Management Of Networked IoT Wearables – Very Large Scale Demonstration of Cultural Societal Applications

(Grant Agreement No 732350)

D8.2 Consolidated Demonstration Platform Pilot Progress Report 1

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1 Executive Summary

This report describes the 10 MONICA demonstrations that have been carried out in 2018.

The MONICA Project follows 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 cultural events. The project plan foresees two big 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 iterative approach should allow to learn and identify issues and pitfalls on several levels (technical, organizational, regulatory, etc.) before investing in the full large-scale deployments in 2019.

The deliverable presents the 2018 demonstration in chronological order, i.e. Rhein in Flammen, Hamburg Port Anniversary, Nuits Sonores, KappaFutur Festival, Leeds Headingley Stadium, Tivoli, Puetzchens Markt, Movida, Hamburg DOM, and Fete des Lumieres. For each demonstration we describe how the MONICA Platform was employed to implement the pilots' use cases and highlight important results and lessons learned.

Figure 1 visualizes the demonstration progress in 2018 (including pre-tests in 2017), highlighting major milestones:

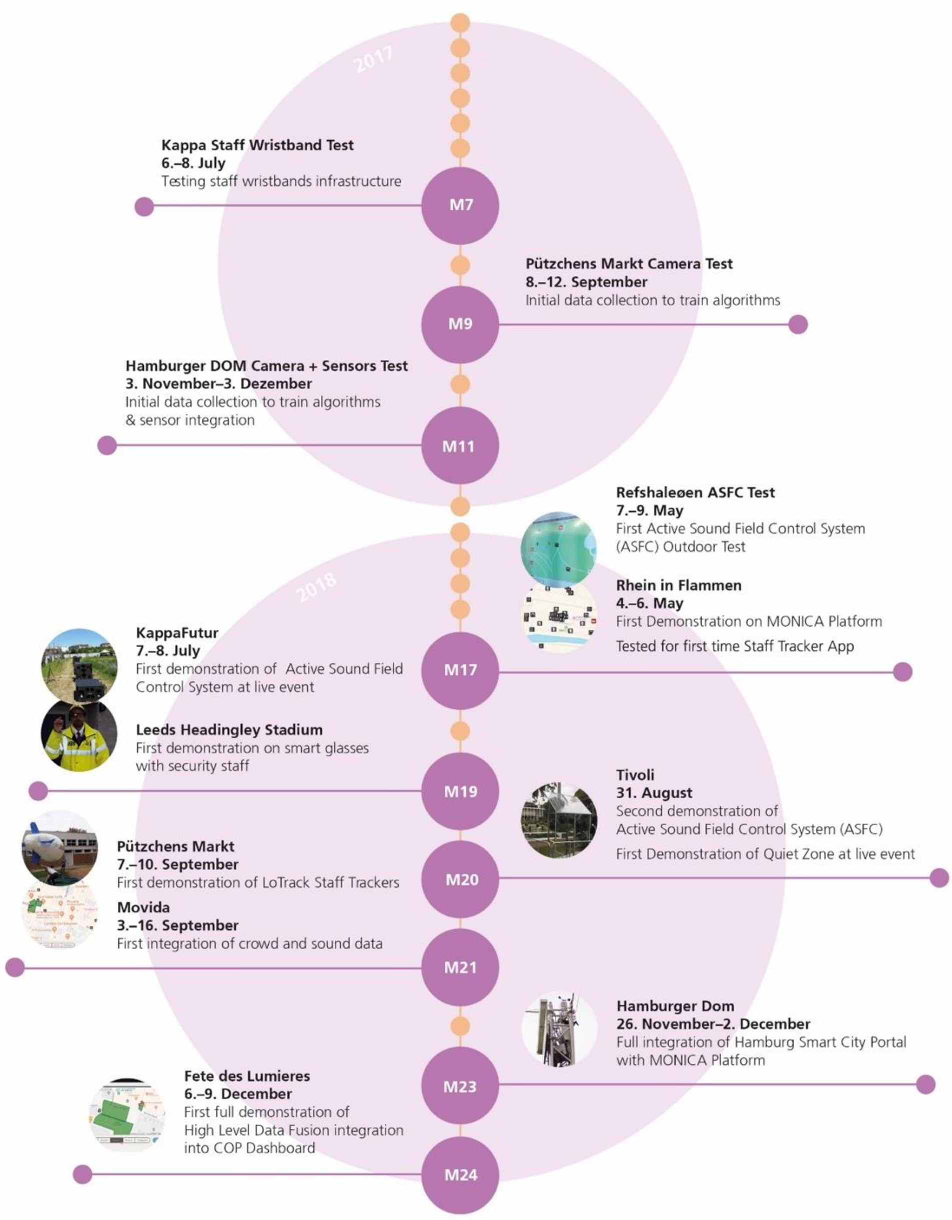


Figure 1 Demonstration Progress

Four pre-tests were carried out before going live with the actual MONICA demonstrations:

The first one happened in July 2017 at KappaFuturFestival Torino to test the staff wristbands integration into the MONICA platform. Twenty wristbands were given to the MONICA crew. They walked around during the active festival in order to test their functionality. A server in a production container gathered location data, as well as signals that were sent out by a press of a button on the wristbands. This first test demonstrated the basic functionalities of the wristbands integrated with the MONICA Platform.

The second pre-test too place at Puetzchens Markt in September 2017. Across the area of the event, four cameras were installed to test integration and collect initial data for training and testing the video analytics algorithms (object detection, crowd size estimation, and crowd flow analysis). This camera test was replicated at 2017 Hamburg DOM.

In May 2018 the first outdoor pre-test in terms of Sound Monitoring and Control was conducted on the peninsula of Refshaleøen. An important step on the way from the controlled lab environment to actual outdoor music events.

The first two official MONICA demonstrations took place at Rhein in Flammen in Bonn and in Nuits Sonores in Lyon in early May 2018. Rhein in Flammen was the first deployment of the MONICA platform, mainly aiming at testing the integrated platform and the hardware deployment at a live event with a large amount of people. The first version of the Common Operational Picture (COP) Dashboard was available on a large touch screen, allowing stakeholder to interact. In Lyon, the focus was on integrating IoT Sound Level Meters for sound monitoring.

In July 2018 it was then time for the first official demonstration of the Adaptive Sound Field Control System at KappaFutur Festival. A reduction of up to 6dB (in the low frequencies) could be achieved in areas outside the festival, while the sound quality inside could be maintained.

In Leeds Headingley Stadium Smart Glasses were introduced as new IoT device to help improviding the communication processes of security staff.

A Friday Rock concert in Tivoli in late August 2018 was second performance of the Adaptive Sound Field Control System and the first real-world test of the Silent Shower, a booth that should reduce the noise level in a smaller area. Though not achieving as good results as in the KappaFutur festival demonstration, a lot could be learned about deploying the technologies under the influence of heavy rain.

At Pützchens Markt, in September 2018, LoRa-based Staff Tracking devices were introduced and demonstrated in combination with cameras and a fully installed Common Operational Picture Dashboard on the event site. Security staff were involved in that test allowing them to track their forces on the digital map and getting live information about crowded areas.

The focus of the two-weeks demonstration at Movida in September was on integration sound monitoring with crowd and capacity monitoring to better understand the behaviour and effect of part-goers in that area. It was also the first fully remote setup of the MONICA visual analytics modules, which helped a lot in terms of efficiency.

During Winter Dom Hamburg, the MONICA platform was fully integrated with Hamburg’s Smart City Portal. For the first time, wind sensors were implemented. If wind velocity passed a certain threshold, the MONICA COP Dashboard displayed dedicated alarms.

In December 2018 at Fête des Lumières, Lyon the high-level data of all MONICA technologies was to fully integrated into the COP Dashboard. At this event, sensors for sound monitoring and cameras for crowd capacity monitoring were installed. Also, staff members’ locations were tracked, based on staff tracker app and smart glasses and (test) security incidents were recorded and submitted to the MONICA cloud.

The knowledge gained from these 10 demonstrations is the basis for efficient and effective deployments in 2019.

2 Introduction

The MONICA project will deploy large-scale pilots in six major cities in Europe, demonstrating an IoT ecosystem that uses innovative wearable and portable IoT sensors and actuators integrated into an interoperable, cloud-based platform capable of offering a multitude of simultaneous, targeted applications.

2.1 Purpose, Context and Scope of the Deliverable

This deliverable provides reports of each of the 10 MONICA demonstrations carried out during 2018.

MONICA demonstrations are driven by use cases which have been elaborated during year 1 (2017) of the project. This report will not go into the detail of the different use cases. Detailed analyses and descriptions of the MONICA use cases can be found in the public deliverable *D2.1 Scenarios and Use Cases for use of IoT Platforms in Event Management 1.0*. The demonstrations are based on the selected use cases and the available MONICA technologies and solutions which are described in more detail in *D8.1 Site Surveys and Pilot Plans for MONICA IoT Platform Pilots 1.0*. Elaborate surveys and descriptions of the different pilot sites can also be found in *D8.1.*

2.2 Content and Structure

The pilot reports are presented in chronological order.

2.3 Acronyms and Abbreviations

For the purposes of this deliverable, the abbreviations and acronyms in Table 1 apply.

Table 1 Acronyms and Abbreviations

Acronym or Abbreviation	Meaning
AE	Application Entity
AIOTI	Alliance for Internet Of Things Innovation
API	Application Programming Interface
ARM	Architecture Reference Model
BLE	Bluetooth Low Energy
BS	Base Station
COP	Common Operational Picture
CRUD	Create, Retrieve, Update, Delete
CSE	Common Services Entity
CSF	Common Services Function
CVE	Common Vulnerabilities and Exposures
DMZ	Data Management Zone
DSS	Decision Support System
EKF	Extended Kalman Filter
GPU	Graphics Processing Unit
GW	Gateway
HLA	High-Level Architecture
HLDF	High-Level Data Fusion
HLDFAD	High-Level Data Fusion Anomaly Detection

Acronym or Abbreviation	Meaning
IAM	Identity and Access Management
IETF	Internet engineering Task Force
IMU	Inertial Measurement Unit
IN	Infrastructure Nodes
IoT	Internet of Things
LL(s)	Lesson(s) Learned
MQTT	Message Queue Telemetry Transport
NSE	Network Service Entity
NWK	Network
OAuth	Open Authorisation
OGC	Open Geospatial Consortium
OSI	Open Systems Infrastructure
REST	Representational State Transfer
RFID	Radio Frequency Identification
RQ	Requirement
RSSI	Received Signal Strength Indicator
SBC	Single-Board Computer
SCRAL	Smart City Resource Adaptation Layer
SFCS	Sound Field Control System
SIEM	Security Information and Event Management
SLM	Sound Level Meter
SSL	Secure Sockets Layer
TDMA	Time Division Multiple Access
TLS	Transport Layer Security
TLV	Type-Length-Value
UC(G)	Use Case (Group)
UDP	User Datagram Protocol
UWB	Ultra-Wide Band
VPN	Virtual Private Network
WP	Work Package
WSN	Wireless Sensor Network

3 Rhein in Flammen

Rhein in Flammen[1] is a festival happening once a year. In Bonn visitors can join the free event from Friday to Sunday. During this time, a variety of concerts take place in 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 exists for 32 years. It welcomes an average of 90,000-120,000 visitors per day making it one of the most popular festivals in the area.

Table 2 Selected Use Cases for Rhein in Flammen

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
UCG 8	Health Incidents		X
UCG 11	Evacuation		X
UCG 13	Event Information		X

Rhein in Flammen was the first of all MONICA demonstrations, i.e. the first deployment of the MONICA deployment during a pilot event. Thus, the focus of this demonstration was on technical feasibility and deployment of the MONICA platform. The selected use cases were sound monitoring, crowd monitoring (video analytics) and locating staff.

The MONICA team was located in the command centre where the COP Dashboard was shown on a 75" smart panel so that the staff of the coordination group were able to interact with it (see Figure 2 and Figure 3). This was an important factor from the user involvement perspective.

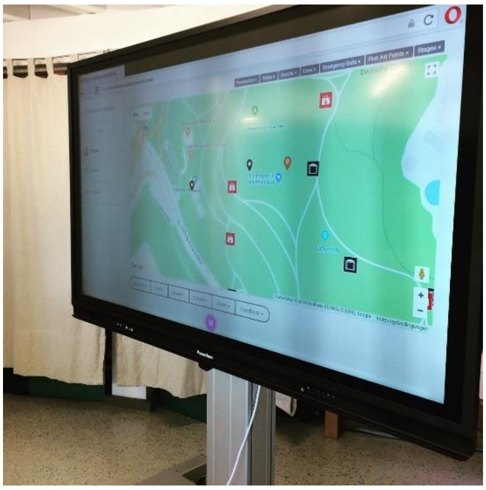


Figure 2 COP Dashboard Rhein in Flammen

Figure 3 COP Dashboard in action

The initial and basic challenge was the deployment of network infrastructure. As during the event, mobile networks are weak and even unavailable due to the large number of visitors. Therefore, it was decided to

[1] (http://www.rhein-in-flammen.com/)

extend a WiFi network from the command center to the area of interest in front of the main stage and its surroundings. This was done by the setting up a point-to-point radio link from the command center to the stage area, having a master unit antenna at the command center (see Figure 4) connected to the internet access point and a slave unit at the stage area (see Figure 5). From the slave unit the WiFi was extended with WiFi extenders. The challenge here was mainly the terrain, which includes some hills and trees. Nevertheless, the WiFi worked well and covered a radius of about 200 meters.

Figure 4 Master unit at command center

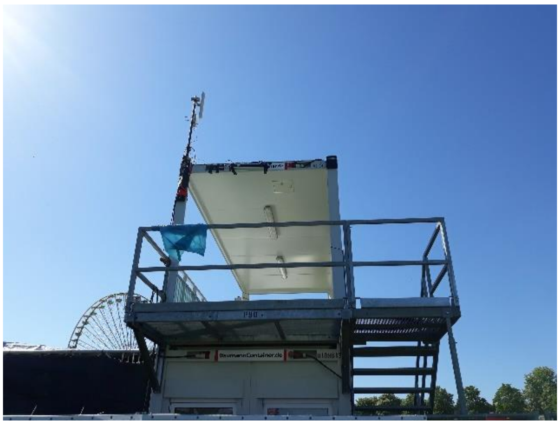


Figure 5 Slave unit in front of stage

This connection was used by the sound level meters. Next year we will try with LTE routers because our tests showed that LTE was still quite ok even during the main hours. Also, the physical setup of the antennas (master/slave units) requires some work of the technicians on site. They need to be mounted by a professional technician and it has to be ensured that no visitor can get in touch with the devices.

Table 3 Summary of deployed IoT Devices

IoT Device Type	Number of deployed devices 2018	Plans for 2019
Cameras	4	6 – 10
Tracking App	10	N/A
LoTrack GPS Tracker		50
IoT Sound Level Meters	6	20
Smart Glasses		TBD
Blimp		1
Visitor App (mobile phones)		> 20.000

3.1 Sound Monitoring and Control

6 sound level meters were installed around the main stage area (2 B&K sound level meters and 4 HAW sound level meters; examples shown in Figure 6 and Figure 7).

Figure 6 two types of Sound Level Meters

Figure 7 Sound Level Meter

While working flawlessly during the afternoon, the connection was lost during the main hours of the event, due to the sheer number of people. Important lessons learned could be derived, mainly regarding the networking approach of the IoT sound level meters: First, it is important to be resilient to instable/changing networks, i.e. be able to look for the best available network and re-connect during runtime. Second, once connected during the ongoing event, it is impossible to reconnect to such devices via cable. The field is too crowded to allow direct access to the devices, so remote configuration should be supported.

3.2 Crowd & Capacity Monitoring

4 IP Cameras were installed at the most critical point, i.e. the place in front of the tram station, where most of the people enter and exit the event (see Figure 8). Cameras were connected to the command centre by fibre cables (see Figure 9).

Figure 8 Cameras

Figure 9 Top view

The use of the point to point wireless connection was not possible due to the terrain (there is a hill between the tram station and the command center, so no line of sight). This setup was working very well and will be installed in the same way next year. The collected data was analysed by KU to prepare the counting and crowd density algorithms for the next year, when the full video analytics modules will be in place.

3.3 Locate Staff (interaction with staff)

Staff localization was tested with the staff tracker app (android app), using GPS and the established MONICA WiFi network. The approach generally worked and the location of the 10 test persons (from MONICA partners) was shown on the COP dashboard in the command center. However, for the next year, dedicated tracking devices using LoRa network will be used (see Chapter 9 for a description of the trackers that were tested at Puetzchens Markt and will be used at Rhein in Flammen 2019). The major issue with the app was that staff are reluctant to deploy additional apps on their phones. Using GPS-based localization is considered the first choice for large outdoor areas were a full coverage with the UWB wristbands would be too complicated (e.g. due to size of the area or the setup of stands or structural conditions).

3.4 Results of the Demonstration

The COP dashboard was displayed on a large screen in the command center during the full event. As all relevant stakeholders were present in the command center and held their regular status meetings, showing the dashboard there was a huge success to gain the interest of all stakeholders involved. Even though various meetings have been held beforehand, presenting the capabilities of MONICA, a live demonstration is a completely different thing. Since the focus of this demonstration was on technical part, we mainly supported direct interaction off staff members with the dashboard and answered questions. For the next year, when the technologies have been tested at more events, the focus will also be on evaluating with the end users. The major (maybe obvious) lesson learned in this regard is that showing things that work in the real environment has huge benefits. Further, approaches to evaluating with end users during a demonstration will require very good planning, because end users such as security staff are very busy during the event itself.

From the MONICA platform perspective this first real deployment was a success. All devices were integrated with the LinkSmart IoT platform and SCRAL and available to all MONICA services in OGC SensorThings format. The platform was up and running for the whole event without any major downtime or errors. The most problematic part here seems to be the Internet connection, when having to deal with unstable network conditions.

In summary, the Rhein in Flammen demonstration is considered successful. There was a lot of media coverage and expectations are high for the next year2019. As said, this was the first MONICA demonstration so the scale in terms of deployed devices was not yet large. Nevertheless, the conditions under which the demonstration took place were very large, so the aforementioned lessons learned can be analyzed and fed into the planning of the next demonstrations.

3.5 Summary and Outlook

For the 2019 we plan to increase the amount of IoT devices. 50 LoTrack GPS Trackers will be deployed with staff from police, fire brigade, first aid, private security staff of the event organizer and public order office to demonstrate the real time localization of staff on the COP dashboard.

Additional Cameras will be added to count the number of visitors will be installed on another entry and we will optimize the camera position of the cameras that have been used this year will be optimized to improve the results. A wireless point-to-point connection

After the first test of the IoT sound level meters their number will be increased with the goal to create a sound heat map around the event. We plan to deploy IoT sound level meters to create a sound heat map around the event.

For what concerns the networking infrastructure, LTE tests during the 2018 event indicate that using LTE will be the most promising way to go. So most probably, we will not do the comparably complex extension of the WiFi as done this year.

4 Nuits Sonores

Nuits Sonores[2] is a music festival (mostly electronic music) that takes place in Lyon every year during the spring and gathers more than 140 000 visitors. Events are present at different places around the city of Lyon.

During the 2018 edition, MONICA project was covering one of the main sites, the Fagor Brand factory, where music is being played on three stages from 22 pm to 5 am.

Figure 10 Aerial view of Nuits Sonores night site: Fagor Brandt factory

Fagor Brandt factory premises are located in Lyon's urban area. Residential areas are located close to the site. In addition to that, Fagor Brandt factory buildings keep the entrances open during festival to facilitate the flow of visitors between the different stages.

During the development phase, the uses cases have been discussed with the direction of Nuits Sonores. The organizers were very interested by having a system playing music in the factory and not making noise annoyance for local residents. Sound Monitoring and Control is thus the main concern for Nuits Sonores.

Table 4 provides an overview of the Use Cases selected by this pilot site.

Table 4 Selected Use Cases for Nuits Sonores

ID	Use Case Group	Tested in 2018	Planned for 2019
UCG 1	Access Control		
UCG 2	**Sound Monitoring & Control**	**X**	X
UCG 4	Missing Person		
UCG 5	Locate Staff		X
UCG 8	Health Incidents		

As shown on, Sound Monitoring & Control was the only Use Case Group tested during 2018 edition. Locate Staff Use Case, by the mean of wristbands and/or Staff Tracker App, is planned to be added for the tests during 2019 edition.

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

Table 5 Summary of deployed IoT Devices

IoT Device Type	Number of deployed devices 2018	Plans for 2019
IoT Sound Level Meter	10	14

Even if there is no command center at Nuits Sonores, a link to COP Dashboard was available. Details on Sound Monitoring & Control tests carried out during Nuits Sonores 2018 are provided here after.

4.1 Sound Monitoring & Control

An acoustic measurement campaign was conducted during the 2018 edition of the Nuits Sonores. IoT Sound Level Meters from B&K and Acoucité were deployed. Acoustics measurements for Sound Monitoring are intended to:

- Characterize the existing sound environment among local residents and evaluate the impact of the event by comparing the sound levels measured during the festival with those usually observed (in the absence of the festival) at the measurement points,
- Characterize the sound environment existing during the festival in the audience area, in order to quantify the sound levels to which the public is exposed throughout the event,
- Characterize the sound environment existing during the festival in the rest hall, in order to quantify the sound levels to which the public is exposed at hearing rest zone throughout the event,
- Be used to make an assessment of sound levels in accordance with the provisions of the new decree applicable to festivals in France (Decree No. 2017-1244 of 7 August 2017 on the prevention of risks related to noise and amplified sound),
- Obtain the information necessary for the development of the Annoyance Index.

The acoustic measurements were carried out in the period from May 7 to May 14, 2018.

The resources deployed were:

- Two acousticians from Acoucité
- 10 Sound Level Meters (one IoT SLM provided by B&K, nine provided by Acoucité)

Two approaches in terms of measurement time were used:

- Long-term measurements (monitoring), allowing the evolution of sound levels to be monitored throughout the whole festival period.
- Short-term measurements (using hand held sound level meters), allowing a finer mesh size to be obtained and thus describing more accurately the variations in sound levels in space.

Figure 11, Figure 12 and Figure 13 provides photos of measurement campaign.

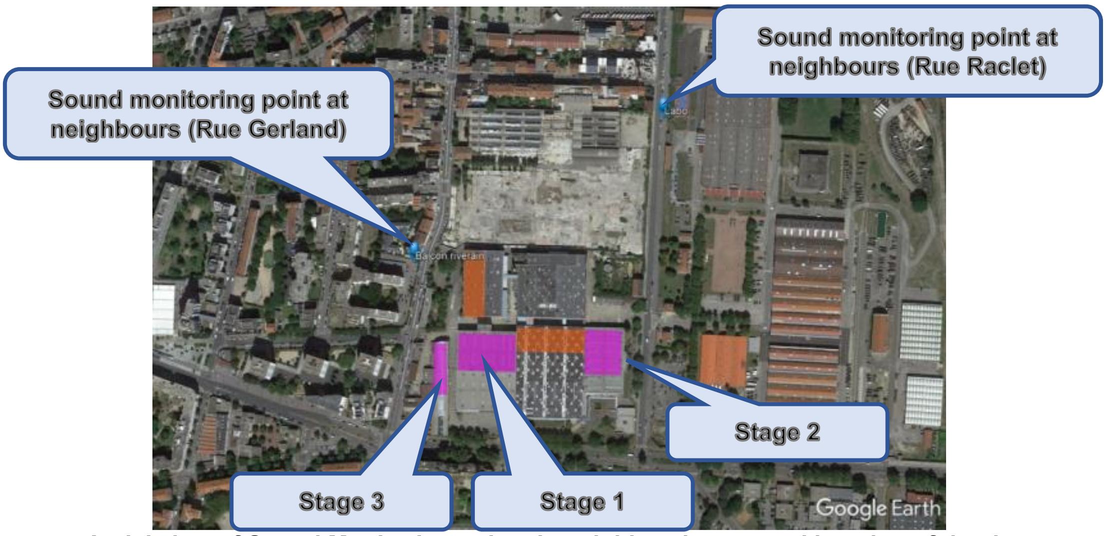


Figure 11 Aerial view of Sound Monitoring points in neighbour's area and location of the three stages

Figure 12 Sound Level Meter at Sound Engineer's console for Stage 1

Figure 13 IoT Sound Level Meter at Sound Engineer's console for Stage 3

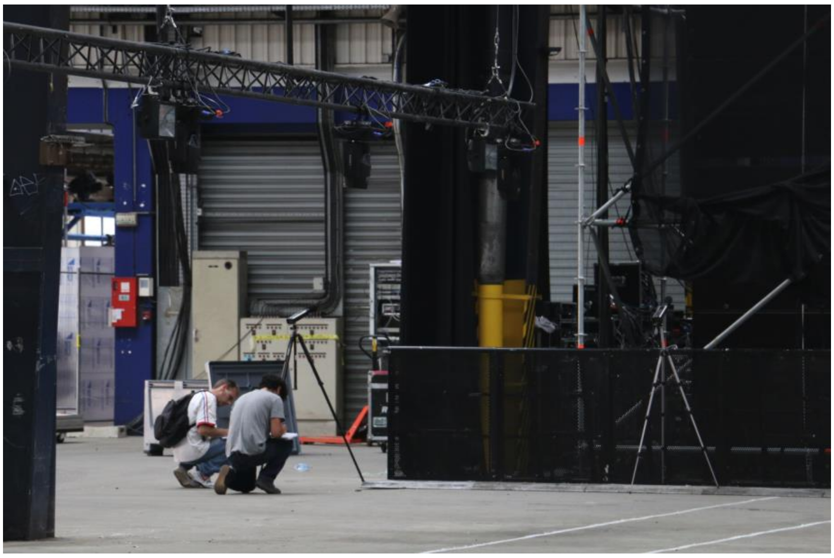


Figure 14 acoustic engineers performing pre-event calibration measurement

Figure 14 shows short term measurements previous to the event for characterising sound field distribution (determining critical positions in audience and the corresponding transfer functions to the long-term sound monitoring point at sound engineer's console) and reverberation time in the audience zone. Measurements are made using pink noise.

Figure 15 Sound Level Meter in rest hall (hearing rest zone)

Figure 16 Sound Level Meter at artist's lodge rooftop

Figure 17 Acoucité's mobile measuring station

The following results of measurements were provided to festival organisers after post-processing and analysis of collected data:

- Sound field distribution in audience area in terms of A-weighted and C-weighted sound pressure levels for the three stages (empty room and during festival)
- Frequency response in audience area for the three stages (empty room and during festival)
- Estimation of reverberation time of stage 1 and 2 (empty room)
- Evaluation of measured sound pressure levels on audience during the festival in accordance to new French legislation
- Sound levels measured at rest hall (hearing rest area).
- Evaluation of measured sound pressure levels in rest hall (hearing rest area) during the festival in accordance to new French legislation.
- Sound levels measured at receiver points in neighbour areas
- Evaluation of measured sound pressure levels in neighbour areas (global levels and spectra) in accordance to new French legislation

A summary report of results was submitted to representatives of City of Lyon.

4.2 Summary and Outlook

The demonstration was carried out at a middle-early stage of the MONICA project and mainly concerned about technical feasibility. There were issues with data transfer and feedback has been provided to B&K to guide the prototype improvements.

Even if collected data allowed having a complete sound monitoring of the event after post-processing, a real-time information was missing (e.g.: Is the festival exceeding regulatory limits? Does the sound engineer adjust PA level to be in accordance with legislation?). This is going to be tested in 2019 when the full closed loop systems are ready to be tested.

Thus, the plans for 2019 are:

- Having 6 to 10 IoT SLM installed (sound engineer's consoles, hearing rest area, neighbours)
- COP displaying measured levels and comparison against regulatory limits in audience and in neighbours
- Locate staff (security staff and/or festival workers)

5 Hamburg Port Anniversary

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, with music, cultural and culinary displays, and a wide range of activities.

It is a street event of 3-4 days in May[3], 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).

It is a free access event without gates and fixed boundaries, with open air concerts in an urban densely populated area.

Table 6 Selected Use Cases for Hamburg Port Anniversary

ID	Use Case Group	Tested in 2018	Planned for 2019
UCG 7	Security and Health Incidents	-	X

The identification of requirements and use case (listed in **Fehler! Verweisquelle konnte nicht gefunden werden.**) for the Port Anniversary has been carried out throughout the first two years of the project in close exchange with the required stakeholders.

As the Port Anniversary happens in early May, the event preparation starts one year in advance. Therefore, the Hamburg pilot partners focus in 2018 was on preparing the deployment in 2019 and getting the commitment of the required local stakeholders. After collecting requirements, regular meetings with the involved stakeholders were set up and a technical map of the event site was built in collaboration. With the help of this map suitable locations for the environmental sensors were identified and discussed. The Port Anniversary has turned out to be very complex in terms of administrative and organisational processes. Therefore, technology could not be tested during the 2018 event. To compensate for that, the focus in 2018 was shifted towards the DOM (see chapter 11) were long-term tests are possible due to the timing of the event (3 months per year).
The experiences from the DOM deployment of the environmental sensors will help for the deployment at the Port Anniversary in 2019.

