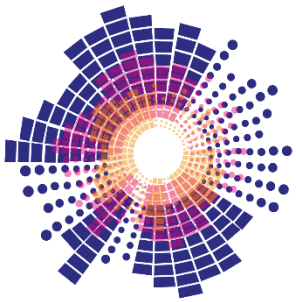

# MONICA

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

# D9.2 Final Assessment, KPIs, and Validation Report of the MONICA IoT Platform

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# Index:

# 1 Executive Summary

Achieving impact and validating end-users' requirements for performance, functionality, usability, privacy and trust are central objectives of the MONICA project. With a very large-scale demonstrations of individuals using MONICA innovations, MONICA proved to be highly likely to have a great impact on citizens, the event industries, and IoT business partners.

We regard impact as an observable and measurable change on individuals, communities and industries from social, economic, and technological perspectives. And we regard validation as a checking mechanism that we have built the right system.

Accordingly, this report aims to present the continuous holistic impact assessment of the pilots experience deploying MONICA technologies, in order to validate the results in terms of societal, cultural, and economic performance. The impact assessment and validation process followed the established IAV framework developed at the early stages of the project and reported in D9.1 Impact Assessment and Validation Framework. It was used internally after every year of the pilot phase to improve the demonstrations potentials, as well as towards the end of the project to inform D9.3 Replication Reference Book.

To achieve that, the impact assessment and validation process undertook continuous Key Performance Indicator (KPI) based assessment of the results, feedback and Lessons Learned from pilots related to organisational, societal, cultural and economic performance impact. The impact assessment team has collected, and analysed pilot performance parameters and lessons learned from the implementations and incorporated the conclusion in the replication framework. A validation of end-user requirements for performance, functionality, usability, privacy and trust took place.

Overall, 18 KPIs were reviewed with around 1.820 questionnaires distributed and analysed (202 questionnaires in 2018, and 1.618 in 2019) in 25 demonstrations to measure the impact of crowd and capacity monitoring, crowd management and communication, sound level monitoring, adaptive sound field control system and visitors experience. In three years, 28 tangible results have been deployed by the consortium and among these; video analytics, crowd and staff wristbands, smart glasses, GPS staff trackers, staff tracker apps, sound apps, visitors' apps, and a common operating platform (COP).

The report shows the impact MONICA had on 100,000+ individuals directly and indirectly affected by the IoT technologies and the attractiveness of the technology to the visitors, represented by visitors' stating their willingness to attend future events if MONICA technologies are to be deployed. This shows how MONICA has the ability to contribute to high tickets sale and increased pilot income as a result of increased number of visitors, and the expected spending that exceeded €700,000 in some events.

In addition to such socio-economic impact achieved via the high likelihood of increasing the number of event visitors, MONICA proved to increase the efficiency of the events staff by helping them carry out their day-to-day tasks in a better effective way. This was reported by staff from different jobs including stewards, fire brigade staff, police officers and events control room personnel. MONICA wearable technologies proved high impact on safety and security of the events via high acceptance rates (greater than 62%) from staff who tested the technologies. Security staff and fire officers were among events personnel who felt MONICA would have a high positive impact on the way they perform their jobs.

Moreover, MONICA had a significant impact at political level: the project has contributed to a political action plan for the nightlife in Torino. The sound monitoring and control solutions deployed by MONICA have played an important part in the development of a political action plan for the Torino nightlife, also known as Movida. The City of Torino has actioned a plan which is the deployment of MONICA sound and crowd monitoring applications, in order to better understand the long-term sound exposure, the number and density of people and seasonality. Moreover, the City of Copenhagen will work closely with the partner of Torino, to share best practices developed during the MONICA project.

Finally, the methodology showed that the impact assessment approach developed in MONICA is replicable for other projects to plan, implement and evaluate their technologies for impact assessment and validation.

# 2 Introduction

## 2.1 Purpose

The purpose of this deliverable is to present the results of the project impact assessment and the validation of the MONICA IoT platform and solutions.

The impacts have been quantified with a set of KPIs identified in the Description of the Actions (DoA), using the tools and methods set out in task 9.1. where the assessment and validation framework has been defined. The framework was informed by the guidance of the G8 Social impact and investment Forum (Impact Taskforce, 2014), REF2014[1], REF2020 (HEFCE, 2017), and Economic and Social Research Council (ESRC, 2017). The fulfilment of the KPIs during the project life has been assessed in WP9 and reported in the interim report which covered the events that took place in year 1 and 2 of the project lifetime and used for feedback to the second pilot phase.

The impacts are presented in three categories: socio-economic impacts, technological impact and user acceptability. The deliverable is part of task 9.2 that undertook systematic quantitative and qualitative assessment of the observed results and lessons learned from the project's activities.

This deliverable is also part of task 9.3 that had the objective of evaluating the feedback of the applied technologies and the demonstrations from all stakeholders involved, in order to evaluate the benefits of the IoT platform to perform as intended and under real operation.

The aim of the Impact Assessment and Validation process in MONICA was to:

- Establish validation methods to assess the impact of the MONICA's solutions against KPIs across and within the pilot sites.
- Undertake an assessment of the methods used in order to obtain qualitative and quantitative results, including lessons learned, that support replication and can be used in the communication and dissemination process.
- Analyse sufficient numbers of relevant data (before, during and after each pilot event), guided by stakeholders, to be able to undertake a formal assessment of the social-economic impacts, technological impacts and user acceptability of the project.
- Demonstrate the generic applicability and interoperability of experimental testbeds and open platforms in validation of the Internet of Things technologies.

## 2.2 Content, context and scope of this deliverable

The process and methodology for the impact assessment and the validation is described in Chapter 3, resuming the principles explained in D9.1 Impact Assessment and Validation Framework, how the questionnaires have been developed and how the data has been analysed.

In Chapter 4 the results of the validation are presented, with an analysis of the feedback collected from the end users during the demonstrations in year 2 and 3.

In chapter 5 the results of the project's impact assessment are presented, with the review of the 18 KPIs listed in DoA and the analysis of the numbers that have been achieved at the end of the project. Chapter 6 contains the conclusions of the whole deliverable.

In Chapter 9 templates of questionnaires and post-demonstration report have been included as Annexes.

[1] https://www.ref.ac.uk/2014/media/ref/content/pub/REF%2001%202014%20-%20introduction.pdf

# 3 Impact Assessment and Validation Methodology

This section describes the methodology followed during the data collection and data analysis phases for both the impact assessment and validation of MONICA IoT technologies.

## 3.1 Data Collection

The method of collecting data was mainly questionnaires. This method was chosen based on WP9 objective, which is to validate the IoT technologies deployed in the pilots and to assess their impacts. Questionnaires are commonly used in situations where the purpose is to collect data from a large number of people. Research (Rowley, 2014) shows that using questionnaires have advantages over other techniques, such as interviews, when collecting a large amount of data. Using questionnaires allows for an easier response from a large number of people, and the gathered data is easier to generate findings or patterns which are more generalisable in the analysis stage.

Questionnaires helped for mass data collection. In Y2 the WP9 team provided the pilots with paper-based questionnaires because the goal was to collect feedback from few end users who tested the MONICA's solutions. In Y3, a higher number of users have been involved, so the surveys have been organised through Survey Monkey. IN-JET had the credentials to log in the MONICA page with the full list of surveys. The credentials have not been shared with other partners in the consortium. The online surveys allowed WP9 team to reach and engage hundreds of users, getting real-time results for quick analysis.

Where it was not possible or useful to distribute questionnaires, interviews and focus groups have been organised at the pilots. Also, a post-demonstration report template has been designed by LBU and IN-JET in order to collect results, feedback and lessons learned from the technical partners who worked on each demonstration.

Collecting data via interviews and focus groups was not exercised in all pilots; however, some pilots feature interviews and observation. Conducting interviews means that less participants are targeted, however the information and discussions conducted are often more in depth. Rowley (2014) suggests that interviews are preferable when it's possible to identify those in key positions to understand a specific situation, but researchers can feel less confident that the data collected supports a wider generalisation. This means that the opinion of one interviewee may not be reflective of a wider group of people. Therefore, in MONICA it's preferred to use questionnaires to get a broader range of feedback, which likely reflects the whole opinion of the group.

## 3.2 Development of the Questions

The questionnaires were divided into sections, each section covered certain aspect of interest to the impact assessment and validation process. The questions were carefully selected to serve the research purpose, and specifically looked at usability, technical aspects and user acceptance. As the type of research is deductive, where questionnaires were designed to extract users and visitors experience, standard questions were used (such as those investigating the usability of the technologies deployed).

Demographic questions were included with non-invasive questions, such as age, gender and job position. These demographic questions have been placed at the beginning of the survey. Moreover, "Job position" is only included if the questionnaire is distributed to event organisers and/or staff. Due to GDPR, any questions which would identify a participant i.e. name, has been removed. This enabled participants to remain anonymous when giving feedback.

The questionnaires included a mix of open and closed questions. Closed questions were very helpful to understand the end-users experience in regard to MONICA technologies, in a way that is controlled to help with data analysis and provide room for comparison among different demonstrations at different cities. Open questions gave a place for the participants to give their opinion, what they did or did not like, and any improvements or suggestions they might have.

Regarding the format of the questionnaires, different forms were adapted (paper-based and online) for mass data collection.

The questionnaires adopted the Likert scale, which can be, a three, five, seven- or nine-point agreement or disagreement scale, used to represent participant's attitudes towards a certain topic. Although studies show a greater number of answers are more effective (i.e. 7 or 9), MONICA adopts the five-point scale in order to avoid overcomplicating the questionnaire and to increase the likelihood of participants' engagement. With this scale, participants are asked to respond to a series of statements based on their level of agreement or disagreement to each, in the form of: *Strongly agree, Agree, Neutral, Disagree, and Strongly disagree.*

Although the questionnaire follows a 5-point scale, for mobile apps questions, to ensure a high end-users response and to adapt to the small screen size, the categories have been combined into three. Therefore, the scale for the validation of results is:

- Agree
- Neutral
- Disagree

With regards to the structure of the scale, to avoid a force choice method questionnaire, a "neutral" option was included. Including neutral is important as it allows the participants to answer even if they do not have an opinion on the question and helps ensuring that they are not led to pick an extreme option. For example, the question "The COP has all of the functions I expected it to have" would be challenging to answer if the participant had no prior expectations of the COP, and so having neutral as an option ensures participants are not forced into agreeing or disagreeing with the statement.

Providing clear standard questions, with enough options in the scale, allowed for the participants to complete the questionnaire relatively quickly, which ensured the participants remain engaged. Moreover, this enabled a more productive analysis since the responses were converted into numbers and a comparison between demonstrations was made. The questionnaires included a mix of closed and open questions. Using closed questions helps to categorise data, whilst open questions can officiate a broader understanding of a certain topic.

