Soundscape design in train stations

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1. Introduction

The aim of this paper is to propose sound design solutions for train stations. The French company SNCF has been working for many years to improve auditory comfort for its travellers, building technical solutions to improve the intelligibility of spoken messages broadcast through the loudspeakers. The question is now to go further and to design the soundscapes of the different spaces that make up a train station. This means that, more than improving auditory comfort, we want to improve the use of train stations by means of the auditory modality. This issue implies several questions that the sound designer will have to deal with: How can we improve the use of a train station? Do we need sound to achieve it? How do we create sounds?
Before creating new sounds and new soundscapes it's important to examine auditory perception of sound sequences recorded in railway stations. The aim is to reveal acoustic cues and sources involved in space recognition on the one hand, and auditory feedback, made on purpose or not, which communicate useful information, on the other hand. So, in a first step, an analysis of existing train station soundscapes is performed by an experimental procedure in a laboratory (1st §). Then, in a second step, a kind of behavioural scenario is proposed to describe the way a typical traveller in a train station finds out what existing auditory information is useful to him at each step of his way, and to anticipate new auditory information associated with recent equipments (2nd §). Finally (3rd §), sound creation principles such as auditory icons or auralization for the design of sounds are presented.

2. Sound signatures of spaces

Considering that the main goal of a traveller in a train station is to go from one place to another, the first hypothesis is that the travellers must understand where they are at each step of their way. Moreover, we wanted to know if the soundscape could participate in the improvement the understanding of these spaces.
So, we wanted to find out the perceptual representation of the soundscapes for the listeners and the factors responsible for it. This will give us a sound signature for each space that will be useful if we want to build new spaces that will be reliably recognized by the travellers. A second intent consists in deducing if useful auditory information participates in the space recognition.

2.1 Study of existing train stations

A perceptual study of soundscapes was carried out in several French train stations. This study consisted of two auditory experiments: a free-categorization experiment and an oriented-categorization one. The following sections resume the main principles of this study (full details in [1]).

2.1.1 Sound recordings
The sound samples were recorded in the six different spaces that make up a train station: Ticket Offices, Corridors Stairs, Waiting Rooms, Platforms, Shops and Halls. Six French train stations were recorded and 66 sound samples were selected to be as representative as possible of existing spaces (old, re-organized and new).

2.1.2 Procedure
During the two experiments, the sound samples were presented binaurally with headphones, and listeners were seated in a sound booth.
Experiment 1: the listeners had to make categories based upon similarity criteria and to describe verbally these categories. 55 subjects were recruited for this experiment.
Experiment 2: the listeners had to recognize each sound sample. 40 new subjects were recruited.

2.1.3 Results

Experiment 1 showed that people perceived the sound samples in 8 perceptual categories. The verbal analysis explained these categories: 3 categories were based upon the recognition of sound sources, 2 were based upon the room effect, 1 was based upon human activity, and 2 were based upon a combination of these 3 factors.

Experiment 2 showed that the spaces were very well recognized. This result is presented in Table 1. It shows for example that the Platforms have been recognized as Platforms by 67% of the listeners, as Halls by 12 %, as corridors by 7 %, etc.

		Associated Spaces					
		Platforms	Halls	Corridors	W.Rooms	T.Offices	Shops
Spaces	Platforms	**67**	12	7	9	1	4
	Halls	19	**52**	11	6	4	8
	Corridors	16	14	**55**	2	5	8
	W.Rooms	5	5	12	**47**	9	22
	T.Offices	2	4	2	11	**53**	28
	Shops	3	20	5	5	9	**57**

Table 1: space recognition scores of Experiment 2

2.2 Description of the sound signatures

The comparison between the results of the two experiments gives us the acoustical cues that determine the space recognition: sound sources, human activity and room effect are the main factors of recognition. Table 2 describes the sound signatures for each type of space. It shows for example that the recognition of platforms is essentially based on sound sources: train noises and whistles. This means that a platform will be recognized whatever its architecture is. These sound signatures will be very useful if we want to keep a good sound recognition of new spaces that will be built.

