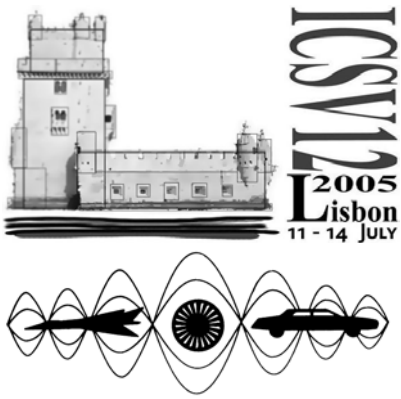

Twelfth International Congress on Sound and Vibration

APPLICATION OF ACOUSTIC AND ARCHITECTURAL DESIGN OF TWO RAILWAY STATIONS IN STOCKHOLM

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Abstract

This paper emanates from an ongoing project that deals with the application of acoustical and architectural design for two railway stations in Stockholm, Sweden. The overall assignment of the project is to specify how sound criteria may contribute in the design of the stations with regard to criteria such as spatial orientation, communication, information and aesthetics. In Sweden this is a pioneering project since it is the first time acoustic design has been implemented to such a large-scale. Since it is crucial to develop acoustic design in accordance with architectural practice, a central issue has been to implement sound criteria in the initial phase of the project. The working hypothesis is that the main function of sounds in railway stations is to mediate information. The starting point is that each type of space has its specific conditions and qualities. In other words, this project deals with the sound sources and with the design of the physical environment; the sound should support the activities of the place. Another central subject matter concerns sonic comfort with regard to functional disabilities. The paper aims at presenting the ongoing project and sharing the experience of how acoustic design of railway stations may be performed in architectural practice.

INTRODUCTION

Ingemansson Technology AB, acoustical consultants, work for Banverket – The Swedish National Rail Authority – with acoustics and noise control for the City Line, Stockholm. The line is a new double-track railway tunnel that extends beneath central Stockholm. When the City Line is opened the track capacity through the city will be doubled, removing the current rail traffic bottleneck. Two stations are planned, City Station and Odenplan Station. These stations will be built some 30 to 40 meters below the ground surface, connected to underground, regional and express trains. Regarding time schedule, the project is in the beginning of the planning and design process so it is now just possible to present basic principles and ideas regarding acoustic design.