In terms of the length of the questionnaire, to ensure participant engagement, the questionnaire is as short as possible, only focusing on the key areas of research. Each question focuses on one aspect i.e. one individual function, and does not feature two questions in one, or include double negatives or phrasing, as this can be confusing for participants. Moreover, the order of questions can also make a difference in the way participants respond to each question (Bryman and Bell, 2011), so questions are grouped in categories for better flow. For example, usability, functions, improvements etc.

## 3.3 Piloting Phase

The questionnaires were reviewed, translated in the local language and piloted prior to each demonstration, to receive pilots' opinions before the questionnaire was distributed. This allowed for minor changes and a better opportunity for feedback.

## 3.4 Sampling

A sample of people affected by MONICA IoT technologies was selected to answer the questionnaires. This included pilots' staff (security personnel, fire brigade staff, stewards, management staff), neighbours, and audience.

The aims were measuring their attitudes towards the MONICA devices.

## 3.5 Data Analysis

Generally, a mix of both qualitative and quantitative techniques were used to analyse the collected data. This included both as follows:

- Qualitative techniques: mainly for the analysis of interviews, focus groups, observations, and post-demonstration reports.
- Quantitative techniques: mainly for:
  1. Analysing the paper-based questionnaires, online Survey Monkey questionnaires, and mobile apps questionnaires.
  2. Indicators: In the DoA, 18 KPIs were presented as indicators of impact. The impact assessment and validation of MONICA technologies was based on such indicators. The results related to the KPIs are presented and described in section 5.4.

After each demonstration, there was a reporting process to the technical partners so that the feedback received could be used to refine the solutions in future demonstrations. This enabled technical partners and also pilot organisers to change certain aspects based on the results of the demonstration. For example, at Leeds Varsity 2019, there was an upgraded Wi-Fi system due to the lack of Wi-Fi in the March demonstration. As a result, the smart glasses testing at Varsity was much improved. Furthermore, Bonn reported that the seamless integration of the environmental sensors to the COP was largely improved based on feedback prior to the demonstration.

Although the questionnaire for each solution has many questions, the validation process requires only looking at the specific interests, such as the usability and functional aspects of the solution. In turn, only relevant questions are analysed. For example; *how easy is the solution to use, can the participant work more effectively, is the solution functional,* etc.

The validation process includes a full analysis of each questionnaire for each solution. This process involved transferring the data collected (specifically closed questions) into graphs and charts. A simple sorting system was designed for evaluating open questions, which divided the open questions into categories which were placed into smaller categories. This helped to visually represent the questionnaires and to conduct a more sufficient analysis.

# 4 Results of the validation in 2018 and 2019

This chapter focuses on the validation of results from demonstrations in 2018 and 2019. The purpose of user validation is to ascertain that the system or services met the expectations and requirements of its intended users.

A total number of 1.823 people replied to the surveys in two years, among security staff (police officers, private security officers, fire brigade officers), event organisers, visitors, and neighbours.

The results have been categorised into the following use case groups (in line with D9.3, D11.5 and D12.6): Crowd and Capacity Monitoring, Crowd Management and Communication, Sound Level Monitoring, Adaptive Sound Field Control and User Experience.

## 4.1 Validation assessment activity in 2018

In table 1 the overview of the validation assessment activity in 2018 is presented. In the first column from left there is the list of events in the six pilots where the demonstrations took place along the year. In the third column the type of questionnaires and the number of respondents is listed, per event. In the last column there are mentioned the partners who contributed to the draft of the post-demonstration reports.

The questionnaires have been mainly paper-based, distributed by the pilots to the end users during or after the event.

**Table 1. Overview of collected questionnaires and reports in 2018**

| Demonstration | Demonstration date | Questionnaires collected | Post-demonstration report |
|---|---|---|---|
| Rhein in Flammen | 2018-05-05 | N/A | Inputs from FIT |
| Port Anniversary | 2018-05-13 | Visitors questionnaire: 10 | |
| Kappa FuturFestival | 2018-07-07 - 07-08 | Sound monitoring and control questionnaires for staff: 2<br>Neighbours questionnaires: 144 | Inputs from LINKS, DEXELS, ACOU |
| T20 Yorkshire Vikings (cricket) | 2018-08-17 | N/A | Inputs from LEEDS, LBU, emergency services feedback report |
| Friday Rock | 2018-08-31 | Wristband questionnaire: 6<br>COP questionnaire: 1 | Inputs from DTU, FIT, ISMB, KU, DEXELS, B&K, CNET |
| Pützchens Markt | 2018-09-07 - 09-10 | N/A | Inputs from FIT, BONN, KU, DIGISKY, CNET, report from the City of Bonn |
| Movida | 2018-11-06 - 11-11 | Smart glasses questionnaire: 9 | Inputs from LINKS, KU |
| WinterDOM | 2018-11-17 - 12-09 | COP questionnaire: 1<br>LoRa tracker questionnaire: 4 | Inputs from HAW |
| Fête des Lumières | 2018-12-06 - 12-09 | Smart glasses questionnaires:3<br>Staff tracking questionnaires: 3<br>Visitors questionnaires: 19 | Inputs from CERTH, ACOU |

## 4.2 Validation assessment activity in 2019

In table 2 the overview of the impact assessment activity in 2019 is presented. In the first column from left there is the list of events in the six pilots where the demonstrations took place along the year. In the third column the type of questionnaires and the number of respondents is listed, per event. In the last column there are mentioned the partners who contributed to the draft of the post-demonstration reports.

In 2019, Survey Monkey was used as the main tool for participant feedback. Survey Monkey allows for wider distribution and a more functional feedback. A study (McMaster et al., 2017) showed that when comparing

web-based and paper-based questionnaires, the web-based questionnaires produced a significantly higher response rate.

**Table 2. Overview of collected questionnaires and reports in 2019**

| Demonstration | Demonstration date | Questionnaires collected | Post-demonstration report |
|---|---|---|---|
| Leeds Rhinos - Rugby | 2019-03-28 | Firefighter interview for smart glasses<br>Security Staff & Firefighter Smart Glasses: 8 | Inputs from KU, LEEDS, ATOS |
| SpringDOM | 2019-03-22 - 04-22 | COP questionnaire: 1<br>LoRa tracker questionnaire: 1 | Inputs from KU, VCA |
| Fredagsrock | 2019-04-26 | Sound app questionnaire: 1<br>Q for smart glasses: 5 | Inputs from TIVOLI |
| Rhein in Flammen | 2019-05-03 - 05-05 | Q for LoRa tracker users: 7<br>Q Visitor app: 28<br>Q COP: 1 | Inputs from KU, VCA, BONN, ATOS, FIT |
| Port Anniversary | 2019-05-10 - 05-12 | Q for COP: 1<br>Q for visitors: 106 | Inputs from HAW, ATOS |
| Nuits Sonores | 2019-05-28 - 06-02 | Q for audience: 60<br>Q for neighbours: 93 | Inputs from ATOS, ACOU |
| IoT Week | 2019-06-18 to 06-20 | Q for WBs: 51 | Inputs from ACOU, DEXELS, LINKS, ATOS |
| Kappa FuturFestival | 2019-07-06 - 07-07 | Qs sound app: 3<br>Q neighbours: 59 | Inputs from DIGISKY, B&K, KU, VCA, CERTH, ATOS, LINKS, DTU, MOVE |
| SummerDOM | 2019-08-03 - 08-25 | Q for visitors: 132 | |
| Woodstower | 2019-08-29 - 09-01 | Q for COP: 1<br>Q for visitors: 233<br>Q for neighbours: 151 | Inputs from CERTH, ATOS, DIGISKY, DEXELS, ACOU |
| Pützchens Markt | 2019-09-06 - 09-10 | Q for LoRa tracker: 7<br>Q for the visitor app: 33 | Inputs from KU, ATOS<br>KU evaluations results |
| Istedgade Fest | 2019-09-08 | Q for neighbours: 138 | |
| Leeds Rugby | 2019-10-02 | Q for smart glasses: 4<br>Q for visitor app: 235 | Inputs from ATOS, KU, CERTH, LBU, LR |
| WinterDOM | 2019-11-7-11-11 | Q for COP: 2<br>Q for LoRa tracker: 3<br>Q for visitors: 252 | Inputs from HAW, LINKS, ATOS |
| Fête des Lumières | 2019-12-05 - 12-08 | Q for smart glasses: 2 | Inputs from ATOS, B&K, KU, VCA, ACOU, CERTH |

## 4.3 Crowd and Capacity Monitoring

The MONICA Crowd and Capacity Monitoring solution has been developed with the aim of supporting municipalities, event organisers and security staff in situations where the build-up of crowds could result in a security risk. The MONICA Crowd and Capacity Monitoring is an on-site solution consisting of a series of components which can be deployed for a variety of purposes using CCTV cameras, wearables and advanced video analytics. The solution hence collects important information about crowd size and flow (crowd counting), advanced object detection, including vehicle detection as well as early warning of security threats.

For the validation of the Crowd and Capacity Monitoring solution no questionnaires were distributed to end users, but KU analysed the results from the demonstrations in 2019, manually counting the frames.

The pilot studies have effectively demonstrated the performance of the crowd estimation algorithms and an estimation accuracy of over 70% is typically achieved. A significant learning from the pilot studies is the impact of ambient noises in the image such as occlusions in the street, lighting variations, and changing illumination in the images due to weather changes. The crowd estimation algorithms are to be further trained to understand the constant variations in the captured images and subsequently improve the detection accuracy.

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

The results of the video analytics in 2019 are reported in D8.3 Consolidated Demonstration Platform Pilot Progress Report 2. However as an example, the validation results obtained at the Pützchens Markt demonstration are presented in this section. At this demonstration, five cameras were used for people counting (providing numbers of people entering through three main access roads) and crowd density monitoring. The graph in figure 1 presents predicted versus actual numbers of people. The blue line indicates that the algorithm tends to underestimate the number of people in the frame. This largely occurs when the frame is crowded and distant from the camera point of view. For a smaller crowd, the difference between the predicted and actual number is relatively low. Therefore this suggests the algorithm in its current state is more accurate for smaller crowds.