	Sound Signatures			
Spaces	Sources	Human activity	Room effect	Other
Ticket Offices	ticket machines	conversations, waiting, crowd	closed spaces, small reverberation	comfort : quiet, intimate, cosy
Corridors, Stairs		steps, walking noises, shoes, wheeled suitcases	large reverberation, echos	
Waiting Rooms			closed spaces, small reverberation	comfort : quiet, intimate, cosy
Platforms	train noises, whistle			
Shops	announcements, music	conversations	large reverberation	high sound level, ambiance confuse
Halls	announcements, departure boards, trains	steps, walking noises, voices	large reverberation	high sound level, ambiance confuse

Table 2: sound signatures of each type of space

Moreover, verbal descriptions of train station soundscapes organised in different categories (non-speech signal, speech signal, human activity, etc.) give to the sound designer some ways to modify the soundscape:

1. Non- speech sound signals:

- The “do-sol-sol” SNCF jingle was created by Louis Dandrel to convey specific information. Results reveal that this sound is well known and useful as an SNCF identity and as an attention focus to spoken announcements.
- Mechanical sources such as ticket punching machines and departure boards produce causal sounds but are in addition recognized, producing fruitful information about the different steps to get the train: for example sounds produced by ticket punching machines and the departure board indicate respectively that the new schedule is being displayed and that the ticket has been validated. Those

sounds were not created with the purpose of producing information but people get used to them and useful information is associated such as user assistant or user feedback.

2. Speech signals:

- Voice of the spoken announcements that convey a message but also the sound identity of the SNCF thanks to voice quality is an un-ambiguous semantic sound signal.

3. Human activities:

- Sounds such as conversations, step noises, glasses or suitcases inform about the activity in the space. The variety of soundscape that can be heard confirms the complexity of the different spaces configurations that can be found in a large train station, from shops to waiting room.

4. Architectural configurations:

- Spaces interact with all produced sounds depending on the reverberation, the absorption etc. The room effect has to be controlled for a more global sound design approach.

3. Behavioural scenario

The previous section presented the elements of the soundscape that are perceived by the travellers and responsible of the space recognition. Now, the goal is to know how can the use of a train station be improved. So, it is important to find the information the travellers need during their way through the train station. To answer to this question, the methodology proposed, inspired by those used in design companies, is based on a behaviour scenario that present a potential user in a daily life situation. This scenario describes the main steps that are pertinent from the user's point of view. At each step, the different information needed by the user is described. This results in a kind of technical specifications for the sound design.

3.1 A first example of scenario

One can imagine the case of a tourist that comes for the first time to a large train station to take his train. The main steps of his course are described in the following.

1st step: he arrives in the train station and goes to the departure board to see the schedule of his train. It is too early and the platform number is not displayed yet. So he would like to wait in a quiet place.

2nd step: he is waiting in a waiting room where there are TV's that display the schedules. He needs to be informed when the platform number of the train is displayed.

3rd step: it is time to go to the platform but he wants to buy a magazine first. So he needs to be informed a short time before the train departure.

This first example is very simple and has to be seen as a preliminary example to illustrate the methodology. In the future, we will create more complex scenarios that will be more innovative and more representative of the different users found in a train station (business man, blind people, etc.).

Nevertheless, this example presents 3 functions needed by the traveller and that could be conveyed with sounds.

1. Location of waiting rooms.
2. A new schedule is being displayed on the departure board and on the screen in the waiting rooms.
3. The train will leave in a few minutes.

The next step is to write the technical specifications in order to design the sounds that will convey these functions. Before, two approaches that have been well known for about ten years in the realm of human-machine interface will be presented.

3.2 Two existing approaches to convey information with sound

3.2.1 Auditory icons

An auditory icon is a sound that refers to a physical action that can appear in our environment [2]. Thus, in the field of sound synthesis, an auditory icon will be a sound that imitates a natural physical phenomenon: waves, wind, objects that are hit or stroked, etc. It can also be synthesized thanks to a

physical model. These auditory icons can be parameterized in order to have sounds that can interact with the user's actions [3].
These principles can be very efficient when we want to create some kind of auditory metaphor, in order to evoke something known by the listener. For example, a well-known computer interface uses the sound of a paper ball thrown into the trash when a file is deleted.

3.2.2 Earcons

Earcons are melodies created and configured as a meaning chain in order to convey an auditory message. Unlike auditory icons, the link between the earcons and the message needs to be learned. Thus, the message is conveyed through the different musical features of the sound: rhythm, pitch, timbre, dynamics, etc. Brewster [4] proposes a set of earcons for various actions on a computer: for example create or destroy a file.

