Management Of Networked IoT Wearables – Very Large Scale Demonstration of Cultural Societal Applications
(Grant Agreement No 732350)

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1 Executive Summary

The MONICA project followed an iterative prototyping approach aiming to demonstrate the deployment of large amount of IoT devices to improve security, sound and user experience at large-scale outdoor cultural events. The project plan contained two main iterations: The first one in 2018 to deploy initial prototypes of the integrated MONICA platform, i.e. gradually increasing the size of the deployment in terms of soft- and hardware functionalities, and involved end users at each event. This first iteration allowed to identify issues and pitfalls on several levels (technical, organizational, regulatory, etc.) that were taken into account to improve the platform and be ready for the second iteration in 2019 involving full large-scale deployments.

In this deliverable events are classified into the following categories: sports events in stadiums (Emerald Headingley Stadium Leeds), gated events (Nuits Sonores Lyon, Kappa Futur Festival Torino, Fredagsrock @ Tivoli Copenhagen, IoT Week Aarhus, Woodstower Lyon, Sound Summit Roskilde), local city celebrations (Fête des Lumières Lyon, Port Anniversary Hamburg, Rhein in Flammen Bonn), city nightlife management (Movida Torino) and fun fairs (DOM, Hamburg, Pützchens Markt Bonn). For each category several individual pilots are presented, detailing how the MONICA Platform was employed to implement the pilots' use cases and important results and lessons learned are highlighted.

In the *Sports Events in Stadiums* category (Chapter 3) four pilot demonstrations, including one pre-test, were held. All of them took place at the Emerald Headingley Stadium in Leeds during rugby and cricket matches. The main use cases were crowd and capacity monitoring, security and health incidents and the localization of staff. During the first full pilot deployment in August 2018 the Smart Glasses were introduced as an aid to improve staff communication during the events. During 2019 demonstrations, further smart glasses tests were performed, video analytics based crowd counting algorithms were deployed and visitor engagement was improved by releasing Leeds Varsity Visitor App.

The category *Gated Events* comprises nine demonstrations and one pre-test at cultural and music events at six difference pilot locations (see Chapter 4). The demonstrations in this category had a strong focus on sound monitoring and control as well as crowd and capacity monitoring. The deployment at Nuits Sonores in Lyon 2018 was the second official MONICA demonstration and focussed on the integration of the IoT Sound Level Meters for sound monitoring. The Sound Field Control System (SFCS) was first introduced and tested at the Kappa FuturFestival in July 2018. The Fredagsrock concert at Tivoli Copenhagen in August 2018 was the second time the SFCS was deployed at a real event and the first real-world test of the Quiet Zone, a booth that reduces the noise level in a smaller area. The demonstration in Tivoli Copenhagen in April 2019 concentrated on the first medium scale crowd wristband deployment. The second medium scale crowd wristband deployment was performed during the IoT Week conference in Aarhus. The largest MONICA demonstration involving more than 6000 participants and IoT wearables connected to the platform happened at Woodstower Festival in Lyon in August 2019. This large-scale demonstration of MONICA crowd wristbands took into account lesson learned from the previous two medium scale preparatory demonstrations in Tivoli in April 2019 and IoT Week in June 2019. Next to this, the test of the Adaptive version of the SFCS during Roskilde SOUND2019 event performed by the MONICA partner Technical University of Denmark (DTU) in November 2019 is presented. After several semi-successful trials achieved during the previous MONICA pilot events (i.e., Kappa FuturFestival in July 2018, Fredagsrock in Tivoli Copenhagen in August 2018 and Kappa FuturFestival in July 2019), the project partners agreed to test the adaptive system in a setting that allowed researchers one week of installation and pre-measurement time. Previous trails had given unsatisfactory results as the complex structure of the event site combined with the short measurement time restrictions prevented successful replication of the laboratory results.

The events in the category *Local City Celebrations* were more focussed on the localization of staff, but also deployed sound control and monitoring technologies as well as crowd and capacity monitoring mostly based on video analytics from CCTV cameras (see Chapter 5). This category presents five demonstrations held in Bonn (Rhein in Flammen), Hamburg (Port Anniversary) and Lyon (Fête des Lumieres). During Rhein in Flammen in May 2018, the MONICA platform was deployed for the very first time. Fête des Lumières in December 2018, showcased the first High Level Data Fusion Integration into the COP dashboard and during the Hamburg Port Anniversary demonstrations in 2018 and 2019 the main focus was the alert function based on environmental sensor data.

The category *City Nightlife Management* features two demonstrations during the MOVIDA in Torino (see Chapter 6). It portrays the holistic solution the city of Torino is working on to solve the noise pollution related conflicts in an inner-city area with resident housing and people gathering in the streets during night-time. MONICA project contributed here with a focus on sound and crowd monitoring.

The last category *Fun Fairs* includes two pre-tests in 2017 and five pilot demonstrations in the subsequent years 2018 and 2019 (see Chapter 7). These took part in the pilot cities Hamburg (Spring and Winter DOM) and Bonn (Pützchens Markt). They mainly focussed on crowd and capacity monitoring, the localization and communication of staff and security and health Incidents. At Pützchens Markt, in September 2018, the GPS based Live Positioning Information System (LiPS) was first introduced and tested in a real-world environment. The Hamburg DOM demonstrations in 2019 featured a staff tracking IoT technology using the public LoRa WAN network and the integration of environmental sensors and the Hamburg Smart City portal with the MONICA platform.

The last Chapter 8 reports about project related activities performed by the MONICA partner Digisky in a non-event environment. The report presents a blimp camera technology test that was initially planned to be performed during pilot events, but had to be cancelled due to regulatory and weather related reasons.

MONICA project was executed by 30 European partners: Research Institutes, Universities, public bodies and private companies. A detailed report and contact details on concerned partners can be found in Deliverable D9.3 Replication Reference Book and Roadmaps for MONICA Market Replication.

Figure 1 highlights all pilot demonstrations and pre-tests during the course of the project in chronological order:

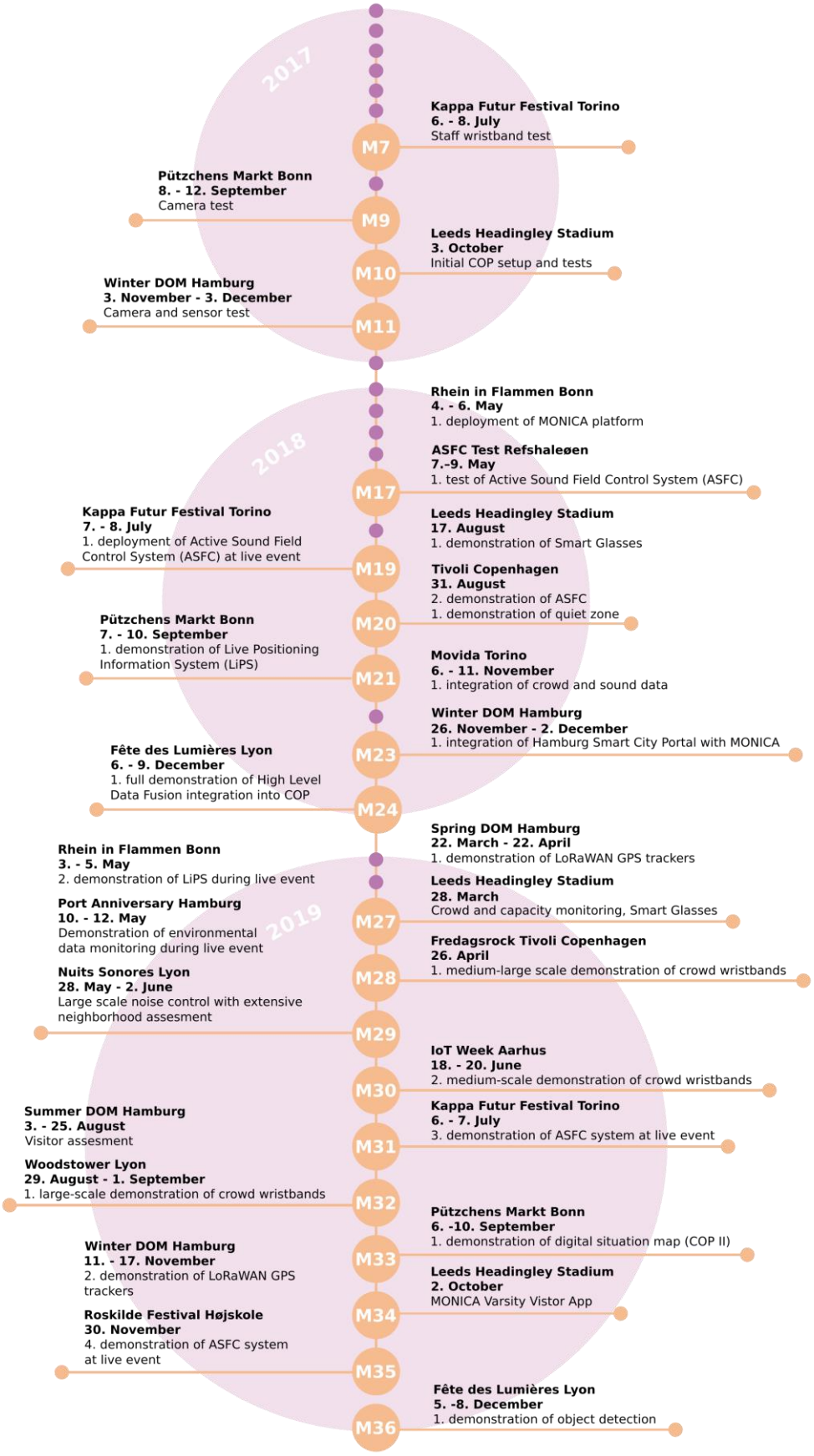

Figure 1: Demonstration Progress

2 Introduction

2.1 Purpose

The purpose of this deliverable is to report on the preparation and implementation of the pilot sites towards the 24 months demonstration period (M13 to M36), to present all MONICA pilot demonstration activities and report on the key results of the project.

This deliverables foundation is the work done under Task 8.2 for the pilot deployment and under Task 8.3 on demonstration execution and coordination as specified in the DoA. Depending on the selected use cases a different set of partners were active in the respective demonstrations. All activities were orchestrated by the executive steering committee “Pilot Coordination Board”, that consisted of the project manager, the technical manager, the pilot coordinator, the impact manager and if needed the Data Security Manager.

2.2 Content, context and scope of this deliverable

This deliverable describes all 15 demonstrations carried out in 2019. As demonstrations carried out in 2018 led to certain decisions throughout the demonstration planning, they are mentioned briefly where needed. More detailed descriptions of demonstration activities in 2018 are available in Deliverable D8.2 Consolidated Demonstration Platform Pilot Progress Report 1.

In order to ease information access to individuals seeking to replicate similar activities during their events, this deliverable groups the demonstration reports by type of event. Chapter 3 will present Sports Events in Stadiums. Chapter 4 will talk about Gated Events like Open Air Music Festivals, Chapter 5 about Local City Celebrations, Chapter 6 about the general City Nightlife Management and Chapter 7 about Fun Fairs, seen as large ungated events in inner-city areas. The last chapter 7 reports about the blimp camera technology test by MONICA partner Digisky.

MONICA project was executed by 30 European partners: Research Institutes, Universities, public bodies and private companies. A detailed report and project partners contact details can be found in Deliverable D9.3 Replication Reference Book and Roadmaps for MONICA Market Replication or on the website: https://www.monica-project.eu/.

2.3 Acronyms and abbreviations

Acronym or Abbreviation	Meaning
AGL	Above ground level
AIOTI	Alliance for Internet of Things Innovation
ASFC	Adaptive Sound Field Control
COP	Common Operational Picture
CAP	Collective Awareness Platform
CCTV	Closed-circuit television
DoA	Description of the Action
DSS	Decision Support System
EHS	Emerald Headingley Stadium
ETSI	The European Telecommunications Standards Institute
GDPR	General Data Protection Regulation
KPIs	Key Performance Indicators
IoT	Internet of Things
LiPS	Live Positioning Information System
LR	Leeds Rugby
MAE	Mean absolute error (MAE) metric indicates the performance of the crowd estimation algorithm. The MAE is the error of estimation of crowd by the algorithm in relation to ground truth i.e. it gives an average difference of number of people estimated by the algorithm vs the actual number.
SLM	Sound Level Meter
UC	Use Case
UWB	Ultra-Wide Band(width)
WHO	World Health Organisation
YCCC	Yorkshire County Cricket Club

3 Sports Events in Stadiums

MONICA project aimed to cover a variety of open-air events. As sports events are very famous all over Europe and happen to take place most of the time in semi covered stadiums, understanding the constraints of deploying the MONICA IoT platform in a sports stadium was a compelling opportunity. It made the MONICA consortium face several challenges, amongst others: structures detaining wireless connectivity, renovation and construction works, challenging the placement of and camouflage design for base stations and shortage of space inside stadium facilities. The following paragraph will describe MONICA demonstration activities at Leeds Emerald Headingley Stadium one of the 11 MONICA pilot sites.

3.1 Summary

The Emerald Headingley Stadium (EHS) is home to the MONICA pilot partners Leeds Rugby (LR) and Yorkshire County Cricket Club (YCCC). It hosts both men's and women's cricket and rugby union and super league matches, including international fixtures. During the MONICA project the EHS hosted a total of five demonstrations including one pre-test. The technologies tested during these demonstrations included the smart glasses for security staff, the incident detection, the COP dashboard and a mobile app targeted at visitors.

3.2 Sports Events at Emerald Headingley Stadium Leeds

3.2.1 Introduction

The following section details the demonstrations held at the Emerald Headingley Stadium (EHS). All events at this venue are specifically sporting events. The Stadium is home to pilot partners Leeds Rugby (LR) and Yorkshire County Cricket Club (YCCC) and hosts both men's and women's cricket and rugby union and super league matches, including international fixtures. Sky TV is often present and broadcasts games around the world. EHS provides other services during the events such as bars and food outlets, toilets, match day entertainers and souvenir stalls. In May 2019 a £50m stadium infrastructure development was completed securing the future of the Stadium as an international sporting venue for the foreseeable future. The crowd capacity for rugby is 19,544. The crowd capacity for cricket is 18,350 and is all seating.

3.2.2 Preparatory activities before 2019

During 2017 and early 2018 extensive consultation with key stakeholder groups, including Ground Safety Officers for Leeds Rugby and Yorkshire County Cricket Club (YCCC), Security Services, the Safety Advisory Group, and Fire and Police Emergency Services, took place. In July and October 2018, two demonstrations took place. During these key learnings were first the general understanding of the organizational and logistical needs for a demonstration and second the identified need to more precisely define the challenges the stadium pilot wanted to focus on in 2019. Following this a safety and security needs analysis for Rugby and Cricket was undertaken and identified two main match day challenges: queues at services and gates leading to overcrowding; and speed and accuracy of incident detection. In addition, observational research during the One Day International cricket game England vs. India on 17th August 2018 helped understanding better the visitor experience during busy games and the challenges of the safety and security personnel. Therefore it was decided that event information should be improved, particularly for first time visitors.

As a result, the Use Cases selected for the focus of the demonstrations reflect the main issues and challenges faced by Emerald Headingley Stadium (EHS). The IoT Devices and Solutions provided by the MONICA Platform seek to demonstrate effective ways of maintaining a safe, secure and enjoyable environment for visitors. The difference between 2018 and 2019, shown in
Table 1, reflects the lessons learned from the Leeds demonstrations held in 2018 and from other pilot partners, as well as the changing operational environment influenced by national and international acts of terrorism.

Table 1: Selected Use Cases for the Sporting Events Pilot at Leeds Stadium

ID	Use Case Group	Selected for 2018	Selected for 2019
UCG 3	Crowd & Capacity Monitoring	X	X
UCG 5	Locate Staff	X	X
UCG 7	Security Incidents	X	X

UCG 8	Health Incidents	X	
UCG 13	Event Information		X

Table 2: Number of deployed IoT Devices at the Sporting Events Pilot at Leeds Stadium

IoT Device Type	Number of deployed devices 2018	Number of deployed devices 2019
Cameras	4	8
Leeds Visitor App	N/A	634 downloads
Smart Glasses	1	15 (inc.4 tested in Control Room)
Staff wristbands	9	-

During 2018 there were two demonstrations: the Yorkshire Vikings T20 cricket match vs. Nottingham Outlaws hosted by YCCC and the Leeds Rugby Varsity Game hosted by Leeds Rugby. The latter was limited in scope due to the ongoing building works which affected both, crowd capacity and egress. The demonstrations in 2018 led to the following conclusions regarding the demonstrations planned in 2019:

- The action recognition/posture detection with the staff wristbands could not be retested as it needed to be tested at a pilot site where Dexel's anchors had already been installed. Following a site visit, it was decided that due to the ongoing construction works it was not possible to install the anchors for 2019.
- The Time of Flight cameras would not be retested in 2019 as the tests had shown they were not a suitable solution for the selected Use Case. Further testing revealed that they were not suitable for a Stadium environment and not fit for purpose as specified by the manufacturer.
- For 2019 the focus would be a more detailed Common Operational Picture (COP), as EHS and YCCC stakeholders emphasized this as most valuable to the Stadium environment and event managers.
- The smart glasses proved to be entirely appropriate and of value to the Stadium environment and event managers. Therefore, stakeholders decided to focus on Smart Glasses as potential Solutions for Use Case: Security Incidents in 2019. A mapping of the network coverage and wi-fi upgrade was undertaken as appropriate to support testing in 2019.
- The camera positions were reviewed and the number of cameras increased as necessary to ensure coverage appropriate to the data capture required for analysis.

In 2019, three more demonstrations had been planned, in March, May and October. However, due to timing constraints the May demonstration was cancelled, to allow technical partners to focus on other pilot demonstrations scheduled for the same time. The first demonstration in March 2019 was a Rugby Super League game hosted by Leeds Rugby: Leeds Rhinos vs Castleford Tigers. The teams playing are local rivals and attracted 12,295 visitors.

3.2.3 Crowd Management to reduce queues based on video analytics

With the aim of effective crowd management in mind, two new cameras were successfully deployed to record video footage. Their set up was similar to that of 2018 but their angles were optimized to better focus on busy areas for crowd counting purposes. In contrast to 2018, in March 2019 the technical partners were granted access 10 days prior to the event, to fine tune camera calibrations and to pretest different algorithms and integration strategies. However server connectivity issues occurred and the video analytics data stream was facing interruptions. The captured data nevertheless was displayed real-time. Compared to 2018 the visualization in the COP dashboard was improved, as was the accuracy and detail of the Stadium Map (see Figure 2 and Figure 3).

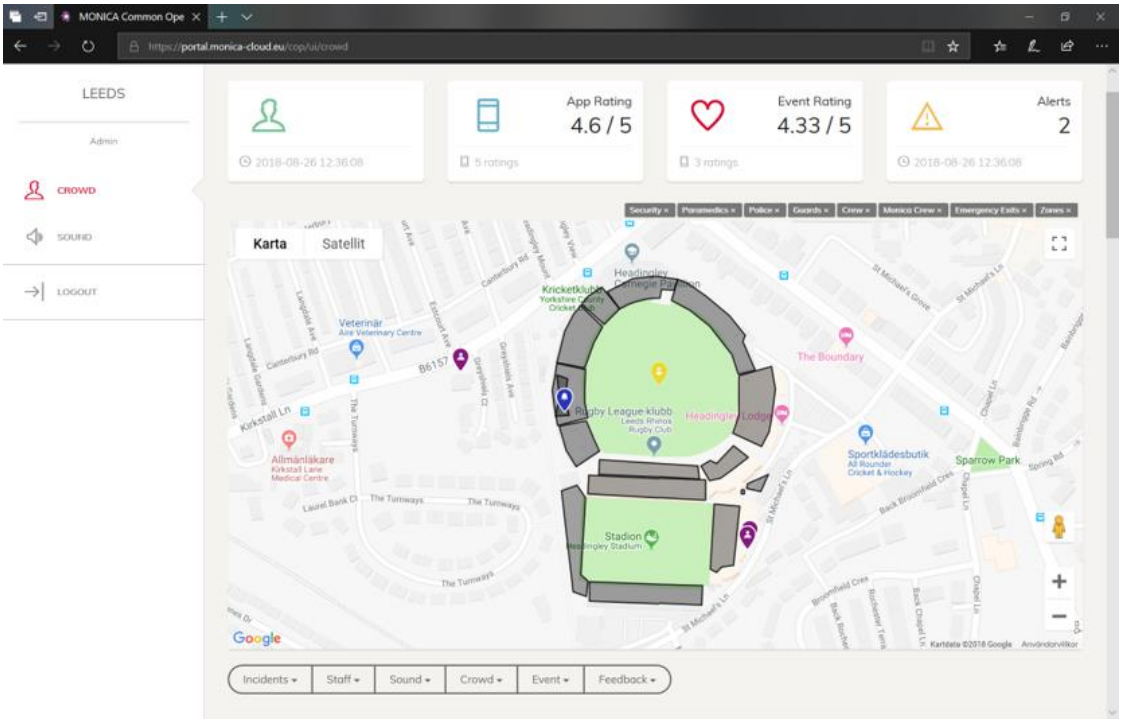

Figure 2 Screenshot of Leeds COP dashboard during demonstration in August 2018

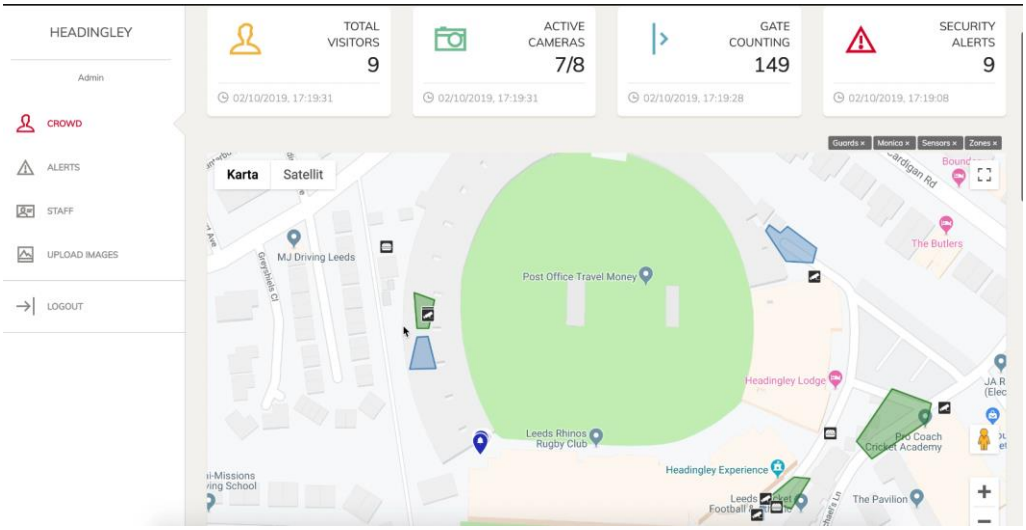

Figure 3 Screenshot of improved Leeds COP dashboard during demonstration in October 2019

The second demonstration in in Leeds in 2019, was the Leeds Rugby Varsity Game in October. This event attracted 8,617 visitors. Three additional cameras were installed at the entrance gates to capture queues and overcrowding. They were situated at the South Stand and Gate B Turnstiles, which helped monitor person traffic at gated entrances. Video analytics was deployed as a solution to check patterns or abnormalities at entrances, show high congestion areas against the predefined maximum number of people allowed on the COP, and finally to assist in identifying and alerting when an area was full or at risk. Figure 3 shows the entrance areas cameras and the color coded (here green or blue) rectangle's that represent the observed areas. The color coding referred to the previously defined maximum number of visitors in this area compared to the real–time video analytics counting results.

The graph in Figure 4, shows that the gap between the predicted and actual numbers is fairly narrow across the graph indicating a closer prediction with the actual numbers.

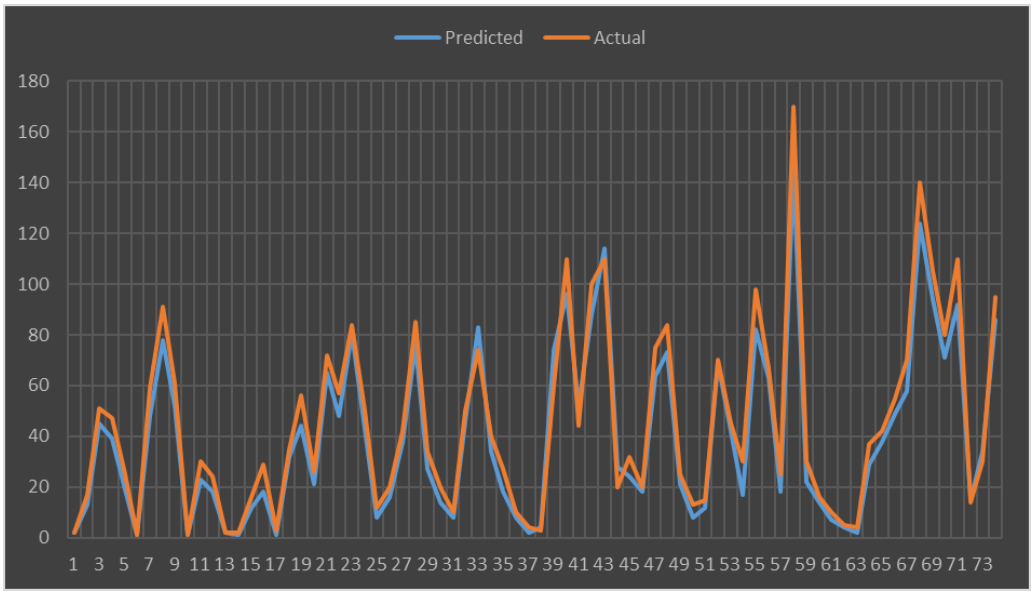

Figure 4 Video Analytics Results Leeds Varsity 2019

The field of view in the images during Leeds Varsity demonstration is relatively small providing a better resolution of crowd with fewer occlusions possibly providing a closer prediction to ground truth.

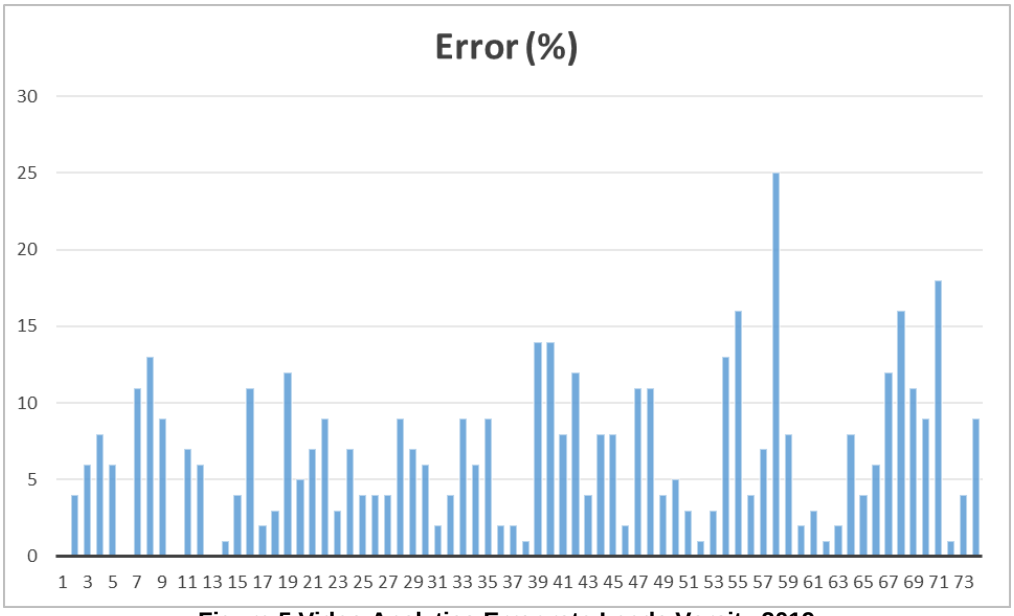

Figure 5 Video Analytics Error rate Leeds Varsity 2019

During the Leeds Varsity demonstration in October 2019 a mean absolute error (MAE) of 6.6216 was observed on a sample of 75 random images.

3.2.4 Smart incident detection using IoT connected smart glasses

Prior to the demonstration in March 2019, stewards from the stadium and firemen from West Yorkshire Fire and Rescue Service were selected to participate in testing the smart glasses. The aim was to analyze how specialized event staff could effectively use the smart glasses for their specialist roles. For example, one steward detected and reported the use of a flare in the away visitor section of the crowd. The steward used the smart glasses to catch a picture of the incident on the glasses and report back to the control room. The picture could be shared using the COP dashboard. The glasses also helped with bag searches, prior to gaining entry to the stadium. During the deployment, technical partners faced difficulties with remote connectivity. Some sections of the stadiums newly completed building parts did not allow a stable wi-fi connection. MONICA team provided mobile phone hotspots as a solution in March, which helped to get the glasses connected. Both stewards and firemen enjoyed testing the smart glasses video feature. This drained the batteries and caused heavy loading and time delays to the COP dashboard.

Following the lessons learned from the smart glasses test in March, the Leeds Varsity October demonstration was prepared by even more time. Due to the connectivity issues, a special focus was to pretest the Wi-Fi connectivity in and around the stadium. Based on the results, the wi-fi network was upgraded to support the Smart Glasses. A comprehensive connectivity survey undertaken by MONICA partner Rinicom after the upgrade indicated it fully suitable for the planned tests.

The smart glasses training session was more carefully preplanned for the October demonstration. Due to the improvements, ten pairs of smart glasses were prepared for the tests with the West Yorkshire Police Officers on duty at the event. Eight officers were recruited and briefed on the Project and their roles. These test users were given about 30 minutes to well understand the main functionalities of the devices. They were explicitly asked to judiciously using the video mode, in order to avoid the overloading of the COP dashboard.

The smart glasses were found to be a valuable source of information if able to provide real time images of an incident to attending fire crews, but may have limited use in smoke filled rooms and if worn with fire safety equipment. The increased speed and quality of communication between control room staff and stewards was the primary outcome of the smart glasses deployment. Orally reporting an incident takes more time than sharing the visual impression in real time.

3.2.5 Sharing event information using Leeds Varsity Visitor App

Based on consultations with key Varsity stakeholders and the ongoing development and positive feedback of a MONICA APP developed by CNET for other pilot partners, it was decided that this solution had potential within a sporting event as an information tool and should be tested. A screenshot of the Leeds Varsity Visitor App can be seen in Figure 6. There was also an issue of student safety and wellbeing, which it was felt, could be addressed through the app. This prompted the decision focus on safety and wellbeing on the APP alongside providing unique competition content and live scores to enhance the student visitor experience. The safety measures included: the Stadiums Top 10 Rules, University coded Map's indicating fan curves and Safety video messages from West Yorkshire Police.

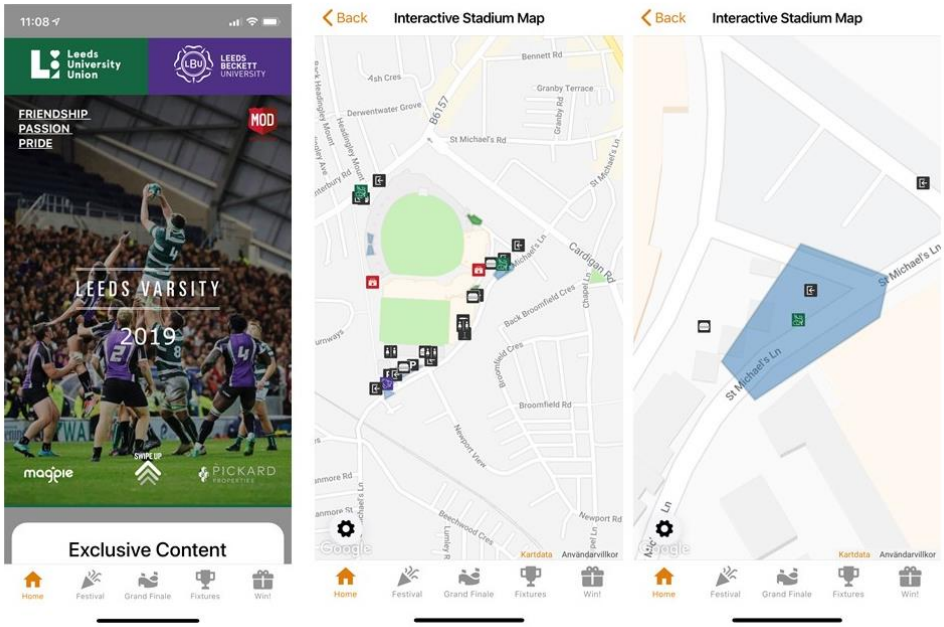

Figure 6: MONICA Leeds Varsity Visitor App

Finalizing the app before University students returned to Campus after the summer would have been ideal to encourage more students to download the full version of the APP. However, with the timing of other MONICA live demonstrations, not everything could be integrated into the APP. An earlier promotion to both universities would have seen a higher number of downloads, as the promotion would have targeted many more students. In terms of features, the ability to check live scores was favored by the students. In previous years scores were communicated only by hearsay or Social Media. Students liked the fact they could look at the upcoming fixtures and past fixtures for both men and women. One suggestion, brought up during the App evaluation process, was to allow sorting by sports, i.e. just football fixtures or just netball fixtures. The conception of the app was also to help raise awareness for other sports which aren't often advertised. 89% of the users that provided

feedback stated that the APP improved their Varsity experience. 64% said they would be more likely to return next year if it was available. All stakeholders involved in the event e.g. Universities, Security, emergency services and Rugby unanimously agreed that it was a much better, safer event, with less incidents, compared to previous years. As a result of the overwhelmingly positive feedback the Varsity organizers are considering how they can develop the APP for Varsity 2020 implementation.

3.2.6 Lessons learned

During the demonstrations in Leeds to pilot ensured access for the technical partners at least 10 days before the event. This enabled testing of the different algorithms and integration strategies, as well as fine tuning of the systems and addressing other problems, such as loss of connectivity. To overcome remote connectivity issues the client/server application (TigerVNC) was used and proved satisfactory performance results.

During the test of the smart glasses, the Wi-Fi would occasionally drop out, which meant features of the smart glasses could not be used. To help with this, the MONICA team provided their phones with a hotspot as a solution, ensure the glasses stay connected at all times. Despite completion of the building works where wi-fi was installed in large sections of the stadium, a need to upgrade became apparent. The upgrade of the Wi-Fi network was completed and successfully demonstrated during the October (Varsity) demonstration in 2019. The Wi-Fi mapping proved to be a very important addition to pilot planning prior to the event ensuring successful coverage during the event.

Major findings for smart glasses application for security staff in a stadium setting are: The smart Glasses may have limited use in smoke filled rooms and if worn with fire safety equipment but would be a valuable source of information if able to provide real time images of an incident to attending fire crews. The over-use of the video feature drained the battery and caused some issues with overloading the COP dashboard with images. This was addressed during the training session at the following demonstration (Varsity). To preserve the battery, use of video mode should be used judiciously. The pilot decided that further testing with the West Yorkshire Police would reveal any further value to this specialist force and thus provide a comprehensive picture of the Smart Glasses for this Use Case across different contexts and emergency services user groups. During the Control room briefing to the Police it was discovered that the smart glasses interfered with the officer's uniform (hats, earpieces etc.), and the decision to not field test the glasses during the demonstration was made as it would have compromised their safety. Following a demonstration by Optinvent and Control Room testing, the Officers were able to provide comprehensive feedback on capabilities and value related to their roles. The stewards and event personnel undertook the field tests. Future testing of the Glasses prior to the live demonstration is critical to ensure they can be safely worn with the relevant emergency services uniform as these differ across the UK and Europe.

The COP dashboard that was placed at the disposal displayed accurate and detailed information in a timely manner and would be a valuable addition to the Control Room to aid decision making.

The deployed incident detection algorithm, the DSS sent numerous alerts to the COP as it was creating alerts when people were walking alongside each other. Based on these findings CERTH had the chance to further improve the DSS and the lessons learned in Leeds have been useful for the next demos.

During the last demonstration in October 2019 the Leeds Varsity Visitor App was published. In terms of features, the ability to check live scores was the favorite feature by the visitors. In previous years scores were only known by hearsay, or via Twitter. They also liked the fact they could look at the upcoming fixtures and past fixtures for both men and women. A suggestion for further improvement was to add a sorting function via different sports, i.e. just football fixtures or just netball fixtures. The general conception of the app was that as well as being able to get information for Varsity, the app also helps raise awareness for other sports which aren't often advertised. 89% of the respondents to the App questionnaire stated that the APP improved their Varsity experience and 64% said they would be more likely to return next year if it was available. All parties involved in the event e.g. Universities, Security, emergency services and Rugby unanimously agreed that the Leeds Varsity event in 2019 was a much better, safer event, with less incidents, compared to previous years. It's possible that some of the information, such as interactive map information and safety messages, had a positive contribution to these outcomes. In general it is important to finalize and publish an event app well in advance to the event, in order to allow enough time to promote it among the visitors. As a result of the overwhelmingly positive feedback the Varsity organisers are considering how they can develop the APP for Varsity 2020 implementation.

4 Gated Events

Cultural and Music events happen to be gated events, for either security reasons or/ and the fact that the event organisers revenue model is based on ticket sales. The following chapters illustrate MONICA demonstrations during fenced events. Chapter 4.2 will describe Nuits Sonores, an electronic music festival at a disused factory site in Lyon / France. Here sound monitoring and measurements of neighbourhood noise were core initiatives. Chapter 4.3 reports on the MONICA demonstration done at another electronic music festival, Kappa FuturFestival in Torino / Italy. The focus here was on sound monitoring, the adaptive sound field control system test and the Quiet Zone system.

The MONICA consortium performed several steps in 2019 to demonstrate the large scale deployment of crowd wristbands. Chapter 4.4 reports on the small scale demonstration performed during Friday Rock concert in Tivoli in Copenhagen / Denmark, Chapter 4.5 tells about the medium scale demonstration during a conference IoT week in Aarhus / Denmark and chapter 4.6 reports about the large scale demonstration of MONICA visitor wristbands at Woodstower Festival near the city of Lyon / France. The latter successfully demonstrated the stable functioning of the MONICA platform, with thousands of active IoT devices. It enabled collection and mapping of crowd and sound monitoring data in the setting of an actual open air music festival. Finally chapter 4.7 elaborates the pilot demonstration of the Adaptive Sound Field Control System during Roskilde Hojskole Sound2019 event in November 2019.

4.1 Summary

4.1.1 Nuits Sonores Lyon

Nuits Sonores[1] is a music festival with gmore than 140,000 visitors per year. It consists of several events taking place at different places around the city of Lyon. For the MONICA pilot the focus was on one of the main sites:The old Fagor Brand factory, where music is being played on three stages from 10 pm to 5 am. The site is in a mixed industrial and residential area.

The main use-case here was sound monitoring and control. The data was collected using the IoT Sound Level Meters (SLM). Receiving those early before the demonstration allowed the MONICA team to properly setup the devices, test their functionality and prevented unexpected events: in fact, it allowed to conduct background noise measurements one week before the planed time slot, because of bad weather forecast (wind or rain will interfere with the measurements). These pre measurements were required to assess and calculate the noise pollution. The COP dashboard visualized the real-time data and allowed to download historical data. A comprehensive survey campaign was performed with neighbours and festival goers.

One mayor lesson learned from this pilot was that a period of 8 months before the event is not sufficient preparation time to set up a fully operational Sound Monitoring tool integrated into the COP. Also the demonstration highlighted the importance of data validation prior to a demonstration to authorities, organizers and sound engineers in order to get valuable feedback from end-users.

4.1.2 Kappa FuturFestival Torino

Kappa FuturFestival (KFF) is Italy's largest summer festival for electronic and techno music. It takes place during a weekend in early July in Parco Dora in Torino. The last two editions of the festival in 2018 and 2019 had 4 stages distributed in a "fenced" area of about 60 thousand square metres. The park is surrounded by residential buildings.

As most outdoor festivals the KFF pilot faced the challenge of the absence of pre-existing infrastructures in the park (wiring and internet connection mainly) meaning that everything such as cable, antennas etc. had to be rented and set up specifically. It is technically difficult to deploy cables on the ground for long distances without creating obstacles for the visitor flow in a crowded event with many emergency exits/lanes. Also deployment costs can grow significantly, especially considering the installation of components such as base stations or antennas on heights, each of which has to be verified by an external certified engineer. Last but not least all the material used or stocked in the venue during the show must be the EC marked to comply with local safety and security rules hence the use of prototypes is subjected to the authorities upon the presentation of a specific dossier. Piedmont regulations are specially restrictive given to casualties during previous outdoor events and non-compliance can lead to the rejection of the license to open the festival.

[1] https://www.nuits-sonores.com/en/

4.1.3 Fredagsrock Tivoli Copenhagen

Figure 7: Tivoli's main entrance (source: Tivoli Database)

Tivoli Gardens is an amusement park in Copenhagen which offers a variety of live events. The Fredagsrock concert is an annual concert-series featuring national and international performers. In the MONICA project this event the main use-cases for this event were Sound and Crowd Monitoring. Additionally Tivoli is one of two MONICA permanent COP locations were the COP is set up independently from any events.

4.1.4 IoT week Aarhus

The IoT week is an annual technology conference. In 2019 it was held in Aarhus Denmark and welcomed about 1600 participants. Over the course of five days it featured around 180 sessions, workshops and panel discussions. This event was not part of the official MONICA pilots, but provided the opportunity to run an additional medium scale test of the MONICA crowd wristbands in preparation of the larger-scale demonstrations at the main pilot sites.

4.1.5 Woodstower Festival Lyon

Woodstower is a music festival taking place in Lyon, France. The MONICA pilot demonstration was held during the 2019 event which was visited by 34.000 people. Over the course of the festival a total of 6.230 crowd wristbands were distributed to visitors; the largest number of wristbands tested at a live event in the MONICA project. Another vital part of this demonstration was the sound monitoring. The IoT platform performed very well without any delay or interruption of the services.

4.1.6 Sound Summit Roskilde

Roskilde SOUND2019 is an annual music festival in Roskilde, Denmark. For this event only the Sound Monitoring and Control use-case was selected, the main objective of this demonstration being to validate the adaptive functionality of the Adaptive Sound Field Control System (ASFC). The festival is held mostly indoors, but for the ASFC test, SOUND2019 had arranged a special outdoor stage. This being one of the smaller demonstrations four IoT Sound Level Meters were the only IoT devices deployed.

4.2 Nuits Sonores Lyon

Nuits Sonores is an electronic music festival that takes place in Lyon every year during the spring and gathers more than 140,000 visitors. Events are presented at different places around the city of Lyon.

