Esquis'sons ! Sound Sketch : A Parametric Tool to Design Sustainable Soundscapes

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How to apprehend environmental complexity in a simple tool for architectural design

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Since the 80s, several researches have developed the theoretical notions of sound effects, sound proxemy, city sound identities, sound comfort, architectural sound prototypes which were meant to help designers consider sound in their projects. Nevertheless, taking care of the inherent sound dimensions in architectural urban projects remains an unresolved challenge. The researches of the last 30 years have shown how the sound environment qualities are forgotten in favour of visual qualities. This article presents a new method dedicated to generating simple sound sketches for architectural conception while preserving the complexity of acoustic simulation. This paper argues that the Esquis'sons! sound sketch tool reconfigures architectural design by considering an innovative view its the temporality, allowed by numeric designing tools able to intervene and offer a continuous feedback regarding sound environment.

Keywords: *sound environment, sound effects, sketch, parametric design, architecture, didactic, grasshopper*

CONTEXT AND ISSUES, SOUND QUALITY PREDICTION IN URBAN SPACES

Since the 80s, several researches have developed the theoretical notions of sound effects, sound proxemy, city sound identities, sound comfort, architectural sound prototypes (Augoyard et al. 1982; Chelkoff and Balaÿ 1987) which were meant to help designers consider sound in their projects. Nevertheless, taking care of the inherent sound dimensions in architectural urban projects remains an unresolved challenge. The researches of the last 30 years have shown how the sound environment qualities are forgotten in favour of visual qualities. Yet today we are aware of the importance of soundscape and its place in the perception of spaces as well as visual cues. It appears important to consider this dimension of space with

a qualitative eye and not only quantitative preoccupation (Rémy 2005). In addition, standardization associated to sonic space concerns tends to forget the characters (Luis Bento Coelho 2015) and variability of the places that are a real design challenge.

Regarding architecture, tools and ways of thinking have yet to be developed in the light of new prospects. From this perspective, the aim would be to "integrate" the soundscapes in the spatial design process based on the potential of tools and instruments proposed by "digital" architectural design.

Sound and "vibrations" in space, in their usual meaning, are often considered as qualifying elements for objects or their materiality. Here, we seek to understand "sounds" as factors, interacting with the rest of space component (Casati and Dokic 1994). Thus, they do not qualify emitting elements, but instead, they become, by their spatial and sensitive presence, real events constituting the << atmosphere>> or ambiance. This work on the quality of sound in dense urban areas questioned the confrontation between the different elements in a perceived sound environment, and thus, in the "sound scenes", specific for each element of the space.

From "room acoustic" to "sound quality design" tool

Today, the only tools developed to "predict" sound qualities for urban and architectural planning are dedicated to room acoustics, therefore they are not relevant for outdoors and complex sound environments. In addition, the complexity of their interfaces make them hard to use and to understand. As a matter of fact, to use these tools (for both indoor and outdoor acoustic simulation) every parameter has to be designed and characterized by the user (volumes, materials, etc.) to assess the design. The logic of the process is closer to correction than design. Facing this lack of tools to design the project and its sound "qualities" conjointly, this article presents new methods that allow simple sound sketching for architecture while preserving the complexity of acoustic simulation.

If the current sketch tools give the possibility - in a very intuitive way - to see and tests formal hypothesis in the early stages of the design, they don't offer anything to hear, and the new perspectives given by the recent development of parametric tools for architectural design finally allow us to think about intuitive and simple tools to produce sketches of the sound space complexity.

THE CHALLENGES OF SENSITIVE SKETCH FOR THE DESIGNER : SIMPLICITY WITH COMPLEXITY, NEW PROCESS AND PRACTICES IN DESIGN METHODOLOGIES

Considering the architectural design process not as a time line, but as a cyclical dynamic *"where the object assumes a place in a continuum by variation"* (Deleuze 2006), means being aware of the impact this transformation necessarily has on design practices. Indeed, our proposal addresses the architectural design as a tool continuum. Thus the design tool, whether it is material, intellectual or virtual exists by itself and tends to detach from the temporal anchor that formerly characterized him. The architect or designer works on the different stages of the process, all articulated and linked to one another, without ever having to query the "temporal relevance" of the tool. Modelization, or building a three-dimensional prototype becomes part of the continuous protocol and design crystallizes itself through action. The activity transforms the object, but "in doing [transforms] the subject itself"(Vergnaud 2006).

