Acoustic Objectives for Designed or Managed Soundscapes

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Abstract
This paper describes acoustic objectives for designed and managed soundscapes, and suggests that these be called "Proposed Acoustic Environments". These acoustic objectives need to be defined on the basis of the information content of the sound, not, as is dominant in conventional noise abatement and control assessments, on the level of the sound. Starting with acoustic objectives specified in this way, there is a logical design process that can be followed that requires separate analysis and assessment of the wanted and unwanted sounds at a site and their appropriate management. Such an approach is essential if soundscape planning is to bridge a major communicational divide that currently exists between the concepts of acoustic ecology and the large body of knowledge and practice represented by conventional noise management.

Introduction

Various authors clearly link soundscape to physical planning and design activities. For example, Böhme (2000) argues that, *" ...city planning can no longer be content with noise control and abatement, but must pay attention to the character of the acoustic atmosphere of squares, pedestrian zones, of whole cities"*, and others (Anon, 1988) advocate that;

- *"Urban and landscape architects should take auditory perception into account. The perceptions of all senses should be dealt with to the same degree and the visual should not be favoured ... .*
- *Urban and landscape planners and designers should create sonic environments which form part of their context over both time and space. … (for example, the sounds of water, wind, songbirds and the human body).*
- *Design tools dealing with auditory aspects should be developed to fit into the process of urban and landscape planning and design ... ."*

This paper provides examples of such a design tool. It suggests an approach to fit acoustic design into urban and landscape planning and design.

While there is a growing interest in, and literature about, soundscapes, much of it has been high in vision—but rather short in means for implementation. This paper attempts to break some new ground, the need for which has been noted by Cusack (2000), *"Where is all the critical debate, lively disagreement, alternative theory, polemic even, which one could expect if ideas are moving forward and breaking new ground? Am I alone in missing this? The basic tenets of soundscape thought, ground-breaking as they were in the 1970s, seem these days to be more often repeated than refined."* It lays the foundations of a pragmatic approach for planners, landscape architects, engineers, acousticians and others involved in the planning and design of the built environment, and for managers of rural, natural and recreational landscapes. The approach is also relevant to those interested in public installations that may have an acoustic component (see, for example, Australian Sound Design Project, 2001).

Appropriate Acoustic Objectives for Designed and Managed Soundscapes

What acoustic experience does the designer propose for users of the space? Putting aside the important issue of the diversity of preferences that will exist amongst different individuals and groups of people (for visual, acoustic, or any other dimension of a place) what guidance exists regarding specification of acoustic objectives for outdoor environments?

Investigation of appropriate proposed acoustic environments outdoors has had little attention from the scientific community to date, primarily because of the over-riding emphasis in acoustic research on environmental noise. For example, there is copious data collected over decades on *What noises do you hear around here?* or *What noises annoy you the most?* (even as long ago as 1929 in New York (Noise Abatement Commission, 1930) but very little on *What sounds do you enjoy/prefer to hear in this place?* A study in Yokohama (Tamura, 2002) is an exception, reporting not only sounds (outdoor sounds heard indoors) that were observed by and were annoying to residents, but also sounds that they found favourable. Sounds regarded as favourable included the twittering of birds and sounds of insects and frogs, the sounds of festivals and fireworks, wind movement in trees and grasses, wind chimes, bells of temples and churches, whistles of ships and the sounds of streams and sea waves. Favoured sounds were mainly natural sounds and some specific cultural sounds, and distinct from sounds that they did not prefer. The latter were so-called daily life sounds (garbage collection, neighbours' sounds etc.) and sounds from traffic. Sasaki (1993) also sought to measure opinions on outdoor sounds that people preferred in urban areas, with somewhat similar results. While his methodology had significant limitations, including relying on surveying respondents away from the context of their own homes, his results are a salutary reminder of the diversity of opinion that will always exist. They show that, for any particular sound, individual responses were widely distributed across the like/dislike scale though the modal response shifted markedly between different sounds. Sasaki went beyond his survey results to proffer the opinion that, in soundscape design, proposed acoustic environments should not be loud, have good tonal qualities, emit sounds at appropriate times and for a suitable duration, match with surroundings and be acceptable to residents of the neighbourhood. He also suggested an important role for quiet.