During the 2019 edition, the MONICA project was covering one of the main sites, the old Fagor Brand factory, where music is being played on three stages from 10 pm to 5 am. As depicted in Figure 8, the site is in a mixed industrial and residential area.

Figure 8: Nuits Sonores venue

As shown in Table 3 this pilot selected Sound Monitoring and Control to be the core topic. Event organisers were collaborating closely with MONICA partners. In 2019 they expected the same as in the previous editions: demonstrate Sound Monitoring solutions to better assess the compliance with the French noise regulation and the noise disturbance caused to the neighbours.

Table 3: Selected Use Cases for this Pilot

ID	Use Case Group	Selected for 2018	Selected for 2019
UCG 2	Sound Monitoring and Control	X	X

Table 4 provides an overview of the devices tested by this pilot.

Table 4: Number of deployed IoT Devices

IoT Device Type	Number of deployed devices 2018	Number of deployed devices 2019
IoT Sound Level Meters (SLM)	1	7

4.2.1 Sound Monitoring and Control

In the 2018 Nuits Sonores Demonstration in May only one IoT Sound Level Meter (SLM) could be deployed. A first simple version of the MONICA COP dashboard was functional, and displayed sound levels on the section “Sound”. While seeing the visual output for the first time, it was decided to add a visual comparison with the French noise regulations to the next version. In 2019 the number of deployed IoT SLMs increased and 7 SLM were deployed. The added measurement data enhanced the available COP “Sound” section and the regulatory compliance assessment was demonstrated successfully.

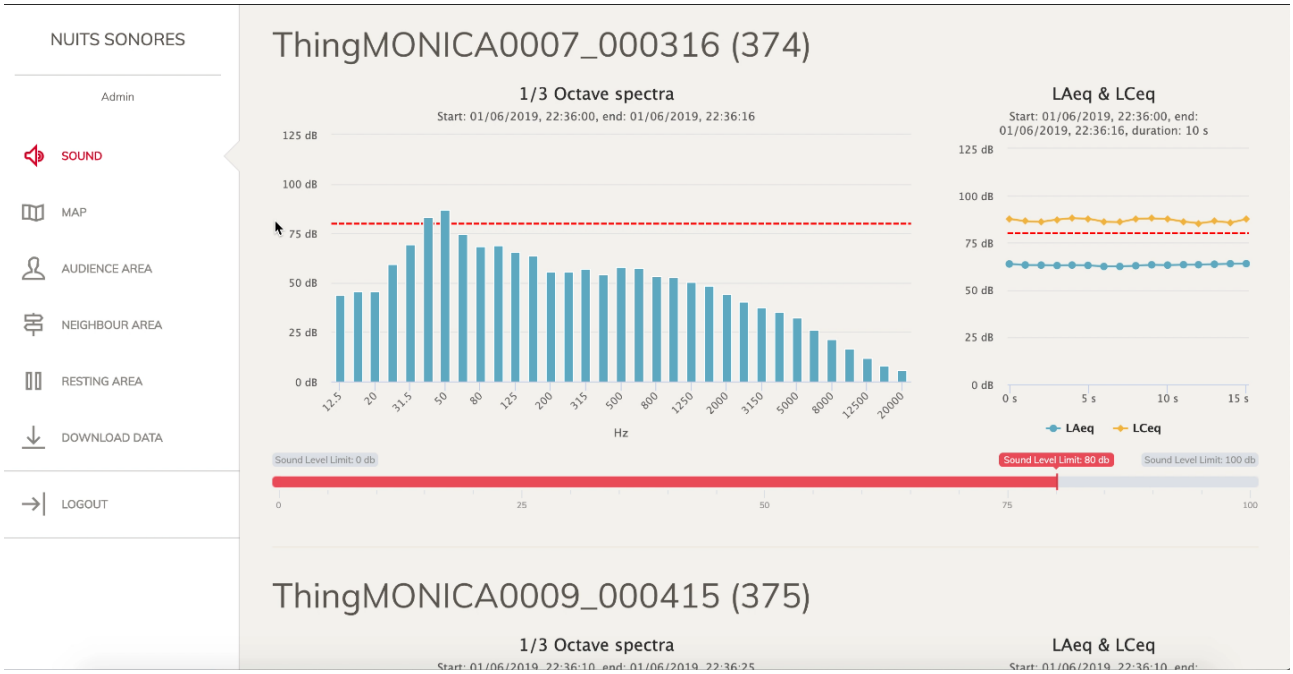

Figure 9 Screenshot of 2019 Nuits Sonores COP real time SLM data

Figure 9 shows the 2019 interface of the COP dashboard. The chart in the center now contains the red dotted line, indicating the limit of 80dB as prescribed by french regulations. The blue vertical bars indicate the measurement results by frequency. The menu on the left enabled navigating to Octave bands data grouped by the SLM standing at the audience area, the neighbour area and the resting area of the festival.

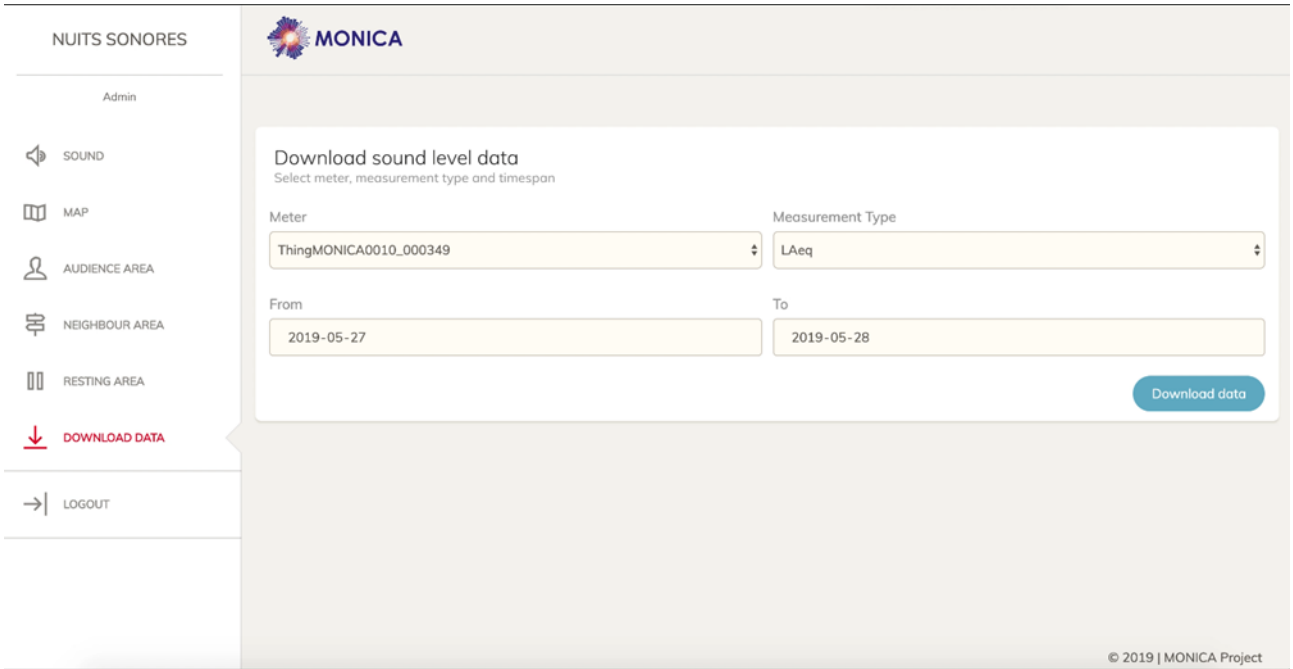

Figure 10 Screenshot of 2019 Nuits Sonores COP Download data function

Figure 10 shows the download data function, enabling stakeholders to retrieve historical data, for the purpose to prove regulatory conformity.

In 2019 four IoT SLMs were deployed inside the venue, one for each stage to assess the audience noise exposure and one at the rest area to assess if sound levels allows the audience to take a break. The last three IoT SLMs were deployed outside the venue to assess the neighbour's noise annoyance. Their locations are shown in Figure 11.

Figure 11: Sound monitoring points locations

Figure 12 shows the 'Gerland' measurement point, on a neighbour balcony in front of the venue.

The COP was configured to display sound levels, spectra and limits of the French noise regulation for each scene. However, a complete display could not be achieved during the demonstration due to technical issues.

Figure 12: View from 'Gerland' sound monitoring point

4.2.2 Sound Monitoring results

With more mature IoT SLMs than in 2019, it was expected to test the advanced functionalities: the contribution algorithm (to evacuate the not-event-related sounds from the comparison between measurement and regulation limits), the annoyance index (to try to link the noise annoyance with the measurement) and the sound heat map (to have an overview of the sound propagation of the stages in real-time).

In 2019 the event organisers decided to slightly change the stage configuration from the previous edition. The building used as a music Hall in 2018 became the restful area in 2019. Hence, the measurements recorded by the IoT SLM in this building could not be compared between 2018 and 2019. The stages were also oriented differently, changing the loudspeakers sound propagation in the music halls, which also should be considered for comparing the two editions.

In practical terms, in 2019 the IoT SLMs were sent early before the demonstration as the lack of preparation time was one of the main lessons learned from the 2018 edition.

Figure 13 presents one example result of the audience noise monitoring obtained by post-processing the measured data. We can see that sound levels at the sound engineer's console remain below limits throughout the show. Sound levels estimated at the critical point (point with maximal noise exposure) show slight exceedances (≈1 dBA and ≈3 dBC) at some times during the festival.

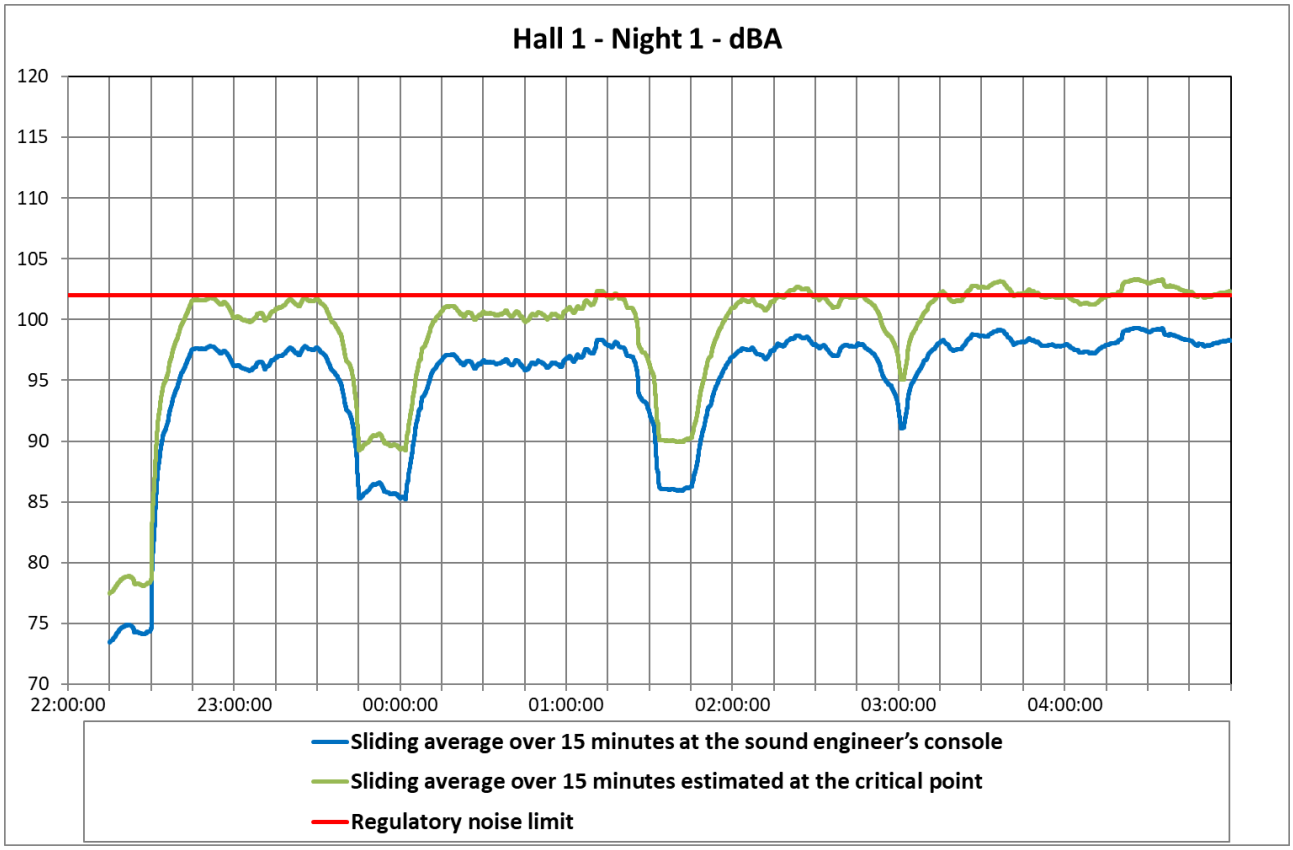

Figure 13: Sound levels fluctuation regarding the regulatory noise limit during the first night

Combined results from the three music Halls along the three nights show that audience noise exposure globally complies with the French regulation. Only short-term exceeding has been recorded at the critical points, with a maximum of 3 dBA.

Major exceeding has been recorded on two of the three IoT SLMs (at the neighbour's balcony and at the edge of the Fagor Brandt factory) deployed for the neighbours' noise monitoring throughout the festival. The vulnerability of these areas can be explained by the proximity of the stages and the orientation of the hall openings. One slight exceeding has also been identified as coming from barking of the security staff dogs.

The various acoustic measurements have shown that the choice of the location of the stages is a determining factor in the festival's impact on neighbourhood noise. Reflection on the choice of use of the spaces, especially in the areas closest to the neighbourhood, can play an important role in the perception of the neighbours of

the festival. The impact study and the models provided by the service provider in charge of installing the sound diffusion systems can be a decision-making tool on which the organisers could rely for future editions.

These kind of results and analysis have been presented to the organisers of Nuits Sonores on a dedicated debriefing meeting.

4.2.3 Sound Monitoring Survey Campaign

Furthermore, three survey campaigns were deployed through Survey Monkey[2] questionnaires collecting:

- Audience's opinion on its noise exposure and the festival
- Neighbours' opinions on their noise annoyance and the festival
- Organiser's opinion on the COP

The survey campaigns deployment required a preliminary work: set up of the online surveys, large-scale communication (online, and several hundreds of flyers sending to the questionnaires distributed). The final dissemination ways are presented in Figure 14.

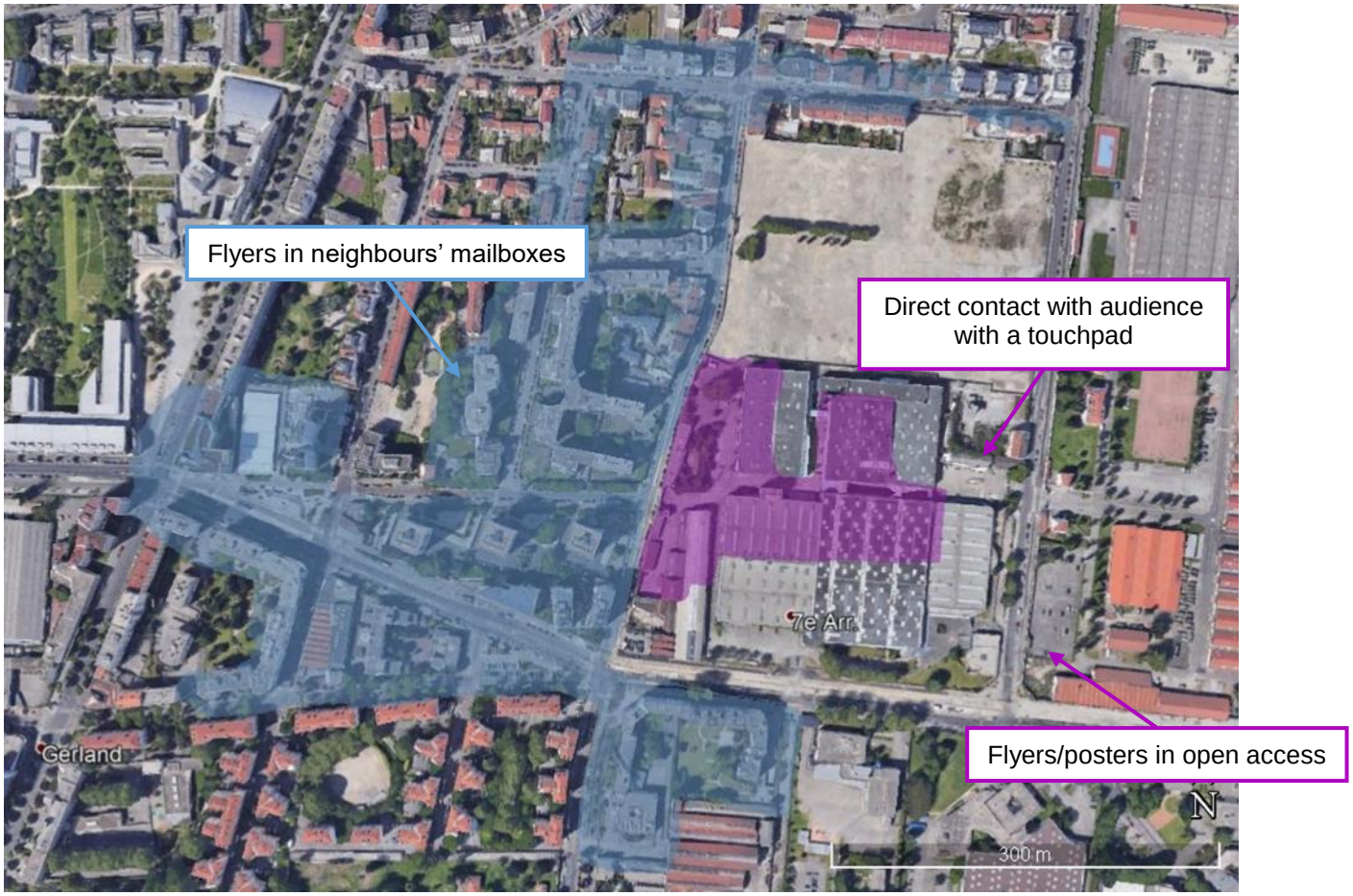

Figure 14: Survey campaigns dissemination ways

59 festival goers answered the noise exposure survey. Main outcomes are that the respondents globally like the festival and its sound quality. However, one-third considered the sound levels too high, which opens possibilities for adapting the sound levels inside the venue.

93 neighbours answered the noise annoyance survey. Main outcomes are that most of the respondents have a negative opinion about the festival and noise is the main annoyance. However, the methodology used

[2] https://surveymonkey.com/

generally favours the expression of inconveniences, which can be confirmed by the similar results of the neighbours' survey using the same methodology during the Kappa FuturFestival 2019 demonstration.

Performing a survey campaign during night time with festival goers while concerts are going on, it was a challenge to comply with GDPR and ethical terms. During face-to-face interviews, the GDPR was too long to explain, and interviewees did not listen and were leaving to go back to party.

The surveys response rate for the party goers could have been higher if the survey would have been integrated in the official app of the event.

4.2.4 Lessons learned

- Receiving the IoT SLMs early before the demonstration allowed the MONICA team to properly setup the devices, test their functionality and prevented unexpected events: in fact, it allowed to conduct background noise measurements one week before the planed time slot, because of bad weather forecast (wind or rain will interfere with the measurements).
- It is not suitable to convoke Authorities, Organisers and Sound Engineers for a presentation of the COP without being sure that the displayed data is validated. Without this presentation it is not possible to get feedback from final users.
- Performing a survey campaign during night time with festival goers while concerts are going on, it was a challenge to comply with GDPR and ethical terms. During face-to-face interviews, the GDPR was too long to explain, and interviewees did not listen and were leaving to go back to party.
- The surveys response rate for the party goers could have been higher if the survey would have been integrated in the official app of the event.

4.3 Kappa FuturFestival Torino

Kappa FuturFestival is the most attended Italian outdoor, urban, dance, summer festival. Dedicated to electronic and techno music, it takes place every year in early July over two days from midday to midnight in the recently renovated Parco Dora. The park spread over 450 thousand square metres where the memory of the industrial past is kept alive by some of the pre-existing structures (pools, steel pillars, smokestacks). The last two editions of the festival had 4 stages distributed in a “fenced” area of about 60 thousand square metres surrounded by residential buildings. The propagation of noise in a densely populated area is the reason why Kappa FuturFestival event organisation joined the MONICA project.

Figure 15: View from the SEAT stage

Kappa FuturFestival was the first pilot to hold pre-tests in 2017 and then actual tests the following year. In 2018 it was decided to test almost all solutions, i.e. sound monitoring and control, blimp, sound app, video analysis and wristbands. The following year the consortium decided for a remodulation. Table 5 shows all the use cases selected and Table 6 shows the IoT devices deployed.

Table 5: Selected Use Cases for Kappa Futur Festival Pilot

ID	Use Case Group	Selected for 2018	Selected for 2019
UCG 2	Sound Monitoring and Control	X	X
UCG 3	Crowd & Capacity Monitoring	X	X
UCG 5	Locate Staff	X	
UCG 7	Security Incidents	X	X
UCG 13	Event Information	X	X
	Deployment of airship	X	environmental sensors only

Table 6: Number of deployed IoT Devices for Kappa FuturFestival Pilot

IoT Device Type	Number of deployed devices 2018	Number of deployed devices 2019
CCTV cameras	8	9
UWB Staff Wristbands	15	0
UWB Anchors	9	0
IoT Sound Level Meters	9	11
Blimp	1	0

4.3.1 Video Analytics using CCTV cameras

In 2018 eight CCTV cameras have been used, covering the main stage and walkways around the site, on which crowd density estimation and flow analysis has been run for the whole duration of the event. The crowd counting algorithm and the related events have been successfully integrated into the MONICA platform and were visualized on the COP. In order to improve the crowd counting algorithm, about 100 images have been taken during the event to perform an offline calibration. In 2018 eight CCTV cameras have been used, covering the main stage and walkways around the site, on which crowd density estimation and flow analysis has been run for the whole duration of the event. The crowd counting algorithm and the related events have been successfully integrated into the MONICA platform and were visualized on the COP.

In 2019 a total number of nine CCTV cameras were deployed in Parco Dora area to cover the main stage area of the event, six of which were HD cameras and three older SD resolution cameras. Due to the incompatibility in camera output resolution no proper connection to the three older cameras could be established. Hence, the six HD cameras were used only.

The results of the counting algorithm analysis can be summarized as follows: A mean absolute error (MAE) of 5.4343 is observed on a sample of 100 random images. In the graph of predicted vs. actual numbers, the blue line shows that the algorithm has slightly underestimated the crowd numbers in most images. This could be possibly because of the presence of crowd at the far end of the frame and occlusions such as trees and other objects in the image (see Figure 16 and Figure 17).

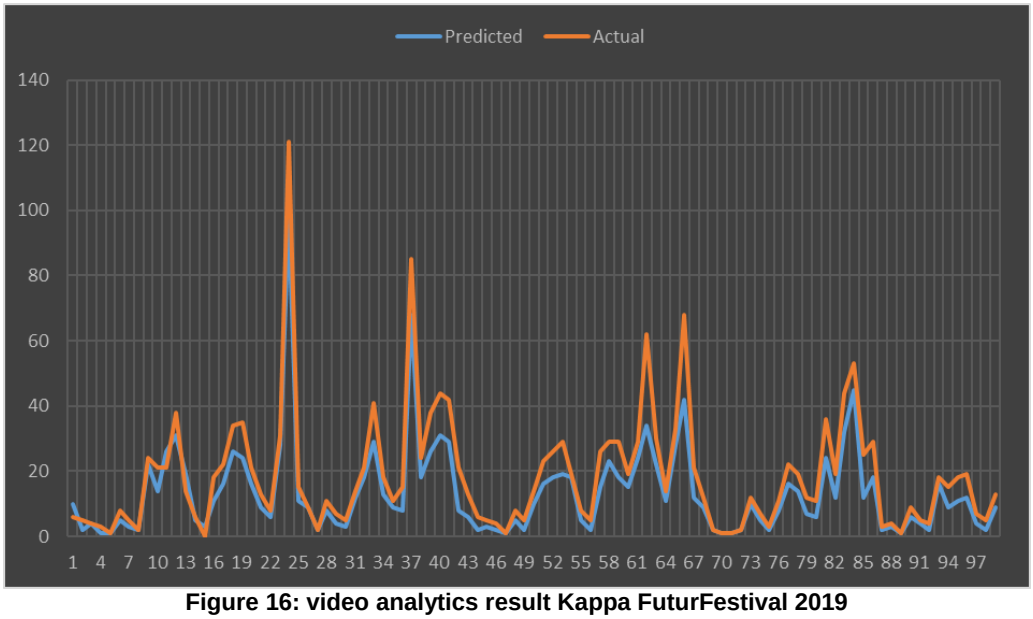

Figure 16: video analytics result Kappa FuturFestival 2019

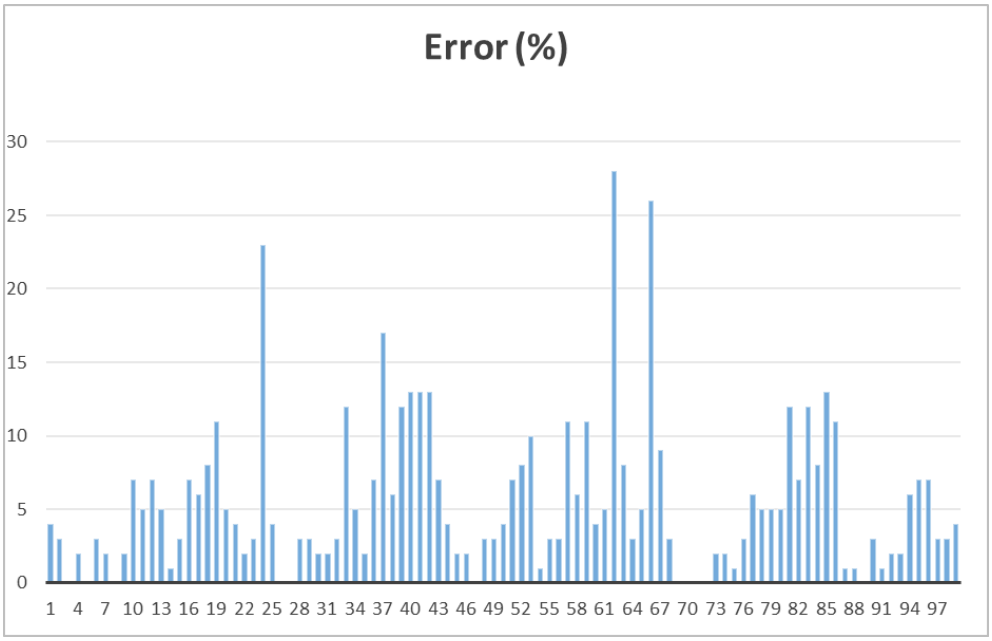

Figure 17: Video Analytics Errorrate Kappa FuturFestival 2019

4.3.2 Staff Wristbands tested in 2018

In 2018, MONICA partners performed a test with 20 staff wristbands in one of the four stage areas. This test required the deployment of an IoT-wristband infrastructure, composed of six 868MHz base stations (BSs) and a UWB network infrastructure, composed of 8 anchors and 1 master anchor. The network proved to be reliable while, due to potential radio frequency interference, the UWB tags were not localized as accurately as expected. This interference was most probably caused by a cellular network station located very close to the event venue. The staff wristbands data was integrated into the MONICA platform and displayed on the COP. The event organization decided to exclude this test in the following year, as it proved to be very complex and much more costly than previously planned. This is mainly due to the absence of wiring and internet connection in the venue, the difficulty to find or build appropriate structures to install sufficient base stations on height and the costs related to the mandatory certification for all installations on sufficient heights in the public entertainment area.

4.3.3 Blimp deployment in 2018

In 2018 a small 5-meter blimp, compliant with the fire regulation and assembled by DIGISKY, has been tested. Given the small size, the blimp featured a basic payload system (maximum 2 kg) carrying a gimbal with a 4K camera and a SLM provided by the City of Torino. The data have been stored in the internal memory of the devices themselves for offline processing. Then, the collected data were integrated into the MONICA platform for online processing. In 2019 Digisky tested the environmental sensors only, because the blimp used the previous year was not stable enough in case of wind and it was not found a structure complying with the local safety and security regulations. In Chapter 8.1 more detailed information on the MONICA Blimp technology and a related field test performed in 2019 is available.

4.3.4 Sound Monitoring using IoT Sound Level Meters

The main interest for Kappa FuturFestival Organisation to join MONICA project as a partner was to improve sound monitoring and control during their life event. In 2018 a total of nine SLMs have been deployed. Four in front of every stage to monitor sound levels, and five more in the most exposed dwellings. The sound data were successfully integrated into the platform and the related sound levels as well as spectral data were displayed on the COP dashboard. A screenshot of the COP dashboard can be seen in Figure 18. The visualization of SLM data was comparable to the interface used for Nuits Sonores (see Figure 9).

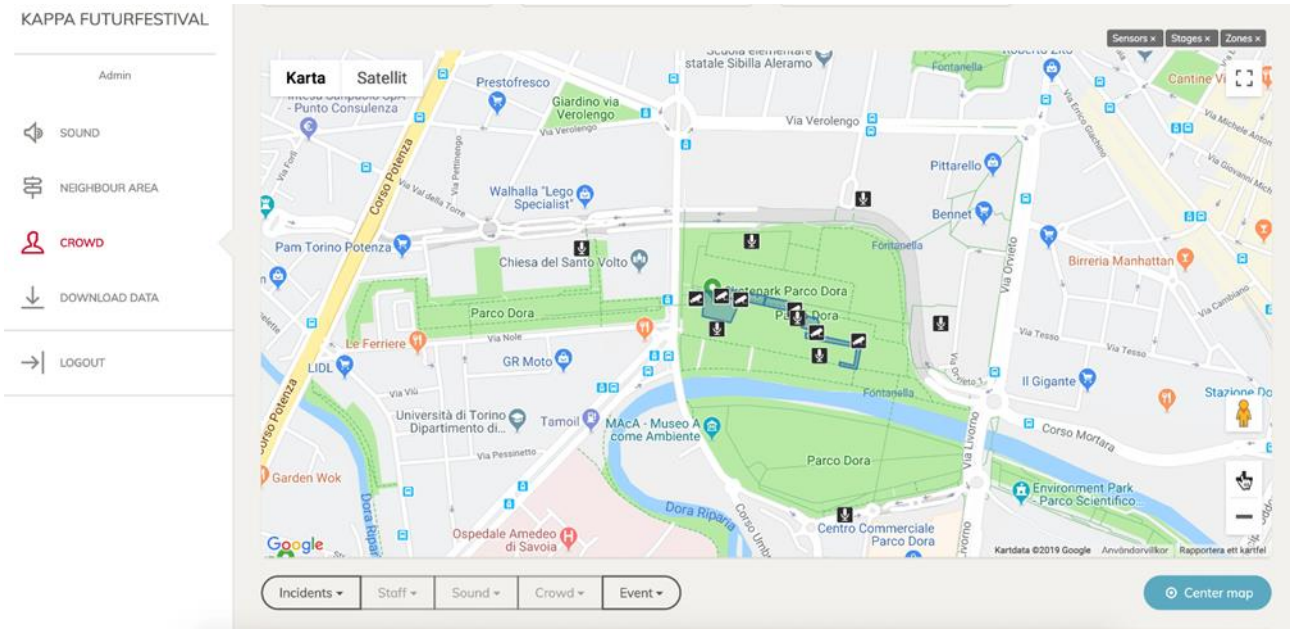

Figure 18: Screenshot of COP dashboard CROWD tab during Kappa FuturFestival 2019

In 2019, a total of 11 SLMs were deployed: 4 inside the park, 5 in private apartments in the neighbouring area and 2 used by DTU to calibrate the adaptive sound field control system. The last two had problems to send sound data because of the instable network bandwidth, hence only a moderate amount of data has been sent to the B&K cloud. The four SLMs inside the park worked very well on Saturday, while some interruptions of data transmission happened on Sunday.

Overall, the sound monitoring outside the venue went smoothly. Sound technicians from event organisers and local authorities appreciated having real time sound levels (i.e. LAeq, LCeq) shown on the newly designed mobile version of the COP dashboard.

4.3.5 Sound Control using the Adaptive Sound Field Control System

Developed by MONICA partner Technical University of Denmark (DTU), the Adaptive Sound Field Control System (SFCS) was tested under real-world conditions during Kappa FuturFestival 2018 for the very first time. The system is composed of 20 amplifiers, wired microphones and a PC. Figure 19 shows the technicians doing onsite measurements at the event site during the MONICA Acoustic Meeting in December 2017. In July 2018 further comprehensive measurements were done during the live event. In the 2018 setup the ASFC system pointed to reducing noise of a stage newly installed for the 2018 edition. This first demonstration helped in preparing the further experimentation of the ASFC system during the Fredagsrock demonstration at Tivoli Gardens in Copenhagen in August 2018.

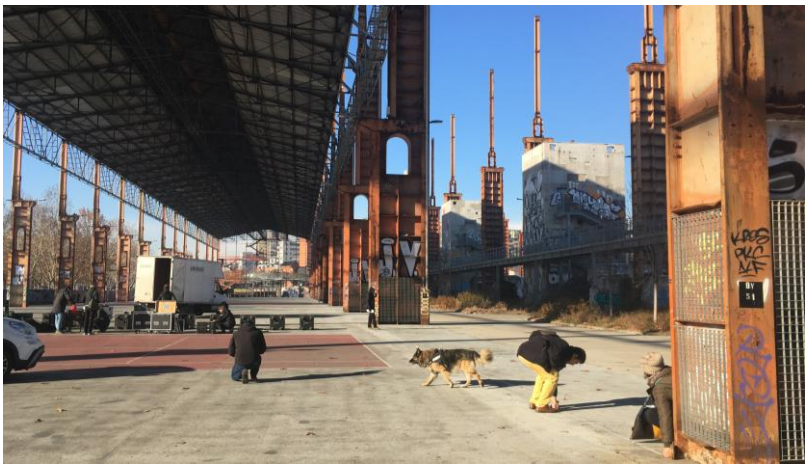

Figure 19: onsite sound measurements to calibrate Adaptive Sound Field Control System in 2017

For the Kappa FuturFestival 2019 edition, the organisers had changed the stage layout. Figure 20 shows the map of the Kappa FuturFestival venue, indicating the deployment locations of the Adaptive Sound Field Control System (here SFCS). This time the aim was on reducing noise from the SEAT stage in a limited area outside the venue. The ASFC system was installed behind the audience, just next to the festival barriers. A neighbouring church courtyard served as a so called dark zone. Functionally the system worked as expected, but did not reach the 10dB KPI previously targeted. The data proves a successful reduction of the level of sound of about 6dB.

The target of 10dB reduction, which roughly corresponds to a halving of the loudness for the human perception, has only been achievable at MONICA tests in open terrain without adjacent activities and buildings complicating the sound attenuation. More detailed information about the ASFC system can be found in D4.3 Validation of the ASFC and Noise Monitoring System Configuration and Model Updating 3.

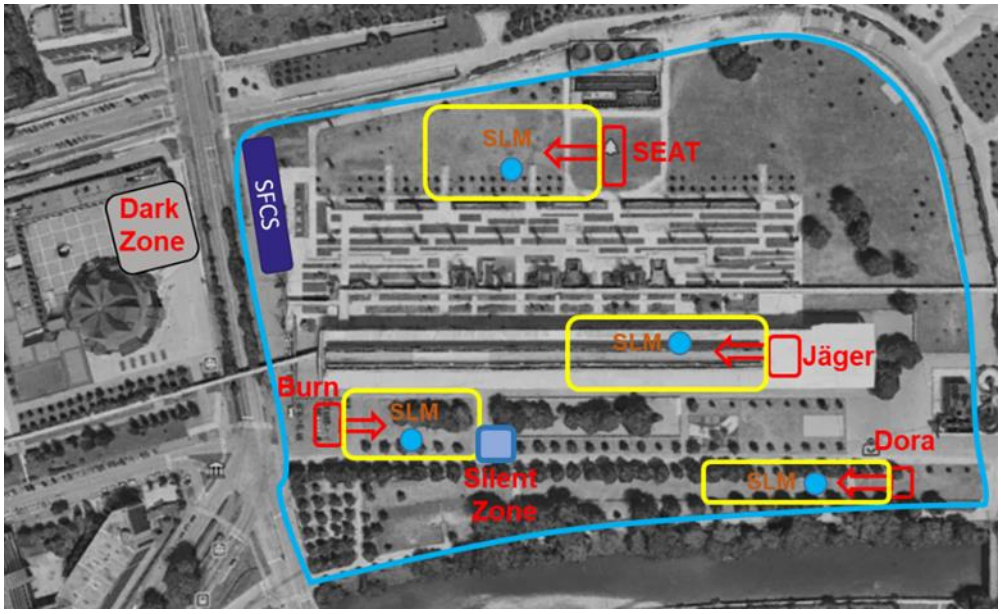

Figure 20: Map of the Kappa Futur Festival venue showing 2019 stage positions, dark zone and silent zone

In 2019 in addition to the Silent zone (Quiet Zone) system, a small area of 3 sqm with reduced noise, was demonstrated at Kappa FuturFestival. It was installed close to the audience area of the Burn Stage. The approach was to adaptively reduce the bass sound from the stage in front. The Silent zone system worked as expected.

Another precious source of information for all partners is the sound data collected at Kappa FuturFestival during MONICA project. Especially the City of Torino and the event organiser were able to setup more points of measurements active for the whole duration of the event thanks to the support of MONICA partners and the project related equipment. Currently it is under evaluation of the consortium which dataset shall be made public and how.

KFF takes place only once a year in a public park, hence the period assigned to the organization by authorities is limited and this requires an extraordinary effort to set everything up and dismantle by the given time (about 10 days prior the event and 5 after it). Indeed, authorities wish to limit as much as possible the period of time during which citizens cannot access the park. In addition, it is very complicated to replicate the same conditions during the rest of the year. Hence it is necessary to use mathematical models to reproduce stage positions, sound direction, weather, humidity, or other factors that may influence sound propagation before the event.

As the park is surrounded by residential buildings, also the timeframe for sound tests is regulated by norms, emanated by the municipality, that allow a certain number of hours of excessive noise (usually 4). The consequence for the MONICA deployment was that the configuration of instruments had to run at the same time of the festival rehearsal making it very difficult to set them up appropriately.

4.3.6 Lessons Learned

- Necessary an accurate planning listing every material that is needed well in advance, from cables and power engines to, for example, a recent geo-mapping of the area where tests are to be held.
- Necessary to ask for permission to the municipality to produce noise for calibration of the system.
- Necessary to held pre-tests in order to have dataset to use for noise impact assessment before the start date of the pilot and to improve stages positions to improve the direction of sound toward the audience vs the surrounding environment.
- Necessary to have an equipped office near the venue accessible also before the event for the COP.
- Necessary to synchronize working hours of those working from remote/abroad partners to pilot schedule.
- Necessary to verify that there are no cellular network stations located very close to the event venue, as they may cause potential radio frequency interference leading to the Staff Wristbands UWB tags not localized as accurately as expected.

4.4 Fredagsrock Tivoli Copenhagen

Tivoli Gardens (Tivoli) is the second-oldest amusement park in the world and one of Copenhagen's most famous venues. It offers a variety of live events and organises Fredags rock Concerts from April through September: a recurrent annual open-air concert-series with national and international performers.

Figure 21: Aerial shot of Tivoli Gardens (source: Tivoli A/S)

Tivoli is located in Copenhagen's city center right next to the Central Train Station and Copenhagen City Hall. Figure 21 indicates in red the main stage area for Friday Rock concerts inside the venue. The small neighboring residential area at the southern border of the venue is indicated in blue. Within this area, residents complain about Tivoli's sound emission. Table 7 shows the use cases the MONICA partner Tivoli had selected.

Table 7: Selected Use Cases for Tivoli

ID	Use Case Group	Selected for 2018	Selected for 2019
UCG 2	Sound Monitoring and Control	X	X
UCG 3	Crowd & Capacity Monitoring	X	X
UCG 4	Missing persons	X	
UCG 7	Security Incidents	X	X

Table 8 lists the deployed IoT Devices at Tivoli pilot during the MONICA demonstrations performed.

Table 8: Number of deployed IoT Devices in Tivoli

IoT Device Type	Number of deployed devices 2018	Number of deployed devices 2019
Cameras	7	7
Glasses	0	6
Visitor wristbands	6	480
IoT Sound Level Meters	15	20
Apps (FriendFinder, Sound app for Staff)	0	2
Loudspeakers(Subwoofers)	21	0

Tivoli pilot ran a first Fredagsrock demonstration in 2018 on Friday August 31st. During this demonstration the ASFC system was the main focus area. A basic setup for Dexels IoT Crowd Wristband infrastructure had been installed in the Garden and was tested in a small scale test, as well as the integration of Tivolis security cameras available in the Garden.

On April 26th 2019 a second demonstration was deployed during a Fredagsrock event. The main interest during this second demonstration was the testing of the MONICA platform with hundreds of crowd wristbands distributed in the field. A dedicated FriendFinder App was demonstrated and 6 smart glasses were deployed and showcased to the Tivoli staff.

4.4.1 Crowd Counting using IoT Cameras

Figure 22: Preferred surveillance areas during MONICA (yellow demarcations) (source Tivoli A/S)

Out of Tivoli's security cameras, seven were successfully connected to the MONICA platform in 2018 as well as in 2019. Five of these cameras focus inside the Garden and two of them to the main entrance area. Figure 22 shows their preferred surveillance area in yellow. On these Tivoli tested car detection algorithms (see Figure 23) and crowd monitoring algorithms, to run crowd flow analysis to identify bottlenecks and develop an early warning system.

Figure 23: Video analytics algorithm identifying a car

Figure 24 and Figure 25 show the video analytics results based on a sample of 80 random images from Winter 2019. A mean absolute error (MAE) of 6.506 is observed. In Tivoli, the MAE is comparatively on the lower side, however, in the graph of predicted vs. actual numbers the prediction number has generally been higher than the actual number. The overestimation could be because of street occlusions and tiled surfaces in the image that sometimes is wrongly estimated as crowd by the algorithm.

