About noise metrics and acoustic impacts

Michel Maurin

INRETS-LTE, case 24, 69 675 Bron cedex France, maurin@inrets.fr

Introduction

Nowadays, in the field of acoustics, it is usual and even thought good form to underline and even gibe at the multitude of indexes and noise metrics [2, 3, 6, 7, 8]. This paper attempts to understand the reasons for trying, perhaps sometime in the future, to refocus noise metrics through improved knowledge of the situation.

The impact of the nuisances and their indicators

To achieve the above, it is useful to go outside the context of noise alone and approach the general aspect of nuisances and their impact. When taking such a global approach, analysis is done by using a morphological grid of impact indicators that explains the main families of data and the major steps involved in building these indicators. Consequently, in such a wide area of study we must use at the outset source magnitudes (of nuisances), target magnitudes (that are affected by the nuisances) and impact magnitudes.

Among the main steps of construction, besides the preliminary conditioning of the input data one usually encounters in varying degrees a step for transforming source magnitudes into impact magnitudes, the crossing of source magnitudes and impact magnitudes with target magnitudes, and the possible aggregation of mono-nuisance indicators [4].

Source magnitudes are essentially physicochemical (or geometric or biological) magnitudes that change the environment and are measured according to metrics, most of which are standardised. The targets are the parts or components of the environment that suffer from nuisances; in other words they are populations exposed to nuisances. Naturally, these populations are human, though populations of fauna and flora and other specific sub-populations have to be taken into account too. All these populations are objective, measurable and countable.

The impact magnitudes are the results of the effects of a source on a target (for example, its response). They can be subjective or factual and require prior thematic definition, for example on excess mortality due to air pollution, a specific acoustic nuisance, etc.

The transformation between source and impact magnitudes is the step that consists in expressing the way in which the chosen impact changes as a function of its exposure to the source [5]. It is a subject of research for each source/impact pair about which a college of acoustic engineers has said "*a major effort*" is required [1], (figure 1 left side), "*A major effort ... directed toward finding a relationship between noise exposure metrics and a measure of activity interference (...) or annoyance ...*".

A diagnostic of the situation in acoustics

Physically, the origin of acoustic nuisances (the source) is excess sound pressure, and many acoustic indexes and other noise metrics now exist that provide magnitudes for measuring these phenomena. Their number has increased through time, the situation has become more complex and it is approached by using the grid of indicators mentioned above:

It should be noted that at the outset in acoustics use was made of a notion that had its heyday in defining the metre (but also the old inch, span, the french "coudée", etc.), though it was not really necessary. This was the notion of metrics that used the human being as reference, using for example the reference pressure $p_0 = 2\ 10^{-5}$ pa and also different classical spectral weighting curves to take into account the sensitivity of the human ear as a function of frequencies (which, moreover, compete with each other).

Carrying on from this initial momentum, a "natural" and continued shift occurred that resulted in creating confusion between "human based reference" for metrics and "human response" for the impact, for example, **perceived** noise dB, **prefered** speech interference level, and other magnitudes such as the fittingly-named **noy**.

By using the human being, this approach undoubtedly wishes to better take account of the description of its effects (on a specific target), but by doing so we create an amalgam between the two magnitudes of source and target, with two consequences thrown in.

The first is to take away the importance of the distinction between the two families of source and impact magnitudes and the transformation that links them. But on the other hand there is little hesitation in cultivating this illogicism, since this step subsists in fact and studies that continue to formulate "dose-response" curves, a task considered in acoustics as deserving "a major effort", as recalled above [1].

The second here concerns noise metrics. This is the unfortunate amalgam that leads to the introduction of as many metrological references as responses, each dealt with specifically (according to a "local" viewpoint), and which lead to a considerable number of noise metrics that have been developed individually with the particularity of each effect, figure 1, right hand side.

Elements for discussion

One might also imagine that the perseverance required by the effort made regarding the correspondences between source and impact entails the implicit recognition of the fact that metrics developed for each occasion is not really satisfactory. However, in this case, since observation shows that new metrics are conserved, then another rather irrational behaviour must be responsible. Moreover, since these metrics cannot act as equivalents in their role as descriptors of a sound phenomenon, we are obliged (on the sidelines) to make up for this shortcoming with statistical approximations [2].