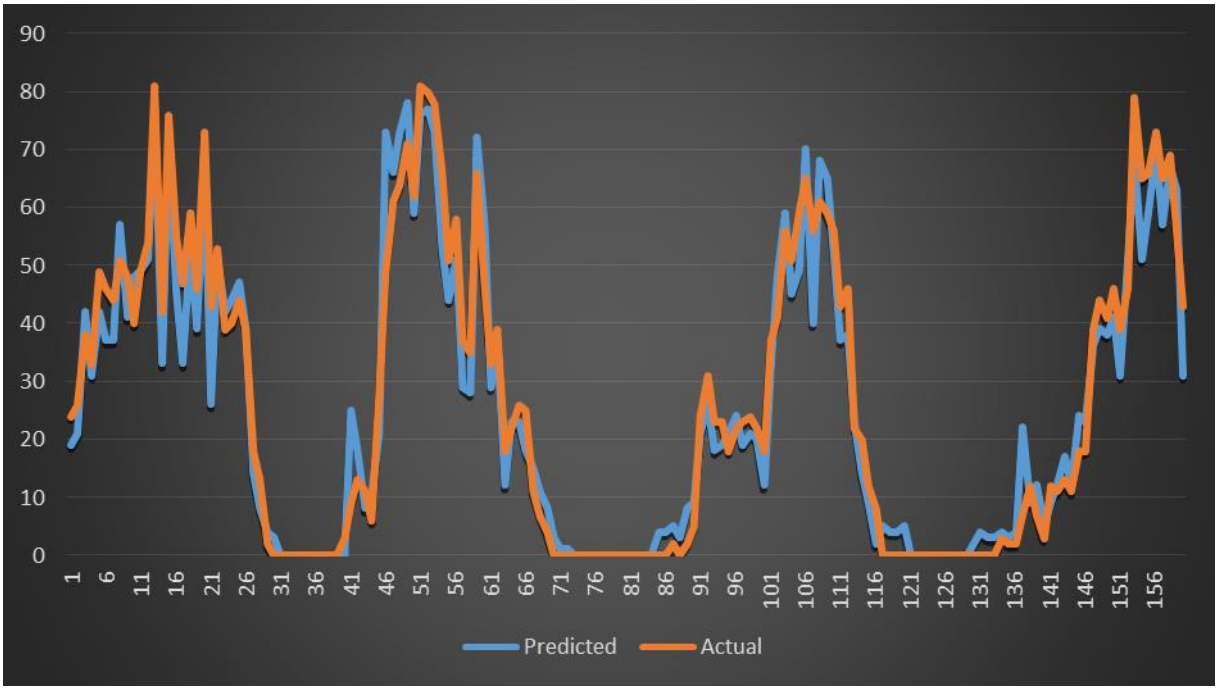


**Figure 1 Graph of predicted vs. actual numbers at Pützchens Markt**

## 4.4 Crowd Management and Communication

CCTV cameras available commercially with on-board intelligence are able to count and track people in uncrowded scenes. However, to work in crowded scenes, the cameras lack processing power so the performance cannot be improved. In MONICA, with the IoT technologies and cloud computing, video analytics processing can be split between edge nodes and cloud infrastructure. As a result, the additional power (from clouds and IoT hybrid processing models) in comparison to commercial cameras, enable more advanced algorithms to be developed, achieving high performance for tracking and counting in both crowded and uncrowded scenarios but still using low cost and commercially available sensors.

MONICA Crowd Management and Communication solution gives an effective overview of event activities in real time as well as means for feed-back and communication to security and first-responder staff. During the

event, security and first responder personnel at the control centre can monitor the situation on large display screens using a web-based interface – the MONICA COP (Common Operational Picture) – which provides an operational picture of the environment in real-time, as collected by the MONICA Crowd and Capacity Monitoring solution.

The MONICA Crowd Management and Communication solution facilitates real time visual, audio and written communication between staff onsite and the control centre. Devices applied cover smart glasses, IoT staff wristbands and staff trackers. For example, onsite personnel can report the incident to the control centre by sending live video stream and images using smart glasses. Staff wristbands and GPS staff trackers make it possible to locate and track staff members and visualize this in the control room using the COP in real time for a better coordination of intervention.

During the Leeds Varsity demonstration, the steward testing the smart glasses stated that they are a "better alternative" to what is already available to security staff. The smart glasses offer real-time images, videos and messaging which the steward states help improve communication compared to his current radio walkie-talkie.

### 4.4.1 The COP

The COP was used throughout 2018 and 2019 at a total of 22 demonstrations. However, quantifiable questionnaire feedback was collected from 8 demonstrations. Qualitative feedback was collected during all demonstrations, based on oral and email interviews, focus group and group discussions.

The COP was used in a control room environment, as a solution to crowd and capacity monitoring, sound monitoring and control and also for environmental factors, such as wind speed.

During the demonstrations, participants were shown how the COP displays data, such as over-crowding areas, positioning of staff, and how it can link with other solutions such as the smart glasses and LoRa trackers. After each test, participants were encouraged to give feedback for the COP via a questionnaire. The questionnaire included questions about functions, organisation and information as well as other aspects of the COP. The COP was evaluated by very few participants at all demonstrations, with most demonstrations having just one user evaluate it, some demonstrations were unable to demonstrate the COP to the correct people due to participants being unavailable. As a result, the sample size we received was not representative or an accurate reflection of the solution.

Some pilots, such as Friday Rock 2018 found that there was not enough opportunity to test the COP or see it in action. This is a limitation throughout the demonstrations as presenting the COP to particular members of staff at demonstrations was a difficult process. The desired situation would be to have the high security personnel evaluating the COP, but live demonstrations meant that these personnel have limited availability throughout the event.

Friday Rock 2018 organisers stated that they did not have the opportunity to test the COP, and only saw the COP working in action for approximately 10 minutes, therefore the participant felt they could not give an accurate evaluation of the COP, in terms of functions but could comment on organisation and information the COP displays.

Leeds Varsity 2019 Ground Safety Officer (GSO) also felt that he did not see enough of the COP in operation to give feedback. However, in a discussion following the demonstration, the GSO stated that he felt the COP could be used to aid decision making in the control room, however he reiterated that he would want the COP to assist staff in specific areas, rather than replace them. The GSO expected the information displayed on the COP to be available on one page as an overview, with further detail on additional pages that can be easily accessible.

Generally, at the demonstration's participants felt that information on the screen was easy to understand and well organised.

"*The information provided by the COP is easy to understand*"

**Table 3 COP easy to understand**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Friday Rock 2018 | X | | |
| Winter DOM 2018 | X | | |

| | | | |
|---|---|---|---|
| Spring DOM 2019 | | X | |
| Friday Rock 2019 | n/a | n/a | n/a |
| Rhein in Flammen 2019 | X | | |
| Port Anniversary 2019 | | | X |
| Woodstower 2019 | X | | |
| Winter DOM 2019 | n/a | n/a | n/a |

"*The organisation of information on the screen is clear*"

**Table 4 Clear organisation of information**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Friday Rock 2018 | X | | |
| Winter DOM 2018 | | | X |
| Spring DOM 2019 | | | X |
| Friday Rock 2019 | X | | |
| Rhein in Flammen 2019 | X | | |
| Port Anniversary 2019 | | | X |
| Woodstower 2019 | X | | |
| Winter DOM 2019 | X | | |

If there are occasional inaccuracies during the demonstration, in terms of the DSS (Decision Support System) or other tools used within the COP, a negative opinion about the COP can be formed, although the potential issue is not necessarily with the COP itself. Organisers at Bonn noted that a greater user experience relies heavily on having a working and usable COP.

As already mentioned, one limitation of the analysis related to table 3 and 4 is the low number of participants. Comparing to the other tables in this and other sections, in table 4 there are no percentages because only one respondent per event participated to the survey. The only exception is WinterDOM 2019 with two respondents.

To conclude the analysis, although the COP did not produce positive results at all demonstrations, each demonstration is of value as technical partners were able to collect important lessons learned. This allowed technical partners to begin adapting and improving the solution in areas to make it even more suitable and correct any errors. To get a wider understanding of the COP generally as well as the users' perception (of the COP), it would be important to have more participants test the solution for a longer period of time. One of the key observations when analysing the feedback and observing demonstrations is that participants felt they needed more time getting to know how the COP works before testing it at the live demonstration.

This aside, the strength of the COP is that it is a solution that has the ability to bring all other solutions in the MONICA platform together, something which is not available on the market today. The COP can be adapted depending on the need for the solution, for example, it can be used at both long (re-occurring events, such as a seasonal sporting fixture) and short-term deployments (a live concert, for example).

When displaying interchangeable solutions, such as the smart glasses or the LoRa Tracker positions correctly, as well as accurately counting crowd flow and density and performing other functions effectively, the COP is an innovative solution to combat the inevitable challenges at large open-air demonstrations.

### 4.4.2 Smart Glasses

The smart glasses were tested throughout 2018 and 2019 at various different demonstrations, including festivals and sporting events. Over both years, 28 participants tested the smart glasses as a solution to safety and security incidents.

After each test, participants were encouraged to give feedback for the glasses via a questionnaire. The questionnaire included questions about functions, ease of use and other aspects of the smart glasses.

From table 5 it can be concluded that the smart glasses are an easy solution to use. Throughout all demonstrations in 2018 and 2019 an average of 89% of participants agreed the smart glasses are easy to use. Although not fully field tested by all participants in two demonstrations (Leeds Rugby Varsity 2019 and Fête des Lumières 2019) participants were still able to recognise the ease of use by testing in a control room environment.

**Table 5 Ease of Use**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Movida 2018 | 56% | 33% | 11% |
| Leeds Rhinos Rugby 2019 | 100% | 0% | 0% |
| Friday Rock 2019 | 80% | 20% | 0% |
| Leeds Rugby Varsity 2019 | 100% | 0% | 0% |
| Fête des Lumières 2019 | 100% | 0% | 0% |

One of the main functions of the smart glasses is to assist with reporting and detecting incidents that may occur during an event. Participants were asked whether they were able to use the smart glasses as a tool for incident detection and reporting.

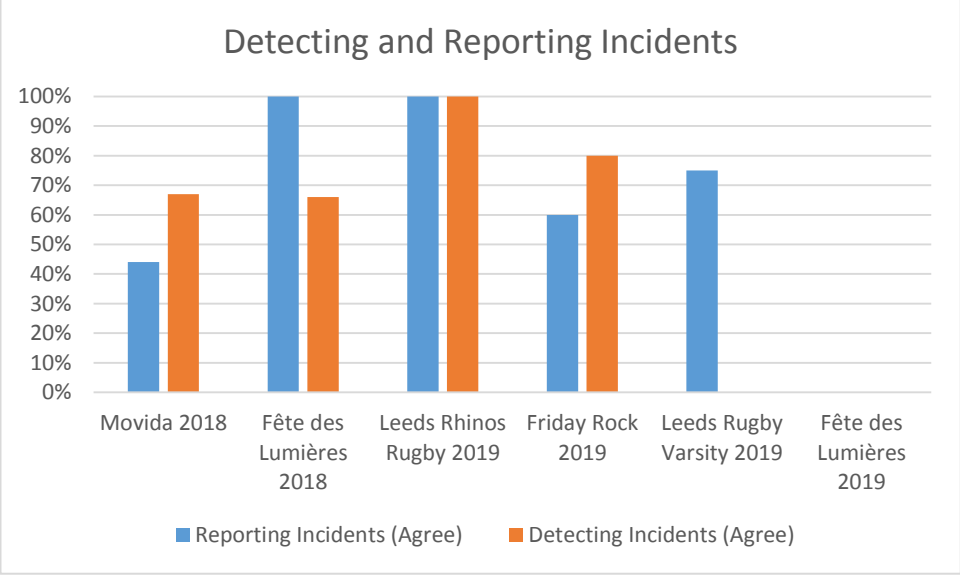


**Figure 2 Detecting and Reporting Incidents via Smart Glasses**

This feedback shows that in general participants found the smart glasses to be a successful tool in reporting and detecting incidents. The feedback highlights that the lack of field testing at Leeds Varsity 2019 and Fête

des Lumières 2019 has an impact on whether participants can determine if the smart glasses can help to report and detect incidents.

