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2013 | INNSBRUCK | AUSTRIA
15.-18. SEPTEMBER 2013
NOISE CONTROL FOR QUALITY OF LIFE

Orlando theme park acoustics – A soundscape analysis

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ABSTRACT

Theme parks are self-contained environments creating a fantasy world with a very special purpose - entertaining. It is self-evident that sound plays a crucial role in the design of a visitor's experience. In order to identify the relationship between a park's architecture, the prevalent activities and the acoustics the soundscape approach is applied. It not only comprises quantitative measures but also perceptual and context-based measures and therefore seems to be most promising for the task. For this research four different theme parks in Orlando, USA, were evaluated during one day each. Soundwalks using binaural microphones as well as standard sound level measurements of single points-of-interest and the daily sound exposure were carried out. Further the sound quality and the context were captured by filling out evaluation forms. These methods helped in identifying characteristics, e.g., of noise sources of a contextual positive quality as well as sources having a rather negative effect. Examples of destructive acoustic design were identified and sound levels of attractions and of the daily exposure were measured that reach critical values. This work also discusses the use of the soundscape analysis for the consulting on the acoustic design of new theme parks.

Keywords: soundscape, theme park, exposure level, consulting

1. INTRODUCTION

A theme park is a kind of amusement park in a fixed location that tries to entertain in a very specialized way letting visitors experience fantasy worlds known from movies and cartoons. Such a park is mostly an open area resembling an urban park. However, it is a more complex environment in that it assembles attractions, rides, food & beverage and retail shops following a specific theme. This theme can vary for different zones of the park, e.g., the comic zone for kids is followed by an adventurous dinosaur zone. The architecture is fit to the theme in the visual appearance and in most parts music supports the thematic intention to directly shape the experience of the environment. When entering the park people are usually introduced into the general theme of the park and then guided by the architectural layout to follow different paths through the park. On these paths a visitor experiences the different sub-themes and the corresponding attractions which can be a roller coaster, a multidimensional cinema, a walk-through or a dark ride. Except for roller coasters all attractions take place inside a building or at least below a roof. Although some of the coasters are also constructed inside a building. A typical itinerary is to walk around the circulation areas, enter an attraction, wait in the queue, experience the attraction, exit the attraction into the park again, walk on, enter next attraction, etc. Guests spend usually a full day in a theme park.

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In this project the acoustics and the soundscape of different theme parks in Orlando, Florida, USA, are measured and analyzed. Orlando is the perfect place to pursue such a study because of the high density of different theme parks in the city. Several parks were visited in just a few days. A single theme park was visited during half- or a full day at the beginning of Januray 2013. This means that the measurements and the analysis presented here, strictly speaking, are only representative for this season of the year and January is rather off-season. However, the park as such does not change by season, only the number of visitor's increases or decreases. Hence, it can be expected that the sound created by visitors increases in intensity but does not change the soundscape substantially.

In order to analyze such a compact but intense environment the soundscape approach seems to be most interesting. As a theme park is an environment that directly tries to influence the experience of a visitor, the mood and the excitement, an understanding of the acoustic processes that occur can only be achieved by taking context and expectations into account. The effect of a sound event can differ substantially dependent on the meaning, in real life as in a fantasy world.

Soundscape analyses of urban and natural environments have been widely published in literature. This paper applies methods known from the soundscape literature such as observation and qualitative description of places, recorded soundwalks, calibrated binaural recordings, short-term sound level measurements and long-term measurements of daily exposure.

Further, new theme parks state an ideal opportunity for soundscape design because of the focus on designing the experience rather than focusing on practical issues, as it is necessary in urban planning. At the end of the paper design guidelines will be presented that result from the analysis step.

2. THE SOUNDSCAPE APPROACH

The term soundscape means the sonic environment and the corresponding perception of listeners. Physical sound sources and the space that shape the sound sources create a sound field that is perceived by in different ways depending on the context, i.e., dependent on the input of other sensory modalities, the purpose of the space, the activities, motivations and expectations of people being there and the individual sonic and cultural background. The term seems to fit best for outdoor spaces but is not limited to this [1].