Other scientific investigations into perceived quality of soundscapes include that reported by Berglund *et al* (2001) and Berglund and Nilsson (2002). Their work, in residential areas, is directed towards new tools to measure the way people perceive soundscapes, including sound-source identification, quantification of loudness, and attribute profiling of sound quality. Some of their field results suggest labelling soundscapes in residential areas in four ways: adverse, reposing, affective (inducing feelings or emotions) and expressionless. There is also interest in Sweden (Anon 2001) with respect to how preferred soundscapes (particularly access to quiet in courtyards) can be supportive of health and well-being. Carles *et al* (1999) conclude that further research into soundscape preferences is required, after reporting the results of their laboratory study of the interaction between visual and acoustic stimuli on perception of the pleasantness of environment. Using images and sounds covering natural and semi-natural scenes and urban green spaces, they concluded that natural sounds, particularly of water, create positive feelings towards the landscape, but they also reported the importance of sound-image congruence in shaping environmental preference. In certain environments any acoustic disturbance can lead to a rapid deterioration in environmental quality, but natural sounds may improve the quality of built-up environments to some extent.

While these research results are in no way counter-intuitive, to date they still provide little or no guidance to any prospective designer/manager of outdoor space as to appropriate acoustic objectives. How then is a designer to set acoustic objectives? Borrowing limits used in noise control, based largely on minimising adverse human response, is not appropriate. Where 'quiet' is the intent, conventional acoustic measurements could be used to describe the objective, but even then, say in the management of a wilderness area, both the notion and measurement of quiet are problematical.

The solution is to depart radically from the nature of most acoustic criteria used in practice and to set acoustic objectives for soundscape design by the *information content* of the sounds. We postulate, in Table 1, acoustic objectives of this sort for different outdoor spaces. The list, indicative not necessarily comprehensive, is a personal list, based on experiences and intuition, but it is suggested that is does embody much of the observation, opinion, and commentary found in the soundscape literature to date, and in the limited research regarding human acoustic preference. Most of the objectives in Table 1 are related to natural sounds, particularly the sounds generated by wind, by waves or running water, or by animals; or to ensuring human sounds predominate over mechanical or amplified sounds. They also represent soundscapes that are good communication environments for speech or music or that ensure that the geographical or cultural identity of a place is enhanced. In some cases they relate to "quiet", but in other they may relate to high activity, or "noisiness".

TABLE 1:
Acoustic objectives for outdoor spaces

a	Moving water should be the *dominant* sound heard.
b	A particular (iconic) sound should be clearly audible over some area.
c	Hear, *mostly*, (non-mechanical, non-amplified) sounds made by people.
d	*Not* be able to hear the sounds of people.
e	The sounds of nature should be the *dominant* sound heard.
f	*Only* the sounds of nature should be heard.
g	Suitable to hear *unamplified* speech (or music).
h	Suitable to hear *amplified* speech (or music).
i	Acoustic sculpture/installation sounds should be clearly *audible*.
j	Sounds conveying a city's vitality should be the *dominant* sounds heard.
k	Sounds that convey the identity of place should be the *dominant* sounds heard.

This list should cover the majority of outdoor spaces where acoustic design or management is appropriate. It includes, for example, objectives for urban spaces where one may wish to provide respite from the sounds of traffic (c,g), for parks or gardens that include water structures or specific acoustic installations (a,d,i), for spaces that are intended for speech or musical communication (g,h), for amenity in pedestrianised areas of both old and new cities and villages (c,g), and for wilderness (d,f) and outdoor recreational areas (e). Other objectives related to identity of place (b,j,k) may be appropriate in cities or rural areas, say for the pealing of a bell, the call to prayer from a mosque, the lowing of cattle or the tinkling of sheep bells. In addition to providing a starting point for designers and managers to use in practice, Table 1 is intended to encourage debate, suggested additions, and further research to test, and modify, its robustness. It is suggested that the acoustic objectives of this type be referred to in the design or management process as the *Proposed Acoustic Environment* for a particular place and context.

Listing such objectives is not a trivial exercise. Unless designers clarify the specific acoustic objective for a particular space, time and context, in the way suggested in Table 1, then the potential to convert the objective to quantifiable acoustic parameters that can be measured and predicted will not be possible. The approach is a response to Böhme's comment (2000) *"... it is a matter of overcoming the narrow natural science based approach which remains at best capable of grasping noise as a function of decibels, and to ask instead what type of acoustic character the spaces in which we live should have"*. The use of Proposed Acoustic Environments is necessary to overcome the legacy of decades of noise control approaches where, if any criteria have been specified at all for the acoustics of outdoor space, they have been unidimensional limits regarding the level, or loudness, of all sounds present, and likely set to limit adverse human reaction.