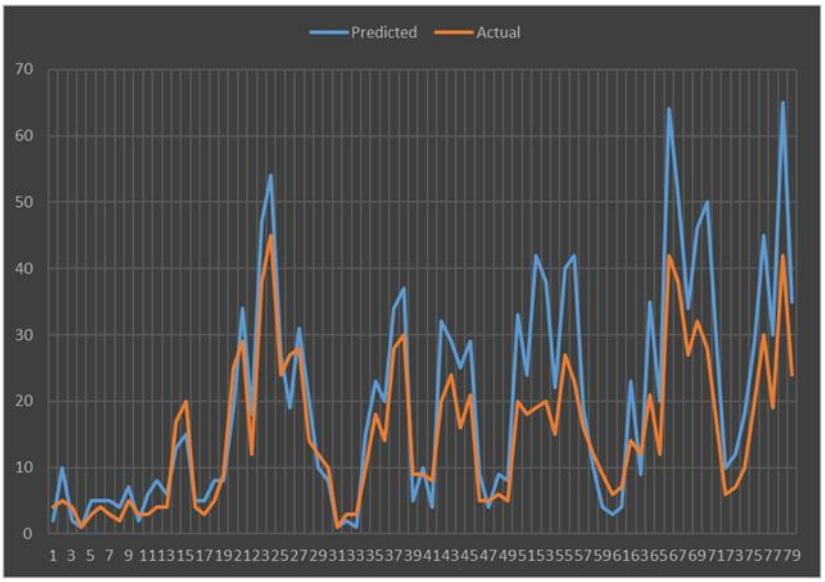

Figure 24: video analytics result Tivoli 2019

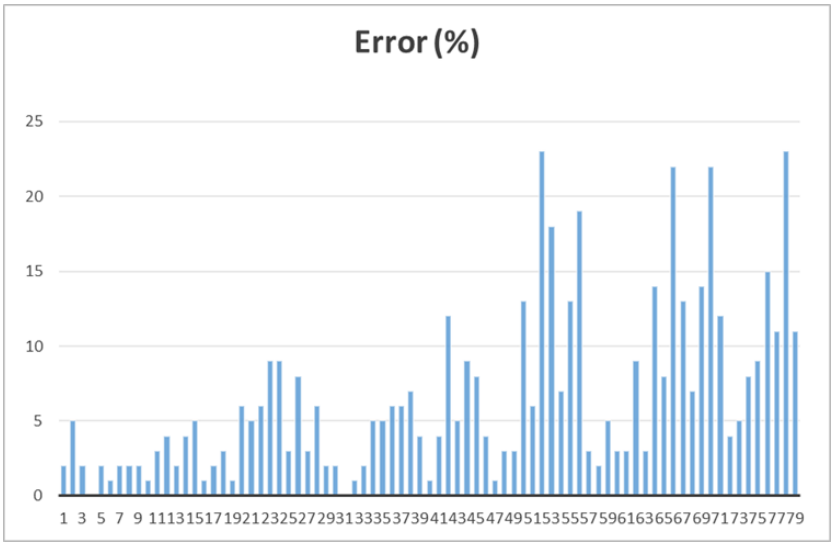

Figure 25: Video Analytics Errorrate Tivoli 2019

4.4.2 The Tivoli Permanent COP

Throughout the summer season, Tivoli had two SLM´s permanently installed. These measured the noise level at the Stage as well as on the concert hall roof and sent this information to the COP.

Tivoli is one of two MONICA permanent COP locations. Throughout 2019 the Tivoli COP was available when no other demonstrations happened. During the last months of the project Tivoli implemented hardware updates to strengthen graphic controllers power and technical partners installed and tested the latest software and algorithm versions. After completion of the MONICA project in March the COP will remain as a local application. As there is a further interest to test the fight detection algorithm and queue analysis in the garden. Tivoli considers the COP as a dashboard to support the safety of daily operations.

4.4.3 Crowd Wristband Demonstration in April 2019

On April 26th 2019, Tivoli performed a crowd wristband demonstration during a Friday Rock Concert. The setup of Wristband Gateways and Base stations had already been performed in 2018, therefore Tivoli was chosen for this biggest test of crowd wristbands planned up to that date. About 470 wristbands were given into circulation among Tivoli's guests for Friday's Rock. The guests were incentivized by a free drink coupon. The main interest was to see how the wristband could be used for in the Tivoli Garden. In order to distribute the

wristbands, appointments to get one could be made on the Facebook Page of Tivoli prior to the event. More than 200 guests used this offer. However, during the event it was hard to persuade the visitors of the benefits that wearing the crowd wristbands would bring them. Most visitors perceived the GPS tracking component negatively. It became apparent that a clear short function statement of the Wristbands would have been appreciated.

That night, four smart glasses from Optivent were also tested by the Security staff walking around in the park. Footage from the glasses worn by security personnel seemed too heavy and slow for the network around in the Garden. More comprehensive information about MONICOra IoT smart glasses tested can be found in section 3.2.4.

Figure 26: Crowd wristbands grouped by pairs of 50 to ease distribution and counting

In order to distribute the hundreds of crowd wristbands Tivoli built a MONICA distribution booth inside the venue, located right on the way of the visitors from entrance to the concert main area. Next to the 200 pre-registered visitors about 270 additional visitors were convinced and agreed up on wearing a crowd wristband during the evening. In order to ease their distribution, the crowd wristbands were unpacked and grouped in pairs of 50 pieces (see Figure 26 and Figure 27).

The crowd heatmap for wristbands was not yet ready to be displayed in the COP dashboard, but this first medium scale demonstration of crowd wristbands allowed good understanding of the distribution process and served well to prepare the large scale demonstration in August 2019 (see section 4.6 Woodstower).

Figure 27: Prepared booth for Crowd wristband distribution during Tivoli Friday Rock Concert

On Friday, July 26th, another major internal test in Tivoli was made in order to simulate the system setup to be used at the Woodstower Festival in Lyon in August 2019. During this dry run about 330 wristbands were placed around the garden in bundles of 20 pieces. There were also boards with 20-25 pieces that were used to test voting via the wristbands button in preparation of the deployment during IoT Week. Finally, the LEDs in the bracelets were tested. The tests showed that there should be a focus on performance as slight time delays became apparent.

Concluding, there were not enough beneficial functions to the Tivoli Guests on the crowd wristbands. The lightshow was weaker than expected, therefore the light around the stage needed to be considerably lowered. Only a part of the visitors were wearing the wristbands, and it did not have the expected effect in front of the stage. As the coverage of the base stations was limited to the lawn, in front of the main stage the testing of the crowd wristbands did not deliver

4.4.4 The Quiet Zone and Sound Monitoring activities

In September 2019, a complete test of the adaptive sound field control system (ASFC) at Friday Rock was planned. However, after the test during Kappa Future Festival it had to be cancelled as the system was not mature enough for the complex conditions in Tivoli. This was the reason why the test was moved to Roskilde Musik Højskole for the Sound Summit day on November 30th (see Chapter 4.7). After positive results there, Tivoli is hoping to be able to test the ASFC in the future. The demonstration at Kappa FuturFestival 2019 showed once more that due to the complexity of the environment, it has not yet been possible to achieve the 10dB reduction during the demonstration. Therefore, DTU decided to consider the deployment of ASFC system at less environmentally challenging events.

Tivoli Gardens has a complex geography with many variable parameters and obstacles that reflect the sounds make the deployment of the adaptive sound field control system extremely challenging. In order to further develop the adaptive sound field control system more tests need to be performed in a simpler setting. The expectations of Tivoli Gardens Management for the sound control were high and had to be lowered.

Instead of the ASFC, the “Quiet Zone” (see Figure 28) as well as the audio app from CNET were tested during Friday Rock Concert on September 20th 2019. The “Quiet Zone” is also known as “Quiet Zone System” and was used in a simplified form in Tivoli (see Figure 29).

Figure 28: Quiet Zone Set-Up in Tivoli in September 2019

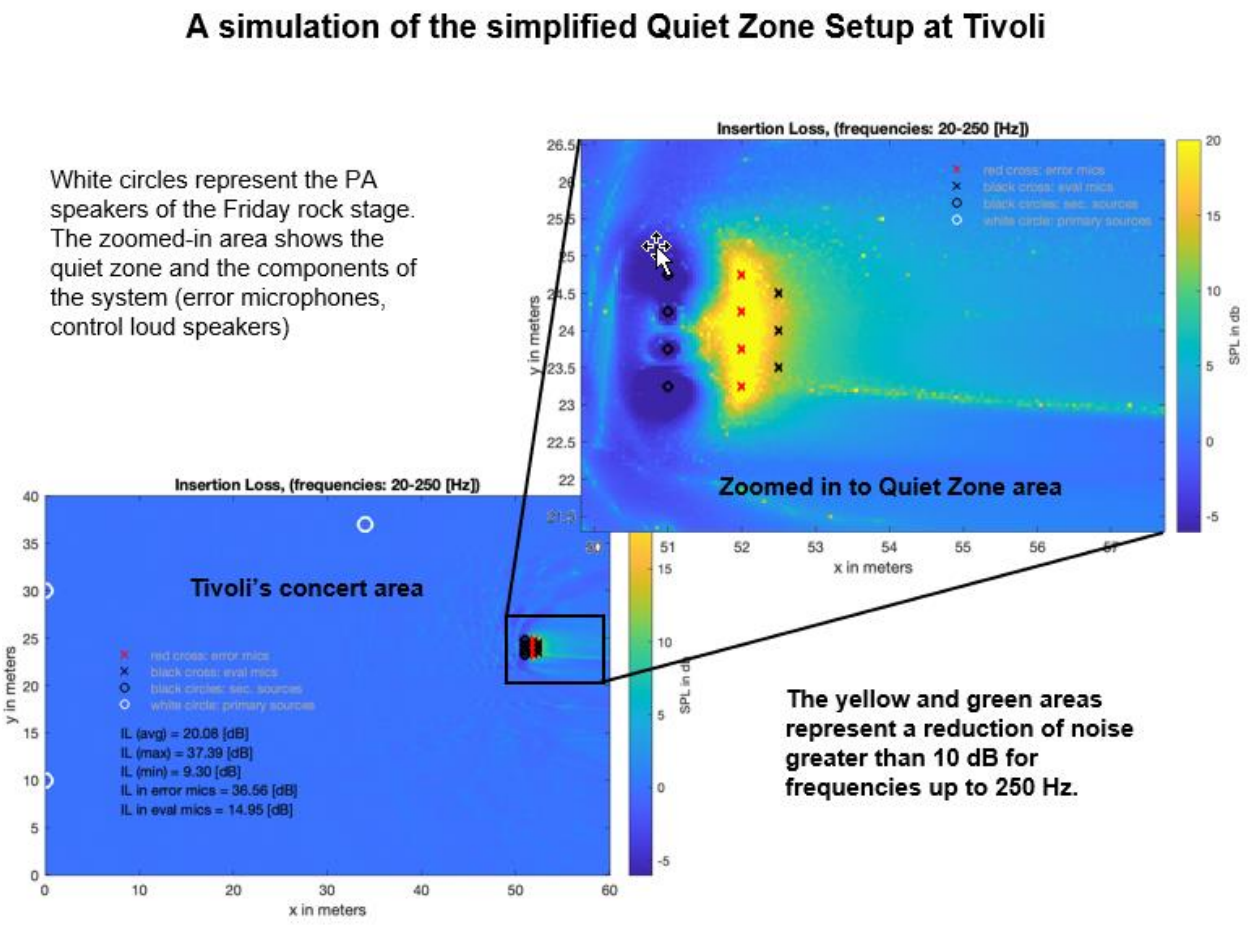

Figure 29: A simulation of the simplified Quiet Zone Setup at Tivoli

Its performance has shown promising results, as it was demonstrated that such a system can achieve a reduction greater than 10dB in the entire frequency spectrum. On the other hand, the coupling of the passive and active elements of control was not sufficient in the area of interest, if we presume an overall minimum reduction of 10dB. Here the performance dropped to only 4dB around 150Hz (see Figure 30). Concluding, it can be said that the system showed a reasonable reduction of 50% of loudness throughout the whole listening spectrum. Moreover, is it expected that the performance in general and so also the gap around 150 Hz can be further improved by adjusting the system's geometry or applying extended technics of active control. More detailed information about the Quiet Zone system can be found in D4.3.

The COP dashboard was made available as a mobile version on a tablet device. It was presented and tested by the sound staff in Tivoli.

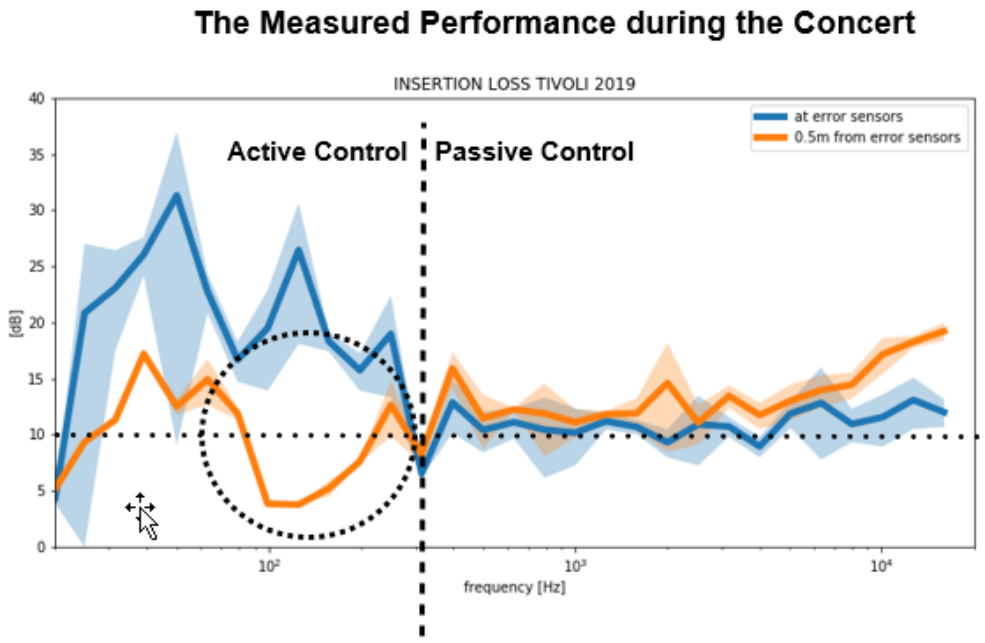

Figure 30: The Measured Performance during the Concert

4.4.5 The Tivoli FriendFinder App

Another use case that Tivoli was interested in, was the "Missing person" use case. It was addressed by combining the "FriendFinder" feature of the MONICA crowd wristbands with a Smartphone App (see Figure 31). The use scenario was to offer groups of Tivoli guests this service via a crowd wristband that would be connected to the App on their Smartphone. The service was tested extensively during the spring period including productive dialogues with the developers. Nevertheless, Tivoli Management decided to dismiss this service, based on two reasons. First, the App stores already offer Apps for this use case with significantly more features. Second, due to certain prototype related weaknesses such as slightly inaccurate positions, cumbersome registration procedure and stability problems. As this did not match the high quality ambitions that Tivoli claims to offer to all guests the solution was aborted.

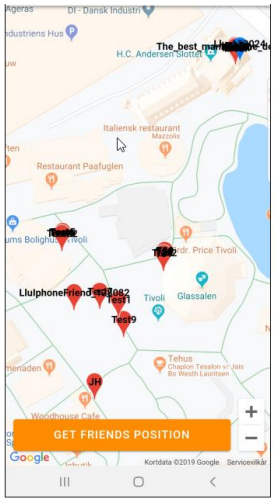

Figure 31: Prototype of Friend Finder App

4.4.6 Lessons learned

- Tivoli Gardens has a complex geography with many variable parameters and obstacles that reflect the sounds make the deployment of the adaptive sound field control system extremely challenging. In order to further develop the adaptive sound field control system more tests need to be performed in a more simple setting. The expectations of Tivoli Gardens Management for the sound control were high and had to be lowered.
- There were not enough beneficial functions to the Tivoli Guests on the crowd wristbands. The light-show was weaker than expected, therefore the light around the stage needed to be considerably lowered. Only a part of the visitors were wearing the wristbands, and it did not have the expected effect in front of the stage. As the coverage of the base stations was limited to the lawn, in front of the main stage the testing of the crowd wristbands did not deliver
- Over the course of the whole project, it was further seen that test pilots require:
    - suppliers who understand Tivoli's business.
    - technicians in close dialogues about functionalities.
    - coordinating and delivering solutions as planned.
    - training and transferring knowledge from developers to users at testpilots.
    - technicians on site at the test-pilot events.
- Additionally, in order to successfully involve visitors, simple communication is essential. Tivoli's guests arrive late for events and have little patience. Therefore the registration process should not not involve too many steps and activities for the visitor. Also the quality and real content in IOT-devices/functions must be guaranteed. As a further incentive something of value can be offered to participants.
- During the MONICA Project, Tivoli constantly weighed MONICA project involvement against the impact on the daily business. This meant weighing quality and quantity of functionality in IOT devices featured by MONICA against their brand image and related quality expectations of their guests, depending on services delivered from MONICA technicians and suppliers, balancing the logistics to match the requirements for MONICA services versus the effects on Tivoli's daily operations and whether guests perceived it positively. Furthermore Tivoli had to consider areas that could be included in tests versus what the MONICA project as a whole needed.

4.5 IoT week Aarhus

The IoT week is an annual conference that presents future technology and its impact on business and life with representatives from the world of business, technology and science. In 2019, it was held in the Musikhuset in Aarhus, as shown in Figure 32. It welcomed about 1600 participants and featured around 180 sessions, workshops and panel discussions during 5 days. MONICA project was happy and thankful being invited to run a medium scale test of the MONICA crowd wristbands technology during this conference.

Figure 32: IoT week venue at Concert Hall Park Aarhus

The MONICA demonstration took place during three days at the public exposition from 18 to 20 June 2019. Table 9 shows the selected Use Case while Table 10 shows the number of devices tested during this pilot.

Table 9: Selected Use Cases for this Demonstration

ID	Use Case Group	Selected for 2019
UCG 3	Crowd & Capacity Monitoring	X

Table 10: Number of Deployed IoT Devices

IoT Device Type	Number of deployed devices 2019
IoT Wristbands	400

4.5.1 Crowd Wristband Deployment

As described in chapter 4.4.3, the April demonstration in Tivoli was MONICA consortiums first experience with handling and distributing a large number of crowd Wristbands. These first experiences on wristband logistics, the distribution and recollection processing provided important learnings to plan the IoT Week demonstration. The chance to deploy the crowd wristbands during IoT Week at the conference site again allowed to focus on technical matters and the constraints of actively sending data back and forth from a large amount of crowd wristbands. This second step proved to be a valuable preparation for the latter large scale crowd wristband demonstration in Woodstower Festival (see chapter 4.6).

The crowd wristbands were offered to visitors and exhibitors of the exposition. The crowd wristbands were connected and integrated to the conference App Grenadine and provided three functions. The first function was to alert the wearers to specific events or times of day by activating the wristbands LED. Moreover, at the end of the conference, the LED were set to blinking mode to remind to return the wristbands. The second

function was the option to exchange profiles between participants. For this, two people wearing the wristbands had to stand next to each other and press the button on their respective wristband to exchange (LinkedIn profile, email). The third function enabled the wearer to participate in session evaluations in the two primary conference rooms. During the sessions, the speakers asked decisive questions and people who wanted to vote “Yes.” pressed the button on their wristbands. The results were displayed on screens in the room. Lastly, the wristbands tracking function was used to create a first iteration Crowd Heat Map.

4.5.2 Integration with Event App Grenadine

For the registration process, MONICA subcontracted Grenadine and developed a Registration App that was used for registering the Wristbands. When registering at the registration desk of the IoT week, people were asked if they would like a smart wristband. In case of a positive answer, an information sheet was given to them which included the location of the MONICA booth. There, the visitors could download the Grenadine event app to register and then connect a wristband, provided by the personnel at the booth. To assist, there were 10 to 15 volunteers available each day in addition to the MONICA representatives. All people were asked to return the wristband with the incentive of participating in a lottery where an iPhone X provided by the organisers of the IoT week could be won. When returning the wristbands, participants were invited to evaluate about their experience using a Survey Monkey Questionnaire.

In order to allow the wristbands to operate inside the conference halls, ten base stations were installed within six hours by an installation company. Ethernet cables and PoE switches were added to fully set up the network. After hardware setup was completed, the configuration of the system was completed within one hour.

During the demonstration, 400 wristbands were active. That being said, about 500 wristbands had actually been distributed during the event. The technical setup showed issues and post-demonstration analysis unveiled that the wristband Gateway sent a message to the SCRAL for every single wristband as soon as there was a localization update. The number of these messages to the cloud needed to be reduced to enable proper functionality for the planned large-scale pilot in Woodstower (see Chapter 4.6) thus the setup was modified to send aggregated messages containing more wristbands’ positions in a single message.

However, this number could be increased by improving the distribution method. It would have been helpful if the wristbands had been incorporated in the general registration flow of the IoT week. Apparently, for some participants of the event it was not clear that the wristbands were part of the event and could be collected for free.

While the fact that new visitors were directly redirected by IoT Week volunteers to the distribution stand after the conference registration was a good idea, it did not have the expected impact as the distribution stand location was not so close and hard to be identified.

The booth could have been better identified by the visitors if there would have been a sign like ‘Wristband stand’. However, the IoT Week volunteer presence at the stand helped to a better identification.

The association of the Grenadine App to the wristbands worked fine. The direct integration of MONICA features in the app is a real advantage for user experience. However, the registration via Grenadine App proved to be a cumbersome, as new profiles didn’t show up immediately and sometimes took up to thirty minutes to appear. Moreover, the download of the App itself took time and this caused some willing participants to give up half way during the registration process. Unfortunately, as the app was developed by a third party, MONICA could not really influence this.

The visitor alerting worked well from a technical perspective. However, room for improvement could be identified by more communication to the participants. Also, the wristbands LEDs were noticed to be insufficient in very bright environments.

The voting function worked well. Just in one instance issues with the Internet connectivity were experienced and caused the voting application to fail.

According to the participants feedback, the profile exchange was the favourite feature offered. However, in order for the profile exchange to work, the wearers had to at least give their email address during registration. As this wasn’t mentioned in the “How To” post card, it had to be mentioned during the explanation speech by the volunteer and caused some dissatisfaction. Some other participants claimed that the time to connect to the Grenadine App took too long and didn’t work to the full satisfaction of the participants

4.5.3 Lessons learned

The four features developed for this event were functional. The demonstration just could have been better in terms of number of participants. Main identified obstacles were the location and the setup of the distribution booth. The important lessons learned are as follows:

- Very helpful to have a professional installation company to assist but detailed briefing of the company is essential, to avoid things to be explained on site.
- Breakdown of the hardware should be taken into consideration as well and planned
- To achieve a higher number of participants and therefore active wristbands the distribution of the wristbands should be made a part of the general registration flow at the entrance of the event. The registration of the wristbands to the Grenadine APP and therefore enabling the profile exchange function could be supported by the MONICA staff afterwards.
- To optimize distribution, Wristbands should be functional without registration.
- Crowd Wristbands could be distributed to groups instead of one person at a time.
- Giving an incentive seems to maximize the Wristbands collection.
- New batteries should be used every time a Wristband is distributed, especially if the feature ‘alert visitor’ is planned or if a light-show is expected.
- The features using the LED should be in dark environment to work efficiently.
- Voting functionality should be implemented on a local server not on the cloud, as it is a time-based application.

These results were especially helpful in regards to the planning of the demonstration at Woodstower Festival. Most importantly, it was found that scalability at that moment was not limited by the number of active wristbands, but by the up-link to the Cloud. Message aggregation could be applied to mitigate this scalability issue.

4.6 Woodstower Festival Lyon

Woodstower festival takes place in the Grand Parc Miribel Jonage (a 22,000 hectares natural park located 15 minutes by car from Lyon, France) each summer since 2005. Every year, Woodstower offers a large program of music with different influences, from electro to rap and reggae, which brings together both exciting artists and international icons but also the best of the local artists.

The 2019 edition took place from August 29th to September 1st and gathered more than 34000 people in three evenings (Figure 33).

Figure 33: A concert show at the main stage of Woodstower Festival in Lyon 2019

Table 11 shows the selected use cases for the demonstration on Woodstower Festival and Table 12 shows the number of deployed IoT devices.

Table 11: Selected Use Cases for Woodstower Pilot Demonstration

ID	Use Case Group	Selected for 2019
UCG 2	Sound Monitoring and Control	X
UCG 3	Crowd & Capacity Monitoring	X

Table 12: Number of deployed IoT Devices

IoT Device Type	Number of deployed devices 2019
IoT Sound Level Meters	8
Wristbands	6231
Environmental Sensor	1

Since the start of the MONICA project in 2017, the Woodstower festival has been a replicability site for the Lyon pilot. A sound monitoring system was deployed in 2017 and 2018, allowing to study both sides of the acoustic constraints faced by the organisers of this large outdoor music festival: compliance with the national noise regulation and complaints from the neighbours due to the noise annoyance.

In 2019, the MONICA Consortium decided to include the Woodstower festival as a dedicated pilot site. The two chosen Use Cases were to Monitoring Sound Levels and Inform Staff about sound and crowd density. The acoustic impact assessment of the festival has been a request from the organisers since 2017. The significant wind effect on sound propagation also made this pilot site very special from an acoustic point of view. The crowd density estimation was a proposal from the MONICA Consortium to the organisers. Woodstower's venue was indeed an ideal event for large scale demonstration of the MONICA crowd wristbands, as it was a fenced open air event with several stages during three days.

4.6.1 Sound Monitoring and the Sound Heat Map

The first objective of the sound monitoring was to assess the acoustic impact of the festival with regards to the requirements of the new French decree, in terms of sound exposure of festival-goers and sound impact in the neighbourhood. Eight IoT SLMs were deployed for the demonstration: Four inside the venue at each stage near the sound engineer console (see Figure 34 and Figure 35), four outside the venue in municipalities where the impact of wind could be assessed easier (see Figure 36 and Figure 37). Due to the wind, the impacted neighbourhood was in fact around two kilometers away. Simultaneous measurements, inside the venue in front of each stage and at receiver points in the neighbourhood area outside the venue, provided information about sound levels at those locations. They also allowed a deeper analysis for estimating the contribution of sound emissions from the festival to the total sound measured in the surrounding populated zones.

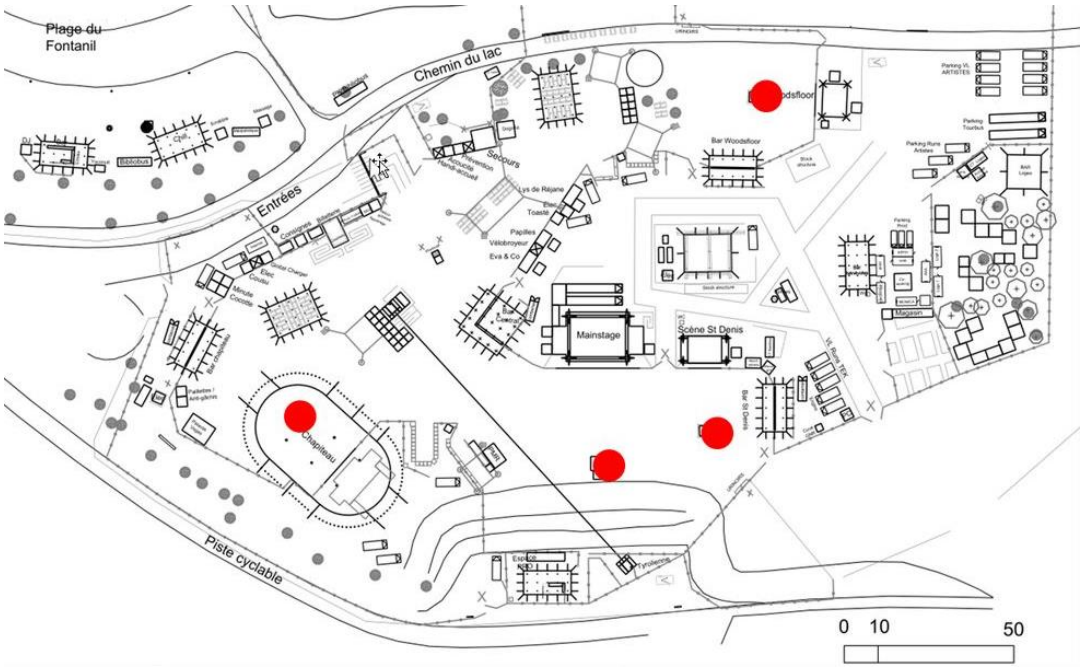

Figure 34: Sound monitoring points location in the venue

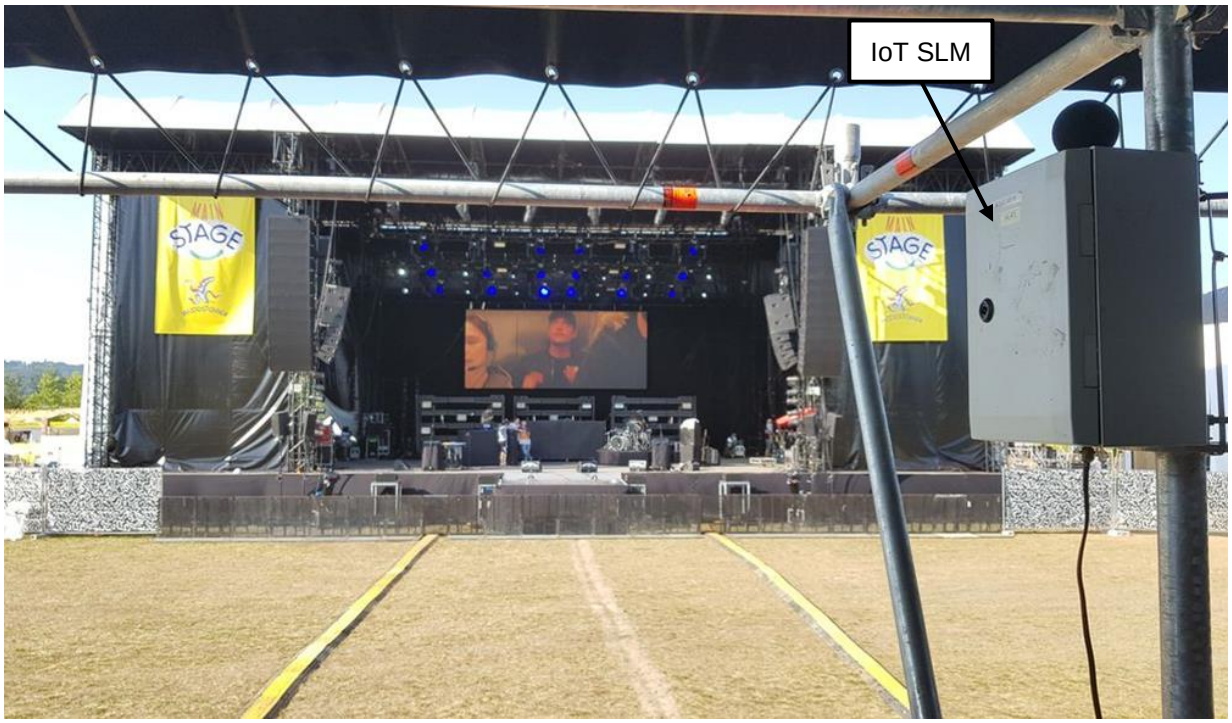

Figure 35: View of the IoT SLM deployed at the main stage

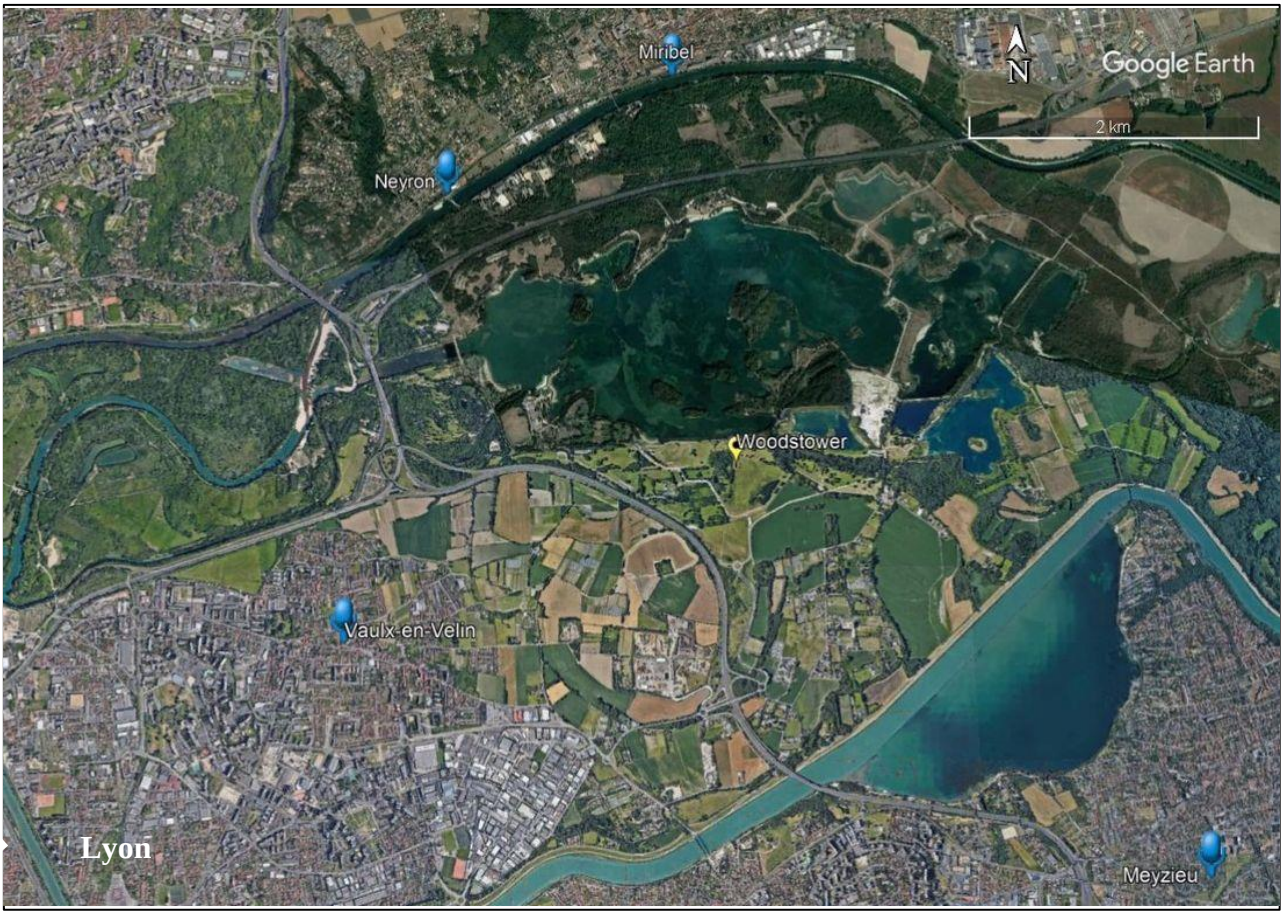

Figure 36: Sound monitoring points location in the neighbourhood

Figure 37: View of one IoT SLM deployed at a neighbour's house

Furthermore, one environmental sensor was tested on the ground by Digisky to collect wind speed and then explain any sound levels that may be increased by the downwind.

4.6.2 Participants Survey

The second objective of the sound monitoring was to assess the festival-goers' and the neighbours' perception of the festival through surveys. The festival-goers' survey was distributed with the online thank you letter of Woodstower organisers after the festival. It was focused on their opinions on the sound quality of the festival, their hearing protection habits and their opinions about the festival-goers' wristbands. The surveys were mentioned via several media channels (cities' websites and halls, local newspaper, social networks, festival's newsletters). A second questionnaire was distributed to the neighbours. It was focused on the type of annoyance perceived from their homes, the type of noises perceived and the impact on their day-to-day life. Figure 38 presents one article published in the local newspaper. It is titled "Festival-goers can contribute to research!" and a weblink is shared at the end to answer online questionnaires made with SurveyMonkey.

e de Crecy, pour une soirée d'ouverture 2019 qui s'annonce explosive.

De nombreuses animations sont au programme, comme ces initiations gratuites à la breakdance. Photo d'archives Progrès/Brice ROBERT Photographe

QUESTIONS À

Bruno Vincent, directeur d'Acoucité, docteur en psychoacoustique

« Les festivaliers pourront contribuer à la recherche ! »

Photo Progrès/Alice MUGNIER

Quel est le rôle d'Acoucité (observatoire de l'environnement sonore de la Métropole de Lyon) pendant le festival Woodstower ?

« Notre travail consiste tout d'abord à réaliser des mesures sonores avant le début du festival, grâce à des sonomètres. Ces informations permettront aux organisateurs d'être sûrs de respecter la nouvelle réglementation sur l'exposition du public dans les lieux diffusant des sons amplifiés. Et les mesures se poursuivent aussi pendant le festival avec, cette année, des bracelets connectés qui seront proposés aux festivaliers. Ces derniers enregistreront l'exposition réelle des gens, dont l'anonymat est préservé. 10000 bracelets seront distribués vendredi et samedi soir. En les portant, les festivaliers peuvent ainsi contribuer à la recherche ! Toutes ces données vont être affichées en temps réel sur un écran qui va permettre aux organisateurs d'adapter le niveau de puissance acoustique en temps réel. »

Dans quel cadre est inscrit ce partenariat avec le festival ?

« C'est la 3e et dernière année que nous réalisons des mesures dans le cadre du projet Monica. Ce projet européen, financé par la Commission européenne, porte sur la sécurité et le confort pendant de grands événements publics. Sur le territoire de la Métropole de Lyon, nous avons trois terrains d'expérimentation : les Nuits sonores, la Fête des lumières et le festival Woodstower. Des stands sur le projet seront présents sur place, si les festivaliers veulent en savoir plus… »

Et après le festival ?

« Nous proposons une enquête après Woodstower à destination des festivaliers et des riverains pour recueillir leurs perceptions. L'enquête sera ouverte à partir du lundi 2 septembre à l'adresse internet suivante : www.acoucite.org/enquetes »

Propos recueillis par A.M.

Figure 38: Promotion of the surveys campaign in a local newspaper

Besides the achievement of these two objectives, a Sound Heat Map considering the directivity and the schedule of the four stages has been developed and was displayed successfully on the COP (Figure 39).

Figure 39: Display of the Sound Heat Map on the COP

4.6.3 The Crowd Heat Map using Crowd Wristbands

The main objective of the crowd density estimation was to assess the deployment of the MONICA crowd wristbands on a large scale. Figure 40 shows, after some post-processing, the crowd density in the venue in terms of people number.

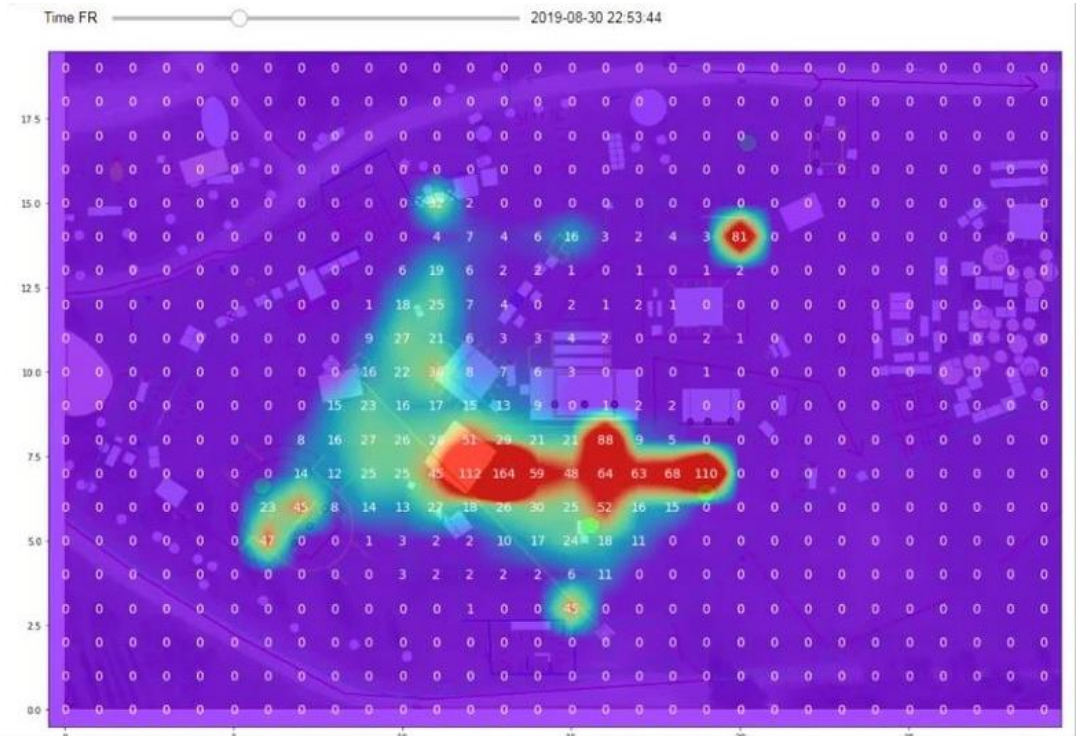

Figure 40: Display of the crowd density

A lightshow functionality of the crowd wristbands was the incentive to facilitate the wristbands distribution to the festival-goers. The festivals light engineer at one stage was able to manually light up all the wristbands, in a way that the festival-goers could feel part of the concert. Figure 41 shows the wristbands lighting up during a concert at Woodsfloor stage.

Figure 41: Wristbands lighting up during a concert

4.6.4 Lessons Learned

- As noticed by CNET, the output of both octaves conversion and sound contribution calculation for each stage SLM was forwarded to COP using the same data stream, resulting in inefficiency in their processing. This addressed and improved by using separate data streams per SLM for octaves conversion and sound contribution calculation for later demonstrations.
- The environmental sensor did not have the results expected from the test bench. Digisky will invest more effort in test report and definition.
- Sound Level Meters in neighbour area had to be troubleshooted six times during the event in different locations as they stopped sending data. It took several hours (not counting manpower and kilometers made). In order to identify a power supply failure the battery power level could be displayed in remote mode. Furthermore, the power packs did not act as backup power supply. In fact, when the power was switched off, the power pack switched off as well. This made the prototype vulnerable to power supply failure.
- In terms of data transfer instabilities, progress can be made in investigating the sources of data loss (i.e. monitoring the Wi-Fi network with a second device “sniffing” to determine if anomalies are coming from network or from transmitter in IoT SLM). A local save system like a SD card will also help to avoid any data loss since the network transmission is sometimes difficult, e.g. many active mobile phones in a festival in the countryside and that no buffer is used as a failsafe if the network is down.
- The preliminary measurements using pink noise, required for feeding DSS computations, were difficult to carry out because of lack of time, as the festival was rushing and a lot of work is being done in “last minute” or “improvised” way. A dummy value of 5 dB was used instead.
- It is advisable to have the COP visualisation ready before the festival in order to troubleshoot data transmission, validate displayed measurements and calculated values and teach the functionalities to the local technical staff so that during the event it can be used. MONICA partners managed to explain the Sound Monitoring functionalities to the Woodstower sound engineers. In one situation the COP served as backup tool for one sound engineer in Woodsfloor stage when his own system failed (Figure 42). His feedback was collected afterwards using the COP survey: Overall the feedback was very positive. He mentioned that the tool is useful and especially appreciated the function to check the maximum sound level produced by the live broadcasted music. An instantaneous dB A display (per second) was proposed to be an interesting feature for future iterations, as this feature would allow sound engineers to verify their actual conformity to noise regulations.