This concept has been introduced in the 1970s when a group of researchers in Vancouver started the "World Soundscape Project" [2]. The leading researcher in this project, R. Murray Schafer, and his book [3] established the line of thinking that forms the basis of a paradigm shift in the way that environmental acoustics and noise are evaluated nowadays. In order to grasp a problem in a holistic way it combines objective physical measurements (sound levels) with psychoacoustic parameters (loudness, roughness, sharpness, etc.) and subjective impression (verbal descriptions, interviews, questionnaires). Especially the extension of the evaluation process to subjective and contextual analysis by conducting interviews with local experts leads to enriched results [4]. Psychoacoustic parameters then state the attempt to connect the physical measurements of a sound field to perceived properties of this sound field [5]. Applying both methods results in a holistic analysis of a problem and in a more profound design of environments.

Regarding the design of environments the soundscape approach tries rather to define qualitative criteria than quantitative criteria, i.e., focusing on what should be heard rather than on how loud something should be heard [6]. Further, an aspect is to direct attention towards sounds that are perceived to be more pleasant than other. This does not reduce the overall sound level, but it can reduce annoyance [1]. Soundscape design can also be to take care of when a sound should be heard. By analyzing the temporal or rhythmic characteristics of other elements in the soundscape, a new element can be designed that does not disturb existing ones [7].

3. ANALYSIS METHODS

In order to capture the characteristics of a soundscape several methods were applied. On the one side it is important to gather qualitative data, i.e., verbalized impression and ratings. Thereby, the semantics of sound sources and the context they are set in are inherently included in the analysis. Further, possible qualitative design criteria might be directly identified. On the other side quantitative or physical measurements should be carried out. This is also of high importance because these data allow direct comparison of the acoustic properties of the prevalent soundscapes and are more meaningful to acousticians who are most familiar with the measures. The quantitative data can then be correlated to the qualitative perceptions and design criteria can be enhanced by defining physical values that should be achieved. The soundscape measurements used in this project were:

- Filling out evaluation forms for qualitative description of single soundscapes
- Soundwalks with binaural recordings
- Short-term binaural recordings
- Short-term sound level measurements
- Long-term exposure measurement

The qualitative description technique is realized by filling out a short evaluation form on the perception of a local soundscape. The listener is situated in an environment, takes a listen and then describes the soundscpae concerning the heard elements, the perceived pleasantness and loudness and possible other observations. The results include context because the listener is assumed to understand the purpose and activities of the environment. This states a verbal, qualitative description of a soundscape and therefore deals with the semantics of sound sources and reveals the cognitive categories that arise in a listener [8].

A technique that has found a wide acceptance in soundscape research is the soundwalk method. It means in-situ listening by walking through an environment. With this method the change in the soundscape, the transitions and its relationship to the architecture and the activities of people can be evaluated [9]. In each park a soundwalk was conducted. This means that a route through the park was chosen and a walk lasted for approximately 30 minutes. By using binaural microphones to record the changing sound fields during the soundwalk and by taking photographs, the influence of the architecture and the activities of people on the soundscape experience can be efficiently evaluated.

Short-term binaural recordings and sound pressure level measurements were done at specific points of interest in the parks. The recordings can be used to evaluate the soundscape at later points or even conduct listening tests. With the sound pressure level measurements the recordings can be calibrated.

Additionally, the sound pressure level experienced over the whole day spent in a park was measured. This is an exposure level or dose measurement using a microphone placed on a person's body as close as possible to the ears.

4. RESULTS

The soundscape analysis took place in four different theme parks in Orlando, Florida, USA, during a few days at the beginning of January, 2013. All measurements and evaluations were done by the authors. The theme parks were:

- Universal Island of Adventures (UIA)
- Universal Studios Florida (USF)
- Disney Magic Kingdom (DMK)
- Sea World (SW)

The presented results focus on the soundscape of theme parks in general and not a comparison of these.