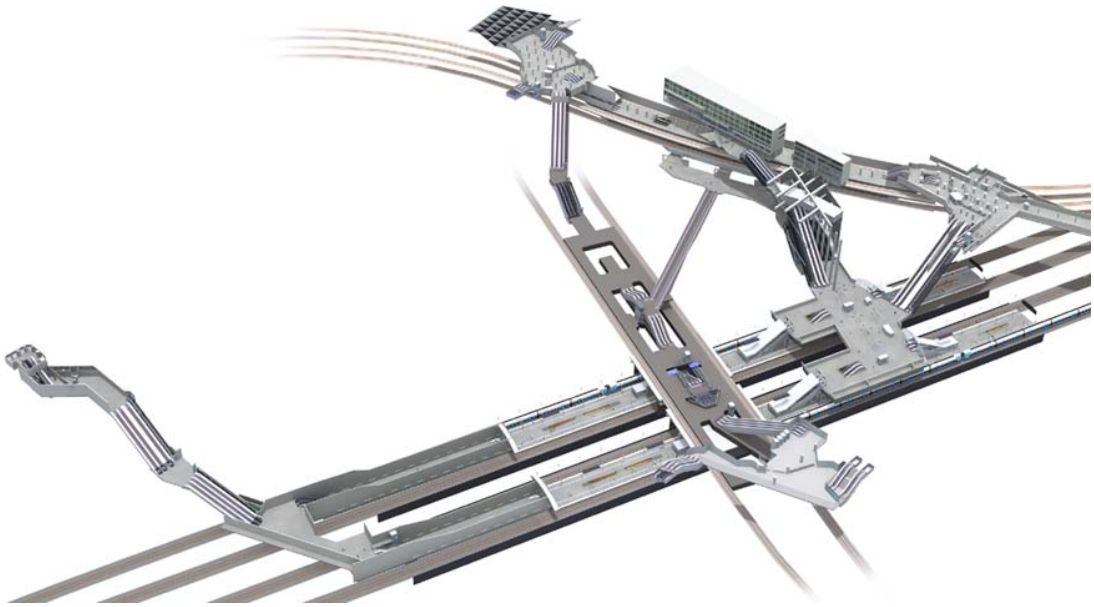

Figure 1 – Model of City Station

In the initial phase of the planning of the City Line stations, the acoustic consultancy company Ingemansson Technology AB has investigated a number of general questions:

- What types of activities take place within the different spaces (entrance, passage and platform)?
- What about the relations between sounds and activities?
- What criteria are desirable within the different spaces – in regard to acoustic and architectural design, information, communication, orientation and aesthetics – and how can these criteria be fulfilled by acoustic design?

This paper, however, does not discuss all these aspects, simply because there is not space enough to give a thorough description. Instead, it focuses on applications of acoustical and architectural design in regards to spatial issues. The paper presents a series of design tools, which are operative in that they permit a synthesis of sonic spatial issues in railway stations, to be used in the acoustical and architectural process. It is important to emphasise that these tools must be understood and used on an interdisciplinary level. Therefore, the acoustical discipline and the architectural discipline cannot embrace the whole subject area individually, but they need to co-operate.

Even though this paper focuses on the two railway stations in Stockholm, the subject matter may be applicable to any railway station. Again, it is important to have in mind that the City Line project is in the introductory phase. Therefore, in this stage, it is just possible to describe design criteria from a general point of view.

This paper is closely connected to the submitted paper *Theories and Methods adaptable to Acoustic and Architectural Design of Railway Stations*, which focuses on general theoretical and methodological issues.

DESIGN TOOLS IN REGARD TO SONIC SPATIAL ISSUES

Spatial Decomposition of Monotonous Milieus

One crucial issue concerns the design of passages that function as transits between entrances and platforms, especially when the traveller has to walk long distances. Unlike entrance halls and platforms, passages do not contain a variety of activities and facilities (seats, shops, connection to urban space and trains etc.), but usually these environments are monotonous and static since there is only one type of activity – movement [fig. 2]. The effect is that travellers often feel the atmosphere to be insecure and unpleasant. In a case study on the underground in New York the importance of avoiding the high tempo and rush in such long transit spaces is emphasized (Rubin).

Figure 2 – Example of a Monotonous Passage

Some of the passages in the City Station and Odenplan Station are very long – almost 100 m – which enhances the monotony. Therefore, it is an important task to design

these environments to make them as comfortable as possible. Accordingly, there are a number of criteria that should be taken into account regarding the design:

- to break the monotony;
- to slow down the fast tempo;
- to create a dynamic atmosphere, and;
- to establish a safe and secure environment.

These criteria can be articulated by acoustic design. One method is to create a longitudinal rhythm of the long passages by varying the acoustic conditions, for the purpose of producing spatial and dynamic effects. To attain such a rhythmic variation one may shift between absorbing and reflecting materials, which weakens and enhances the sound reflections.

In a design context, the architect and acoustician decide on a number of spatial nodes in the passage, where the rhythm shall be articulated. The material in these nodes consists of reflecting materials, such as enamelled steel sheet or tempered glass. In order to strengthen the change in acoustic atmosphere in these nodes, it is also crucial to establish a further variation in room acoustics. Changing the physical spatial proportions could carry this out, but this is complicated and expensive. An alternative way to create a variation in room acoustics is to use electroacoustical devices to increasing the reverberation time and sound level in these nodes. Compared with a change of the physical space, this is a flexible and inexpensive method. Thus, the static and monotonous spatial atmosphere in long passages is decomposed. In order to intensify the spatial and dynamic effects, the variation of acoustics could also be synchronised and supported by the lighting design [fig. 3].

