Management Of Networked IoT Wearables – Very Large Scale Demonstration of Cultural Societal Applications
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D4.6 ASFC System and Noise Monitoring System for Pilot 1-6 1

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1.0	Patricio MUNOZ (ACOU)	2018-06-29	Final version submitted to the European Commission

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Index:

1 Executive Summary

A demonstrator will be deployed during Kappa Futur Festival 2018 (KFF 2018) in Turin, Italy. The main purpose of demonstrator is to test the systems' performances in real conditions at different stages of advancement during the project. By the date systems have been tested separately in laboratory and in on field conditions. Kappa Futur Festival 2018 will be the first time both ASFC and Noise Monitoring System will be deployed and tested together.

This document presents a description and a review of the current state of progress of three systems: Noise Monitoring System, Adaptive Sound Field Control (ASFC) System and Quiet Zone System. Corrective actions taken after feedback from tests carried out up to now are also described.

It also provides a description of the site where the KFF 2018 takes place and the systems set up as it is planned to be operating during demonstrator on July 2018. Limitations on systems deployment, mainly related to that the systems are still under development, are pointed out.

An overview is provided here below:

Adaptive Sound Field Control (ASFC)

- The concept of the ASFCS has been verified in the laboratory in anechoic conditions and small scale and in an outdoor experiment in a realistic scale.
- The ASFCS reduces the sound level in the dark zone considerably when using directly and densely measured transfer-functions between the loudspeakers and the control zones. The propagation model can be used to use less microphone positions in the two zones.
- During KFF 2018, Stage 4 will be equipped with the ASFC system. The system will be used to mitigate noise in the direction of the nearest neighbours. The ASFC loudspeakers are planned to be positioned in between the dark zone and the PA system of stage 4.
- The ASFCS has until now been tested with known test signals. For real time applications music signal has to be processed in real time. The digital signal processor responsible for this processing is still under development and the "sniffer" (device for converting the loudspeaker amplifier output signal for using in digital signal processor) has to be thoroughly tested.
- The transfer-function measurements have until now been conducted with standard wired microphones. In the pilots the dark zones are far away from the venue and system rely on B&K's wireless sound level meters. It has to be verified that these can be used for accurate transfer-function measurements. One possible issue could be the clock synchronization between the sound level meters and D/A converters. To ensure accurate transfer-function measurements for Kappa Futur Festival, B&K will provide an alternative system that can perform time synchronisation over large distances.

Noise Monitoring System

<u>Sound Level Meter</u>

- Tests in May 2018 have revealed abnormal sound pressure level readings (around 20 dBA in a noisy environment). Causes were investigated by B&K. Corrective actions were taken and the problem has been fixed.
- A total of 10 SLM IoT prototypes are planned to be deployed on KFF 2018. Prototypes are expected to provide overall sound pressure levels, 1/3 octave band spectra. Audio data (FLAC format) is under development.
- Exact positioning of SLM IoT prototypes are still under discussion. A compromise should be taken between ASFC system precision, monitoring covering on audience and neighbour areas, as well as network availability.
- Tests in May 2018 have revealed some network connection instabilities of the SLM prototype. SLM prototype WiFi has been updated with new firmware which has dramatically improved the connectivity, so connection problems should not be due to the SLM anymore. Limitations should

arise depending on network traffic at the site. B&K has worked to be ready to connect using both WiFi where that is available and 4G where there is no WiFi.

- GPS functionality is currently under development. GPS functionality will allow both automatic location and, probably most important, GPS time stamps for synchronization of data.

Annoyance measures

- Since SLM IoT prototypes are under development, Acoucité has been collecting data by using classical non IoT SLM during: Nuits Sonores 2017, Kappa Futur Festival 2017, Movida, Fête des Lumières 2017 Nuits Sonores 2018. Collected data consist in overall sound pressure levels stored every second, as well as audio recordings in WAV file format. All of that corresponds to raw data used to build the acoustics and psycho-acoustics indicators for annoyance/comfort likelihood and sound quality perception estimation.
- Indicators for annoyance/comfort likelihood and sound quality perception estimation are by the date still under development. Work is being focused in finding an appropriated approach to take into account low frequency noise, which has been identified as being source of annoyance.
- Getting feedback from goers and neighbours concerning expressed annoyance/comfort and sound quality perception are also required in order to evaluate the pertinence of the acoustics and psycho-acoustics indicators. A survey concerning noise annoyance in neighbours will be conducted after the festival period by using Google Forms. This survey will be an improved version of the one carried out during KFF 2017. Improvements planned to be done are: 1) changes on semantics to bring more precision to questions, 2) changes on the order of questions to decrease bias effect, 3) provide a "rough" geolocalisation of data to help the comparison between survey results (perceptual dimension) and acoustics measurements (physical dimension). This is planned to be done by separating the residential area within the surroundings in a certain number of zones.

Noise Heat Map

- The propagation model of the ASFCS (which estimates the transfer-functions) could be used to compute a map of sound level distribution around the convert venue. However, this model is not yet available
- Until now a preliminary *sound heat map module* has been developed using LAeq measurements of the wireless sound level meters to compute such a map and makes it available to the MONICA cloud via a REST API (this preliminary module has been used in Rhein in Flammen 2018).
- In the future, it is planned though to combine the two systems such that a meaningful noise heat map can be computed.
- In the meanwhile a simplified Sound Heat Map is being developed with the joined effort of Movement, Politecnico di Torino, DTU and City of Torino (based on to pre-calculated sound maps). Unfortunately, this method for generating Sound Heat Maps will not be ready for KFF 2018 (expected to be operating for tests in Friday Rock, Tivoli, august 2018).

Source Separation/Contribution techniques

Source contribution algorithm is under development and will not be tested during Kappa Futur Festival 2018. However, some information about the status of source contribution algorithm is provided in §3.2.3.

Quiet Zone System

The Quiet Zone System is still under development, and will not be used at Kappa Futur Festival in 2018. The progress in the development is however still described in §3.2.2.

2 Introduction

European research project MONICA aims to demonstrate how cities can use IoT technologies to manage sound and security at large, open-air cultural and sporting events taking place in the city. Six major European cities are involved as experimental sites, also called pilots: Bonn, Copenhagen, Hamburg, Leeds, Lyon and Turin.

During the process of requirement engineering (WP2), 4 pilots have expressed their interest on the Use Case Group Sound Monitoring and Control (Use Case Group 1) for their events: Bonn (Rhein In Flammen), Copenhagen (Friday Rock), Lyon (Nuits Sonores and Fête Des Lumières) and Turin (Kappa Futur Festival and Movida). Three systems are being developed and tested:

- Noise Monitoring System
- Adaptive Sound Field Control (ASFC) System
- Quiet Zone System

This document presents:

- A description of the three systems
- The current state of progress of ASFC System based on tests performed in laboratory conditions and in outdoor conditions in Refshaleøen (Copenhagen, May 2018).
- The current state of progress of Noise Monitoring System based on:
    - Tests on Brüel & Kjær Sound Level Meter IoT prototype during Rhein in Flammen (Bonn, May 2018) and Nuits Sonores (Lyon, May 2018)
    - Latest information (by the date) on the development of Source Separation/Contribution techniques, Annoyance measures and Noise Heat Map
- A description of the Kappa Futur Festival tests (description of the site and the planned configuration of systems) were both ASFC and Noise Monitoring System will be deployed and tested together for the first time.