As mentioned previously, the smart glasses were not able to be fully field tested by all participants at Leeds Varsity 2019, and this could highlight as to why 25% of participants feel they can effectively complete their work. In order to get a better reflection of the impact the smart glasses can have on effectively completing work, a second more extensive test with the same participants would be required.

**Table 6 Effectively Complete Work**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Movida 2018 | 56% | 11% | 33% |
| Leeds Rhinos Rugby 2019 | 67% | 33% | 0% |
| Friday Rock 2019 | 20% | 80% | 0% |
| Leeds Rugby Varsity 2019 | 25% | 50% | 25% |
| Fête des Lumières 2019 | 100% | 0% | 0% |

To summarise, participants were asked if they were overall satisfied with the smart glasses. Overall satisfaction takes into account all aspects of the smart glasses, including detecting and reporting incidents, the ease of use, information and organisation and the physical aspects, such as weight, suitability for role, etc.). Table 7 shows that just 8% of participants disagreed they were overall satisfied with the glasses. The outcome of this feedback shows that participants are satisfied with the glasses to be used as a solution to safety and security incidents. To get a further accurate insight into the solution overall, it's important that the smart glasses are fully field tested during future demonstrations.

**Table 7 Overall Satisfaction**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Movida 2018 | 56% | 22% | 22% |
| Leeds Rhinos Rugby 2019 | 75% | N/A | N/A |
| Friday Rock 2019 | 40% | 40% | 20% |
| Leeds Rugby Varsity 2019 | 75% | 25% | 0% |
| Fête des Lumières 2019 | 100% | 0% | 0% |

### 4.4.3 GPS staff trackers

In this deliverable what were previously called "GPS LoRa trackers" are the devices deployed by FIT. At the very end of the project FIT changed the name of this wearable to "Live Positioning Information System (LiPS)". But in the previous years they were known as LoRa trackers, so the name hasn't been changed in the deliverable as questionnaires and participants used this term.

LoRa trackers have been deployed in 6 demonstrations throughout 2018 and 2019 and used by event staff during their shift. In total, 22 respondents provided feedback on the LoRa Tracker.

Participants were asked a range of different questions regarding the device, such as weight suitability, functions and desired features.

Participants were asked whether the tracking device was easy to use. The table below shows that majority of participants found the device easy to use.

**Table 8 Device usability**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Winter DOM 2018 | 67% | 33% | 0% |
| Spring DOM 2019 | 0% | 100% | 0% |
| Rhein in Flammen 2019 | 86% | 0% | 14% |
| Pützchens Markt 2019 | 71% | 0% | 29% |
| Winter DOM 2019 | 100% | 0% | 0% |

Participants were also asked if the weight of the device was suitable. Feedback shows that mostly the participants were happy with the weight.

**Table 9 Weight suitability**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Winter DOM 2018 | 67% | 0% | 33% |
| Spring DOM 2019 | 0% | 100% | 0% |
| Rhein in Flammen 2019 | 100% | 0% | 0% |
| Pützchens Markt 2019 | 100% | 0% | 0% |
| Winter DOM 2019 | 33% | 33% | 33% |

Table 10 shows mixed results on whether the device is comfortable to wear. In the general comments section of the questionnaires, most participants stated it would be a good idea to have a smaller device, to make it more comfortable.

**Table 10 Device comfort**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Winter DOM 2018 | 0% | 67% | 33% |
| Spring DOM 2019 | 0% | 0% | 100% |
| Rhein in Flammen 2019 | 71% | 0% | 29% |
| Pützchens Markt 2019 | 100% | 0% | 0% |
| Winter DOM 2019 | 33% | 33% | 33% |

Participants were asked if the "*tracking device made it difficult for me to do my normal daily job*". The feedback shows that all participants found that the device did not hinder or obstruct them whilst they were completing their daily tasks at work in 2019. This is very important as the solution allows the user to carry on with their normal daily job with the added benefit of being able to communicate and being tracked by the control room.

**Table 11 Device obstructing user**

| | Agree | Neutral | Disagree |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Winter DOM 2018 | 67% | 0% | 33% |
| Spring DOM 2019 | 0% | 0% | 100% |
| Rhein in Flammen 2019 | 0% | 0% | 100% |
| Pützchens Markt 2019 | 0% | 0% | 100% |
| Winter DOM 2019 | 0% | 0% | 100% |

Furthermore, the results show that at Winter DOM 2018, 67% of participants found that the tracking device did make it difficult for them to do their job. In 2019, no participants found the device to hinder or obstruct at Winter DOM and more significantly, at any of the demonstrations. This highlights the improvement of the device over the two years of demonstrating. Moreover, this result shows that the device has the potential to further improve in the future.

Participants determined whether the device met their expectations.

**Table 12 Expectations of device**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Winter DOM 2018 | N/A | N/A | N/A |
| Spring DOM 2019 | 0% | 0% | 100% |
| Rhein in Flammen 2019 | 57% | 43% | 0% |
| Pützchens Markt 2019 | 57% | 14% | 29% |
| Winter DOM 2019 | 33% | 67% | 0% |

Overall, generally there is a positive opinion about the tracking device. With added extra functions, such as a status bar (Hamburg), and changing the size of the device (Bonn), it's possible that participants would be even more satisfied with the device.

**Table 13 Overall satisfied with device**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Winter DOM 2018 | N/A | N/A | N/A |
| Spring DOM 2019 | 0% | 0% | 100% |
| Rhein in Flammen 2019 | 57% | 43% | 0% |
| Pützchens Markt 2019 | 71% | 29% | 0% |
| Winter DOM 2019 | 33% | 33% | 33% |

### 4.4.4 Staff Tracker App

The staff tracker app was deployed at one demonstration (Fête des Lumières) in 2018. The app was to track staff throughout the event.

Participants mainly found that the mobile app was an easy app to use.

**Table 14 Ease of use**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Fête des Lumières 2018 | 67% | 33% | 0% |

100% of participants found that the tracking device met their expectations. Although expectations were met, participants suggested when testing the app that they would like to add the ability of background refreshing, and a low battery sign.

**Table 15 Expectations**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Fête des Lumières 2018 | 100% | 0% | 0% |

Overall, 67% of participants stated they were in general satisfied with the app. The app had met 100% of participants expectations and they found the app very easy to use. Participants did not find the idea of their location being tracked an issue, and particularly liked the idea of being able to explicitly turn the tracking on and off and another participant discussed that they felt safer because of this. However, one participant did wonder if their location/journey would be discussed. Overall, participants had a generally high acceptance of the device.

**Table 16 Overall satisfaction**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Fête des Lumières 2018 | 67% | 33% | 0% |

## 4.5 Sound Level Monitoring

The MONICA IoT Sound Level Meter (SLM) solution provides real-time monitoring (measuring and displaying) of sound levels at discrete outdoor locations in the city.

### 4.5.1 The COP

In 2018 and 2019 during the demonstrations, the data from the MONICA IoT Sound Level Meters have been sent to the COP. Questionnaires have been distributed to a total of 2 participants (sound staff, production managers).

Participants were asked if the COP system as it is could help the users to comply with the legislation in force.

**Table 17 Comply with legislation**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Rhein in Flammen 2019 | | X | |
| Woodstower 2019 | X | | |

Table 18 shows that participant at Woodstower festival felt that the acoustic information was relevant. At Rhein In Flammen, the feedback shows the participant remained neutral. So no participants found the information to not be relevant.

**Table 18 Relevant acoustic information**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Rhein in Flammen 2019 | | X | |
| Woodstower 2019 | X | | |

Participants were asked if the display of the sound levels measured helped them to adjust the sound level. The feedback shows that although the COP produced relevant acoustic information, the participants do not find that the COP can help to adjust the sound level.

**Table 19 Adjust Sound Level**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Rhein in Flammen 2019 | | X | |
| Woodstower 2019 | | | X |

One limitation of the analysis related to table 17, 18 and 19 is the low number of participants. Comparing to the other tables in this and other sections, here there are no percentages because only one respondent per event participated to the survey.

To conclude, further testing by the same participants at Rhein In Flammen would be necessary to give a better insight into the COP being used as a solution for sound monitoring and control. At Woodstower, the feedback shows that the participants felt the acoustic information was relevant and that the COP helped users to comply with the legislation, although more improvement is needed on the measured sound levels helping to adjust the overall sound levels. Although not all participants found the COP to be a complete success, the demonstrations and feedback given at each event is very valuable as it ensures technical partners receive feedback from a user's perspective which enables the solution to be improved based on user feedback.

### 4.5.2 Sound App

The COP developers (CNET) introduced the COP onto a mobile device. This helped participants to easily view the sound information on their smartphone and meant they did not have to be in a control room. In total, 5 participants tested the Sound App as a solution to sound monitoring and control at two demonstrations in 2019.

Participants were asked to determine whether "*The app helped me do my job better*". Kappa FuturFestival sound staff found that the app aided them during they day-to-day tasks which resulted in them doing their job better. However, Friday Rock sound staff found that the app did not help them to do their job better. It's possible that, given the low accuracy of the sound data, they found that the app did not improve their job.

**Table 20 Improve job**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Friday Rock 2019 | 0% | 0% | 100% |
| Kappa FuturFestival2019 | 100% | 0% | 0% |

Respondents were also asked if using the app during work helped to save them time. The table 21 below shows that Friday Rock 2019 users testing the app found that the app did not help them save time. It's likely that a better accuracy of results at Friday Rock 2019 would have helped the testers to save time at work. In comparison, at Kappa FuturFestival, 67% of sound staff found that the app saved them time. This could be impacted by the improved results.

**Table 21 Save time**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Friday Rock 2019 | 0% | 0% | 100% |
| Kappa FuturFestival2019 | 67% | 33% | 0% |

Although Kappa FuturFestival had improved accuracy compared to Friday Rock 2019, a better accuracy of results would be important for future demonstrations, and may increase users acceptance of the technology in the future. Participants were asked if "*all information related to sound levels were correctly displayed on the app*". The results are shown in table 22.

**Table 22 Correct sound levels displayed**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Friday Rock 2019 | 0% | 0% | 100% |
| Kappa FuturFestival2019 | 33% | 0% | 67% |

Current legislations refer to staying with EU regulations with regards to sound. Participants were asked whether the sound app could help them comply with these legislations.

**Table 23 Comply with legislation**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Friday Rock 2019 | 0% | 0% | 100% |
| Kappa FuturFestival2019 | 33% | 67% | 0% |

Table 24 shows that the participants at Kappa FuturFestival were able to successfully adjust the sound levels as a result of the app. The questionnaire stated, "*the app helped me adjust the sound levels*". This table shows that users at Friday Rock 2019 were not able to adjust the sound levels because of the app. However, the sound levels were successfully adjusted at Kappa FuturFestival by 100% of participants.