This methodological shift results in a potential for the instrument itself, which could be apprehended as a sound space conception tool. Therefore, it seems appropriate to think of technical tools not as simple "means" or unconcealment (Heidegger 1980) for designed spaces, but as a "part" of them, the informant and the listener nourishing both process and method. A sound sketch tool allows both representation and conception activities.

Thus, this work seizes contemporary technical tools to exploit their adaptive capacities and the associated thought processes. It aims at articulating

those tools with the creative process and at providing an alternative to normalisation and to digital automation. Indeed, despite considerable progress in terms of knowledge and experiences regarding sound environment, the current works are still struggling to make concrete proposals likely to help designers to create new "variable" sound environments that offer a variety of sound affordances (Gibson 2011) .

These questions, which attempt to couple a reflection on the contemporary changes in architectural design process and a special attention to the quality of perceived areas raise questions about new dynamics and "concept-in-action" (Vergnaud 2009): it comes to seize the digital tools in this perspective in order to develop the potential for the field of spatial design.

Didactic potential of programming tools for design

We present here a potentiality linked to design methods associated with digital programming tools that engage "cognitive" processed related to the assembly and error logic found in works based on models or sketches. Unlike other types of tools, the different elements of a script are built gradually and conjointly to the creative process: The elements in the script interchange, feed, cancel themselves and even cannibalize some part of it in the manner of a sketch that transforms itself under the designer's impulses and the previous layers which produce the shape or "silhouette" of space.

There is a didactic potential of the scripting and programming (visual or not) to which is associated an aesthetic of the "system" that approaches the "intuitive" process of models and sketches. These new tools have a great potential for a continuous design process, which needs to be mobilized in design and building spaces.

These considerations lead us to consider using digital design tools by summarizing the known process of sketching and model through a visual programming tool : Esquis'Sons! then tries to fit within this process by allowing the technical articulation and a sound sensitive and interactive variability. Seen this way, the tools allow to develop unfrozen systems, intuitive, variables and parametric and so to not mobilize artefacts to design but instruments of design. Indeed, the designer takes the artifact and personalises it through a process of instrumentalization, at the same time it creates a set of schemes of use through an instrumentation process (Rabardel 2002). Esquis'sons! then offers to take over these processes through a sketch tool that unlike a validation tool is not intended to be a frozen artifact but articulate and facilitate this personalization by incorporating it into the design process.

The sketch as a physical and mental design tool

Working with numeric simulation and evaluation today appears to add an unwanted complexity to the designing process. Yet, with the ever evolving power of new tools and computers, we start to think of tools capable to change this complexity of data in an understandable way without leading to an oversimplification and loss of information. The "sensitive sketch" developed with these tools, able to adapt to these new design paradigms (Saggio 2013) should allow to experience sensitive issues within the architectural or urban project.

This work seeks to exploit new cyclical processes that emanate from the contemporary configuration of architectural design. This means switching from a linear process consisting in a logical sequence where the sketch creates the project and its design, which is then validated or invalidated by simulating some phenomena; to a more complex articulation between the different phases that feed each other and a interact to continuously actualize the process. The various tools related to these phases end up existing by themselves, breaking away from their temporal position in the process. The paradigm behind the development of this tool emphasizes the need for a simultaneity of sketching and assessing within designing processes.

By questioning the design of environments we

consider the posture of sketching more relevant and versatile in comparison with a simulation and validation posture which is defined through its timing in the design. Indeed, the relationship between project and sketches is not a causal relationship but a constitution, or an evolution of the same "effect" constituted of a single essence. In the way of the sensitive sound environment, we do not try to categorize items according to a specific sound character but to bring out a constituent assemblage (Deleuze and Guattari 2005) of the sensitive soundscape.

In its first meaning, sketching includes both a preparatory tool for design work and an equalizer for the final project which the nature must match the main ideas promoted by the sketch. This is actually a "first" act of representation, but also of design.

The sketch, by evolution, builds itself around elements and events that transform the process of sketching, and requires a number of conditions to become a physical and mental design tool, stimulating the imagination. Then, more than an evolution, the sketch becomes "revolution" in a rotating way, exacerbating the complexity of its design. The sketch as a design tool is the initiator of the project, it is both the essence and the project itself.

The simplicity of the sketch illustrates the stakes of its use in the era of digital design tools. It has to stay easily usable and understandable, but also capable to manage and to fill the gaps left by unknown information. The architectural project today is no longer defined by the sequence of events and project items aimed at a final achievement, but constitutes a whole, reacting as a system of interconnected processes ; therefore, it involves a reflection on continuous and non-linear systems which have to be taken into account from the beginning of the process.