Table 7 Summary of deployed IoT Devices

IoT Device Type	Number of deployed devices 2018	Plans for 2019
Environmental sensors	-	20
RIOT - LoRaWAN GPS Tracker		TBD

5.1 Health and Security Incidents

Along the waterfront 30 towers are deployed by the event organizer. These are very suitable positions to deploy the environmental sensors. Another option is also offered by the construction for the elevated train tracks which run parallel to the event site as well as other surrounding buildings. It is still in discussion which places are the most suitable ones for the deployment of the environmental sensors. Figure 18 shows the possible positions of the towers highlighted in orange.

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

Figure 18 Map of the harbour with possible sensor deployment positions

The applications which have been developed for the DOM COP Dashboard will be further developed during the DOM deployment 2019 and will be used for the Port Anniversary as well. The wind speed is expected to be shown in the Port Anniversary COP Dashboard similar to the one in Figure 19.

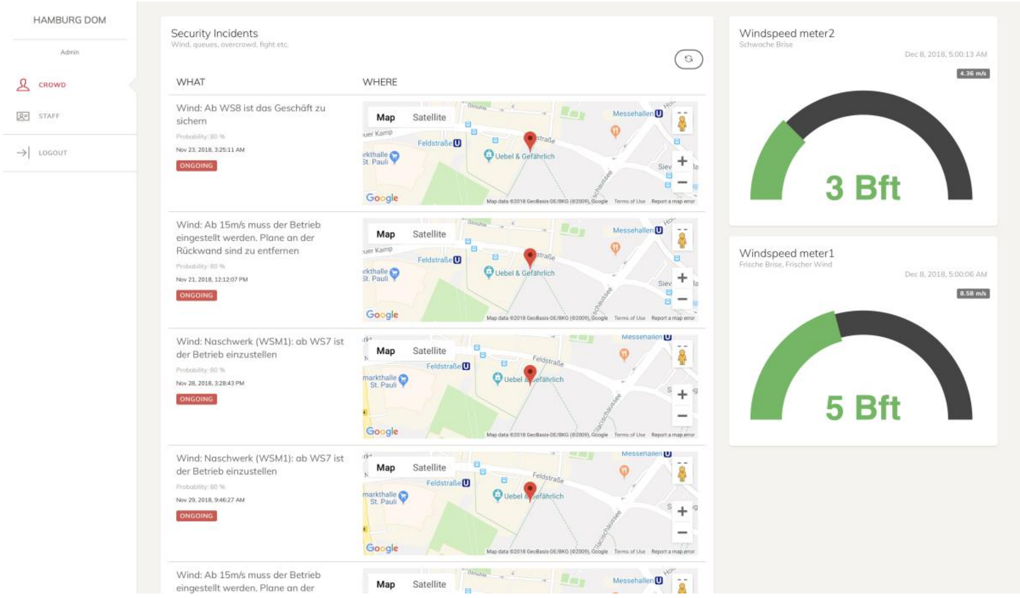


Figure 19 COP visualisation of wind speeds and security incidents

5.2 Summary and Outlook

The plans for the first test of MONICA technologies at the Hamburg Port Anniversary 2019 are in progress. The Hamburg Port Anniversary remains a challenging event to deploy MONICA technologies. The long stretched out venue, the existing rigid security concept and the number of stakeholders involved exceeded the expectations. These factors make it especially demanding to set up infrastructure needed for MONCIA technologies and adding to the existing ones.

6 Kappa Futur Festival

Kappa Futur Festival (KFF) is the first dance Italian daytime summer festival. Dedicated to electronic and techno music, it takes place every year with two full days of concerts from midday to midnight in the new Parco Dora, which has recently completed the overall urban transformation of this area.
The park offers its residents, but also others inhabitants and tourists, 450 thousand square metres of green areas for sports, entertainment and relaxing, and giving them back a river that was exploited for decades by factories, making it polluted and inaccessible. The park, however, keeps alive the memory of the industrial past of this part of the city, maintaining some of the pre-existing structures (pools, steel pillars, smokestacks). Concerts take place in a “fenced” area of about 10000 mq.

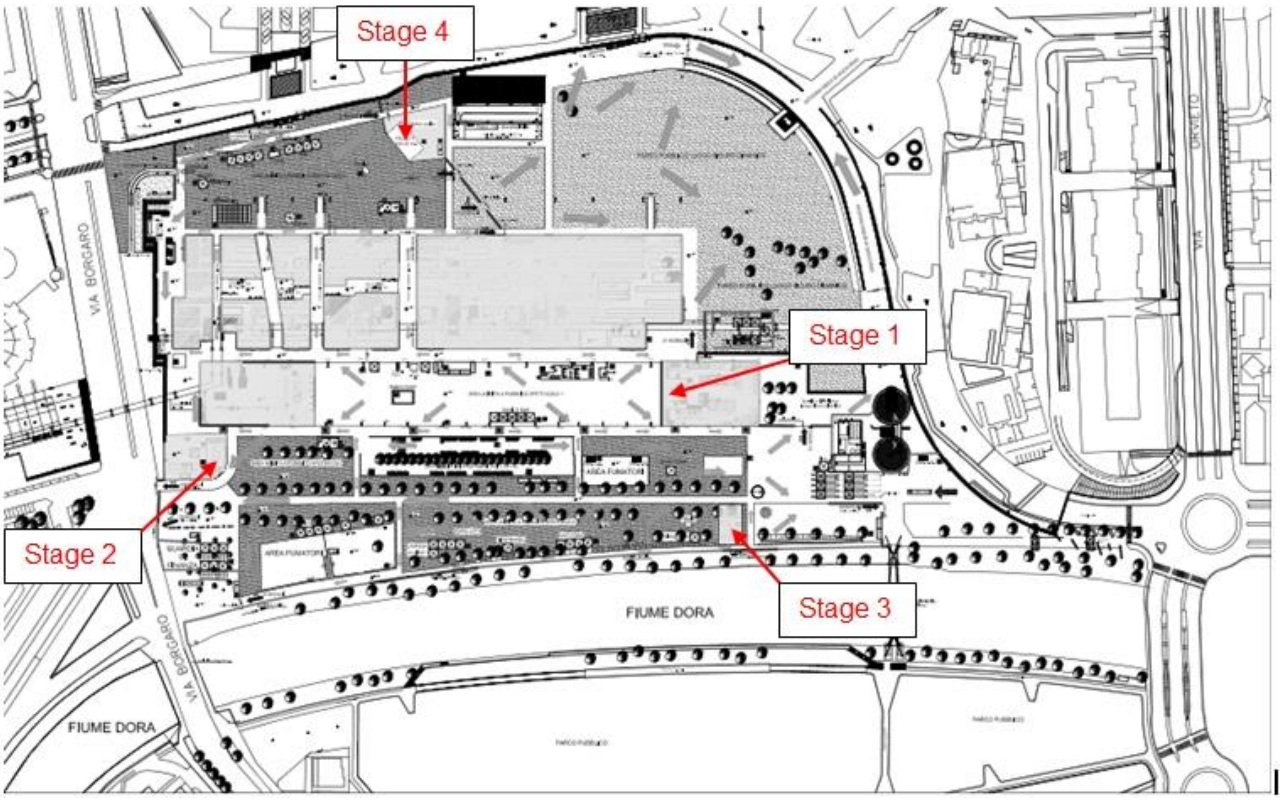


Figure 20 KFF 2018 Blueprint

Table 8 Use cases selected for Kappa FuturKFF18 Pilot

ID	Use Case Group	Tested in 2018	Planned for 2019
UCG 2	**Sound Monitoring & 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**	X

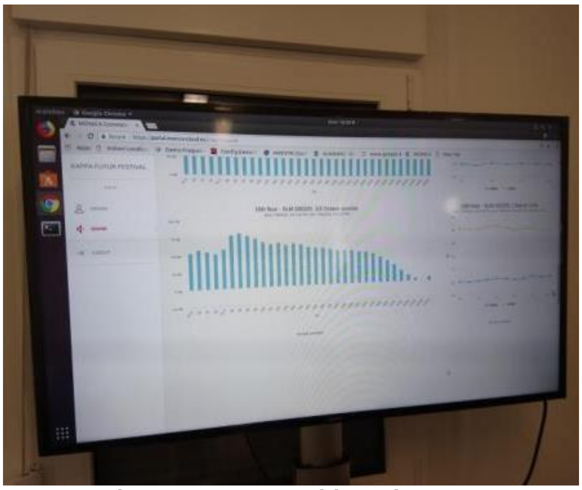


Figure 21 COP Dashboard at KFF

Figure 22 MONICA Container at KFF

The command centre was located in a container (see Figure 22), near the 4th stage, named FUTUR. During the festival, members of the production team as well as sound engineers came to the container to see the Common Operational Portal Picture (COP) dashboard (see Figure 21) to get information about the data sensed by the SLMs, data measured in sound engineer area or in the nearby dwellings.

Below the features displayed on the COP:

- Map with points of interest (POI) e.g. stages, bars, first aid, exits etc.
- Position of visitor and staff wristbands
- Sound level meters: First visualization of sound data in the COP 1/3 octave spectra and LAeq/LCeq
- Crowd count: data from cameras counting people within the area covered by the camera

Table 9 Summary of deployed IoT Devices

IoT Device Type	Number of deployed devices 2018	Plans for 2019
Cameras	9	9
UWB Staff Wristbands	15	0
UWB Anchors	9	0
Crowd Wristbands	20	0
Blimp	1	1
Sound Level Meters	14	TBD depending on needs for ASFC
Staff App (mobile phones)		10
Visitor App (mobile phones)	5	> 20.000 (TBD)

6.1 Crowd & Capacity Monitoring

6.1.1 Wristbands

A total number of six base stations have been deployed around the Futur stage area, which is one of the four stages at Kappa FuturFestival. Preparation has started three days in before the first day of the festival. Since a base station is powered by P.o.E. and used Ethernet to offload data to the server, cables needed to be installed to each of the six base stations and the production container.
The base station boxes were put on the ground while the antenna was put up high on either a tripod or on the roof of a container, attached to the box via an antenna cable.

A total number of 20 wristband were available for testing. The MONICA crew that was present tested the wristbands by walking around during the festival. Location data and buttons presses were collected by the server in the production container and send to the MONICA cloud. Some simple tests were done to check whether the reported position corresponded more or less to the actual (ground truth) position of the person walking around.

6.1.2 Crowd Counting and Density Estimation

9 cameras have been used, deployed along the main stage, and dedicated to crowd counting monitoring and analysis operations. The cameras where installed in tilted with roughly 45 degrees angle to facilitate crowd counting operations.

All 9 cameras were calibrated prior to event. Camera calibration and configuration unit is an interactive application fully developed by KU which facilitates cameras configuration, registration and calibration. Geospatial information such as cameras GPS coordinates, field of view, orientation, height, bearing and height was registered into camera configuration unit. This unit helps to maintain compatibility and adaptability of the crowd counting, analysis and monitoring algorithms to the wide variety of the camera vendors and environment.

Crowd counting and density estimation is using state of the art deep convolutional neural network algorithm to count, localize and generate the density map of the crowd. The algorithm works thanks to the head counting which is resilient against occlusion. The proposed algorithm is capable to deal with a variety of resolutions and image sizes which improves the compatibility of the algorithm with various types of cameras. The algorithm takes images with titled camera angle with no rigid restrictions in terms of illumination, tilt angle and resolution. The deep network in this algorithm uses cascade network structure with three stages including:
(1) the shared convolutional layers stage, (2) generates initial feature map which can be shared between high-level prior and (3) density map estimation stages. This shared infrastructure significantly improves the performance off the algorithm and reduces the computational complexity. The high-level prior estimation stage gives a global estimation of the crowd count through a deep network. This classifies the frame into 10 classes based on the density of the crowd in the frame. Density map estimation stage generates local density map of the given input frame. The density map is a grey scale image which localizes the head presents in the image through a Gaussian distribution. The sum of elements in this density maps denotes the total head count in the frame. The algorithm uses Adam optimizer to optimize the weights and biases in training stage. The following shows some example results of crows counting and density estimation.

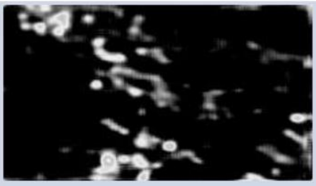
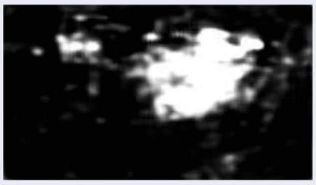
Original Frame	Density Map	Actual Count (Ground Truth)	Estimated Crowd Count
		67	48
		~300	184
		39	18

Figure 23 Example results of crowds counting and density estimation

6.2 Locate Staff (interaction with staff)

The real-time localization of staff serves the overall objective of improving the overview in the command centre of all staff and emergency services. Thus, the current positions of the staff out in the field are always to be displayed on the digital map. The purpose is to improve the response and planning in action during the event. The operations management is therefore always in the picture of the current positions of their forces and can act according to the current situation.

At KFF18 the real time localisation of 15 staff wristbands was tested successfully (see Figure 24). In the FUTUR stage 9 UWB anchors were deployed (see Figure 25).

Figure 24 UWB Staff Wristbands deployed in KFF18

Figure 25 Positions of 9 UWB anchors for staff wristbands deployed in KFF18

The inter anchor distances and the automatic determination of the anchor positions were very accurate (0,07 m). Figure 26 shows the results of the anchor positioning procedure.

Staff wristbands (UWB) can suffer from 4G/5G interference, especially in a densely crowded area such as a festival. In the future this aspect will be improved by using a proper high pass filter.

Figure 26 Result of the automatic anchor positioning procedure at KFF18

6.3 Sound Monitoring & Control

In order to monitor both the sound levels and quality and the effectiveness of DTU control system, 14 Sound Level Meters were deployed inside the Festival area and in the neighbourhood.
There were 9 B&K SLMs sending real time data to the COP (Figure 27 and Figure 28), 2 SLMs brought by Acoucité and 3 SLMs brought by ARPA Piemonte.

Figure 27 B&K SLM near the FUTUR stage

Figure 28 B&K SLM on a building in Via Orvieto

The information collected was used as a reference by Movement KFF18 sound technicians to adjust the levels of the loudspeakers, in order to comply with the local regulation.

Figure 29 Sound Level Meters locations in KFF18

6.3.1 Experimental Setup

DTU tested its sound field control system on the FUTUR stage only. With being the first demonstration of the ASFC at a MONICA event, the test posed several challenges: complex, uneven terrain with many reflecting structures and surfaces around the venue and dark zone, i.e. late reverberant reflections which cannot be captured in a short FIR filter; microphone positions neither in line of sight with the primary source nor the secondary sources, i.e. indirect sound must be cancelled by the indirect sound from the secondary sources; restrictions in placement of secondary sources and microphones, i.e. fewer samples of the transfer-functions to the dark zone; and time constrained measurements in noisy environment at large distances, i.e. low signal to noise ratio in transfer-function measurements.

Figure 30 Control subwoofer (the festival stage can be seen in the back)

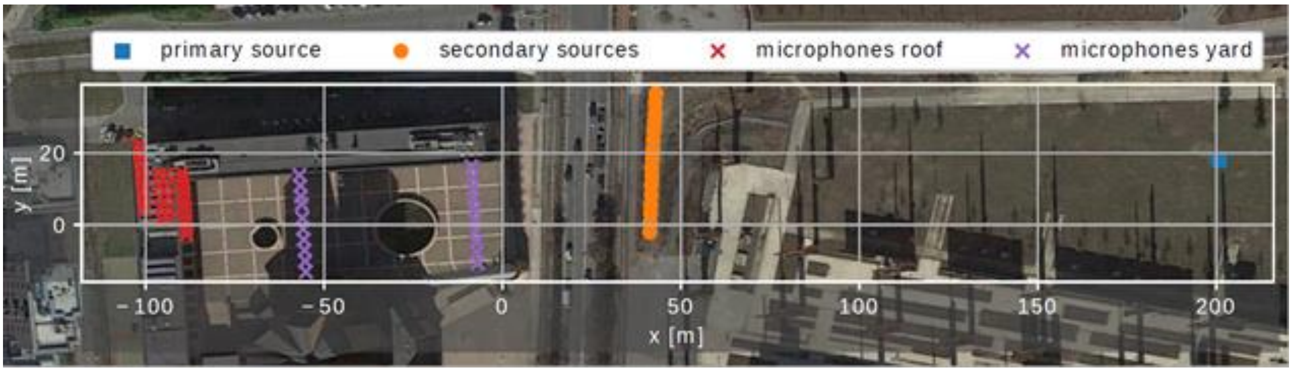


Figure 31 Arrangement of control sources and microphones

Figure 31 gives an overview of the venue, the setup of loudspeakers and the microphone positions in and around a part of the festival area that spans around 300 m. The primary source (main stage subwoofer system) comprised 20 cardioid subwoofers in a digitally curved line array configuration. The secondary source array consisted out of 16 subwoofers of the same type arranged in a single line with 2.55 m spacing (center-center) and facing the negative x-direction. The stage sound system also featured two vertical line arrays for the higher frequencies, but these were not included in the transfer-function measurements and thus also not accounted for by the sound field control system. We assumed that the secondary source configuration and the large distance of the secondary sources to the audience area would lead to a low impact of the control system onto the audience area, which was approximately the area between x = 100 m and x = 200 m. In fact, a difference from switching the control speakers on and off could only be noticed up to around x = 90 m. Closer to the audience area the sound from the secondary sources was completely masked by the sound from the primary source.

The dark zone (i.e. the zone where the sound should be reduced) was defined as the area between x = −100 m and x = 0 m. It was sampled at 20 microphone positions in an elevated courtyard and 30 positions on a rooftop. After measurement of the transfer-functions from all sources to all microphone positions, a set of control filters was computed, and the regularization parameter was chosen by hand such that the gain of the control filters was not overly extreme.

6.3.2 Results and Discussion

Generally, the diffusion system used at KFF18 had a good effectiveness in directivity, although there were important differences between the front and the back-stage (e.g. more than 10 dB for the Future stage).
On the dance floor there was the impression of homogeneity of sound levels. Average sound levels at which the audience was exposed never exceeded 95 dB(A) and 118 dB(C) at the closest point from the stage.

From a “dance floor perspective”, on the left side of the Jager scene, next to the VIP area, the suspended line array created a delay/echo for mid and high frequencies. On the right side of the Jager scene, you can hear the low frequencies coming from the Dora scene (juxtaposition). Conversely on the Burn stage, 10 meters from the crash barrier, you can hear the low frequencies of the Jager stage. After verification it was also audible from the sound engineer area.

Regarding the Adaptive Sound Field Control, a gain of up to 6dB was achieved at the line of microphone positions around x = −10 m (in Figure 31). If we use the prediction also for all other positions, we estimated the average reduction in dB at all microphone positions by offline prediction as shown in Figure 32 and Figure 33.

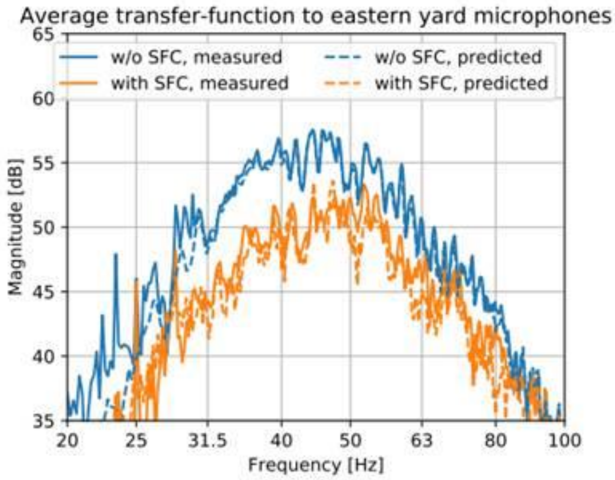


Figure 32 Results

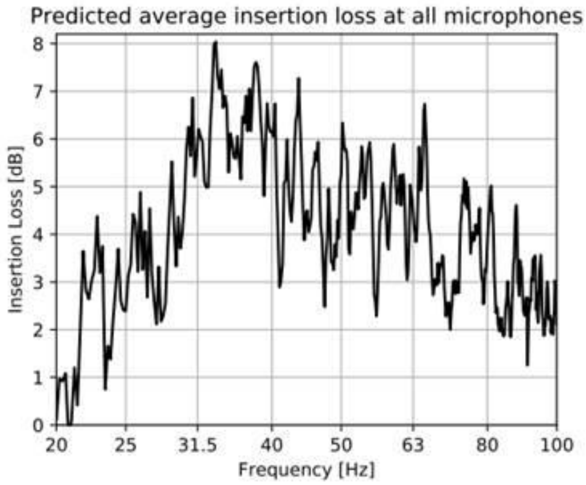


Figure 33 Results

The sound field control system was successfully tested under live conditions. However, the reduction of sound pressure level is below the set target of 10 dB in the low frequencies. MONICA partners are working on improved solutions for KFF19.

6.4 Deployment of Airship (blimp)

The blimp represents an alternative way to get video and sound data from the site and get an overview of crowd movements from a bird-eye perspective. The aim of this test was to collect video data on the test site under real conditions as well as to collect additional sound recording.

On the second day of the Festival, DigiSky tested its prototypal tethered aerial platform configured as a 5-meter-long zeppelin inflated with helium and deployed up to 32 meters above the ground of Parco Dora (see Figure 34).
The wind conditions were not ideal with a medium wind speed of 10 km/h and gusts of 20 km/h, therefore we had to wait for the wind to calm before start testing and we kept the zeppelin anchored to the ground. We waited almost an hour for the wind to slow down but the gusts persisted and we decided to try either way. We mounted the payload bay and run the first tests of manoeuvre in the area.

The first manoeuvre tests we carried out were successful, raising the blimp to 15 meters just behind the stage 4. The strong wind often made the blimp bent up to 30 degrees from the vertical and the ground operator were constantly adjusting their position to have the blimp facing the correct direction to be more stable.

Figure 34 Blimp setting up at KFF18

6.4.1 Video

The camera is mounted on the blimp on a high precision gimbal which is connected to a receiver mounted on the bay area. The video operator on the ground has the ability to move the gimbal through the radio link with the transmitter up to 2 km away. However, the video from the camera is only live transmitted to a distance of a 20-30 meters from the camera through a Wi-Fi connection with a tablet running the Sony app, which also enables the zooming and recording capabilities. Here comes the need to be able to extend this Wi-Fi connection between tablet and camera to at least 300 hundred meters, so that the video operator doesn't have to be right beneath the blimp and is able to know where the camera is directed.

Figure 35 The airship payload

Windy condition may affect the quality of the zoomed filming but these wobbling images can be corrected with editing software. Moreover, the current configuration that counts two holding ropes (one in the front and one in the back of the blimp), may degrade the quality of the image for media and promotion purposes but it does not interfere with general monitoring of the area.
When the video link was stable we were able to follow e.g. medical responders and security, which greatly enhance the capability of such a platform to get a general overview of the area but also its ability to target specific sectors and follow the development of an event.

A second round of tests was performed in the afternoon. The blimp was raised closer to the stage 1 to altitudes ranging from 15 to 32 meters. The major problem we encountered was related to the camera link.
The current set up does not allow to take the video stream away from the Sony app and send it to the MONICA Platform. We need to come up with a wireless solution that is capable to achieve this.

6.4.2 Sound monitoring

The sound monitoring on the blimp was performed with a microphone from ARPA Piemonte consisting in a smartphone with an external microphone plugged. The smartphone was running the ARPA monitoring app and recorded data during the flight.

6.5 Event Information

The first version of the MONICA visitor app (see Figure 36 and Figure 37) was tested internally with MONICA partners. The Visitor App, includes the event schedule (feature that was accessible offline), lists of POIs, map showing POIs, directions to nearest POIs and rating/feedback opportunity. The event schedule could be accessed offline, which was considered an asset during a live festival, as smart phone battery power is limited.

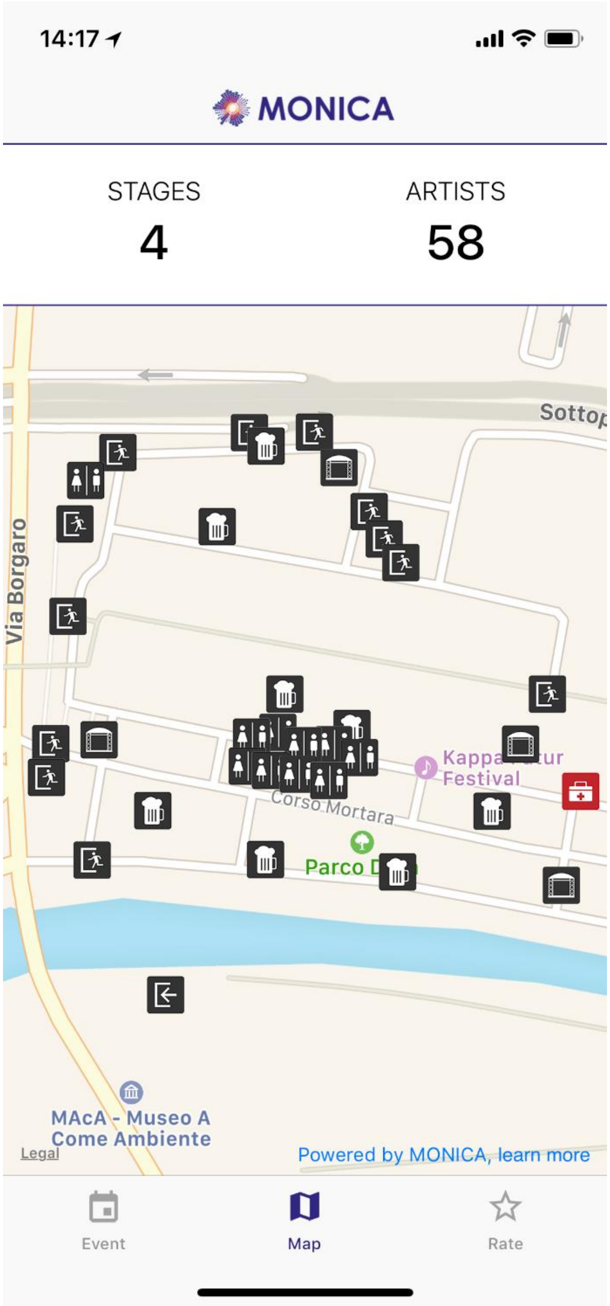


Figure 36 MONICA Visitor App showing the Festival map of KFF18

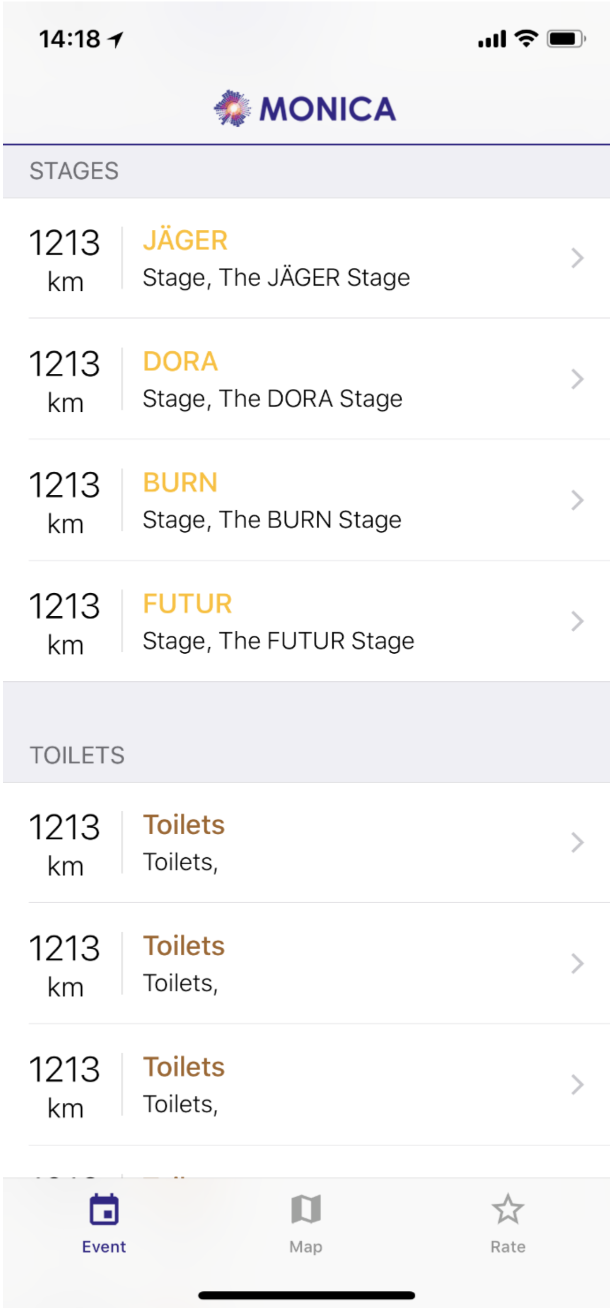


Figure 37 MONICA Visitor App showing the Festival timetable

6.6 Summary and Outlook

The first field test on MONICA technologies at Kappa FuturFestival in Torino has successfully been completed. Numerous data was collected and dedicated findings have been obtained. A careful cost-efficiency analysis of each tests should be carried on before planning for next year.