**Table 24 Adjust sound levels**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Friday Rock 2019 | 0% | 0% | 100% |
| Kappa FuturFestival2019 | 100% | 0% | 0% |

Overall, the tables above show mixed results regarding the sound app at two demonstrations. It would be important to deploy the sound app at further demonstrations so that the impact can be analysed more in depth. More participants involved in the testing stage would help to generalise user opinions and spot patterns which may be difficult to find with few participants. Moreover, a better accuracy of results would most likely improve the overall acceptance of the sound app and enable participants to feel like the app improves their job and have a better impact on their tasks at work and could improve the overall participant level of agreement in the questionnaire.

There are many positive aspects evident in the feedback. The feedback from both demonstrations helps the technical partners to understand the needs of the user and what they believe the sound app can improve on. As a result, the technical partners are able to improve the sound app and make it a more useable solution in the future.

## 4.6 Adaptive Sound Field Control System

Research into commercial systems prior to testing the Adaptive Sound Field Control (ASFC) system in MONICA evidenced that there were no existing systems that were able to work in outdoor conditions, where the atmosphere conditions can change frequently, more specifically with the purpose of minimising the noise spread to neighbouring regions. In addition, the MONICA ASFC solution is adaptive and uses IoT devices to extract the data, whilst existing systems do not.

The ASFC system minimizes the annoyance in neighbouring areas. In 2018, DTU used the ASFC system for the first time away from a lab environment. The result was a reduction of 10 dB[2] during the first large outdoor testing environment at Refshaleøen (an area of Copenhagen) where rock and metal festivals amongst other events are held every year.

The first proper demonstration of the ASFC system at a real music event took place at the Kappa FuturFestival on 7th and 8th July 2018. To demonstrate the control of sound, one stage called FUTUR worked as the main experimental area for the MONICA ASFC system. The ASFC system was based on a set-up of four sound level meters and 20 loudspeakers. . To understand how large-scale events can affect the neighbouring community, MONICA conducted a survey targeted at local inhabitants. This helped understand not only their feelings but also indicate if there was any perceived improvement, i.e., less sound annoyance from year to year after the deployment of the sound control system.

In the following edition of Kappa FuturFestival (in 2019), MONICA completed the second demonstration of its acoustic applications. Results showed progress but also challenges to overcome. Made up of 20 subwoofers, the ASFC system would have reduced the sound coming from the SEAT stage in an area outside the festival which hosted a church. The subwoofers were installed behind the audience to attenuate sound in the courtyard of the church. Results indicated a reduction of 7 dB[3] which was a slight improvement from 2018 where a 6 dB reduction was achieved.

After each edition of Kappa FuturFestival, MONICA in collaboration with the City of Torino organised a neighbour survey. The most interesting result is here below:

*"If you were at home last year during the festival, this year the situation regarding the nuisance is:"*

**Table 25 ASFC system: neighbours survey results**

| | Worse | The same as last year | Better |
|---|---|---|---|
| Kappa FuturFestival 18 | 26% | 57% | 17% |
| Kappa FuturFestival 19 | 21% | 29% | 50% |

The result of the survey in 2019 shows that the effect was audible but not impressive, mainly because DTU faced a strong sound spill-over from the surrounding stages.

The target of 10dB reduction, which roughly corresponds to a halving of the loudness for the human perception, has only been achievable at MONICA tests in open terrain without adjacent activities and buildings complicating the sound attenuation. Here, a reduction of up to 20 dB[4] has been achieved.

The demonstration at Kappa FuturFestival 2019 showed once more that due to the complexity of the environment, it has not yet been possible to achieve the 10 dB reduction during the demonstration. Therefore, DTU decided to consider the deployment of ASFC system at a less environmentally challenging events.

The Sound Summit at the Roskilde Festival Højskole (Denmark) that took place on the 30th November 2019 was the right location for the last demonstration. The main purpose of the demonstration was to test the adaptive algorithm in the ASFC. During the demonstration day, one such algorithm was tested successfully during a 1-hour concert (with about 100 persons attending). This algorithm was based on a propagation model being updated about every minute. The insertion loss (reduction) was about 11 dB[5] in the controlled low-frequency range in the intended dark zone, and the adaptation was working. In the days before the demonstration, another test was also done, including testing using an alternative adaptive algorithm. This version was also working well, with the insertion of around 15 dB[6].

Public servants from the municipality of Copenhagen assisted to the demonstration and their feedback have been collected:

*- What was your impression during the demo?*

[2] 10 dB from D4.2 Validation of the ASFC and Noise Monitoring System Configuration and Model Updating 2
[3] According to DTU
[4] 20 dB: source https://www.monica-project.eu/estimating-and-controlling-the-sound-impact-of-outdoor-music-events/
[5] Source: DTU's note
[6] Source: DTU's note

"It was interesting. You could clearly notice that the bass was reduced, but the noise level was the same. The test worked well under the optimal open conditions at Musicon (the venue of the Sound Summit), but we find it very difficult to see how it can work in a narrow urban space, with everything that reflects the sound. The results in Tivoli were, as we understand it, for precisely these reasons, also not significantly good".

*- Could it be a solution for open air music events in the city of Copenhagen in the future?*

"It is a very complex set-up and there are far too many factors involved. Especially our changeable weather will be a difficult factor to plan around. In addition, preparation of the counter phase requires a great deal of data, and quite a lot of equipment, which we only see possible (if at all) in very financially strong organizations. We therefore do not think that this technology, in its present form, will be particularly useful for the many small events held in the city".

*- Would the municipality be interested in knowing more about the system (costs, investment, equipment needed, venue features and so on)?*

"At present, the technology cannot do enough and is therefore not something we can use as an environmental authority. The technology is new and exciting, so perhaps it is relevant to the Department of Culture and Leisure in their dialogue with music venues about funding, etc".

In fact, at the moment of the redaction of this deliverable, DTU is planning to meet the public servants who assisted at the demonstration to show the progress of the ASFC system and to discuss about the next steps. Moreover, DTU and Tivoli are discussing about the possibility of deploying the ASFC system during a FridayRock concert, after the end of MONICA project. DTU has proved that the system can mitigate the sound annoyance of the neighbourhood indeed, and there are customers in Denmark potentially interested in its deployment.

## 4.7 Visitor Experience

The MONICA User Experience solutions aim to improve the visitor's experience of an event and consist of two digital applications:

1) an event app, enabling visitors to access and navigate the event more easily and

2) a Smart IoT wristband solution, interacting with users through concert lightshows at festivals or at events with features like polls, attention notifications and connecting through social media.

### 4.7.1 Visitor Apps

Three visitor apps were developed and implemented at demonstrations in 2019; Rhein in Flammen 2019, Pützchens Markt 2019 and Leeds Varsity 2019. The apps were provided as a solution to bettering the user experience and engaging with visitors.

Overall, 326 participants provided feedback on the apps. The questionnaires were slightly different in terms of content, although comparisons can be made between questions. For Leeds Varsity, the questionnaire was much shorter due to the target audience being students.

In terms of ease of navigation and use, MONICA app development team made sure of incorporating ease of use, faster loading time, ability to complete specific tasks in a minimum number of actions possible. Table 26 shows that the positive impact of the app on users navigation experience.

- Rhein in Flammen - "*I can easily browse and navigate through the app*"
- Pützchens Markt – "*The app was easy to use*"
- Leeds Varsity visitors - "*The app was easy to use*"

These results can be compared as all questions are focused on finding out if the app is easy to use.

**Table 26 Ease of Use**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Rhein in Flammen 2019 | 68% | 14% | 18% |

| | | | |
|---|---|---|---|
| Pützchens Markt 2019 | 83% | N/A | N/A |
| Leeds Rugby Varsity 2019 | 93% | 5% | 2% |

Visitors were also asked if the app met their expectations in terms of functions. The feedback in table 27 shows that the participants felt that the app did not feature all functions they expected.

**Table 27 App Functions**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Rhein in Flammen 2019 | 36% | 14% | 55% |
| Pützchens Markt 2019 | 28% | N/A | N/A |

Participants were also asked which amenities they could find through using the app at Rhein in Flammen and Pützchens Markt. The graph below highlights the amenities found via the app at both festivals.

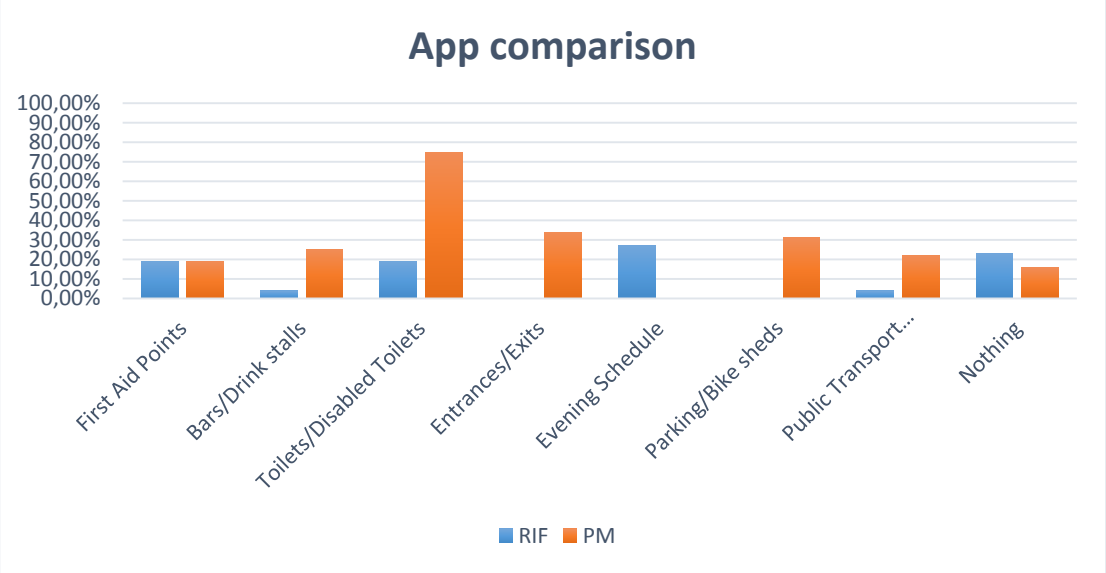


**Figure 3 App amenities at Rhein in Flammen (RIF) and Pützchens Markt (PM)**

The questionnaires also feature open questions, in which the participants could suggest improvements for the app. Improvements are mainly focused on the level of detail of the interactive map:

- A better detailed map
- Ability to pinpoint yourself on the map
- Colour coded maps
- Better updates (pictures etc.)
- Include all features on map i.e. food stalls

Participants were also asked if the app would make them want to attend the event again in the future, which would improve ticket sales (if a ticketed event) food and drink sales as well as potential tourism in the local area.