The architectural sketch needs to be integrated in the design process through this new perspective of timing in the architectural project and as a part of an on-going multiplicity. Thereby, we constructed an understandable tool which can manage and translate the complexity of an environment by sketching acoustic spaces and phenomena, but also include interaction to change and impact the whole project.

The second issue is the media that will figure the sketch and its role in the constitution of it, through the degree of abstraction, and liberty or rigor it proposes. Thus "the type of dialogue between the user and the system"(Ciblac et al. 2005) plays a key role since it is essential to question how the tool interacts with the user and offers solutions to the data highlighted by the designer. Sketch methods then determines the creativity and imagination of the designer; and the tool becomes a condition to elements the designer has to "coerce" through a set of parameters decided previously or during the formalization of the sketch.

ESQUIS'SONS ! THE INTERFACE AS A CASE STUDY, ASSUMING AN URBAN SOUND QUALITY

The dense habitat today partially solves the urban sprawl problem, but it still runs some challenges in raising the question of the quality of life through the social link it offers, the concept of privacy, and interaction with the surrounding context. Residents could accept the density more easily, setting aside "the ideal of the house with garden", if their accommodation can offer some extensions to the outside such as deep balconies, large covered terraces, patios, courtyards, gardens, etc. Whatever their use, these intermediate spaces are at the interface between private and public spaces. From an acoustic point of view, these interfaces can be characterised by the qualities of the environment, and by the uses they receive, which are also interfering with the qualities of the public spaces.

The question that arises is the following: how to create outdoor spaces attached to the apartment that can offer enough insulation to enjoy privacy, but also remain connected to the outdoor sonic environment ? Interfaces as a typology of spaces can resume the majority of the acoustic issues studied at the neighbourhood scale. The research proposes to study it at an architectural scale, in another words at the human body in movement scale (Chelkoff 2005)

where sound qualities have meanings for the inhabitants.

Methodology and case studies

In its first stage the software Esquis'Sons! is dedicated to sustainable neighbourhood design and offers the possibilities to sketch and listen sound qualities that might be experimented both within building facades (form and material used for balconies, terraces and loggias) and in public spaces (form of city blocks, with or without vegetation, etc.). To achieve this goal, a one-year in situ study assessed sound qualities in a large spectrum of sustainable neighbourhoods (France, Sweden, Germany and Spain), the analysis of the recordings collected in these neighbourhoods was used to create and integrate several scenarios to the tool.

Figure 1
Balconies in Paris, Trapèze de l'Île Seguin (up), Grenoble Vigny-Musset (down).

Assuming that interfaces are spatial arrangements, classified in 4 types (balconies, terraces, loggias and circulations or BLTC), the goal was to focus on their dual role : both creator and receiver of urban soundscapes. As they are one of the "aesthetic" outdoor expression for architecture, these BLTC are in specifically developed in terms of spatial types and surfaces in recent dense eco-districts. As these housing extensions meet a strong demand from the inhabitants and add value to the uses inside this density, it seems appropriate to assess and to design them according to their potential uses and sounds in different urban and climate contexts.

The tool "Esquis'sons!" as a design support to sustainable soundscapes, strives to present a set of realities observed in the field and organized into categories according to the work of Gregoire Chelkoff distinguishing "form", "forming" and " formality "of a space (Chelkoff 2011). Thus, the categorization "form" allows firstly to objectify a system: it is considered through its dimensions, materiality, orientation, degree of openness towards outside, etc. The aim is to reveal the type of planning designed as presented formally to the surrounding elements

The "forming" category is more specifically related to the modes according to which the system will form over sound. We will consider the degree of form in relation to the use and listening and the characteristics of the sound space to apprehend the sensitive variables of the system (hermetism and "exhaust degree", or special sound effects for example).

Finally, the category of "formalities" specifically reports "best" or singular uses occurring in the system and characterized by it ("forms" and "formings"). Especially, we are interested in the practices and their temporalities pertaining to "sensible uses".

This research aimed at working on a broad panel of fieldworks that could bring out remarkable and innovative architectural forms, and reflect morphological evolutions that occur on interfaces (see Figure 1). Furthermore, the international perspective of this typology was necessary to take into account cultural, climatic and geographic variations in the uses of similar BLTCs. That way, this work tries to consider a reciprocity between technical / productive and contextual / projective methods (Leatherbarrow 2009), joining measurements and theoretical situations to an attention to adaptability and context.