Further demonstrator of advancement state of the three systems will be covered in deliverable D4.7 planned to be issued by month 32 (August 2019).

3 ASFC System, Quiet Zone System and Noise Monitoring System

3.1 General

ASFC System, Quiet Zone System and Noise Monitoring System are the three main components of MONICA project dedicated to manage sound environment. These systems aim enhancing sound experience of the audience and mitigating noise annoyance in residential areas surrounding large scale events.

MONICA deliverables D4.1 and D4.4 provide detailed information about ASFC System, Quiet Zone System and Noise Monitoring System. A brief description of each system (extracts from deliverables D4.1 and D4.4) and a simplified flow diagram are presented 3.1.1 to 3.1.4.

3.1.1 ASFC System

Here below some extracts from deliverable D4.1 to describe the ASFC System:

“Loudspeaker systems for outdoor sound reinforcement typically consist of two loudspeaker line arrays and a set of subwoofers arranged in a horizontal array or as two left-right clusters. In the ASFC, these systems (primary sources) are extended by the use of additional low frequency loudspeakers (secondary sources). These are placed behind the audience in between the primary sources and the neighbouring region in which the sound from the event should be reduced (dark zone).”

“The basic idea is to optimize the radiation from the secondary sources in such a way, that the sum of sound pressures from the primary and secondary sources effectively reduces the total sound pressure level in the dark zone. Use of additional loudspeakers to control the sound in the dark zone must not negatively impact the sound experience in the audience area, the bright zone. This restriction must be included in the loudspeaker configuration design by either using directive loudspeakers facing away from the bright zone for the secondary sources or in the formulation of the loudspeaker signal optimization problem.”

“A well performing ASFCS will enable a high sound pressure level in the bright zone relative to the sound pressure level in the dark zone. A performance indicator for this problem is the acoustic contrast, which is the difference of the mean SPL in the bright zone to the mean SPL in the dark zone”.

3.1.2 Quiet Zone System

Deliverable D4.1 provides also a description of the Quiet Zone System, some extracts hereafter:

“The quiet zone system is a noise barrier which makes use of active elements to cancel out low frequencies and passive elements to block high frequency noise. The goal is here to obtain the highest possible attenuation of noise across the whole listening spectrum. The system is integrated into the ASFC environment and provides local quiet zones within or close to the optimized sound-field of the ASFC system without interference.”

3.1.3 Noise Monitoring System

The following paragraphs were selected from deliverable D4.1 to briefly explain the Noise Monitoring System:

“The Noise Monitoring System consists of the Source Separation/Contribution techniques (T4.4), the Annoyance measures (T4.4), the Noise Heat Map (T4.3&4) and the Sound Level Meter (T4.2); the latter, including the first version prototype of the Sound Level Meter as well as its interface with the MONICA Cloud through the Sound Level Meter Gateway, is in detail described in deliverable D4.4, and is thus not further covered here.

Regarding the Source Separation/Contribution techniques, the aim is to estimate the amount of noise contribution - in sound pressure level in decibels (dB) over time or similar - that originates from the actual concert in the presence of background noise originating from other noise sources (such as traffic noise, people talking, etc.).

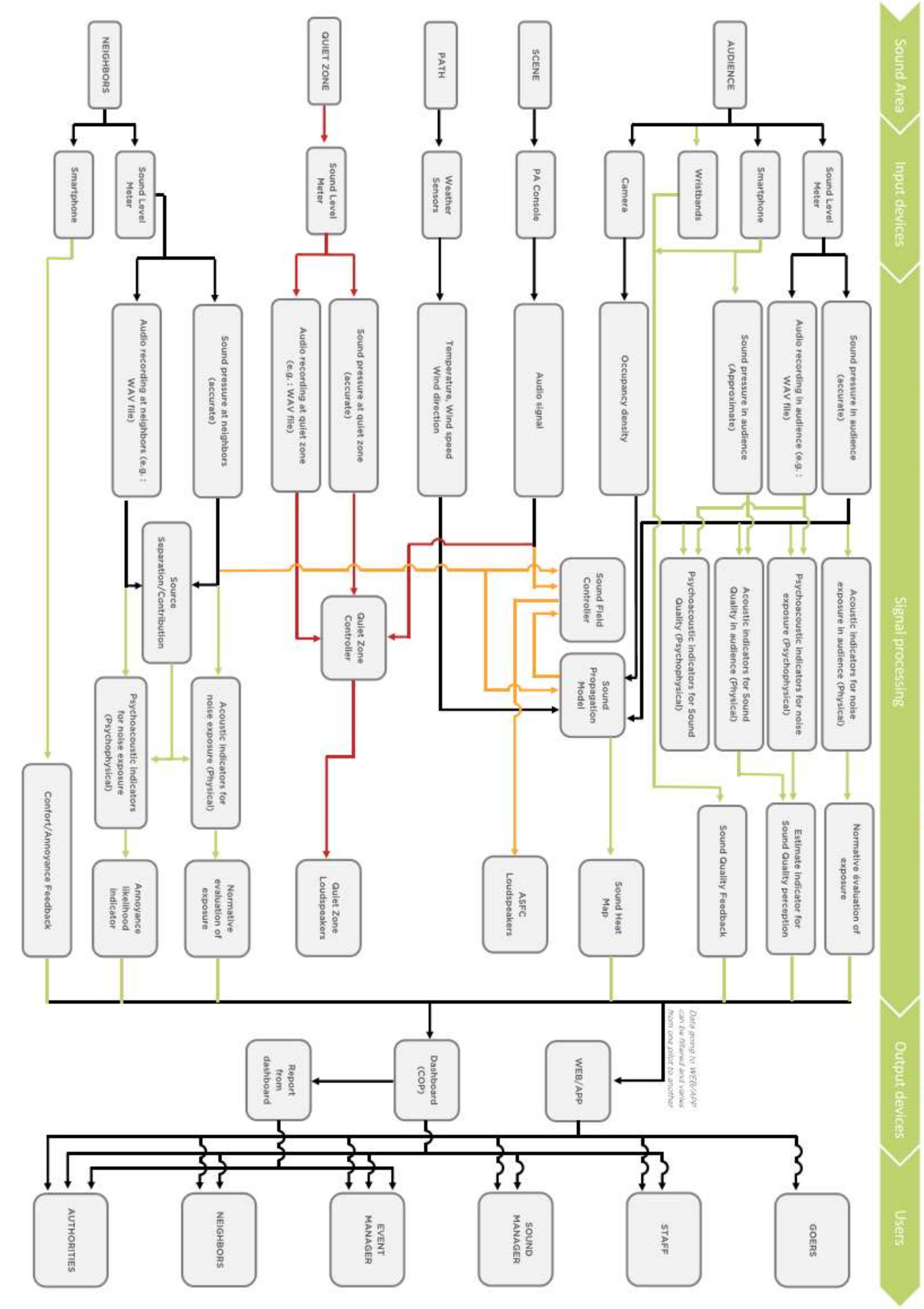
Thus, it should answer the question: Is the noise coming from the concert or from other sources?”

“The purpose of the Annoyance index is to give a more accurate estimate of noise annoyance, based on subjective perception data. This will require an app that can provide subjective feedback, which is still under development.