4.1 General qualitative analysis

Analyzing the soundscape evaluation forms of different places it becomes apparent that the main or most dominant sound sources are music from the public address system (P.A.) and people noises (mainly talking). This is true for all visited parks and changes in intensity dependent on the location in the park.

In case of the parks UIA and USF, Music is being played back via a global P.A. system and changes with the different zones. Each zone has a different theme, e.g. the super hero zone is followed by a cartoon zone (see Figure 1). The music can be imagined to be similar to film music. It tries to directly influence the mood, excitement and expectations of visitors.

The sounds created by people consist mainly of speech. Often laughter and screams can be heard. Dependent on the volume of the background music and the specific architecture, the sound levels of human noises is higher or lower. Open spaces tend to have lower sound levels than closed, round squares because the sound energy is preserved more easily.

Figure 1 - Map of the UIA park. The black line indicates the path of the sound-walk. Single point sound level measurements are given as $L_{A,eq}$. [Source: https://www.universalorlando.com/Resort-Information/Theme-Park-Maps.aspx]

Next to thematic music and human sounds, mechanical sounds played a vital role in the soundscape which originate mainly from outside coasters. The mechanical sounds from coasters are either due to chain lifts or drive-by noise. One example is of very high interest in this context. In the UIA park a high-speed roller coaster is located on the left, right after the entrance (see Figure 1). The drive-by noise is of high intensity and resembles the roaring sound of a gorilla or lion. This generates a sound quality that perfectly matches the theme of the ride (The Incredible Hulk) and the sound creates excitement and attracts people. This sound can also be heard nearly throughout the whole park. This is an example how a mechanical sound can possess a very constructive quality when the context and the meaning fit together. On the other hand some examples were experienced where the continuous noise generated by a chain lift can destroy the otherwise very pleasant soundscape.

Sound sources

Following the terminology of Schafer, the general classification of sound sources inside the parks is:

- Keynote sounds:
    - Themed music (program music)
    - People talking
    - Waterfalls and fountains
    - Birds (real or playback)
- Foreground sounds:
    - Coaster noises
    - Single sound events from stands and shops (e.g., bells)
    - Sound design integrated in scenic elements (e.g., dinosaurs behind trees)
- Sound marks
    - Roller coaster (e.g., Hulk coaster in UIA)
    - Screaming from people roller coasting

Categorization

In general, the categories of the soundscape and the ranking of dominance were identified as:

1. Musical
2. Human
3. Mechanical/Technological
4. Natural

Musical and human sounds were rather of equal dominance dependent on the specific location. This applies also for mechanical and natural sounds.

Assessments

In general the tenor of the soundscape inside the theme parks is: It is loud but exciting! Lo-fi soundscape that are eventful but chaotic can be found, but mostly the soundscapes were rated to be of hi-fi, creating excitement and little annoyance and serving the purpose of the space.

4.2 Acoustic itineraries

A typical itinerary for a visitor in a theme park is to walk around in the park, enter attractions, retail shops or restaurants and then walk around again. Figure **2** shows the development of sound levels for a typical itinerary of a visitor during one hour. It starts in the park itself (open areas), then an attraction is entered and one stands in the queue for in between 20-60 minutes (dependent on time of year). Queues were found to be inside at most times or at least under a roof. The acoustics of these places was mostly lacking design. High level fan noise collided with repeating media content inside a reverberant space. Before entering a show or the main attraction, mostly pre-shows are provided that last for somewhat 5-10 minutes. These spaces tend to be of good acoustic design so that the content of the pre-show can be fully enjoyed. After the pre-show the main show or ride is entered which usually lasts just for a few minutes. A media production or theatrical ride is presented usually at very high sound levels. After that visitors are guided to the exits through a retail shop into the park area again.