It needs to be recognised that the acoustic objectives in Table 1, while the essence of simplicity in their intent, are actually statements about quite complex acoustic outcomes that include, at least, *two components of sound* within the space— t*he waned signals* and the *unwanted signals*. All the statements recognise that these two sound components are present, specifying the sound that we want (or in some cases the sounds that we do not want) but implicitly recognising that other sounds will also be present. The statements also indicate the proposed relationship between the wanted and unwanted signals that the designer will have to achieve.

The context obviously dictates whether a sound is wanted or not wanted, and in different contexts the same sound may be one or the other. For example, in a pedestrian mall, the Proposed Acoustic Environment may be: *hear (non-mechanical, non-amplified) sounds made by people.* The sounds of voices and footsteps are wanted, but amplified music and traffic noise would be unwanted, and the design would ensure that the former were not masked by the latter. By contrast, in a space intended for contemplation or reflection, the Proposed Acoustic Environment may be: *not be able to hear the sounds of people.* Here the sounds of voices and footsteps would be unwanted, and the design would aim to ensure either that voices or footsteps were not present or that these were masked by some other acceptable sound.

Most acoustic descriptors common in noise management have no interest in, and make no recognition of, the *information content* in the sound. They measure the overall level and loudness of all the sound present at a specific location. Noise scales that rely on concepts such as equivalent continuous sound level (L_{eq} and L_{den}) simply integrate all the sound signals present, irrespective of their source. Scales based on exceedance levels (such as L_{10} and L_{90}) are equally non-discriminatory with respect to different sound sources. While microphones faithfully transduce, and tapes faithfully record, the sounds that are present, immediately these signals are processed through most noise measurement equipment used for assessment (sound level meters, *level* recorders, and noise level analysers—all of which are interested only in the level of the sound) all source discrimination is lost. Berglund and Nilsson (2002) have previously commented on the inappropriateness of conventional noise measurements for soundscape planning. They noted that unwanted sounds, discerned amongst other sounds, may be what people do not like about certain soundscapes, even though the contribution of the unwanted sounds to overall loudness or sound level, as assessed by conventional noise measurements, may be negligible.

An Approach to Acoustic Design

With these principles in mind, it is appropriate to suggest a design approach (Figure 1) for soundscape planning and management, equally applicable for urban or non-urban areas, and independent of the scale of the planning/management activity. The steps in Figure 1 are self-explanatory. The *wanted* and the *unwanted* sounds have to be identified in each situation. Each has to be measured/predicted or otherwise estimated, and then managed separately. Examples below demonstrate these principles.

