

CHARACTERISATION OF THE URBAN SOUND ENVIRONMENT BASED ON PSYCHO-ACOUSTIC CRITERIA

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ABSTRACT To have a most complete characterisation of urban sound environments it is necessary to take other criteria than the L_{eq} , which is only based on the energy approach. We made a choice for the so called psycho-acoustic criteria like loudness, roughness, the fluctuation strength or the sharpness,..... A first comparative study of which some results are given here, shows the newly acquired acoustic quality information on urban spaces in relationship with the areas' morphology. Particularly the composition of the façade and its cornice outline are taking into account by the measurement of the architectural elements with a portable photogrammetric system.

THE MEASURED SITES

The study here presented has been carried out in the framework of more general research ("Listening to a city") on the qualification of transport noise in the urban environment. The study aims to establish significant indicators of the sound environment which are more relevant than the L_{aeq} [1].

The research process [2] is based on the comparison of the measured data with the results of a survey among the residents of the different areas where we did acoustic measurements. The chosen sites are situated along a route that corresponds with the tramway circuit under construction in Bordeaux ; they present varied urban forms (canyon's streets , wide and narrow, open tissue,....) but a great uniformity in façade material.

The choice of the studied spaces is based on the fact that on the one hand, the different sites present these specific urban forms, and, on the other hand, that the passing of the tramway will noticeably modify the traffic in these places. The studied route starts at the right Garonne riverbank at the level of the Galin relay car park, follows the Avenue Thiers to the Pont de Pierre, crosses the river (line A) and goes down the Quays to the Quinconces esplanade (line C). From this point it goes up to the Comédie Square and it takes the Cours de l'Intendance, the Rue Vital-Carles (line B) goes around the Place Pey-Berland, and joins the Quays by the Cours d'Alsace-

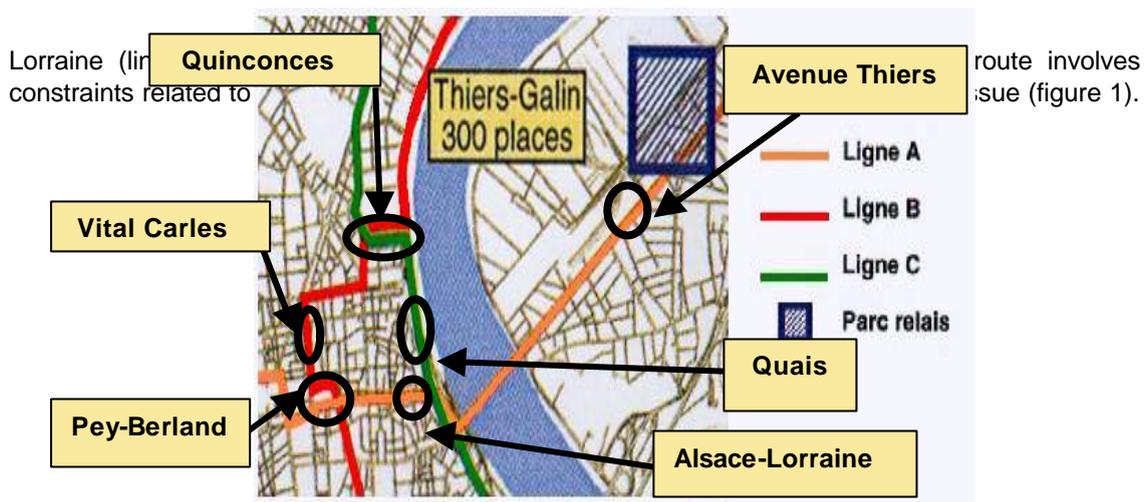


Figure 1 Map of the measurements areas

ACOUSTICAL DATA

During one week we carried out sound measurements on each site and, when possible, simultaneously with a traffic count. The measurements were done with an adapted version of the dBENV software developed by the 01dB-Stell company and includes dBTRIG32 for the measurements and dBTRAIT32 for the off-line analysis. This set allows a lasting observation of a site by the backup of the spectra and by the sound triggered recordings.

As one of the fixed objectives was to describe the urban sound environment, in relation to means of transport, using indicators other than the Leq , at first we evaluated the psychoacoustical criteria commonly used to determine the nuisance produced by flying aircraft (such as the PNL and PNLT), as well as loudness measures. This option was chosen because of the frequency of use and the supposed relevance of these techniques for evaluating the nuisance level due to transport noise. As a result of bibliographical research, it appears that the subject of non-stationary urban noises has been very little considered and that the majority of the existing indicators have not been proposed for this work.