Whatever the case, the profusion and Babel-like disarray evident in noise metrics due to the confusion between response and reference in acoustics leads to a situation in which the management of noise magnitudes cannot be free from logical errors. This entails placing a heavy burden on an inclination (forcing the objective description of a physical phenomenon on a specific effect). It is easy to imagine that this was initially inspired by good intentions, a "collection" of good intentions mutually unaware of each other, though on closer inspection it has shown itself harmful to the unity of a physical discipline as well as the coherence of its structure, especially since multi-exposure situations are increasing in the environment. One can only take a very circumspect stance vis-à-vis this unwelcome confusion and its possible justifications.

These considerations stem from a wider view of nuisances and impacts and shed light on the current state of the world of acoustics and physics related to man from another angle, and may explain one of its (currently recognised) problems.

Furthermore, although the need to refocus noise metrics is apparent, it can be useful to refer to an analysis grid such as this, and eventually reach agreement on a voluntarily limited number of metrics for studying each response and impact with a specific and particular source-impact transformation. This is an undoubtedly more stable, coherent and satisfactory solution than that of proposing new metrics for every occasion.

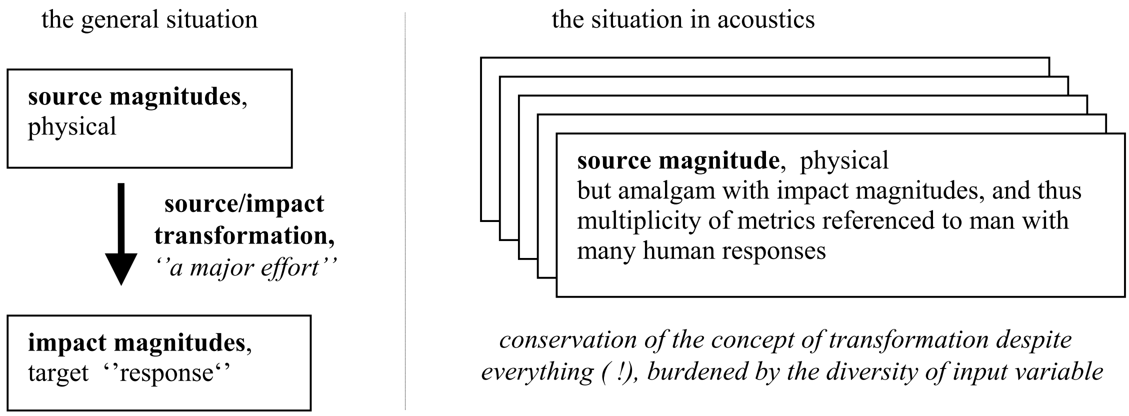

figure 1: from source magnitude to impact magnitude
left side: the general grid of nuisances, right side: the acoustic shift and situation

References

[1] Federal interagency committee on noise (FICON), 1992, Federal agency review of selected airport noise analysis issues, Hegland J., Dickerson W., Danforth R..
[2] Liénard P., 1978, Décibels et indices de bruit, Masson.
[3] Maurin M., 2002, Les indicateurs d'impact autour des aéroports, Journée spécialisée sur la réduction des bruits des avions commerciaux, Lyon décembre 2002, Les collections de l'INRETS n° 88, 151-170.
[4] Maurin M., 2003 a, Une conception structurelle des indicateurs pour l'impact des nuisances sur l'environnement, 1er Colloque Environnement & Transports, 246-251, Avignon.
[5] Maurin M., 2003 b, Réflexions à propos des relations numériques entre le bruit des transports et la gêne exprimée, RTS n° 78, 63-77.
[6] Smith M.J.T., 1990, Do we really need 57 ways of rating aircraft noise ?, Internoise 90, 467-470.
[7] Vallet M., 1996, Caractéristiques et indicateurs de la gêne due au bruit des avions, Synthèse INRETS n° 29.
[8] van den Berg M., 1999, Position paper on EU noise indicators, EC DG-XI.