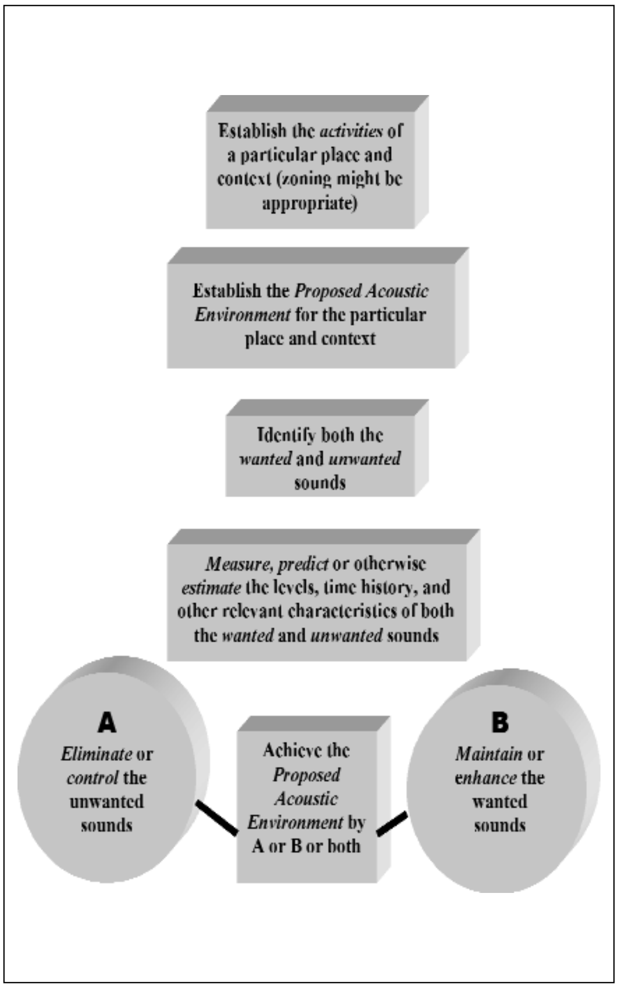

Figure 1. An approach to the acoustic design of outdoor space

An Urban Example

Figure 2 shows a small urban square that has (or in which is planned) a water structure. This is located, typical of most urban areas, in the proximity of a roadway. The example can be used to demonstrate at least three hypothetical acoustic design scenarios.

(a) The first scenario is the intent to create a pleasant place in an inner city area in which users may have some respite from city noises. This intended "activity" suggests a Proposed Acoustic Environment of: *moving water should be the dominant sound heard.* The wanted sounds can be identified as the sound from the water structure. Similarly the unwanted sound is that from the traffic. Achieving the objective requires that, by and large, the sound of water must mask the sound of traffic. Measurement and/or estimation of the relative levels, time histories and other characteristics of the two sounds is required, and measures put in place for either the reduction in the level of road traffic to ensure it remains masked, or to increase the levels of the sound emitted from the water structure to achieve the same end. What should actually be implemented depends on the context of the place, technical possibilities, and funding available. But what the approach described in this paper does, is to make absolutely clear what the objective is, and then breaks down a complex situation into a series of specific technical tasks which the planners, the acousticians, the traffic engineers and others involved can subsequently tackle: proposing and evaluating different solutions until one that achieves the objective—of the sound of water dominating—is identified.

(b) The second scenario could be a quite different intent, but in the same situation as described by the diagram in Figure 2. The intent now may be to create a place in which the people under the trees can communicate easily—perhaps the plan is to place park benches, or street theatre, there. This intended "activity" suggests a Proposed Acoustic Environment of: *suitable to hear unamplified speech.* (Note that one could even specify the likely distance between speaker and listener as part of this objective). Now the wanted sounds can be identified as the sounds of speech, and the "unwanted" sounds being from both the water structure and traffic. Achieving this objective requires that, by and large, the sounds of water and traffic must *not* mask the sounds of speech. Again, measurement and/or estimation of the relative levels, time histories and other characteristics of the three sounds is required, and measures put in place to ensure that speech sounds are not masked by the unwanted sounds. In this situation, once more, the approach has broken down the complex situation to one that is tractable for a design team, and from which a potential design solution can emerge.

(c) The same diagram provides the opportunity to consider even a third scenario to illustrate the utility of this acoustic design approach. It could be reasonable for a designer to have concerns that a visually impaired person, or a child, on the footpath between the water structure and the roadway might be in danger if the warning signals of the presence of traffic were to be masked by the sounds of the water structure. Here the "activity" is negotiating traffic, and the appropriate Proposed Acoustic Objective may be: *warning sounds of approaching traffic should be clearly heard* (this is not in Table 1 because it is an objective for safety rather than an objective for human enjoyment). The "wanted" sounds in this case are the sounds of passing vehicles, and the "unwanted" sounds are those of the water structure. Design solutions would have to ensure that the water structure sounds did not completely mask the sounds of approaching vehicles.

A Wilderness Example

The same design approach is also illustrated by an example from the literature, but in a completely different context. The US