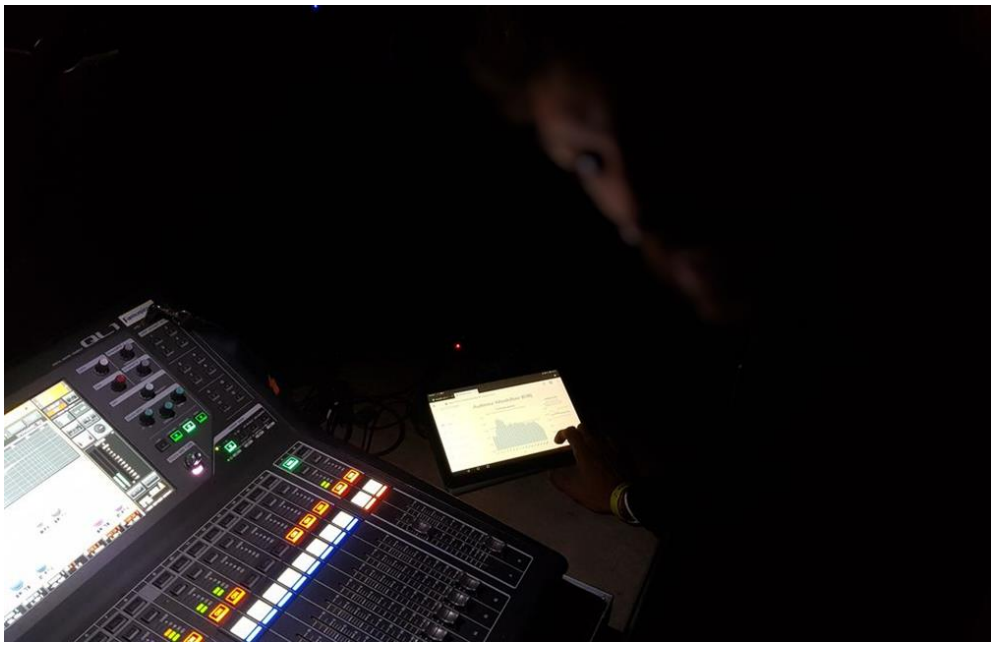

Figure 42: A sound engineer using the COP on a tablet PC during the festival

- In order to use the light show as an incentive for festival goers to wear the wristband, exchanges with light engineers/designers need to be done well before the event in order to include the wristbands as one more component of the light system. In that way, the light engineer/designer will create conditions that allow the wristband light to be clearly visible and more impressive. During Woodstower oral feedback from users showed a non-unneglectable number of people who were disappointed with the blinking LED not being powerful enough and mismatching the music rhythms.
- A lot of energy was put for the distribution of the wristbands (Figure 43). The success of the technical demonstration depended a lot on this step. Effectiveness could have been increased by enhancing this step (more and earlier integration with the Woodstower festival deployment and communication plan) or even by directly giving the wristband to each festival goer, with the cashless function at the dedicated booth or by mail (like the Tomorrowland festival). In fact, last year the cashless booth was at the exact spot of the MONICA booth, so some people were queuing to load money on it: they thought the wristbands were cashless wallets like in some other festivals like Nuits Sonores for instance. Also, at the entrance, some festival goer's thought the volunteers assigned to the distribution were sellers and passed through, until they knew it was free. The wristbands have been mentioned in the press conference and in the newsletter before the festival: this seems not to be sufficient since a lot of people were discovering the item when we approached them.

Figure 43: Distributing the wristbands to the festival-goers

- The fact of being GPS tracked, the cheap design of the prototype based on a simple plastic watchstrap and the servers, gathering data and consuming power, did not match to the eco-responsibility image of the festival and was one of the major obstacles for festival guests to accept wearing the wristbands. The data privacy and the fact to be a 'free' producer of data were ones of the main obstacles. Some festival goers could have been reassured if they knew where and how they could access the results of the demonstration (e.g. noise exposure). There is still no plan to publish data publicly to inform the participants of the results. If we could promise them that the analysis of the movement of all wristbands and the related sound exposure map will be published on MONICA's website by the end of the year they would have been helpful and some of them would have been less reluctant to test the wristbands.

4.7 Sound Summit Roskilde

4.7.1 Introduction

Roskilde SOUND2019 is an annual Music Festival held by Roskilde Festival Højskole, which is a modern college in a new creative district, based on the ideals of the famous Roskilde Festival. The event is known as a meeting place for the Danish music and festival culture. It is mainly held indoors (Old Hal10, see Figure 44) but for the ASFC test, SOUND2019 had arranged a special outdoor stage at Søjleplatsen which is a large outdoor event venue near the area (see Figure 44).

Figure 44: Scenes from the Roskilde SOUND2019

Figure 45: The outdoor stage at Søjleplatsen, Roskilde (Right), An invited musician at the session (Left)

Table 13 shows the selected use case and Table 14 shows the IoT devices deployed in this Demonstration.

Table 13 Selected Use Cases for this Pilot

ID	Use Case Group	Selected for 2018	Selected for 2019
UCG 2	Sound Monitoring and Control	No Event	X

Table 14 Number of deployed IoT Devices

IoT Device Type	Number of deployed devices 2018	Number of deployed devices 2019
IoT Sound Level Meters	No Event	4

4.7.2 The Adaptive Sound Field Control System

The ASFC system was tested successfully in previous demonstrations during Kappa FuturFestival in 2018 and 2019 (see Chapter 4.3). The sound field control system achieved similar insertion losses. However, the significant attenuation is limited to very low frequencies, below 63 Hz. We could see that practical limitations on the measurement process in both events have greatly limited the performance of the ASFC. First, the dark zone in the churchyard was completely isolated from the festival venue by a tram railway. Without electricity or any means of Wi-Fi or cellular phone connection. Due to this environmental limitation, the required simultaneous data recording, monitoring and synchronization using a wired connection was not possible.

Second during Kappa Futur Festival in 2019, the production schedule was severely delayed due to bad weather, which meant that the data and measurements needed for the adaptive algorithm were not collected. The results of this test and the results of the ASFC demonstration performed in Tivoli in August 2018 (see Deliverable 8.2 for more details) formed the decision to look for a venue with less complex structures than Tivoli and a possibility of at least several days for performing the needed pre-measurements.

Therefore, Roskilde SOUND2019 was selected to test the adaptive solution of the ASFC where simultaneous data recording/monitoring and synchronization is possible. Moreover, the propagation model-based approach, where a much-reduced set of microphones can be used, was tested. The main objective of this demonstration was to validate the adaptive functionality of the ASFC, so only the Sound Monitoring and Control use case was selected and four IoT Sound Level Meters were the only IoT devices deployed.

4.7.3 Lessons learned

Practical non-scientific/non-technical aspects are limiting. For the calibration of the system it is essential that measurements can be done at good signal to noise ratios, i.e. close to concert levels, so if local regulations prevent this, as it was the case for Tivoli 2018, the preparation of the system will be more difficult and time consuming. In addition, a good collaboration with sound engineers and venue organisers is critical.

Overall the ASFC works well and achieved 10-12 dB of attenuation in the dark zone. The adaptive procedure was working during the test.

The SOUND2019 test showed that the ASFC can run with few microphones and achieve good performance. Two adaptive algorithms were tested and both worked well. The model-based approach worked well and allowed good performance to be obtained using only a few microphones. The possibility of using few control microphones makes the system much easier to deploy.The minimum number of microphones required is closely related to the “openness” of the venue. The venue of the SOUND2019 was a quite open space, and it is expected that applying various strategies in predicting the accurate propagation model in space would delimit this “openness” constraint. The use of a few control microphones makes the ASFC more usable in many real outdoor events.

As the delay in production schedule during Kappa FuturFestival 2019, prevented any real test of adaptation of the sound field control system, we ran the fully adaptive algorithm for the first time under live conditions at Roskilde SOUND2019. Five days were reserved and used for preparation time for the ASFC to be setup to work properly. Much of this time was used for validation and tuning of the system. It is expected that this preparation time can be reduced significantly, possibly to less than one day, when more experience from live applications have been obtained. This extra preparation time adds to the cost for the organiser and could therefore make the system less attractive to deploy.

5 Local City Celebrations

The following Chapter describes MONICA demonstrations that can be classified as non-gated large city festivals. Chapter 5.2 discusses the activities during Fête des Lumières, a yearly free light festival in the city centre of Lyon. Here a special focus is on crowd monitoring using video analytics. Chapter 5.3 reports about Hamburg Port Anniversary with a focus on environmental sensors and staff tracking. Chapter 5.4 reviews the MONICA demonstration during Rhein in Flammen 2019, a free open-air festival with three music stages and funfair rides in Bonn focusing on staff tracking features and Sound Control. All of these have a dedicated focus on crowd monitoring and safety and security.

5.1 Summary

5.1.1 Fête des Lumières

Fête des Lumières is a free cultural event hosted by the city of Lyon. It features several light performances, mostly including sound, over an area of over one square kilometre. The first demonstration, in December 2018, showcased the first High Level Data Fusion Integration into the COP dashboard. During both demonstrations the following technologies were tested: IoT Sound Level Meters, crowd and object monitoring, staff tracking and the Smart Glasses. For the Smart Glasses this demonstration was of particular interest in order to assess the efficiency of this solution during night-time.

5.1.2 Port Anniversary Hamburg

The port of Hamburg is the most important port in Germany, and one of the leading cargo handling centres in the world. Each year, more than one million visitors from Germany and abroad come to the Hamburg Port Anniversary to join the atmosphere created by ships from all parts of the world in the heart of Hamburg.

After two years of planning it became clear that the Hamburg Port Anniversary remained a challenging event to deploy MONICA technologies. The long stretched out venue, the existing rigid security concept and the number of stakeholders are just a few examples of the different factors which have to be considered during the planning. These factors made it especially demanding to set up infrastructure needed for MONCIA technologies and adding to the existing ones. On top of that, the use case for crowd and capacity monitoring which is of high interest for the event was covered by the project “Sucre” (Fraunhofer IOSB Karlsruhe) starting just a bit earlier than the project MONICA.

Irrespective of the challenges, it was possible to deploy the environmental sensors. The deployment was successful and without any barriers as it did not intervene with the existing security concept but added to the safety on site. As the Port Anniversary had witnessed some severe weather conditions in the previous years, the piloting within the project supported the event organisers in their security briefings and decision-making processes.

5.1.3 Rhein in Flammen Bonn

Rhein in Flammen[3] is a festival in the city of Bonn. Visitors can join the free event from Friday to Sunday. During this time, a variety of concerts take place on three different stages; the highlight of the event being a fireworks show and an illuminated boat parade on the river. The main use-cases for Rhein in Flammen were Sound Monitoring, Crowd Monitoring and Staff Tracking. One of the mayor challenges this event faced was the deployment of the IoT sensor network, given the topography of the event location which does not allow the use of WiFi-devices. In order to solve this problem the decision was made to rely on a combination of WiFi-network for the relevant area and the mobile network to cover the rest of the area. This approach worked very well for both demonstrations; high-quality video streams could be transmitted via the mobile LTE network without any issues.

For the staff tracking use-case the demonstration in 2018 revealed, that the approach to rely on an app on the staff´s mobile phones for the location tracking, was not very well received. Only few people were willing to participate when the had to install an experimental app on their (private) phones. For the next demonstration in 2019 we introduced the Live Positioning Information System (LiPS) which uses GPS tracking devices. This was widely accepted by end-users and yielded very good results. Specially the “offline”-approach of the system, which can be deployed completely independent of an internet connection, turned out very promising.

5.2 Fete des Lumieres Lyon

5.2.1 Introduction

Fête des Lumières[4] is a free cultural event hosted by the city of Lyon every year around the 8th of December. For four nights, a variety of different artists light up buildings, streets, squares and parks. Since 2016, to prevent terrorism-related risks, it has been held for the most part on a perimeter closed to traffic on the peninsula of Lyon between the Rhône and Saône rivers as depicted in Figure 46. Only the metro service remains accessible within the perimeter and safety controls are carried out at the accesses of the metro stations. Pedestrian accesses are possible on the whole perimeter. The area size of the event is more than one square kilometre. During the 2019 edition, 36 light performances took place, mostly including sound. One major installation of the festival was the light show on the facade of the cathedral at Place Saint-Jean (see Figure 47). The light installations were shown from 7 pm to 11 pm or from 8 pm to midnight depending on the days. The festival welcomed approximately 1.8 million visitors[5] in 2019.

Figure 46: Perimeter of Fête des Lumières 2019

[4] http://www.fetedeslumieres.lyon.fr/en
[5] https://www.fetedeslumieres.lyon.fr/en/news/2019-festival-lights-facts-and-figures

Figure 47: Light show on the cathedral facade of Place Saint-Jean

The selected use cases for this demonstration can be seen in Table 15.

Table 15: Selected Use Cases for Fete des Lumieres Demonstration

ID	Use Case Group	Selected for 2018	Selected for 2019
UCG 2	Sound Monitoring and Control	X	X
UCG 3	Crowd & Capacity Monitoring	X	X
UCG 5	Locate Staff	X	X
UCG 7	Security Incidents	X	X

Table 16 shows the number of deployed devices during the Fete des Lumieres Demonstration in Lyon.

Table 16: Number of deployed IoT Devices during the Fete des Lumieres Demonstration

IoT Device Type	Number of deployed devices 2018	Number of deployed devices 2019
Cameras	7	7
IoT Sound Level Meters	3	3
NoiseCapture[6] App	11	9
Smart glasses	5	5

[6] NoiseCapture is a free and open-source Android application that allows users to measure and share the noise environment. It has not been created within MONICA project, but it is a cooperation action between the MONICA Consortium and the French research institute IFFSTAR. For more information about the app, see http://noise-planet.org/noisecapture.html

As in the previous edition, the security impact that the MONICA platform could have on the event was the main expectation of the organisers of Fête des Lumières. The organisers already enjoyed the previous deployed Use Cases, so the Use Case Groups remained the same. However, due to the national context on French data privacy, it was decided to remove or restrain the Use Cases involving personal data recording. Concerning the deployed IoT devices, only some have been changed. This is described below by **Use Case**.

5.2.2 Sound Monitoring and Control

Two different approaches were used for applying the MONICA Sound Monitoring feature during this event:

1.) fixed, using sound level meters (SLMs) fixed to a specific location and

2.) mobile, using the NoiseCapture app on a mobile device.

- Besides the three SLMs sent by B&K, two SLMs have been deployed by ACOU for the Sound Monitoring. In 2019 they were fixed on the same spots of the House of Youth and Culture of Old Lyon district as in 2018 to measure sound levels from the Place Saint-Jean installation (Figure 48 and Figure 49). Furthermore, the same Wi-Fi configuration was used, allowing to send sound levels and spectra with 4G local sim cards to the MONICA Cloud and then displaying the MONICA sound indicators on the COP (Figure 50). Audio recording was deactivated according to the data privacy regulations.

Figure 48: View from the first sound monitoring point

Figure 49: View from the second sound monitoring point

Figure 50: Display on the COP of the sound monitoring measurements

- The new feature for the Sound Monitoring is the integration of the NoiseCapture app in the MONICA platform. This app was already tested in 2018 by involving MONICA partners in a NoiseCapture party. However, in 2019, the results have been successfully integrated in the COP. Nine participants' measurement campaigns were recorded. In Figure 51 a microphone lent and calibrated by ACOU to enhance measurements quality of the NoiseCapture sound monitoring is depicted. Figure 52 shows the final contribution map. Each hexagon refers to the maximum sound equivalent level from all collected measurements without filtering.

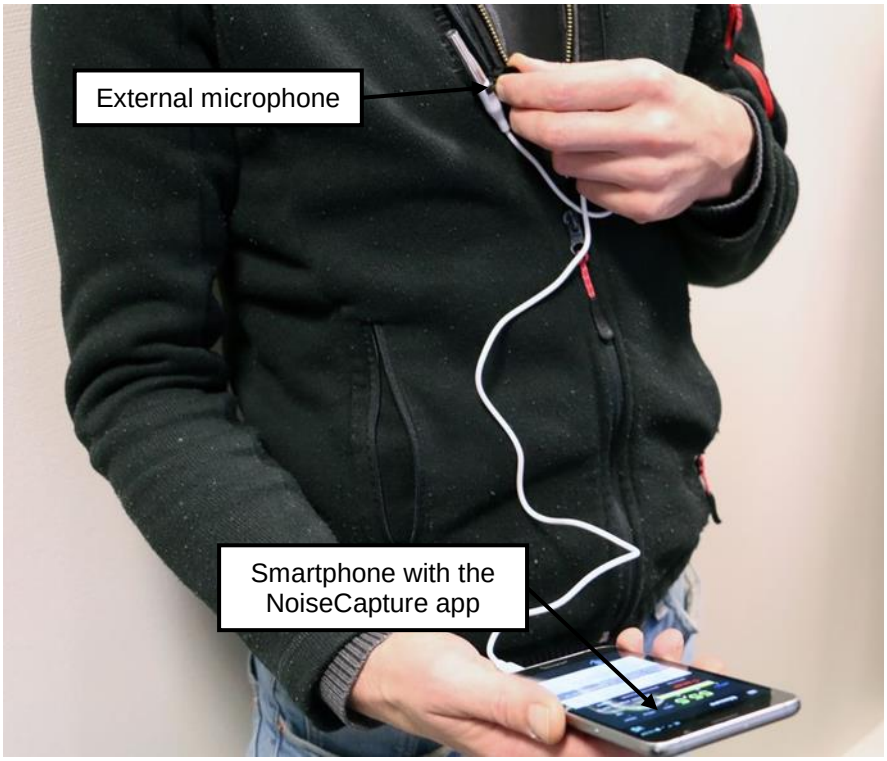

Figure 51: Measurement equipment of a NoiseCapture Party goer

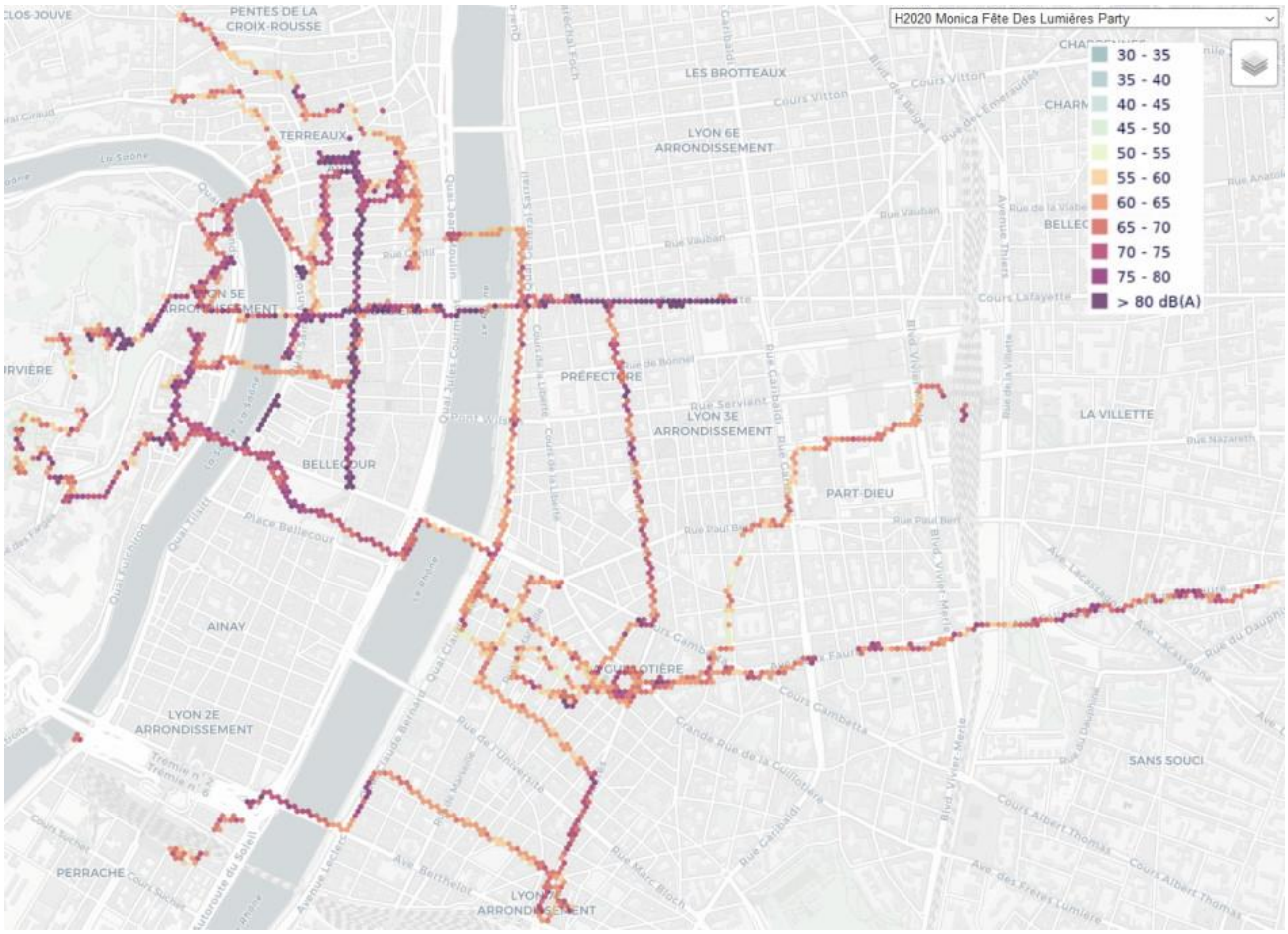

Figure 52: Display on the COP of the final Noise Capture Party contribution map

5.2.3 Crowd and Capacity Monitoring

The Crowd and Capacity Monitoring use case scenario is illustrated in Figure 53. The numbers refer to the same seven CCTV cameras around Place Saint-Jean, already used in 2018. Therefore, the configuration could be repeated in 2019. MONICA partners had remote control of the Processing node to test and deploy the counting estimation, density estimation and object detection algorithms (Figure 54, Figure 55 and Figure 56). The Processing node, former central unit provided by the City of Lyon, was deployed in the COP room, near the City Hall of Lyon.

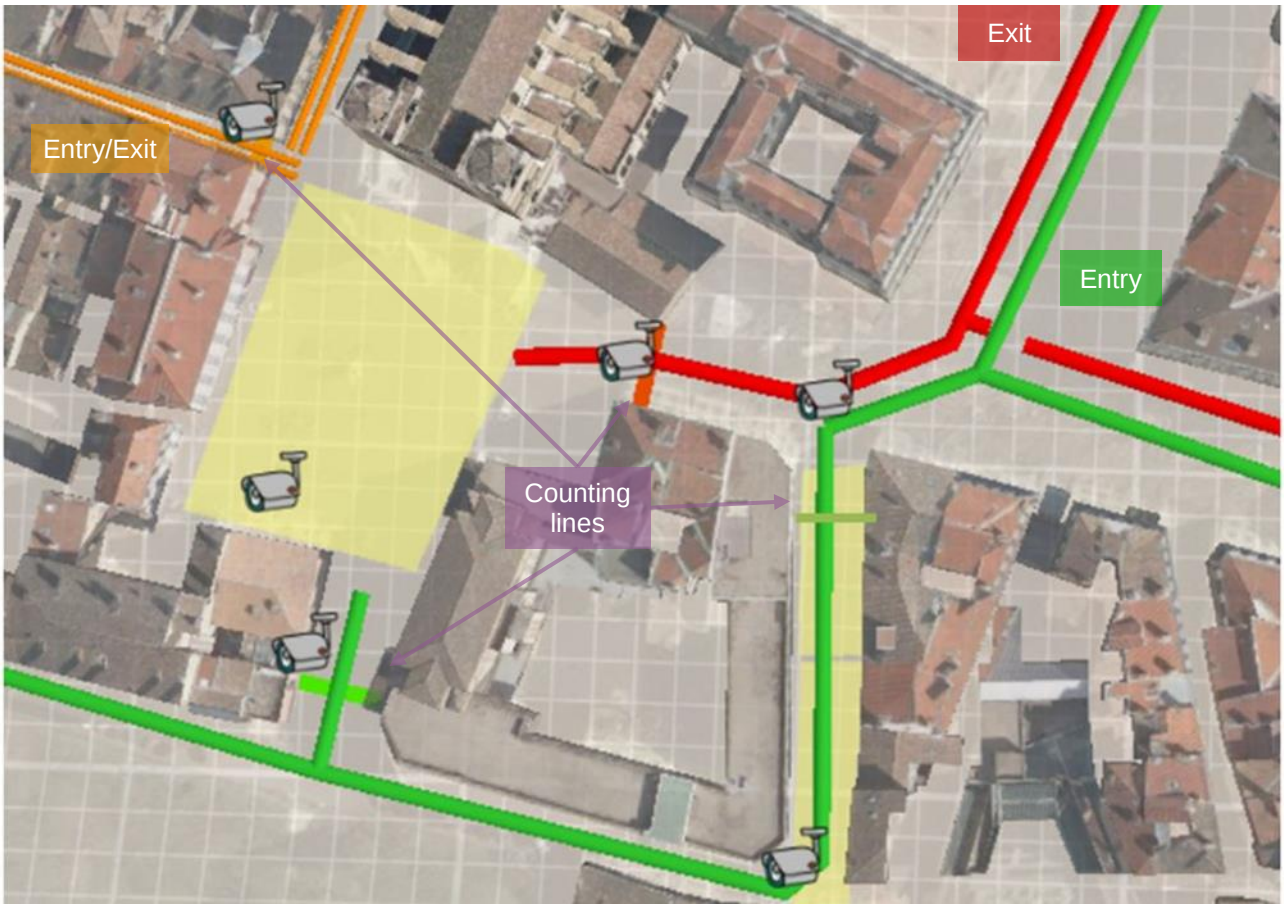

Figure 53: Crowd and Capacity Monitoring scenario for Place Saint-Jean

Figure 54: Remote access to the Processing node by KU and VCA

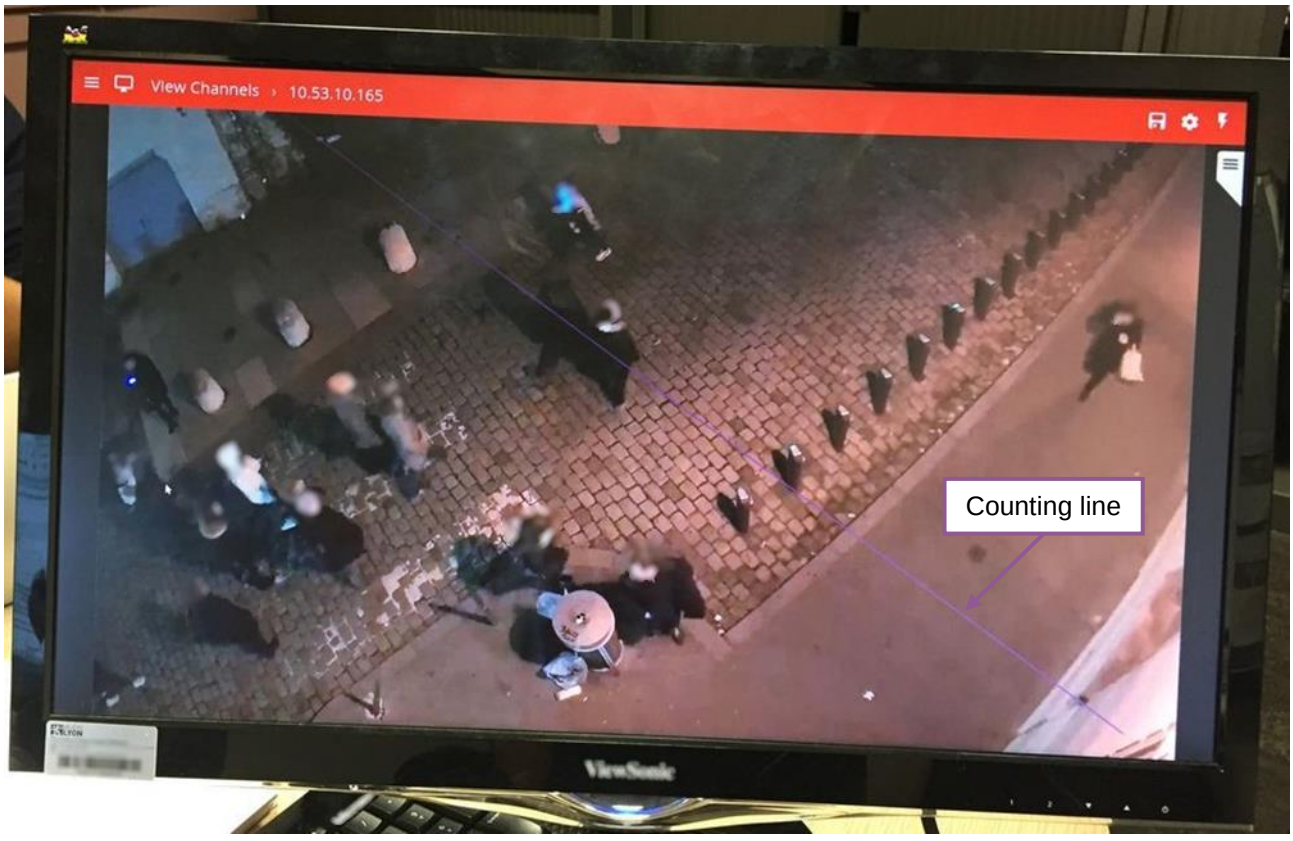

Figure 55: Counting algorithm working on Camera Nr. 5

Figure 56: Object Detection algorithm working on Camera Nr. 1

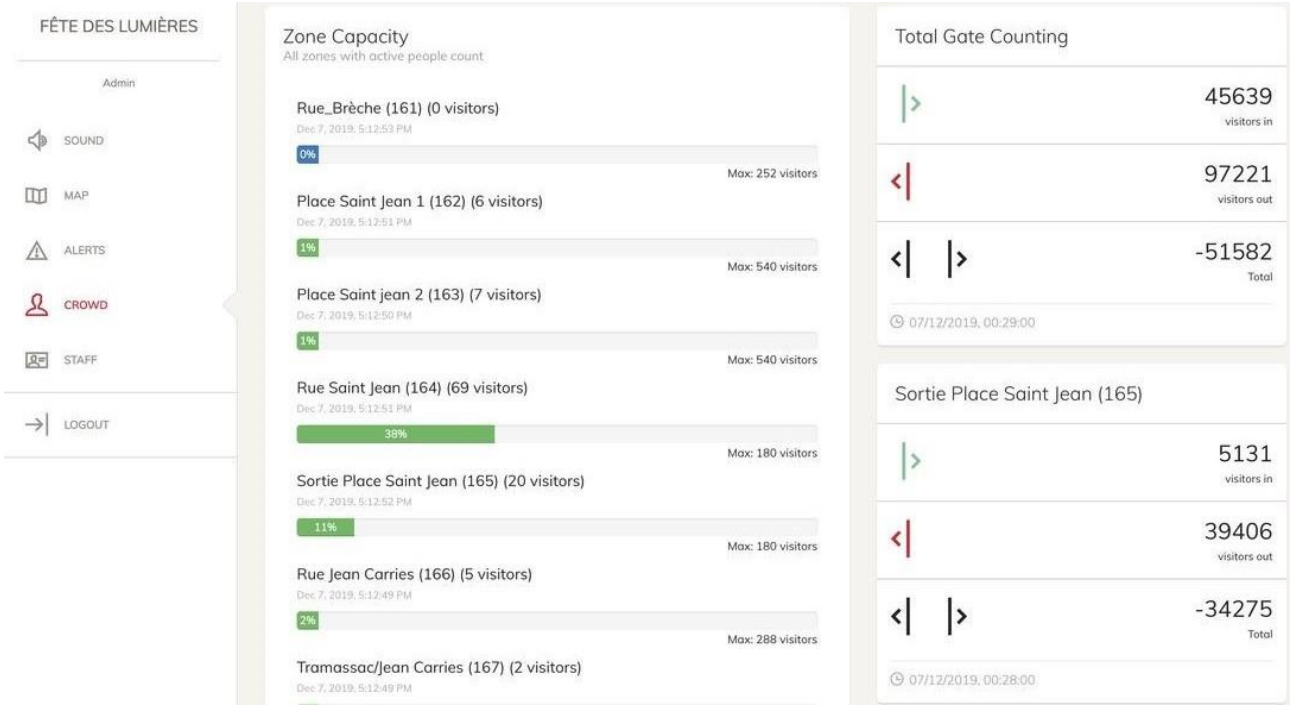

Figure 57: Real-time Crowd Counting estimation on the COP

Figure 57 shows the real-time Crowd Counting estimation on the COP CROWD tab. In addition to the estimation of the real-time density and counting of Place Saint-Jean, it was also tested to estimate the total count of people going to Place Saint-Jean for the three evenings of the event. It was indeed a valuable information for the organisers to communicate after the event. ACOU post-processed the results in Python, which allowed to correlate the exit counting and sound level fluctuations with the light show schedule, as shown in Figure 59.

The crowd density measurement observed a mean absolute error (MAE) of 11.519 on a sample of 102 random images. Figure 58 shows that in majority frames the actual number (orange line) is higher than the predicted number (blue line). The Fete de Lumiere (FDL) event in Lyon had a significantly high crowd density. The

crowd estimation algorithm has underestimated the crowd density indicating that in high crowd density the accuracy of the algorithm reduces.

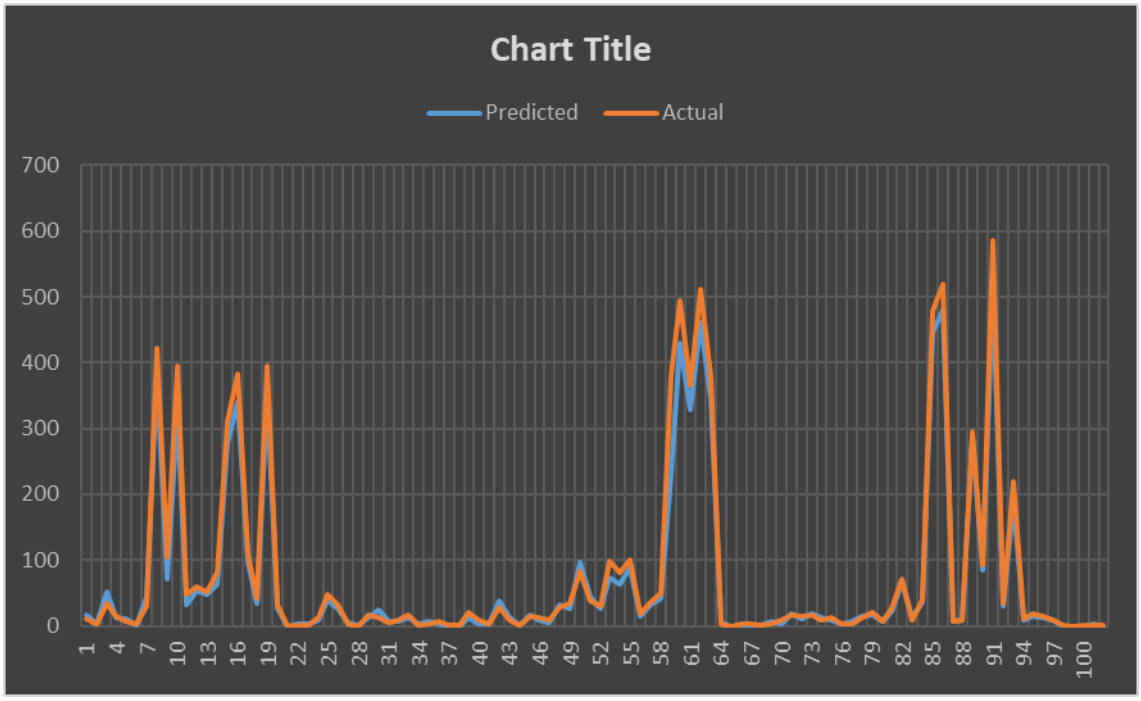

Figure 58: Predicted and actual count of people in random frames during FDL2019

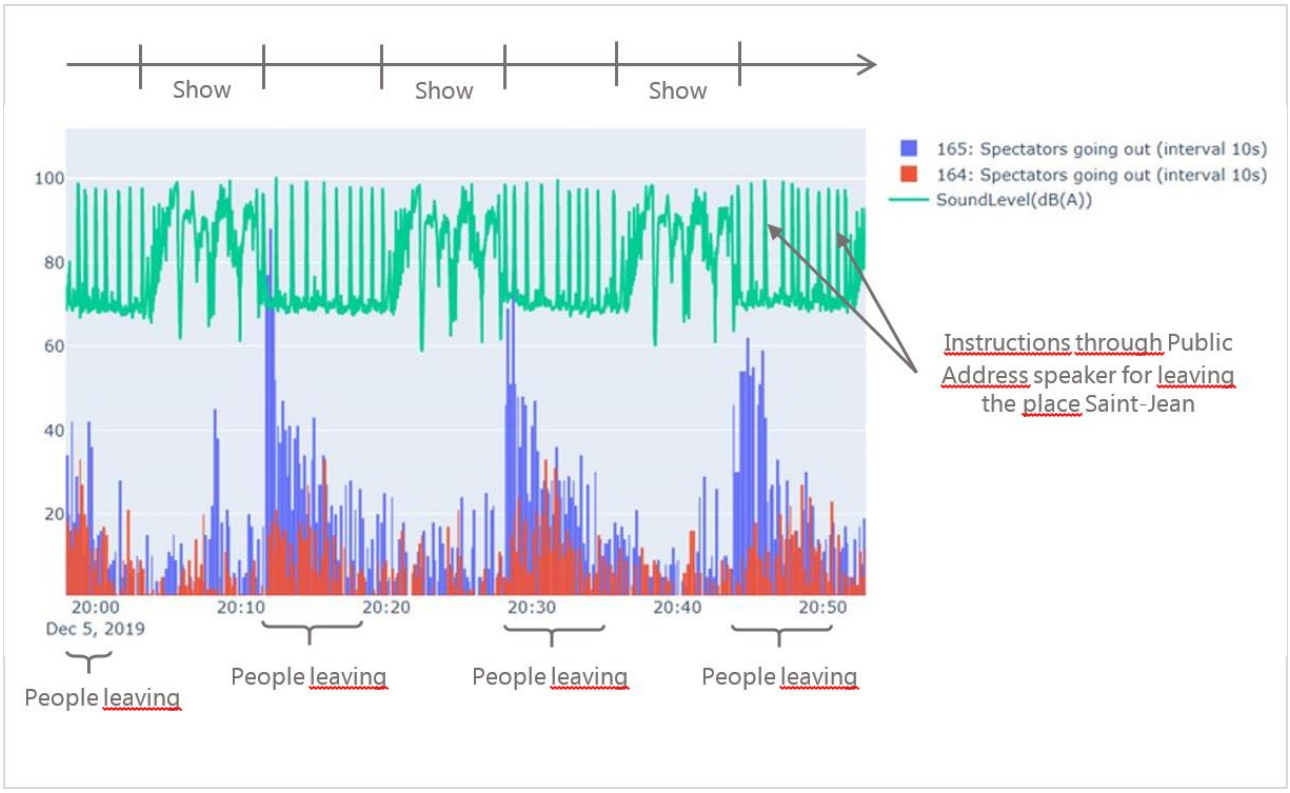

Figure 59: Correlation between exit counting, sound level fluctuations and the light show timeframe

5.2.4 Locate Staff

For the staff monitoring and management use case five smart glasses sent by Optinvent were tested. Their built-in GPS allowed the MONICA team and two representatives of the City of Lyon to test the staff real-time tracking and display it on the COP (Figure 60 and Figure 61). Reporting incidents with the smart glasses also marked the location at the time the alert was sent.

Figure 60: Test of the smart glasses by two representatives of the City of Lyon

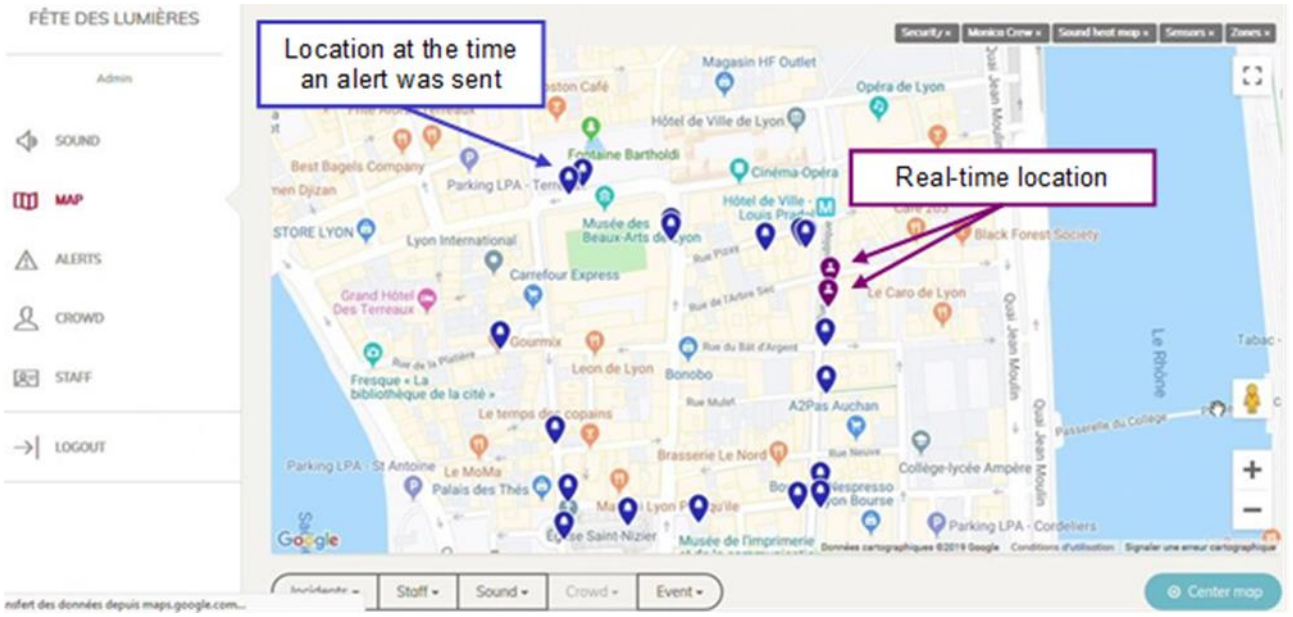

Figure 61: Tracking staff location on the COP

5.2.5 Automatic detection of security incidents

The Use Case **Report incident** of the **Security Incident** Use Case Group has been deployed through the testing of the smart glasses as well. The tested functionality consisted of message exchange between the COP and the smartglass wearer (predefined from the wearer and free-text from the COP). For this demonstration all sound, picture and video recording functionalities were deactivated, according to the decision about data privacy. Two representatives of the City of Lyon tested the message exchange with the COP by walking in the city centre, as shown in Figure 62 and Figure 63. OPTIN did remote support to configure the smart glasses.