The Noise Heat Map will give an estimate of the sound pressure level (SPL) at other positions than the one being measured by the Sound Level Meter. This will be done using the forward sound propagation model developed in T4.3, based on the existing sound propagation model Nord2000”.

3.1.4 Flow diagram

Here below a simplified flow chart to synthetize how the different steps on every system are linked.


Common
Noise Monitoring System
ASFC System
Quiet Zone System
Sound Area
Input devices
Signal processing
Output devices
Users
AUDIENCE
SCENE
PATH
QUIET ZONE
NEIGHBORS
Sound Level Meter
Smartphone
Wristbands
Camera
PA Console
Weather Sensors
Sound Level Meter
Sound Level Meter
Smartphone
Sound pressure in audience (accurate)
Audio recording in audience (e.g. : WAV file)
Sound pressure in audience (Approximate)
Occupancy density
Audio signal
Temperature, Wind speed Wind direction
Sound pressure at quiet zone (accurate)
Audio recording at quiet zone (e.g. : WAV file)
Sound pressure at neighbors (accurate)
Audio recording at neighbors (e.g. : WAV file)
Acoustic indicators for noise exposure in audience (Physical)
Psychoacoustic indicators for noise exposure (Psychophysical)
Acoustic indicators for Sound Quality in audience (Physical)
Psychoacoustic indicators for Sound Quality (Psychophysical)
Sound Field Controller
Sound Propagation Model
Quiet Zone Controller
Source Separation/Contribution
Acoustic indicators for noise exposure (Physical)
Psychoacoustic indicators for noise exposure (Psychophysical)
Normative evaluation of exposure
Estimate indicator for Sound Quality perception
Sound Quality Feedback
Sound Heat Map
ASFC Loudspeakers
Quiet Zone Loudspeakers
Normative evaluation of exposure
Annoyance likelihood indicator
Confort/Annoyance Feedback
Data going to WEB/APP can be filtered and varies from one pilot to another
WEB/APP
Dashboard (COP)
Report from dashboard
GOERS
STAFF
SOUND MANAGER
EVENT MANAGER
NEIGHBORS
AUTHORITIES

3.2 State of progress

At this time, solutions are still under development. Thus, systems are not yet ready to work under their full functionalities. An overview of the state of progress of each system is provided hereafter.

3.2.1 ASFC System

During the months 12 to 16 the active sound field control system has been tested in both laboratory conditions and in a larger scale outdoor test using professional audio equipment.

Laboratory experiment

Figure 1 shows a photo of the experiments. The primary loudspeakers on the right hand side are simulating a subwoofer line array of a sound reinforcement system (PA loudspeakers). The secondary double layer loudspeakers in the middle (ASFC loudspeakers) are cancelling the sound of the primary loudspeakers to the region left of the secondary loudspeakers (dark zone) while minimizing the impact of the secondary sources to the area left of them (bright zone).

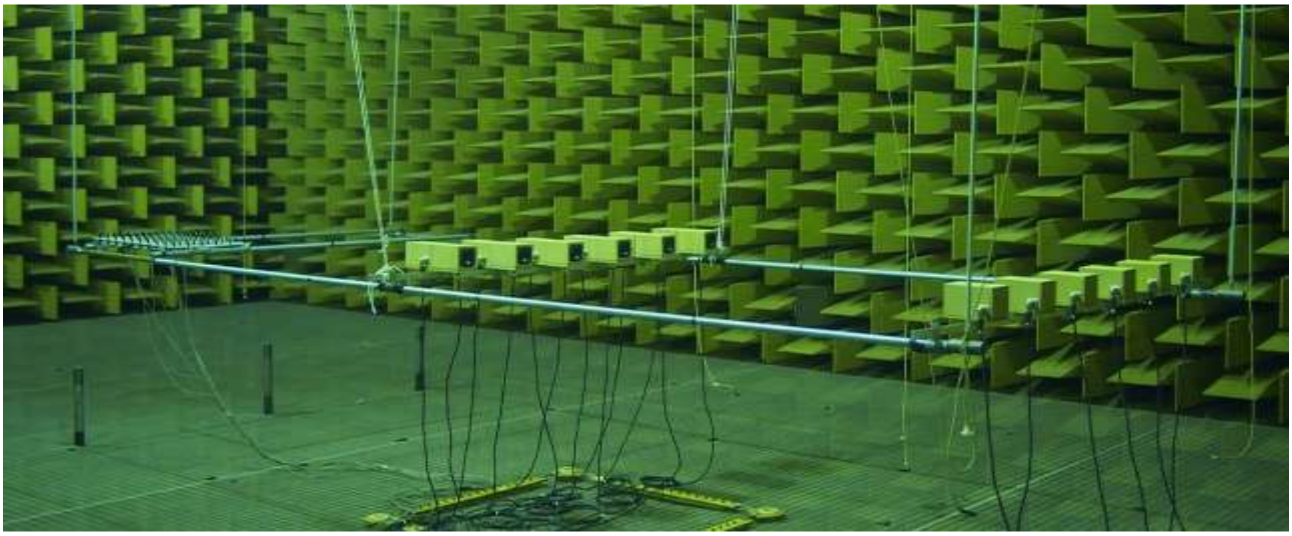


Figure 1: Laboratory experiment of the sound field control system in DTU's anechoic chamber

The loudspeaker signals controlling the secondary sources are optimized according to two objectives: 1) reducing the total sound pressure in the dark zone and 2) reducing the impact of the secondary sources onto the bright zone. Two performance metrics can be used to quantify these objectives.

The *insertion loss* is defined as the mean decrease in sound pressure level in the dark zone. Activating the sound field control system will reduce the sound pressure level in the dark zone by the given amount. Higher values mean a better reduction in sound level.

The *primary to secondary ratio* is defined as the ratio of mean sound pressure levels in the bright zone due to primary and secondary sources. The value quantifies how much louder the primary sources are in the dark zone in comparison to the secondary sources. A higher value means that the secondary sources are less likely to interfere with the sound experience in the bright zone.

Figure 2 shows the two metrics for the laboratory experiment. In words, these numbers show that the sound in the dark zone can be considerably reduced below 1 kHz while the secondary sources are not noticeably in the bright zone. Displayed results are based on a dense grid of measurements and on a few number of measurements in combination with a sound propagation model. It should be noted that the former case is not realistic to be in use in a real venue setup.

The relatively large bandwidth in which there is considerable insertion loss is due to the small scale of the experiment. At larger scales the reducing will be more focussed towards lower frequencies.