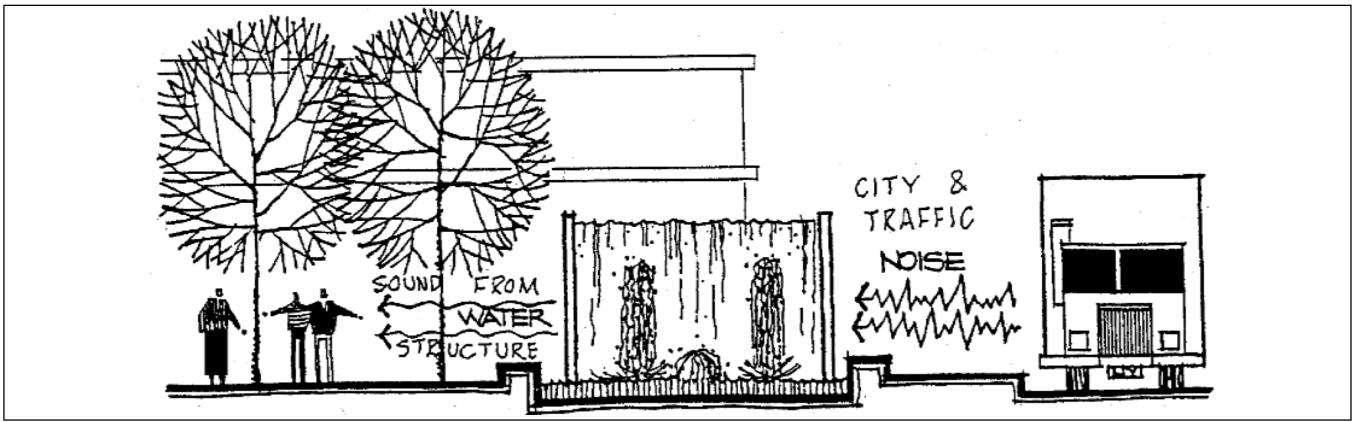

Figure 2. A hypothetical urban design context (diagram modified from Booth (1983))

National Park Service reported their initial steps in the development of a Soundscape Management Plan for Biscayne National Park (United States National Park Service, 2000). In this park the planners clearly recognised that sound was a resource—*"Preservation and restoration of diminishing natural sound environments or soundscapes has become a foremost challenge in the protection of park resources" and "Natural sounds are part of the special places we preserve. Rustling winds in canyons and the rush of waters in the rivers are the heartbeat and breath of some of our most valuable resources"*. While they did not use this author's terminology, in the first place they identified Proposed Acoustic Objectives for the intended activities of the park—*"the ability to hear clearly the quieter intermittent sounds of nature, for extended periods of time."* This is identical to Objective (e) in Table 1. They also recognised that this may not be the appropriate objective over the entire park and used a zoning scheme to accommodate different types of activities with different soundscape possibilities. For example, the visitor centre was zoned differently to the hiking trails in terms of acoustic objectives. Secondly, they noted that the sounds needed to be separated into the wanted sounds (*natural ambient sounds* or, in some zones, *the sounds that reflect Biscayne National Park's marine heritage* such as those of small motor vessels or of a yacht's sails flapping) and the unwanted sounds (*noises of civilization and technological conveniences,* such as vehicles or rangers' mobile radio sets). Thirdly, they identified that the objectives would be achieved through appropriate management of these different sounds to achieve the design objective, rather than relying on setting some overall measure of acoustic level as the design objective.

Time Varying Characteristics of Both Wanted and Unwanted Sounds

Achieving the Proposed Acoustic Objectives requires comparing the levels and other acoustic characteristics of the *wanted sounds* and the *unwanted sounds* and, where appropriate, managing either the wanted or unwanted sounds, or both. Most of the Proposed Acoustic Environments require that *wanted sounds* will not be masked by the *unwanted sounds* (or in some cases this is more appropriately described as ensuring that the wanted sounds will mask the unwanted sounds). Masking is a complex phenomenon determined not only by the relative levels of the masking and masked sounds, but by the frequencies present in both—see, for example, Jones and Chapman (1984)—particularly the tonal or broadband nature of the two sounds.

Most sounds that one will encounter in outdoor acoustic design, both the wanted and unwanted sounds, are time varying. Assessment of the masking of one sound by another will have to take the temporal patterns of both into account. For example, where masking of unwanted traffic noise is required, masking of the troughs of the road traffic noise may be possible but masking of the peaks may not be. The difference between the troughs and peaks of road traffic can be quite variable—only a few decibels if the source of road traffic noise is distant, but 10 or 15 dB if the source of road traffic noise is close to the design site. Figure 3 illustrates the nature of the likely time-history of unwanted traffic sounds in the examples of Figure 2 depending on whether the road traffic source is close to the site in question, as in a roadside setting for the water structure, or distant, as in a mall setting.