7 Leeds – Yorkshire County Cricket Club

Yorkshire County Cricket Club (YCCC) is one of eighteen first-class county clubs within the domestic cricket structure of England and Wales. Yorkshire are the most successful team in English cricketing history with 33 County Championship titles, including 1 shared. The team's most recent Championship title was in 2015, following on from that achieved in 2014. Yorkshire play most of their home games at the Emerald Headingley Cricket Ground in Leeds, part of the Emerald Headingley Stadium complex, currently undergoing major redevelopment and due for completion May 2019.
Professional cricket is played in four different competitions under three global brands:

- Specsavers County Championship Division 1 (SSC1) – team is known as the Yorkshire County Cricket Club and play is over four days.
- Royal London One Day Cup (RLODC 50) – the team is known as the Yorkshire Vikings and play is over one day and limited to 50 overs per team.
- Vitality Blast (T20) – the team is known as the Yorkshire Vikings and play is normally over an evening and limited to 20 overs per team.
- Kia Women's Super League T20 – the team is known as the Yorkshire Diamonds and play is limited to 20 overs per team.

The first live demonstration took place on 17th August 2018 during the Yorkshire Vikings T20 cricket game against Nottinghamshire Outlaws. T20 games are the most popular and fastest growing competitions with an average of 8,000 spectators per game rising to excess of 18,000 at some fixtures. In T20 cricket, each team is allowed one innings to try and score as many runs as they can within a period of 20 overs (120 balls). T20 has a wide appeal due to the fast pace of the game and the crowd is much more diverse than for the County games. Games are usually played in the evenings under floodlights.

Figure 38 Emerald Headingley Cricket Ground – T20 game

The use cases and preferred solutions were identified during a series of consultative workshops, over 2017 and 2018, with key internal and external stakeholders, including YCCC and Leeds Rugby Ground Safety Officers, G4S senior staff, Emergency Services and Sports Governing Bodies. This was an iterative process which informed the selected Use cases for the first live demonstration which took place at the Emerald Headingley Stadium on 17th August 2018 during the Yorkshire Vikings T20 cricket game against Nottinghamshire Outlaws. Set up took place on the 16th August, including App installation and testing, camera

calibrations and COP Dashboard set up. From 2pm – 8pm live demonstrations took place. Two control rooms were set up: on site in the Carnegie Stand for demonstration participants; and at the offsite offices of the Stadium's IT providers mtech. The COP Dashboard was simultaneously displayed in both locations as a backup and to facilitate access for any staff and emergency services personnel who wished to observe the COP.
In order to ensure that the existing IT security infrastructure deployed at the Stadium was not compromised a separate VLAN and server were installed on site and new cameras mounted in selected locations.

Table 10 Selected Use Cases for Leeds

ID	Use Case Group	Tested in 2018	Planned for 2019
UCG 3	**Crowd and Capacity Monitoring**	**x**	x
UCG 5	**Locate Staff**	**x**	x
UCG 7	**Security Incidents**	**x**	x
UCG 8	**Heath Incidents**	**x**	x
UCG 13	Event Information		x

Table 11 Summary of deployed IoT Devices

IoT Device Type	Number of deployed devices 2018	Plans for 2019
Cameras	4 (6 installed)	7-9
GPS Tracker (smartphones)	7	0
Wi-Fi-based Tracker and/or Staff Wristbands	-	TBD (>20)
Action recognition device	1	TBD
Smart Glasses	1	2- 4
Staff App (mobile phone)		20
Visitor App (mobile phone)		> 10.000

7.1 Locate Staff and Action Recognition

LBU were responsible for the use cases Locate Staff, Health Incidents and Security Incidents. The aim of the demonstration was to test the solution integrating action recognition and location tracking for monitoring security and health incidents.

7.1.1 Test objectives

The objectives of the test were to:

1. test the posture detection algorithm in-situ (in the wild)
2. to collect feedback on devices.

In order to achieve these objectives, the demonstrated features were:

- the simultaneous detection of stewards' actions and location
- visualization of stewards' location on the COP
- Fusing detected action tracking information and sending to Security Fusion Node (SFN)

The posture detection/action recognition algorithm can identify 8 different postures. Those tested are standing (still), walking, running, jumping, and lying on the ground. Certain actions are performed by stewards in the normal courses of carrying out their duties. However certain actions namely 'lying' and 'running' can be seen as abnormal activities since during a normal proceeding there is no need for these. The detection of abnormal activity is the means by which incidents were detected. Two types of incidents were considered: health incidents and security incidents. From the perspective of incident detection algorithm, there is no difference. In the test, only the "lying" action was defined as a health incident.

7.1.2 Test setup and Infrastructure

'Dummy' stewards were recruited via Leeds Beckett University for the purposes of the demonstration. The use of G4S and event staff during live events will be reviewed with YCCC Operations Director and G4S Ground Safety Officer once the impact of the first pilot on the event organization and visitor experience has been assessed. Six stewards were recruited to participate in the event. They were given written information about MONICA, explained the overall aims of the project and the aims for the experiment and asked to sign a consent form.

1. Stewards were required to wear **a wristband for the action recognition** and **a mobile phone for location tracking (uploaded to COP)** through the Staff Tracker app.
2. **A Wi-Fi enabled laptop or other mobile was used to collect** the data from the sensors (timestamp, acceleration (x,y,z), rotation (x,y,z)).
3. In the offline method, the action recognition algorithm classifies the actions from data.

For the purpose of benchmarking, the stewards were given a script of the actions they were to perform and timings of these.

- All the stewards were asked to perform the following actions: "walk" and "stand" actions as normal actions.
- One steward was asked to perform the following actions: "standing", "walking", "sitting", "running" and "lying" actions.

The action of "lying", "running" would be considered abnormal actions if these occurred during an event and therefore during the test, these were carried under restricted conditions with a single steward.
The wearable sensors used were a 3-axis accelerometer device for posture detection and Android phone running the GPS-based Monica Staff tracker app. At the time of the event, failure of available devices meant that alternatives were used. The alternative accelerometer device did not support real-time connection to the network. The tracker connected to MONICA COP Dashboard in real time.

During the event two MONICA control rooms were set up, both equipped with a smart screen to observe the COP Dashboard. The first control room was located at the mtech office close to but outside the stadium (see Figure 39). mtech is the company that provides network management for the pilot site. This location was selected to enable support by mtech staff as required. The second control room was located at the stadium (Figure 40). It was also the meeting/base room for all MONICA staff and stadium personnel contributing to MONICA tests.

Figure 39 MONICA control room #1 at mtech office

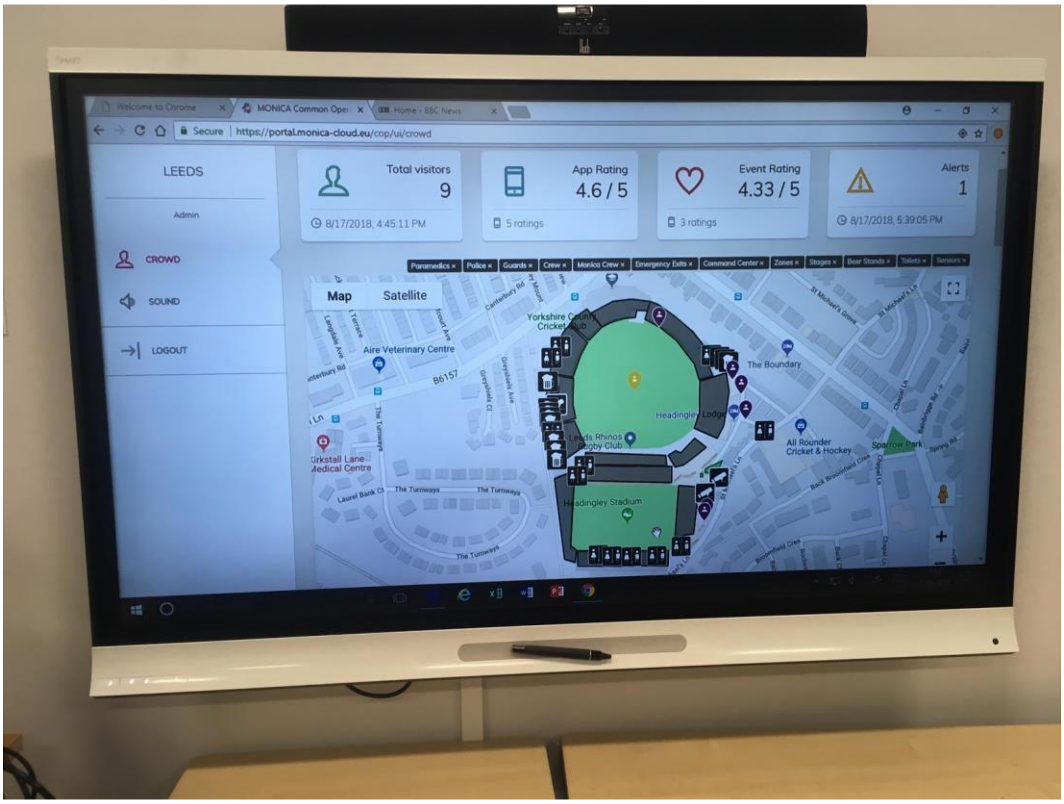


Figure 40 MONICA control room #2 in stadium

7.1.3 Results of the tests

The test showed that the data send from the MONICA staff tracker app and the used motion detection device was transferred to COP Dashboard in real time. The staff tracker App was used by novice users after a short explanation. The technology was successfully used to determine current actions in real time and visualized staff location on the COP Dashboard (Figure 41).

For the purpose of the benchmarking, the steward was following a script indicating which action to perform in view of MONICA cameras. Figure 41 shows the results of action and posture recognition conducting pre-match with a single steward. The figure shows the integrated information of actions and positions can be visualized the COP Dashboard.

Figure 41 Integrated action postures and positions collected wristband and mobile phone tracker App

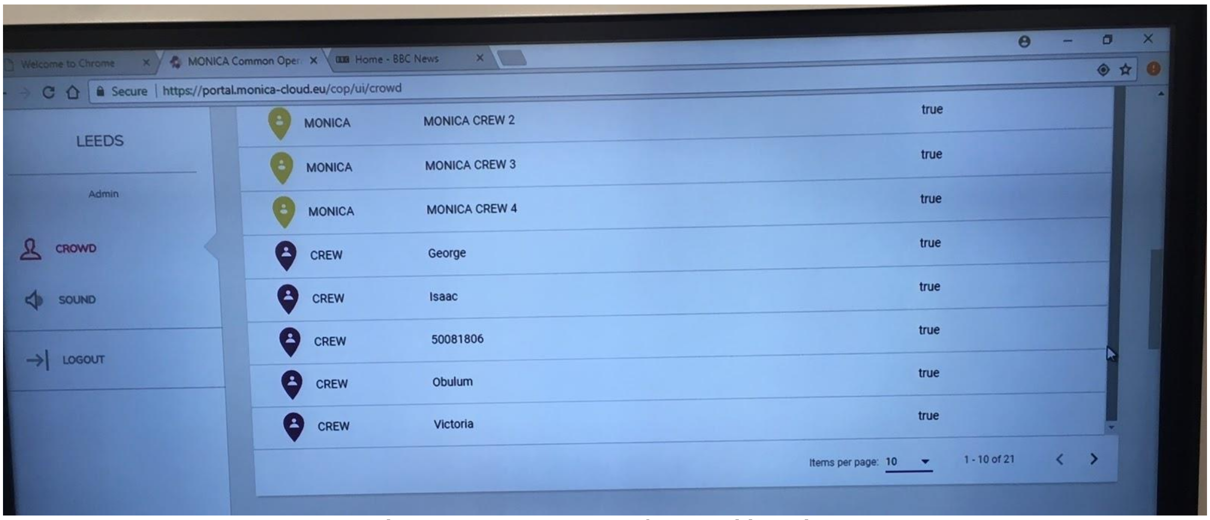


Figure 42 MONICA crew/steward location

7.1.4 Challenges and lessons learned

Posture detection was developed to operate from the staff wristbands with the posture algorithms running on the processing node within the device. However, since the staff wristbands UWB infrastructure could not be deployed during that time at the stadium (due to restrictions resulting from the refurbishment activities), the Staff Tracker App, which doesn't need any infrastructure, was tested.
However, as expected, the GPS tracking of the staff tracker app did not meet the granularity for accurate tracking in a stadium situation. This result was as expected and it is clear the GPS tracking should only be used for large outdoor events. For the stadium, other technologies that are more suited for indoor tracking will be tested in 2019. Depending on the result of current technical assessment this will be either WiFi based positioning or the staff wristbands, or both.

7.2 Crowd and Capacity Monitoring

KU were responsible for the use case Crowd and Capacity Monitoring. The aim was to monitor crowds and queueing activity and send data to the COP Dashboard to aid decision making.

7.2.1 Test objectives and set up

Total number of 6 cameras have been installed and dedicated to crowd monitoring and analysis operations have been installed: two TOF (Time of Flight) cameras assigned to detect risky queues, two cameras for crowd counting and density estimation and the other two for gate counting.

In order to ensure that the existing IT security infrastructure deployed at the Stadium was not compromised a separate VLAN and server were installed on site and new cameras mounted in selected locations (see Figure 43 and Figure 44).

Figure 43 Time of Flight cameras installed over the bar area to observe queues


Figure 44 Dome cameras to observe density and flow

The cameras were acquired and installed based on the designated requirement by KU and VCA. The camera location, angle and point of view adjusted to maximize the performance of the crowd counting and monitoring algorithm. Aside from physical calibration, the cameras were calibrated using KU developed camera calibration software. This calibration is a necessary preliminary operation in each pilot and serves several purposes including:

- Tests and verifies the connectivity of the cameras using RTSP streaming protocol.
- Provides interactive tool which allows to select the desired monitoring area.
- Allows to filter out areas which introduces noise to the system.

- Allows to compensate and control the field of view perspective and creates the top-down view.
- Registers the cameras geographical location (latitude and longitude). This information will be used to create global geo-spatial map which will be used in COP Dashboard.

7.2.2 Results of the tests

Crowd Density Algorithm employs state of the art deep convolutional neural network based cascaded multi task learning of high level prior and density estimation for crowd counting. The algorithm is capable to estimate the number of the people as well as generating a localization density map which shows the distributions. Figure 45 shows some example key frames along with the count estimation and localization density maps.

Original Frame	Density Map	Actual Count (Ground Truth)	Estimated Crowd Count
		84	32
		124	82
		61	41

Figure 45 Sample key frames along with density maps and estimated number of crowd counts. The Ground Truth provided as a reference. Frames have been shrunk and blurred to address privacy concerns

The crowd flow analysis algorithm Computes optical flow by means of convolutional neural network (CNN) and FlowNet architecture. The crowd flow analysis results are expressed through a flow heat map as well as flow magnitude and direction (see Figure 46).

Original Frame			
Flow map			
Magnitude	0.016	68.12	8.43
Direction	-0.92	0.47	-0.83

Figure 46 Sample key frames along with flow maps and estimated number of flow magnitude and direction relative to camera. Frames have been shrunk and blurred to address privacy concerns

The solutions for crowd capacity monitoring were successfully demonstrated. We monitored the crowd count and density in real-time and the related crowd data and statistics were shown in the COP Dashboard. An estimation about the overall distribution of the crowd was made available to the event organizers, as well as the crowd flow direction and magnitude.

7.2.3 Challenges and lessons learned

It was not possible to use the Time of Flight cameras for the test as, during set up, they were found to be not suitable for the purpose. The primary problem with the cameras was found to be the ‘noise’ in the scene coming from the barriers, posts, floor and the bar door shown in Figure 47. A theoretical solution to the problem would have been to cover all the surfaces in the cameras’ view, which, as well as being impractical, would contravene the Stadium health and safety regulations. The secondary issue was the limited range of these cameras which means queues of any significance would be outside the view of these cameras.

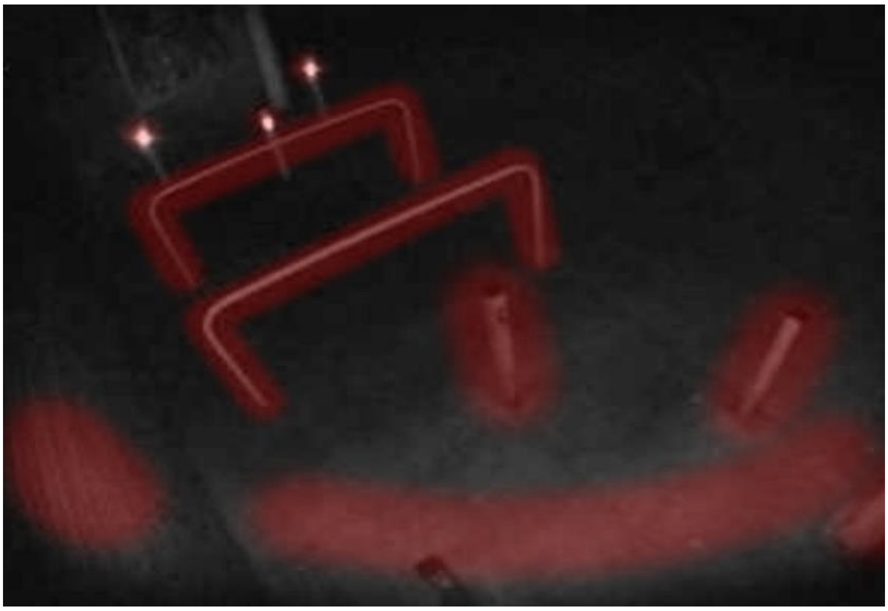


Figure 47 ToF cameras require significantly controlled environment to operate correctly. The reflections from the barriers and flooring interferes with the camera operation

7.3 Summary and Outlook

The Leeds Demonstration plan for 2019 has been informed by the detailed review and evaluation of the live demonstration on 17 August, together with a series of consultative meetings with key stakeholder groups, including emergency services. We plan to demonstrate the improved locate staff functionalities in real-time using either WiFi-based positioning and/or staff wristbands. We will test the real-time transmission of staff messages on incidents using smart glasses. At the same time, we want to use the staff app to provide event information to the staff members, to communicate alerts on time and if required additional real time information too.

Monitoring the crowd count and density in real-time should be further improved to show statistics on the COP Dashboard and get information about the overall distribution of the crowd. Therefore, crowd flow direction and magnitude should be improved to avoid congestion.

For the last test in October 2019 we plan to have a visitor app ready that should improve the communication on alerts and general event related information to the visitors.

8 Tivoli

The Tivoli Gardens is a famous amusement park and pleasure garden in Copenhagen, Denmark. The park opened in 1843 and attracts around 4.5 million visitors annually. From April through September, Tivoli organises 24 outdoor concerts on Friday evenings featuring both national and international performers, with over 400.000 concert guests attending these concerts each year. The City of Copenhagen also has vital interest in such large events in order to develop an attractive city environment with an international flavour.

Tivoli is struggling with emissions of noise to the neighbourhood, in particular from the outdoor music performances as well as general noise from the amusement park. The neighbours are filing complaints over the sound levels with the Municipality resulting in severe caps being put on the total sound levels that can be emitted. The capping means that international artists have refused to play at the outdoor stage at reduced audio levels. Also the music audience complains about low sound volume during concerts. On the security and safety side, the Tivoli Gardens is not a typical concert venue, as the rest of park is open for normal guests during concerts, and as there are many buildings, trees and rides in the concert area. The flow control during concerts is thus complex and requires a lot of safety personnel.

Table 12 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 Person**	**X**	X
UCG 7	**Security Incidents**	**X**	X

The goals of the first Friday Rock demonstration were:

- to demonstrate the Adaptive Sound Field Control System at the main stage during Friday Rock concerts
- to improve the guest counting method within specific area and at any given time during a Friday Rock concert
- to test the crowd wristbands for implementing the missing person/child use case
- to facilitate the communication among the stakeholders involved in the missing person/child use case (control room, staff, parent/guard)
- to detect fights, abnormalities, high-risk queues, and objects

For the test of the COP dashboard we established a medium size panel on the stage in the venue “Glassal” in the middle of Tivoli Gardens.

Table 13 Summary of deployed IoT Devices

IoT Device Type	Number of deployed devices 2018	Plans for 2019
Cameras	6	6
Crowd Wristbands	6	2.000
IoT Sound Level Meters	9	9

Staff App (mobile phones)		10

8.1 Sound Monitoring & Control

Solutions and technologies deployed during the sound monitoring demonstration was provided showing sound levels in the COP Dashboard and the Staff App. The Adaptive Sound Field Control was tested for the first time aiming at optimizing the sound experience for the audience and reduce noise impact on neighbouring areas. Additionally, the quiet zone was proposed to the visitors for the first time.

Figure 48 Subwoofers Subwoofers on the roof of the Concerthall – trying to stop the unwanted noise

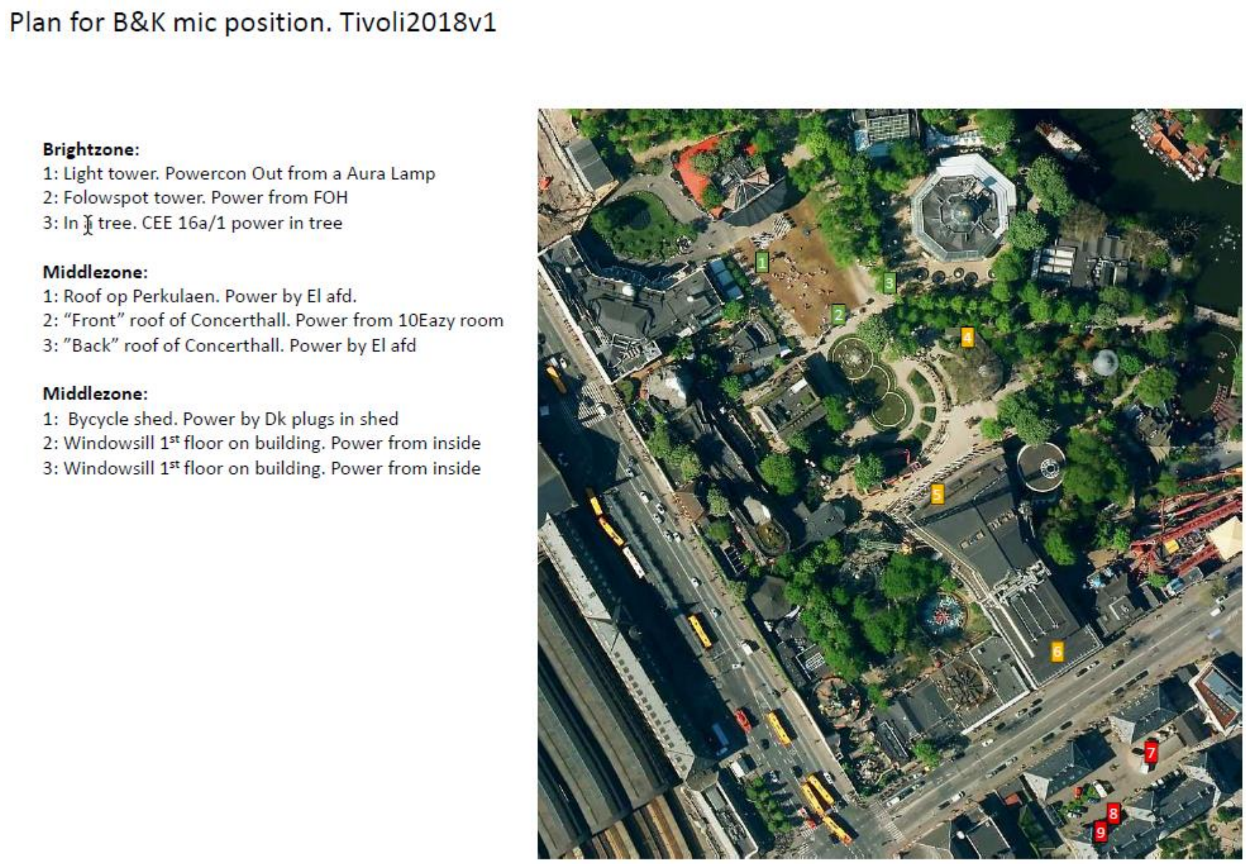


Figure 49 map of Tivoli gardens showing positions of the nine B&K SLM deployed

The first version of "The Silent Shower" – an area with reduced noise was placed in the back of the primary area for guests and can be seen in Figure 50 and Figure 51.

Figure 50 The quiet zone aka silent shower installed in Tivoli

Figure 51 The quiet zone aka silent shower – view from front angle

8.1.1 Results of the Test

The deployed 9 Sound Level Meters were running very stable, and Sound Levels and 1/3 octave spectra were displayed in the COP Dashboard and in the App. The setup of the Sound Level Meters would be easier and less time consuming if GPS coordinates could be transferred directly to the MONICA cloud (and COP).

The deployed ASFC data stream was running without interruptions. However, the system did not perform as it should acoustically. The main hypotheses for the failure are:

- Problems with time reference when measuring transfer function
- Problems with poor signal to noise ratio (SNR), both during measurement and concert
- The weather conditions were too much changing for a static solution

For the Quiet Zone (QZ) it was the first ever test outside of controlled lab conditions. The results leave room for improvement. Of course, the experience from testing under harsh conditions, even hard rain, are taken into the ongoing improvement of the Quite Zone, so better results are expected in 2019.

Both, the ASFC and the Quiet Zone had problems with getting permissions from the local authorities for acoustic measurements. So, for next year we are in the progress to establish a collaboration in an earlier stage.

The Sound Heat Map will be deployed in 2019. The acoustic model behind it is running but full integration into the MONICA Platform will be ready be February 2019.

8.2 Crowd & Capacity Monitoring

As part of the Friday Rock demonstration, six IP cameras were installed on the venue. Two of these cameras were used to cover the entrance place in front of the main gate the other 4 were placed inside the garden.

Figure 52 and Figure 53 show the camera positioning of the two entrance cameras, circled in red.

Figure 52 Camera postion 1 Tivoli

Figure 53 Camera postion 2 Tivoli

8.2.1 Visitor Counting

The event in the Tivoli pilot went well and we had no issues from a setup or running point. Since the software used within WP5 has been designed to be as remotely deployable as possible, so we installed all the required software, VCA core, and the SFN docker remotely. However, a WP5 representative was present at this pilot to do a specific part of the software calibration, required to ensure the top down projection of crowd density is as accurate as possible.

Tivoli pilot provided us a good access and decent internet, so the connection to the processing node via fibre was very smooth and fast. Consequently, at times when the event was very busy, the mobile network was sufficient to transmit the data up to the cloud.

In this pilot, the access to the cameras was set up well in advance. However, it's worth mentioning Tivoli's restrictions on accessing their network. Tivoli has strict restrictions that we could not have access to it, accordingly, they provided a separate network for our work.

As Tivoli allowed us to capture some outputs from the site during the event, a few images have been included to highlight good and bad cases of the crowd density algorithm. The frequency of image saving is very low, around one frame per hour with low resolution for privacy concerns. In the following three figures, you can see the automatic crowd density results generated by the algorithm. The left image is the original frame captured from the camera with the camera id, timestamp and the total count generated by the algorithm overlaid. The right image is the density map produced by the algorithm, where white areas represent people (specifically heads).

8.3 Locate Staff (interaction with staff)

The deployment was successful. Everything was running fine during the demonstration on Friday. Figure 54 shows the configuration of the deployed base stations. An obstacle was the proper installation procedures for the base stations used for the staff tracker. The IT department of Tivoli was doing the installation and after the first tests the base installation had to be replaced for better functionality. Lessons learned is that the required base stations installation needs to be performed installed by a certified installation company with the right experience.

The crowd wristband was tested by 6 people from the security staff. The COP Dashboard was able to visualise the location of these wristbands as shown in Figure 55. The location of 3 different crowd wristbands is indicated by red dots.

Accuracy was, depending on the location (location specific biases), found to be between 5m and 15m. The localisation algorithm used was a naive method based on a weighted average of the signal strength to selected base station locations. The aim is to further improve the localisation accuracy by employing more elaborate algorithms for 2019.