To illustrate these differences, we worked in 6 fieldworks located more or less on a north-south axis and in 4 different European countries, as described below :

1. The Caserne de Bonne (CB) district in Grenoble, France

2. The Sarriguren "EcoCiudad" (EC), Metropolitan area of Pamplona, Spain
3. Französisch Viertel (FV), Tübingen, Germany
4. Hammarby Sjöstad (HS), Stockholm, Sweden
5. Trapèze de l'Île-Seguin (TIS), Boulogne-Billancourt, France
6. Vigny-Musset (VM), Grenoble, France

On this methodological basis, the research results in a catalog of situations studied and based in particular on the upstream study of sound recordings through a series of "cross listenings" (Remy et al. 2015)

These analyses, especially through "comparative listening", allowed us to update a number of questions / scenarios related to architectural design for this kind of spaces and to architectural gestures and constructive choices or material that will impact on the quality of sound - produced and listened. Those are simple gestures or scenarios, but they act as an architectural formulation for listening assumptions. These "development" stages will then guide us to representation and auralization questions which are the main topic here according to our goal to bring a simple way to design by listening to sounds. What would be the consequences for listening if : "I am no longer on a balcony but on a loggia" / "the materiality of our designed space changes" / "my balcony is double-height" / "I am facing a street or not" etc., are the kind of questions the tool is able to answer.

FROM IN SITU ANALYSES TO A DIGITAL TOOL FOR ARCHITECTURAL DESIGN

The software interaction between sound and space parametric modelling is incarnated in a modelled 3D sketch in Grasshopper and an acoustic sketch in a standalone application connected with each other interactively. Thus, the program is developed as a design aid for the auralization (Kleiner, Dalenbäck, and Svensson 1993), that is to say a spatial visualization in interconnected and interrelated ways. It seeks to introduce the digital tool as an instrument which could articulate sounds and spatial dimensions as a whole and translate the complexity of acoustic calculations in auralizations. That way, we are keeping most of the complex information from sound in space, but rendered in an acoustic auralization which allows the designer to hear it in real time.

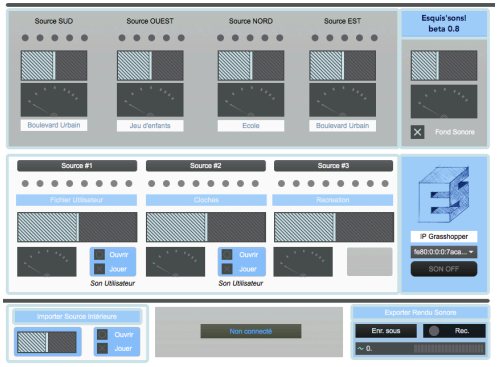

Figure 2
Esquis'Sons! interface visualization [2].

Soundsketch tool, the basics

The Esquis'Sons! module offers listening points on a project for pre-hearing, with the same level of accuracy than the architectural visual sketch, various sound scenarios that the designer might want to test. This stage also includes a formulation of architectural questions that, at that sketch "level", could affect the sound quality: formal, material and functional qualities of urban voids - which will focus on the effects on the propagation of sound, the organization and the distribution of activities, on the aesthetic dimensions of the project that may influence the sound qualities by future users.

The ambition has been to engage a 3D modeling software (Rhinoceros3D) with a module capable of broadcasting and modulate the sound (see Figure 2), the aim was to link these two elements by exploiting the interactivity and the potential of parametric tools. We chose to use Grasshopper3D and MaxMSP that, focusing respectively on formal modeling and acoustic modeling, were able to adapt to each other according to determined parameters.

The main idea of linking these two parametric softwares comes from the fact that they both use the

principle of settings (variable and mainly digital) as background information. Therefore, a normal user using Rhino during his design process can download and install the Max / MSP module (compiled as an application) that will dialogue with the spatial model trough the rhino plugin Grasshopper.Designers have to declare some basic parameters of geometry, and they can hear the sound live, informed directly by the digital sketch: it then produces a "sound sketch".

The interactivity principle between the two softwares, one that generates spatial forms and the other that generates sound events, is managed by a UDP communication protocol (User Datagram Protocol (Postel 1980)), preferred for its simplicity, versatility and fastness of use (see Figure 3). The idea of having these two softwares communicate is based on the parametric principle (variables and math) they both use as their basis information to generate forms or sounds. We then use the information from one to another.