**Table 28 Attending the event next year (because of app)**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Rhein in Flammen 2019 | 21% | 36% | 43% |
| Pützchens Markt 2019 | 22% | 50% | 28% |
| Leeds Varsity 2019 | 64% | 28% | 8% |

Table 28 shows that more visitors from Leeds Varsity are most likely to attend the event again because of the app compared to Rhein In Flammen and Pützchens Markt. When analysing other aspects of the feedback, it's possible that Rhein in Flammen and Pützchens Markt visitors would like to see improved functions on the app, which could influence them to attend again in the future. This feedback shows the positive impact that the app had on visitors at the events (in particular Leeds Varsity) in terms of boosting visitor experience and enjoyment. This result shows the significance of how being able to use the app successfully, encourages visitors to attend again in the future.

Table 29 shows the average spending of visitors at the three events where the apps were distributed. Although the app did not include an online payment option, many visitors expressed the positive impact, the app had on their experience and expressed an intention of visiting the pilots again if the MONICA app is to be used again in the future. More visitors attending the event (because of the app) will also mean that there will be an increase in spending at the events.

**Table 29 Average spending**

| | Highest Average Spend | Visitor % |
|---|---|---|
| Rhein in Flammen | €10-€24 | 37.04% |
| Pützchens Markt | €25-€50+ | 80% |
| Leeds Varsity | £10-20 | 40.43% |

Rhein in Flammen: with 21% of participants wanting to attend Rhein in Flammen again, MONICA can have a direct impact on €357,000 of the income generated at the event where the average spend is €17. Although scaled down in the sample size, this figure shows that MONICA has the ability to contribute to more income at the event and encourage visitors to return again.

Pützchens Markt: with 22% of participants wanting to attend Pützchens Markt again, MONICA can have a direct impact on €726,000 of the income generated at the event, where the average spend is €37.5. Although scaled down in the sample size, this figure shows that MONICA has the ability to contribute to income at the event and encourage visitors to return again.

Leeds Varsity: the results at Leeds Varsity show that MONICA has already guaranteed that 64% of the participants will return next year, if the app is installed for future Varsity events. Although scaled down, this figure shows that MONICA has the ability to contribute to more ticket sales and income at the sporting event and encourage visitors to return again. Taking into account that 40.43% of visitors spend around £15, then if 64% (of an average crowd of 10,325) return again in the future, the total expected spending will be equal to around £40,000.

**Table 30 Overall, I am satisfied with the app**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| Rhein in Flammen 2019 | 50% | 18% | 32% |
| Pützchens Markt 2019 | 55% | 27% | 18% |

| | | | |
|---|---|---|---|
| Leeds Varsity 2019 | 95% | 4% | 1% |

Table 30 shows that on average 66% of participants were satisfied with the apps. Rhein in Flammen and Pützchens Markt have quite similar results. Although more than half of participants are satisfied with the app, certain aspects would need changing before they are fully satisfied with the app.

Leeds Varsity visitors have a very high percentage of satisfaction, which is reflected in the questionnaire on a whole; as feedback shows participants are likely to attend the event in the future and also had a better experience because of the app, compared to previous years without it.

Furthermore, the Varsity app had a positive impact on not only visitors but event organisers and safety personnel at Leeds Rugby Varsity 2019. The ability to provide important event information (such as the security video) to a wider audience was beneficial to all. As a result, there was less congestion in areas and students used the correct entrances for their respective universities. Furthermore, there were fewer needs for sanction on behaviour grounds at the student sporting event. Upon evaluation of Varsity 2019, it's possible some of the information featured on the app played a part in this positive outcome. In fact, Leeds Varsity organisers are in discussion with relevant parties to permanently instate the application as a full-time application for Varsity in future years. Moreover, students at both universities are also hopeful that the Varsity app will be a feature of future Varsity tournaments.

On the whole, the results resonate the positive opinion that the apps have the potential to be installed permanently at not only these three demonstrations but offers the opportunity to be replicated at other events. The app offers the opportunity to improve the visitor experience at events which is reflective in the results of the feedback at the three demonstrations where the app has been deployed as a solution to event information.

### 4.7.2 Crowd Wristband

Few units of crowd wristbands have been tested in few occasions in 2018, but once optimised the deployment, the MONICA partners were ready to use them at large scale in 2019.

The first opportunity was during a Friday Rock concert in Tivoli on April 26th, 2019, where around 400 crowd wristbands have been distributed to the concert goers, mainly to test the logistics, the distribution and the collection of the wearables.

The second demonstration took place during the IoT Week in June 2019, where the MONICA consortium invited participants to try out the crowd wristband. In the project, the wristbands are mainly supposed to be used for crowd monitoring at the events, however, they can also be designed for more interactive features. Thus, at the IoT Week, participants could exchange profile information by bumping wristbands, vote at sessions and be notified by the wristband's LED lights at keynote sessions and breaks. The feedback from the end users are reported in the following tables. More than 500 people used the MONICA crowd wristband at the IoT Week in Aarhus. Even though there were a few challenges along the way, the response to the IoT crowd wristband and its interactive features was very positive, generating increased interest in its potential.

A survey conducted with the users shows that most of them (74%) found it easy to use the wristband (table 32) and especially the connecting feature worked well. Since the wristband can have many functions and features, people were interested in knowing more about how it could be used in other settings and situations.

The third demonstration took place at the Woodstower festival, where volunteers distributed more than 6.000 MONICA wristbands, offering festival goers to be part of music-synchronised light shows. Whereas many happily accepted the wristbands, others were more reluctant because of GPS tracking.

The MONICA IoT wristbands had two main functions at Woodstower. They were used for crowd interaction, generating light shows by synchronising the LEDs on the wristband with the music on stage. Secondly, the wristbands were used to create heat maps to enable the organiser to estimate the crowd density. It was especially this aspect of tracking that some of the festival goers were sceptical about. One reason for the scepticism is that it has not been possible to inform the festival goers personally about the wristband beforehand. They were directly approached at the entrance with no knowledge of the wristband but could seek more answers at the MONICA booth close by.

Key lessons learned are therefore:

- Integrate the wristband communication and distribution into the festival process in order to make the wristband better known to people beforehand, thereby ensuring better acceptance and adoption;
- Add extra features to the wristband, such as a cashless function, making it more usable. Since the MONICA booth was placed where the cashless stand was at last year's festival, some visited the booth thinking they could load money onto the wristband.

In the following tables (31-35) the answers of the participants are presented with regards to the crowd wristband surveys.

*"The wristband was comfortable to wear"*

Participants were asked whether they found the wristband to be comfortable to wear on the wrist. Feedback shows over the two demonstrations that participants agreed that the wristband was comfortable to wear.

**Table 31 Wristband comfortable to wear**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| IoT Week 2019 | 60% | 32% | 8% |
| Woodstower 2019 | 65% | 20% | 15% |

*"The wristband was easy to use"*

The feedback shows that participants found that the majority of participants at both events found that the wristband was easy to use.

**Table 32 Wristband easy to use**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| IoT Week 2019 | 74% | 24% | 2% |
| Woodstower 2019 | 50% | 31% | 19% |

*"Compared to the previous years, I prefer the event with the wristband"*

For most participants in the questionnaire, 2019 was the first time they had visited the event(s). Therefore, the participants are unable to compare whether they prefer the event with or without the wristband. Nevertheless, when taking into account agree and disagree, more participants agreed at both demonstrations that they preferred the event with the wristband than without.

**Table 33 Prefer this year event (because of wristband)**

| | Agree | Neutral (This was my first visit) | Disagree |
|---|---|---|---|
| IoT Week 2019 | 32% | 68% | 0% |
| Woodstower 2019 | 19% | 65% | 16% |

*"Expected functions worked (light show, voting etc)"*

Participants were also asked if they could use the wristbands for their desired functions. For example, at IoT Week 2019, participants were able to use the wristband to bump with other participants and share their individual profile. They were also able to participate in voting during the IoT sessions by pressing the buttons on the wristband. At Woodstower, participants were able to participate with the light show, which used LED lights to match the music at the stage (white sensation). At both demonstrations, the location of the

wristbands (not the participants) were tracked, in order to estimate crowd density. Feedback from the Woodstower demonstration showed that participants were not keen on the idea of being tracked during the festival.

**Table 34 Use wristband functions**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| IoT Week 2019 | 47% | 23% | 30% |
| Woodstower 2019 | 39% | 0% | 61% |

*"Overall I am satisfied with the wristband"*

Overall, nearly 60% of participants at IoT Week 2019 found they were generally satisfied with the device. However, at Woodstower 45% of participants remained neutral. This is most likely due to the fact that not all participants were able to use the wristband and participate in the lightshow and other functions. On average, less than 15% disagreed that they were satisfied overall with the wristband.

**Table 35 Overall satisfaction**

| | Agree | Neutral | Disagree |
|---|---|---|---|
| IoT Week 2019 | 58% | 34% | 8% |
| Woodstower 2019 | 37% | 45% | 18% |

# 5 Impact assessment

According to the DoA, the impacts are organised in three categories: socio-economic, technological impact and user acceptability.

The impacts are discussed in this chapter. Some of the impacts have been quantified with a set of KPIs for each category.

## 5.1 Socio-Economic Impacts

IoT technology is increasingly being deployed to solve societal challenges in various different ways. The rapid growth of Smart City platforms enables cities to assemble digital applications on uniform communication networks to deliver diverse applications such as health, energy and resource efficiency and traffic management to help the city provide a better quality of life for citizens and become more environmentally sustainable. In MONICA, the focus is on improving the quality of life for workers, event organisers, visitors and neighbours.

The socio-economic impact assessment investigates the advantages for society as a whole, focusing on the relationship between social behaviours and economics. Particularly in MONICA, the emphasis is on impacts such as social impacts (quality of life), economic impacts (employment and business). In this instance, the focus area is how solutions and the IoT platform provided by MONICA can have an impact on visitors, staff and event organisers, and more in general on citizens, business in the tourism and cultural industry, and what this means for the demonstration economically.

The assessment of the socio-economic impact has been made considering five areas, as defined in DoA: the value chain, new business opportunities, business models, improved quality of life, the MONICA Development Toolbox.

More impacts will be discussed in section 5.4.1 with a set of KPIs for the socio-economic impacts.

### 5.1.1 The Value Chain in MONICA

Expected impact from DoA: *The very large demonstrations validated with 14.000+ users will create impact across the full value chain: from supply-side actors like the telecom industry to demand-side actors like cultural event organisers, cities & the public at large. The range of user and business driven applications demonstrates the socio-economic potential of IoT platforms*.

The MONICA solutions have been demonstrated at real-life situations (demonstrations), such as large outdoor festivals, sporting events and street parties. During each demonstration, end users could see the potential of the IoT platform. MONICA offered the opportunity for stakeholders to give feedback on the solutions and over 1.800 people responded, with MONICA reaching hundreds of thousands more with the solution. All stakeholders in the value chain were involved in the process. This included security and sound staff, event organisers, stewards, police and fire officers, municipalities, neighbours and visitors and smart city managers.