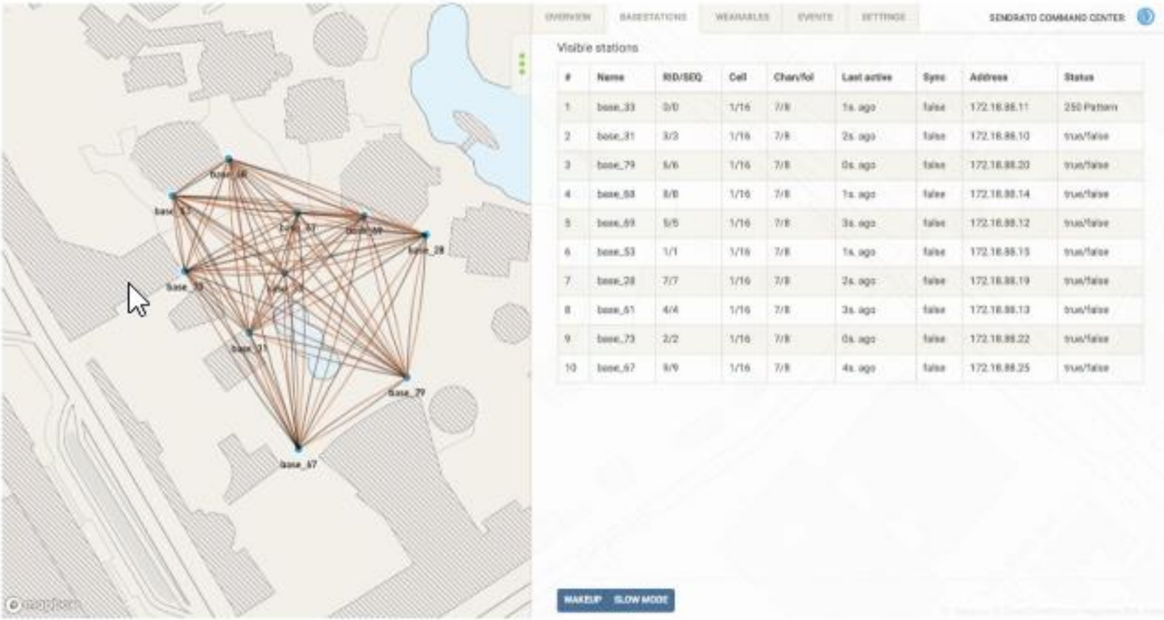


Figure 54 Screenshot of the deployed base stations in Tivoli – showing base station position and their RF connectivity

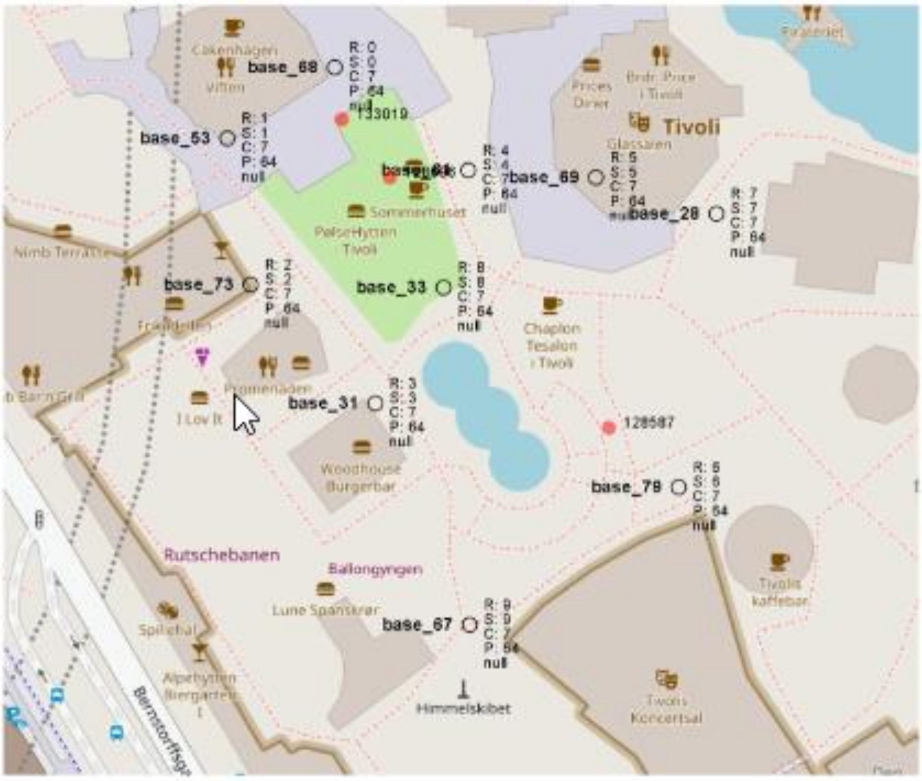


Figure 55 Digital Map on COP Dashboard. The red dots indicate the position of a wristband in test

8.4 Summary and Outlook

Real-time localization of people with crowd wristband was executed and in 2019 will be extended to test the missing person/child use case with "real" people, taking into account valuable feedback received during post-event workshops carried out with the end users and stakeholders. This concerns hardware and software, like visualization of data on the digital map in the COP Dashboard.

To realize this, Tivoli is working on a permanent installation of the wristband base stations to have large-scale demonstrations with crowd wristbands, cameras and sound measurements in 2019. We are aiming to have a permanent installation of the COP in our control centre in the Tivoli Gardens. This means, that we have the opportunity to test the components several times during the next season on selected Fridays

The second topic for optimization is the counting algorithms. The aim is to further improve the counting results in collaboration with MONICA partners, in order to optimize the conditions for video data capturing by integrating all parameters in the best possible way.

Last but not least, Tivoli are also going to test the App-version of the COP by several staff members.

9 Puetzchens Markt

Puetzchens Markt[4] is a street festival that takes place in Bonn every year in the second week of September. During five days, the event offers all kinds of attractions such as traditional merry-go-rounds, 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 m2. Visitors can enjoy the festival for free and can access it from 6 different open entrances. The opening hours vary from midday to midnight or until the early hours of the next morning.

Table 14 Selected Use Cases for Pützchens Markt

ID	Use Case Group	Tested in 2018	Planned 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

The requirements for the solutions to be tested were developed in the course of the project in various workshops with end users in a co-creation process. Co-creation takes care to involve all stakeholders involved in a product right from the start to ensure the greatest possible added value for real-world use. For example, various approaches and prototypes were discussed with representatives of public order office, fire brigade and police. Nevertheless, the interests of the organizers as well as data protection and privacy requirements have been incorporated into the development right from the start.
The close collaboration between researchers and users was given top priority during the field test at Pützchens Markt. During the event, the researchers were available in the command center where also the coordinating group was working, which resulted in a regular exchange. All staff and forces were given access to the COP Dashboard.

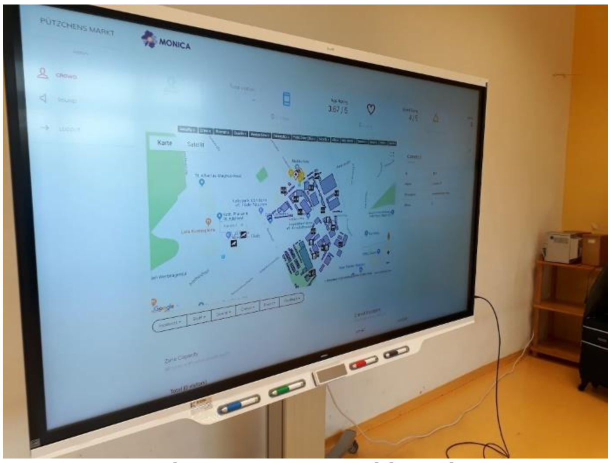


Figure 56 COP Dashboard

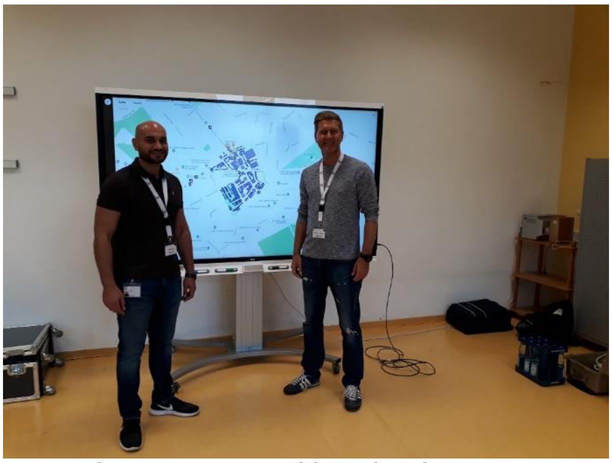


Figure 57 COP Dashboard and partners

The command center was located in a school building. In a separate room, a 75" smart panel was set up to demonstrate interaction with the COP Dashboard (see Figure 56 and Figure 57). The interactive features of the platform were explained and lively discussions with many different members of staff from the field and from the command center took place.

[4] http://www.freundeskreis-puetzchensmarkt.de/

Table 15 Summary of deployed IoT Devices

IoT Device Type	Number of deployed devices 2018	Plans for 2019
Cameras	4	6 – 10
LoTrack GPS Tracker	16	50
Blimp	1	0 or 1
Smart Glasses		to be decided
Visitor App		> 20.000

9.1 Crowd & Capacity Monitoring

Figure 58 Map showing camera positions

During the MONICA field test, four IP cameras were installed on the Pützchens Markt venue (see Figure Figure 58). Two of these cameras were used to count visitors on two main access routes and two to measure crowd densities (i.e. count people in a defined image area).

9.1.1 Visitor Counting

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

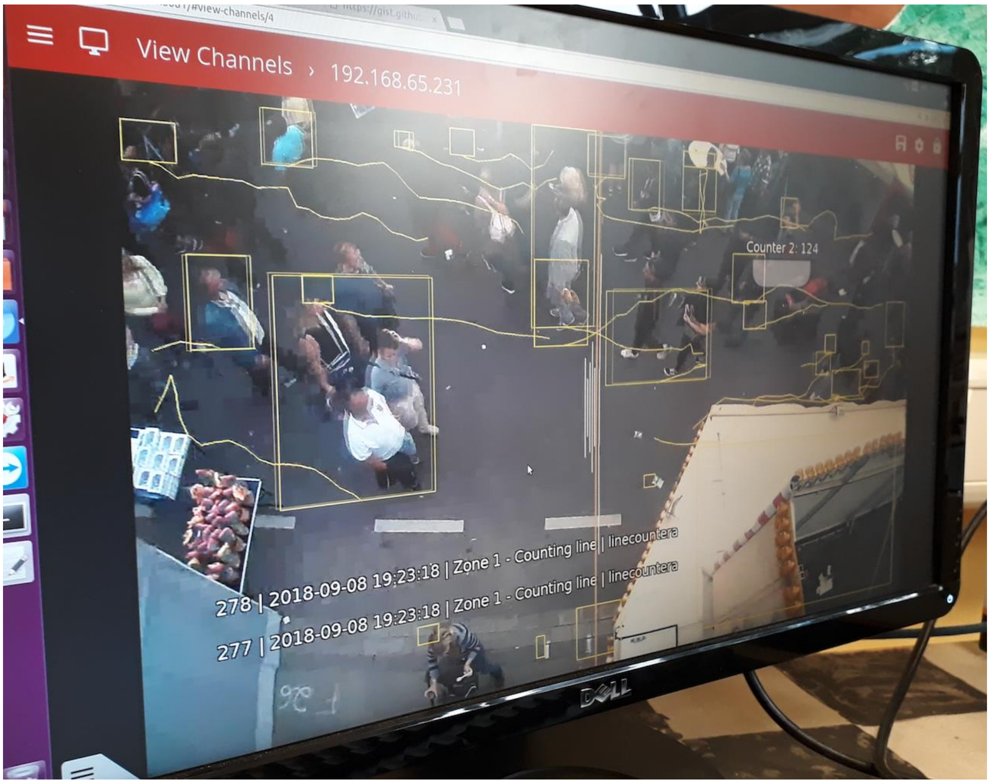


Figure 59 Gate counting algorithm at work

Basic functionalities of VCACount are shown in Figure 59. The software places a virtual line in the center of the picture filmed by the camera. As soon as a person is detected to move over this virtual line, the algorithm adds or subtracts the people who cross the line, depending on their direction. In order to improve the algorithm's result the camera position should be precisely on the top of the scene.

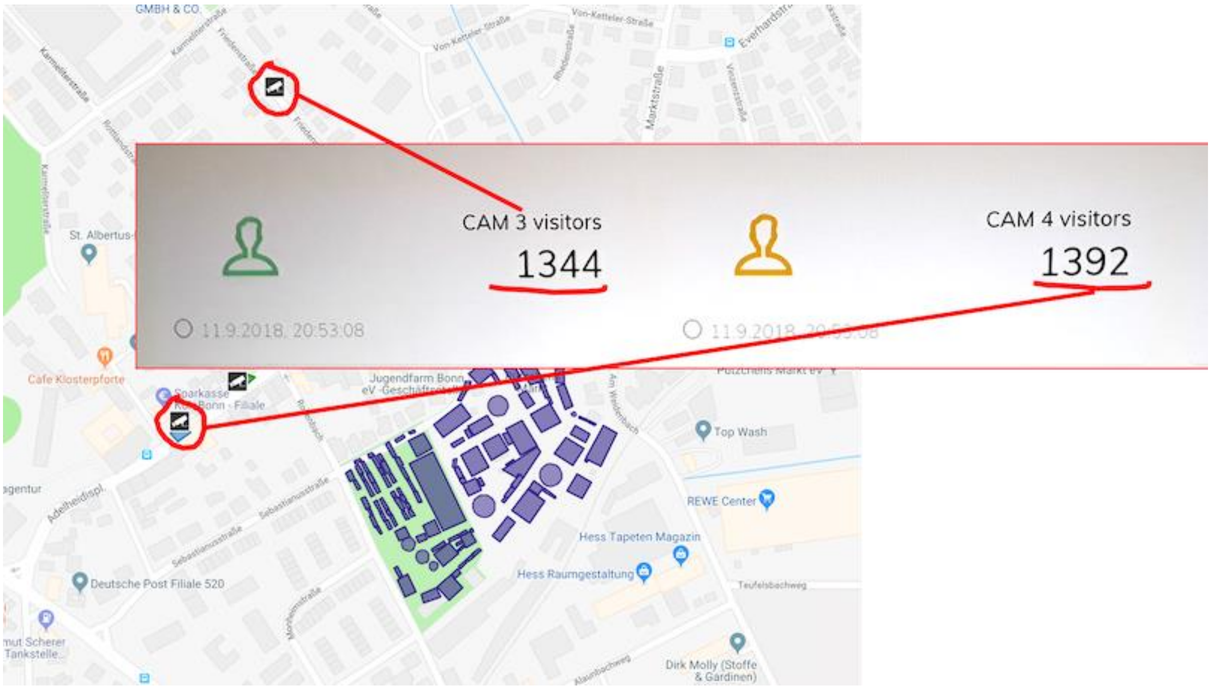


Figure 60 Visualization of visitor counting on COP Dashboard

Figure 60 shows the visualization of the visitor counts in the context of the digital map on the COP Dashboard. In this example the numbers refer to the total of counted visitors (sum of people entering and leaving).

9.1.2 Crowd Density Estimation

The crowd density measurement technology is provided by Kingston University. The corresponding software module is seamlessly integrated into the MONICA platform. The following two figures show how crowd density is visualized in the COP Dashboard.

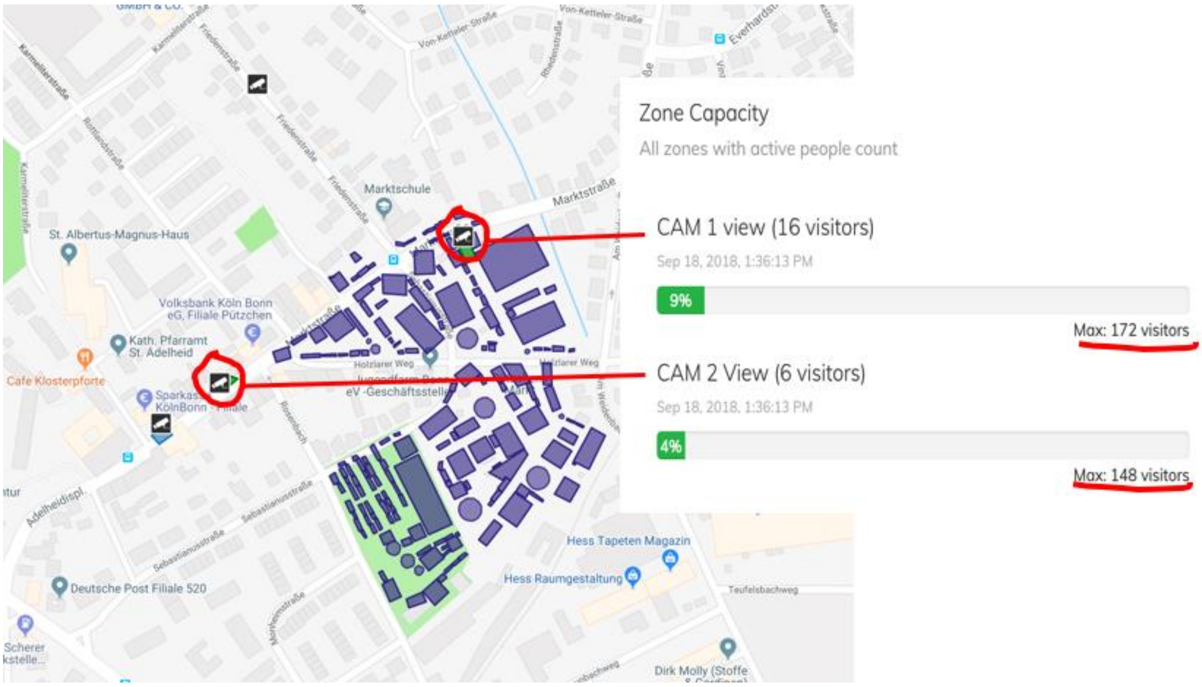


Figure 61 Visualization of crowd density 1

Figure 61 shows the combination of absolute figures and a density percentage, based on the maximum number of people allowed in this area. This maximum crowd density can be predefined within the system. In this example the maximum number of people allowed in this area has been provided by the public order office based on the width and length of the camera's visible field.

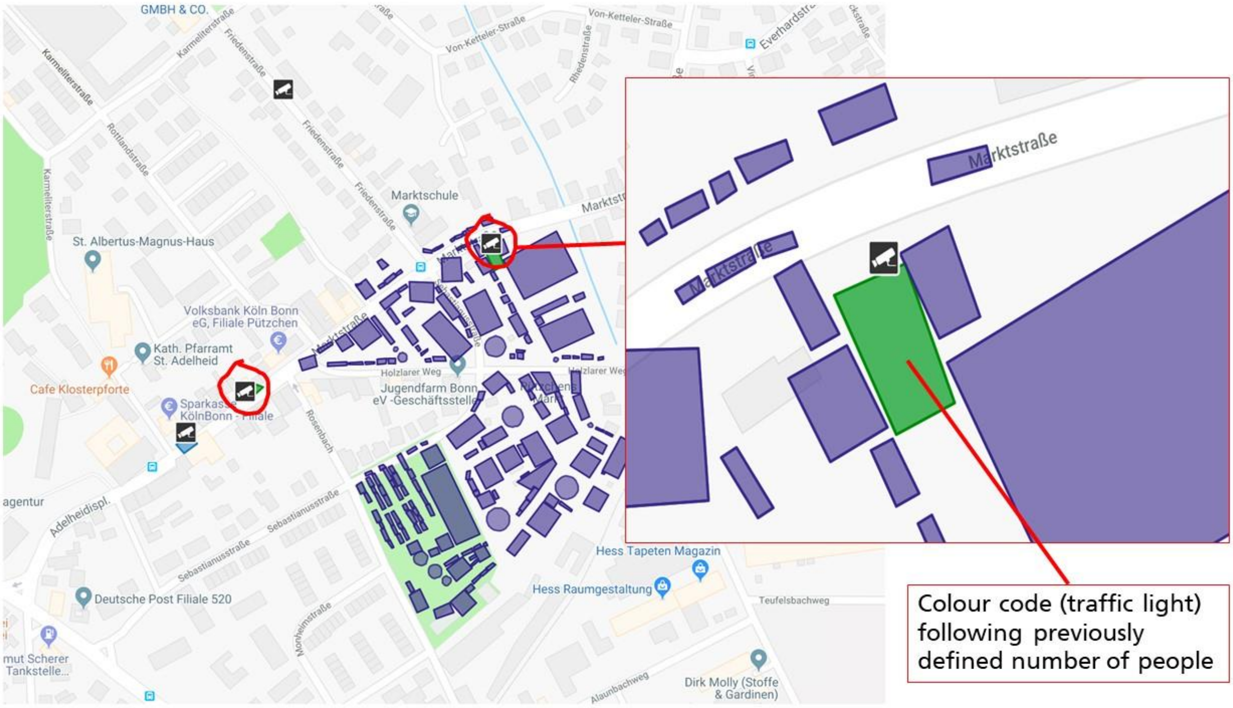


Figure 62 Visualization of crowd density 2

As another visualization the COP dashboard shows color coded areas (Figure 62). Color coding changes based on the number of counted people this area and predefined thresholds from green to yellow to red. Thresholds need to be defined in the system in advance according to the local authorities.

9.1.3 Results of visitor counting and crowd density measurement

The following explains the results of the visitor counting and crowd density measurement.

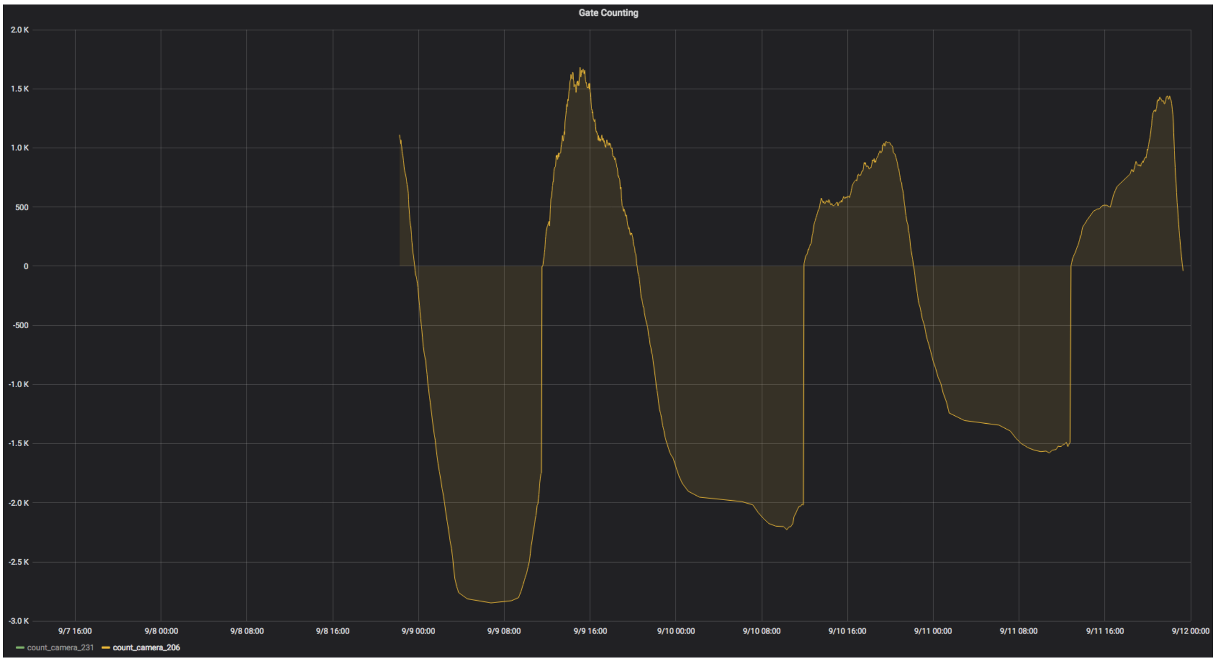


Figure 63 Visitor counting raw data

Figure 17 shows the results of the visitor counting on one street (Cam 4 in Figure Figure 60). The counting algorithm started to run on Saturday 08.09. at 10:13 PM. This leads into negative results, since more visitors are leaving the area than new visitors arrive. From this moment until 4:30 AM, the algorithm counted 2,847 people leaving the site. The following Sunday, the counter was reset to zero at 11:30 AM. From this point, the curve shows a steady increase in visitors, which reached its peak at 3:03 PM counting 1,682 visitors. At this point the number of people on the site decreases steadily. There are two possible ways to explain the negative total. One is that already before setting the counter to zero, a larger number of visitors was present at the site. The other explanation highlights that this exit was used by more visitors that people who had used it as an entrance the preferred exit used also by visitors who had entered the site by one of the other entrance paths (only the two main entrance roads were camera observed). Let's take a comparative look at the two cameras counting visitors.

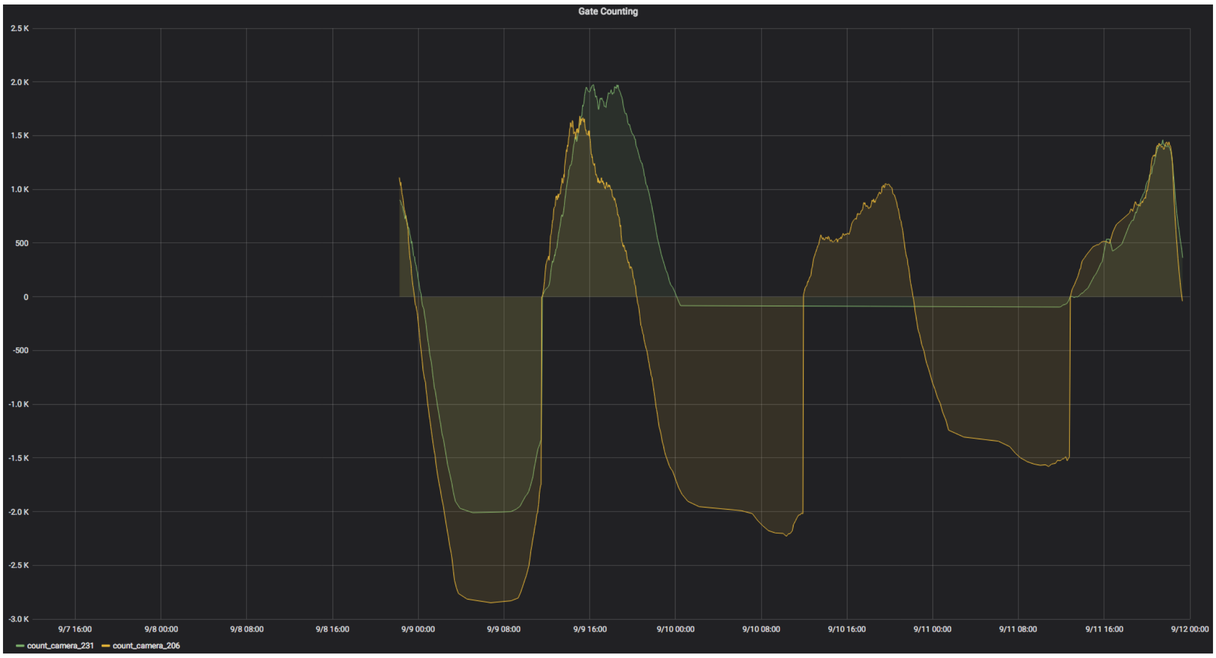


Figure 64 Comparison of raw data of visitor counting cameras

Figure 64 shows the counted number of visitors of both cameras. Camera 4 was out of order within the timeframe from Monday night 00:35 AM until Tuesday 12:01 PM for a technical reason. Nonetheless, interesting insights can be drawn from the numbers. It becomes clear that the number of visitors who arrive on site via one way (1,972 people) on Sunday is larger than the number of visitors using the other way (1,682 people). We can also see that the visitor stream leaving the site starts earlier at one street (3:16 PM) than on the other street (6:40 PM).

As expected, Monday sees the number of visitors being significantly lower than on Sunday. The peak measured by one camera shows 1.053 visitors at 7:35 PM. After that, visitors start leaving the site until approx. 01:28 AM.

Another peak can be spotted on Tuesday night during the fireworks performance. The length of stay is much shorter at this moment. The total number of visitors measured does not differ significantly between the two main access points.

The results of the camera-based visitor counting algorithm require further improvement. Random samples show that the number of visitors counted by the software differs from the actual numbers. For this purpose, we selected five-minute samples and counted manually using the video data to compare the manual count with the results of the software. The following table shows these results for three different time periods.

Table 16 Random sample evaluation of the camera-based visitor count

	13:00 – 13:05	18:20 – 18:25	22:30 – 22:35
count 1	-24	54	-369
count 2	-21	51	-381
Software	9	10	-143

The results reveal a difference between the total numbers counted manually and the software count. This difference varies substantially, by a factor of 2 in the best case and a factor of 5 in the worst case. These results lead to two problems. First, the difference itself and second the variance. There is no pattern visible yet. The first analyses lead to the fact that the algorithm counts groups of people walking close to each other as one person. Using these experiences, the work to improve the algorithm for visitor counting is going on. One step to improve the results is to improve the camera position, trying to install the cameras in an exact vertical position to allow them to oversee the street from perfect bird's eye view. Further algorithm optimization happens in collaboration with the project partners VCA and Kingston University.