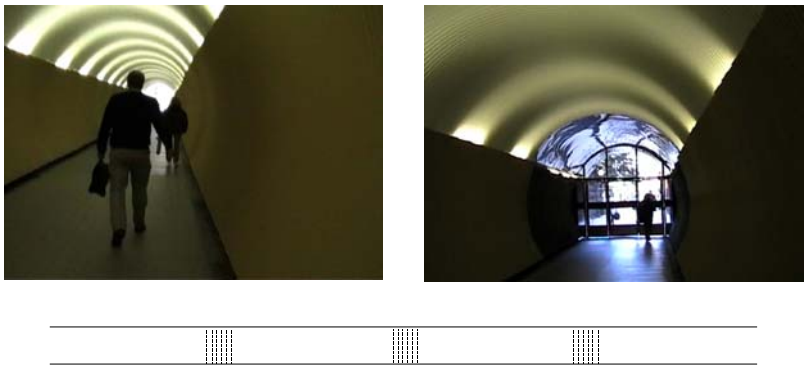

Figure 3 – Schematic Example of Rhythmical Articulation, nodes with variation of room acoustics and light

Sonic Aesthetical Additions

The environment in entrance halls and platforms can be very stressful, especially during rush-hour traffic. In this respect, there is a need for private spaces, especially when the traveller has to remain for a while, waiting for a train. Such private spaces could be executed by the design and distribution of music and sounds via loud-

speakers, i.e., to create a qualitative sonic space, which differs from the surrounding sound environment and which has a relaxing effect on people.

This is, however, a delicate issue in that such examples of acoustic design very often fails. For instance, some metro stations in Paris play muzak on the platforms (e.g. Magenta and St Lazare station). The intention is to create a qualitative sonic ambience, like a sound perfume that makes people feel comfortable. Yet, it has the opposite effect. Instead of bringing qualities, the music rather enhances the public hubbub – the muzak reduces the subtle borders between public and private spaces. Another example is the new international tendency to play classical music in railway stations for the purpose of preventing loitering and crime. [This is thoroughly discussed in the paper *Theories and Methods adaptable to Acoustic and Architectural Design of Railway Stations* – section heading: *Principles for Acoustic Criteria*.]

So, there are some basic criteria that have to be taken into consideration in the creation of a qualitative sonic space, executed by music and sounds via loudspeakers.

- Firstly, the aesthetical qualities are crucial. Music/sounds should be site specific in terms of that they need to be connected to the certain place where they are distributed. In other words – music/sounds requires a context.
- Secondly, the sonic spatial propagation needs to be defined. When distributing music/sounds via loudspeakers, it is important to control its spatial impact in public space, and not as in the metro stations in Paris, where the muzak is performed all over the platform. People need privacy and, accordingly, the possibility to choose sonic environment when they want.

Spatial Differentiation – Virtual Sonic Space

The purpose of a "virtual sonic space" is to offer the traveller a private and aesthetical space, which differs from the surrounding sound environment. Such a space is suitable for people who wait for the train, and especially for those who need privacy.

A so-called virtual sonic space has no physical spatial boarders, but the "space" is executed by ultrasound technology that makes it possible to create a focused, well-defined listening area. This technique works with ultra-sound, modulating the audible sound onto an ultrasonic carrier frequency. The effect is that one may create a focused sonic space, either directly or via reflections on a surface. It is, thus, a matter of a transparent and distinct space. Since the adjacent areas could be kept sound-free, the travellers in the underground simply have the possibility to chose if they want to enter such a space. This virtual sonic space could be located on platforms and entrance halls, and in connection to seats.

In accordance to the above discussion, the music/sounds in these virtual spaces should be site specific in order to emphasize the typical characteristics of the station (urban, geographical, socio-cultural and aesthetical aspects etc). For instance, composers and artists could make installations consisting of sound-recordings from the urban area, close to the station. Beside aesthetical criteria, this also establishes a sort of contact or dialogue between the underground and street level. This virtual

sonic space should also be synchronised and supported by lightening design, in order to emphasise its transparent shape.