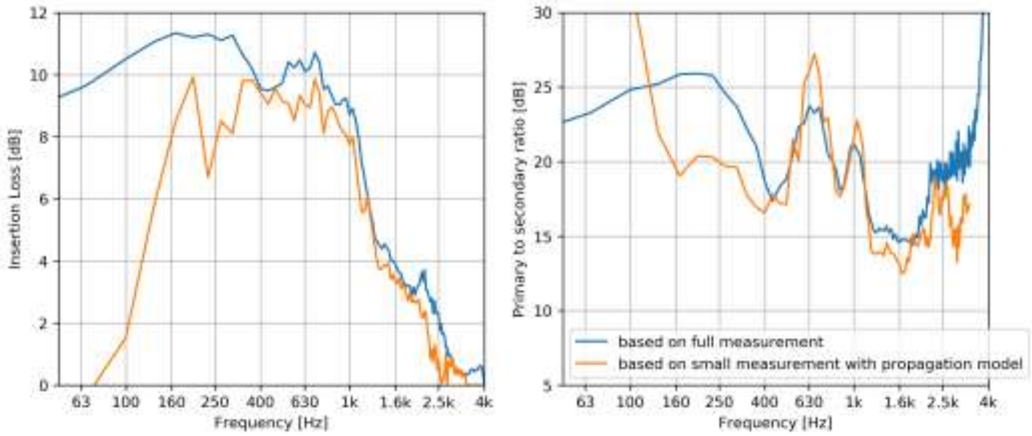


Figure 2: Comparison of performance of sound field control system based on transfer-functions that were directly measured or estimated by the sound propagation model.

Outdoor test with professional audio equipment

Figure 3 shows a photo of the larger scale experiment from beginning of May 2018 on the peninsula of Refshaleøen. At this test DTU could verify that the sound field controller is also working with professional audio gear at large scales in a realistic environment.

Figure 3: Outdoor test of the sound field control system with a professional sound reinforcement system.

Figure 4 shows the two performance measures of the sound field control system at this test. These are estimated from a dense set of transfer-functions measurements.

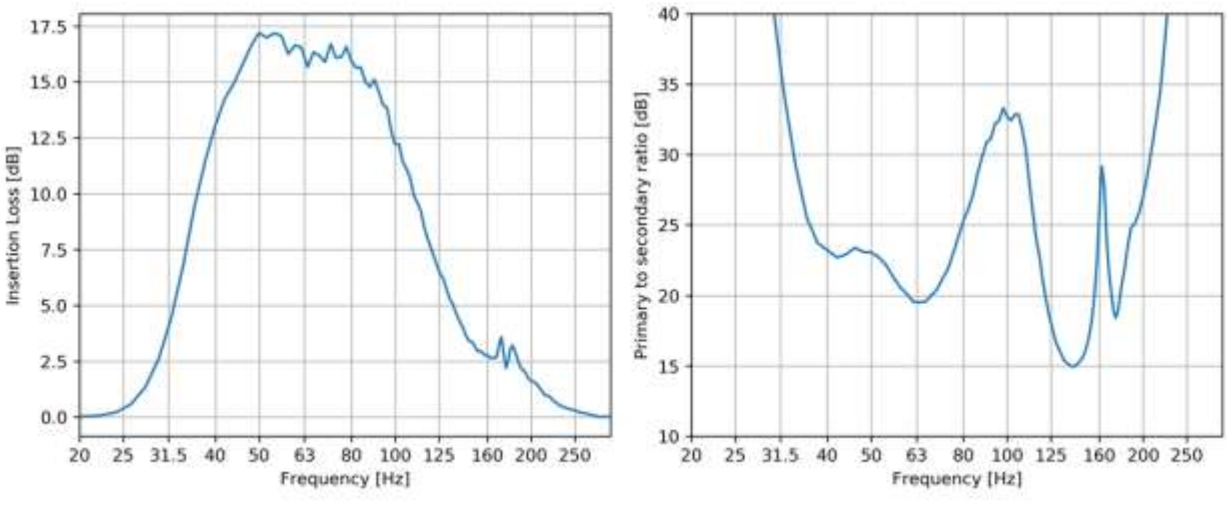


Figure 4: Performance metrics of sound field control system at the outdoor test.

Current status

The concept of the ASFCS has been verified in the laboratory in anechoic conditions and small scale and in an outdoor experiment in a realistic scale.

The ASFCS reduces the sound level in the dark zone considerably when using directly and densely measured transfer-functions between the loudspeakers and the control zones. The propagation model can be used to use less microphone positions in the two zones. This approach leads to similar results in anechoic conditions. In the more complex conditions, e.g. the outdoor test, the propagation model needs to be improved to reach similar performance.

A device for converting the loudspeaker amplifier output signal to line levels, the "sniffer", has been developed. It will be used to feed the amplifier output signal into the ASFC system as a reference signal.

Development plan until Kappa Futur Festival 2018 pilot

The ASFCS has until now been tested with pre-convolved test signals. For real time application of the ASFCS the music signal, or "sniffer output", has to be convolved in real time with the Finite Impulse Response (FIR) filters for each control loudspeaker. The digital signal processor responsible for this multichannel convolution is still under development and the sniffer has to be thoroughly tested.

The transfer-function measurements have until now been conducted with standard wired microphones. In the pilots the dark zones are far away from the venue and system rely on B&K's wireless sound level meters. It has to be verified that these can be used for accurate transfer-function measurements. One possible issue could be the clock synchronization between the sound level meters and our D/A converters. To ensure accurate transfer-function measurements for Kappa Futur Festival, B&K will provide an alternative system that can perform time synchronisation over large distances.

Development plan for next year

Changing environmental conditions can change the sound propagation over time. Until now, the ASFCS is tuned once for the conditions during that tuning. A change in conditions can degrade the performance. DTU is planning to look into ways to make the ASFCS adaptive to such changes, i.e. the system is continually tuned for maximum performance, such an adaptive algorithm is planned to be tested in 2019.

One way of adapting the propagation model to changing conditions is by pre-calculating as many weather scenarios as possible for the same venue. This data can be used to train a statistical model which will behave in the same way as the physical model but with a faster calculation time, allowing real time adaptation during the concert. So far only LAeq levels are shared in the MONICA cloud and the weather sensors are not deployed.

3.2.2 Quiet Zone System

The Quiet Zone System is still under development, and will not be used at Kappa Futur Festival in 2018. The progress in the development is however still described here.

Design Parameters

In simulations, different aspects of the design of the quiet zone system have been investigated. The design is constrained by practicalities, costs and its impact on the surroundings, which means that unwanted acoustic energy could be emitted by the quiet zone system itself. A quiet zone, which is quiet in a defined area but introduces noise into the surrounding, lacks meaning. The positioning of the secondary sources is e.g. limited by the dimensions of the speakers – which means they can't be put very close to each other. On the other hand having them far away from each other would just be impractical. The number of speakers and microphones should be as low as possible in order to minimize the costs.

In that sense the simulations investigate specifically:

1. the optimal distance of the quiet zone to the secondary sources
2. the optimal distance in between the secondary sources
3. the optimal number of secondary sources.