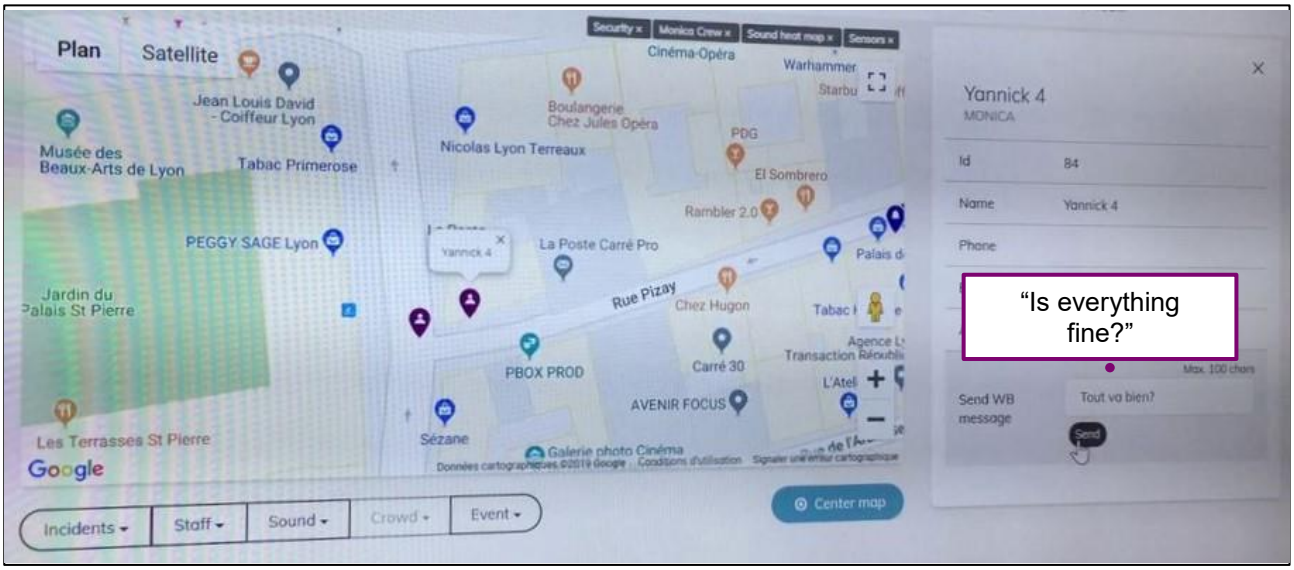

Figure 62: Report Incident: sending a message from the COP

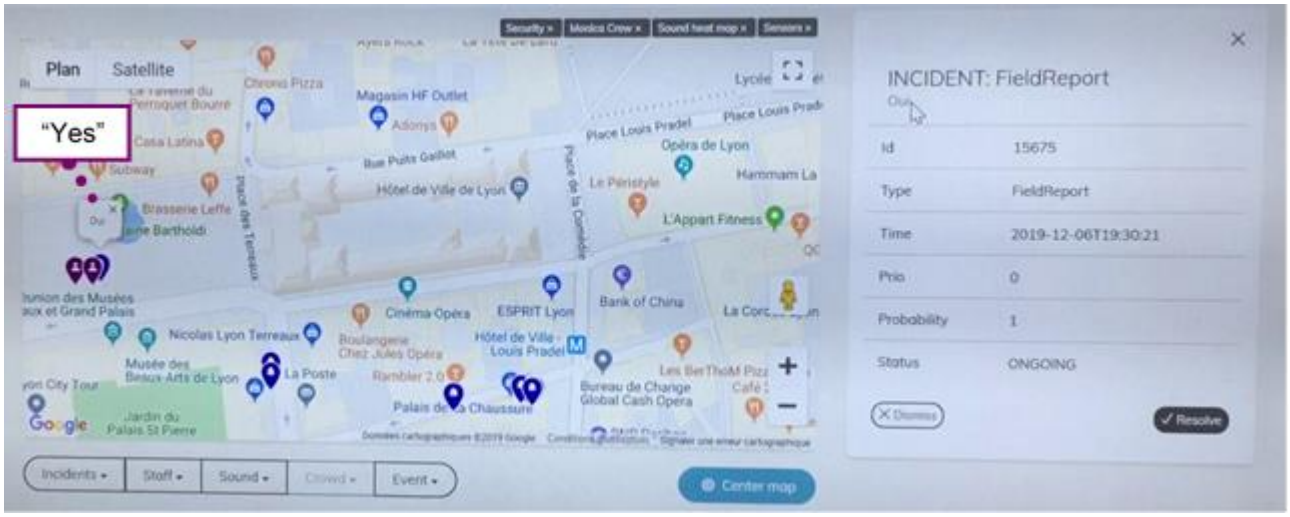

Figure 63: Report Incident: sending a message from the smart glasses

The second Use Case **Detect incident** of the **Security Incident** Use Case Group has been tested in two ways. First by using a fight detection algorithm through cameras and second by using a sound detection algorithm through an IoT SLM.

The **fight detection** algorithm test was deployed on the cameras around Place Saint-Jean. Each fight alert was marked on the COP through the MAP tab (location at the fight detection time) and the ALERTS tab (notification at the fight detection time), as shown in Figure 64 and Figure 65.

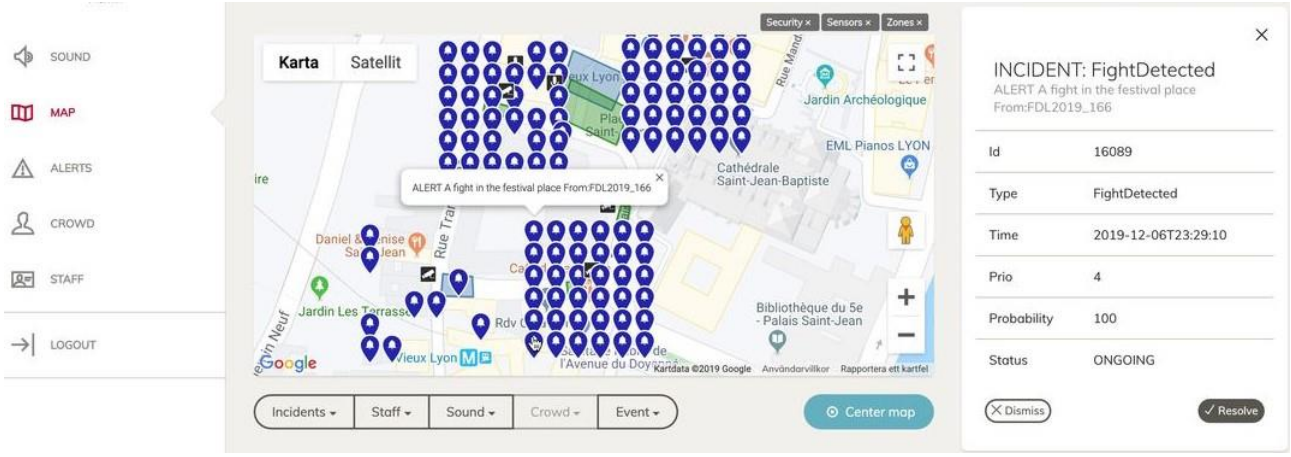

Figure 64: Detect Incident: fight detection alert on the COP MAP tab

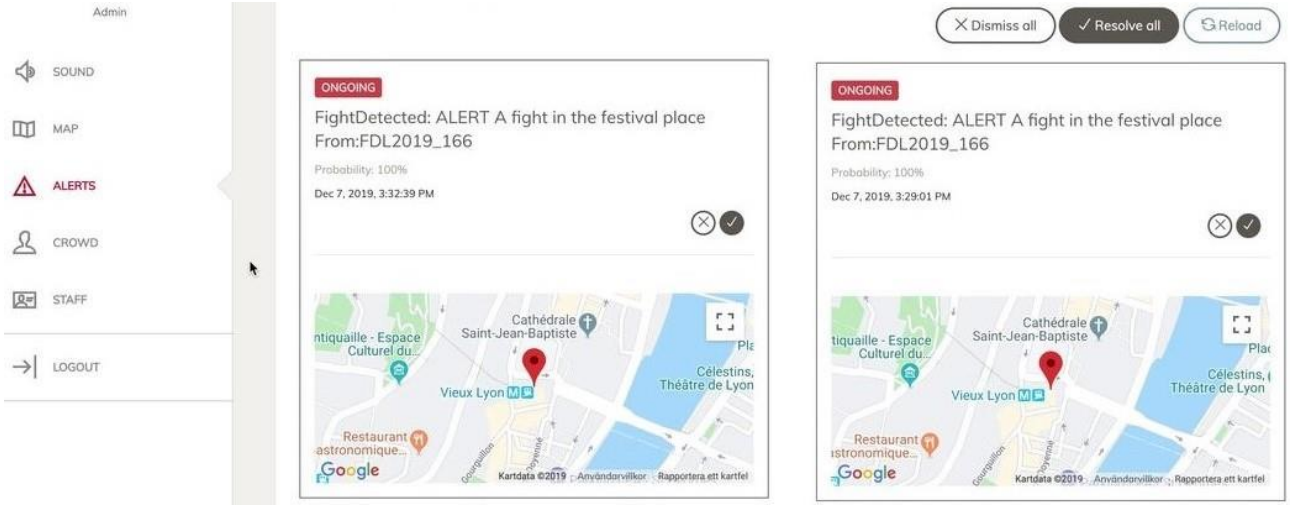

Figure 65: Detect Incident: fight detection alert on the COP ALERTS tab

The **sound detection** algorithm test has been deployed by ACOU with the third IoT SLM sent by B&K. The microphone was put 10 cm from a loudspeaker to minimize the effect of the room's acoustics (in fact, as we are very close to the source, the direct sound is much more important than the reverberated sound). Three sounds provided by B&K were played separately: female shout, male shout and gunshot. B&K was asked to provide us with the events identified "blind" over the test period (about 2-3 minutes). Unfortunately, the results did not show a consistent identification of sound events.

5.2.6 Lessons learned

- NoiseCapture map can be successfully integrated in the MONICA platform.
- The Processing Node was optimized in terms of Performance, Stability and Autonomy. The main services on the Processing Node are starting automatically after rebooting to avoid a manual intervention. A well described manual for how to start all Security Fusion Node services was prepared and implemented for the permanent COPs in Tivoli and Movida. Each processing node now has own VPN account to attach MONICA VPN and is periodicaly checking connection. If needed a new connection is started automatically. The same process has been implemented VCA-cored and cameras registration.

- Concerning the smart glasses:
  - It is difficult to use devices taking photos and videos in public spaces with the GDPR: if people's faces are in the field of vision their signed authorisation is required. Thus taking one picture or a video next to the crowd with smart glasses would require hundreds of signatures. Because of this legal issue, not all the functionalities of the smart glasses were tested in real conditions. The light festival area is already monitored with CCTV but adding MONICA signs in the dark is not really a solution: the people cannot refuse to be filmed or turn back (one-way entrances only). There is a need for a legal way to prove that the recordings are used for research purposes with people having the security clearances to film crowds (security guards, police, civil servants etc.).
  - The batteries of the smart glasses emptied quite fast (less than two hours). Having a joystick, a power pack and a special Wi-Fi paired smartphone to enable its functionalities was perceived inconvenient for security staff. The smart glasses can't be folded or protected from rain easily.
  - Deactivation of the Bluetooth connection between the joystick and the smart glasses was quite tricky and caused malfunction without the right process. The joysticks were reset according to the process explained by Optinvent. With such a blocking bug, you cannot lend the devices to the test users for extended tests or long periods of time
  - The free version of Vysor software (used to easier set up the smart glasses with a computer) sometimes popped up ads, making it difficult to navigate through the user interface.
  - The rigidity of the smart glasses' temples were sometimes a constraint when the eyes needed to rest. Especially in winter, it could be too tight to put them over the head when wearing a hat or a bonnet. The string to hang them around the neck was a good alternative but was not provided for all the smart glasses.
  - When not used, the joystick was in the pockets. It often caused the standby mode of the smart glasses to deactivate because the joystick was accidentally moved.
- Concerning the COP:
  - Having the COP active during the event only prevented officials and stakeholders to test it or ask for details, as they were busy managing safety and security during the event.
  - The COP located the alerts on the MAP tab but it needed to refresh the web page. It could be more efficient if the refresh could be automatic, as well on the ALERTS section.
  - Message queuing has to improve to prioritize certain events. This is echoed in the feedback for Video analytics (crowd density algorithm). In fact, all types of alerts are displayed in the ALERTS section. Sorting alerts by type and priority would help the event manager.

5.3 Port Anniversary Hamburg

5.3.1 Introduction

The port of Hamburg is the most important port in Germany, and one of the leading cargo handling centres in the world. Each year, more than one million visitors from Germany and abroad come to the Hamburg Port Anniversary to join the atmosphere created by ships from all parts of the world in the heart of Hamburg. The attractions of the Port Anniversary extend six kilometres along the waterfront and include displays on both land and water. There are more than 200 programme items on shore. Major attractions are several ship parades during the event. It is a street event of three to four days in May[7], usually opening on Thursday (from 10 am to 10 pm), Friday and Saturday (from 10 am to 12 pm) and Sunday (from 10 am to 9 pm). The event area is ungated without fixed boundaries and access is free of charge.

Table 17: Selected Use Cases for Demonstration at Hamburg Port Anniversary

ID	Use Case Group	Tested in 2018	Tested in 2019
UCG 14	Safety Incidents	-	X

The identification of requirements and use case (see Table 17) for the Port Anniversary has been carried out throughout the first two years of the project in close exchange with the required stakeholders. The technical and scientific partners in Hamburg (Hochschule für Angewandte Wissenschaften Hamburg (HAW), Landesbetrieb Geoinformation und Vermessung (LGV)) together with the technical partners of MONICA and the project's management board developed and suggested devices and systems to address the use cases. All deployments were discussed with regard to MONICA's ethical and data protection guidelines.

The following use cases were considered, but aborted for varous reasons:

- Control system for vehicles accessing the area. The organiser asked for a solution that would allow an automated and real-time control of vehicles intending to enter the restricted zone of the event. This use case would have required a close cooperation with the police. Furthermore, a suitable solution was not part of the MONICA repertoire.
- Sound control: Even though the event has multiple stages with concerts and possible noise pollution, the event organisers were against sound control. The reason lies in the locally applying transparency law which obliges all publicly collected data to be made available to the public.
- Crowd monitoring: This use case would have been of interest as especially Friday with its fireworks witnesses large crowds particularly around the public transport. However, another project in Hamburg (Sucre) was already working with crowd control.

Due to the long planning process of the event (security concept is finalised one year prior to the actual happening), the focus in 2018 was put on the planning of the deployment in 2019. Besides regular meetings with the involved stakeholders, the planning did also involve acquiring a technical map of the event site. With this map the suitable locations for the environmental sensors were identified and discussed. The technology had been tested and developed during the days of the DOM event (see Chapter 7.2). The experiences from the DOM deployment of the environmental sensors helped for the deployment at the time restricted and in many organisational ways constrained Port Anniversary.

Table 18: Summary of deployed IoT Devices at Hamburg Port Anniversary

IoT Device Type	Number of deployed devices 2018	Number of deployed devices 2019
Environmental sensors	-	7

5.3.2 Environmental Sensors

In 2019, along the waterfront 30 towers were deployed by the event organiser. These were very suitable positions to deploy the environmental sensors although they were already packed with other service-related signs. The maximum weight could not be exceeded. In addition, private operators (buildings, companies,

[7] Editions: May 5-8 2017, May 10-13 2018, May 10-12 2019

university, restaurants) offered their premises so that sensors could be installed there. This allowed for greater flexibility in terms of spreading and height.

In Figure 66 the position of the deployment sides (marked in red) are shown which were spread across the event site. The applications which had been developed for the COP at Hamburg DOM were further developed during the DOM deployments in 2018 and 2019 and were then used for the Port Anniversary as well. For the MONICA COP the area was highlighted and sensors were illustrated using icons (see Figure 67).

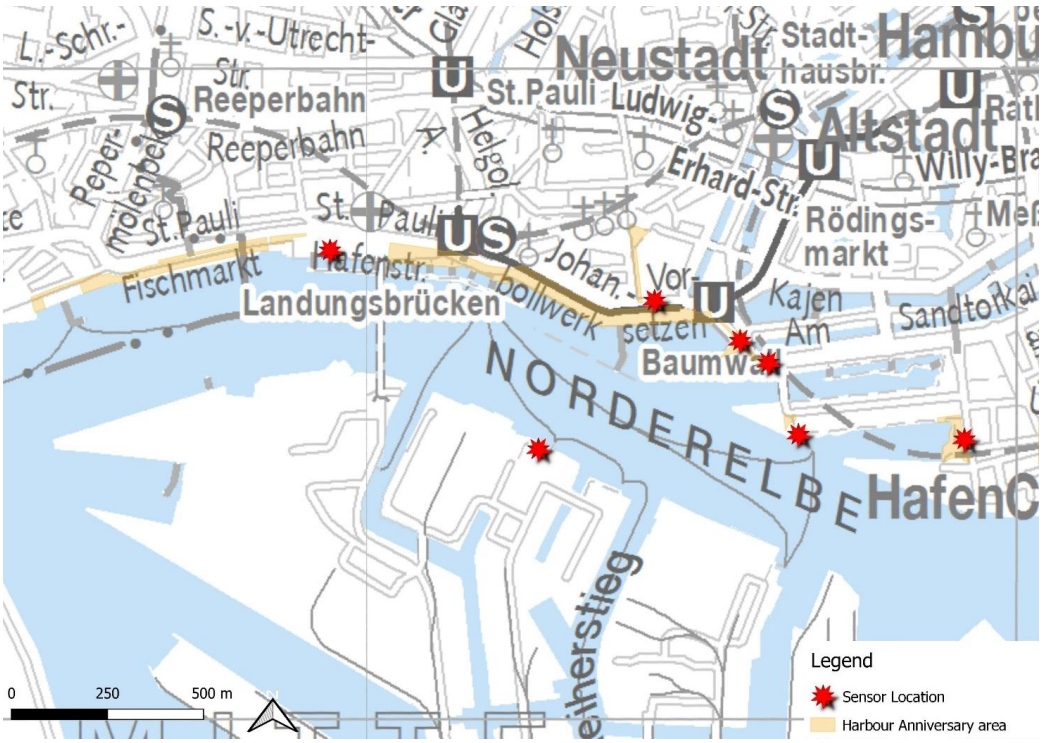

Figure 66: Map of Hamburg Harbour with sensor deployment positions

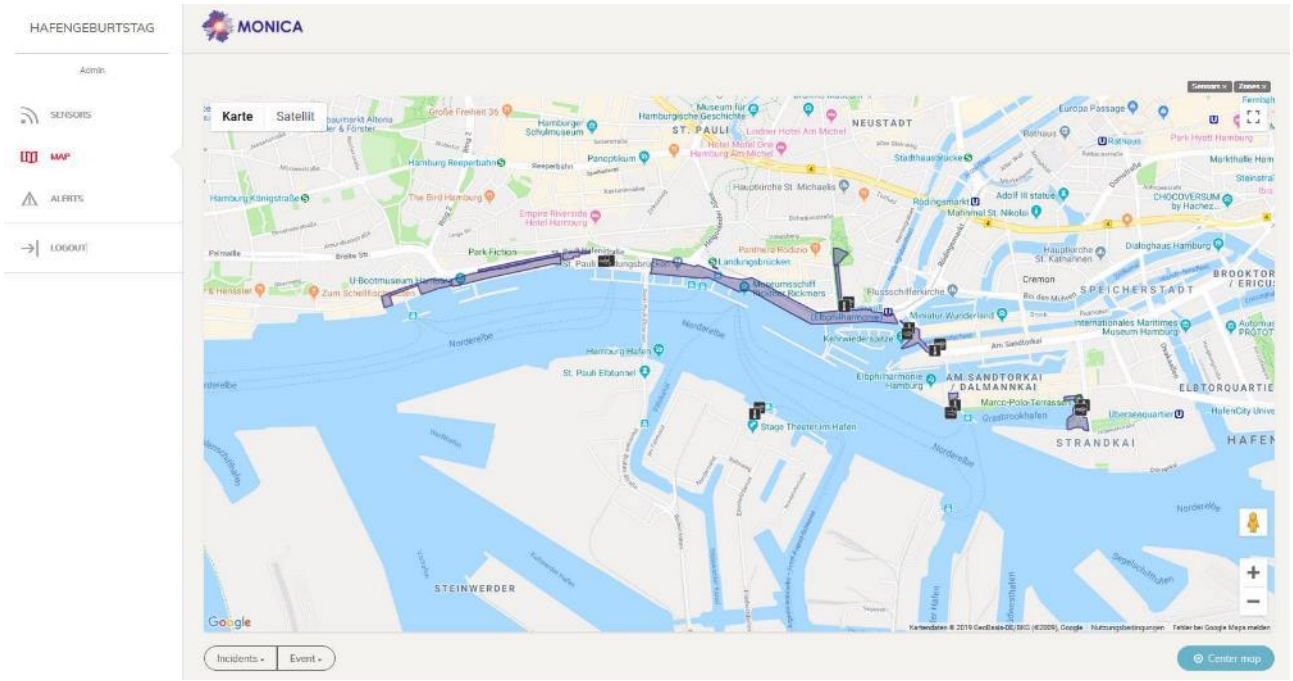

Figure 67: COP visualisation of the area of the Harbour Anniversary 2019

The wind speed and the current temperature were visualized in the Port Anniversary COP in a separate tab (see Figure 68). Another part of the COP contained information about safety incidents (see Figure 69) to inform the event organiser about severe weather conditions.

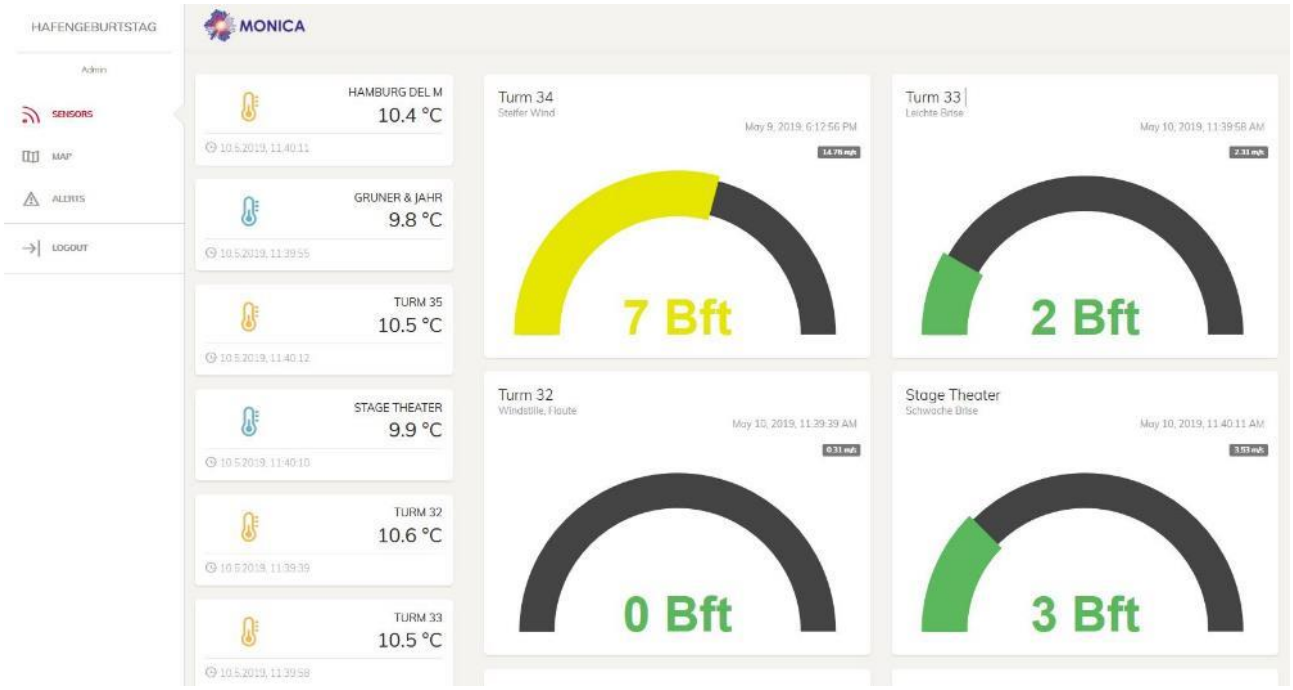

Figure 68: COP visualisation of wind speeds and temperature

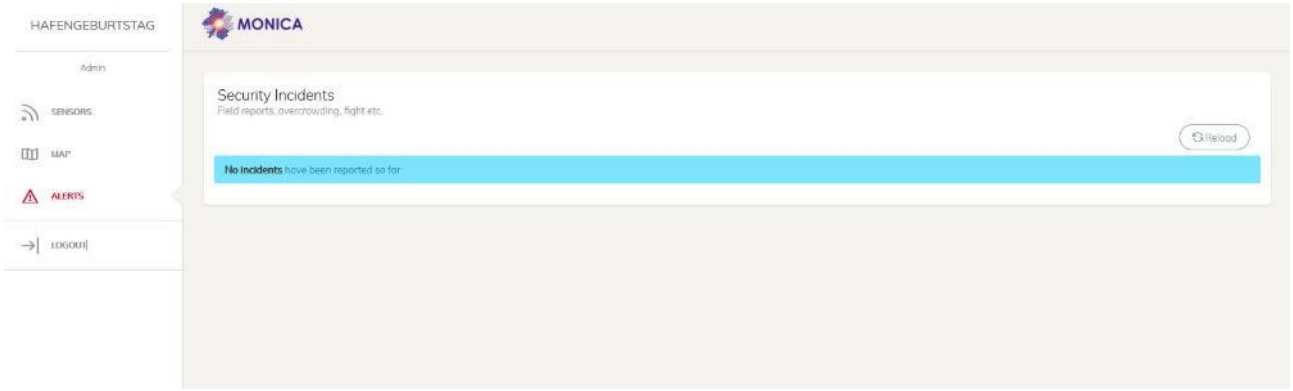

Figure 69: COP visualisation of safety incidents

The following graphs show the results form an initial evaluation of the sensor and network data acquired during the Hamburg Port Anniversary. The first two graphs in Figure 70 show temperature and wind speed measurements from all seven sensor boxes over the four event days. Temperature values are stable and clearly follow the course of a day, i.e., highest temperature around midday and lower during the night. Wind speed values are more spread out, but in general all sensors show the same tendency on average, e.g. increase wind speed on the last day.

Note that sensor m14 ran out of battery on the last day, and m17 had a hardware failure after the first day, hence there is less data from these two sensor boxes.

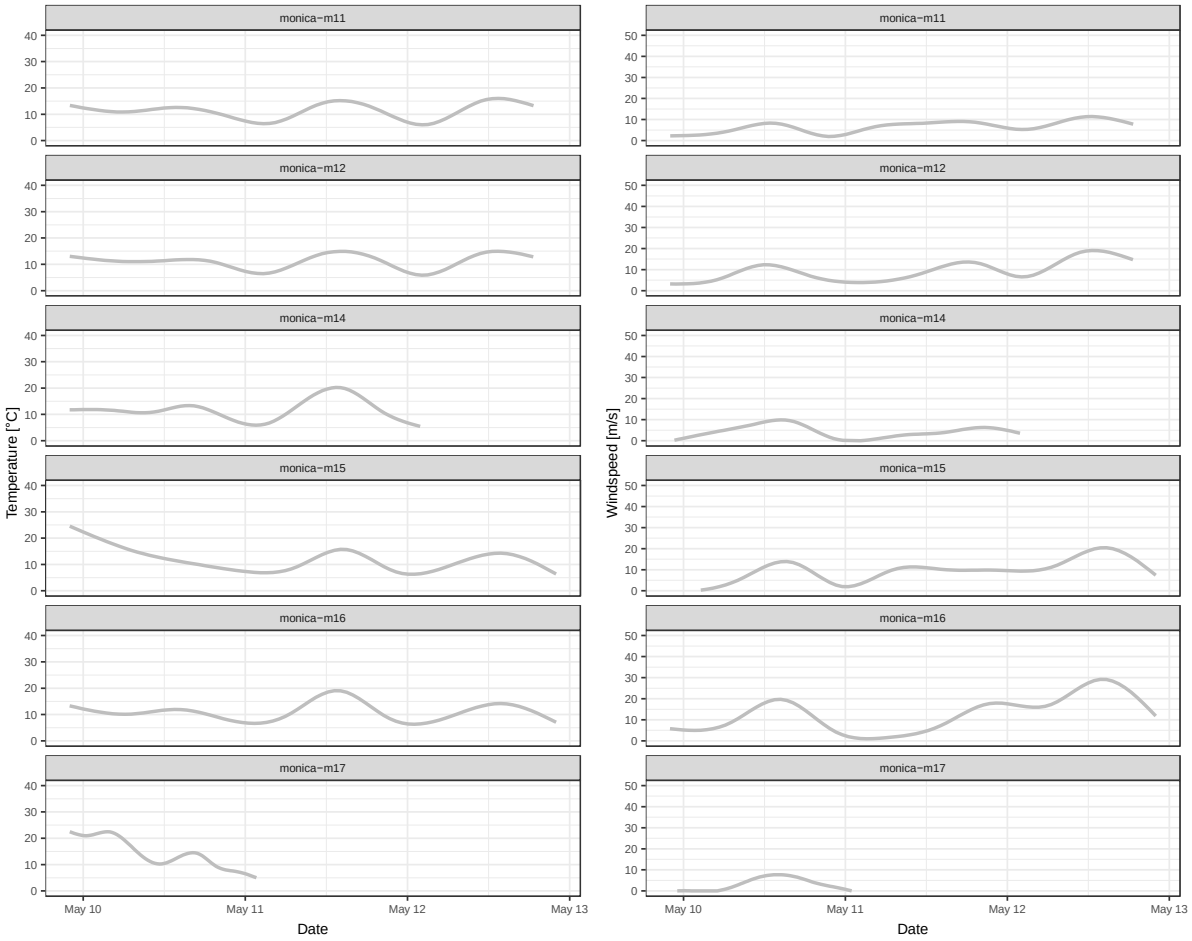

Figure 70: Data of all 7 sensor boxes showing temperatures (left) and windspeed (right) measurements

Besides the environmental measurement, the network communication of the sensor boxes was also investigated. It uses LoRaWAN to send data via OneM2M (provided by project partner TIM) to the MONICA backend. The graphs in Figure 71 show the number of gateways reachable by each sensor box / node (left) and the inter message arrival time (right). The latter provides insight on data freshness and packet loss.

Overall, we found that all sensor boxes could reach more than one gateway most of the time, and an overall low packet loss. Typically, a sensor should send one data value every 40 to 60 seconds. Hence, if the inter arrival time is higher, i.e., > 100 seconds, it indicates packet loss. The graph (Figure 71 right) shows that most messages arrived within the interval without packet loss, but nodes m11 and m12 also have higher latencies which sum up to 5 consecutive packet losses at maximum.

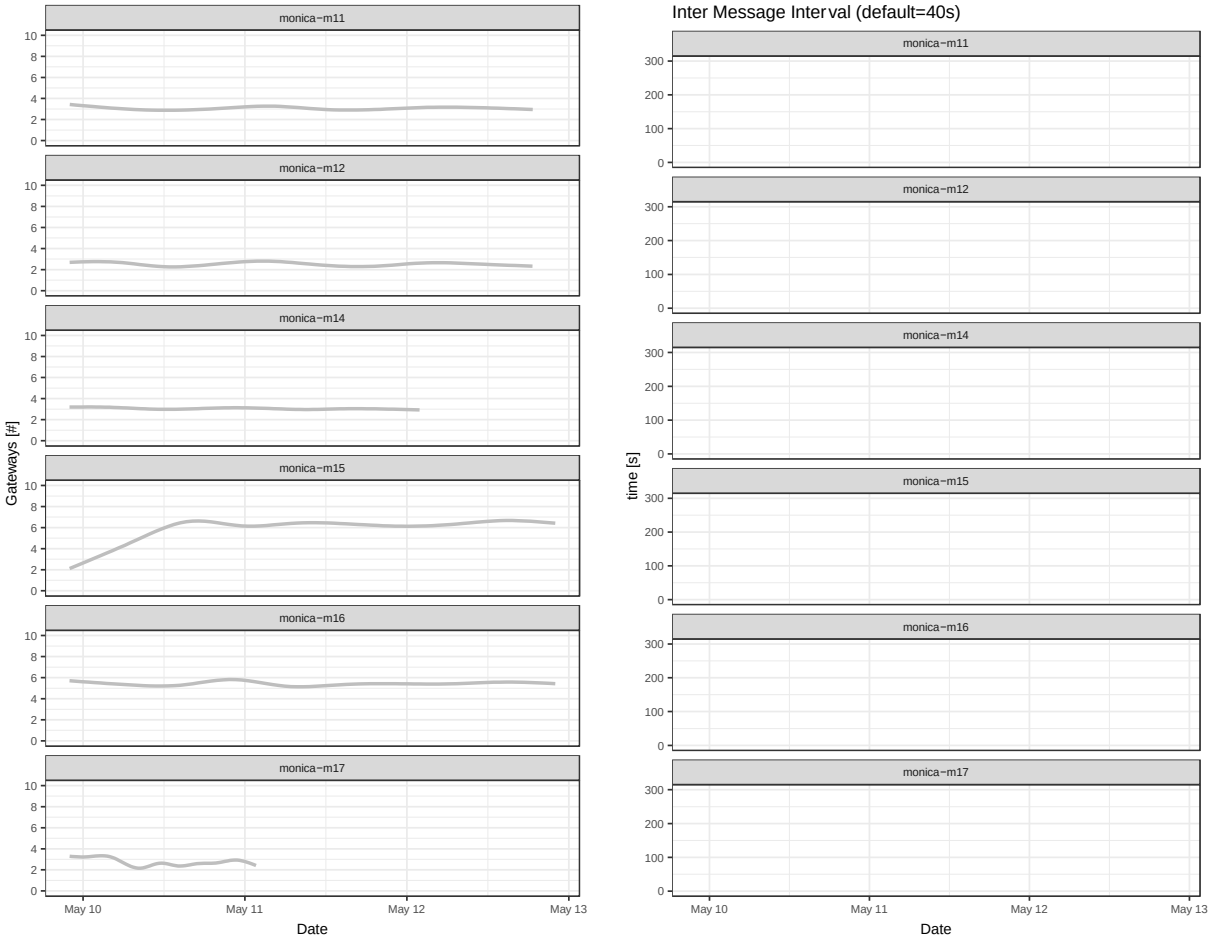

Figure 71: number of LoRaWAN gateways in range of each node (left) and inter message interval (right)

5.3.3 Lessons learned

After two years of planning it became clear that the Hamburg Port Anniversary remained a challenging event to deploy MONICA technologies. The long stretched out venue, the existing rigid security concept and the number of stakeholders are just a few examples of the different factors which have to be considered during the planning. These factors made it especially demanding to set up infrastructure needed for MONCIA technologies and adding to the existing ones. On top of that, the use case for crowd and capacity monitoring which is of high interest for the event was covered by the project “Sucre” (Fraunhofer IOSB Karlsruhe) starting just a bit earlier than the project MONICA.

Irrespective of the challenges, it was possible to deploy the environmental sensors. The deployment was successful and without any barriers as it did not intervene with the existing security concept but added to the safety on site.

As the Port Anniversary had witnessed some severe weather conditions in the previous years, the piloting within the project supported the event organisers in their security briefings and decision-making processes.

5.4 Rhein in Flammen Bonn

5.4.1 Introduction

Rhein in Flammen[8] is a festival happening once a year during the first weekend of May. In Bonn, visitors can join the free event from Friday to Sunday. During this time, a variety of concerts take place on three different stages and food stalls surround the whole area of the public park “Freizeitpark Rheinaue”. On Saturday evening, the most crowded day out of the three, thousands of people join to witness the firework show and the illuminated boat parade along the river Rhein. This part of the program is considered to be the highlight of the event. Rhein in Flammen has existed for 33 years. It welcomes an average of 90,000-120,000 visitors per day making it one of the most popular festivals in the area. The event area is large and contains a varied geography (hills, roads, trees, water).

The command centre was set up in a youth recreation facility in the middle of the event area. All stakeholders (event management, fire department, police, paramedics etc.) met there for hourly briefings during the event days. The MONICA COP was available on a big touch screen monitor during the whole event and interested parties were welcomed to check out the available features and provided valuable feedback on functionalities. After excellent weather in 2018, the weather was cold and rainy in 2019 which led to a very low visitor turnout.

Table 1Table 19 shows the selected use cases for the Rhein in Flammen Demonstration in Bonn.

Table 19: Selected Use Cases for Rhein in Flammen Demonstration

ID	Use Case Group	Selected for 2018	Selected for 2019
UCG 2	Sound Monitoring and Control	X	X
UCG 3	Crowd & Capacity Monitoring	X	X
UCG 5	Locate Staff	X	X

Table 20 shows the number of IoT Devices tested during this demonstration.

Table 20: Number of deployed IoT Devices at Rhein in Flammen Demonstration

IoT Device Type	Number of deployed devices 2018	Number of deployed devices 2019
Cameras	4	5
Staff Location App	10	N/A
LiPS GPS Tracker	N/A	45
IoT Sound Level Meters	6	6
Visitor App (mobile phones)	0	~1400

After the initial MONICA deployment at Rhein in Flammen in 2018 it was decided to focus on the same use cases for Rhein in Flammen 2019 while improving the outcome according to the lessons learned of last year´s event. The most obvious problem to solve was the unreliability of the event area´s internet connection as well as the wireless connectivity of the IoT devices (see Table 20). Since we observed in 2018 that a mobile LTE connection provided by Germany´s largest mobile network provider was available even during the event highlight (the fireworks on Saturday evening), Bonn pilot decided to use LTE mobile connectivity to fulfil three network requirements:

- Fast and reliable Internet connection at the event´s command center.
- Connectivity of the sound level meters to the MONICA cloud.
- Transmission of video streams from one of the camera sites to the processing machine at the command center.

This meant that the pilot did not rely on the low bandwith fixed-line Internet connection at the command center. Furthermore, it was not needed to set up a Wi-Fi network infrastructure to extend this Internet connection into the event area.

[8]http://www.rhein-in-flammen.com/

5.4.2 Sound Monitoring

In a similar setup to 2018 six Sound Level Meters (SLMs) provided by B&K were deployed in 2019, four near the main stages and two closer to affected residential areas (see Figure 72 and Figure 73). After problems encountered in 2018 with providing a stable Wi-Fi connection to the SLMs, in 2019 each device brought its own LTE router and was equipped with a prepaid SIM card of the local mobile network provider. LTE volume was bought as needed. Since the devices sent more data than expected by B&K after some initial tests under laboratory conditions, at the end of the event about four hundred Euros were spent on LTE volume. The LTE connection was very reliable and did not suffer from the connectivity problems encountered in 2018 while using a Wi-Fi connection.

Figure 72: Installed sound level meter

Figure 73: Sound level meter interior

The collected data was shown live in the COP, most prominently the Sound Heat Map near the main stages was visualized (see Figure 74). The raw sound level measurements as well as the Annoyance Index could be analyzed live graphically using the tool Grafana. Everything regarding the sound monitoring worked according to plan. As mentioned above, it turned out to be surprisingly expensive. A need to optimize and reduce the amount of data sent over the network was identified.

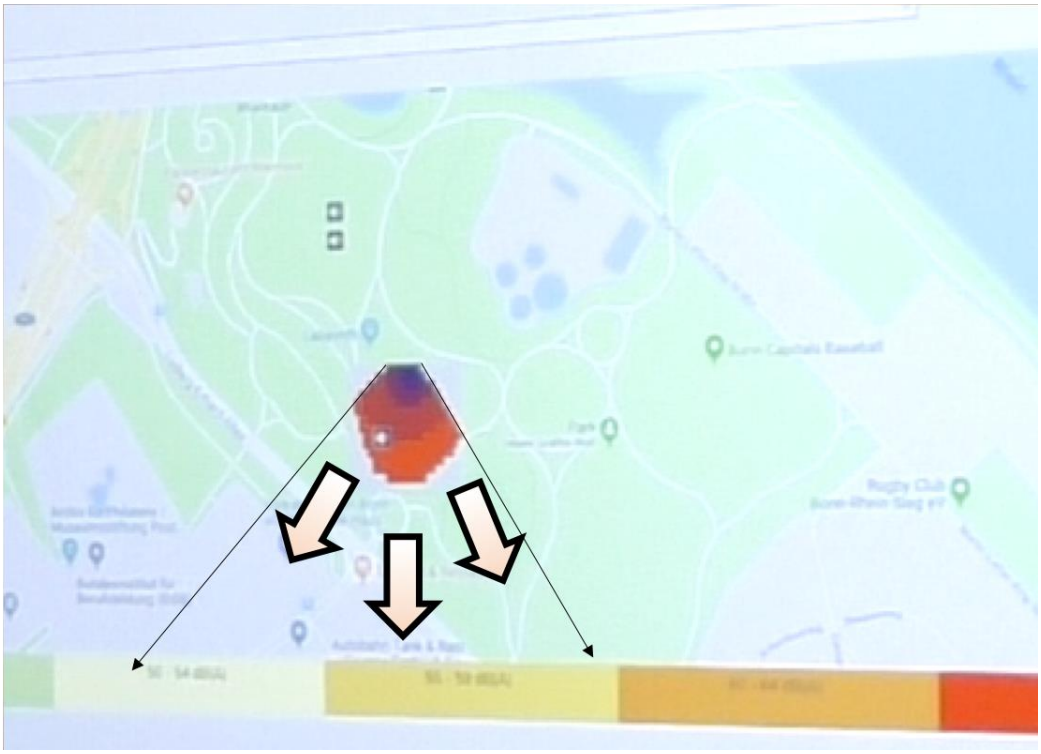

Figure 74: Sound Heat Map during Rhein in Flammen 2019

5.4.3 Crowd and capacity monitoring

In 2018 four cameras were placed near the Autobahn bridge and connected via optical fibre cable to the command centre. This provided optimal reliability at high installation costs. In 2019 this camera site was re-used for three cameras with optimized placement (see Figure 75 on the top left number one). Two of these were optimally calibrated to provide a vertical view for VCA´s Gate Counting algorithm. One camera was observing the area under the bridge in order to implement KU´s Crowd Density algorithm. A second camera site was set up in the opposite direction from the command centre and optimally calibrated for Gate Counting (see Figure 75 on the bottom right number two). Instead The data generated by the camera was transmitted via a VPN connection over the LTE mobile network in order to save time and installation costs compared to wired data transmission. In this case, no prepaid SIM but a contract SIM was used which allowed to buy an LTE flat rate for each day at manageable costs. The connection turned out to be fast and reliable enough to transmit two video streams to the command centre. The video streams were then analysed on a performant computer on site. See Figure 75 for the vertical camera position to optimize Gate Counting results.