The discussion on the "virtual sonic space" could be described in terms of a sharply marked sonic space that is put inside another sonic space. This is a typical example of acoustic design, which makes it possible to create sonic spaces with different qualities within the same room. In such a way the spatial atmosphere in a station may be given a characteristic architectonic expression and identity.

Another obvious application of high directivity loudspeakers is to distribute verbal traffic information. The purpose is to establish a well-defined auditory space by isolating the surrounding sounds and improving communication and speech intelligibility. This could be used in places such as ticket kiosks, cafés, waiting rooms and seats on platforms and in entrance halls.

Spatial Differentiation – Sound Dome

Large domes function as the type of semi-spherical cupolas one finds in cathedrals and churches, often with a huge reverberation time.

Hence, a sound dome may execute a well-defined sonic space, which differs from the surrounding sonic space. The spatial sonic effects within the radius of the dome are articulated by its specific acoustic qualities – reverberation time, intensity and propagation. The particular geometry within the radius also produces different focal points, which may strengthen the transmission of sounds to certain spots.

In a design context, a sound dome is favourable in open spaces, for instance in the large mezzanine in the City Station, which is a central connection area between the passages and the two platforms [fig. 4]. The dome effectuates a well-defined sonic space and has an effect on the kind of monotonous movement that often arises in such communication systems. In this respect, in comparison with the surrounding acoustic condition in the mezzanine, the acoustic spatial effects within the radius of the dome will have an influence on spatial conception and behaviour of people.

Figure 4 – Schematic Example of a Sound Dome, City Station

SUMMARY

This paper focuses on applications of acoustic and architectural design in regard to spatial issues in railway stations. It supports a general discourse on sonic spatial issues and also it presents qualitative tools that are operative in the architectural and acoustical design process. In this respect, the main intention is to present interdisciplinary design tools to bridge the gap between acoustics and architecture, and so be useful within both fields of practice.

Concluding remarks

This paper is a result of an ongoing project at the acoustic consultancy company *Ingemansson Technology AB*, Sweden. The title of the project is City Line, Stockholm, and the paper deals with the design of the two stations. Theoretical and methodological proposals are presented in the paper *Theories and Methods adaptable to Acoustic and Architectural Design of Railway Stations*.

REFERENCES

[1] Amphoux Pascal, *L'identité sonore des villes Européennes*, rapport de recherché, no. 117, Cresson/Irec, 1993.

[2] Augoyard Jean-François, Torgue Henry, et al, *A l'écoute de l'environnement – répertoire des effets sonores*, Parenthèses, Marseille, 1995.

[4] Delage Bernard, *On sound design*, proceedings of the conference *Stockholm, Hey Listen!*, The Royal Swedish Academy of Music, Stockholm June 9-13, (second edition), 1999.

[6] Hellström Björn, *Noise Design – Architectural Modelling and the Aesthetics of Urban Acoustic Space*, ISBN 9188316386, Bo Ejeby

[7] Ingemansson Technology AB, http://www.ingemansson.se/

[8] Rubin Ben, *Audible Information Design in the New York City Subway*, http://www.earstudio.com/projects/projects.html

[9] Remy Nicolas, *Maîtrise et prédictibilité de la qualité sonore du projet d'architecture. Application aux espaces souterrains*, Cresson, Grenoble 2000.

[10] Rydén L. & Hellström B., *Akustik i Citybanan, Bygg & Teknik*, nr. 3, 2005.

[11] Ultrasound technology, see Sennheiser Audiobeam http://www.sennheiser.com/sennheiser/icm_eng.nsf/root/09859

Figure 1 & 4
City Line, Stockholm – City Station, Samuel Raitio, Ahlqvist & Almqvist Arkitekter AB, Stockholm, Sweden.

Figure 2 & 3
Björn Hellström, Ingemansson Technology AB, Stockholm, Sweden.