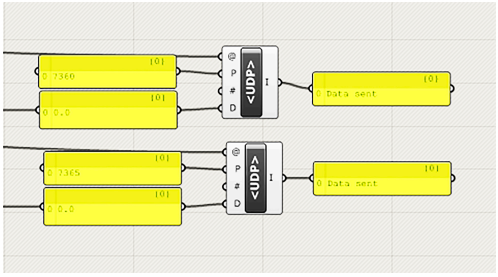

Figure 3
User Datagram Protocol in Grasshopper – gHowl plugin.

Soundsketch tool Principles

The software solution considers a "BLTC" attached to the listener: a cuboid with adjustable dimensions accompanies the declared points (see Figure 4). This volume is characterized by a degree of closure for which the following principles were applied:

1. The cuboid around the listening point can fit the dimensions of a front "BLTC".
2. The porosity of each of the 6 faces can be adjusted with an individual slider : the cover of the BLTC, the possible closure of the side walls, the floor and the wall overlooking the ground (partial for a railing or or total for a double skin) is expressed by a closure percentage on each face.Esquis'Sons! on this basis, allows to compare two listening points. A stereo listening to these two points selected by the user is then used as a tool to update (to hear) differences that are actually sound translations of space designer questions.

It is possible to assign an absorption coefficient on the declared "BLTC" to reflect the capacity and quality of materials. That coefficient is comprised between 0 and 1 and is relative to the entire "BLTC".One to four buildings can be declared, for which the length, width and height can be adjusted. They also can be rotated to adjust the opening or closing of the block. The designer can also import one or more of his own Rhinoceros/Grasshopper modelled volumes.

The user then declares 4 "cardinal" soundscapes around the block (in the North, East, West and South), and their "distance". He could assign pre-recorded tracks (neutral and loop) to these environments or import his own sounds. Finally, it is possible to declare localized sources as fountains (different types), playground, ball games, school (courtyard, retracted or classes), cafes terraces, shops, bells, public spaces call (languages), sounds steps on different soils, sounds of wildlife and fauna (birds, wind in the leaves), electroacoustic sounds (radio, TV, music), mobile phone ringtone + voice, passage 2 wheels, bus pass - tram - truck, boat passage, etc. A simple algorithm should also introduce random elements in sound environments: a passing car, a motorcycle, a pedestrian conversation, etc. An urban rumour - like a sound environment - from beyond the area and composed with identity sounds (such as bells) could be heard according to the block degree of opening and the height of the listening point (distant sounds) is also present.

Using the same process, we define three situated sources with "Esquis'Sons", which are permeable regarding position, height and size in Rhinoceros / Grasshopper (see Figure 4).

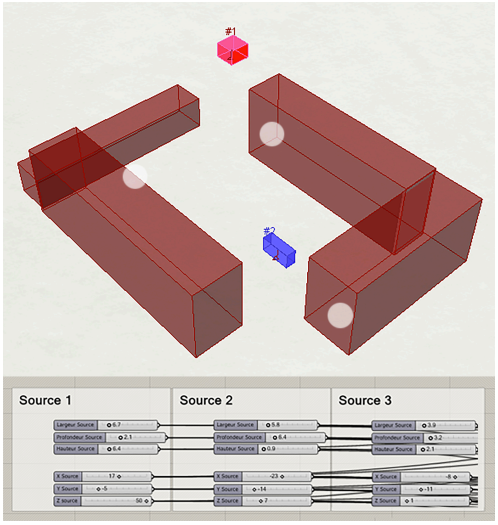

Figure 4
Situated sources assignation and listening points with their “attached BLTC” in the 3D model.

Finally, Esquis'Sons! includes a "block scale reverb" (developed as a parametric reverb) to make the difference from closed spaces with mineral surfaces and wide open spaces with vegetation.The entire script operation, starting with the sources positions and two receivers, consists in a calculation of filters paired with a mix made from geometric data only (distances) calculated and exported from the 3D model in Rhinoceros, through Grasshopper.

Such specifications allow "to sketch a sound answer to the questions listed above". The easy and intuitive handling of these criteria then enables the designer to validate the choices and / or to seek other alternatives. The posture of a sketch is more relevant than a simulation tool because of its versatility: it allows a "first" act of representation, but also of design and space sound design through an introduction to experiencing the changing parameters and some relationships between space, uses and sounds.