The optimal distance of the quiet zone to the secondary sources

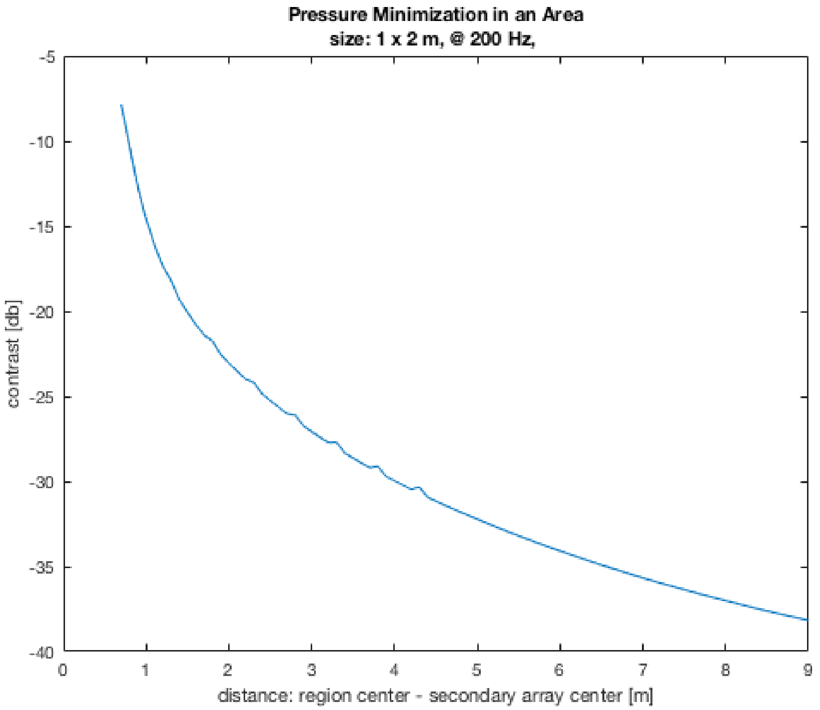


Figure 5: the maximum amount of attenuation of noise increases with the distance in between the secondary array and the quiet zone. The figure shows the amount of attenuation achieved in average in a 1x2m zone of quiet and by using five secondary sources. (contrast: SPLtotal average in QZ – SPLnoise average in QZ)

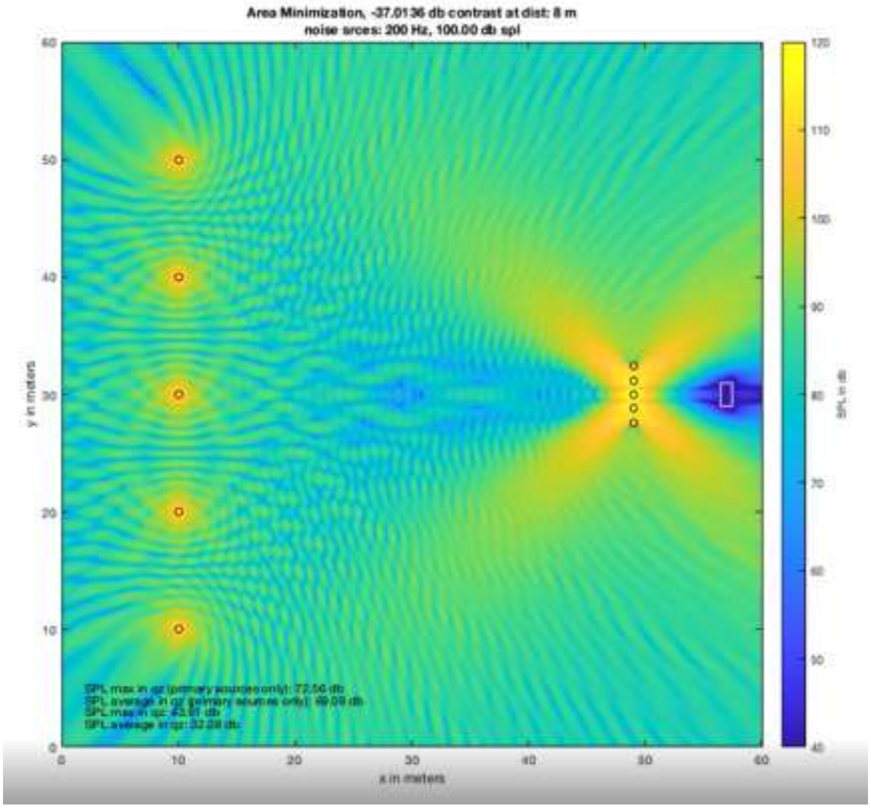


Figure 6: this figure shows how the output power of the secondary sources increases with distance to the quiet zone. In order to produce the maximum of attenuation in the quiet zone at 8m distance the secondary sources have to produce very high sound pressure levels which radiate into the environment.

As a result it can be determined that the distance of the zone of quiet to the secondary sources is a trade off in between the maximum amount of attenuation possible and the maximum allowed output power of the secondary sources. Finally, a distance of about 1.5 to 2m will be chosen which is also practical for the physical implementation of the system.

The optimal distance in between the secondary sources

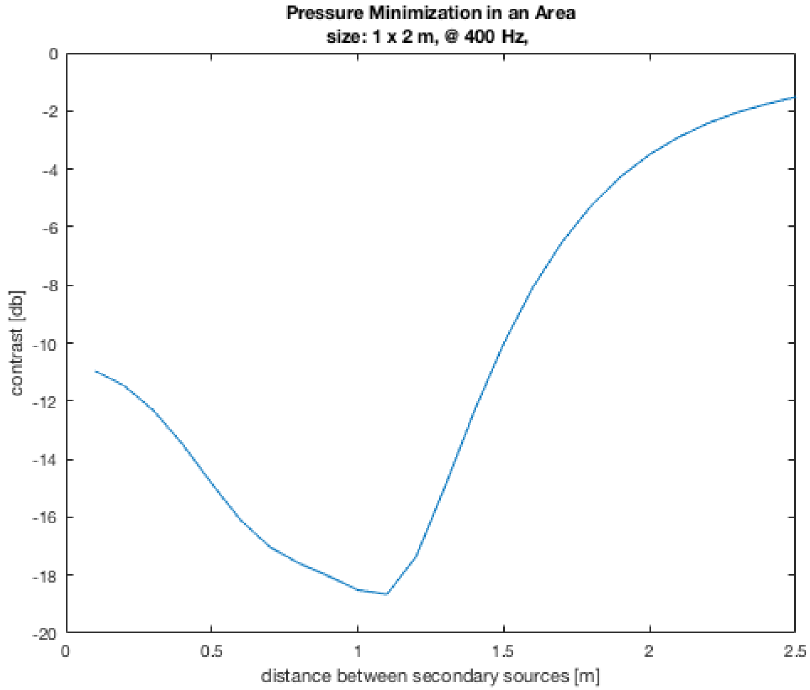


Figure 7: the amount of attenuation is shown in dependence of the distance in between the secondary loud speakers. For a series of frequencies this dependency has been plotted and it seems that there is an optimal distance of 1-1.2m secondary source distance for frequencies up to 500 Hz.

As a result it can be determined that the distance in between the secondary speakers has an approximate optimum in about 1-1.2m. For very low frequencies this distance actually increases but does not have a big impact on the contrast so that deviation from the optimum doesn't result in big losses of attenuation.

The optimal number of Secondary sources

The number of secondary sources has a big impact on the costs of a quiet zone system. In so far should the number of these as small as possible. From simulations it has been investigated that the number of speakers also depends on the frequency range of interest. For frequencies up to 200 Hz more than three speakers do not have a significant impact anymore. For frequencies up to 500 Hz more than 5 speakers only result in marginal increase of attenuation. A final decision about the number of speakers will be postponed until the passive noise barrier has been introduced, which is supposed to block the high frequency part of the noise. When the passive element achieves good attenuation down to low frequencies then the number of secondary sources can be reduced.