So, rather than doing numerous trials using a great number of criteria, measures using loudness and its modified versions (which are the easiest to use in software) were preferred. As the strict application of their definition would lead to believe, the scrutiny carried out using spectra of bands of one third of an octave over different periods (from several seconds to a whole day) shows that these three indicators do not describe urban soundscapes better than the $Laeq$, as their variations are similar [3].

The sequel to the study will be concerned with the comparison of the last criterium with psychoacoustical indicators such as roughness, fluctuation strength and sharpness which no doubt translate the spectral aspect of the perception better than the previous indicators which are more linked to the global level.

During a second phase, the aim of this work is to relate the currently-used indicator (L_{aeq}) to the characteristics typical of the urban environment. As the conditions of the propagation of sound energy are modified by the geometry, the dimensions, the topology and the façade materials, it is justifiable to select sites showing a great diversity of urban forms. Our attention was first given to morphological parameters for evaluating the role of the structure.

One can observe that for each site, no matter which day was studied, the spectral envelope has the same appearance at different times. This fact draws one to think that this is maybe the "mark" of the site.

With the aim of showing the relationship between the urban morphology and the acoustic data, we compared the spectra taken from different sites. A comparative study of the average spectrum, calculated from different days and weeks, confirms that Tuesdays and Thursdays are the most representative of the whole week. The following graphs correspond to the results recorded during :

- a day representative of urban traffic (a Tuesday or Thursday) from 6am to 10pm
- a week, so as to even out the fluctuations in traffic (days, from 6am to 10pm)

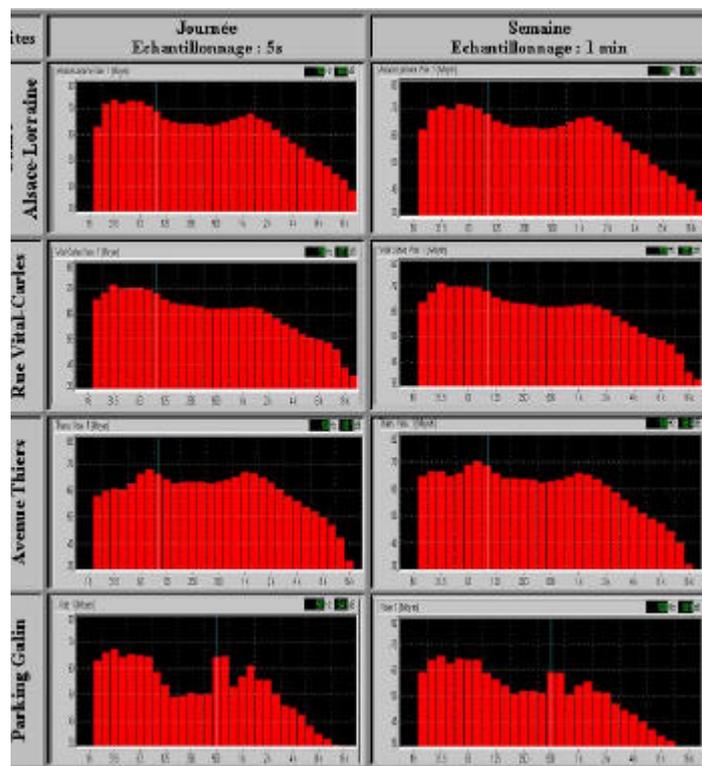


Figure 2 Comparison of the spectral envelopes in accordance with the urban form

A modification in the shape of the spectra from one site to another, which appears in these graphs, seems to be linked to the urban form. For the Rue Vital-Carles and the Cours Alsace-Lorraine, which are canyon street, the spectral envelopes are very similar ; the differences may be due to differing road widths and façade heights. The Avenue Thiers is very large with two-storey façades, and presents a dissimilar spectrum. The last site is a very open space, little affected by traffic, and has a particular spectral spread.

As our object is to demonstrate the relationship between sound environment and urban structure, and thus to show the "acoustic image" of an urban space, something analogous to a "sound colour", a representation of the phenomenon similar to that of a sonogram is possible, to facilitate

the comparison between sites. The maps below (figure 3) give the Sunday spectra. They show the differences between the Galin car park and the three streets.

These demonstrations let the image of the background noise of the city show through : indeed, even when human activity is reduced, all sorts of noises are present, emerge and spread, "ringing out" through the roads and districts. Each site has its own influence on the soundscape, and thus on our perception.

