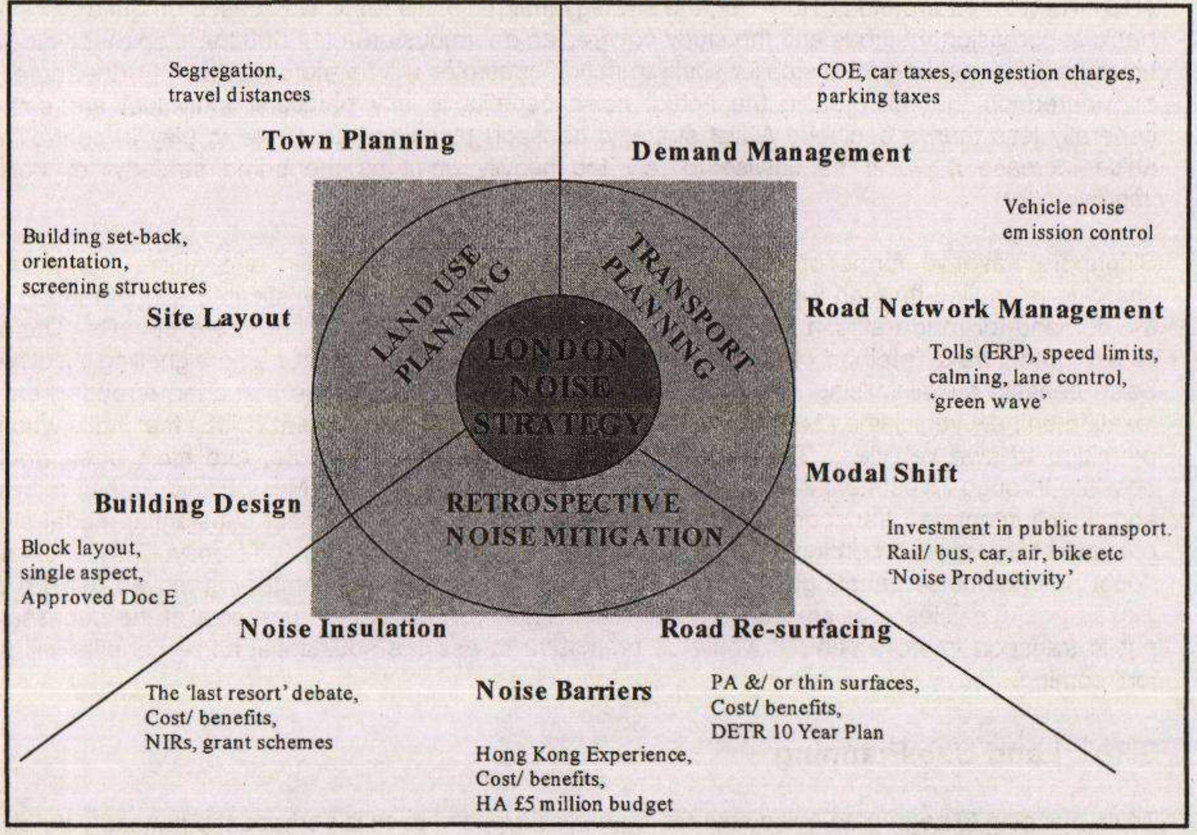
The Singapore study covered the three main steps required to formulate a city noise strategy:

- quantifying the noise profile;
- reviewing current policies and practices that effect noise control; and
- prioritising and adjusting these policies to maximise noise benefit in the future.

This section considers the final stage of the process by identifying the essential elements of a city noise strategy, and the issues surrounding their prioritisation in the case on London.

There will inevitably be many elements of a city noise strategy if all possible ways of controlling noise are to be exploited. The various elements are shown in Figure 1, and are then discussed briefly under the three categories illustrated.