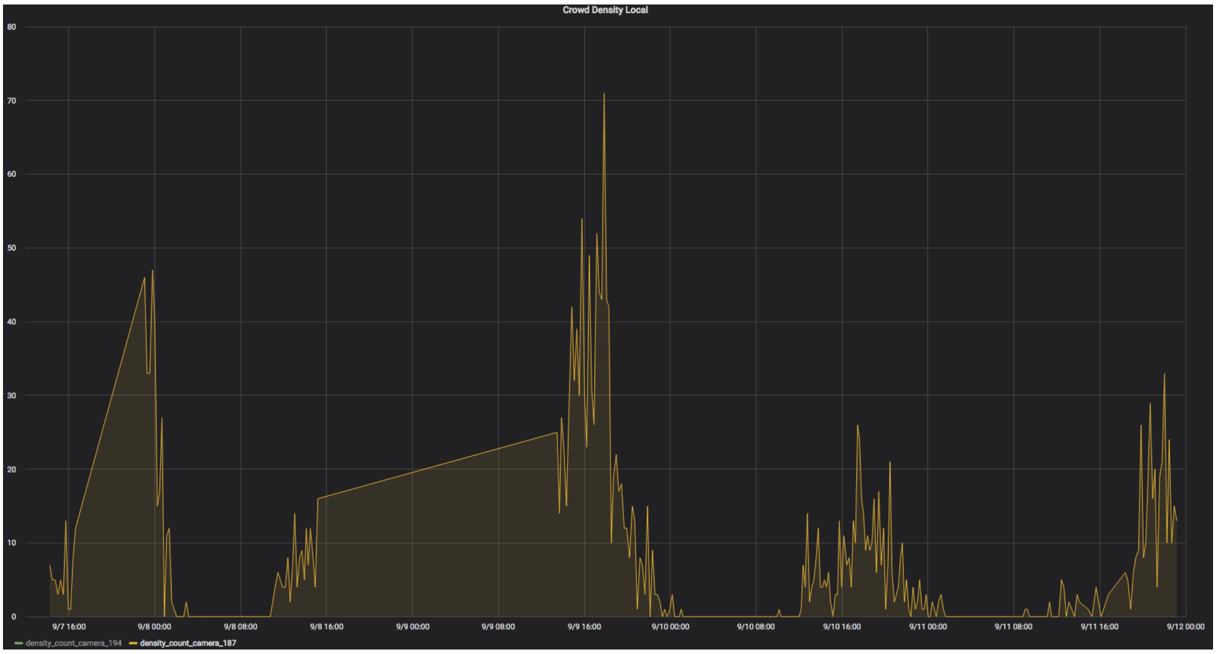


Figure 65 Crowd density estimation raw data

Figure 65 shows the raw data of one of the crowd density estimating cameras (Cam 1 in Figure 61, the one in front of the beer tent). There have been two camera downtimes. First on Friday 07.09. from 4:47 PM until 10:59 PM and second on Saturday 08.09. from 3:17 AM until Sunday 09.09. 1:20 AM. Scanning the data available for the rest of the time, visitor peaks can be spotted easily. The threshold of 172 visitors as a maximum number allowed for this area has never been reached. The maximum peak happened on Sunday at 5:50 PM with 71 visitors counted by the system.

Similar to the counting of incoming and outgoing visitors, the accuracy of the crowd density measurement needs to be improved.

Table 17 Sample evaluation of camera-based crowd density measurement

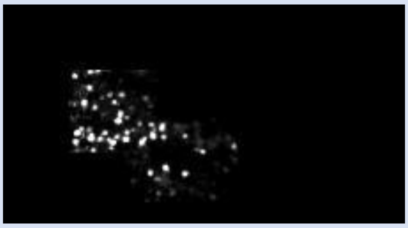
Original frame	Recognized frame	Manual	Software
		ca. 65	37
		ca. 61	58
		ca. 70	45

Table 17 shows three samples of results of the algorithms compared with a manual count. Three pictures/scenes on varying daylight and crowd conditions from the original video were selected. The comparison between the manual count and the software result show a significant difference. At the current level, the algorithm results are not reliable for use in real world conditions yet. The goal is to optimize the algorithm to produce a result with a maximum difference of 10% compared to manual count.

9.2 Locate Staff (interaction with staff)

The real-time localization of staff serves the overall objective of improving the overview in the command center 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 66 Digital Map on COP Dashboard

Figure 66 Digital Map on COP Dashboard shows a section of the digital map. The marked symbols show the position of the corresponding workforce, which are transmitted via the GPS trackers. Fraunhofer FIT and the City of Bonn have equipped 15 teams with such GPS trackers on Puetzchens Markt and tested their use during all five days of the event. The GPS trackers as seen in Figure 67**Fehler! Verweisquelle konnte nicht gefunden werden.** were developed by Fraunhofer FIT

Figure 67 LoTrack GPS Trackers

Features:

- Dimensions (mm): 33 X 50 X 72
- Can be turned on/off with a switch
- Wireless charging

The devices consist of a microcontroller, a GPS module and a LoRa module. LoRa (Long Range) is a wireless transmission technology characterized by very long range and low power consumption. In Europe, LoRa uses among others the royalty-free 868 MHz band.

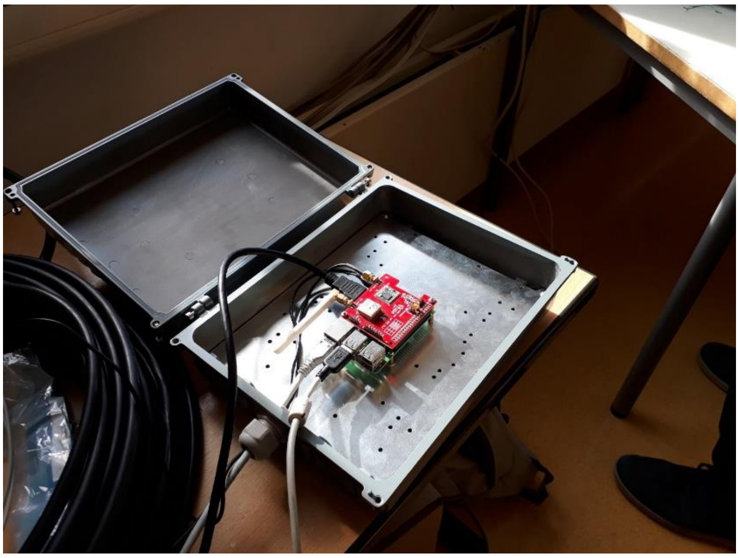


Figure 68 LoTrack Gateway

The gateway (Figure 68) was a standard Raspberry PI 3B + with a LoRa expansion board and an 800 MHz antenna. This was installed in a waterproof aluminum housing which was powered by PoE (Power over Ethernet). In order to use the receiver outside of buildings.

The 15 units were divided among the staff as follows:

- Public order office: 4 devices
- Fire brigade: 3 devices
- Police: 4 devices
- First aid: 2 devices
- Security: 2 devices

In the following, the results of the field trial of the LoRa Trackers are described from a technical point of view.

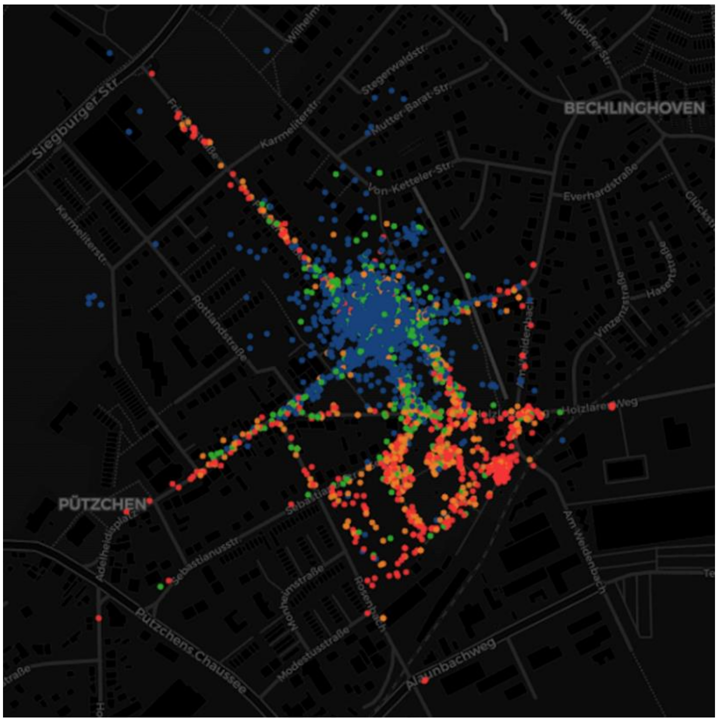


Figure 69 Range of the LoTrack GPS Trackers

Figure 69 visualizes the range of the LoTrack trackers. Blue indicates the best signal strength, decreasing in green but still good. In the red area, the signal strength decreases but is still strong enough to ensure proper functioning. The picture shows the last 500 received signals of the 15 different trackers. The range of the devices during the field test was about 800 meters, which means that the entire market area could be covered with only a single gateway (i.e., one antenna). Even at peak times with an estimated 100,000 visitors, the transmission worked flawlessly. In order to improve the reception strength even in the southern areas, another gateway could be placed in this area. The only requirement is an internet connection.

Figure 70 Inaccuracy of the GPS signal (Delusion of Precision)

Figure 70 shows the accuracy of GPS signals, showing very nicely the ways and road of the market area. Depending on the structure of the exhibitors, the accuracy can slightly decrease, but it is always visible on which street a staff member wearing LoTrack is currently located. The quite large scattering circle around the command center in the center of Figure 70 shows, that, the LoTrack accuracy suffers, as soon as the devices are inside a building, when staff members entered the command center.

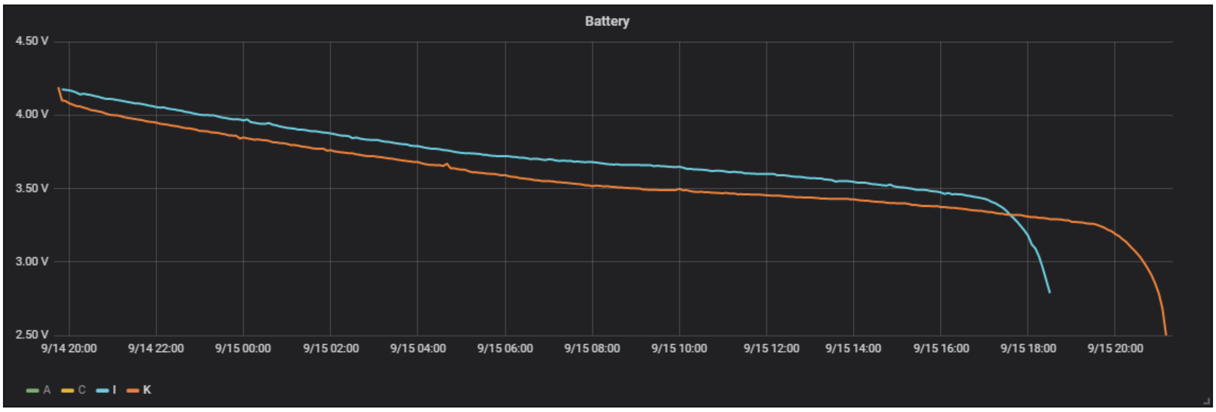


Figure 71 Battery runtime of two LoTrack trackers

The runtime of the devices during the field test was about 24 hours. Figure 71 shows the battery life of two devices in use.

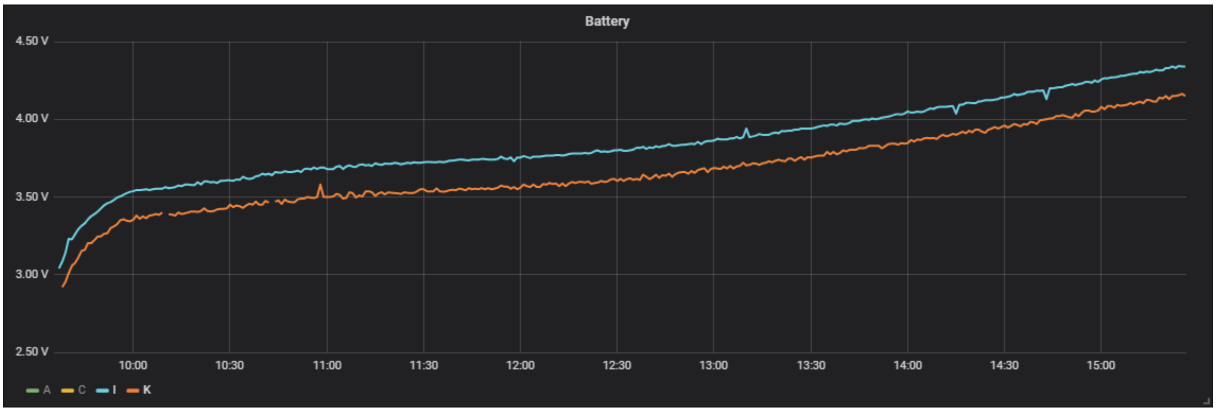


Figure 72 Loading time of two LoTrack trackers

Figure 72 shows the loading time of two empty LoTrack trackers. It was less than 7 hours with the devices switched on. For the first field trial in the context of Puetzchens Markt, the transmission frequency of LoTrack was set to an average of 30 seconds, i.e. every 30 seconds the position on the COP Dashboard was updated. Over the course of the test, this frequency has proven to be too low, as emergency personnel can move a significant distance in 30 seconds. For the next field trial a transmission frequency of 5-10 seconds is desired. Battery life may be expected to decrease, however, with the effects likely to be in the acceptable range. The minimum duration should not be less than 12 hours.

The 15 devices were worn by the test persons during use. Feedback was mainly regarding the size and robustness of the devices. Both parameters will be optimized in the next version. Furthermore, an "emergency button" is desired, i.e. a button that when pressed will raise the attention on the COP Dashboard.

The general idea of the localization of staff was received very positively. The next version will be tested at the next event, most likely Rhein in Flammen.

9.3 Health and Security Incidents

Detecting and communicating about health and security incidents was merely implemented by the previously described technologies. Realtime localization of staff is a part of improving the communication during health and security incidents. For what concerns the detection of such incidents, the fight detection module could be activated for the crowd density cameras, however, the number of false positive detections at a crowded goose fair could be too high. Tests in that regard will be performed in 2019. Furthermore, smart glasses are still in the scope of being tested in 2019 for detection of incidents.

9.4 Deployment of Airship (Blimp)

The blimp represents an alternative way to get video data from the site and get an overview of crowd movements from a bird-eye perspective. The aim of this test was to collect video data on the test site under real conditions and to evaluate the data quality in order to use this data for further analysis.

Figure 73 Blimp

Figure 73 shows the blimp during the test. Due to the weather conditions and strong wind during the testing days, the blimp was unable to be kept in a straight position, in order to collect useful video data. Nevertheless, important findings for the deployment of a blimp as a video data collection device were gathered. The next deployment is planned at Rhein in Flammen festival in 2019. The local conditions on the site of this festival promise to be better, as it takes place at an open field, while Puetzchens Markt is within a narrow neighborhood with many private houses and closed courtyards. The Monica consortium tries to prepare and test a variety of camera carrying systems for the tests scheduled in 2019, in order to react on changing weather conditions on site and to ensure video data with a birds-eye-view can be collected. There are other options, e.g. using drones or installation of a camera on one of the festivals constructions, which are being evaluated.

9.5 Summary and Outlook

The field test on MONICA technologies at Puetzchens Markt in Bonn has been completed successfully. Numerous data was collected and dedicated findings have been obtained.

Real-time localization of staff gained high respect within all stakeholders involved and will be further developed taking into account valuable feedback received during post-event workshops carried out with the end users and stakeholders. The feedback concerns hardware, like the size and robustness of LoTrack trackers carried by the staff, and software, like visualization of data on the digital map in the COP Dashboard.

The second topic for optimization is the counting algorithms. In 2019 we will optimize the conditions for video data capturing by integrating all parameters in the best possible way.

10 MOVIDA

Nightlife activities in open-air create increasing challenges for cities, in terms of security and noise pollution. The Movida nightlife in San Salvario in Turin Italy 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 causes increasing disturbances to the neighbors. 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.

Table 18 Use Cases for Movida Pilot

ID	Use Case Group	Tested in 2018	Planned for 2019
UCG 2	**Sound monitoring & control**	**X**	X
UCG 3	**Crowd & Capacity Monitoring**	**X**	X
UCG 7	**Security Incidents**	**X**	X
UCG 8	Health Incidents		X
UCG 11	Evacuation		X
UCG 13	Event Information		X

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.
Consequently, the main challenges of the MONICA demonstration 2018 for Movida have been deploying and testing a long-term monitoring system, coupling noise and crowd monitoring. Together with this task, the application of wearables has been verified by local Police, testing future scenarios for security incident detection and management, together with a permanent deployment of the COP Dashboard.
The deployment for the pilot demonstration was complete before the 6th of November, while the official integration and testing period was between 8th and 11th of November, in conjunction with the Urban Space Hackathon[5].

Table 19 Summary of deployed IoT Devices

IoT Device Type	Number of deployed devices 2018	Plans for 2019
Cameras	3	3
IoT Sound Level Meters	9	12
Smart Glasses	2	4

10.1 Sound monitoring and control

City of Torino put in place in 2016 a low-cost IoT noise monitoring network using several Android smartphones in San Salvario district. The location of six sensors was optimized to cover all significant feature of Movida area: one in Largo Saluzzo (S_03), the very crowded square, three in narrow streets with pubs and bars (S_01, S_04 and, 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. Data collected with a sampling time of 1 seconds

[5] https://www.monica-project.eu/the-shhh-project-wins-the-third-monica-hackathon/

are continuously sent via Wi-fi or 4G to the regional IoT Open Data Platform which is integrated with the MONICA Open Data Platform[6].

The City monitoring network was improved for pilot demonstration with three B&K IoT Class 1 Sound Level Meters: one installed on long-term on a light pole in Largo Saluzzo and two temporary extra points, placed on balconies of two dwellings, one in via Saluzzo 32 and the other in via Baretti 4. The locations of these SLMs were designed to fulfill the monitoring of via Saluzzo and via Baretti, the two narrow streets used by Movida-goers to meet in the hot spot of Largo Saluzzo. The deployment on the light pole was done with a cherry picker provided by the energy provider; deployment on balconies was done with the support of the technicians of Regional Environmental Agency.

Pictures below (Figure 74, Figure 75, Figure 76, Figure 77) provide an overview of deployment, installation and ckeck-up activities in San Salvario.

[6] https://torino.monica-project.eu/

Figure 74 Deployment of SLM000325, Largo Saluzzo, long-term

Figure 75 Check of SLM000325

Figure 76 Deployment of SLM000349, via Baretti 4, temporary

Figure 77 Check of SLM000304,via Saluzzo 32, temporary

Figure 78 and Figure 79 show the final deployment in Movida on the map and visualized on the COP Dashboard.

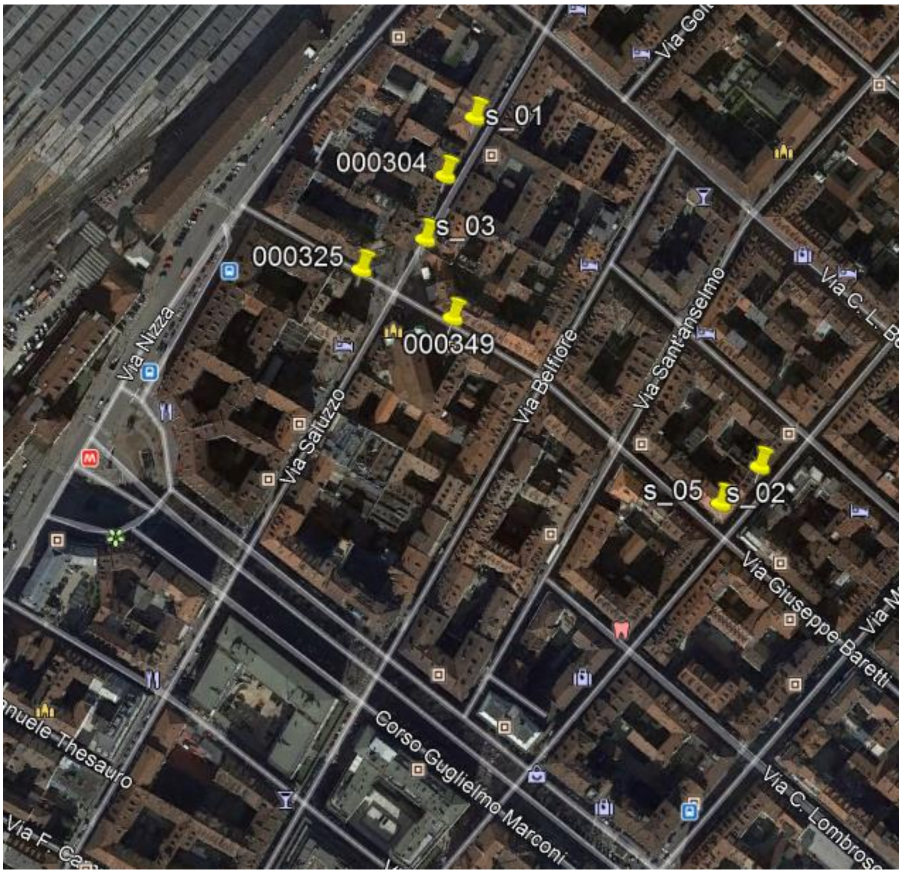


Figure 78 SLMs position and ID on Google Maps

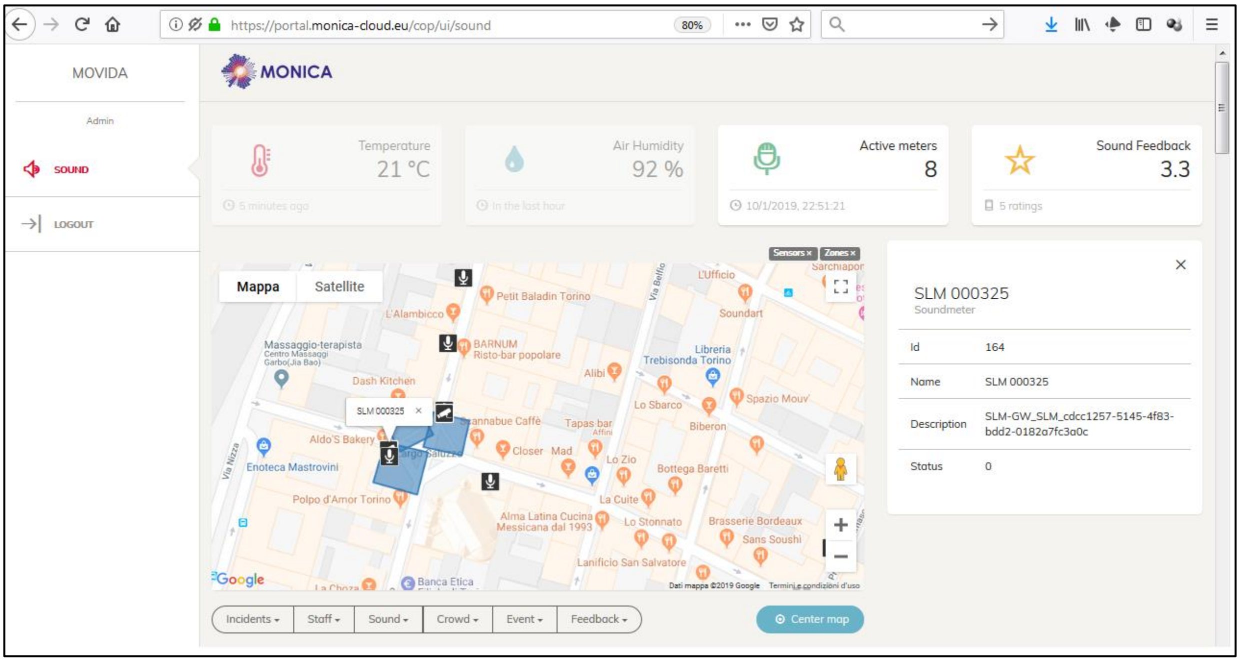


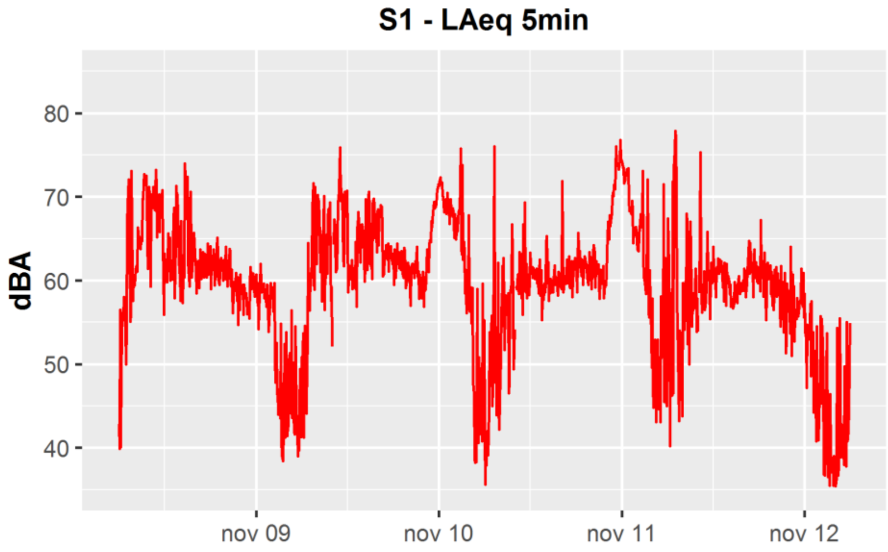
Figure 79 Information about SLMs position and ID shown thought the COP

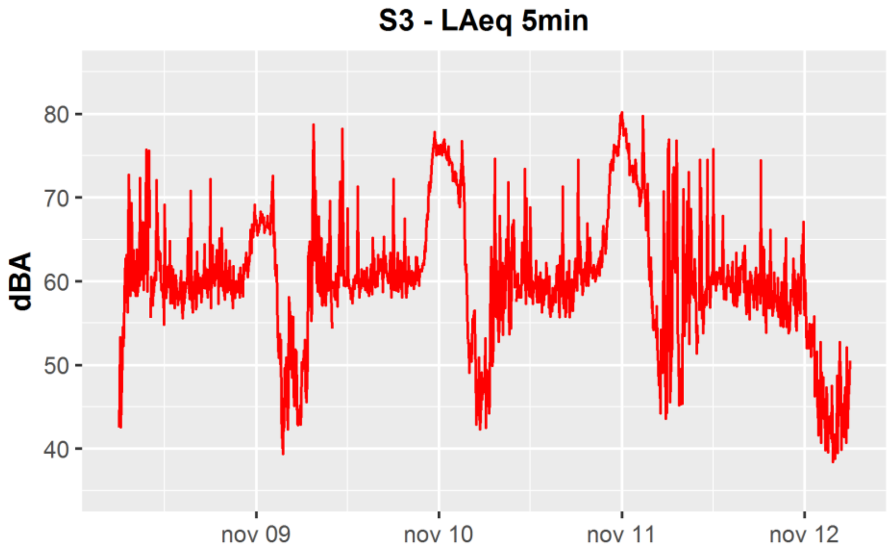
10.1.1 Monitor sound level

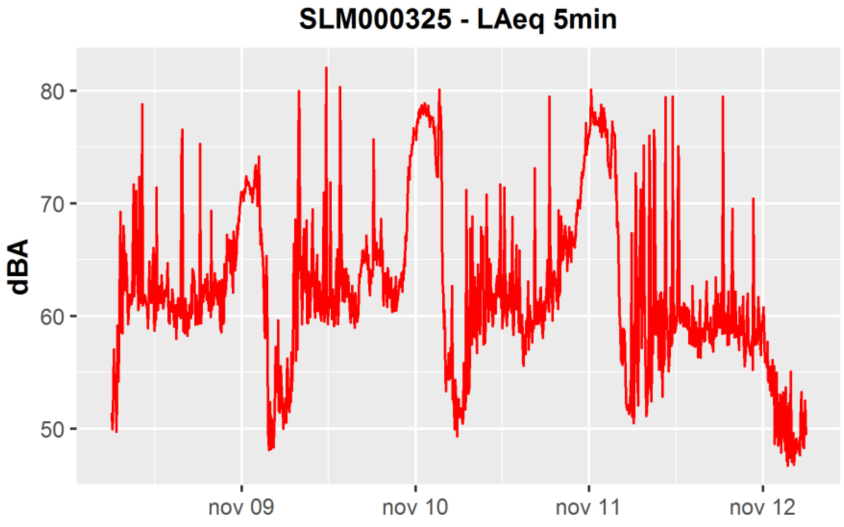
The main purposes of monitoring sound levels for Movida are:

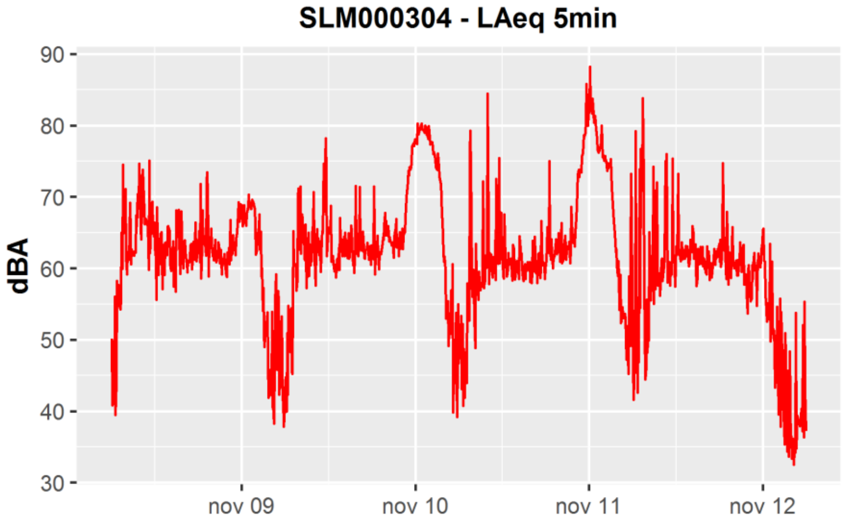
- comparing the noise levels to legal limits and thresholds;
- providing data to be correlate to crowd density on a long term, also feeding the MONICA Platform in order to develop predictions and rules to be implemented in the Decision Support System;
- strengthening the local low-cost IoT network with the use of Class 1 Sound Level Meters.