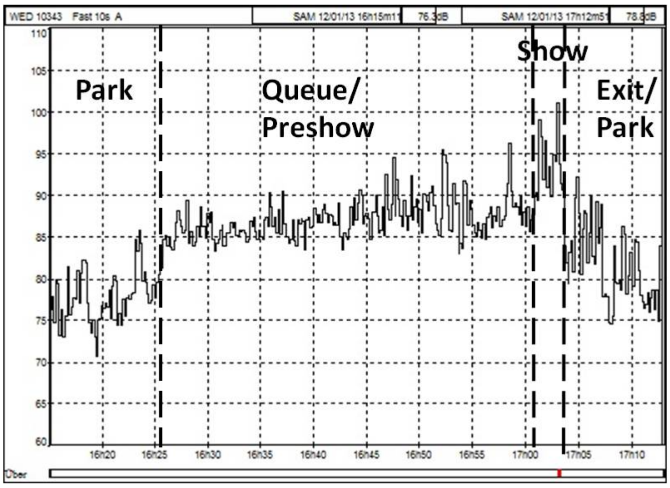

Figure 2 – $L_{A,eq}$ over time. Course of sound level along a typical itinerary of a visitor during one hour.

4.3 Architecture

The architecture of the theme parks is dedicated to the themes of the zones. In Figure **1** an overall ground floor of UIA is shown. It can be seen that visitors can only move along defined paths, with a few side paths, which are surrounded by buildings of approximately 6m-13m height. The facades are dedicated to the theme of the area. Figure 3 shows a few representative photographs. It can be seen that the facades are hardly designed to be flat but rather staggered which means that sound is generally diffused and hard reflections are reduced. However, areas of circular geometry were found which exhibit low acoustic quality. Sound energy originating from outside or inside the area is preserved because of the geometry. This leads to high sound levels that create a rather chaotic soundscape. As materials gypsum or plywood with plastering is generally used.

Figure 3 - Pictures of parts of the theme parks. Upper row: DMK, lower row: UIA and USF.

4.4 Soundwalk

In order to analysis transitions inside the parks and to capture the soundscape of the whole park in short time, a soundwalk recording with binaural microphones was conducted. Additionally photographs were taken to capture the visual architecture. As an example, in Figure 1 the route of the soundwalk in UIA is indicated and in Figure 4 the corresponding spectrogram for left and right ear recordings is shown. What can be seen is the difference in sound level dependent on the zone/location and the drastic change of the soundscape when global P.A. music is changed or when it is off. Further the high intensity of the sound produced by the Hulk coaster, in between 200Hz - 500Hz, can be seen. The soundwalk also made clear how important the soundscape is for orientation. A change in location goes together with a change in soundscape.