VALIDATION AND PROSPECTIVES

Different stages of tests led to a development and an improvement of the tool and continues today, especially through educational workshops and with the community of architects and researchers gathered around these teachings. The tool has also been validated and improved by a return of use and field work of the research members that has enabled its development and improvement. In this sense, through the whole process of construction and validation that we have implemented, we tested with other users the realism of the sound scenes produced. We also noted user/designers desires in Esquis'Sons! about the options available when they were testing. These desires are considered like architectural gestures to integrate into the tool.

It seems important now to make the tool evolve, in particular through the optimization of the module and a better flexibility using Python, and to consider a larger field of use for this tool (Generative potential, inside sketches, etc.). We are also listening to participatory impulses and perspectives related to the open source status and to the "grasshopper community".

This tool - which is not a modelization or simulation tool - is primarily intended to evoke a sound situation. As a sketch, it escapes the question of fidelity of the model and metrological "reality". Consistency of sonic results is validated by listening and by the "realism" of sound productions thus generated. This question of the sketch tool thus developed in the course of the research "esquis'Sons! "And focused on the interface between housing and outdoor amounts to a new way of designing space. We're leaving the post-project approval process and proposing solutions, which become inherent in the design process. These "technics" raise the issue of the use of the tool in these processes including learning and design "by doing" for the architectural discipline.

At the moment, we are exploring future uses and issues that arise while using the tool, whether in technical or theoretical dimension so as to integrate the tool to a continuous design process to allow it to consider variable, adaptive and qualitative sound environment, which lead to considering occurrences (Picon 2011) rather than elements for the design of lived space.

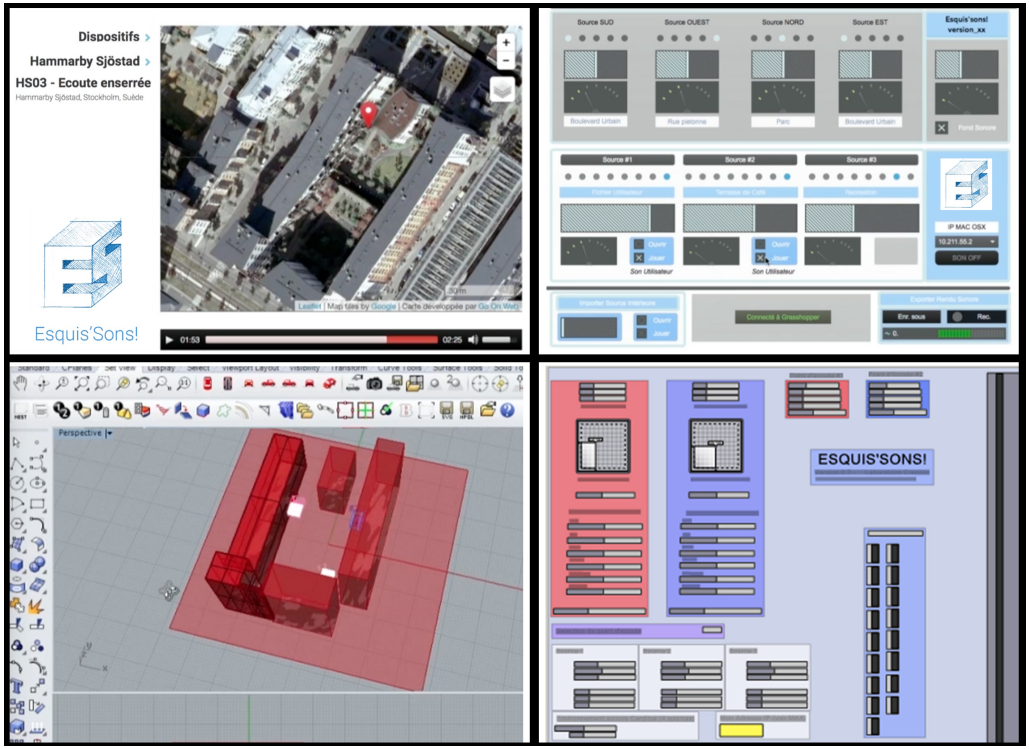

Figure 5
Split-Screen of the tool during a validation step : In situ sound (top left) , Sketch sound in Esquis'Sons! (top right), Model definition in the Grasshopper module (bottom right), Model visualisation in Rhinoceros 3D (bottom left) – Video : [2].

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