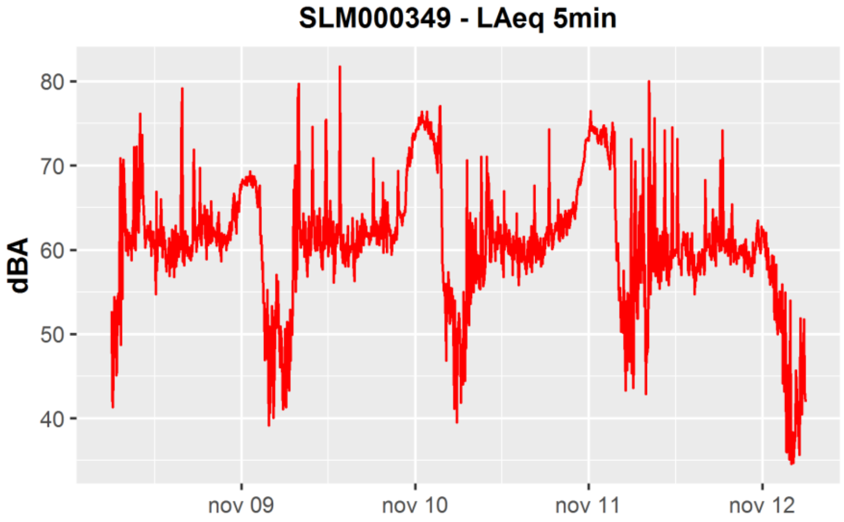
The Class 1 IoT Sound Level Meters provided sound levels (LAeq, LCeq) and spectral information to the MONICA Platform. In addition, the 5-minute average LAeq message has been integrated and tested for the first time. The low-cost IoT Sound Level Meters provided sound levels (LAeq) and spectral information to the MONICA Platform too. This parameter has been considered of great interest for long term monitoring. Data collected for all four days of the demonstration in November 2018 are shown in the following charts:






SLM000325 - LAeq 5min
dBA
80
70
60
50
nov 09
nov 10
nov 11
nov 12


SLM000304 - LAeq 5min
dBA
90
80
70
60
50
40
30
nov 09
nov 10
nov 11
nov 12


SLM000349 - LAeq 5min
dBA
80
70
60
50
40
nov 09
nov 10
nov 11
nov 12

During the demonstration, real-time monitoring was displayed in the COP Dashboard (Figure 80). The noise legal limit is set to 55 dB(A).

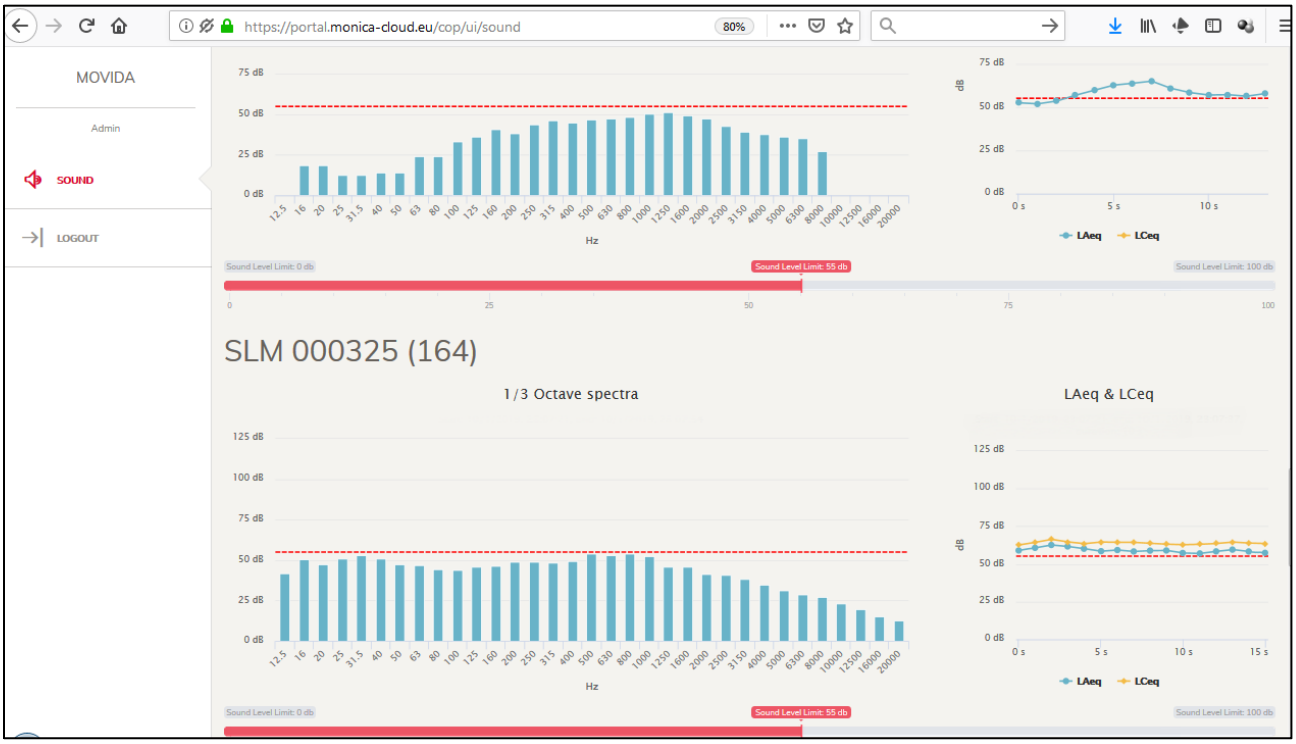


Figure 80 Leq 5min and spectra measured by the local IoT network and by B&K SMLs, showed in real-time during the demonstration.

Data collected confirmed the highest noise levels between midnight and 2 AM, and an extra peak due to cleaning service at 3 AM. A great difference could be appreciated perceived comparing levels on Thursday, Friday and Saturday, with Sunday night. This trend is clearly related to the increase of the number of people in the streets. Comparison between L_{night} (22:00 6:00) measured by SLM000325 (class 1) and S_03 (low-cost) confirmed a good reliability of the low-cost IoT network: the two results for Sunday night were respectively 73,5 dB(A), and 74,5 dB(A), considering the precision of 0.5 dB(A) for Class 1 SLMs.

10.2 Crowd and capacity monitoring

The Torino municipality employs in San Salvario an advanced video surveillance system composed of three IP HD cameras, with PTZ function. This video surveillance system is used to record the images of events and carry out any subsequent analysis of the recordings, in fact the images are not usually subject to constant monitoring by operators of security, but live view is conducted under certain circumstances. Being Largo Saluzzo an open area and considering the positioning of the cameras, MONICA operations do not proceed to access control at Movida, but to monitor the mass of people who routinely gather in this place especially at night. The monitoring of the square is therefore intended to ensure the repression of any crime, but also the ability to prevent danger and monitor the crowd to ensure both security and safety of Movida-goers. As part of the MONICA project, the Torino municipality has made available a powerful data processing node to crowd density analysis and incident/object detection.

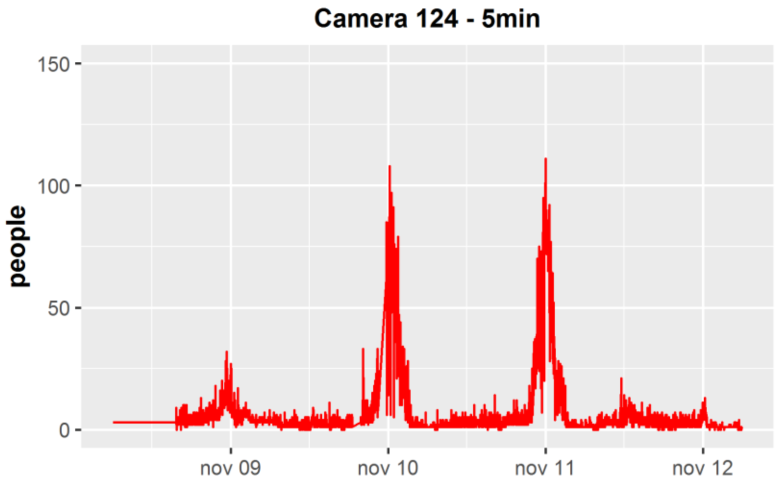
10.2.1 Monitor crowd based on capacity

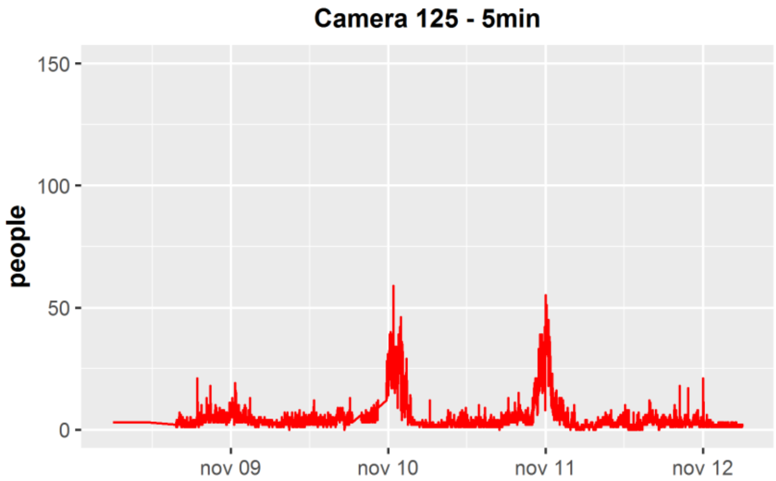
MOVIDA was the first truly remote deployment of the MONCIA video analytics subsystem. The software has been designed to be as remotely deployable as possible, in an effort to reduce the need for a representative to be present at every pilot. The only requirement for an onsite presence is to do a specific part of the software calibration, required to ensure the top down projection of crowd density is as accurate as possible. Given the maturity of the software being deployed and the experience in deploying it, and in situations where this top down view is not a specific part of the pilot use cases, then remote deployment has no major drawbacks and is the preferred method. MOVIDA was also the first pilot where the processing node was run off a 4G modem, this caused issues with signal strength from the beginning, remote access was slow and made setup a lengthy process, however it was not prohibitive.

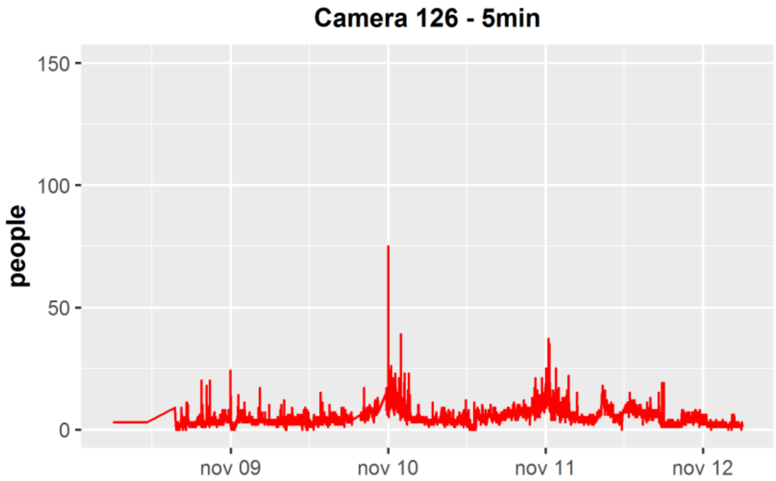
During the event, a MONICA video analytics expert was on hand to remotely address issues throughout the event. There was one such issue where the processing node stopped sending messages to the MONICA cloud. At the same time, remote access to the machine stopped, and this was likely caused by the 4G modem dropping connection. The connection was re-established when the processing node was rebooted by a Torino representative and there were no further incidents.

As Torino municipality allowed to capture some outputs from the site during the event, a few images have been included to highlight good and bad cases of the crowd density algorithm. At this point it should be stressed that, to date, the algorithm itself has not been changed for any of the pilots, however the MOVIDA environment produced better results than any of the other pilot sites so far. This is likely down to a similarity with the images that the algorithm was originally trained with, this is of course coincidence and although favourable, should not necessarily be expected at other sites (see Figure 81).

Figure 81 Three examples of crowd density: (left) the original frames captured from the camera with the mask, camera info, time and total count overlaid. (right) the density maps produced by the algorithm, where white areas represent people







The results of people counting where compared with information coming from wifi scanners provided by H2020 Rock Project in which the City of Torino is involved. Wifi scanners, counting smartphones and wearables, installed in the four access corners of the square, show a larger number of (non-unique) presences in the area of Largo Saluzzo, with the same trend on time-basis showed by cameras (see Figure 82). A more detailed analysis is planned, in order to perform a better estimation of the number of Movida-goers; an extra wifi scanner provided by Telecom Italia has been installed. Data analysis is ongoing at the time of writing of this report.

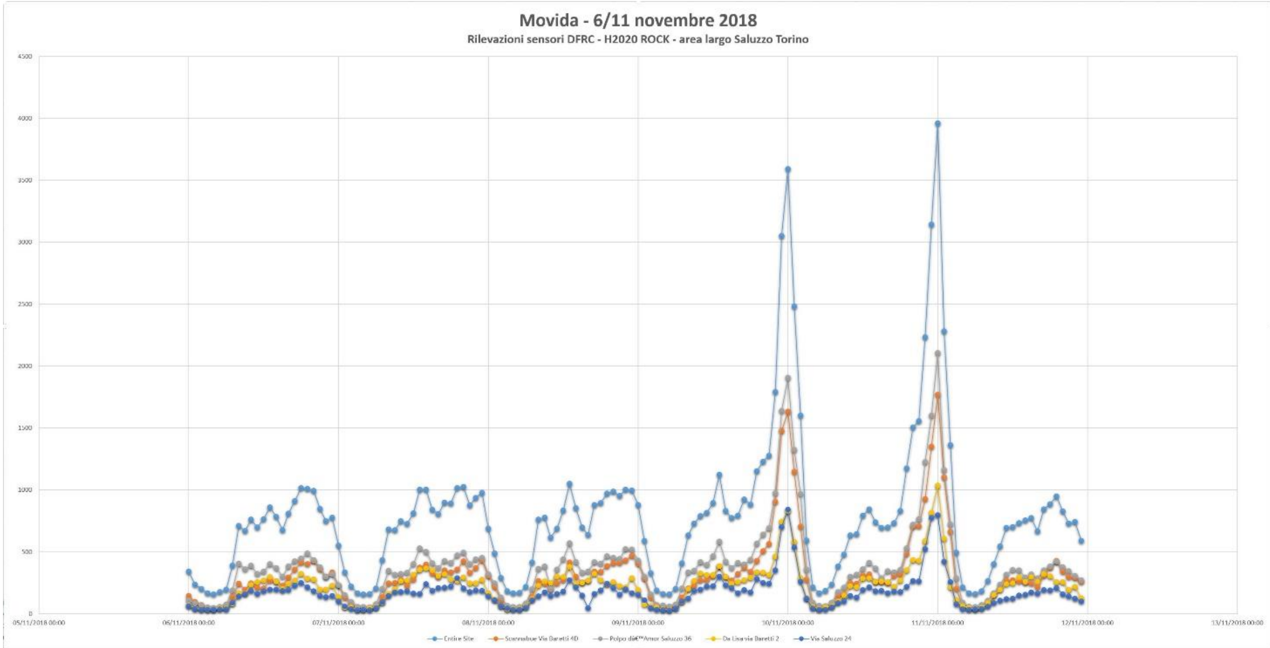


Figure 82 Raw data from WiFI scanners, post processed after the demonstration in Movida

City of Torino expected that a better calibration of algorithms could provide a better estimation of the number of people in crowded situations. On the other side, objects could lead to false results also in empty scenarios (see Figure 83).

Figure 83 Examples of mis reads where objects such as cars or bikes produce false results

10.3 Security Incidents

Security issues are one of the major concerns in San Salvario, given the large number of people gathering in that area especially during the evening. In addition to the security and safety of Movida-goers, ensuring security staff which monitors the district 24 hours a day is of great importance. For this reason, the Municipality of Turin is looking for technological solutions that can make the work of security operators easier and safer. Among the existing IoT technologies it was decided to deploy the smart glasses to ensure better communication between security operators on the street and the operation center, with which there is already a robust radio communication. In fact, the smart glasses represent an IoT instrument capable of guaranteeing the stable transmission of multimedia files (images and videos) in order to support the work of the first line operators during their daily activity, but above all where safety incidents occur.

10.3.1 Handling an incident

In order to test and demonstrate the use of smart glasses during the normal activity of security operators, some local police officers in Turin have voluntarily made themselves available to wear the ORA2 smart glasses, provided by Otinvent, and to test some functionalities that could be particularly useful during working activities. In this sense it was decided to demonstrate a check on the personal identity of a subject, also voluntary, to test the reliability and stability of this IoT instrument (Fig. 7). During the check, police staff on the street exchanged files (jpeg images) with the operation center (Fig. 8 and 9). In order to allow this interaction, Optinvent has developed a specific application called MonicOra for the MONICA project. Movida was the first pilot where the MonicOra application was deployed and tested. The use case (UC) implemented by MonicOra application is the following: the MonicOra server sends to police officers, who were in the street, a message saying that there is a suspicious person to be checked. The officers need to check an Identity Document (ID) of a man by exchanging some photos in both ways, from the officers to the MonicOra server and vice versa. The police station then checks the ID, tells the officers that it is ok and closes the intervention (see Figure 84).

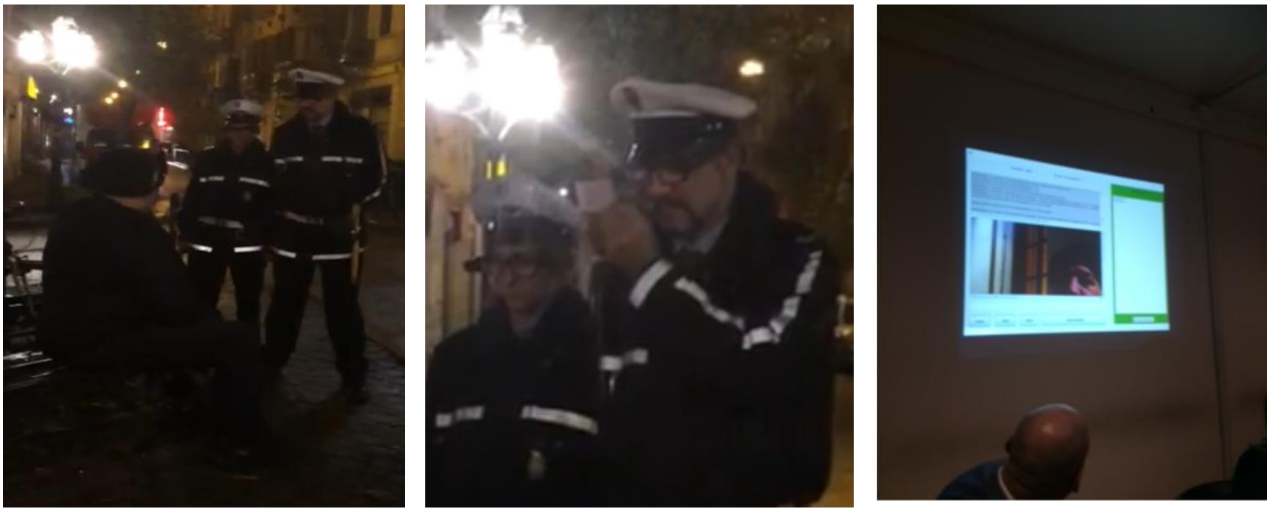


Figure 84 Check of an ID using smartglasses and MonicOra

The two glasses worn by the two officers used a stable internet connectivity provided by their smartphones. On the contrary, the Internet connectivity used by the MonicOra server at the police station was not reliable and this caused several connection issues related to the security & administration, as well as VPN connection. During the first attempt of the demonstration, the officers have received the messages from the MonicOra server but the MonicOra server did not receive any message back from the officers. The reason was a connectivity issue between the glasses and the MonicOra server. The second attempt went well, the exchange of messages and images between the glasses and the MonicOra server were successfully demonstrated.
The security operators appreciated the lightness and functionality of the smart glasses, but their use proved to be useful only if combined with the traditional communication systems in use, especially via radio. In fact, smart glasses offer at the moment a reduced possibility to send text messages, through the use of standard phrases (templates) to be selected on the MonicOra app. For this purpose, it was necessary to use a remote wrist controller, connected to ORA2 via Bluetooth; in fact, the ability to operate directly on the touchpad of smart glasses currently offers a very limited and difficult interaction due to the small size of the pad itself and the display that projects the desktop a few inches from the eye of the wearer of smart glasses. The Internet

connectivity for the glasses and the MonicOra server have been tested in advance in the pilot area. Nevertheless, using a 4G modem as a Wi-Fi hotspot showed its limits during the demonstration, also due to the numerous connected devices. This has also made it more difficult to update and configure the smart glasses in the minutes before the demonstration.
In fact, 4G modems are susceptible to issues of signal strength both by geographic location (i.e. there just isn't a good signal strength where the processing node is) and usage (i.e. in the presence of a large number of people using the 4G network the signal quality decreases). This was a major concern as this provides a weak link in the communication chain, both from a remote access perspective and for stability during the actual event. A more stable data connectivity would be desirable for future demonstrations. For obvious reasons we recommend that connections to the processing nodes be fixed over the use of a 4G modem, however Movida deployment have proved that it can be workable solution if required.

10.4 Results of the Test

Movida Pilot has unique characteristic if compared with other MONICA pilots: it is a long term, weekly based spontaneous event in open urban spaces. The demonstration should be considered as a special improvement of activities to be performed continuously. The following list recaps the results for each the use case demonstrated at Movida:

Sound monitoring:

- connection to network was achieved and stable, even using 4G connection and data transmission of sound levels in dB(A), dB(C), spectra accomplished without significant data loss;
- integration of local network in MONICA platform worked accurately;
- an annoyance index based on L_{Aeq} should be provided with the COP Dashboard, together with L_{night} indicator; threshold on spectra seems not so useful;

Crowd Monitoring:

- due to network bottleneck, a local deployment of workstation and SFN was needed, losing wired connection from the node to Monica platforms;
- remote support was sufficient for installation and calibration of cameras;
- better performance from the algorithms in all situation are expected;
- more details on algorithms result should be integrated in the COP.

Security Incidents Handling:

- the lightness and functionality of the smart glasses was appreciated by security operators;
- without further development, smart glasses can be useful only if combined with the traditional communication systems in use, especially via radio;
- connectivity issues led to a second attempt in order to demonstrate the use case; a 4G modem as a Wi-Fi hotspot showed its limits during the demonstration, also due to the numerous connected devices;

10.5 Summary and Outlook

Movida is a long term, weekly based spontaneous event, that the City wants to monitor and – at the same time, to provide the MONICA project long term set of data. Consequently, the preparation of the demonstration of this Pilot was focused on long term deployments, partially finished (power supply, cameras, sound level meters) and partially to be completed (network connections, workstations). A devoted permanent installation of the COP Dashobard was provided and presented to local authorities (Local Police, Environmental Deps, National Police, see Figure 85 and Figure 86.

Figure 85 Presentation of permanent installation of COP to local authorities

Figure 86 Presentation of permanent installation of COP to local authorities

New techniques for people counting (video analysis, Wi-Fi scanner) were tested. Detailed analysis on data are currently underway; first results shows that most more robust algorithms and ad hoc algorithms should be developed.
Form the technical point of view, data transmission, especially in environments where there are numerous devices connected at the same time, requires a wide and stable data connection; a wired connection is required for the processing node and any MonicOra client / server.

In 2018, the main challenges of the MONICA demonstration for Movida have been deploying and testing a long-term monitoring system, coupling noise and crowd monitoring and security incidents handling by the use of wearable IoT devices.
In 2019 the City of Torino will try and focus more on security and safety due to the presence of such a large number of people in an open urban space; the development of evacuation and health incident use case is planned. In order to achieve a noise reduction, a soft approach by giving information, engaging the goers and using a mix of IoT technologies, apps on smartphone as personal wearables and reward systems (set up by the district/sellers' associations) is planned, exploiting results of Hackathon "Urban Space"[7] .

[7] https://www.monica-project.eu/the-shhh-project-wins-the-third-monica-hackathon/

11 Hamburg DOM

The Hamburger DOM is Northern Germany's biggest funfair with 7-10 million annual visitors during the 91 DOM days.

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 largest fair in Northern Germany, and the longest running fair in the whole of Germany.

The funfair takes place in the premises of the Heiligengeistfeld with a total of around 251 attractions8.

Table 20 Selected Use Cases for Hamburg DOM

ID	Use Case Group	Tested in 2018	Planned for 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 local stakeholders (event organiser, police, and security staff). The technical and scientific partners in Hamburg 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. For 2018 solutions were deployed during two DOM events, the Springdom and the Winterdom. 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.

Table 21 Summary of deployed IoT Devices

IoT Device Type	Number of deployed devices 2018	Plans for 2019
Cameras	2	4-6
RIOT - LoRaWAN GPS Tracker	6	>6
Environmental sensors	8	>8
Staff App (mobile phones)		10

[8] http://www.hamburg.de/dom/

11.1 Crowd & Capacity Monitoring

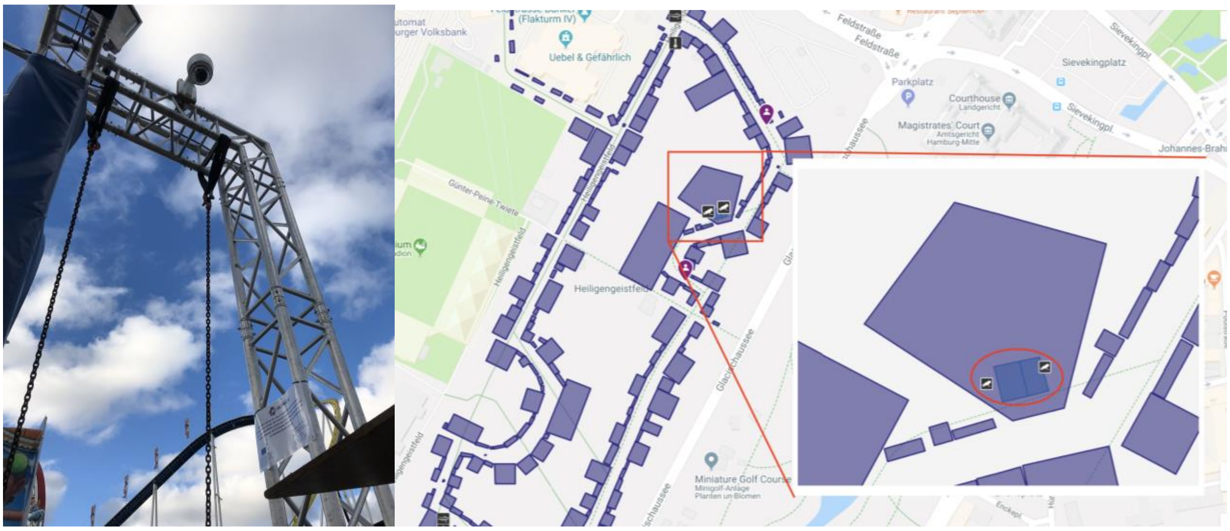


Figure 87 Position of cameras Hamburg DOM

As part of the MONICA pilot demonstration, two outdoor IP cameras were installed during Winterdom 2018 at the entrance of the special event area of the Hamburg DOM funfair. These cameras were used to count the number of people and to observe crowd density in that area to ensure that these numbers do not exceed the allowed capacity. The main technologies used here were the gate counting algorithm the crowd density measurement. Both technologies are seamlessly integrated with the MONICA platform to store and publish results for further usage by other MONICA components such as the COP Dashboard.

Figure 87 shows a map in the COP Dashboard with the camera positions and a photo of one camera deployed at a scaffolding spanning the entrance of the special event are on the Hamburg DOM funfair in November 2018. This allowed a birds-eye position of the camera, in order to improve counting results.

For the crowd density estimation several screenshots of raw footages and the corresponding processed images as well as the count from the algorithm of one day were provided after the event. Figure 88 shows example footage of raw (left) and processed (right) camera images with the corresponding crowd count generated by the algorithm. The results of this test were not satsifying. For instance, the first row of images were taken when the venue was closed, no people present but the algorithm counted 6. In the second row the raw image shows a number of people, however on the processed images they are not visible anymore but the algorithm still counted 15 people (which is still more than in reality). We discussed this issue with the involved project partners and a new version of the algorithm will be tested and evaluated at the next DOM funfair in April 2019.