Figure 75: Camera setup Rhein in Flammen 2019

The results of the Gate Counting algorithm could be visualized live in the tool Grafana (see Figure 77). It turned out that the algorithm provided very good results with over 80 % accuracy under optimal conditions, i.e. when the camera and the algorithm configuration were optimally calibrated and not too many people crossed the line at the same time. In very crowded scenarios, the accuracy dropped sharply.

Figure 76: Vertical view

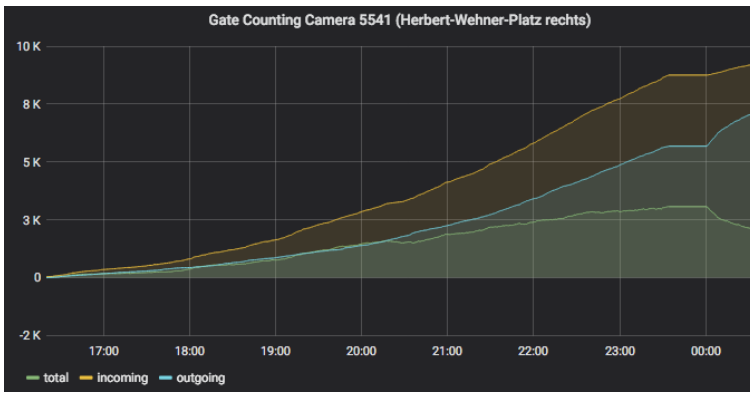

Figure 77: Results in Grafana

The results of the Crowd Density algorithm for Rhein in Flammen were not representative and therefore not evaluated, since the event in 2019 had few visitors due to cold and rainy weather conditions. The camera view

never showed a very crowded scenario, even at peak hours. Furthermore, KU´s experts suspected the algorithm could experience problems with the cobblestone in the monitored area (see Figure 78). Thus, KU´s evaluation efforts were later focused on the experiences at Pützchens Markt 2019 (see Chapter 7.3).

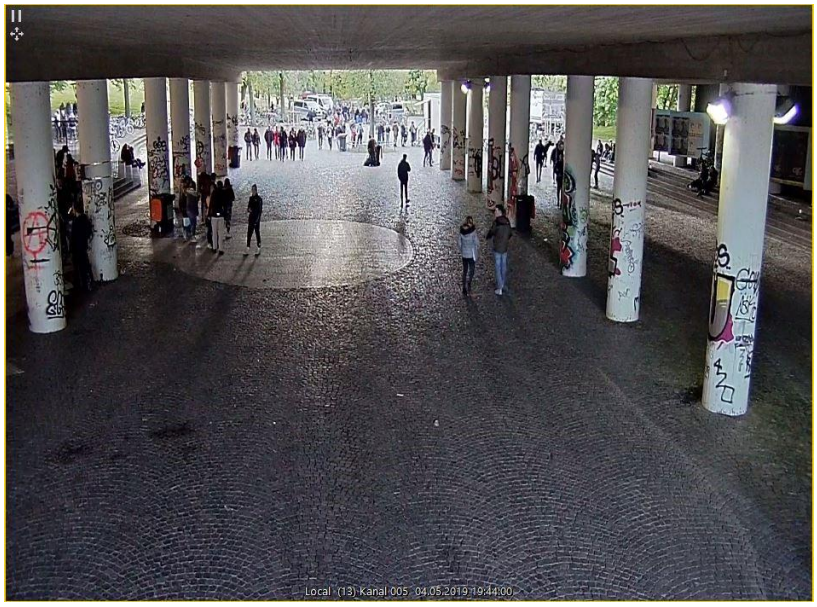

Figure 78: Camera view for Crowd Density

5.4.4 Locate staff

Much effort was put into optimizing the technology for the staff location use case. Since in 2018 the mobile staff tracking app was unpopular among the target group and was based on unreliable Wi-Fi and mobile network connections, Bonn pilot decided to develop the Live Positioning System (LiPS) a dedicated GPS tracker hardware transmitting the GPS location data via a low-power wide-area LoRa network. The LiPS prototype allowed to build an independent network at an affordable price.

Figure 79 shows two generations for LiPS staff tracker hardware. The second iteration has the size of a car keyholder. It is smaller, handier and with some internal hardware improvements. The devices can be charged wirelessly, last for about 16 hours on battery and also provide a “panic button”. The GPS location is transferred via LoRa wireless network to gateways and then shown online in the COP.

Figure 79: first iteration prototype (blue) and second iterations prototype (black) of LiPS staff tracker hardware

After problems with an unreliable cabled Internet connection at the command centre in 2018, it was decided to develop a digital location map software that is independent of the MONICA cloud and can be run “offline” at a local computer in the command centre. It is now part of the Live Positioning System (LiPS). This potential offline solution worked as planned, a screenshot is shown in Figure 80. Since the Internet connection showed enough stability when using a LTE mobile Internet connection at the command centre, the locations could additionally be shown in the MONICA COP. The users were able to switch between these two maps on the big screen at the command centre.

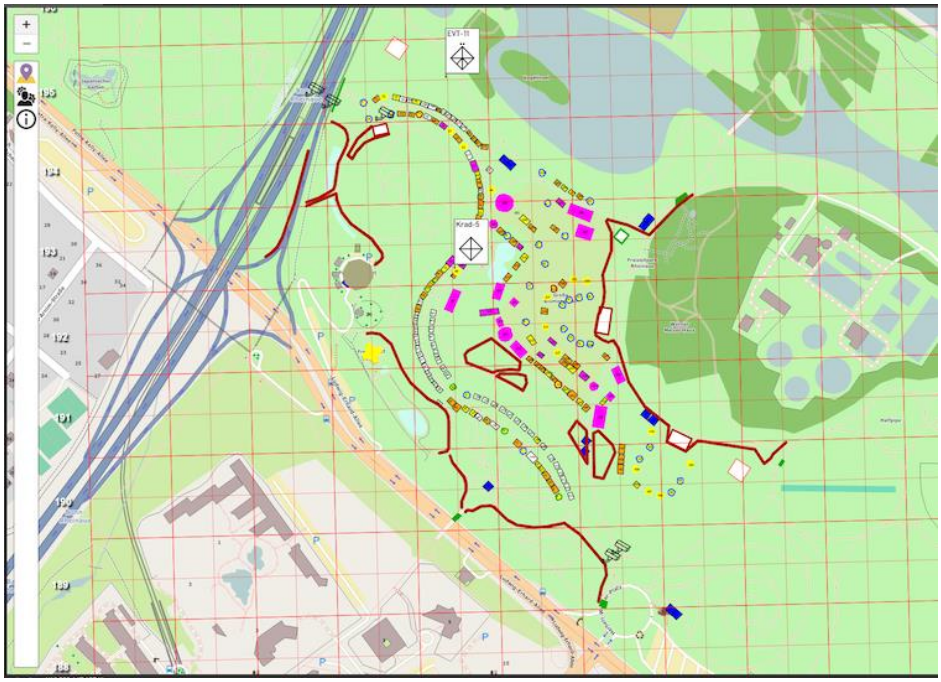

Figure 80: Digital location map “Digitale Lagekarte”

The performance of the LoRa technology was excellent. Figure 81 shows that the two gateways equipped with two small antennas covered the whole event area and even several more kilometres, reaching the other side of the Rhine river.

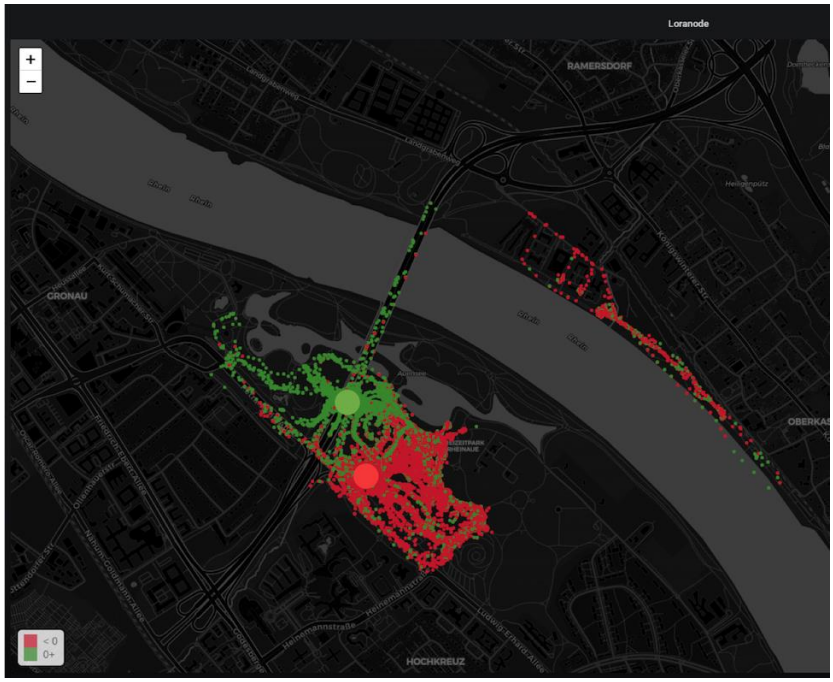

Figure 81: LoRa range of LiPS trackers during Rhein in Flammen 2019

5.4.5 Mobile event app

For the Rhein in Flammen pilot in 2019 a mobile event app dedicated to be used by the visitors was developed. The app is available for iOS and Android smartphones and provided the following information for visitors:

- Security advice
- Flyers of event sponsors
- Event time table
- Link to public transport information
- Map of the event area including points of interest (first aid, toilets, food offers etc.) and navigation functionality
- Information about the MONICA project

Since the app was finished on the last days prior to the event there was little time to do extensive marketing. Despite that fact, about 1400 visitors downloaded the app on the weekend of the event.

Figure 82: The Rhein in Flammen mobile visitor app

5.4.6 Lessons learned

Connecting the sensors to a network is one of the biggest challenges for an IoT deployment. In case of open-air events this is especially challenging because everything needs to be set up ad-hoc. Two years of MONICA at Rhein in Flammen provided the following valuable insights regarding this challenge.

- Using Wi-Fi bridges is impossible if line of sight visibility between bridge endpoints cannot be provided because of the event´s geography (hills, trees in between). Also, Wi-Fi routers at bridge endpoints will fail during the event´s peak hours because of too many connection attempts by visitor´s smart phones. Wi-Fi bridges can work in scenarios where line of sight connections are available and the IoT devices are connected to the bridge endpoints via cable instead of Wi-Fi (see Pützchens Markt 2019 in Chapter 7.3).
- Relying on the LTE mobile network is a viable alternative to the original approach of 2018 to establish a private Wi-Fi network in the relevant event areas. The results of the tests in 2019 were excellent, even high-quality video streams could be transmitted via LTE without issues. It is an open question whether the LTE connection would be performant even if the event is more crowded.

For the staff location use case the self-developed LiPS system and the LoRa infrastructure provided excellent results. Also the “offline first” approach of the new LiPS Digital Location Map turns out to be promising. The whole setup could be deployed completely independent of an Internet connection even in remote areas (think of forest fires etc.).

The experience of 2018 showed that it is not useful to rely on an app on the staff´s mobile phones for the location tracking. Only few people are willing to participate if it involves installing an experimental app on their (private) phones. But in exchange the target groups (policemen, firefighters, paramedics) were very excited about the possibilities of using the LiPS tracker.

6 City Nightlife Management

Nightlife activities in open-air create increasing challenges for cities, in terms of security and noise pollution. Within MONICA project San Salvario district in the city of Torino has been selected as a pilot site, to demonstrate long term sound measurements and crowd control mechanisms. The following chapter will detail activities of MONICA project within this pilot, that exceed possibilities of IoT technologies, like street theatre.

6.1 Summary

The Movida pilot confirmed that open air night life is a challenging problem for cities and that technology canhelp municipalities and public authorities to manage but not to solve it. In particular, non-gated events require special strategies. A data-driven approach has been chosen in Turin to improve the management.

Concerning noise monitoring, the permanent pilot activities allow to strengthen the knowledge of the event, even if no direct feedback could be given for noise control reduction. Class 1 SLMs IoT are necessary in social gathering places as Largo Saluzzo for robust long-term analysis, as small changes in noise are expected by management action. In short terms: low-cost IoT SLMs are still useful for a better knowledge of the spatial distribution of noise or for the characterization of a specific source (like a terrace). More investigation is needed about the correlation between noise and annoyance index.

Crowd counting could be performed through AI, applying algorithms to streams from existing video-surveillance IoT cameras. This approach requires a good network, a powerful workstation and good algorithms, as well as cameras who are well calibrated, especially during the night, with different luminosity areas. Results are not fully satisfactory and would require further effort on calibration or a redesign of camera deployments.

The use of wristbands wasn’t considered applicable: the Movida goers do not perceive the idea of being part of an event and tend to maintain an errant, unpredictable behaviour: these behaviour traits are almost conflicting with the use of a site-specific wristband, requiring to be returned at the end of the night.

At the same time, personal connected devices (smartphones or smartwatches) could be used for crowd counting and monitoring, as demonstrated during a few months of Wi-Fi scanner application. A statistical anonymized data analysis of MAC addresses could provide a satisfying level of knowledge, in terms of density and duration of presences.

The correlation between noise and crowd density shows very interesting results useful for a better knowledge of the Movida as well as for a realistic qualitative analysis of possible future improvements.

The critical evacuation scenarios could be really complex to be modelled and the arising problems would require special efforts which could be solved in a new project.

Communication and event information in night life reflect all its complexity, but promising different approaches have been tested in Movida Pilot. Mixing technologies, arts and cultural events is one of the added-value results of the project.

All lessons learnt will been capitalized in the Movida Noise Action Plan, ready to be approved in 2020 by the Torino City Council after its publication and a good public debate.

6.2 Movida Torino

6.2.1 Introduction

The Movida nightlife in San Salvario has been increasing since 2010, due to a huge amount of people that are in the streets every night. People attracted there, and a large number of pubs, bars, restaurants and little shops, cause increasing disturbances to the neighbours. The nightlife hot spots in San Salvario are in Largo Saluzzo and Via Baretti, where crowds gradually increase, from the areas in front of bars until occupying all public spaces, thus causing huge side effects: noise (chatting, shouting, quarrels), traffic blockages, irregular parking, obstruction of driveways, rubbish on the ground, etc. A detailed analysis of the event can be found in D8.1.

Table 21 provides an overview of the use cases selected by this pilot while Table 22 provides an overview of the devices tested by this pilot.

Table 21: Selected Use Cases for the Movida Pilot

ID	Use Case Group	Selected for 2018	Selected for 2019
UCG 2	Sound Monitoring and Control	X	X
UCG 3	Crowd & Capacity Monitoring	X	X
UCG 5	Locate Staff	X	
UCG 7	Security Incidents		
UCG 8	Health Incidents		
UCG 11	Evacuation		X
UCG 13	Event Information		X

Table 22: Number of deployed IoT Devices at Movida Pilot

IoT Device Type	Number of deployed devices 2018	Number of deployed devices 2019
Cameras	3	3
IoT Sound Level Meters – class 1	3	1
IoT Sound Level Meters – low cost	5	6

As the Movida is a long term, self – organized event, where sources are mostly people with their behaviors in an urban open space, a data-driven approach has been chosen by the City to support planning, communication, monitoring, and policies assessment process, from short-term and experimental initiatives to long-term urban planning.

For 2019, no extra technical deployment was planned for MOVIDA, but the focus was given to permanent long term installations, data analysis, a workshop and communication activities based on artistic performances, in cooperation with the Local Health Department.

A site visit instead of a Pilot Demonstration was planned Saturday 6th of July, the same weekend of Kappa Futur Festival, in conjunction to the visit of reviewers in Turin; during the site visit, a first application of the Urban Space Hackathon winning solution was performed, hosted by “Casa del Quartiere”.

6.2.2 Sound monitoring and control

Sound Monitoring deployment for Movida is based on Class 1 SLMs and low-cost IoT SLMs. MONICA permanent COP deployment is guaranteed by one B&K IoT Class 1 SLM, installed long-term on a light pole in Largo Saluzzo. The location of B&K SLM 325 was designed to cover the hotspot of Largo Saluzzo, providing a robust data stream for long term analysis of noise. Data is collected with a sampling time of one second and is continuously sent via 4G to the Monica Platform, through a B&K Gateway. The SLM calibration has been checked periodically since 2018 and it always showed a great stability without the need of any adjustment.

The B&K SML is integrated by the low-cost IoT noise monitoring network, put in place in San Salvario District by the City of Torino in 2016, using several Android smartphones. The location of sensors was optimized to cover all significant feature of the Movida area: one in Largo Saluzzo, the very crowded square, three in narrow

streets with pubs and bars (S_01, S_04, S_05), one in a boulevard for traffic noise measurement (S_06) and the last one in a quieter area with no crowd and low traffic (S_02) for global reference. Figure 83 shows the final deployment in the map and through the COP.

Figure 83: SLMs position and ID on Google Maps, 2019 deployment

Here also, data collected with a sampling time of one second is continuously sent via Wi-Fi or 4G to the regional IoT Open Data Platform “SDN”. These points have been integrated in the MONICA platform, using API of the regional IoT Platform. Due to a stop to maintenance to bike sharing stations (providing power to the low-cost IoT sensors), S_04, S_05 are out of order. Both Class 1 and low cost SLMs data are shown in the COP (see Figure 84, Figure 85 and Figure 86).

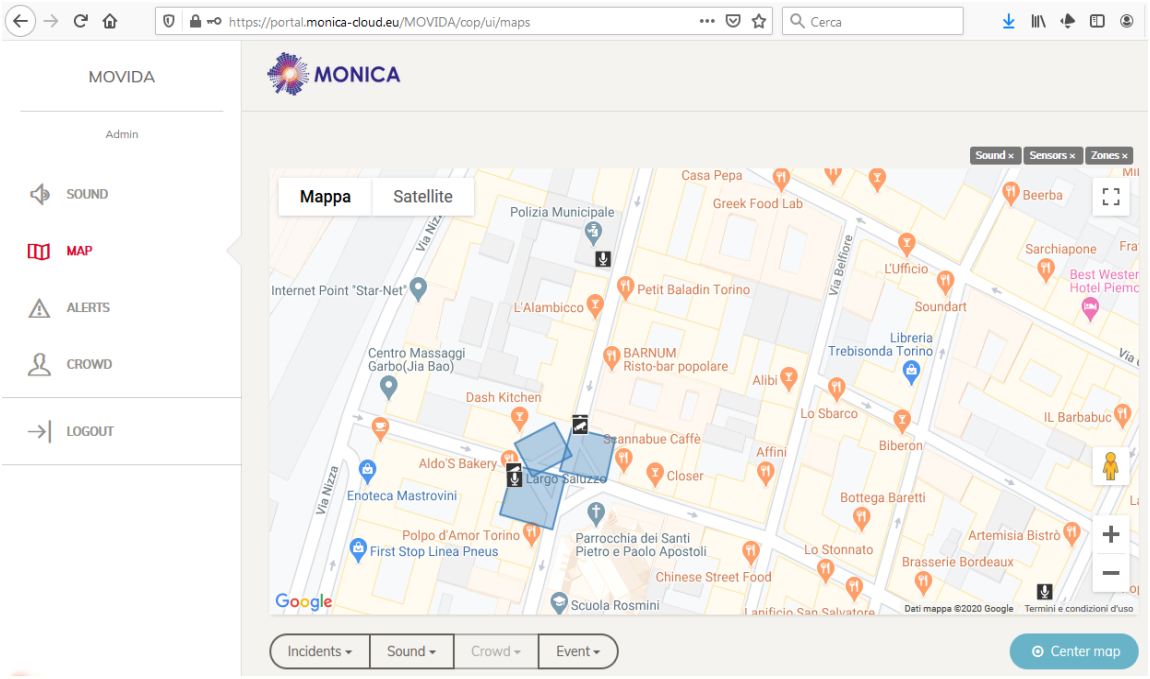

Figure 84: Screenshot of Movida Permanent COP, showing deployment of sensors

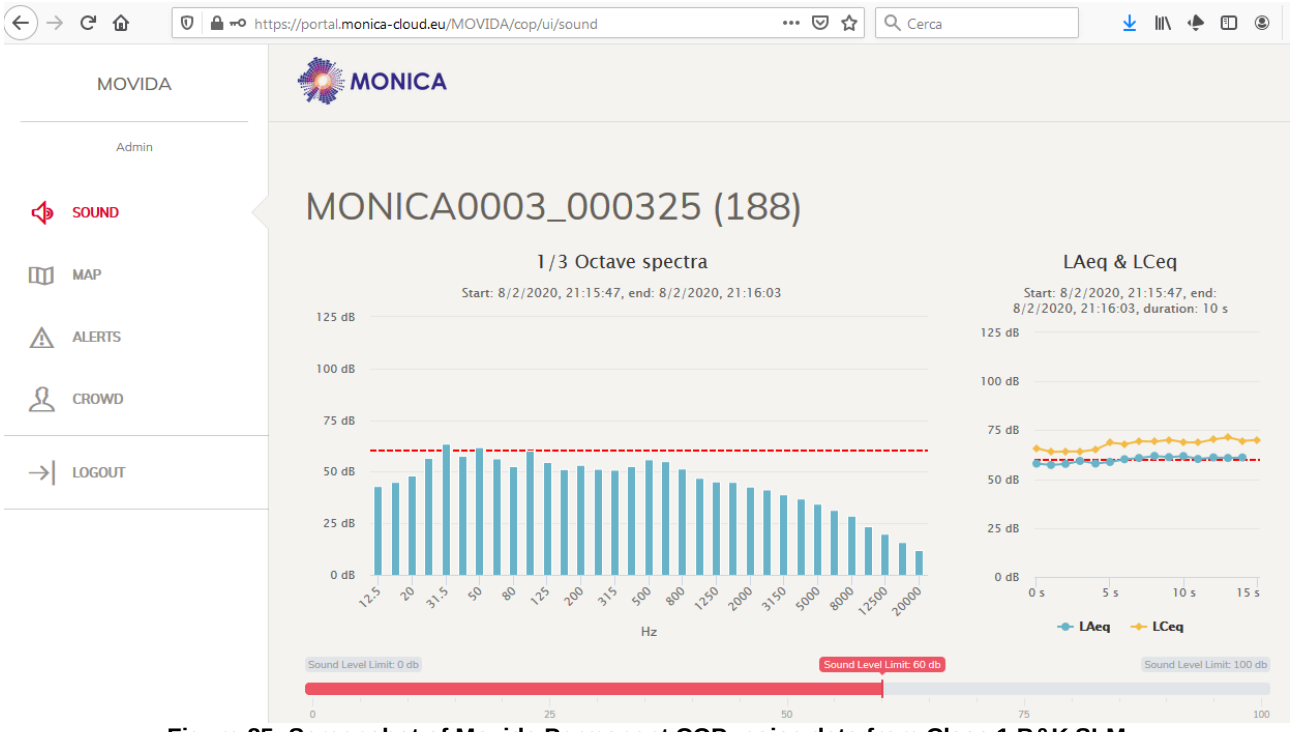

Figure 85: Screenshot of Movida Permanent COP, noise data from Class 1 B&K SLM

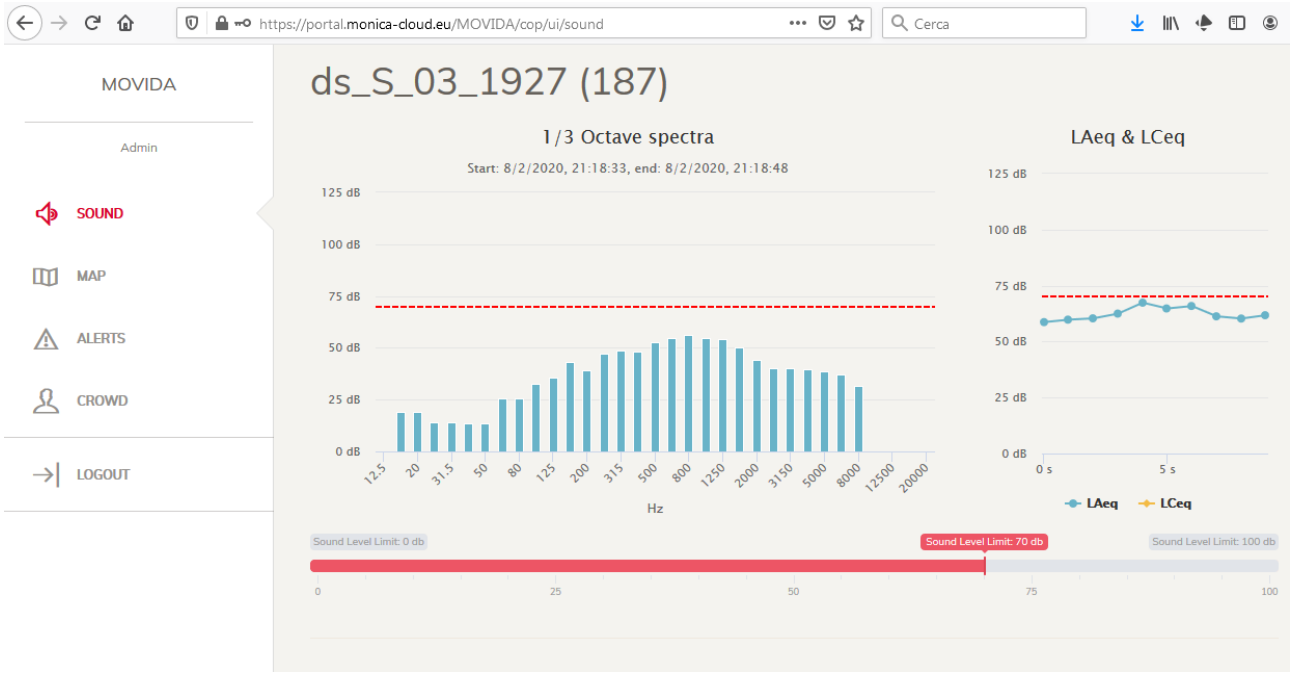

Figure 86: Movida Permanent COP, noise data from low-cost Iot sensor

A statistical analysis has been carried on, in order to compare data collected by the low-cost IoT network and by the Class 1 SLM. The results indicated that there was a very strong correlation between low-cost IoT and Class 1 SLM noise LAeq 1hour levels.

The scatter plot and a comparison between the two distributions confirm a good coherence between 60 and 80 dB $L_{A1\ hour}$. At lower levels the two sensors show differences (see Figure 87). The sensor responses and dynamic should be investigated, as well as local variations of background noise.

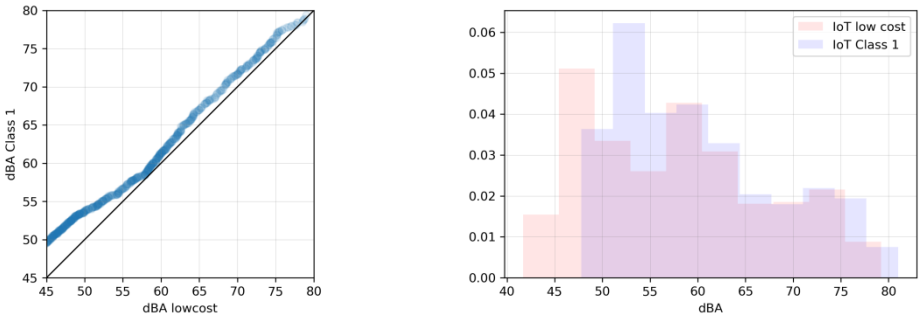

Figure 87: Scatter plot (left) and distribution (right) of hour noise levels in Largo Saluzzo, low-cost vs class 1

Data collected during 2019 has been summarized in a calendar plot (see Figure 88), to be published on the web site for communication purposes.

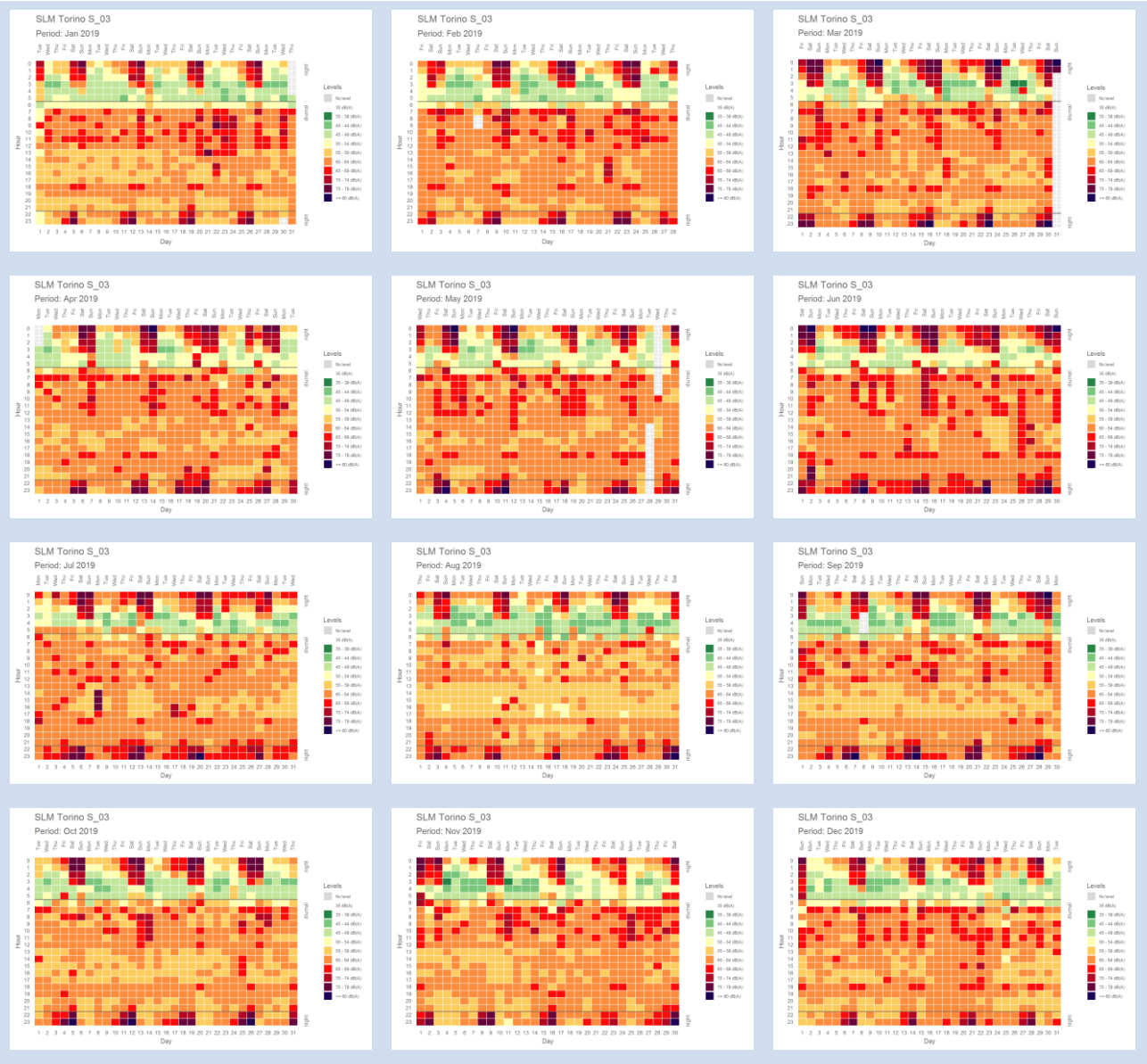

Figure 88: Crowd noise levels in Largo Saluzzo during 2019, averaged over a period of 1 hour

The long-term observation of the data collected shows a certain regularity of the distribution of hourly noise levels. As shown in Figure 89, levels are distributed in three clusters considering LAeq at evenings-night (22:00-06:00). Cluster 1 includes Sunday, Monday and Tuesday, cluster 2 groups Wednesday and Thursday and cluster 3 groups Friday and Saturday. Further corrections have been made considering the feast days as Sundays and the pre-feast days as Saturdays. A seasonal trend is noticeable, with higher levels in spring and autumn, and lower in winter and in summer, in particular in August.

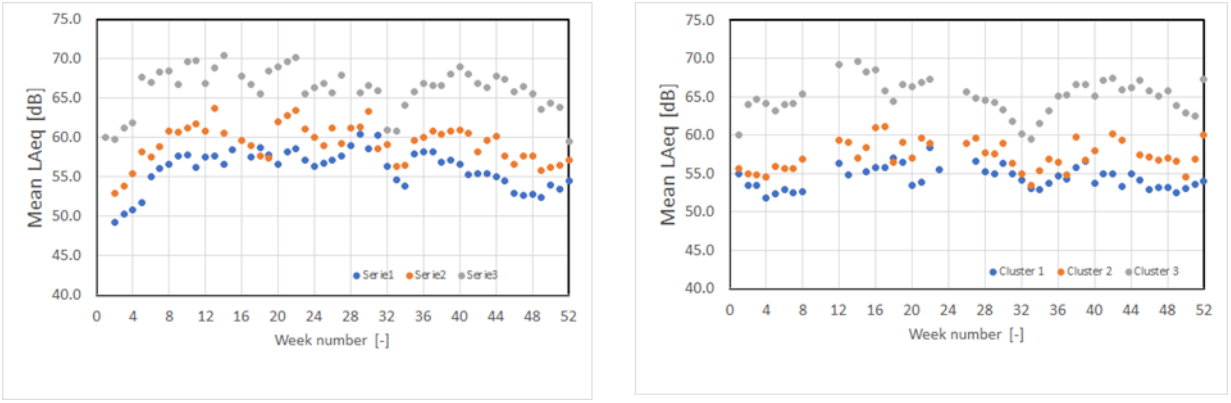

Figure 89: Crowd noise levels during (01/06/2016-31/12/2017) and (01/01/2018-03/03/2019) averaged over a period 21:00-06:00 and grouped in three clusters (cluster 1=Sunday, Monday and Tuesday; cluster 2=Wednesday and Thursday; cluster 3= Friday and Saturday).

6.2.3 Crowd and capacity monitoring

The Crowd and Capacity Monitoring scenario was confirmed as the second permanent use case for Movida. In Largo Saluzzo, the Torino municipality employs an advanced video surveillance system composed of three IP HD cameras with PTZ function.

During the last demonstration in 2018, due to a network bottleneck, a local deployment of workstation and SFN was needed, thus causing the loss of wired connection from the node to Monica platform.

For 2019, a complete redesign of the local network was planned, in order to allow better performance. In particular, the SFN was moved to the central Police station and a new glass fibre connection was designed (see Figure 90). The yellow dot shows the actual network bottleneck c/o Local Police station. This was done in order to connect all cameras to the SFN in the fastest way, also allowing new tests on crowd counting, expecting better performance in night-time overcrowded situation.

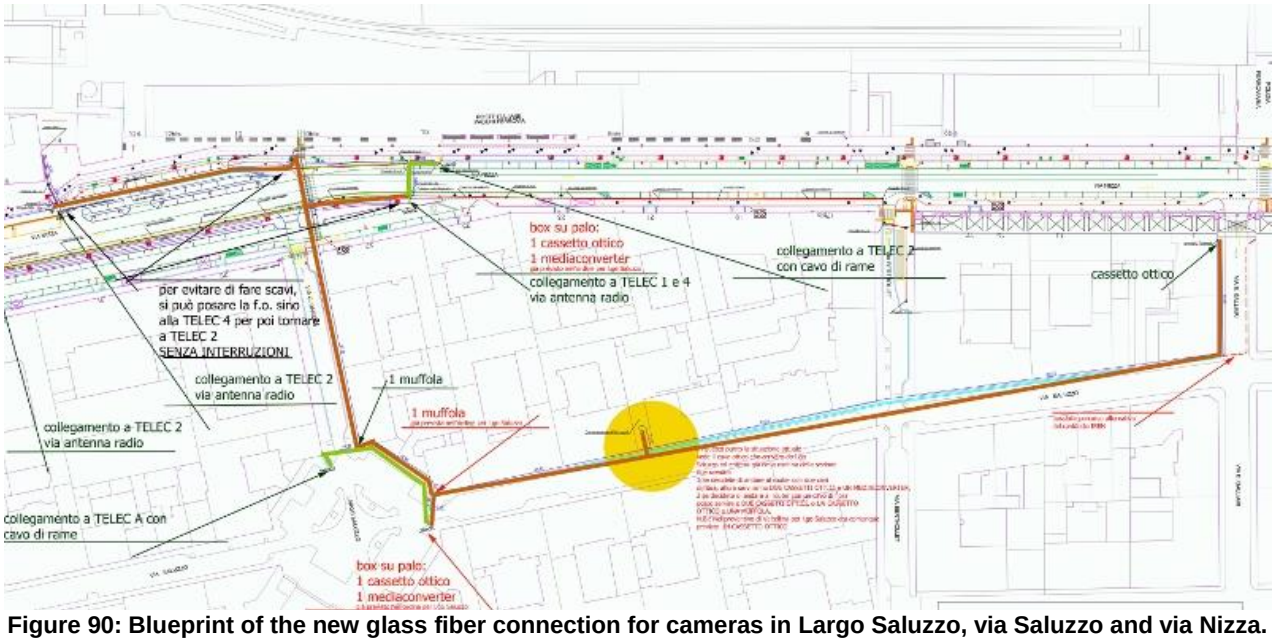

Figure 90: Blueprint of the new glass fiber connection for cameras in Largo Saluzzo, via Saluzzo and via Nizza.

Due to administrative difficulties, works will be completed at the beginning of 2020. Until then, an unstable data stream is provided to SFN, and usually only two cameras out of three are available for analysis.

Crowd counting could be performed through AI, applying algorithms to streams from existing video-surveillance IoT cameras. A mean absolute error (MAE) of 4.1348 is observed on a sample of 90 random images. The MAE is fairly low in this pilot. The images consist of several street occlusions such as trees, poles and parked

vehicles. The algorithm tends to fail in detecting people at the far end from the camera due to which there is underestimation in the crowd count (see Figure 91).

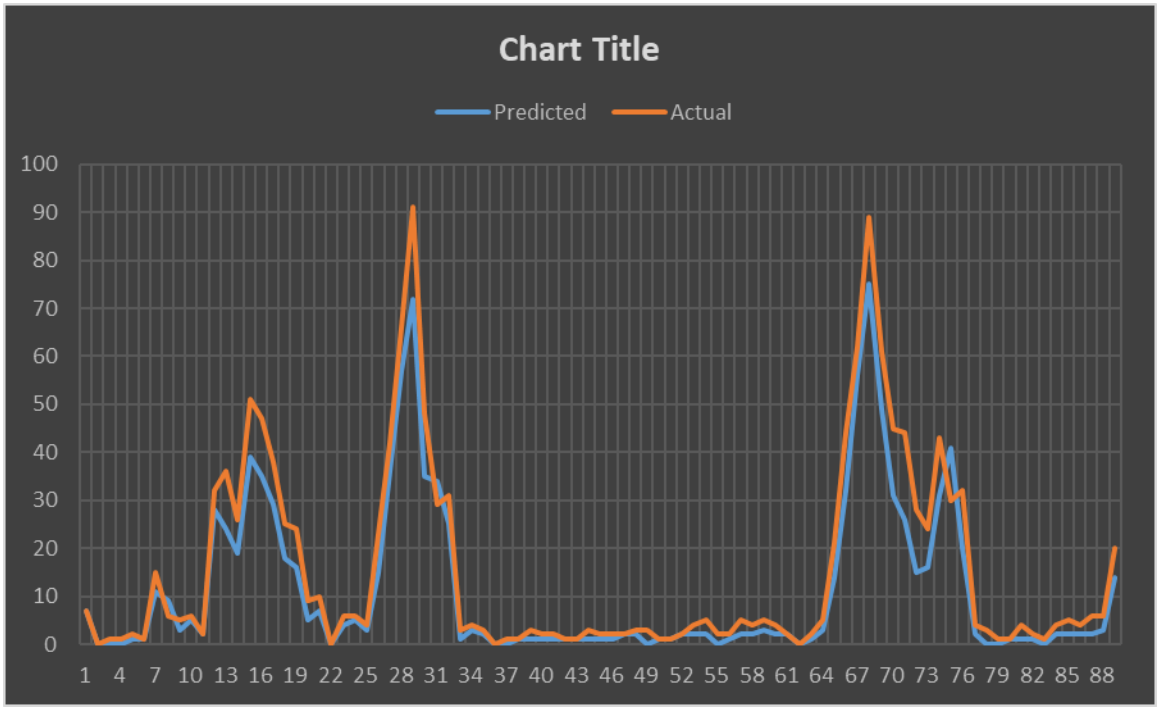

Figure 91: Predicted and actual count of people in random frames during Movida 2019

In order to strengthen **Crowd and Capacity Monitoring**, in 2018 Wi-Fi scanners, counting smartphones and wearables were installed in the four accesses to the square, showing a larger number of (non-unique) presences in the area of Largo Saluzzo.

The assessment of the number of people on an hourly basis has been computed by cumulating all durations from 5 to 180 minutes (weighted if sub-hourly). This value is set as the minimum of a range in which the maximum is estimated considering also visitors detected for a duration between 180 and 360 minutes.

Charts of a Friday evening (see Figure 92) show a great variability in the number of gathering visitors up to 180 minutes (orange), while the long term presences (yellow) are stable until midnight (customers of restaurants) and decrease during the night. Visitors crossing the area (red, less than 5 minutes) seem proportional to values of gathering visitors, while stable devices (grey, more than 360 minutes) show a strong regularity of presence along the night.