3.3 Technical specifications

In the behaviour scenario, 3 functions that were need by the traveller were presented. They will be then described acoustically in order to specify how it will be conveyed by a sound. These specifications concern the sound composer but also the people that will put the sounds in the train station (broadcasting).
To indicate a New Schedule, we wanted a sound that evokes the sound of mechanical departure boards "flap flap flap" in order to make an auditory icon. The main idea is to profit from this well-known sound (as it was shown in the 2nd section) that is disappearing with the new electronic departure boards.
To indicate the Departure Train, the main idea is to convey the imminence of the departure. So we wanted a small melody (earcon) with two different rhythms that evoke two different states of imminence.
The specifications for these two functions are presented in Table 3. The third function (localization of waiting rooms) will be developed later.

	Technical Specifications	
Functions	**For the sound composer**	**For the broadcasting**
New schedule	Its rhythm, 8 beats per second. Percussive sound. One second is enough so that it will not interfere with the spoken messages.	It must be heard near the departure board and all the screens that display the schedules. So, directive loudspeakers must be used so that the sound will not be heard in other places. It must be synchronized with each change of schedule.
Departure of the train	In order to respect the sound identity of the SNCF, the timbre of the sound used for the melody have to be similar to the do-sol-sol used before each spoken announcement.	The two melodies must be heard on the platforms but also in the nearest places where people could be waiting including shops. The slow melody will be broadcasted a few minutes before the departure The fast melody will be broadcasted a few seconds before, and looped until the train leaves.

Table 3: Technical specifications for the sound design of two functions.

4. Sound design tools

In the previous §, describing what a typical traveller needed, we gave the several functions we want to convey with sounds. We will now describe the different principles of sound creation we used for creating the first sound examples. The sound creation will be constrained by the technical specifications, but also by the sound signatures of the spaces and finally by the sound identity of the SNCF. This final point deals more with the esthetical sound identity of the SNCF that exists yet (jingles, voice used for the announcements) and that we want to develop.

4.1 Sound synthesis and sampling

For the two sound examples presented, here are the main principles used.
The auditory icon for the New Schedule was created with digital processing of a ticket punching machine sound. Time stretch was used in order to have a short percussive and "incisive" sound. The sound is repeated 8 times in the first second (original rhythm of a departure board) and then the

rhythm slows down until the end (1 second more). This change in rhythm is supposed to focus the user's attention on the new schedule.
The earcon for the departure train was created by additive synthesis based on the analysis of the original sound of the SNCF jingle in order to have a similar timbre. The 2 melodies (Fast and Slow) are composed of two tones: C – G(-1). To have a more realistic percussive aspect, the attack has been sampled (the first 8 milliseconds).

4.2 Auralization
In order to have a more realistic simulation it is important to hear these new sounds like if they were in the train station. Moreover, spaces configurations in the train station can be very useful for the sound composer. For example, auralization is essential for listening to the impact of a sound in all the spaces of the train station.
There are many auralization software, the problem will be to choose between two of them. On one hand it is possible to calculate a complete modelling of the room, with all architectural parameters such as volume, building materials, etc. This is a physical approach. CATT Acoustics is maybe the best example of this kind of software. The main disadvantage of this software is the computing time that can be very long. On the other hand, there is a signal approach that gives a modelling of the impulsive response of the room, which is done by the Spat (Ircam). The main disadvantage of this software is that coupled rooms are not supported yet.

5. Conclusions - Perspectives

In this paper, we first presented a study on existing train stations that gives the perceptual representation of soundscapes and acoustical cues responsible of space recognition. These results show that all the elements of the soundscape are perceived by the listeners and thus should be used by the sound designer. After that, we propose a methodology to find out what is need by the traveller to improve its use of a train station. This methodology is based on behaviour scenarios and its finality is a technical specifications table for the sound composer and the broadcasting in the train station.
A simple and intuitive example is presented here to illustrate the methodology, and our main perspective is to create more creative scenarios based on a stronger methodology. We will probably find solutions in the field of ergonomics. After that it will be possible to propose more precise technical specifications for the sound design.

6. References

[1] Tardieu, J. & al. (2004). *Soundscape design in train stations: Perceptual study of soundscapes.* Proceedings of the CFA/DAGA Strasbourg 2004.

[2] Gaver W.W. (1988). *Everyday listening and auditory icons.* PhD thesis, University of California, San Diego.

[3] Conversy S. (2000). *Conception d'icônes auditives paramétrées pour les interfaces homme-machine*. PhD thesis Université Paris-Sud XI.

[4] Brewster S. *Non-Speech audio output.* Chapter 12 of the Human-Computer Interaction handbook, Jacko and Sears Editions.