Schafer (1977) had introduced the terms *hi-fi* and *lo-fi* to describe different soundscapes but, for practical design, it is necessary to develop this concept further. The reality is that each of the wanted and unwanted sounds may, by themselves, be hi-fi or lo-fi. For example, hi-fi speech may be masked by traffic noise that can be either hi-fi traffic noise or lo-fi traffic noise[1] , depending on the context as shown in Figure 3. By contrast, in another context, the lo-fi sounds of a water structure may be the wanted sounds, and required to mask either hi-fi or lo-fi types of road traffic noise. Understanding this complexity is all part of the requirement for an adequate assessment of the acoustic characteristics of both the wanted and unwanted sounds. Assessing the masking of one sound by another where one, or both, are highly variable (hi-fi) is an inexact science. The Proposed Acoustic Environments in Table 1 have included modifiers such as 'the *dominant* sound heard' or 'the *only* sound heard' in their definitions to provide guidance in this assessment where the masking will not be continuous and complete, but only parts of the unwanted sound will be masked.

Conclusions

Acoustic design of outdoor space needs new tools and ideas if the visions so often described in the acoustic ecology literature are to have more widespread application. One of the major impediments to wider implementation is the gap in concepts, thought processes and skills between the soundscape approaches and the conventional environmental noise management approaches. The latter is, by far, the paradigm that dominates most acoustic discourse and action amongst those who are in a position to promote, influence and design our urban environments and manage our rural and wilderness areas. The approach suggested in this paper is intended as far more than a design tool—as important as that is in its own right—and more a bridge between these currently disparate fields. Its further development and trial may help to convert, then harness, the large body of people, knowledge, tools and energy that resides in both the *environmental noise* and *design* professional areas to *soundscape* design.

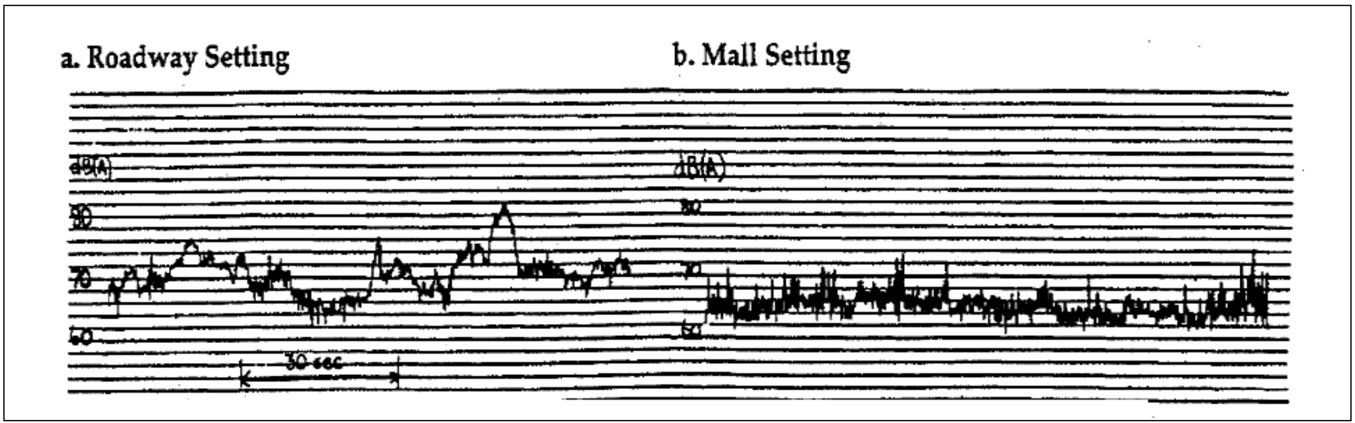

Figure 3. Typical examples of the time histories of levels of road traffic noise depending on whether the traffic noise source is close (a) or distant (b) from the site of interest (from Brown and Rutherford (1994)).

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Footnote:

1. In many situations, road traffic noise has a high "signal-to-noise" ratio, in which the "signals" of individual vehicles stand out remarkably from the "noise" of the stream of traffic as a whole. These individual vehicle signals are not at all "crowded" or "masked". These situations occur on lower volume roadways, or close to major roadways, particularly where there might be trucks in the traffic stream. It is a mistake to think of all traffic noise as being the same—and usually thought of as all lo-fi. Figure 2 is an attempt to illustrate this, showing a hi-fi traffic noise signal (a) and a lo-fi traffic noise signal (b).

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