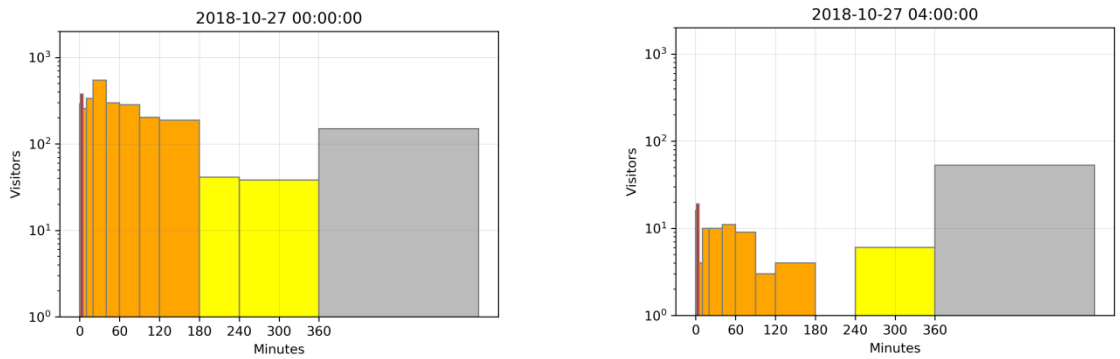

Figure 92: Number and durations of visits in Largo Saluzzo venue: Saturday 27.10.2019 0 AM / 4 AM

This analysis of data has been used to calibrate an acoustic capacity model, based on Rindel's prediction model for the background noise estimation in places for social gathering.

$$L_{N,A} = \frac{1}{1-c}\left(69 - c \cdot 45 - 10log\left(g\left(\frac{0.16V}{T \cdot N} + Ap\right)\right)\right)(dB) \qquad \text{formula (1)}$$

This model can be useful for calculating the maximum number of people (Nmax) allowed within Largo Saluzzo square once the background noise level threshold is set. Usually these levels are given as LAeq, however here they are referred to as LA90. The parameters that have been tuned above for each cluster based on the prediction model are used in the formula (1) where the unknown factor becomes the number of people (N=Nmax). Table 23 shows the results on number of people compared to the background sound pressure level L90 at thresholds indicated with LN,A values.

Table 23: Number of people compared to the background sound pressure level

LN,A (dB)	Cluster 1		Cluster 2		Cluster 3	
	N_{max}	Crowd density (people/m²)	N_{max}	Crowd density (people/m²)	N_{max}	Crowd density (people/m²)
50	87	0.04	69	0.03	62	0.03
55	213	0.11	132	0.07	109	0.05
60	551	0.28	257	0.13	191	0.10
65	1644	0.82	516	0.26	342	0.17
70	-		1109	0.55	629	0.31

This approach seems quite promising for all open-air not-gated events. As Wi-Fi scanners provided by H2020 Rock Project[9] were decommissioned and deployed in other city locations, Local Police is now testing two new sensors, one provided by TIM and one provided by a start-up company based in Turin. Analysis on raw data has been developed, but the two sensors are still not operational, due to calibration issues.

6.2.4 Evacuation simulation

Evacuation simulation was considered as a possible use case for Movida. In 2019, in order to simulate evacuation scenarios, a dxf blueprint of Largo Saluzzo venue was sent to CERTH, together with raw data about the number of Wi-Fi devices hourly detected in Largo Saluzzo, in October, November and December 2018 (see Figure 93). The simulation was performed with 500, 1000, 1500 and 2000 people.

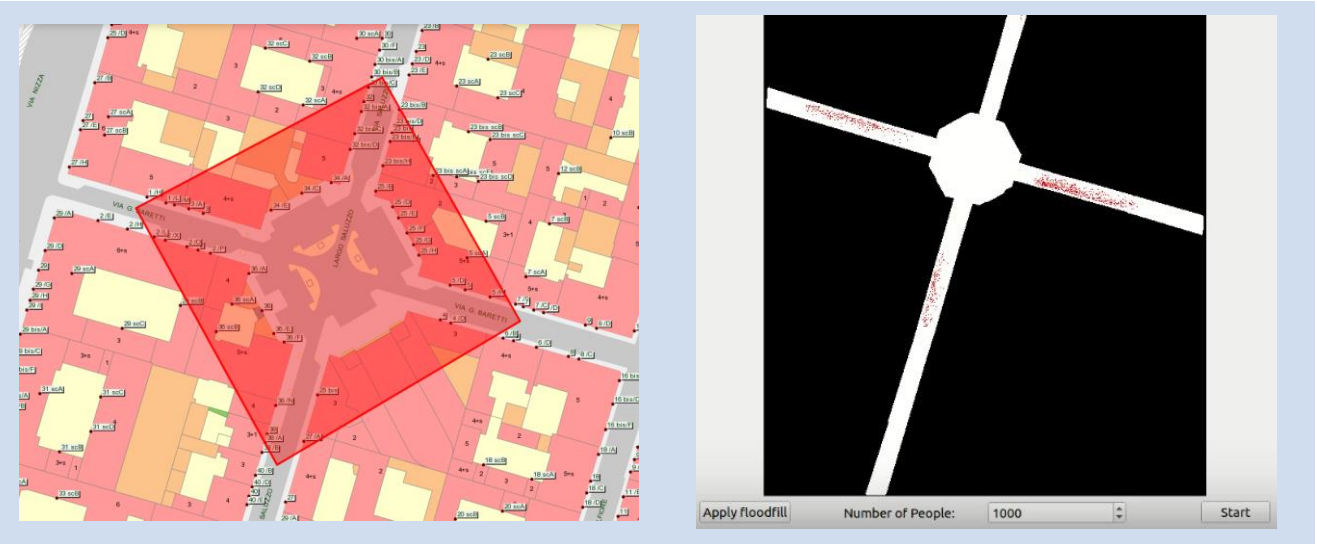

Figure 93: Largo Saluzzo crowded area (in red) and a frame of the evacuation simulation for 1000 people

The geometries considered in the 2D model were highly simplified, if compared with the real state of the venue. To have a realistic simulation, other 3D elements have to be added: cars, mopeds, bikes, light poles, trees as well as terraces and garbage cans. The model results were considered not useful by the Local Police due to such limitation. No further development has been communicated.

[9] https://cordis.europa.eu/project/id/730280

6.2.5 Event information

Event Information for a spontaneous event like Movida requires a special focus on strategies and messages. The purpose is not increasing the number of people joining the event, but suggesting a quieter and gentler way to behave in public space, in order to avoid part of the noise due to unaware noisy behaviour, trying to avoid both commanding or paternalistic approaches. Therefore in 2019 three different strategies where developed:

- empathy based on gentle or ironic messages
- fun through games and street art performances
- amazement through dance, costumes and whispered songs

The first strategy was developed by the MONICA Hackathon Winner Team within their project. It targets people in front of bars and pubs. Messages flow on a screen, using a bot whose behaviour is related to the noise levels and the number of interaction with the neighbours (see Figure 94). A first demo was performed in “Casa del Quartiere”, in order to give feedback to the noise in the courtyard. The solution based on a web-app and a low-cost SLM was presented during the visit of the reviewers in July 2019.

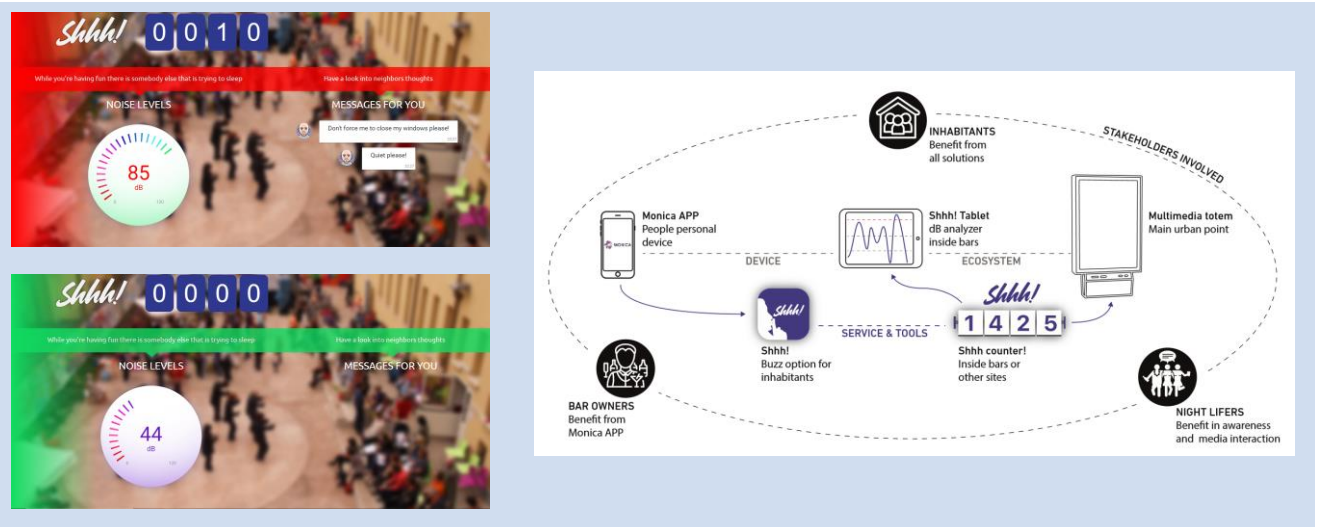

Figure 94: “Shhh!” project ecosystem and feedbacks, mixing colours and bot messages

The second strategy was developed in cooperation with the Local Health Department and was based on the artistic performances “VisibiLords” by Pindarica (see Figure 95 and Figure 96), mixing video projection, games and magic. The purpose of the performance is making people aware of potential personal night life risk (alcohol, drugs, unprotected sex) and impact on public space (noise, rubbish, safety). The performance is a hook for a follow-up by professional educators that offers more information and support (alcohol test, condoms, leaflets, etc.). The campaign of twelve nights launched the #ladolcemovida hashtag, with the idea of building a communication campaign and an app managed by the Youth Department.

Figure 95: #ladolcemovida leaflet and performances by VisibiLords in Largo

The third approach was tested one night, hosting “Les Pierrot de la Nuit” performers from Paris, as a conclusion of a workshop about the impact of artistic performances in night life districts, sharing experience between Turin, Paris and Florence. Three dancers and singers played an elegant performance in Largo Saluzzo (see Figure 96) mixing dance and songs whispered. An empiric observation showed a good reaction of Movida goers whose conversation were suspended during the performances and attention was oriented to silence and calm in order to pay attention to the songs.

Figure 96: #ladolcemovida performances by Pierrots de la Nuit in Largo Saluzzo

7 Fun Fairs

Funfair events are usually held in a park or an open field at which people pay to ride on various machines for amusement or try to win prizes in games. While Festivals and Large City Celebrations usually have a manageable number of involved stakeholders and don't take longer than a weekend, fun fairs usually fight with an extremely large number of stall owners and a high fluctuation with the security staff responsible for the protection of the visitors. The Live Positioning System (LiPS) developed within MONICA project and tested during Pützchens Markt event in Bonn has proven to be an acceptable solution to improve and speed up decision taking during large fun fairs, as on the one hand the tracking devices carried by the various security staff teams (paramedics, police, public order office and social workers) allow the command center to oversee staff positions and directly contact the nearest team, and on the other hand the common visualization of all the temporary amusement stalls on the COP dashboard allows all stakeholders to have a common source of information and real time orientation available for decision taking.

7.1 Summary

7.1.1 Hamburger DOM

Three field tests on MONICA technologies at Hamburger DOM have been completed in 2019. While the overall planning and organisation prior to the deployment was smooth and transparent, and the launch of the deployment successful, some technical issues arose during the SpringDOM 2019 event which could not have been foreseen. In the beginning, the main challenge lay in the integration of the data into the cloud and the reliable transfer to the COP. This could be solved and an automated work flow was used to quickly and easily update the backend information in 2019.

The environmental sensors (temperature and wind) as well as the GPS trackers did not always transfer valid and comprehensible data. Consequently, wrong values were displayed in the COP and, hence, the event organiser could not always rely on them. It is assumed that these errors occurred due to wrong conversions in the cloud.

During the spring DOM 2019 the temperature sensor caused some erroneous data. For the winter DOM 2019, the posting of updated measurements for temperatures and wind speeds was correct and mostly stable.

Furthermore, the feedback of stakeholders regarding the COP was overall positive and minor suggestions have been communicated in order to make it more manageable. These changes could be implemented for the winter DOM 2019. Especially, the access to historical data for each sensor, once as visualisation for the preceding hours but also as a separate data download enhancing the user experience.

While the responsible event organiser used a mobile phone during Winter DOM 2018, in 2019, he received an iPad. This clearly enhanced the visualisation and user experience of the COP.

The implementations at the DOM event were overall successful. The COP was improved step-by-step and adjusted to the requirements of the event organiser. Unfortunately, the usage of trackers at this event is not wanted by the responsible parties due to the fear of losing privacy. Therefore, there could only be tests regarding the usability and reliability of the trackers for future exploitation.

The cameras for the visitor count were implemented successfully. Because of the comparably low number of visitors there were not any safety incidents because of a non-manageable number of people in a certain area. The gate counting just worked for the events in 2018, in 2019 there was not the necessary infrastructure available at the fair ground.

7.1.2 Pützchens Markt

During the course of MONICA project two field tests at Pützchens Markt (PM) in Bonn in 2018 and in 2019 were completed successfully. The researchers gained interesting insights into the applied use of MONICA technologies and had the chance to develop and implement customised prototypes for an innovative Live Positioning Information System (LiPS) to support staff in coordinating security, rescue and municipal forces. The realtime localisation service based on the combination of LoRa and GPS technology proofed to be a reliable and beneficial solution for improving the communication and coordination of interdisciplinary teams during health and security incidents.

The Live Positioning Information System (LiPS), including the digital event map and the LiPS GPS-trackers developed by FIT, received a great acceptance among all stakeholder-groups involved in the PM 2018 and

2019 events. One of the most promising features of this system turned out to be the independence of a working, wideband internet connection during such events as this was a major issue on many events priorly conducted. Further cooperation between the city of Bonn and FIT including continued development and application of LiPS beyond the end of the MONICA project is planned.

Although some valuable insights for fine-tuning video analytics algorithm and different camera position were gained, for a venue like Pützchens Markt the gate counting technology is not entirely adequate. One reason for this might be that the event takes place in a residential area which means that the event area will never be entirely empty thus influencing the visitor count. Secondly, as the event area can be accessed by many different entrances, all of them would have to be surveyed in order to obtain accurate numbers.

Regarding the crowd density measurement the average error rate was calculated at 4,36 analysing 160 random samples. Although this rate seems to be fairly accurate a maximum deviation of almost 40 % was observed. To get more reliable measurements further research to improve the counting algorithm and the camera positions has to be conducted.

7.2 DOM Hamburg

7.2.1 Introduction

The Hamburger DOM is Northern Germany's biggest funfair with 7-10 million annual visitors during the 91 DOM days.[10] In the 1930s, the original wintertime market was expanded with a spring market in an effort to help local merchants through the economic crisis. After the end of World War II, a summer market was added as well. With its three recurring festivals in spring, summer, and winter the DOM is today the longest running fair all over Germany. The funfair takes place in the premises of the Heiligengeistfeld with a total of around 251 attractions.[11] A detailed description of the event can be found in D8.1.

Table 24: Selected Use Cases for this Pilot

ID	Use Case Group	Tested in 2018	Tested in 2019
UCG 3	Crowd & Capacity Monitoring	X	X
UCG 5	Locate Staff	X	X
UCG 7	Security and Health Incidents	X	X

The use cases addressed have been identified throughout the first year of the project in close exchange with the required stakeholders (event organiser, police, and security staff). The technical and scientific partners in Hamburg (Hochschule für Angewandte Wissenschaften Hamburg (HAW), Landesbetrieb Geoinformation und Vermessung (LGV)) together with the technical partners of MONICA and the project's management board developed and suggested devices and systems to address the use cases. All deployments were discussed with regard to MONICA's ethical and data protection guidelines. They were also presented to Hamburg's data protection officer. During the event and the deployment launch, the event organiser was always on site in order to test and observe the deployments. The police, first aid and security service on the DOM had been informed previously. The technical partners involved (HAW, KU, VCA, LINKS, TIM and CNET) were partly located in an office at the HAW and others joined remotely, e.g. via audio/video calls. They were in constant exchange with LGV, the Senate Chancellery and the event organiser of the Hamburger DOM. This way, an open and regular communication was guaranteed.

Table 25: Number of Deployed IoT Devices

IoT Device Type	Number of deployed devices 2018	Number of deployed devices in spring 2019	Number of deployed devices in winter 2019
Cameras	2	1	1
RIOT - LoRaWAN GPS Tracker	6	3	5
Environmental sensors	4	2	4

[10]2017 Edition: March 24 - April 23 2017, July 28 - August 27 2017, November 3 - December 3 2017
2018 Edition: March 23 – April 22 2018; 27 July - 26 August 2018, November 9 - December 9 2018
2019 Edition: March 22 – April 22 2019; 26 July - 25 August 2019, November 8 - December 8 2019
[11]http://www.hamburg.de/dom/

7.2.2 Crowd and capacity monitoring

Specialized cameras were installed at the fair ground during the Winter DOM demonstration in 2018, Spring DOM demonstration in 2019 and the Winter DOM demonstration in 2019. These cameras were used to count the number of people and measure the crowd density in the observed areas (see Figure 99: Map in the COP Dashboard with position of MONICA Crew) to ensure that these numbers did not exceed the allowed capacity. The main technologies used here were the gate counting algorithm (VCAcount) provided by the project partner VCA and the crowd density measurement provided by Kingston University. Both technologies were seamlessly integrated with the MONICA platform to store and publish results for further usage by other MONICA components such as the COP dashboard.

During the Winter DOM in November 2018, two outdoor IP cameras were installed at the entrance of the special event area of the Hamburg DOM funfair. Figure 99 shows a map in the MONICA-COP with the camera positions. This camera spanned the entrance of the special event area on the funfair.

For 2019s editions of the Hamburger DOM in spring (22.03. – 22.04.) and winter (08.11. – 08.12.), the position of the camera was moved from the entrance of the special event area to one of the higher security towers in front of a popular ride. This was necessary as the contractor of the area changed the setup and there was no crossbeam at the entrance gate to safely mount the camera.

However, the new camera position proved to be more suitable to improve the KU algorithm for the detection of the number of visitors. The major advantage was that more people were passing by or standing in the area in front of the popular ride, which was also an intersection of the round course (see Figure 99) and near a main entrance of the DOM.

7.2.3 Staff monitoring and management

To locate staff during the deployment, LoRaWAN GPS Trackers which were adapted and configured by the MONICA partner HAW were used (see Figure 97).

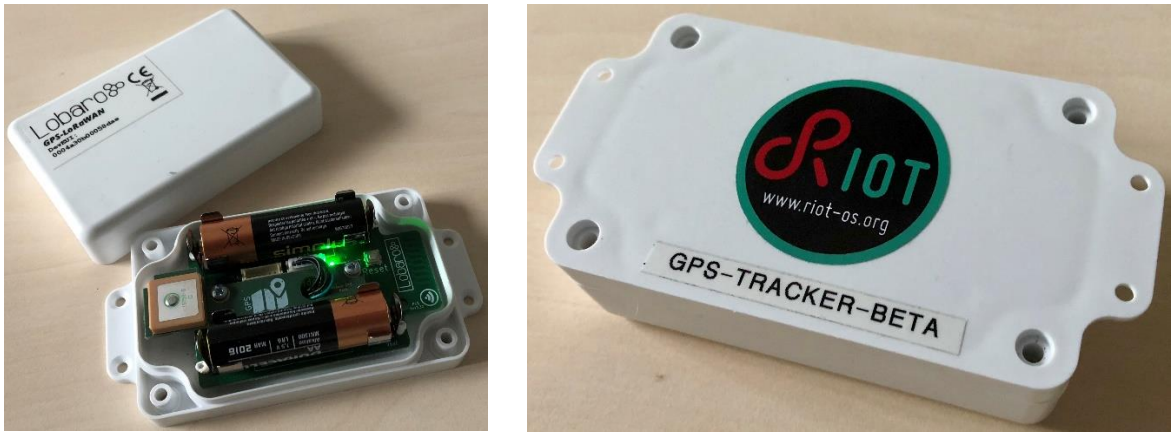

Figure 97: RIOT - LoRaWAN GPS Trackers

Some features of these GPS-trackers are:

- Dimensions (cm): 6x10.
- Is on when the power supply is ensured, the green light signalizes enough power supply.
- To charge the device the case has to be removed and the batteries changed.

The device uses GPS for the localization and LoRaWAN network to transmit the data. Due to sufficient public gateways it was not necessary to set up a LoRaWAN gateway near the DOM. The nearby gateways provided within The Things Network are situated north and west of the DOM as shown in Figure 98. With this network available it was also possible to receive signals away from the event venue as well.

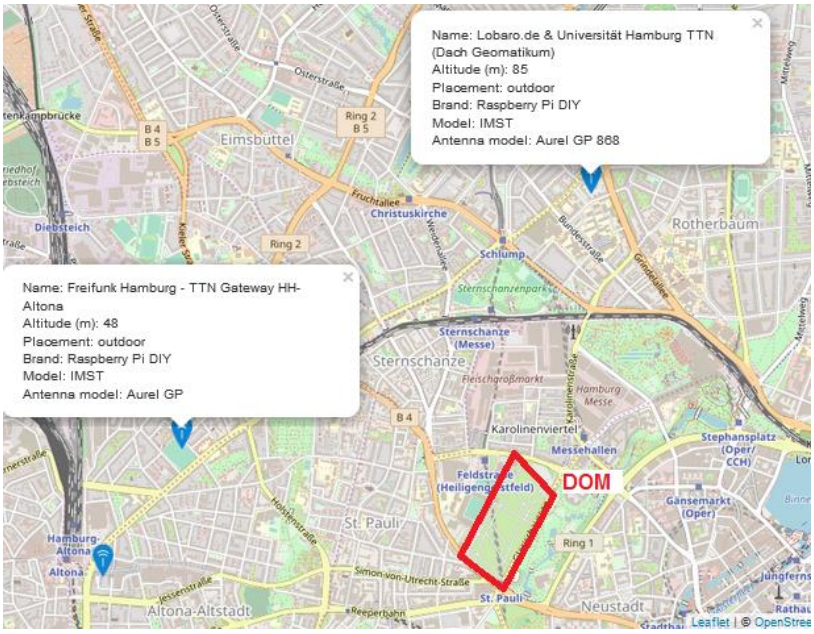

Figure 98: Gateways from the TheThingsNetwork

During the Winter Dom 2018, six GPS-trackers were tested including visualising their positioning data in the digital map of the COP. The use case allowed to locate staff from the event organiser team. The purpose was to support the planning and communication for the staff so that the right action could be taken in the right moment. During the event, three of the six available devices were given to the event organiser to use during the last week of the DOM. The police, paramedics and fire brigade were very hesitant to use this application and they rejected the offer to take part to use the devices to locate their staff.

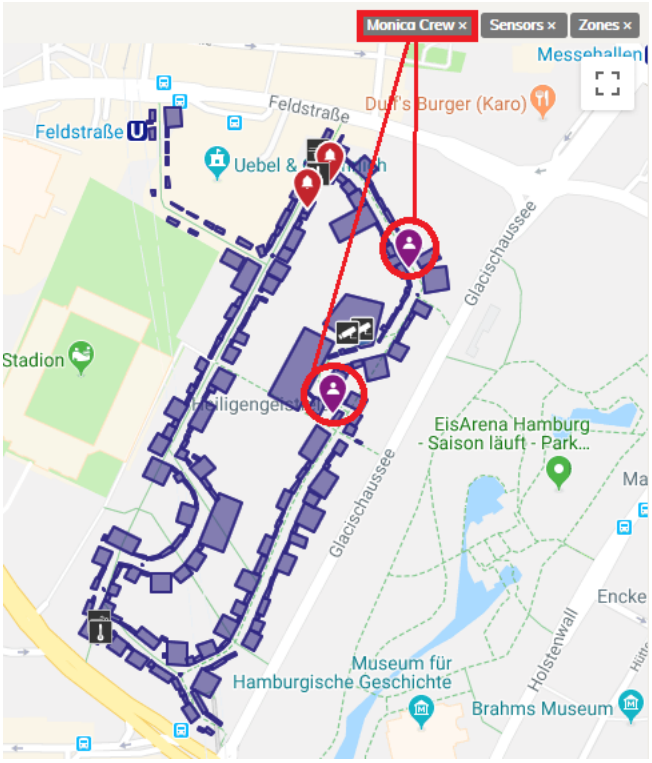

Figure 99: Map in the COP Dashboard with position of MONICA Crew

Figure 99 shows the digital map in the COP with the position of the GPS-trackers. These positions were set for the purpose of demonstrating the visual appearance of the GPS-trackers in the COP. HAW came up with the GPS-trackers due to several reasons. First, even though the event organiser has planned to install permanent Wi-Fi throughout the project, no progress has been made so far. Intending to use Dexels wristbands for tracking, anchor points would have had to be installed every 100 meters, exceeding the financial and logistical limits of the pilot. Thus, a solution had to be found that could use alternative connections, similar to the staff tracking solution developed in Bonn (see Chapers 5.4 and 7.3).

At the 2019 Spring DOM, due to the reluctance of the event staff to use the tracker to support their work, the trackers were tested with the event organiser and the event mascot (DOM bear).

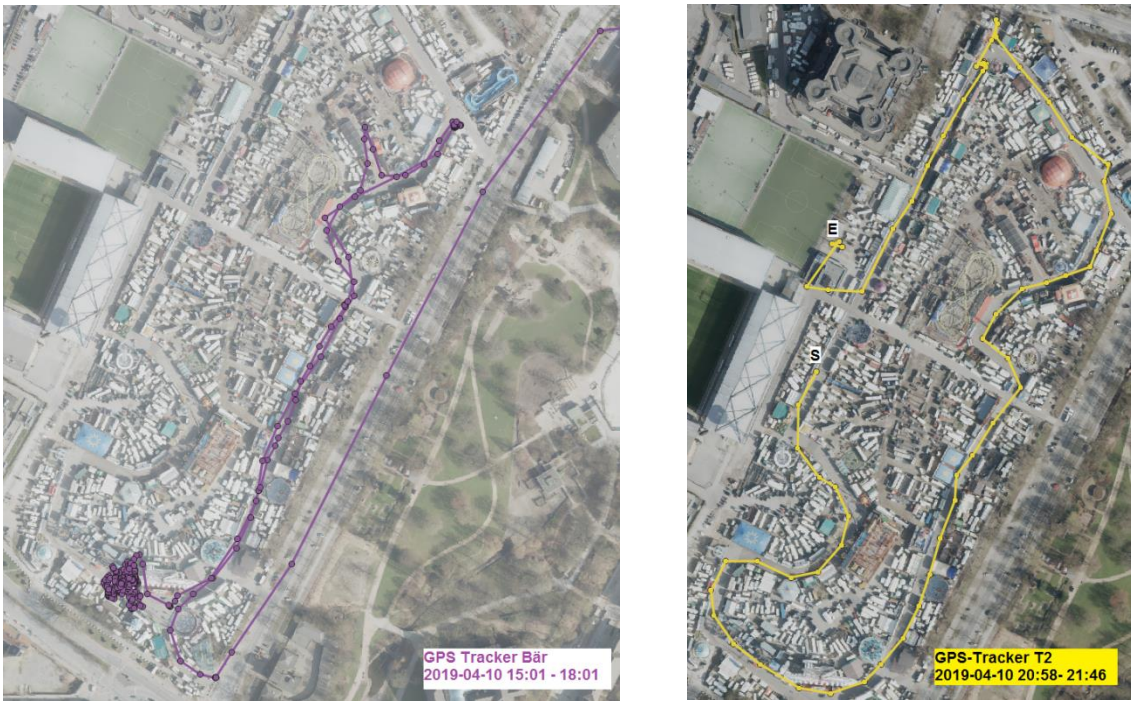

Figure 100: Selected positions of the GPS tracking devices

At the Winter DOM 2019, the GPS tracking devices were again tested by the event mascot (DOM bear), the event organiser and the MONICA team.

7.2.4 Environmental sensors

While tracking health and security incidents, in order to measure the wind speed and to be alarmed in case of high values, wind speed sensors along with two environmental sensors (temperature and air humidity) were deployed at the DOM site.

The visualisations and information displayed in the COP were evaluated before the event in a workshop with the stakeholders. The COP used a colour scale to show the different wind speeds. The rules were taken from the German Meteorological Service as shown in Table 26. According to the values and the according colour definitions the measurement results shown in the COP were coloured. The two gauges can be seen in Figure 103.

Table 26: Wind speed scale

Wind speed (m/s)	Wind speed (Bft)	Color
< 14 m/s	<6	Green
14-18m/s	6-7	Yellow
18-29 (24) m/s	8-9	Orange
29-32m/s	10-11	Red
> 32 m/s	>11	Dark red
Wind speed (m/s)	Wind speed (Bft)	Color

Some stalls have to take specific measures when a wind speed is reached to ensure the safety of the visitors. A list of 20 stalls and their wind speed limit and the actions to be taken was provided by the event organiser.

During Winter DOM 2018, wind speed sensors along with two environmental sensors were deployed at the DOM site. The sensors were put on 7m - 7,5m high poles which can be seen in Figure 101. They were positioned as seen in Figure 102 at the northern and southern parts of the DOM

Figure 101: Deployment of environmental sensors with wind speed meters

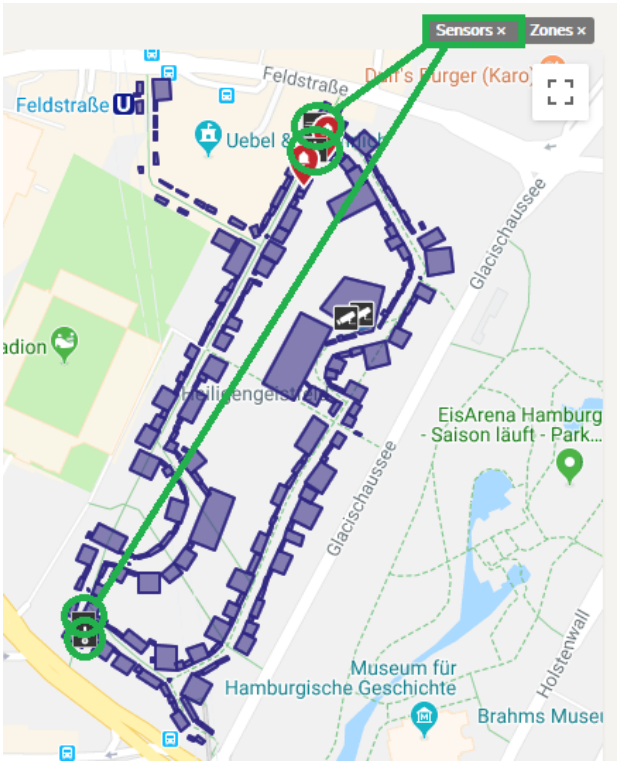

Figure 102: Location of environmental sensors at the site

Due to the manner of integration of the wind speed data, not all the stalls could be monitored but for two stalls security incidents were given if the wind's speed was higher than their limit. In Figure 102, there are four security incidents shown.

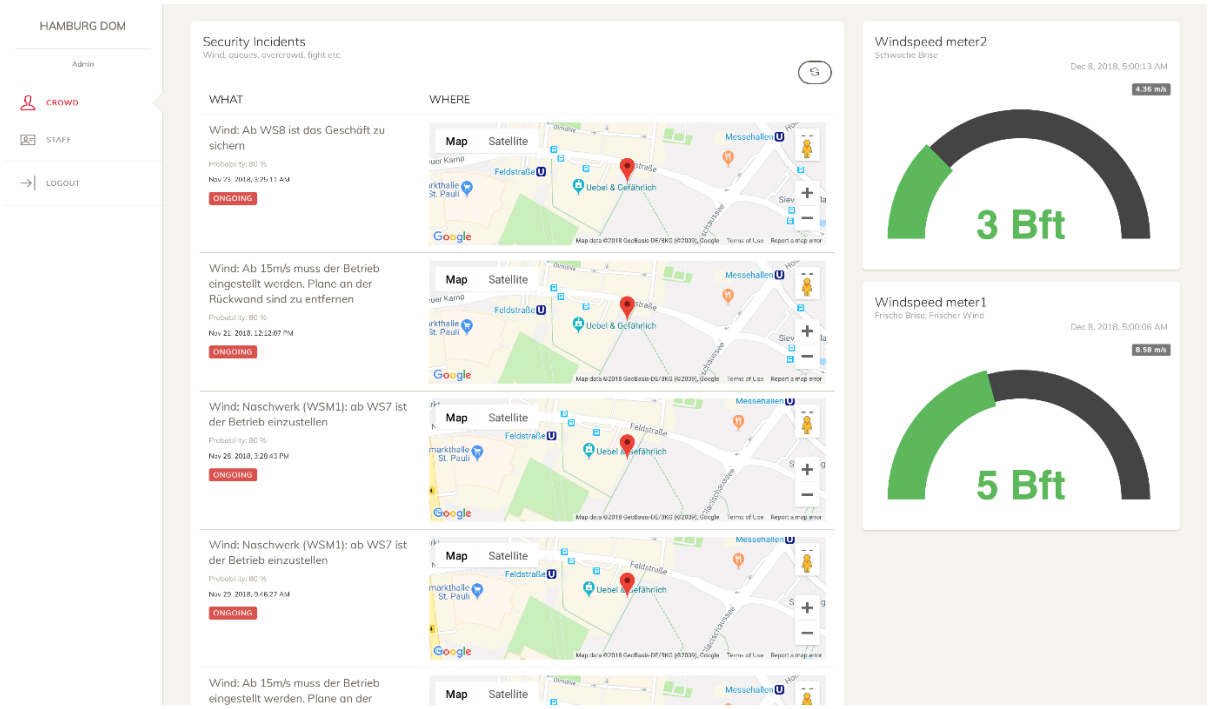

Figure 103: COP visualisation of wind speeds and security incidents

During the spring DOM 2019, there were two environmental sensors implemented to detect hazardous weather conditions at the festival site. Using the COP, the event organiser was able to see the real time wind speed and temperature. Moreover, alerts were visualized in a separate alerts tab.

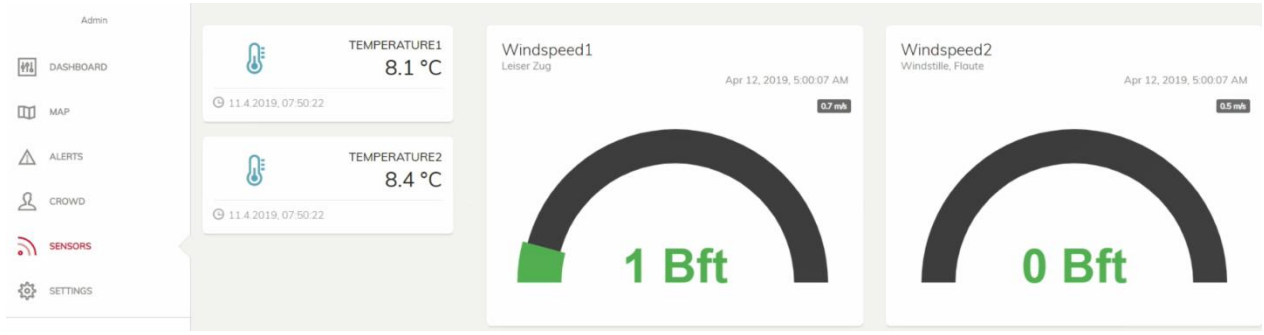

Figure 104: COP Visualisation of sensor data (wind speed and temperature)

For the winter DOM 2019, new features were implemented in the user interface of the COP following the findings from the previous events. These new features allowed the event organiser to have a summarized overview about all the activities regarding safety incidents, weather conditions and visitor count on the fairground in one dashboard and to have a spatial overview about the weather activities in a map.

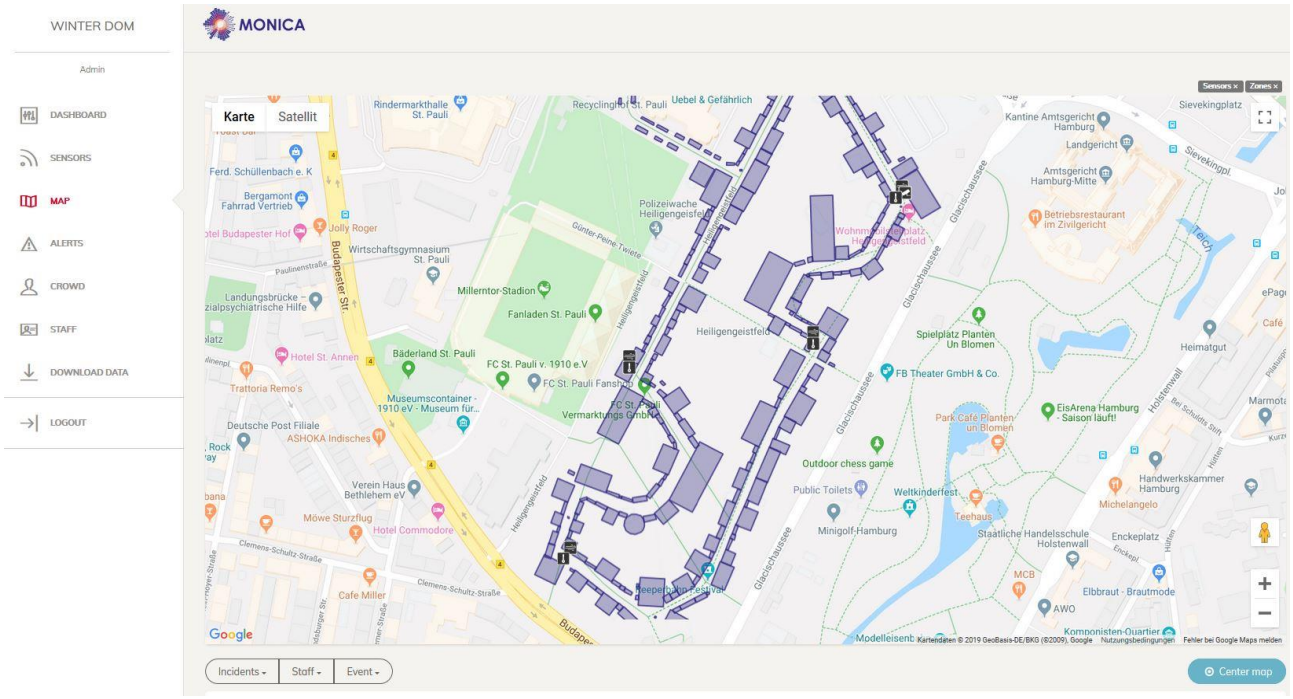

Figure 105: Winter DOM 2019 COP map with implemented temperature and wind speed sensors

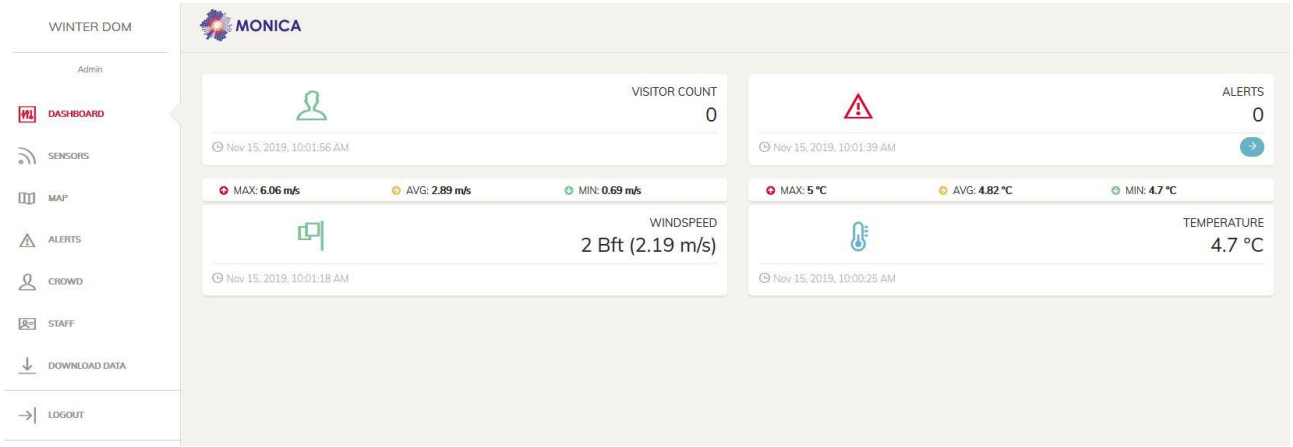

Figure 106: Winter DOM 2019 COP dashboard with safety incidents, current average wind speed and temperature

Moreover, there were additional historical functions implemented, which allow the event organiser to not only monitor the current situation on the fairground but also the weather conditions of the preceding hours. This supported the decision-making process to push the appropriate measures for the current situation, e.g. if the wind is gusty or stormy.