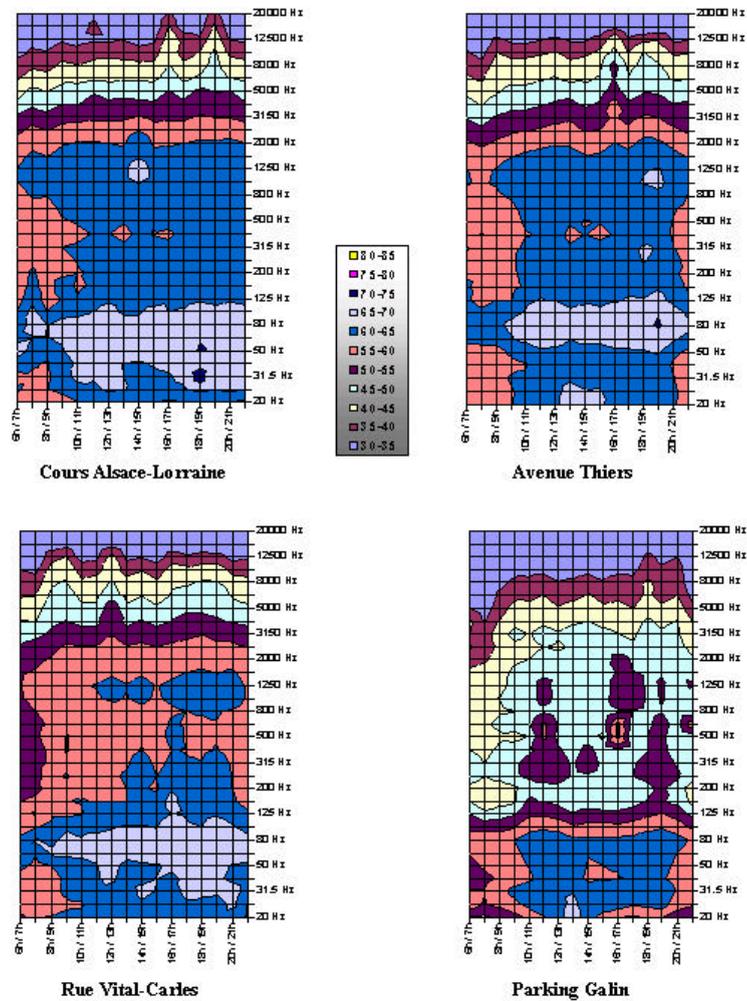


Figure 3 Comparison of the Sunday's "acoustic image" (sonogram) for different urban form

ANALYSIS OF THE URBAN AREA'S MORPHOLOGY

At this stage of the study, it appears indispensable to refine the analysis of the urban morphology, especially by going further than the description of the site simply with the geometrical and typological data such as the form of the street or the degree of openness of the space, for example. The composition of the façade (the nature of the materials and their distribution) and its cornice outline (allowing the definition of the relationships between smooth and rough surfaces) are deciding factors in the reconnaissance of the architectural style, especially by the participants in the urban project.

The parameters that describe the urban form refer to the density of the urban tissue : they concern the domination of the public and semi-public spaces, the existence of a regular structure or not... The methods that permit to underline them depend on the evaluation on the different levels, from the "global" to the "local" of the photographic documents taken from different angles and of plans.

Our typo-morphological site analysis is made around the measuring point which means that the area is not bigger than the district. The for this analysis necessary data have to be measured in a readable way. That's why we used a portable photogrammetric system. This type of measuring is based on the topographical principle of the intersection of the points of view recorded by two photos : each detail of the object gives two images and the orientations in the space of the homologous beams of light are determined by the characteristics of the camera (focal, optical centre, distortion) and by the position of the images of the negatives. The fulcra measured and calculated as ordinates served to fix the size and orientation of the object in real space.

The used RolleiMetric system works with a semi-metric camera. A measuring instrument for photographed space, this camera gives calibrated photos on which one sees reference points and homologous points. The analysis is computerised : after scanning, the shots are treated by a programme which orientates the perspective lines and calculates the spatial intersections. After adjustment of the readings the restored project is transferred in a *. DXF format to CAO type programmes which give a 3D model of the space.

As well as giving the dimensions, this method has the advantage over the classic survey of recording on the photos a great quantity of information about the cornice outline of the façades, the appearance of the materials, the existence of architectural elements denoting "roughness", the irregularity of the surfaces in different scales. On the chosen sites one can verify a similarity between these "accidents" : the presence of balconies, windows with sculpted string courses, cut-stone structures,...characteristic of Hausmann-style façades.