Active Noise Control

The active cancelling of noise is performed with adaptive filters. Until now a single input/single output (SiSo) FxLMS (Filtered-X Least-Mean-Square) algorithm has been successfully applied to cancel low frequency noise up to 1 kHz under laboratory conditions (an anechoic chamber). The same installation has been used as shown in figure 1 and which is used to validate the Active Sound field Control algorithms. Figure 8 shows a spectrum of the attenuated white noise signal in steady state of the adaptive filter – which means the filter has reached its optimum. Attenuation of up to 20db has been achieved.

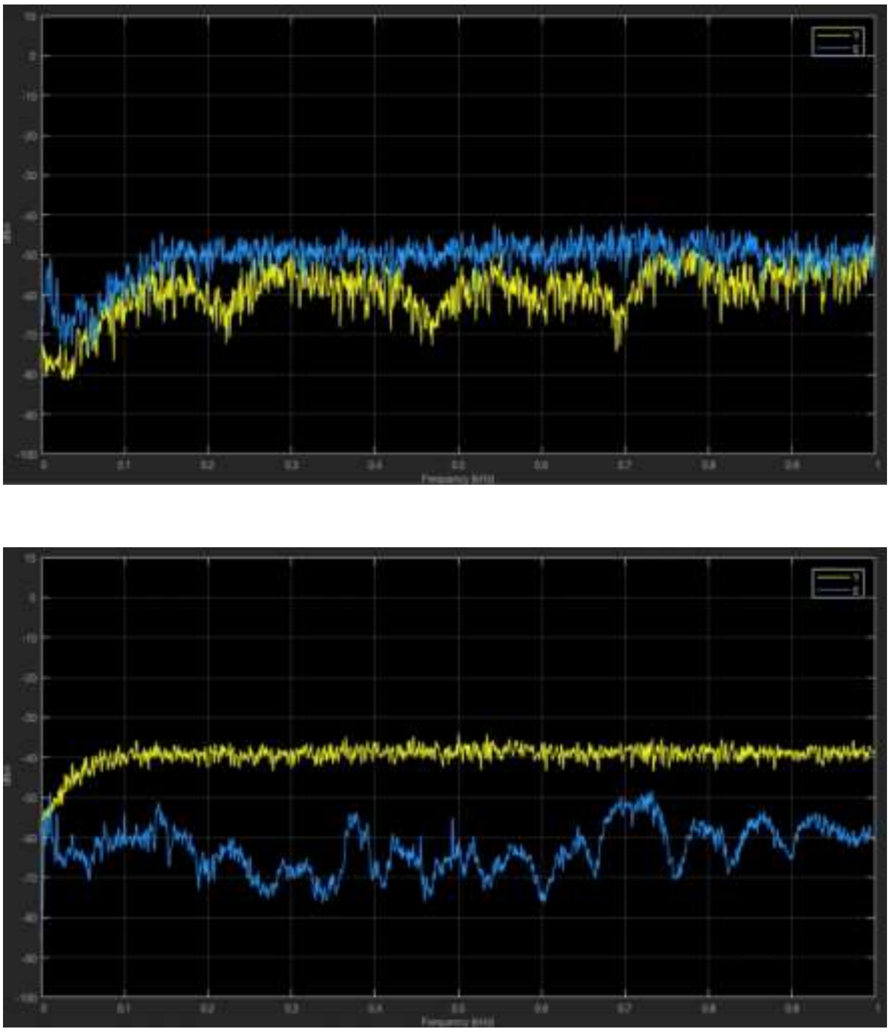


Figure 8: This figure shows the noise signal (blue) and the controller signal (yellow). TOP: The adaptive filter hasn't converged yet, the noise signal looks like without active control (around -50db). BOTTOM: The adaptive filter has converged/reached steady state and the noise signal is attenuated up to 20db (-50db -> -70db).

A multi-channel Active Noise Cancelling algorithm has very recently been implemented which successfully cancels sound in simulations. See Figure 9 where three secondary sources cancel sound in three microphone positions.

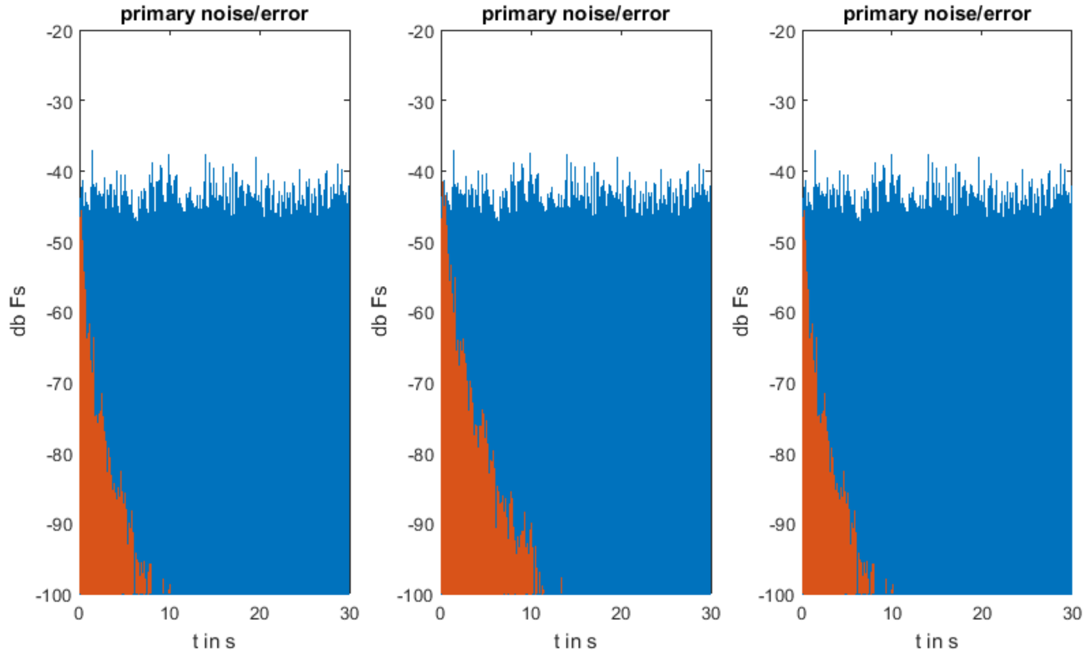


Figure 9: This figure shows the noise signal (blue) at three error microphone positions. The red signal is the total pressure at the error mics. It can be seen how the adaptive filter comes in and reduces the total pressure over time.

Next Steps

1. **Multichannel:** The multichannel FxLMS algorithm is very close to being tested in real conditions. During month 19-20 such a multichannel system will be tested and optimized.
2. **Passive Barrier:** A passive noise barrier will be added and the coexistence will be investigated. The existence of the passive element might introduce problems into the active part.
3. **Prototype Development:** a prototype has to be physically implemented in July/August, which means a robust system, which is ready to be tested in Tivoli, end of August. Thus, the system will not be tested at Kappa Futur 2018.

3.2.3 Noise Monitoring System

Sound Level Meter

Tests of Sound Level Meter (SLM) IoT prototypes were carried out in May 2018 during Rhein in Flammen and Nuits Sonores. During this tests, SLM prototype only provided overall sound pressure level (SPL). Sound Pressure Level spectra and audio recordings were not available yet.

B&K aims to have spectra ready for KFF 2018. By the date, spectra is already working (1/3 octave band values), and Audio data is under development. Audio data will be in FLAC format.