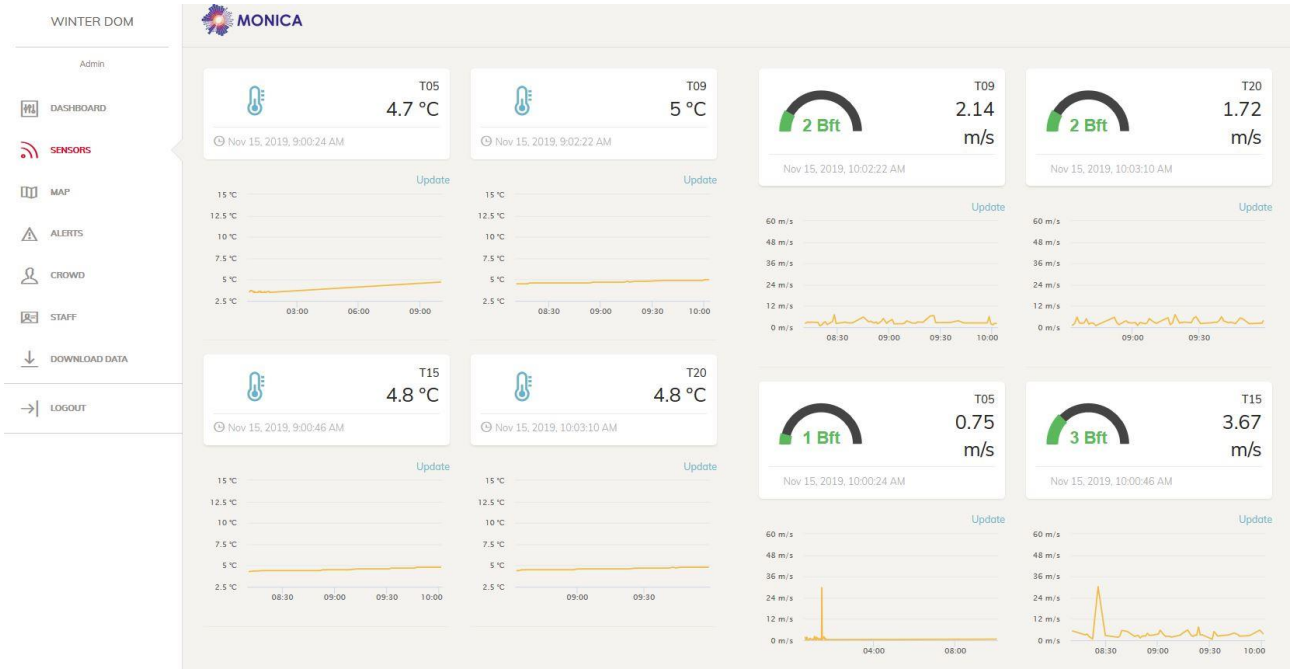

Figure 107: Winter DOM 2019 COP sensor portal at the MONICA COP for wind speed (real time, historical data) and temperature (real time, historical data)

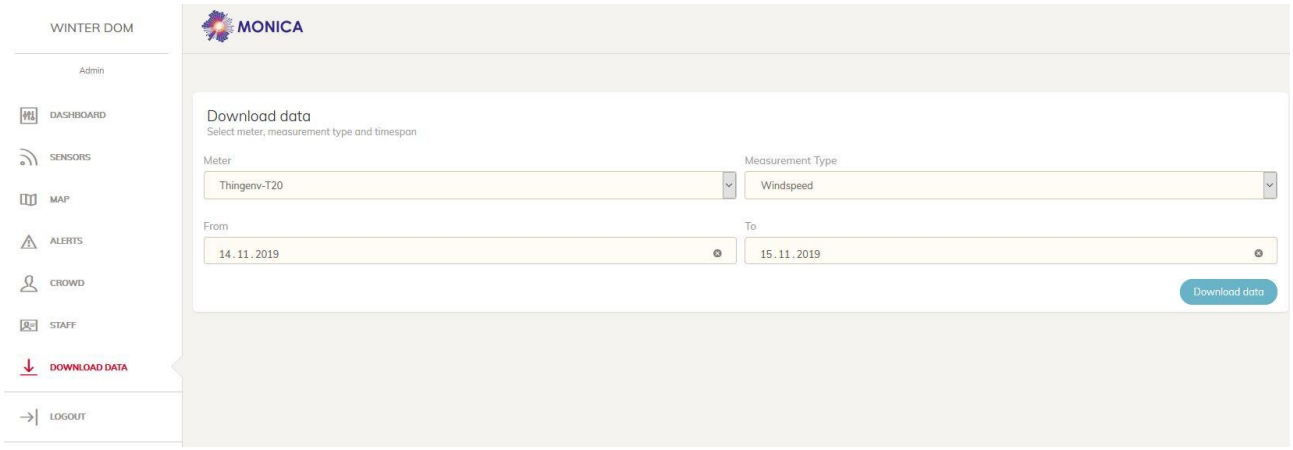

Figure 108: Screenshot showing the COP with data download function

A new feature was the data download service which enabled the event organiser to download sensor data for a predefined period of time for each stall and sensor. Therefore, in case of any weather related incidents or accidents, the data accessibility was enhanced tremendously.

7.2.5 Lessons learned

Three field tests on MONICA technologies at Hamburger DOM have been completed. While the overall planning and organisation prior to the deployment was smooth and transparent, and the launch of the deployment successful, some technical issues arose during the first event which could not have been foreseen. In the beginning, the main challenge lay in the integration of the data into the cloud and the reliable transfer to the COP. This could be solved and an automated work flow could be used to quickly and easily update the backend information in 2019.

The environmental sensors (temperature and wind) as well as the GPS trackers did not always transfer valid and comprehensible data. Consequently, wrong values were displayed on the COP and, hence, the event organiser could not always rely on them. It is assumed that these errors occurred due to wrong conversions in the cloud.

During the spring DOM 2019 the temperature sensor caused some erroneous data. For the winter DOM 2019, the posting of new measurements for temperatures and wind speeds was correct and mostly stable.

Furthermore, stakeholders feedback to the COP was overall positive and minor suggestions have been communicated in order to make it more manageable. These changes could be implemented for the winter DOM 2019. Especially, the access to historical data for each sensor, once as visualisation for the preceding hours but also as a separate data download enhancing the user experience.

While the responsible event organiser used a mobile phone during Winter DOM 2018, in 2019, he received an iPad. This clearly enhanced the visualisation and user experience of the COP.

With regard to the GPS trackers, smart wristbands from Dexels could not be used as the deployment was depending on the availability of glass fibre network at the event location.

The implementations at the DOM event were overall successful. The COP was improved step-by-step and adjusted to the requirements of the event organiser. Unfortunately, the usage of trackers at this event is not wanted by the responsible parties. Therefore, there could only be tests regarding the usability and reliability of the trackers for future exploitation.

The cameras for the visitor count were implemented successfully. Because of the comparably low number of visitors there were not any safety incidents because of a non-manageable number of people in a certain area. The gate counting just worked for the events in 2018, in 2019 there was not the necessary infrastructure available at the fair ground.

7.3 Pützchens Markt Bonn

7.3.1 Introduction

Pützchens Markt is a funfair that takes place in Bonn every year during the second week of September. For the duration of five days the event offers a diversity of amusement rides, more than 550 commercial stalls and two stages. This massive offer extends over the length of 4.5 km in an area of 80,000 m^2. Visitors can enjoy the festival for free and are able to access it from six different open entrances. The opening hours vary from midday to midnight or until the early hours of the next morning.

Figure 109: Pützchens Markt venue at sunset

Table 27 indicates the selected Use Cases for Pützchens Markt Pilot. Table 28 lists the deployed IoT Devices.

Table 27: Selected Use Cases for Pützchens Markt Pilot

ID	Use Case Group	Selected for 2018	Selected for 2019
UCG 3	Crowd & Capacity Monitoring	X	X
UCG 5	Locate Staff	X	X
UCG 7	Security Incidents	X	X
UCG 8	Health Incidents	X	X
UCG 11	Evacuation		X
UCG 13	Event Information		X

Table 28: Number of deployed IoT Devices during Pützchens Markt in Bonn

IoT Device Type	Number of deployed devices 2018	Number of deployed devices 2019
Cameras	4	5
Visitor App (mobile phones)	-	>1000

LiPS GPS Tracker	15	45

A detailed description of the setup used in 2018 is given in D8.3. The setup for 2019 fun fair event included cameras for crowd and capacity monitoring, the Live Positioning System (LiPS) GPS trackers for staff and security forces and a mobile app for visitors. During the event, the researchers were available in the command center which was also used by the coordinating group for staff and forces in order to allow regular exchange. All staff and forces were given access to the COP Dashboard and supplied with LiPS GPS-trackers. The command center was located in a school building next to the venue. At the beginning of the event a meeting with a live demo of the COP features was held with members of the staff and security forces.

For the second deployment in 2019 the use cases from 2018 were further explored using the knowledge gained during the first deployment. Additionally, MONICA partner CERTH did a demo of an evacuation simulation and visitors were provided with a mobile app which was published in the AppStore and Playstore respectively. During the event in 2019, user interviews were performed with stakeholders from the police, medical response teams and the fire brigade.

7.3.2 Crowd and capacity monitoring

Within the MONICA platform, the company VCA provided its crowd counting technology using the product VCACount. This product has been integrated into the MONICA platform during the MONICA project.

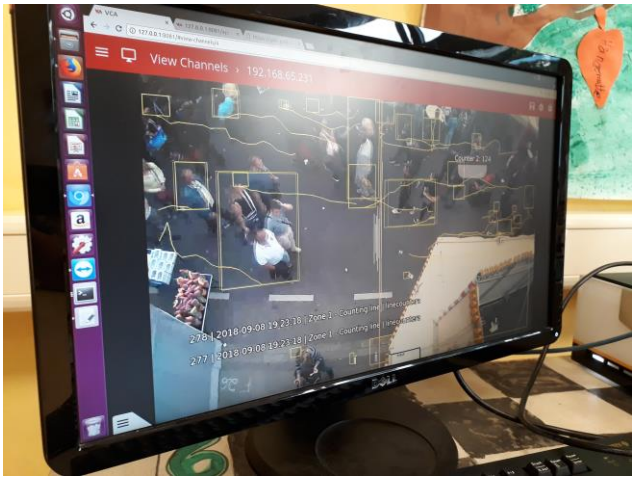

Figure 110: Camera position in 2018

Figure 111: Camera position in 2019

After a first successful deployment of the cameras in 2018, the gained insights were used in order to further improve the quality of the algorithms and the camera calibrations for 2019. In 2018 the first year of Pützchens Markt demonstration, two cameras were installed for visitor counting. This worked quite well, but an evaluation revealed that a vertical calibration of the cameras would improve the accuracy of the algorithm. In 2019, three cameras were installed for visitor counting and calibrated to a completely vertical position (see Figure 110 and Figure 111). As expected this led to much better results.

The crowd density measurement technology was provided by Kingston University. The corresponding software module was seamlessly integrated into the MONICA platform. For the crowd density measurement in both years two cameras were installed at key points of the event area. In 2018, one camera was installed overseeing one of the main access roads and one overseeing the area in front of the 'Bayern' tent. In 2019 the first camera was placed overseeing the area next to the ferris wheel whilst the second camera location remained unchanged. When the visitors in this area exceeded a previously configured limit the area was highlighted in red.

Figure 112: Camera view in front of the ferris wheel (left) and the Bayern tent (right) in 2019

The crowd density measuring technology was evaluated in 2018, comparing the numbers to manually counted results. Here the results showed a significant difference. For 2019 the goal was set to optimize the algorithm to produce a result with a maximum difference of 10% between the estimation and the manual count. Considering the random sample images of Pützchens Markt 2019, a mean absolute error (MAE) of 4.356 is observed. In the graph of predicted vs. actual numbers (see Figure 113), blue line indicates that the algorithm tends to underestimate the number of people in the frame. This largely occurs when there is crowd in the frame and distant from the camera point of view. For thinner crowd, the difference between the predicted and actual number is relatively low.

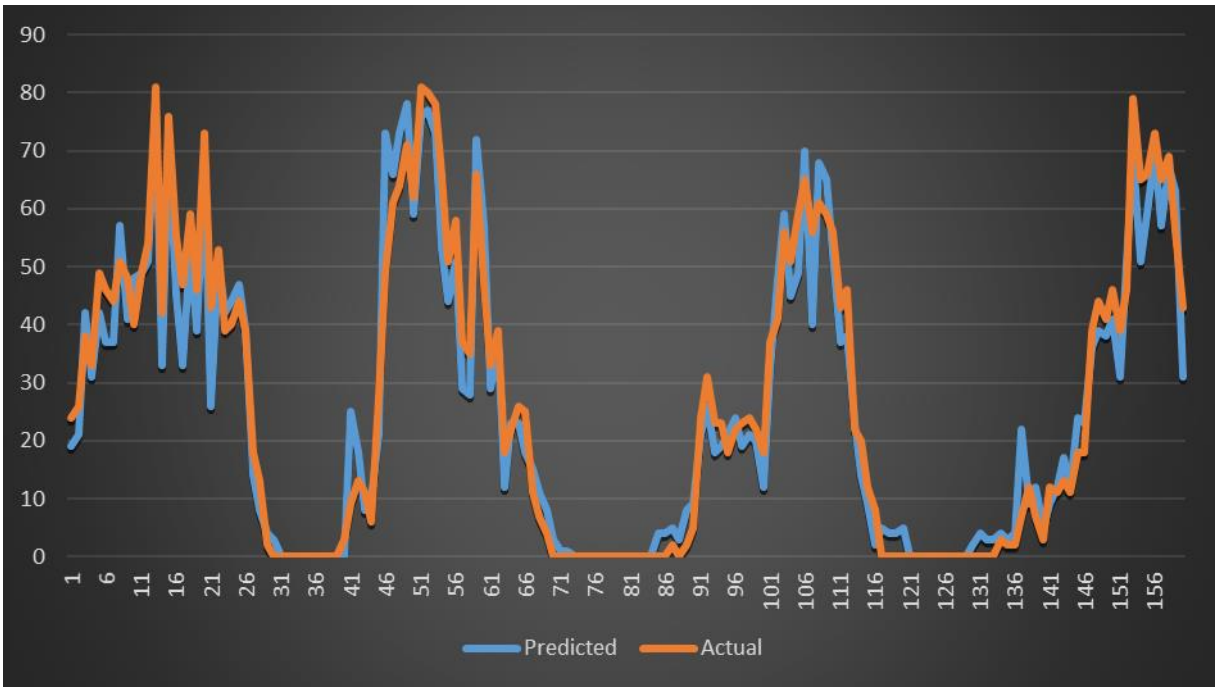

Figure 113: Predicted and actual count of people in random frames during PM2019

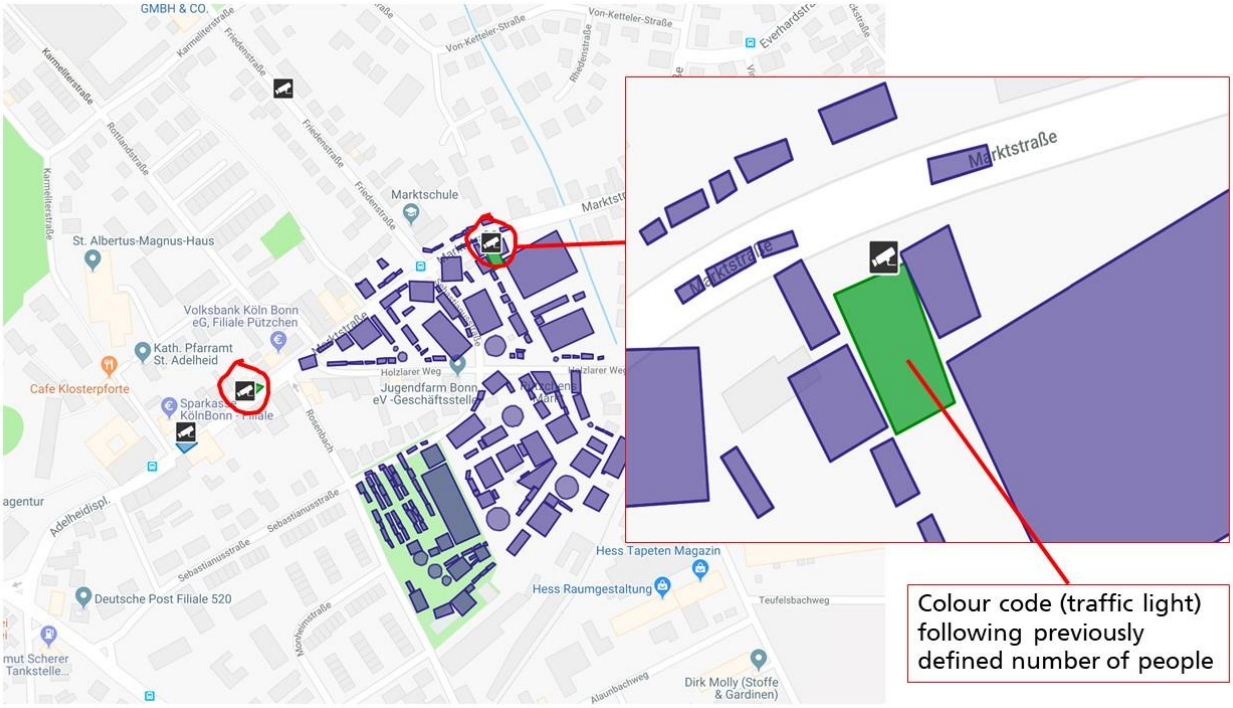

Figure 114: Crowd density displayed in the MONICA COP

7.3.3 Staff monitoring and management

The real-time localisation of staff serves the overall objective of improving the overview in the command centre of all staff and emergency services current positions. Therefore, the staff members' positions out in the field always have to be displayed on the digital map. The purpose is to improve response times and planning in action during the event. The operations management is enabled to oversee the current positions of their forces and can act according to the situation in real time.

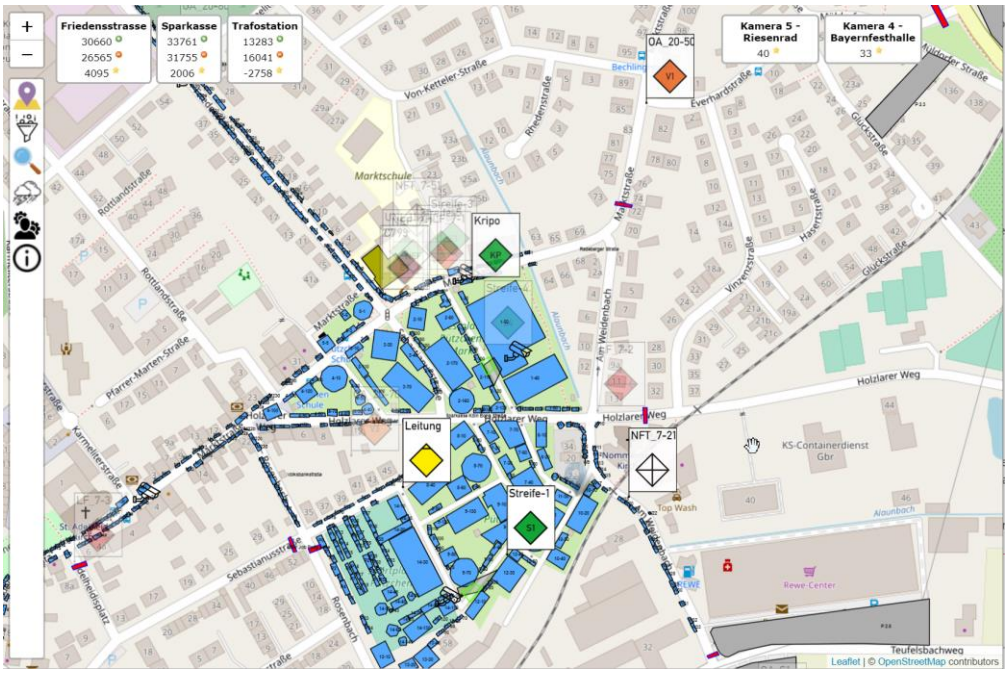

Figure 115: LiPS Digital location map displaying the location of staff

During the first year of Pützchens Markt, the localisation was run inside the COP dashboard deployed in the MONICA cloud. However, this first deployment revealed that a stable internet connection could not always be relied upon. For this reason, for the second year a digital location map (Live Positioning System, LiPS) was deployed independent from the MONICA cloud. Additionally, an 'online' version of this map was deployed on a secure server. The location of the forces was implemented via LiPS GPS trackers using the LoRa technology for the transmission. As a gateway, a Raspberry Pi with a LoRa extension was used. In Pützchens Markt 2018, fifteen LiPS tracker prototypes were distributed to public order, fire brigade, police, first aid, security. In 2019, 45 devices were handed out to the same user groups. The transmission worked very well in both years.

Following the feedback from 2018 that the first LiPS prototypes were too big, the devices were decreased in size for 2019. Also, an emergency button in order to call for backup was desired in 2018 and implemented in 2019 (see Figure 116).

Figure 116: First (top) and second generation of LiPS trackers (bottom)

7.3.4 Automatic fight detection

In 2019, a fight detection algorithm developed by CERTH was deployed and tested. The fight detection algorithm analyses video material and gives a percentage as for the possibility of a detected fight. It was configured to trigger a warning when a percentage of 60% or more appeared. For the fight detection, the camera at the Bayern tent was used since according to the police this is an area where most of the fights occur. A manual evaluation of the video material showed that all fights detected turned out to be false positives. Therefore a need for further calibration of the algorithm could be identified.

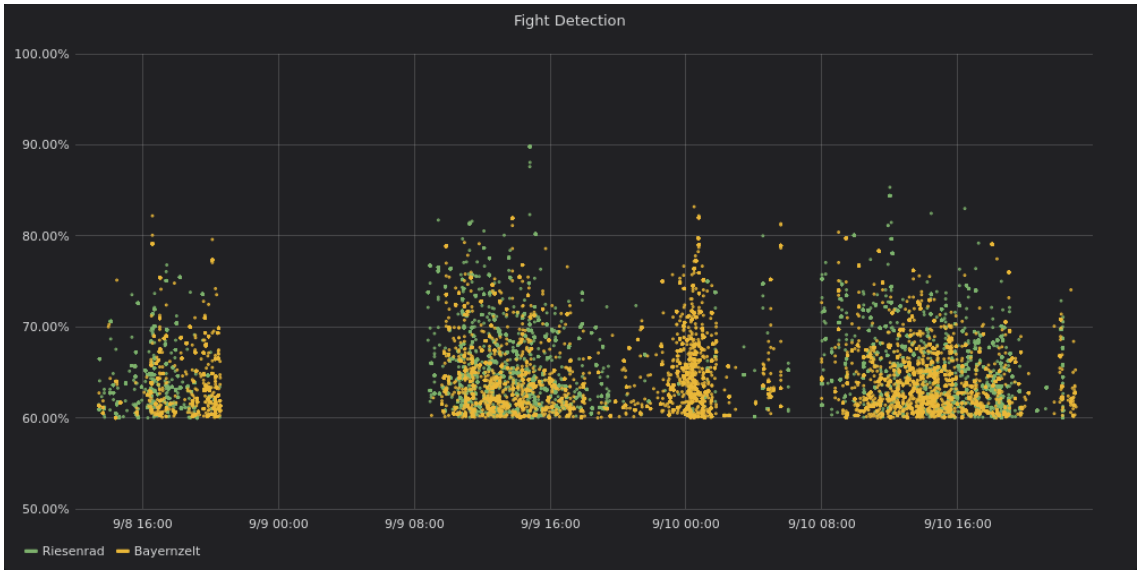

Figure 117: Results of the fight detection algorithm

7.3.5 Mobile event app

For the event a visitor mobile app was developed by CNET. This app targeted the visitors of the event and contained event information such as highlights, information about particular rides and attractions, event history, security information, weather information, information on public transportation and a map of the venue. It was made available via the AppStore and the Google Playstore and advertised on posters with a QR-Code (see Figure 118). After the event more than 1000 users had downloaded the application.

Figure 118: Poster advertising the visitor app

7.3.6 Lessons learned

- The real-time localization of staff was very well received by all stakeholder-groups involved, some of them even expressing an interest in further use of the tool. One of the most promising features turned out to be the ability to function without the need of an internet connection, this being a mayor issue on a lot of events.
- The first version of the LiPS GPS-trackers developed for the project was perceived as too big and heavy. Based on this findings we created a second and improved version which was tested during the 2019 event and was very well received by staff and forces.
- The gate counting technology proved to be not entirely adequate for a venue like Pützchens Markt. On one side the event takes place in an area where people live, so there is no time, when the area will be entirely empty thus influencing the visitor count. On the other hand, the venue has multiple entrance points which all would have to be surveyed in order to obtain accurate visitor numbers.

8 Other activities

For the demonstration at Pützchens Markt 2018 the Blimp airship was taken into consideration for the gathering of video and image material for the crowd and capacity monitoring and a first test was performed. However these tests revealed that unstable weather conditions and the layout of the event location were not ideal for the use of this device. The event location is within a narrow neighborhood with many private houses and closed courtyards were it is not possible to collect data with a birds-eye-view due to privacy concerns. The weather during the test was very windy and the blimp was unable to be kept in a straight position, in order to collect useful video data.

8.1 Blimp deployment test

This chapter reports on the DigiSky blimp deployment tests which have been performed on the 9th and the 16th of December 2019 at Turin Aeritalia airport. This deployment test was planned in Aeritalia airport due to the impossibility of deployment of the blimp during the 2019 Pilot events. ATOS, HAW, LINKS partners were involved in this test for the server configuration.

For safety reasons during the first test the blimp was not deployed as wind was 5 to 10 knots. The following test points have been tested with blimp anchored indoor. The second test did not require particular preparations aside for what has already been prepared for the first test as the payload bay was ready and the balloon already inflated.

Both tests addressed to test the points listed below:

- Blimp deployment to 30 m AGL (above ground level)
- Air to Ground Full HD video streaming
- On ground streamed video recording
- 4K camera 3-axes movement control
- 4K camera zoom and focus control
- 4K camera full handling with one controller
- Meteorological data upload to SCRAL
- Blimp emergency fast recovery

The following 12 mandatory requirements were defined beforehand:

- Maximum flight altitude: 38m AGL
- Minimum ballast number: 2
- Minimum ballast weight: 20 kg each
- Minimum operative team: 3 people
- All operators shall wear appropriate PPE
- Blimp shall be anchored with a minimum of 2 cables of the same material
- Blimp shall be recovered in 45 sec. maximum
- Operations Executive shall be in radio contact with airport control tower
- All operations shall be described in the operative manual
- Emergency procedures shall be described in the operative manual
- Flight permission shall be issued by ENAC
- Wind shall be less than 5 knots

Both tests were intended to take place in the area of Turin Aeritalia airport where DigiSky is based, highlighted in red in Figure 119. Referring to Figure 120, the blimp was supposed to be inflated and loaded with the payload indoor (Hangar), to be transferred to the apron and deployed in the glider's area. After DigiSky formal request,

the use of such area was approved by ENAC (Italian Civil Aviation Authority), the control tower was notified of the activity and a NOTAM (NOtice To AirMan) was issued accordingly.

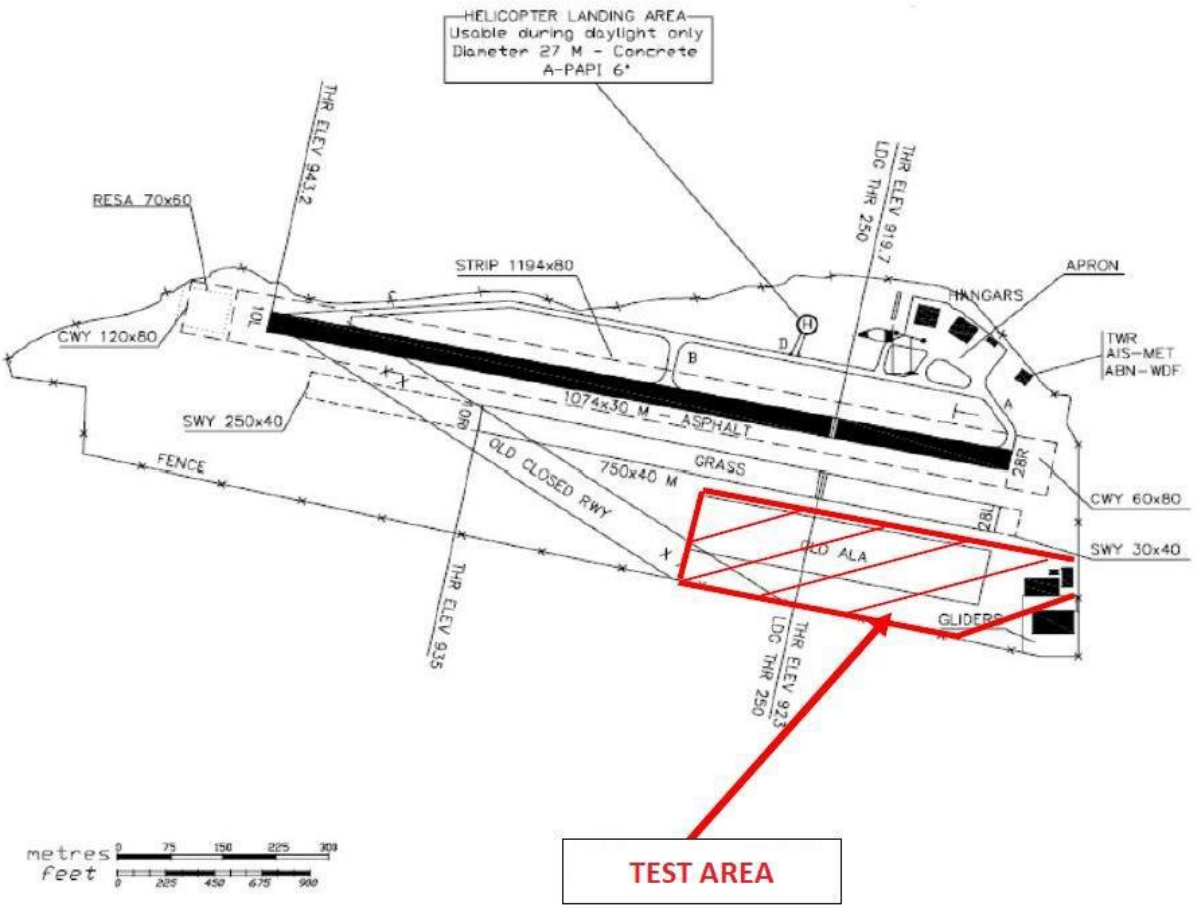

Figure 119: Turin Aeritalia aiport map, test area is highlighted in red

Figure 120: Test area detail

The test area was composed by an Air segment and a Ground segment. The Air segment contained a payload bay carried by the blimb. It is composed of: Meteorological sensors board, transmitters, batteries, a power bank and a gimbal supporting a Blackmagic Micro Studio Camera equipped with 14-42 mm lens. As shown in the pictures, all these devises are protected by a PLA 3D printed case. Both camera and gimbal were controlled by a single radio controller (see Figure 121 and Figure 122).

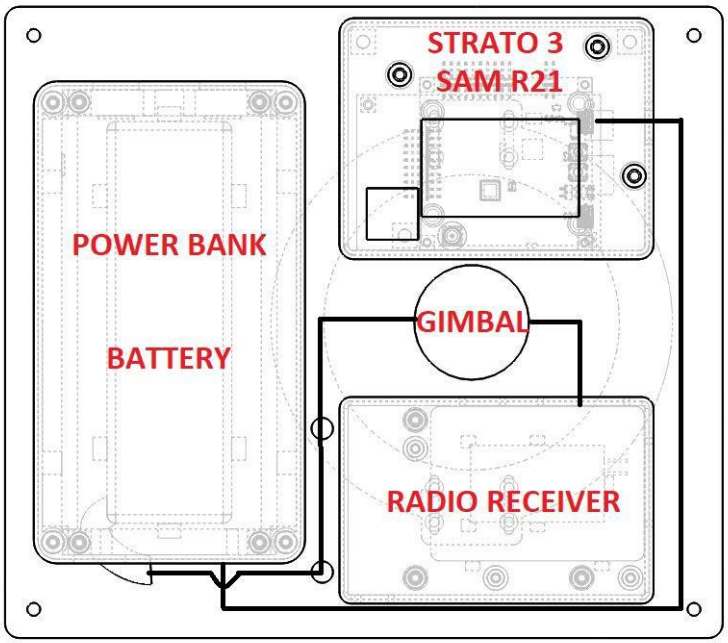

Figure 121: Payload board layout

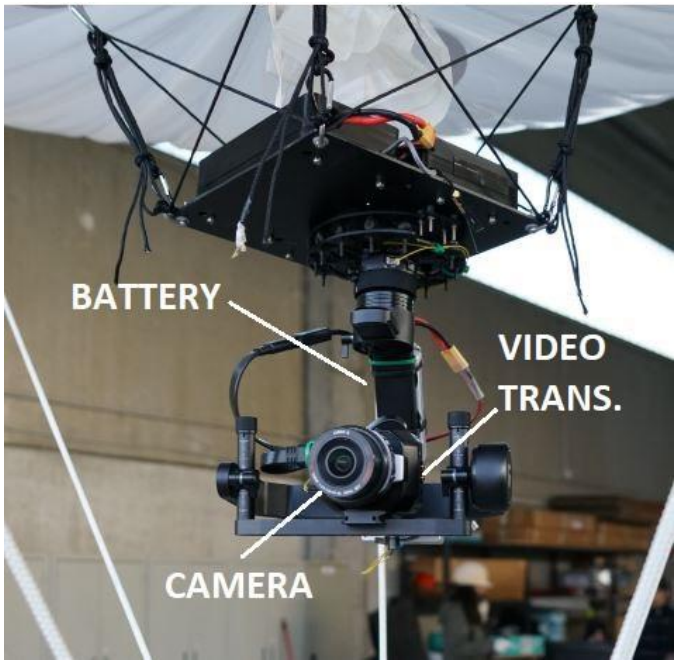

Figure 122: Gimbal detail

The Ground segment was composed of a Raspberry Pi 3 connected to the Atmel SAM R21 which streams to the SCRAL meteorological data through internet connection provided by a mobile hotspot, the Radio controller to handle gimbal and camera, a full-HD video receiver, Video screen, a mobile phone used as Mobile Hotspot and a Laptop. A laptop was used to connect to the Raspberry through Wi-Fi to monitor its status (see Figure 123)

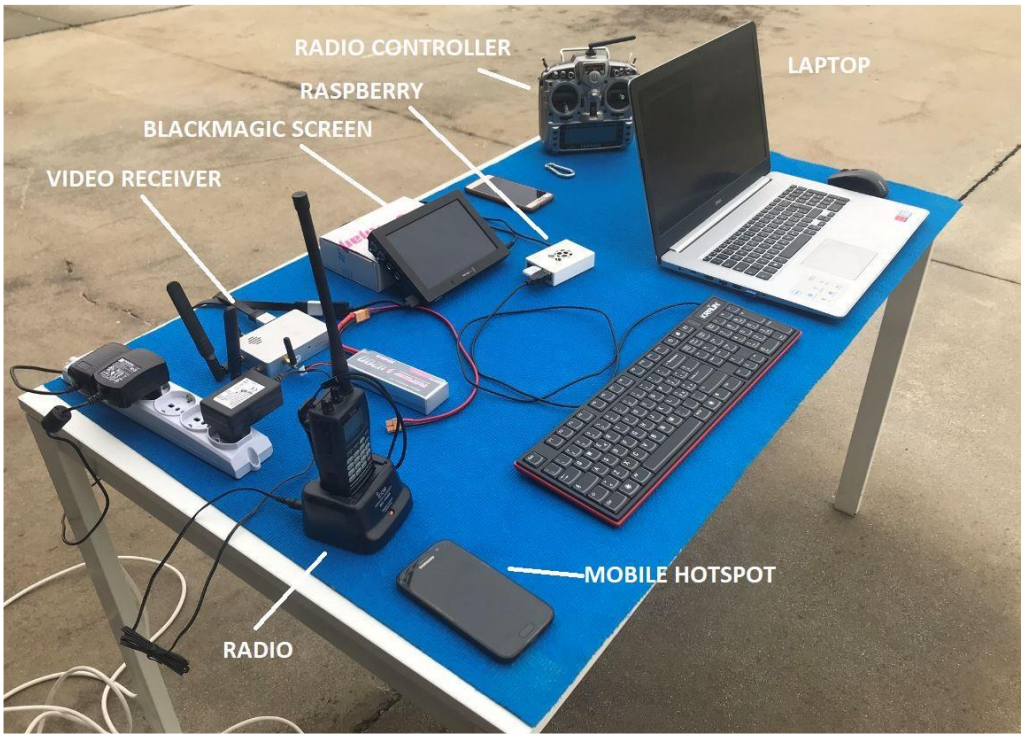

Figure 123: Ground station organization

Besides the full deployment in air of the blimp, which was tried again on December 16th according to weather conditions, the first test was considered successful.

The meteorological payload transmission which failed the previous tests at KFF19 and Woodstower pilots, was flowless as well as the never tested before camera and gimbal control with the same radio controller and long-range HD video streaming. Zoom power could be significantly improved with a higher focal length lens. Using such kind of high focal length lens, the interference of the ropes in the video would be almost negligible.

Having a constant view from above is very helpful for security purposes on large scale events where precise and punctual meteorological data are useful for sound mapping and control. The blimp solution can meet those requirements, however, there are severe restrictions imposed mainly by weather conditions.

The system can be replicated in different kinds of outdoor events, the main issues to be promptly addressed while planning the participation to an event are:

- Helium availability. For large helium quantities, is necessary to contact a supplier in advance to make sure the gas availability.

- National airworthiness requirements meeting. Depending on the Country, regulations may vary in terms of technical requirements, documentation needed and permit to fly process request.

The second test demonstrated successfully that the deployment and retraction of the blimp is an easy operation if conducted by 4 to 5 people. Once deployed in air and ballasts set, no person is necessary to operate the balloon, 3 people shall however remain close to the system for continuous monitoring and gimbal operation.

The meteorological payload transmission as well as the camera and gimbal control with the same radio controller and long-range HD video streaming were working.

9 Conclusion

The MONICA project followed an iterative prototyping approach and successfully demonstrated the deployment of large amount of IoT devices to improve security, sound and user experience at large-scale outdoor cultural events.

The Sports Events demonstrations in Emerald Headingley Stadium in Leeds showed that applied IoT technologies (Camera, staff wristband and smart glasses) have a clear potential to improve real time communication between on-site staff and their command center. An IoT connected Visitor App improved visitor experience during the Leeds Varsity Event.

All demonstrations during gated events had a strong focus on sound monitoring and control as well as crowd and capacity monitoring. The deployment at Nuits Sonores in Lyon focussed on the integration of the IoT Sound Level Meters for sound monitoring. The demonstration during Kappa FuturFestival in July 2018 introduced the Sound Field Control System (SFCS) for the first time during a live event. The Fredagsrock concert at Tivoli Copenhagen in August 2018 was the second time the SFCS was deployed at a real event. At the same event in Tivoli the first real-world test of the Quiet Zone, a booth that reduces the noise level in a smaller area, was successfully demonstrated at.

In 2019 the Adaptive Sound Field Control system as an advanced sound control solution was introduced during Kappa FuturFestival in July. As sound level reduction results during this event and the demonstration in Tivoli in August 2018 fell short behind expectations, due to a lack of time for performing premeasurements and the complexity of the venues surface and structures, a previously scheduled second demonstration in Tivoli in September 2019 was aborted. Instead a replicator event was organised at Roskilde Sound Summit in November 2019. During this event the following main Lesson Learned from the previous MONICA demonstrations and reference deployments were applied:

- The AFSC system works best in open terrain with a simple geometry.
- A dedicated 4-hours timeslot without interruptions was provided for thorough and complete testing of the ASFC system prior to the event.
- The ASFC system was calibrated prior to the event to establish references values.

It is still important to keep in mind, that weather conditions may impact measurements. For instance, the wind might propagate noise very far from a venue. The reference values will help to discriminate against other sound sources during the event, calculate the weather effect, set up the sound system according to the local regulations and prepare the tuning of the ASFC system. However the excellent conditions during the demonstration at Sound 2019 led to the promising result of an average total reduction of 11dB.

The crowd management and control focus was mainly addressed during three crowd wristband demonstrations held in 2019. Tivoli demonstration in April 2019 was the first medium-scale crowd wristband deployment. More than 400 wristbands were distributed to visitors and recollected at the end of the event. The platform proved to run stable and the wristband distribution concept went through a first test run. The second medium-scale crowd wristband deployment happened during the IoT Week conference in Aarhus. Again the platform delivered stable data transmission and the integration with IoT week event App was demonstrated successfully. Finally the largest MONICA demonstration in terms of participants involved and IoT wearables connected to the platform happened at Woodstower Festival in Lyon in August 2019. This large-scale demonstration of MONICA crowd wristbands. Here a sound heat map and a crowd heat map were visualized on the COP dashboard for the first time. The demonstration actively involved more than 6200 festival visitors.

Three events categorized as Local City Celebrations were more focussed on the localization of staff, but also deployed sound control and monitoring technologies as well as crowd and capacity monitoring mostly based on video analytics from CCTV cameras. During Rhein in Flammen in May 2018, the MONICA platform was deployed for the very first time. The test proved the functioning of the integrated platform (COP) and the hardware deployment at a live event with many visitors. During Fête des Lumières in December 2018, the first High Level Data Fusion Integration into the COP dashboard was showcased and in December 2019, the last MONICA demonstration, extensive video analytics algorithms have been tested. Although the Lyon use case show extremely high crowd density, algorithms showed a mean absolute error (MAE) of 11.519. During Hamburg Port Anniversary 2018 and 2019 the main focus was the alert function based on environmental sensor data. The COP dashboard was adopted and successfully tested to a small screen (mobile) version, in order to enable staff and event organizers to monitor security risks due to high wind speed in real-time. In general all pilot studies that implemented video analytics, have effectively demonstrated the performance of the crowd estimation algorithms. An estimation accuracy of over 70% was typically achieved. A significant

learning from the pilot studies is the impact of ambient noises in the image such as occlusions in the street, lighting variations, and changing illumination in the images due to weather changes. The crowd estimation algorithms are to be further trained to understand the constant variations in the captured images and subsequently improve the detection accuracy.

The performance of crowd estimation can be significantly improved through continuous re-training of the algorithm with new annotated image datasets. However, annotating new image datasets can be expensive and laborious. Newer methods of computer vision and image engineering need to be incorporated into the existing crowd estimation workflow to further improve the detection accuracy.

During the MOVIDA demonstrations in Torino the MONICA project contributed with a focus on sound and crowd monitoring. The MOVIDA pilot in Torino is one of two pilot sites, next to Tivoli in Copenhagen, where the MONICA platform is installed permanently. The city of Torino orchestrated activities of a large bandwidth, like a data collection approach based on SLM data, a hackathon to evoke citizen engagement as well as an artistic approach.

The Fun Fair events demonstrations in the pilot cities Hamburg (Spring and Winter DOM) and Bonn (Pützchens Markt) mainly concentrated on crowd and capacity monitoring, the localization and communication of staff and security and health Incidents. At Pützchens Markt, in September 2018, the GPS based Live Positioning Information System (LiPS) was first introduced and tested in a real-world environment. A second iteration was developed and tested in 2019. The plug&play solution triggered strong public interest within municipality and political stakeholders in Bonn, North-Rhine-Westphalia and Donauwörth. Fraunhofer is currently establishing a follow up contract with the city of Bonn for the future deployment of the LiPS system at public events in Bonn. The Hamburg DOM demonstrations in 2019 featured a staff tracking IoT technology using the public LoRa WAN network as well. The integration of environmental sensors and the Hamburg Smart City portal with the MONICA platform was successfully demonstrated.

MONICA project was executed by 30 European partners: Research Institutes, Universities, public bodies and private companies. A detailed report and contact details on concerned partners can be found in Deliverable D9.3 Replication Reference Book and Roadmaps for MONICA Market Replication.

10 List of Figures and Tables

10.1 Figures

10.2 Tables