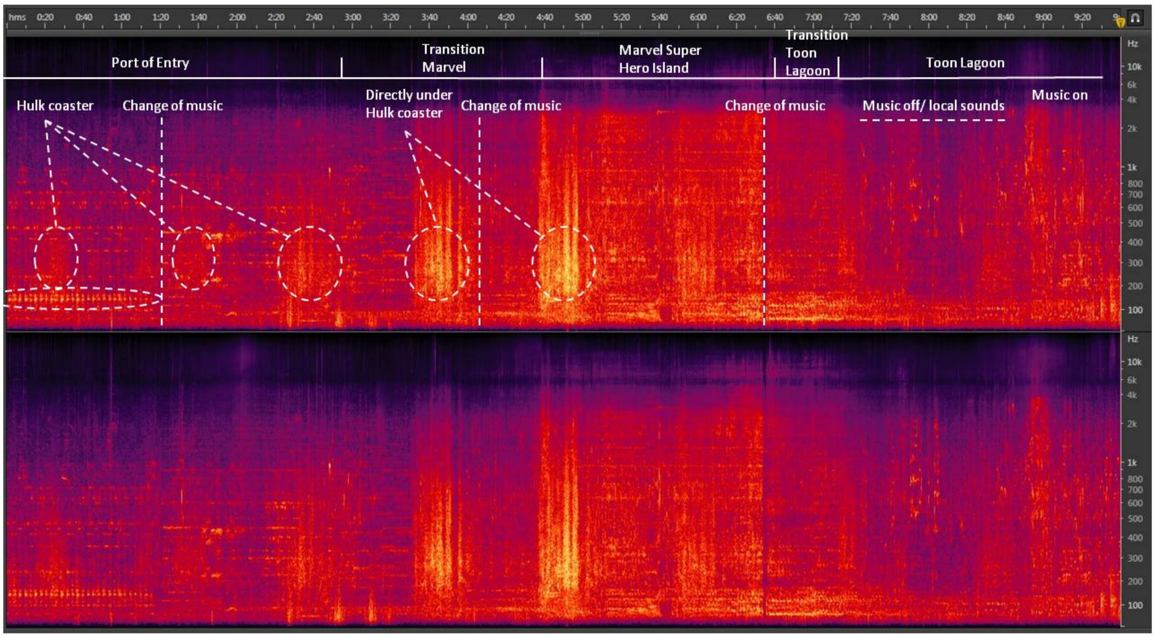

Figure 4 - Spectrogram of a 10 minutes soundwalk in UIA. Description of locations and events is included. Upper half shows left ear and lower half right ear binaural recording. Colour coding: The brighter the higher the intensity.

4.5 Short-term sound level measurements

In order to evaluate the noise generation of single elements, i.e., a carousel or a coaster, single point measurements were done. Additionally binaural recordings were taken at most of these locations. Figure **1** shows the equivalent sound levels, $L_{A,eq}$, of the measurement points in the UIA park.

As an example of detrimental acoustic design a queue area and the sprctrogram of a binaural recording is shown in Figure 5. In this example people had to wait for entering the attraction. In this time media productions were provided for entertainment. However, the audio was not hard to understand as the fans created noise masking the audio. The wall surfaces were all hard and flat so that reverberation was high.

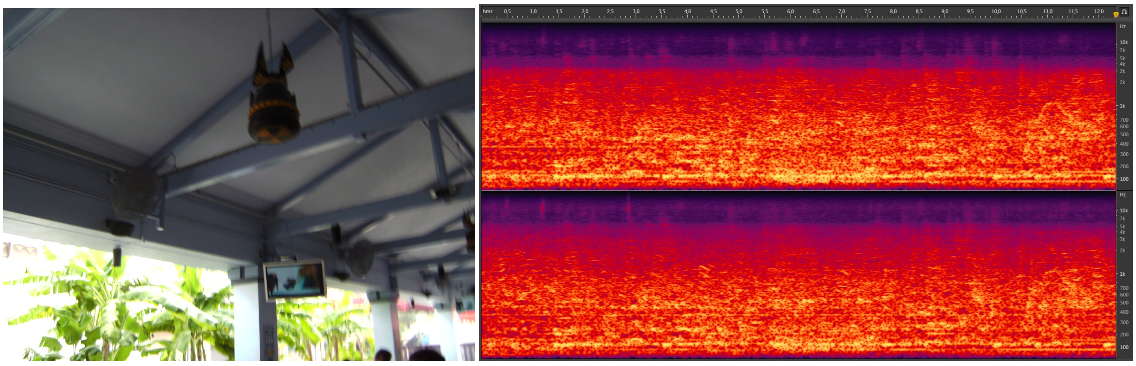

Figure 5 - Left: Queue area with fan noise, hard reflection walls, loudspeakers and screens. Right: Spectrogram of a recording. The noise floor that mask the audio content can clearly be seen.

4.6 Long-term exposure measurements

Using a dosimeter the long-term sound levels an average visitor is exposed to were measured. Table 1 shows the results of the different parks.

Table 1 – Long-term exposure measurements. All levels in dB.