Tests in May 2018 has revealed some network connection instabilities of the SLM prototype. Also, abnormal values (around 20 dBA in a noisy environment) were identified. Causes were investigated by B&K in order to take the following corrective actions:

- SLM prototype WiFi has been updated with new firmware which has dramatically improved the connectivity, so connection problems should not be due to the SLM anymore. Limitations should arise depending on network traffic at the site. B&K has worked to be ready to connect using both WiFi where that is available and 4G where there is no WiFi.

- Abnormal sound pressure level values issue has also been fixed.

GPS functionality is currently under development. GPS functionality will allow both automatic location and, probably most important, GPS time stamps for synchronization of data.

Annoyance measures

Getting data for developing indicators for noise monitoring are limited by SLM IoT prototypes capabilities. Since SLM IoT prototypes are under development, Acoucité has been collecting data by using classical non IoT SLM during:

- Nuits Sonores 2017 (by using 1 SLM and a binaural audio recording system from Acoucité)
- Kappa Futur Festival 2017 (by using 6 SLM and a binaural audio recording system from Acoucité)
- Movida (by using a binaural audio recording system from Acoucité. Data collected by Turin fixed monitoring system has also been exploited)
- Fête des Lumières 2017 (by using 3 SLM provided by B&K and 5 SLM and a binaural audio recording system provided by Acoucité)
- Nuits Sonores 2018 (event by using 1 SLM IoT prototype provided by B&K and 8 SLM and a binaural audio recording system provided by Acoucité)

Collected data consist in overall sound pressure levels (A-weighted and C-weighted) stored every second, as well as audio recordings in WAV file format. All of that corresponds to raw data used to build the acoustics and psycho-acoustics indicators for annoyance/comfort likelihood and sound quality perception estimation.

Indicators for annoyance/comfort likelihood and sound quality perception estimation are by the date still under development. Work is being focused in finding an appropriated approach to take into account low frequency noise, which has been identified as being source of annoyance[1].

It is to notice that getting feedback from goers and neighbours concerning expressed annoyance/comfort and sound quality perception is also required in order to evaluate the pertinence of the acoustics and psycho-acoustics indicators.

Noise Heat Map

The propagation model of the ASFCS (which estimates the transfer-functions) could be used to compute a map of sound level distribution around the convert venue. However, this model is not yet available and until now a preliminary *sound heat map module* has been developed using LAeq measurements of the wireless sound level meters to compute such a map and makes it available to the MONICA cloud via a REST API (this preliminary module has been used in Rhein in Flammen 2018). In the future, it is planned though to combine the two systems such that a meaningful noise heat map can be computed.

In the meanwhile a simplified Sound Heat Map is being developed with the joined effort of Movement, Politecnico di Torino, DTU and City of Torino. The main idea is to pre-calculate sound maps in the area of the festival, using an advanced propagation model, and find the best fitting of the gain of the sources to the measured data at the microphones. This will be possible thanks to the deployment of IoT microphones, allowing more accurate results than the usual forward predictions. Unfortunately, this method for generating Sound Heat Maps will not be ready for KFF 2018 (expected to be operating for tests in Friday Rock, Tivoli, august 2018).

Source Separation/Contribution techniques

Source contribution algorithm is under development and will not be tested during Kappa Futur Festival 2018. However, some information provided by B&K about the status of source contribution algorithm is provided here below:

The recordings done in Tivoli Friday Rock 2017 were processed with the transmissibility approach, and the contribution of concert activities in neighbouring areas shows a clearer picture on the noise impact of concert

[1] Survey results of Kappa Futur Festival 2017 in "D10.2 Acoustics Assessment Report of MONICA Pilot Sites".

activities. The algorithm was also validated in a laboratory environment where the true contribution is known. The approach will be extended to take multiple microphones in the concert area into account simultaneously, and the preparation for implementing the algorithm in B&K Gateway has started. Labelling of audio recordings in Tivoli is currently in progress for the contribution analysis based on machine learning. The initial classification of concert activities has been performed. In the future, the performance of these two approaches will be compared.

4 Pilot 1-6: Kappa Futur Festival

The Kappa Futur Festival is an electronic music festival that takes place every summer, at the beginning of July in the Dora Park in Turin, Italy. The Dora park covers an area of 450,000 m². Close to the city centre, this urban park highlights Turin's industrial past.

The festival runs from noon to midnight for two days (Saturday and Sunday) on different stages, and welcomes 12,000 spectators per day. The 2018 edition will take place on 7th and 8th July.

A description of the venue and nearest residential areas is provided here below.

4.1 The venue

Edition 2018 of Kappa Futur Festival will include four stages (see Figure 10).

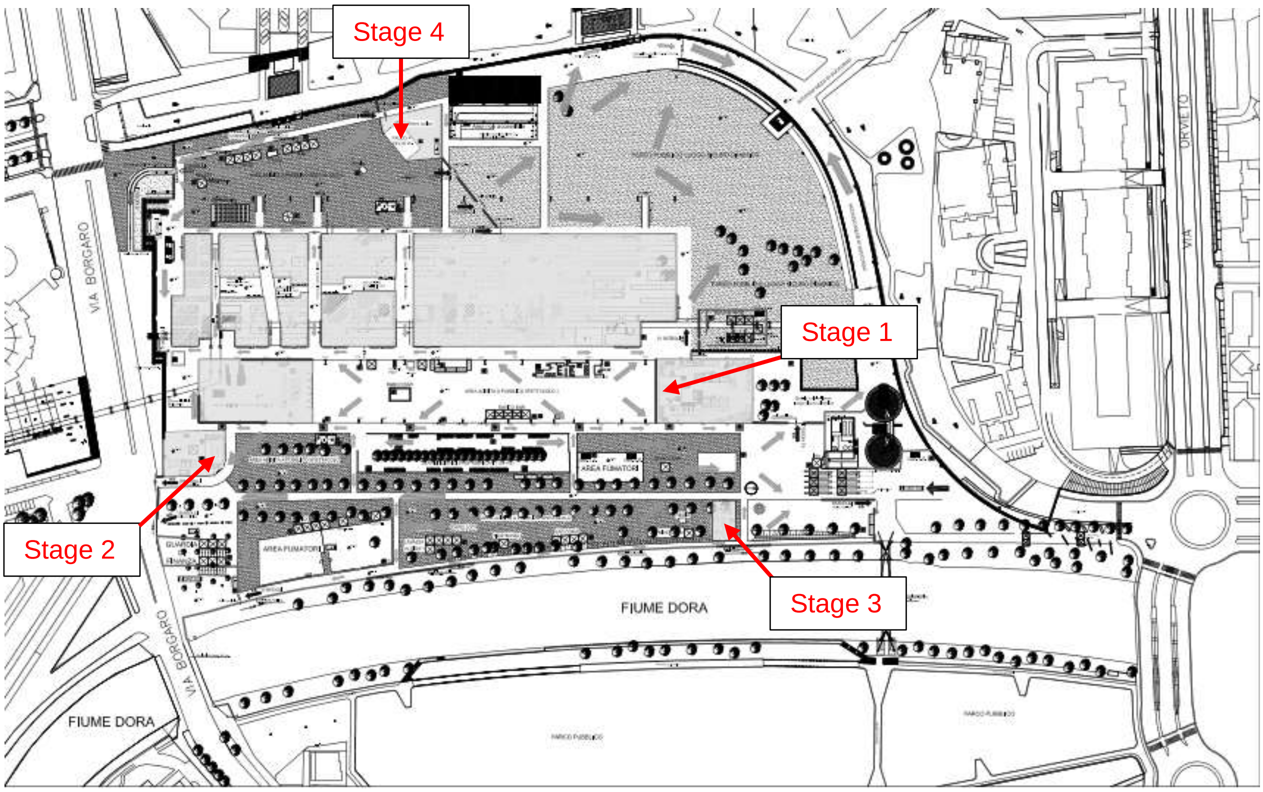


Figure 10: Kappa Futur Festival 2018 Pilot area

4.2 The neighbours

One of the particularities of the festival is that it takes place in the open air, in an urban environment, with residential areas nearby. Next figure highlights the residential buildings closest to the venue, expected to be the more critical receivers in terms of noise exposure.