As a result, the pilots have decided to continue the collaboration with some of the technical partners after MONICA and to include some of the MONICA solutions in their daily operations.

MONICA has had two great impacts at political level. The first impact is related to the fact that the project has contributed to a political action plan for the nightlife in Torino. The second impact is related to a White Paper guidance for the drafting of a good urban policy for live music.

About the first impact, the Torino municipality have discussed a recovery plan for Movida which will be promoted to improve the quality of life of the visitors and residents based on the sound data collected during the MONICA Project and the CAP.

MONICA has contributed to a political action plan for the nightlife in Torino. The sound monitoring and control solutions deployed by MONICA have played an important part in the development of a political action plan for the Torino nightlife, also known as Movida. The City of Torino has actioned a plan which is the deployment of MONICA sound and crowd monitoring applications, in order to better understand the long-term sound exposure, the number and density of people and seasonality.

The Environmental Engineer and Team Coordinator at the City of Torino, Enrico Gallo, explains that "monitoring the noise over a longer period has enabled us to get more precise information about Movida and by clustering the sound with crowd data, we have identified patterns on which to act upon and build new strategies of crowd awareness".

The plan includes strategies for monitoring, planning of new venues and events, hard actions (opening hour restrictions, sale of alcohol) and soft actions (street behavioural change interventions and street performances). Enrico Gallo concludes that the plan is focused on a "progressive reduction of noise in hot spots and on the improvements of the nightlife management, using an evidence-based approach, in which data collected by sensors play a key role".

In addition, Copenhagen municipality has the same problem of noisy night life in the city centre, as it is also a residential area with many bars and restaurants. Following the experience of the Torino Municipality with the noise monitoring and the consequent action plan, the Copenhagen municipality will be in touch with the City of Torino to discuss the best practices for the Movida countermeasures adopted by Torino after MONICA to replicate the recovery plan.

Both municipalities can use the data collected during MONICA to gain a better understanding of sound at the demonstrations. The results from the project can provide a platform to improve the quality of space around these areas and have a positive impact on neighbours, promoting a better social cohesion between event organisers and neighbours.

About the second impact, MONICA has contributed to a White Paper which provides guidance for the drafting of a good urban policy for live music. See here: https://www.monica-project.eu/music-is-not-noise/ The White Paper, launched in July 2019 by the European Live Music Network, Live DMA suggests that music is a 'meaningful cultural activity made on purpose', and the paper was launched to counteract the report by the World Health Organisation (WHO) that suggested that night clubs, concerts and live music venues fall into the category of 'Leisure Noise'. The paper states that policy makers and the live music sector have an equal partnership and the common belief is that live music is a key element of European heritage, culture and wellbeing; not just 'noise' to the environment.

### 5.1.2 New business opportunities

Expected impact from DoA: *A very high impact is expected in all ecosystems. Citizens may improve health and comfort and they will enjoy safer public events and spaces. The project's large European-wide deployment will facilitate uptake and create vastly improved business opportunities for industry, the flexibility and open architecture will create new opportunities for entrepreneurs. Public authorities will have much improved means for ensuring security and safety thus leading to even more cultural events in the European landscape.*

MONICA's activities have been business oriented and entrepreneurship has always been one of the main components of the daily operations. Three big activities had or will have an impact at business level:

- The online Replication Reference Book prepared by the end of the project;
- The three hackathons organised in 2018;
- The Business Growth Programme.

One of the main MONICA's product is the online Reference Book, the online version of D9.3 Replication Reference Book and Roadmaps for MONICA Market Replication, that will be useful for smart cities and companies working in tourism, event management and entertainment, that want to replicate the MONICA experience through the adoption of the solutions deployed in the demonstrations. The online reference book is in the MONICA's website (https://www.monica-project.eu/monica-replication-reference-book/ ) and provides information related to the implementation of each solution, to technical and business aspects.

Moreover, three hackathons were organised in 2018 in Roskilde (Denmark), Leeds (UK) and Torino (Italy). Developers – entrepreneurs, start-ups and students were invited to apply to the MONICA hackathons which took place during 2018. Apart from €5.000 in prize money, the winners of each hackathon entered into a Business Growth Programme with the possibility to integrate and test the prototype at one of the MONICA pilot sites during 2019. Three articles on MONICA's website were published: the winning solution of the first hackathon is described here: https://www.monica-project.eu/innovative-audio-device-wins-the-first-monica-hackathon/ , the second winning solution in Leeds is described here: https://www.monica-project.eu/hackathon-winner-impresses-with-solution-for-stadium-visitors/ , the third hackathon in Torino is here: https://www.monica-project.eu/the-shhh-project-wins-the-third-monica-hackathon/

The Business Growth Program developed by EHSJ has involved entrepreneurs and start-ups from Denmark and other EU countries in the participation of the program at Growth Factory Copenhagen Sound, in Copenhagen. It offered customised consulting with a business development consultant, either through physical meetings or Skype meetings, workshops in business development, the opportunity to participate in networking events, and guidance by technical and pilot project partners through physical meetings or Skype meetings.

Here the description of the activities by the end of the project:

The Copenhagen MONICA Hackathon winner Pedro Costa with his Company Auricle:

- had at least six customized meetings with our Growth Consultants. Besides this he is in weekly dialog with EHSJ. He has participated in business development workshops
- has been set in dialog/connected with MONICA Technical partners (like DTU, DEXELS, CNet)
- has been set in dialog/connected with MONICA Pilot Partners Tivoli and Hamburg
- has participated in the Thessaloniki MONICA Plenary where his winning idea was presented and has been introduced to all the MONICA partners.
- has got further seed money (Innoboooster) as a result of the Consultancy Service from the MONICA Business Growth Program

The Leeds Hackathon winner Pauline O´Callahan and her Company Hearable:

- had at least six meetings/sessions. Besides this EHSJ has been in weekly dialog with Pauline.
- has been set in dialog/connected with MONICA Technical Partner DTU
- has been set in dialog/connected with MONICA Pilot partners in Leeds and Tivoli
- She participated in the Thessaloniki MONICA Plenary where her winning idea was presented and has been introduced to all the MONICA partners.
- She has, as a result of the consulting sessions, been accepted in a SoundTech accelerator program

The Torino Hackathon winners “Elephant” ( 5 Persons company) with their winning Idea “Shyyy”:

- had 5 Sessions/ meeting with our Growth Consultant.
- participated in the Thessaloniki MONICA Plenary where their winning idea was presented via Skype.
- have been set in dialog/connected with MONICA Technical partners
- have been set in dialog/connected with MONICA Pilot Partners

Besides this other at least 5 other starts-ups has been involved in the MONICA Pilots and events.

### 5.1.3 Business models

Expected impact from DoA: *The project will develop, validate and publish a range of new business model proposals based on the new values created by the IoT platform for all involved actors to explore. Market analysis for the tourism industry will show new business opportunities for this important industry*.

In the MONICA project three deliverables on business models have been submitted:

D11.3 Using IoT and Smart City Platforms to Support European Tourism and Culture

D11.5 New Markets segmentation and Sustainable Business Models for IoT Platforms

D12.6 Final Replication, Exploitation and Business Plans

During the project, the solutions implemented by the partners have reached a level of technology readiness of TRL6-8 which means that they are close to being commercially available on the market.

- MONICA Sound Level Monitoring solution (TRL 7)
- MONICA Adaptive Sound Field Control solution (TRL 6)
- MONICA Crowd and Capacity Monitoring solution (TRL 8)

- MONICA Crowd Management and Communication solution (TRL 7)
- MONICA Collective Awareness Platform solution (TRL 9)
- MONICA Visitor Experience Apps solution (TRL 8)

Six new business model canvas have been described in D11.5. These business model canvas provide useful information for entrepreneurs who plan to use MONICA solutions to tackle issues related to sound and security in the event management business or in the tourist industry.

### 5.1.4 Improved quality of life

Expected impact from DoA: *Noise is an important factor for good health and wellbeing; personal security in public spaces is obviously a marker for citizens' quality of life. MONICA contributes notably to the quality of life, widening of European culture, stimulating tourism, and increasing access to public and private leisure services, such as concerts, festivals and sport events*.

The MONICA solutions contributed to improve the visitors and neighbours wellbeing during cultural events (concerts, festivals and sport events), according to the results of the questionnaires presented here below.

Citizens of neighbouring areas and visitors of cultural events (table 36) are positive about MONICA implementing solutions to help with noise and measuring sound levels.

"*The event organisers are involved in an EU project where innovative technologies are used to monitor the sound level of the music at [festival]. How do you feel about this*?

**Table 36 Neighbour and Visitor perception of measuring sound levels**

| | No of participants | Very favourable | Favourable | Neutral | Unfavourable | Very unfavourable |
|---|---|---|---|---|---|---|
| Nuits Sonores 2019 (Visitors) | 60 | 55% | 31% | 14% | 0% | 0% |
| Nuits Sonores 2019 (Neighbours) | 93 | 34% | 27% | 21% | 4% | 14% |
| Istedgade 2019 (Neighbours) | 138 | 41% | 44% | 12% | 3% | 0% |
| Woodstower 2019 (Visitors) | 233 | 50% | 33% | 15% | 2% | 0% |
| Woodstower 2019 (Neighbours) | 151 | 38% | 36% | 14% | 5% | 7% |

MONICA also has the potential to continue contributing to improving the wellbeing of visitors and neighbours. Tables 37, 38 and 39 indicate that visitors at cultural events are very favourable of using technology to improve safety and security. Moreover, it's possible that their feelings of safety and security would be improved if solutions (used in MONICA) are implemented at the demonstrations in the future.

"*We are testing a new technology on Port Anniversary to improve visitors' safety (sensors that measure wind speed, to alert the event organiser if the speed becomes dangerous). How do you feel about that*?"

**Table 37 Port Anniversary safety perception**

| | No of participants | That's excellent, I feel more safe | That's good | This won't make a difference in the way I feel | I do not find it necessary | I don't like it |
|---|---|---|---|---|---|---|
| Port Anniversary (2019) | 106 | 26% | 39% | 25% | 9% | 1% |

As well as safety, visitor well-being can also be improved in terms of security. The smart glasses were used at several MONICA demonstrations as a tool to effectively streamline staff processes.

Table 38 and 39 show that staff found they were able to use the smart glasses to both report and detect incidents at cultural events. This shows that the glasses can be used as a tool to improve event safety (improving visitor well-being) and provide assistance with staff processes, as they can be used as an effective tool to streamline the processes of security staff, stewards, firefighters and police services. These functions enable to influence a better quality of life and help to secure the event.