Park	Time, h	$L_{A,eq}$	$L_{A,max}$/ $L_{A,min}$	$L_{C,max}$	$L_{A,1}$	$L_{A,50}$	$L_{A,95}$
UIA	~5	88	120/61	133	100	78	69
USF	~6	88	111/44	131	100	80	67
DMK	~10	86	111/51	129	96	78	68
SW	~7	85	107/56	137	96	76	64

It can be seen that an energy-equivalent sound pressure level, $L_{A,eq}$, of in between 85-88 dB(A) was measured. Regarding the time visitors usually spend in theme parks, namely a whole day, these levels reach critical values as the EU Directive 2003/10/EC defines 85dB(A) to be the maximum a working person should be exposed to during 8 hours without having to wear ear protection. This means regular visitor and also staff are endangered of hearing damage in long-term. In general, visitors are exposed to sound levels that cause fatigue and communication at normal speech effort is not possible.

Regarding the maximum sound levels, $L_{C,max}$, it can be seen that levels above 130dB(C) are experienced. These values are very critical because such high levels can cause hearing damage even if experienced for a short time.

The sound level percentiles, $L_{A,1}$, $L_{A,50}$, $L_{A,95}$, represent the sound levels that are exceeded for one, fifty or ninety-five percent of time, respectively. The average maximum level, $L_{A,1}$, was found to be in between 96-100 dB(A) which can be expected in such an entertainment environment. The base level, $L_{A,95}$, is found to be in between 64-69 dB(A). This means that normal speech effort (57-60dB(A) in 1m distance) is not enough for communication in between people at most times.

Sound pressure levels separated in time spent in attractions and in the park areas can be seen in Table 2. In between 10% - 20% of the time is spent inside attractions, show or ride only.

Table 2 – Separated exposure levels for time spent inside attractions and in the park. All levels in dB.

	Park			Attractions		
	$L_{A,eq}$	$L_{C,max}$	Time, h	$L_{A,eq}$	$L_{C,max}$	Time, h
UIA	84	127	~4,8	98	133	~0,2
USF	85	131	~5,3	97	130	~0,5
DMK	82	129	~8,8	92	125	~1,5
SW	80	120	~4,5	90	137	~1,5

5. SOUNDSCAPE CONSULTING

The soundscape approach is relatively new field of research and strategies for design are not obvious and easily applicable. However, the standard approach of defining A-weighted sound levels and noise criteria (NC) is especially in such a specialized environment not appropriate. An international standard on this topic is in work (ISO 12913) but no draft or similar documents are known to the authors. Nevertheless, it was found that the soundscape analysis directly leads to criteria for the design of new parks.

The indentified strategies are:

- The soundscapes of existing theme parks should be taken as reference
- Definition of what should be heard
- Temporal and/or spectral adjustment of sound sources
- Evaluation of the sound design of rides and roller coasters
- Reduction of HVAC noise sources
- Definition of quiet zones
- The use of speech spectra and levels as reference for background noise evaluation
- Definition of equivalent sound levels for the general P.A. system
- Definition of equivalent sound levels for restaurants and retail shops

6. SUMMARY

This study presented an analysis of the soundscape of different theme parks in Orlando, Florida, USA. Qualitative descriptions of the soundscape were used to capture the context sound sources are set in and to evaluate overall characteristics of a soundscape. The most dominant sound sources were themed music from the general public address system and people talking. Typical itineraries were examined concerning the development of sound levels. The architectural properties are generally acoustically diffusing but unfortunate layouts of building were identified. Soundwalks were conducted for the evaluation of changes and transitions in the soundscape and thereby more or less pleasant areas were quickly identified. Single point measurements provided insights in the sound levels and quality of outdoor attractions and helped in describing areas of detrimental acoustic design. The exposure of visitors to sound was evaluated using long-term sound level measurements. It was found that in all parks a daily dose of in between 85-88 dB(A) is experienced. These values are of critical concern. The soundscape approach directly aided in defining requirements and guidelines for the design of new theme parks. Possible disturbing sound sources were quickly identified and the matter of the contextual sound quality was raised which clarifies the need of specific sound quality evaluation or sound design for new attractions. The measurements methods applied aided in the process of development of strategies.

Theme park soundscapes are loud but exciting. A diverse soundscape, dominated by musical and human sounds, only partially influenced by mechanical sounds, yields a lively combination. As a design goal this should be preserved. Only the general sound levels of music reproduction should be reduced.

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