Figure 11: Residential buildings closest to the venue (highlighted in yellow)

5 Planned configuration for Kappa Futur Festival 2018

5.1 ASFC System

The Kappa Futur Festival 2018 is hosting musicians on four stages, see Figure 12. Stage 4 (S4) will be equipped with the ASFC system. The system will be used to mitigate noise in the direction of the nearest neighbours (blue circle in right hand picture). The ASFC loudspeakers (in the red circle area) are planned to be positioned in between the dark zone and the PA system of stage 4 (green circle).

Figure 12: Left: Positions of the four stages at Kappa Futur Festival 2018. The ASFC system will be deployed at S4. Right: Positions of the stage (green circle), the secondary sources (red and black circle) and the dark zone (blue circle).

The wiring scheme is shown in figure 7. The ASFC system is connected to the primary loudspeakers via the sniffers and to the wireless microphones via the MONICA cloud. All internal components are connected via a Dante network.

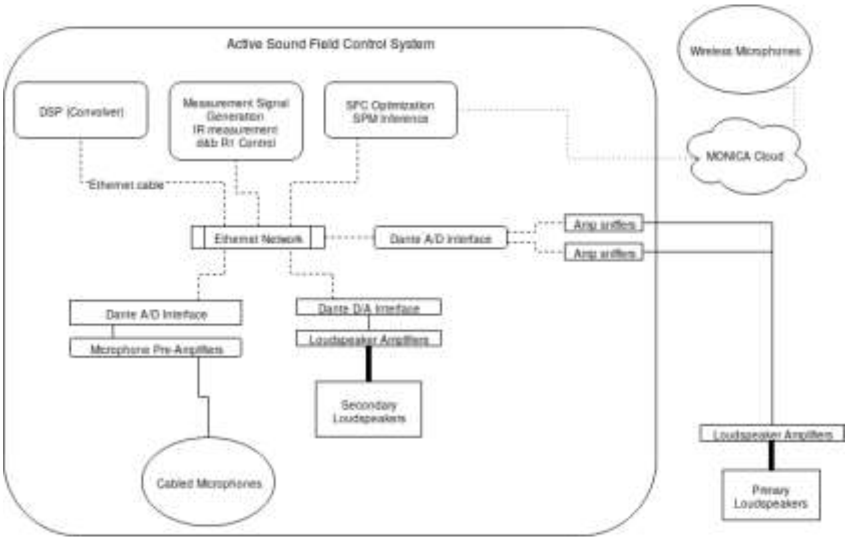


Figure 13: Wiring scheme of the ASFCS deployment at Kappa Futur Festival 2018

5.2 Quiet Zone System

The Quiet Zone System will not be tested at the Kappa Futur Festival. DTU think about applying the adaptive methods used by the Quiet Zone System to the ASFC arrays. This depends on the state of development and especially the robustness of the algorithms. Adaptive algorithms imply a chance that filters “diverge” which can cause highest sound pressure at the speakers.

5.3 Noise Monitoring System

SLM prototypes

A total of 10 SLM IoT prototypes are planned to be deployed on KFF 2018. Prototypes are expected to provide overall sound pressure levels, 1/3 octave band spectra.

Exact positioning of SLM IoT prototypes are still under discussion. A compromise should be taken between ASFC system precision, monitoring covering on audience and neighbour areas, as well as network availability.

Source contribution algorithm

Source contribution algorithm is under development and will not be tested during Kappa Futur Festival 2018.

Complementary measurements

In order to allow covering a higher number of measurement points for noise monitoring, some complementary measurement should be required. These measurements will be performed “manually” (by using classical non IoT equipment). Some measurement equipment will be provided by Acoucité.

Sound Heat Map

Unfortunately, the Sound Heat Map module (currently being developed with the joined effort of Movement, Politecnico di Torino, DTU and City of Torino) will not be ready for KFF 2018. However, it is expected to be operating for tests in Tivoli (Friday Rock, august 2018). Sound Heat Map for KFF 2018 is thus expected to be generated by using sound pressure levels measured by IoT SLM prototypes.

Survey

A survey concerning noise annoyance in neighbours will be conducted after the festival period by using Google Forms. This survey will be an improved version of the one carried out during KFF 2017. Improvements planned to be done are:

- Changes on semantics to bring more precision to questions.
- Changes on the order of questions to decrease bias effect.
- Provide a “rough” geolocalisation of data to help the comparison between survey results (perceptual dimension) and acoustics measurements (physical dimension). This is planned to be done by separating the residential area within the surroundings in a certain number of zones.

6 Conclusion

A description and review of the state of progress of Noise Monitoring System, Adaptive Sound Field Control (ASFC) System and Quiet Zone System have been provided. Current limitations, corrective actions taken and required improvements have been identified for each system thanks to tests carried on separately both in laboratory and in on-field conditions.

A description of Kappa Futur Festival 2018 site, were both Noise Monitoring System and ASFC System will be deployed together for the first time, has been given. The planned configuration of systems for the 2018 edition of Kappa Futur Festival is included.

For ensuring best results for systems' tests during test in Kappa Futur Festival 2018 special attention should be taken on WiFi network covering and stability for data transfer from SLM IoT prototypes.

7 List of Figures and Tables

7.1 Figures

7.2 Tables

Aucune entrée de table d'illustration n'a été trouvée.

8 References

(EC, 2017)	AMENDMENT Reference No AMD-732350-4 of the Grant Agreement number: 732350 — Management Of Networked IoT Wearables – Very Large Scale Demonstration of Cultural Societal Applications (MONICA).
(EC, 2017)	Management Of Networked IoT Wearables – Very Large Scale Demonstration of Cultural Societal Applications (Grant Agreement No 732350) - D4.1 Validation of the ASFC and Noise Monitoring System Configuration 1Version 1.0 of 2017-12-29)
(EC, 2017)	Management Of Networked IoT Wearables – Very Large Scale Demonstration of Cultural Societal Applications (Grant Agreement No 732350) - D4.4 Precision IoT enabled Microphone Sensor version 1 (Version 1.0 of 2017-12-21).
(EC, 2017)	Management Of Networked IoT Wearables – Very Large Scale Demonstration of Cultural Societal Applications (MONICA). “D10.2 Acoustics Assessment Report of MONICA Pilot Sites”.