Figure 1 Element of a London Noise Strategy



The appreciable reductions in vehicle noise emission levels that have been achieved through EC regulation in the past have certainly played a key role in curtailing increases in road traffic noise, and should continue to do so in the future, assuming suitable noise control technologies are available to vehicle designers. Whilst any noise strategy should be supportive of work in this area, it not a matter over which a local noise strategy has any particular control and so would not form a central part of the strategy. There may be enforcement issues to consider, such as that found in Singapore where poorly performing illegal silencers on motorcycles appear to raise the level of disturbance caused, but these are likely to be less significant in the UK.

3.2 Transport Planning

There is currently a great deal of activity in strategic transport planning in the UK, not only to improve mobility but also to improve the environment. Guidance has recently been developed to help quantify and report environmental benefits as part of the strategy development process [1 2]. There clearly are noise benefits to be had but quantifying these is a relatively new process. For example, Transport for London are currently planning a study to monitor the environmental benefits of congestion charging and the Commission for Integrated Transport are currently developing methodologies for monitoring the environmental performance of the DETR's transport 10 year plan. At a strategic level benefits to the overall population can be appreciable. For example, the Strategic Environmental Assessment of the Trans-Pennine Corridor [3] estimated that pursuing one of the more dramatic road traffic management strategies, compared to the do-minimum case, would produce a reduction in the estimated population annoyed by noise of 2,100 people, by the year 2021. The do-minimum increase in estimated population annoyed between the years 1996 and 2021 was 5,300 people, expected due to general traffic growth. It was concluded that this strategy would go some way (about 40%) to offsetting the noise impacts expected from future traffic growth across the study area over a 25 year period. However, the strategy that gave this result was based on quite extreme traffic suppression methods and the study covered an enormous area (14,000 km^2), so that typically noise benefits resulting from smaller-scale transport strategies will be more modest. Furthermore, if considered on the micro-scale the actual noise benefits to any particular individual are small, generally less than a decibel. Whilst strategic transport planning has a role to play in controlling noise increase it would be unwise to rely too heavily on it as the prime strategy for noise improvement.

Singapore has two forms of local transport planning that effect traffic and noise. Congestion charging is applied through Electronic Road Pricing (ERP), a highly sophisticated way of managing the demand for road traffic in and out of central areas, which no doubt has noise benefits. The so called 'green wave' method of smoothing traffic flows through intelligent traffic signalling also has noise benefits by minimising braking and accelerating. Demand is also managed through heavy taxation on new vehicles and a process called the Certificate Of Entitlement (COE) that limits who is permitted to own vehicles. These techniques are not new to Singapore, and have been made possible through investment in world-class public transport such as the Mass Rapid Transit railway and a well integrated transport system. There is clearly potential to effect substantial modal shift onto public transport in London if the public transport system is enhanced sufficiently. This would no doubt produce noise benefit given the greater 'noise productivity' (passenger km moved per dB) of mass transit vehicles over smaller road vehicles. However, given the huge cost of the necessary public transport improvements it would be premature to assume substantial noise benefits will be forthcoming.

3.3 Land Use Planning

Town planning to segregate noise sources from sensitive land uses is perhaps the panacea of noise mitigation, but of course is unrealistic in most urban settings. Even so, studies [4] are highlighting the benefits that can be had.

In general, useful noise benefits through adjusting site layout can only be achieved on larger sites with mixed land-uses. The best examples of this from Hong Kong are generally not applicable to London and the scope for innovation is modest so noise benefits would be small.

Building designs such as the 'reduced aspect' or 'single aspect' block can provide very effective noise mitigation but generally at the expense of reduced development efficiency. Even so, there is a place for such designs in a city noise strategy if avoiding reverting to noise insulation is given a high priority. The importance of the policy on noise insulation is discussed further below.

3.4 Retrospective Noise Mitigation

This category of noise mitigation measures is characterised by those that are applied specifically for noise control purposes, and provide immediate results. Despite the inherent disadvantages of applying noise mitigation retrospectively, there will always be a place for them in a noise strategy that demands results in a short timeframe.