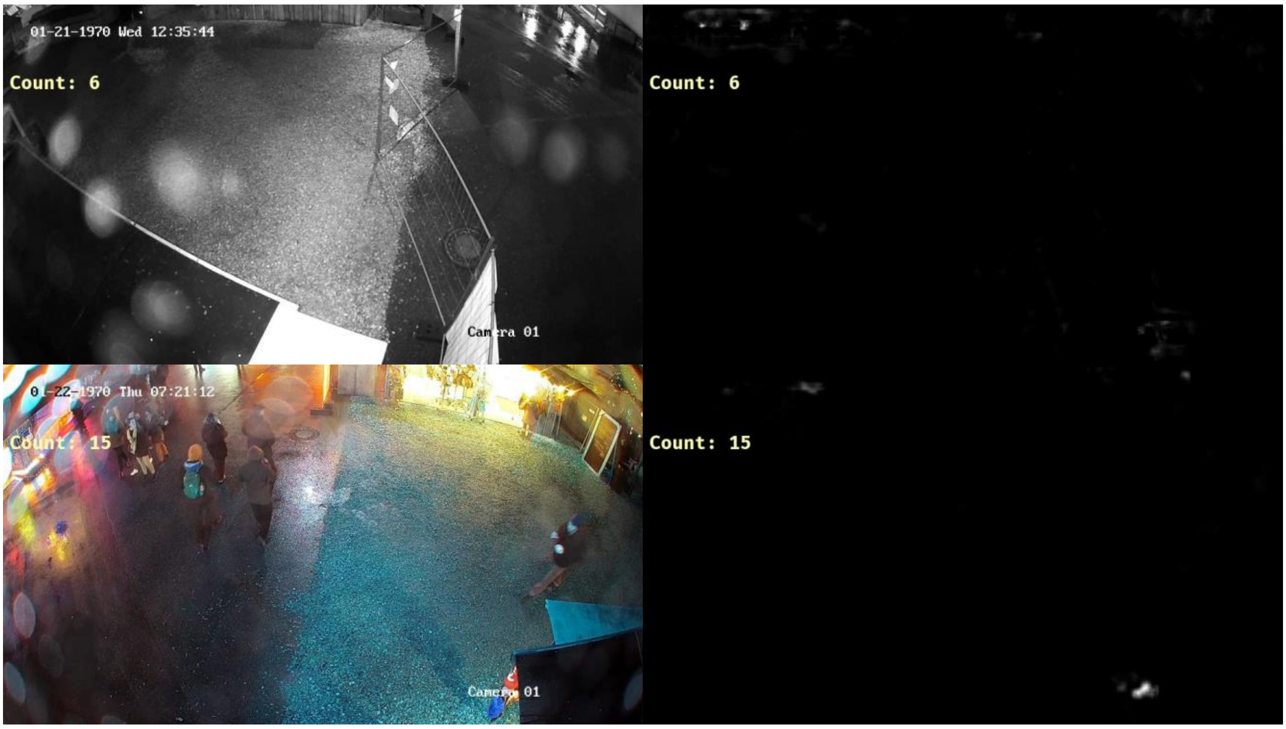


Figure 88 Example pictures showing results from the crowd algorithm. On the left the unprocessed, raw images from the camera stream and on the right the processed images, both show the crowd count

11.2 Locate Staff

During the Winterdom 2018 six GPS-trackers were tested and their positioning data was visualized in the digital map of the COP Dashboard. The use case is to be able to locate staff from the different departments of fire brigade, police, paramedics and the event organizer team. The purpose is to support the planning and communication for the staff so that the right action is taken in the right moment. During the event three of the six available devices were given to the event organizer to use it in 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. Further meetings are planned to discuss the benefit of this use case for the different stakeholders at the event site.

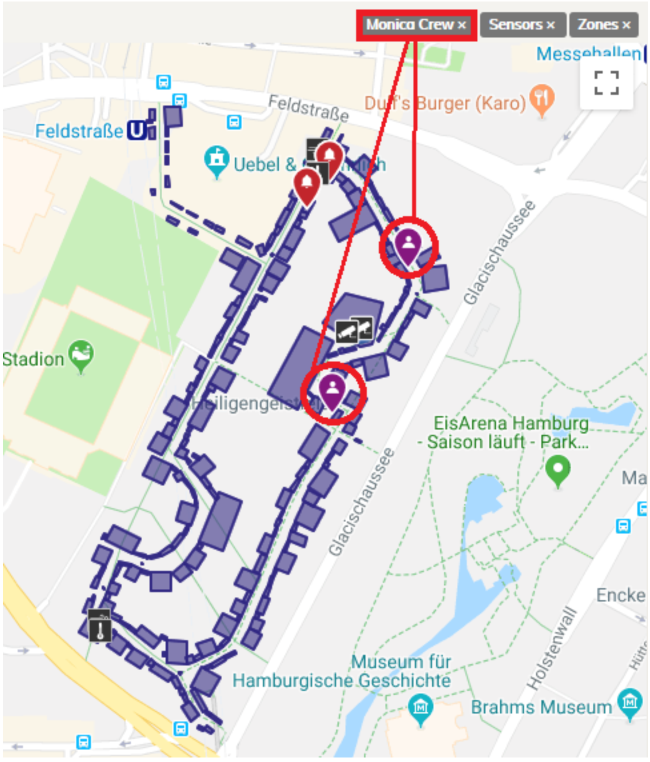


Figure 89 Map in the COP Dashboard with position of MONICA Crew

Figure 89 shows the digital map in the COP of Hamburg DOM, showing with the position of the Riot GPS-trackers carried by MONICA staff members. These positions were set for the purpose to demonstrate the visual appearance of the GPS-trackers in the COP Dashboard and the successful technical implementation.

Figure 90 RIOT - LoRaWAN GPS Trackers

Some features of the RIOT 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 gateways already installed, it was not needed to set up a LoRaWAN gateway near the DOM. The nearby gateways were provided within The Things Network[9]. They are situated north and west of the DOM area as shown in Figure 91. With this network available it was also possible to receive signals away from the event venue as well. Beside a LoRaWAN GPS Tracker other solutions namely the staff wristbands and the StaffTracker App have been tested by other pilots on their events. We decided to use the combination of GPS

[9] https://www.thethingsnetwork.org/community/hamburg/

signals for localization and LoRaWAN for data transmission due to several reasons. Using an app to track the staff has the disadvantage of requiring every staff member to have a mobile to install the app to. Using the wristbands has the advantage of high positioning precision but will cause high installation cost since the DOM venue does not provide the suitable infrastructure. The installation of permanent fiber optic cable at the venue by the owner of the venue would be able to provide the necessary infrastructure for the wristbands. In the beginning it seemed possible to use this new infrastructure for the project but due to delay it is not foreseen to be ready before the end of the project. Without this infrastructure the DOM event will not be able to use the wristbands as a solution to locate staff members.

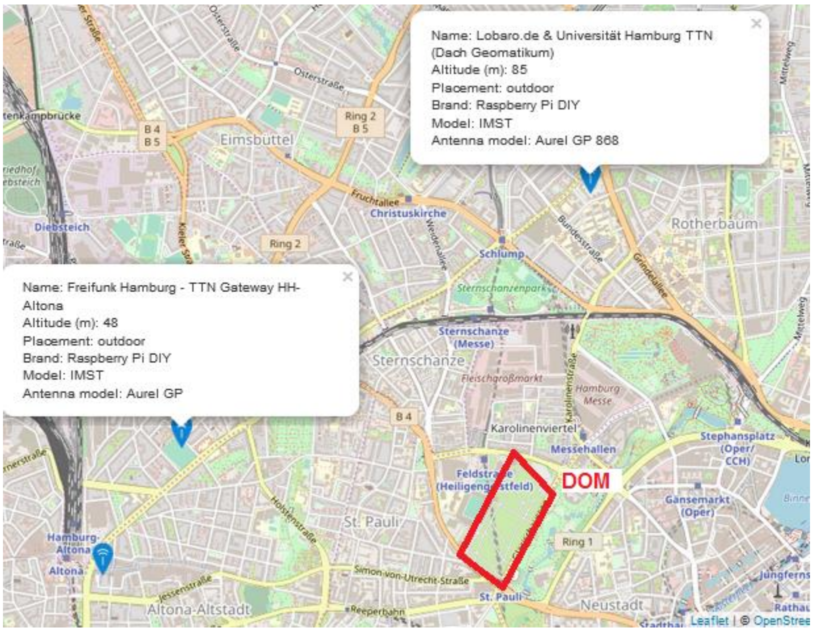


Figure 91 Gateways from the TheThingsNetwork Hamburg

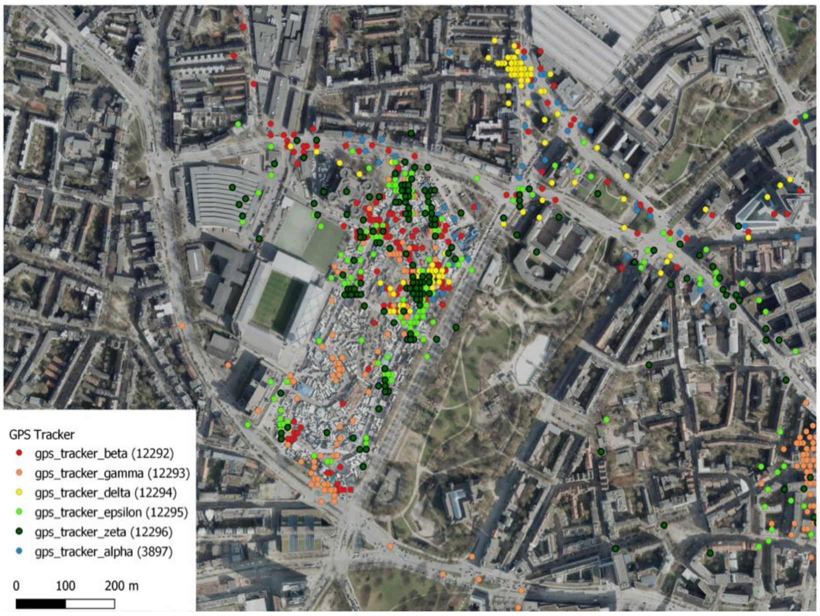


Figure 92 Data from the six GPS Trackers

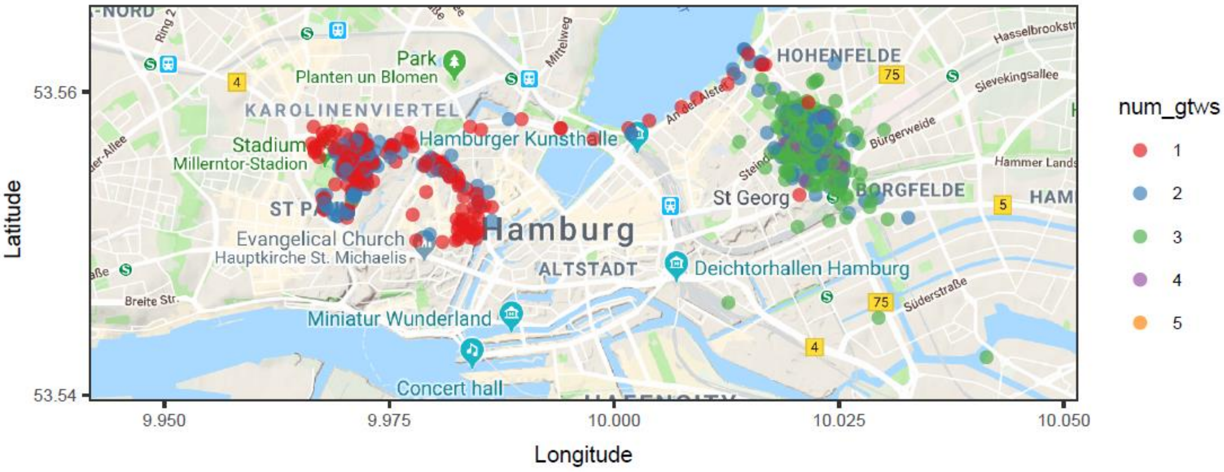


Figure 93 Number of available LoRaWAN gateways for each position

The LoRa GPS Trackers were able to send their GPS position of the staff at various locations on the DOM site via the Urban Data Platform of Hamburg to the COP Dashboard. Figure 93 shows the number of available LoRaWAN gateways from the various positions. At the DOM site only one or two gateways were available at a time. To prevent data loss it is planned for the next deployment in 2019 to setup a LoRaWAN gateway at the DOM site. Further improvement is planned for the GPS Tracker regarding the handling and interaction of the user with the device.

11.3 Safety Incidents

To measure the wind speed and to be alarmed when there are high values two wind speed sensors along with two environmental sensors were deployed at the DOM site during the Springdom and Winterdom. The sensors were put on 7m - 7,5m high poles which can be seen in Figure 94. They were positioned during the Winterdom 2018 as seen in Figure 95 at the northern and southern parts of the DOM.

Figure 94 Deployment of environmental sensors with wind speed meters

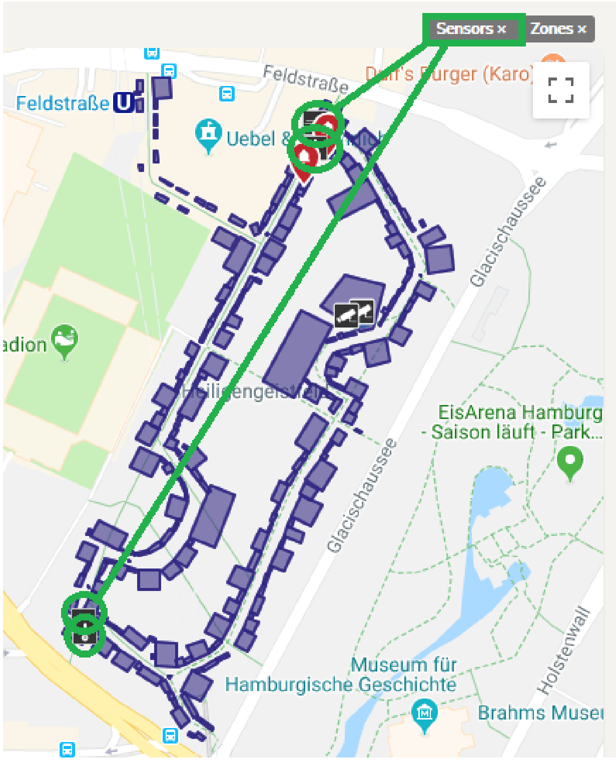


Figure 95 location of environmental sensors at Hamburg DOM

The visualizations and how the information is displayed in the COP was evaluated before the event in a workshop with the stakeholders. The COP implemented a given color scale to show the different levels of wind speed. The numbers were taken from the DWD[10] and are shown in Table 22. According to the values and the given colors in the table the two gauges of the two wind speed sensors in the COP were colored.

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

Table 22 Wind speed scale

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. Due to the way of integration of the wind speed data to the COP 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. **Fehler! Verweisquelle konnte nicht gefunden werden.**Figure 97 shows four security incident alarms.

Figure 96 shows the raw data of the temperature and wind speed sensors. The gaps within the dataset were mainly caused by the reboot of servers or defect sensors. Since during these gaps the COP did not receive any new data and the user would see old values. The user then would interpret them as wrong data since they differ from the current conditions. Beside old values a timewise wrongly applied down-scaling of the data was also an issue during the deployment causing values always around 0. These two reasons caused the user to see wrong data displayed in the COP. For the next deployment the environmental sensors will be running one month ahead of the DOM so that a right calibration can be ensured.

[10] https://www.dwd.de/DE/wetter/warnungen_aktuell/kriterien/warnkriterien.html?nn=5100769

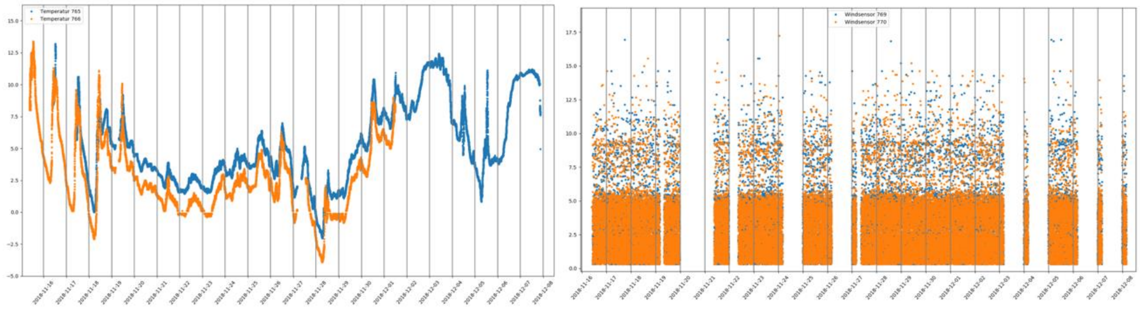


Figure 96 Temperature and wind speed raw data

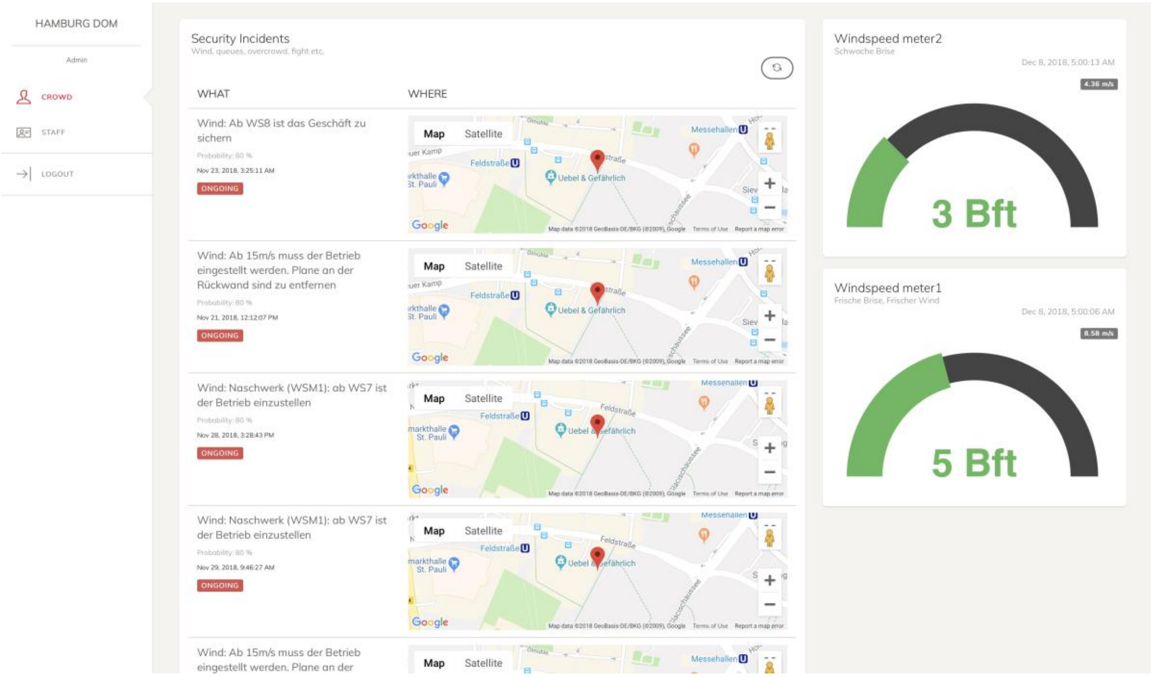


Figure 97 COP visualisation of wind speeds and security incidents

11.4 Summary and Outlook

The first 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 event which could not have been foreseen.

All use cases addressed in 2018 will be continued to be deployed in 2019. For the crowd & capacity monitoring use case the crowd estimation algorithm provided not satisfying results. The plan for 2019 is to test and deploy the improved algorithms and to add two more cameras to the site. After the successful testing of the GPS tracker for the locate staff use case, the plan for 2019 is to improve hardware and the infrastructure. It is also a goal to reach more stakeholders who are using the GPS trackers during the DOM event with workshops. For the safety incident it will be necessary to improve the reliability of the data in the COP Dashboard.

The feedback from the event organizer to the COP Dashboard was overall positive and small suggestions have been communicated in order to make it more manageable. To have a well-functioning COP Dashboard it is necessary to have the data from the sensors integrated properly into the MONICA platform before the next deployment.

12 Fête des Lumières

Fête des Lumières[11] 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, in order to prevent terrorism-related risks, Fête des Lumières has been held for the most part on a perimeter closed to traffic, on the peninsula of Lyon, between the Rhône and Sâone rivers. Only the underground service is accessible within the perimeter and control is carried out at the accesses of the underground stations. Pedestrian accesses are possible on the whole perimeter. The area size of the event is over 1 km^2. For the 2018 edition, around 40 light performances took place, sometimes with sound playing. The timeslots were from 7 pm to 11 pm or from 8 pm to midnight. The site welcomed approximately 1 800 000 visitors[12]. The following figures show the 2018 light performance on Lyon Cathedral façade.

Figure 98 Lyon Cathedral facade, start of the light show

Figure 99 Lyon Cathedral facade, during the light show

Table 23 Selected Use Cases for Fêete des Lumières Lyon

ID	Use Case Group	Tested in 2018	Planned for 2019
UCG 2	**Sound Monitoring & Control**	**X**	X
UCG 3	**Crowd & Capacity Monitoring**	**X**	X
UCG 4	Missing Person		X
UCG 5	**Locate Staff**	**X**	X
UCG 7	**Security Incidents**	**X**	X

For this pilot, the use cases were discussed with the direction of Fête des Lumières. They were interested in the MONICA project because it might help staff to be more reactive and management to have several feedbacks about the feelings of the audience. Their needs for this event were mainly about tracking people and knowing their favourite show. Unfortunately, this makes only sense in the whole city, which required a huge effort in terms of logistics and technics involved, that was not realistic in the scope of MONICA.

For crowd monitoring Place Saint-Jean (Figure 100) was chosen, a very densely crowded area during the festival. It is a very popular place during Fête des Lumières because of the light performance on the Lyon Cathedral façade. The crowd management can be quite tricky without proper anticipation.

For the 2018 edition, the objectives were to test four technologies:

[11] http://www.fetedeslumieres.lyon.fr/en
[12] https://culturebox.francetvinfo.fr/culture/la-fete-des-lumieres-de-lyon-belle-affluence-en-depit-des-circonstances-283267

- IoT Sound Level Meters to monitor the sound level in real time
- Cameras algorithms to estimate the crowd number, the crowd density and to detect objects
- Staff tracking devices to locate people working for the festival
- Smart glasses to assess the efficiency of the solution outdoor during night-time

Additionally, in order to assess the soundscape throughout the event, Acoucité came with the idea of using NoiseCapture, a free and open-source mobile app developed by IFSTTAR[13] that allows users to measure and share the sound environment.

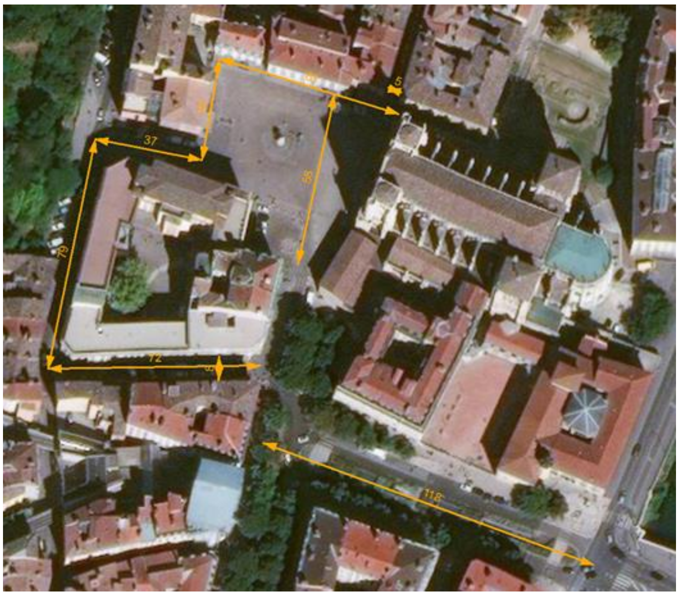


Figure 100 Place Saint-Jean, some dimensions

The command centre was located in an office in the CCTV direction of the City of Lyon involving directly the people managing the festival on the camera side. During the event it was visited by local officials and technical staff working on the festival. Furthermore, international guests of Lyon visited the COP Dashboard and gained an understanding of the possible advantages. Pictures of the COP Dashboard are shown in Figure 101 and Figure 102.

Figure 101 COP Room

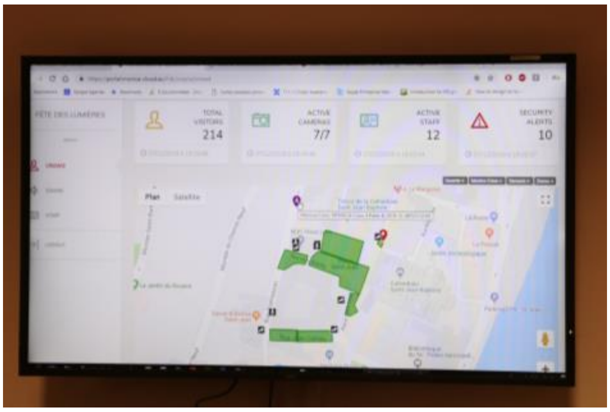


Figure 102 COP Dashboard

[13] The French Institute of Science and Technology for transport, development and networks: http://www.ifsttar.fr/en/welcome/

Table 24 Summary of deployed IoT Devices

IoT Device and APP Type	Number of deployed devices 2018	Plans for 2019
IoT Sound Level Meters	3	3
Cameras	7	7
Smart Glasses	5	5
Staff Tracker app	5	15
LoTrack Staff Tracker		50
NoiseCapture app	11	>30

12.1 Sound Monitoring & Control

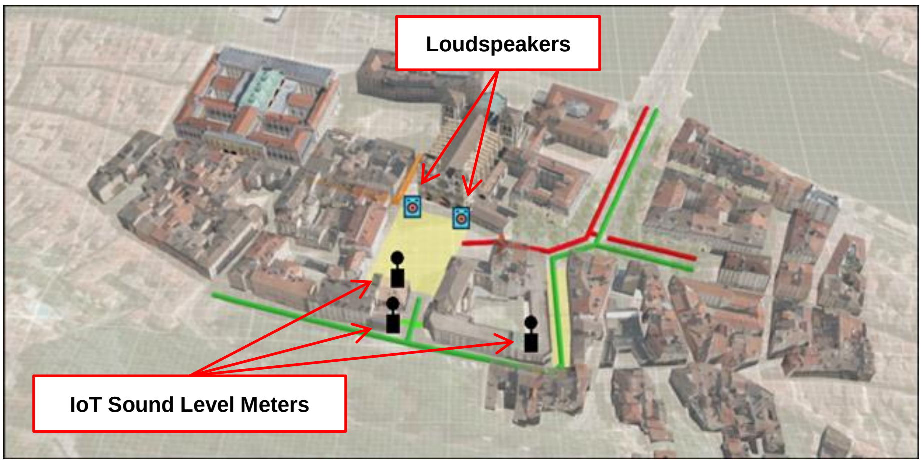


Figure 103 Position of IoT Sound Level Meters (picture made with ArcGIS Online)

12.1.1 IoT Sound Level Meters

Objectives:

- Test, for the first time in Lyon, the data transfer including global sound pressure levels, spectra and audio
- Test the data transfer using 4G connection under overloaded network condition

A complementary Wi-Fi system had to be deployed in the Old Lyon YCM[14] in order to have a reliable signal to send data from the IoT SLMs to the MONICA Cloud: the 4G network expected to be unstable due to huge amount of users at the same place during the same timespan (hundreds of thousands visitors each evening). Figure 103 shows the position of the IoT Sound Level Meters and Figure 104, Figure 105, and Figure 106 show how they were mounted.

[14] House of Youth and Culture of Old Lyon district

Figure 104 Point A IoT SLM on the YCM balcony, in front of Place Saint-Jean

Figure 105 Point B IoT SLM on the YCM terrace, behind the YCM office in front of Place Saint-Jean

Figure 106 Point C IoT SLM on the terrace of Les Lazaristes High School, near to Place Saint-Jean

Figure 107 and Figure 108 show the sound monitoring application of the COP Dashboard. The former one shows the location of the SLMs while the latter one shows live data of one SLM.