After processing all the photos, the edition of an Autocad file enables the reconstruction of a 3 dimensional object (which is a model of the street) in which it is possible to allow for the simulation of the diffused reflection from the façades which is decisive in establishing the conditions of propagation ; We show in figure 4 drawn vues of the façades of the Cours Alsace-Lorraine at the level of the measuring-point.

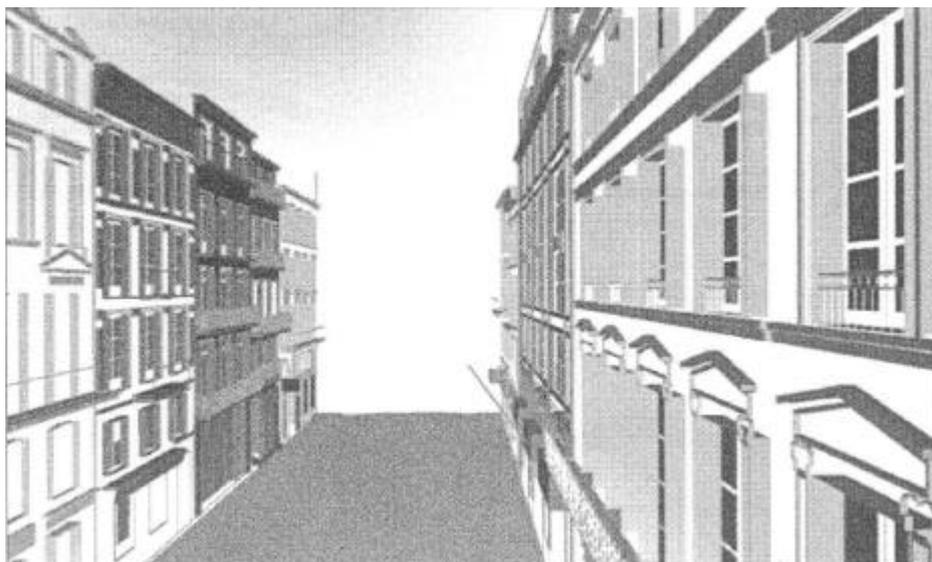


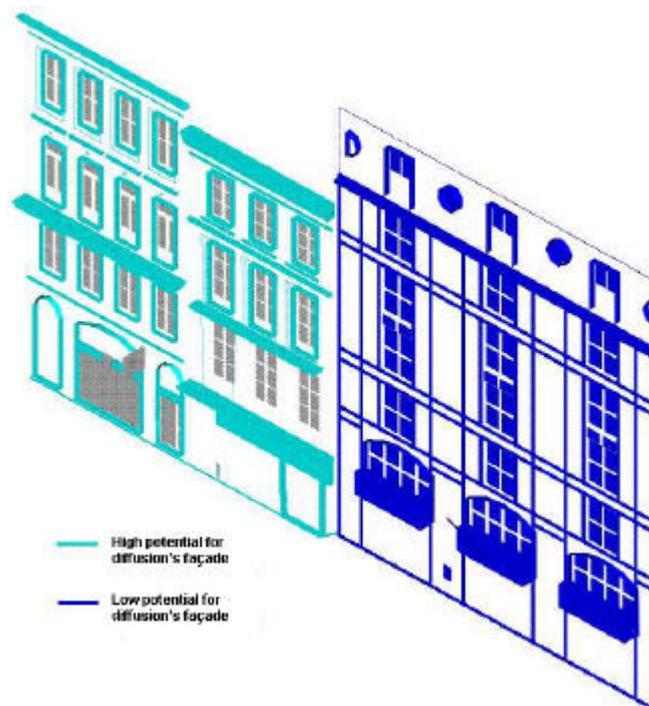
Figure 4 Model of Cours d'Alsace-Lorraine

CONCLUSION

The first phase of this research project allowed us, starting from a campaign of acoustic measurement at different sites with differing urban forms, to begin a system process in order to describe urban sound environments linked to surface transport.

It has been noted that the psychoacoustical indicators used for aircraft do not give any more complete information than the L_{aeq} : it is necessary to develop, starting from spectra and sound recordings, a means of calculating the criteria which best translate the « spectral image » of the site, describing it with a sound « colour » as a function of its morphology.

The analysis of the urban morphology using photogrammetric data allows the description of the potential for diffusion of the façades (figure 5), and the construction of a model of the site in which it is possible to simulate sound phenomena, in order to proceed with a comparative study with the measurements and surveys.



In the end, the totality of the data gathered as the outcome of the multi-criterial analysis should serve to supply a tool to aid the decision linking town planning and sonority, in a form easily employable by the planners.

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