The costs, benefits and limitations of noise barriers are well known in this country and they are widely used in open road situations and on urban railways. In Hong Kong a 6 year study has recently been completed that forms one of the most comprehensive investigations into the use of noise barriers in urban areas. Despite the extent of the study only 29 roads have been identified for retrospective noise barriers/semi-enclosures to target the $L_{A10\ peak\ hour}$ 70 dB planning standard. A budget of HK$ 2,340 million (approx £200 million) has been approved to benefit 24,000 dwellings (approx 1.5% of the population). This conclusion should be viewed in the context of a city in which very large noise barriers have been used for some years. The use of noise barriers on urban roads in London is therefore likely to have a limited role to play in a noise strategy, but nonetheless should not be ruled out for particular cases, for example elevated roads where structural problems can be overcome.

All noise mitigation measures have dis-benefits, but those associated with noise insulation are perhaps the most apparent to the noise receiver. Noise insulation has attractive advantages as a mitigation measure in that it can offer benefit in a very quick time-scale, and it is relatively cheap. In the UK our Noise Insulation Regulations have set a firm precedent that we no longer question, by establishing noise levels above which the inconvenience of noise insulation can be outweighed by the benefit of noise protection. In hotter climates this balance is less obvious because the value attached to an 'open window lifestyle' is greater, even in a polluted city environment. Also, the lack of protection to gardens is a short-coming of noise insulation that is sometimes over-looked in this country. The disadvantages of many noise mitigation measures in urban setting such as London are often prohibitive, particularly if they are to be considered retrospectively, so if we are serious about substantially improving population noise exposure in our cities, we may be forced into considering noise insulation at levels below those in the Noise Insulation Regulations or in situations outside those prescribed by the Regulations. But, are people exposed to such levels prepared to forfeit their open window lifestyle to gain peace and quiet within their homes ?

The resurfacing of roads with the new generation of 'thin surfaces' offers one of the most advantageous methods of retrospective noise control. Indeed the DETR's transport 10 year plan recognises their value by advocating that 60% of trunk roads are resurfaced to benefit 3 million people. The benefits of resurfacing London's roads should not be overlooked. In cities traffic speeds are lower, so noise reductions tend to be lower, but the high density of population means that great improvements in population noise exposure are possible, and at minimal costs if timed to coincide with routine resurfacing. The Highways Agency has been tracking the performance of various new thin surfacings for some years, but there may be further work to do in monitoring their performance in urban settings, in order to help judge what priory should be given to this measure compared to others.

4. CONCLUSIONS

A noise strategy for London will comprise several elements, many overlapping with transport planning and land use planning policies, and some aimed only at noise control which will require new funding. The overlaps with other London strategies are substantial, and if these policies are to be influenced so as to maximise the overall noise benefits achieved, a clear prioritisation of the available noise mitigation measures will be essential. This paper has identified some of the most promising mitigation measures and has discussed the main characteristics of each that will determine their relative priorities within the strategy. The most promising measures are likely to include:

- resurfacing roads with quiet road surfaces;
- traffic demand and network management; and
- noise insulation.

Other measures will have lesser roles to play. Further research on the performance of thin surfacings in urban settings may be required to help set the relative priority for this measure. The true noise benefits of traffic management are currently unknown but work is already in progress to investigate this in the London context. It may be necessary to re-think our existing policies on noise insulation.

Important policy decisions are required on the timeframe over which noise benefits are to be delivered, on the scale of the noise benefits that are expected, and the budgets that are to be made available. The question of the suitability of noise insulation as a retrospective noise mitigation measure is likely to come to the fore as a key issue if an ambitious amount of noise protection is required in a rapid timeframe. If this is the case, an important piece of social research will be needed to investigate at what noise levels, and in what situations, residents would like noise insulation.

Most of the key elements of a comprehensive noise strategy for London are already in place in some form or other. The challenge in developing the strategy is to establish appropriate priorities to each element so that the strategy delivers the greatest noise benefit, over the preferred timeframe, within the given budget and policy constraints.

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