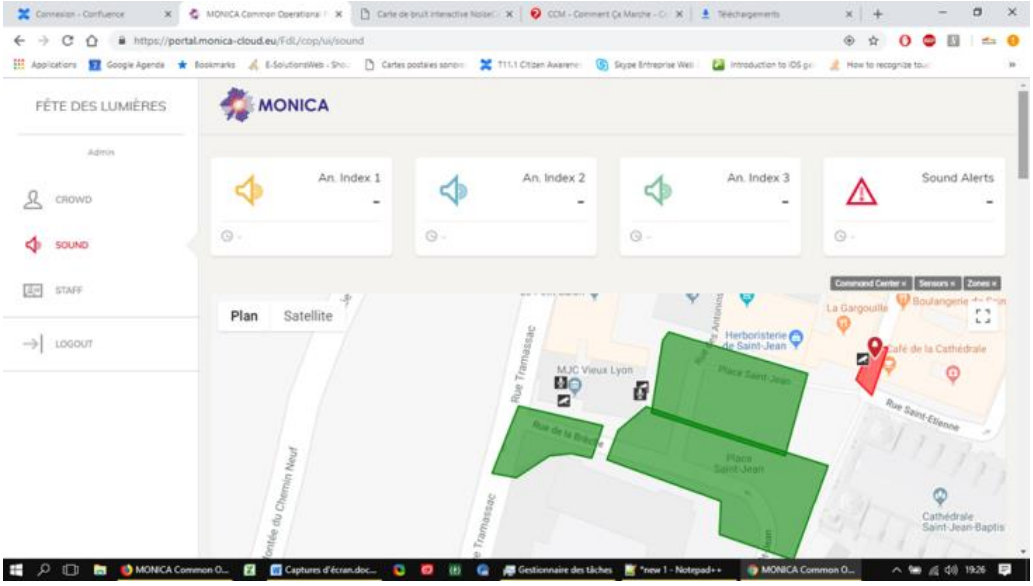


Figure 107 Sound Monitoring tab of the COP

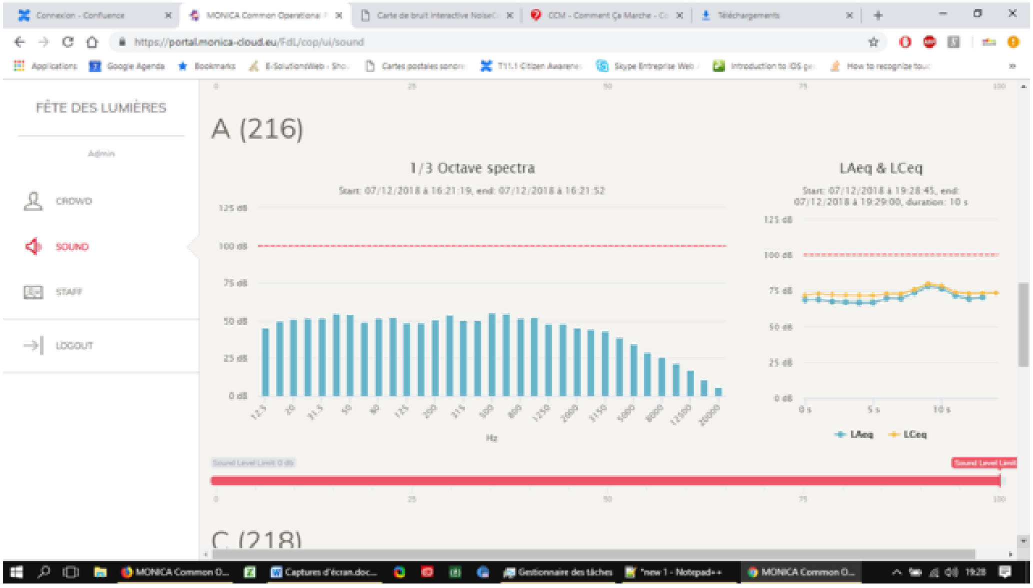


Figure 108 COP display of the frequency spectrum and global sound pressure levels (LAeq and LCeq) at point A

Besides live measurements during the event, additional measurements were carried out two weeks before the event. These data will be used to train the contribution algorithm which will be demonstration in 2019. Figure 109, Figure 110, and Figure 111show the deployment of the additional sound level meters provided by ACOU.


Figure 109 Deployment of first ACOU SLM at point A two weeks before the event


Figure 110 Deployment of second ACOU SLM at point B two weeks before the event


Figure 111 Deployment of third ACOU SLM at point C two days before the event

12.1.2 NoiseCapture Party


Figure 112 Presentation of NoiseCapture by IFFSTAR at ACOU's office

A further effort was undertaken to establish a connection between MONICA and the NoiseCapture Project, aiming at:

- Collecting user data to build an environmental noise map and
- Using and assess wearables in the demonstration

Adrien Le-Bellec (engineer at IFSTTAR) presented the NoiseCapture project[15] at ACOU's office as part of the MONICA project for the 2018 edition of Fête des Lumières.

The presentation began with an overview of the existing results so far in cartographic form: http://noise-planet.org/map_noisecapture/noisecapture_party.html#15/45.7580/4.8318/H2020Monica_Lyon2018 to show the extent of the measurements made on a global scale.

Some statistics were shown: origin of the main contributors to the project, cumulative duration of measurements, number of measurements, use of keywords and feedback of the contributor's sound environment, etc. We also describe the measurements according to the days of the week (details taken from Lyon's area). The meeting ended with loan of quality microphones and the calibration of the application on the smartphones for MONICA people.

The tagging "H2020" of the measurements was aimed to create a special map for this edition Fête des Lumières. Any event could have its own map, user-generated, which could help local authorities and organizers to have a global view on the event and its surroundings (see Figure 113

More information on http://noise-planet.org

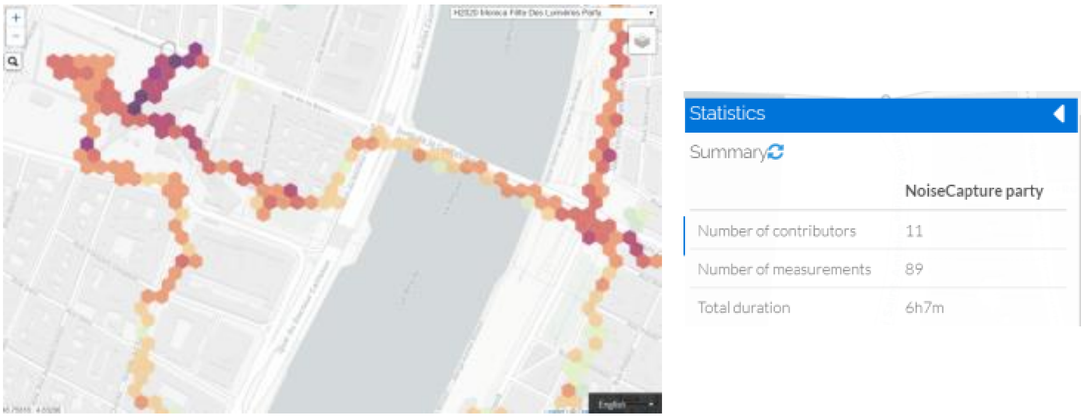


Figure 113 Example of NoiseCapture recording and statistics

12.1.3 Results of the Tests

The following explains the results of the Sound Monitoring and NoiseCapture Party.

- Connection to network was achieved and stable from second night of the event thanks to update of SLM (*.exe file sent by B&K and executed on site by ACOU) even when using 4G connection under overloaded network condition.
- Data transmission of sound levels in dB(A), dB(C), spectra and audio was accomplished but with data loss, particularly for SLM installed on point B (see Figure 114).
- Visualization of live data in the COP Dashboard was working flawlessly (spectrum however too large)

[15] Reference: An open-science crowdsourcing approach for producing community noise maps using smartphones; Judicaël Picaut, Nicolas Fortin, Erwan Bocher, Gwendall Petit, Pierre Aumond,Gwenaël Guillaume

Figure 114 IoT SLM sound level raw data using Grafana software

12.2 Crowd & Capacity Monitoring

As part of the MONICA field test, seven Low-Light High-Resolution RGB cameras were installed on the venue (see Figure 115). A processing unit with Ubuntu 16.04 as OS was also provided and configured remotely for the following algorithms: gate counting, crowd density counting and object detection.

Objectives:

- Count the number of entrances and exits using gate counting
- Estimate the number of spectators on the event
- Count the number of spectators on the square on real time
- Analyse the density and the number of spectators on the seven areas of interest
- Send an alert if the density is over three persons per square meter

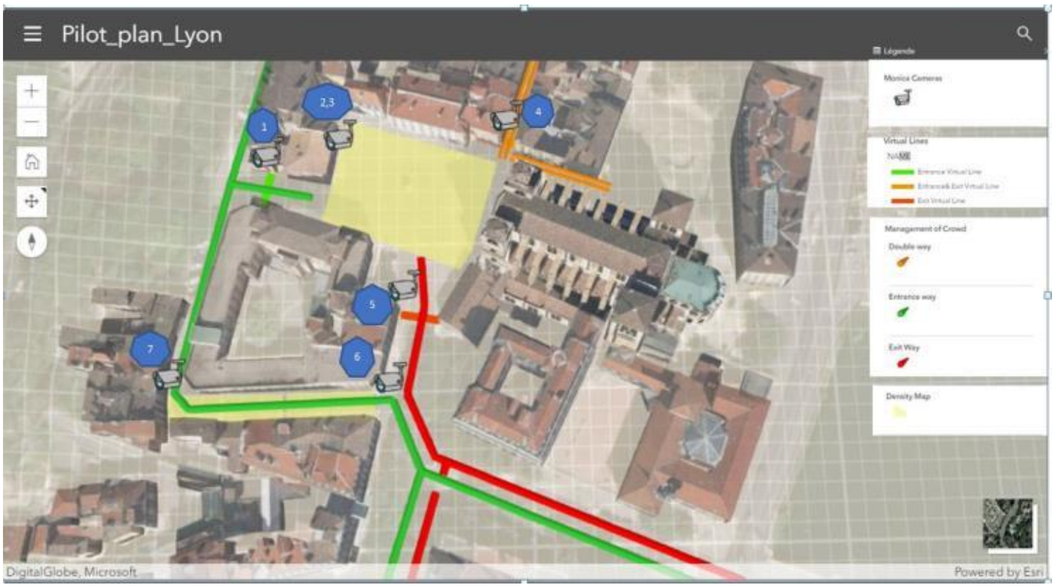


Figure 115 Position of cameras (picture made with ArcGIS Online)

12.2.1 Crowd size estimation based on the visual density of people in a crowded space

The crowd density algorithms were deployed to assess the density, to return the number of the spectators in real time on each area of interest and to send an alert if the density is over three persons per square meter (see Figure 116).

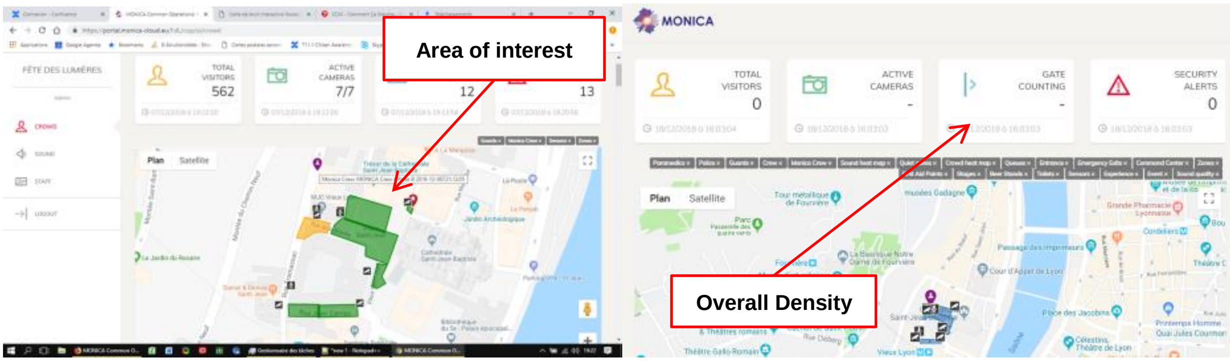


Figure 116 Visualization on COP of the seven areas of interest coloured green and yellow

12.2.2 Capacity Monitoring by counting people through entrance & exits

Three of these cameras were used for gate counting on the main access routes to count entrances and exits and to estimate the overall density on the square by a simple equation between the entrances and exits. The capacity monitoring tab on the COP Dashboard allowed to watch the number of spectators for every area of interest (see Figure 117). The capacity was calculated according to area in square meters.

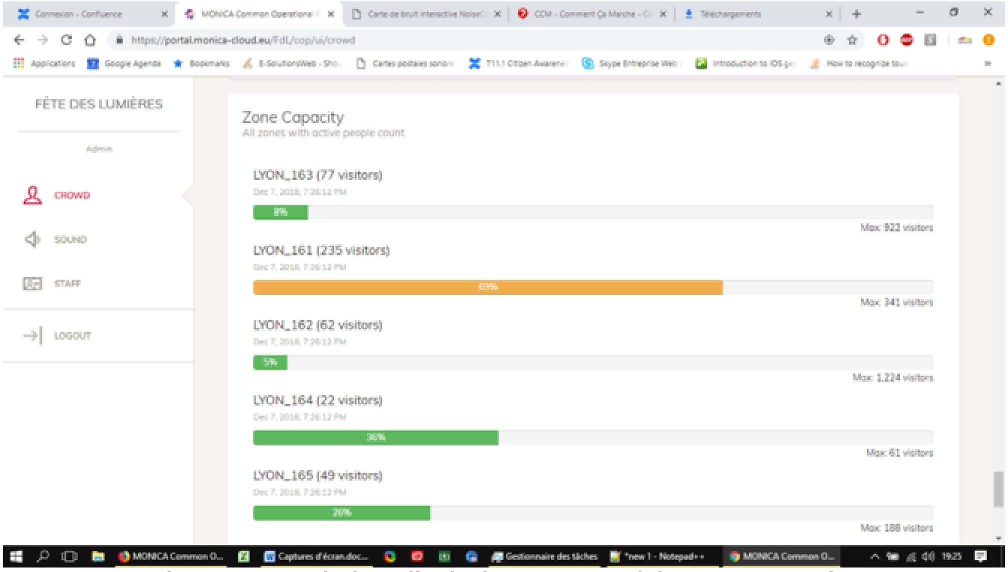


Figure 117 Real-Time displaying on COP of the Zone Capacity

12.2.3 Results of the Tests

For what concerns reliability of data transmission and storage, data was flowing constantly with only to periods of downtime (see Figure 118) for crowd density.

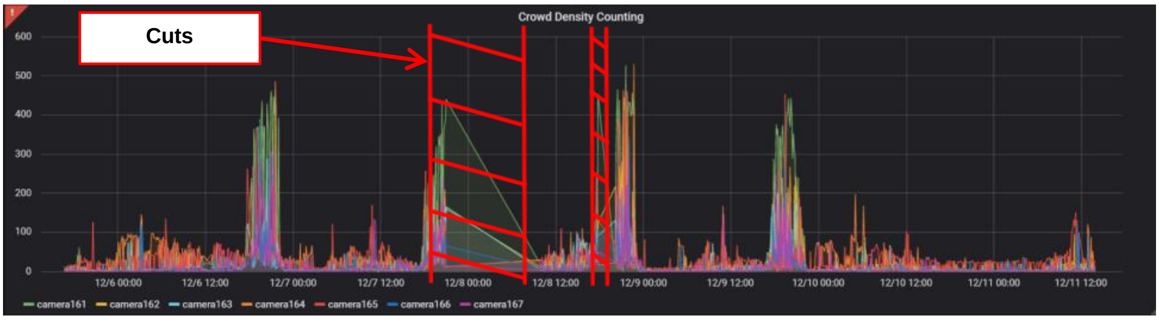


Figure 118 Crowd Density estimation with Grafana software (UTC time)

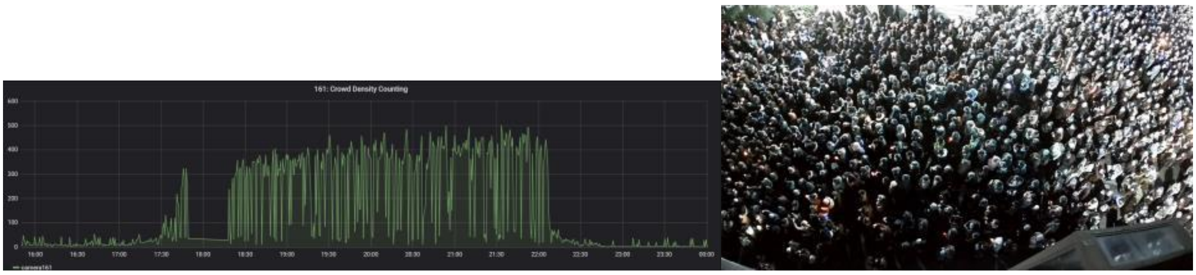


Figure 119 Crowd Density estimation for camera 161, (UTC time, December 6); Crowd picture at high density

For gate counting, data for the night of December 7th have been stored. Camera 161 had a hard time with gate counting although camera 165 presents counting close to what has been observed (see Figure 120).

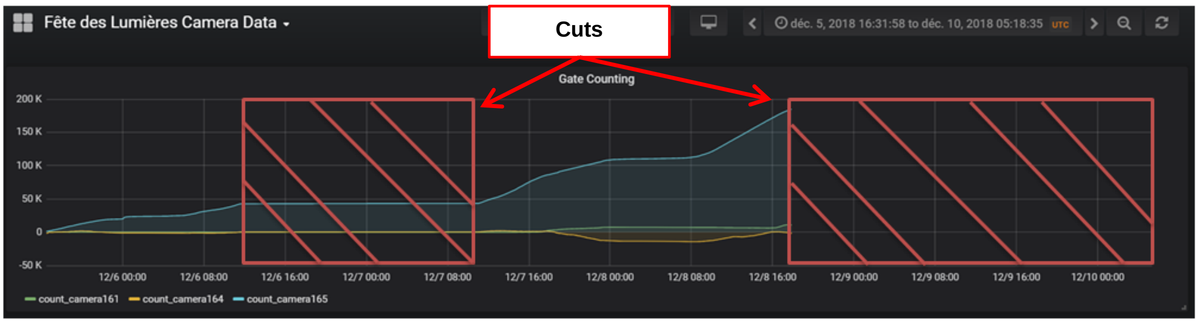


Figure 120 Gate Counting estimation camera 165 with Grafana software

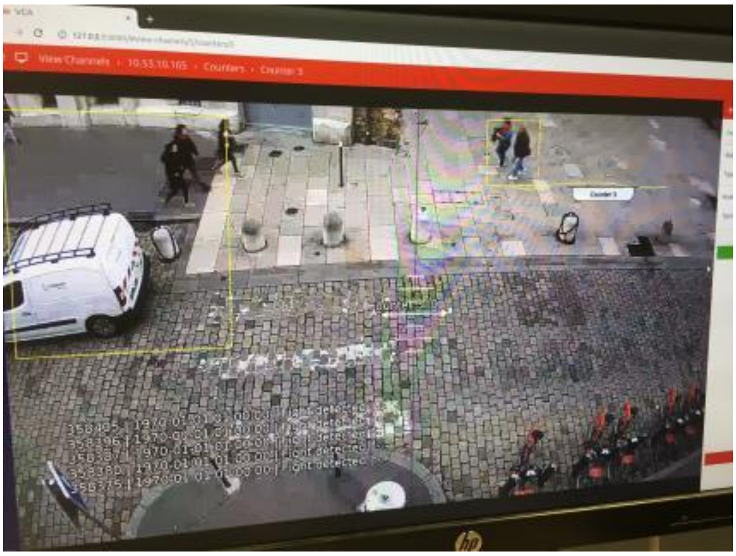


Figure 121 Gate Counting technology for camera 165

12.3 Locate Staff

The staff was not composed with Police, Paramedics, Guards or Crew but with MONICA partners. A dedicated “Active staff” tab was available on the COP to displayed a list of registered and active MONICA staff members who carried IoT devices while walking on the event site (see Figure 122).

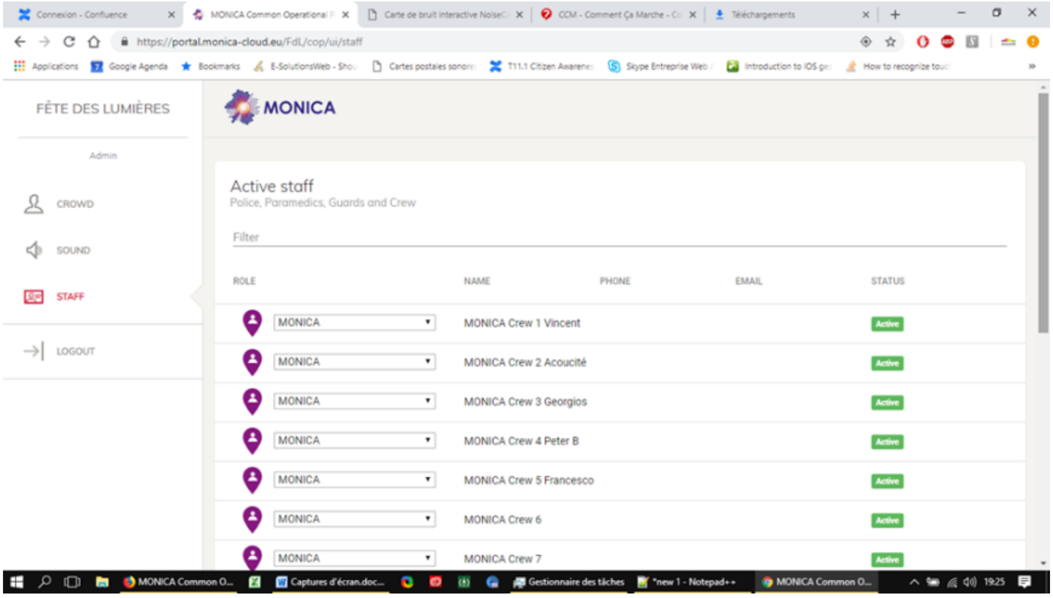


Figure 122 List of some registered and active staff members displayed on COP

12.3.1 Locate Staff using GPS app

Several people from the MONICA project accepted to test the Android StaffTracker app developed by FIT. With high definition localization ON, the results were quite accurate. For the next year the use of the LoTrack Staff Tracking devices is also foreseen.

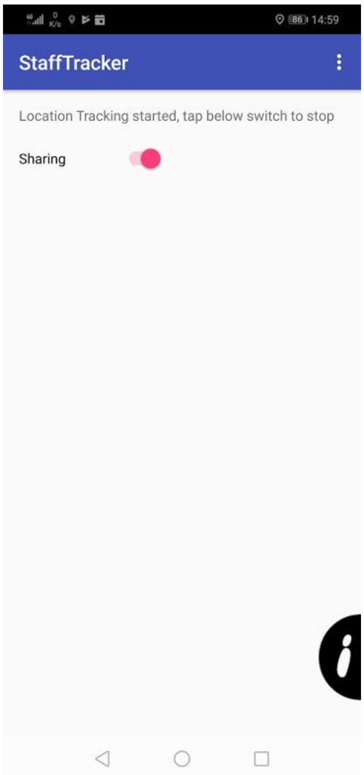


Figure 123 StaffTracker app display on Android OS

12.3.2 Results of the Test

The positioning was working fine, however, data transmission relies on the network available for each mobile phone that is used. Furthermore, the app requires installation on peoples' mobile phones and continuous use of GPS has a significant effect on phones' battery power. Therefore, in 2019, the LoTrack GPS Trackers will be tested at Fete des Lumieres.

12.4 Security Incidents

For this use case, three MONICA solutions were tested: smart glasses, object detection and overcrowding detection, both based on video analytics.

12.4.1 Security Incidents Reporting

The first solution is a wearable linked to a server with an app developed to help staff members to report security incidents quickly. A small test was performed by three MONICA staff members by walking in the event for two hours. Due to political strikes and attacks in Lyon during daytime, the security staff members were not able to test the devices in situ. The event organizers agreed with the MONICA team to avoid the risk of an incident due to the security staff wearing smart glasses on the streets. Nevertheless, a presentation of two hours was made to the directions of CCTV and Fête des Lumières as well as a small test with the director of BYBLOS, one of the security agencies hired to cover Fête des Lumières 2018.

Figure 124 Testing smart glasses at the command centre

12.4.2 Object Detection

The deployment of object detection algorithm in Fête des Lumières pilot was focused on the detection of vehicles such as cars (see Figure 125), buses, motorbikes, bicycles and trucks, moving around the main square. For that purpose, the object detection algorithm was setup to acquire frames from cameras No 164, 165 and 167. The algorithm worked well and the number of objects detected was appropriate to what could be observed from a person.

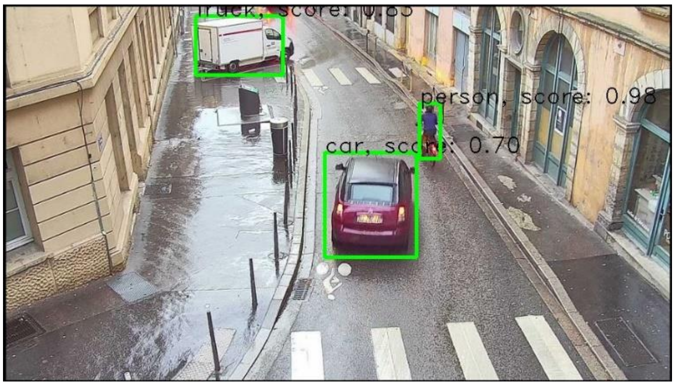


Figure 125 Example of detection, camera 167

12.4.3 Overcrowding Detection

Related to the crowd monitoring use case, the crowd density algorithm allows sending a security incident alert as soon as a density of three persons per square meter is reached.

12.4.4 Results of the Tests

Even though the context of strikes and attacks in the city centre of Lyon, the smart glasses were tested by MONICA staff members and the technology has been presented to some elected representatives of the City of Lyon and to security professional staff members. A list of typical security events (lost children, drunken people…) was tested and the alerts were returned to the COP Dashboard.

The object detection algorithm performed well in the detection of cars, motorcycles and other vehicles (see Figure 125). Figure 126 and Figure 127 serve as evidence for the performance and efficiency of Object Detection container. The picture shows people and a car detected.

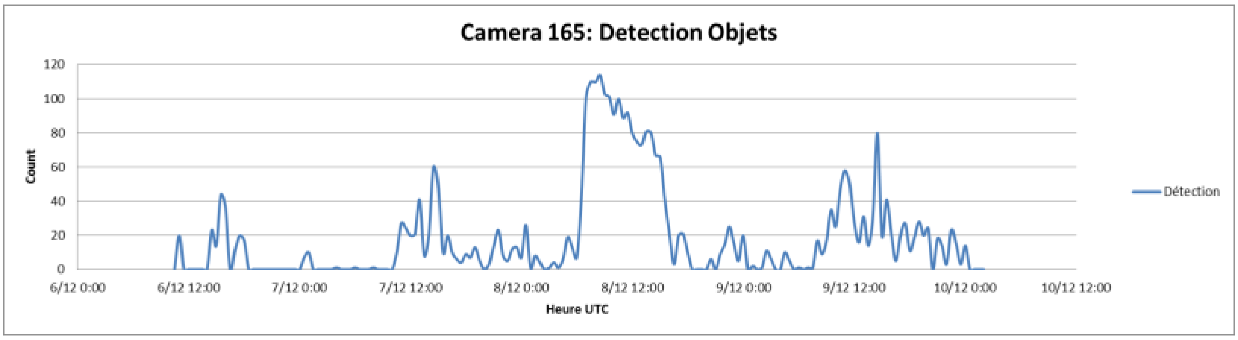


Figure 126 Object Detection in the Cloud database

Figure 127 Efficiency of person and object detection

As expected many overcrowding alerts were sent by the Decision Support System for each of the areas covered by crowd monitoring solutions (see Figure 128).

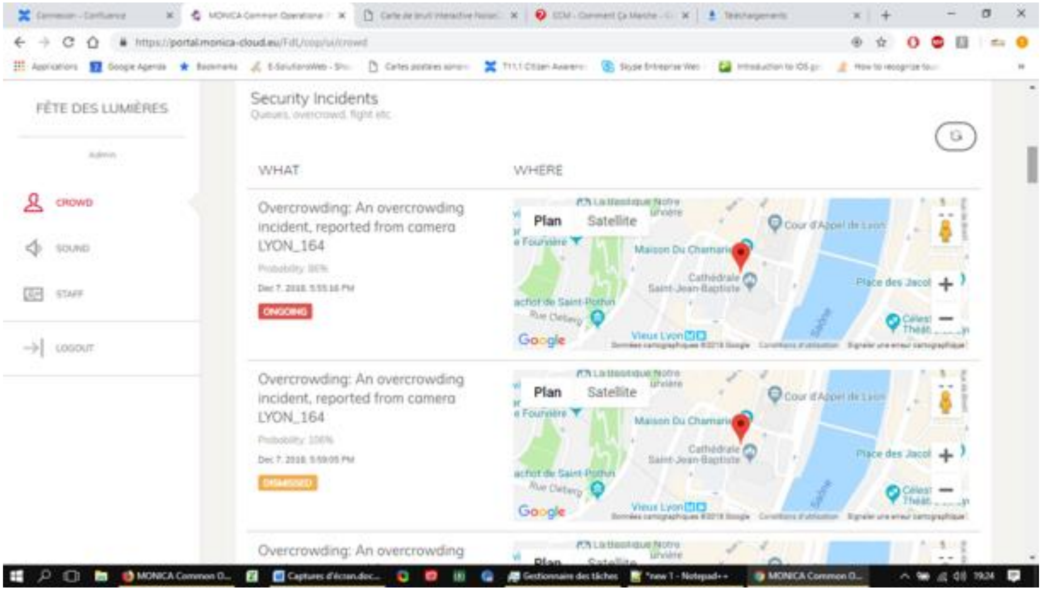


Figure 128 Security Incidents history displayed on COP

12.5 Summary and Outlook

This first demonstration in Lyon was a success thanks to the help of MONICA partners and local authorities: working together in a control room displaying the test field was a great experience and we hope to improve it next year. Despite the difficult context (riots and strike in France) almost all the desired technologies were tested (cameras, SLM, App, COP Dashboard, smart glasses) and even with Noise Capture and object detection as extras.

For 2019, the contribution algorithm and annoyance index will be included in the IoT Sound Level Meters, which is highly appreciated. Improvements on the crowd density and gate counting algorithms are expected.

For locating staff, the LoTrack Staff Trackers will be used in Lyon. Furthermore, the involvement of end users testing the MONICA solutions will be extended.

13 Conclusion

With the experience gained during the described demonstration, the MONICA platform is ready for the full-scale demonstrations that are planned 2019. The technology has been successfully integrated, tested and operated at 10 events. This process allows to put a stronger focus on end user involvement as well as evaluation and marketing activities before, during, and after each demonstration.

14 List of Figures and Tables

14.1 Figures

14.2 Tables