**Table 38 Detecting Incidents**

| | No of participants | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|---|---|---|---|---|---|---|
| Movida 2018 | 9 | 0% | 67% | 22% | 11% | 0% |
| Leeds Rugby 2019 | 8 | 50% | 50% | 0% | 0% | 0% |
| Tivoli 2019 | 5 | 0% | 80% | 20% | 0% | 0% |
| Leeds Varsity 2019 | 4 | 0% | 0% | 100% | 0% | 0% |
| Fête des Lumières 2019 | 2 | 0% | 0% | 100% | 0% | 0% |

**Table 39 Reporting Incidents**

| | No of participants | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|---|---|---|---|---|---|---|
| Movida 2018 | 9 | 11% | 33% | 56% | 0% | 0% |
| Leeds Rugby 2019 | 8 | 50% | 50% | 0% | 0% | 0% |
| Tivoli 2019 | 5 | 40% | 20% | 40% | 0% | 0% |
| Leeds Varsity 2019 | 4 | 0% | 75% | 15% | 0% | 0% |
| Fête des Lumières 2019 | 2 | 0% | 0% | 100% | 0% | 0% |

Visitors of the Summer DOM were also asked how they felt if the security guards were able to record live videos and take images during the event (via the smart glasses) to contribute to the visitors' safety and security.

"*How would you feel at an event if the security guards wear smart glasses to record live videos and take images during the event, to positively contribute to the visitors' safety and security*?"

**Table 40 SummerDOM safety and security perception**

| | No of participants | Very favourable | Favourable | Neutral | Unfavourable | Very unfavourable |
|---|---|---|---|---|---|---|
| SummerDOM 2019 | 132 | 22% | 51% | 13% | 9% | 5% |

In general, visitors at three demonstrations were asked "*How do you feel about event organisers being involved in a project to help improve and manage visitor safety and security*?"

**Table 41 Visitor perception of using IoT to manage safety and security**

| | No of participants | Very favourable | Favourable | Neutral | Unfavourable | Very unfavourable |
|---|---|---|---|---|---|---|
| IoT Week 2019 | 51 | 75% | 15% | 0% | 0% | 0% |
| Summer | 132 | 27% | 52% | 8% | 9% | 4% |

| | | | | | | |
|---|---|---|---|---|---|---|
| DOM 2019 | | | | | | |
| Winter DOM 2019 | 252 | 18% | 47% | 15% | 10% | 9% |

The potential for MONICA to improve visitor and neighbour wellbeing can also impact on more visitors attending the event. If more visitors attend the event because of MONICA solutions, a rise in tourism and sales for businesses (restaurants, hotels etc.) in the local area can also be expected.

The average spending of visitors was collected from 4 demonstrations. Table 42 shows that all visitors spent 10 or more euros/pounds at the four events. The sample of the visitors who filled in our questionnaires stated that they are more likely to attend the events again in the future and encourage others to attend because of the IoT technologies being used. This in turn will have a positive economic effect represented in an increase of the revenue regarding the attractions, food and beverages and ticket sales (if a ticketed event) of the pilots as a result of the increase in visitors' numbers. (Further explanation can be found in section 4.7.1 which discussed the results of MONICA Visitor Apps).

**Table 42 Average visitor spend**

| | Highest average spend | Visitor % |
|---|---|---|
| Port Anniversary | €25-€50+ | 38% |
| Rhein in Flammen | €10-€24 | 37% |
| Pützchens Markt | €25-€50+ | 80% |
| Leeds Varsity | £10-20 | 40% |

Not only does the average spending improve the event, but more visitors attending the event could also mean an increase in local tourism and businesses in the local area could achieve a rise in food and drink sales, accommodation etc.

Further examples of the ways in which MONICA solutions have had an impact on visitors, neighbours and event staff using the solution can be found in Section 4 Results of the Validation in 2018 and 2019.

### 5.1.5 The MONICA Development Toolbox

Another expected impact from DoA: *The MONICA platform and technology enabling toolbox will facilitate market openings with new applications and opens a wealth of opportunities for entrepreneurs, start-ups and established companies alike. The Open Data collected on noise and sound will be one of the important tools to be explored and validated in the project's entrepreneurship funding program. The wide geographical coverage will improve access for local business to the European markets*.

The MONICA Development Toolbox is an open software development toolbox and generic enablers that allows developers to rapidly develop new applications to be deployed within the MONICA platform. The development platform consists of a toolbox, tutorials and guidelines. It can be used to integrate various resources into the IoT Platform and can hide the complexity of the communication with IoT devices.

The toolbox features model-driven development of services that use the MONICA platform, also in connection with available Open Data. The toolbox is based on a structure of service ontologies where a conceptual domain model describes the application, the services that can be deployed and the objects that are involved, such as; devices, users, rules, repositories etc.. The generic enablers will be made available in an Open Source GIT and can be used by entrepreneurs, start-ups and established companies alike. The MONICA Development Toolbox has been tested by developers through the Entrepreneurship and Innovation programme and FIT, to verify that the MONICA IoT toolbox fulfils certain usability criteria and allows enablers to develop customised apps.

The overall test results show that the description published in connection with the MONICA Development toolbox provides a good and reliable tutorial to install and test all components of the toolbox. All six tested developers were able to download the MONICA Development Toolbox, start the docker services, test and modify them and follow the online tutorial autonomously without additional support. The MONICA Development toolbox scored 74 % in the standardised "System Usability Scale" (SUS), which accords to a rating of "Good" (see **Errore. L'origine riferimento non è stata trovata.**) in terms of system satisfaction and

places it in the top 30 % of a benchmarking study on 500 systems[7]. The average user friendliness of the system was rated by the developers as “good” (5,17 out of maximum 6), which states that the majority of potential users will be satisfied in terms of usability of the system.

The test also shows that further improvements can be achieved by including an architecture overview of all components comprised in the docker container. An additional diagram which makes the dataflow visible might support the workflow while installing and testing the MONICA development toolbox.

To make the test setting as transparent as possible a short description of the test setup is given here. Six developers have been tested in order to verify the integrity and usability of the MONICA Development Toolbox. Especially for external developers priory not involved in the MONICA project, FIT carried out dedicated usability tests and designed a test setup specially for this purpose. The test concept follows usability test standards and incorporates well established methods. The test procedure consists of three parts. Part one comprises a screening test including four questions. This pre-test ensures that only experienced developers, who were identified as the target group of the MONICA Development Toolbox, took part in the usability test. Six persons were tested, all of them replied with “yes” to the following four screening questions.

1.) Have you ever used JSON REST services?

2.) Do you have experience using docker infrastructure?

3.) Do you have experience using docker compose tool?

4.) Do you have experience using message-based architecture (e.g. MQTT protocol)?

Part two of the MONICA Development toolbox evaluation was designed according to a remote “Thinking-Aloud-Test”. This established test method gives qualitative feedback on the user experience and identifies most usability issues of the tested system. Usability experts rate it as one of the most valuable usability test methods, because it is robust, easy to use and flexible, so that it can also be conducted as a remote test[8]. Each tested person had to complete step by step tasks in order to download, install and test the MONICA Toolbox on a remote system. During this 45 – 60 min process participants were asked to express any thoughts, approaches and observations out loud which the usability tester recorded on paper. Ensuring this approach the majority of usability issues were identified and problems regarding the user friendliness were monitored and solved. All test persons were able to complete the tasks without major issues.

Part three of the MONICA Development toolbox evaluation comprises the “System Usability Scale (SUS)”-test which is considered as the industry standard for reliable and technology-independent tool for measuring usability (source: https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html). The SUS consists of ten standardised questions, similar to “I thought the system was easy to use”, asking the participant to indicate his/her statement with a number between 0 (strongly disagree) and 4 (strongly agree). The results can be used to calculate the SUS-Usability score, similar to a percentage value, specifying and rating the usability and system satisfaction value achieved[9]. This value gives not only feedback on the usability of a system but also classifies it in a comparable usability-rating (see below).

To further specify the perceived user friendliness of the MONICA Toolbox all six developers were asked to answer the following question:

“*Overall, I would rate the user friendliness of this product as*”

1.) Worst Imaginable

2.) Awful

3.) Poor

4.) Fair

5.) Good

6.) Excellent

7.) Best Imaginable

[7]

[8] https://www.nngroup.com/articles/thinking-aloud-the-1-usability-tool/

[9] https://measuringu.com/wp-content/uploads/2017/07/Lewis_Sauro_HCII2009.pdf

With an average value of 5.17 the user friendliness was rated as “good”.

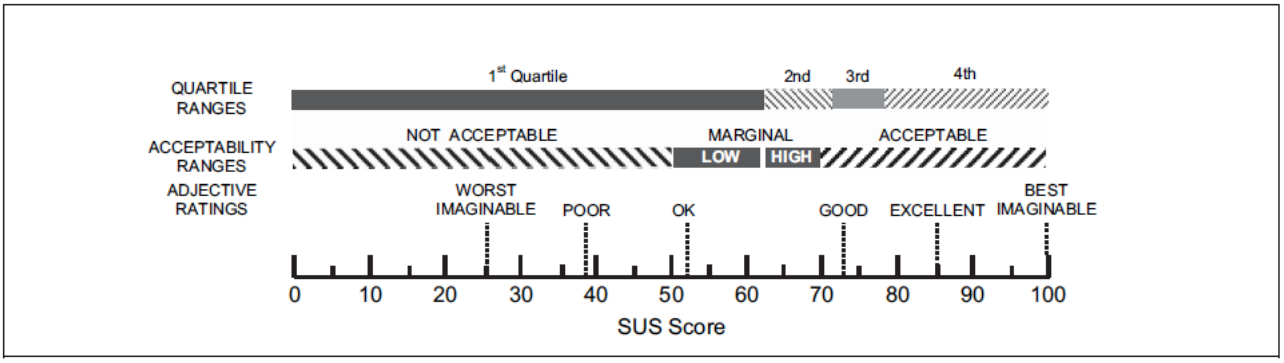


**Figure 4 SUS-Score interpretation**[10]

## 5.2 Technological Impacts

Research suggests (Parayil, 1991) that a technological change is an increase in the efficiency of a product or process, which results in an increase in output, without an increase in input. This means that a product or process is improved or invented and is used to get a bigger reward but for the same amount of work. A technological change is described in three steps; invention, innovation and diffusion, and the technological changes produces technological impacts. MONICA applies the integrated technologies, such as smart glasses or the COP to streamline and better the processes in common tasks at large outdoor events, allowing for the same tasks to be completed but much more efficiently.

The assessment of the technological impacts has been made considering three areas, as defined in DoA: demonstrations under real-life conditions, standards and pre-normative activities, interoperability of the MONICA platform and technologies.

More impacts will be discussed in section 5.4.2 with a set of KPIs for the technological impacts.

### 5.2.1 Demonstration under real-life conditions

Expected impact from DoA: *The scale and complexity of the demonstrations in six pilots in five countries with a mix of 17 different applications deployed in a total of 41 events will clearly demonstrate how IoT platforms that are based on open architectures and standards, offering semantic interoperability and with security and privacy enhancing features in a trust federation scheme that can be successfully used in IoT applications and even integrated with all sorts of Smart City applications*.

Whilst there are further technologies available commercially, the strength is that the MONICA platform allows for the devices and components to interact seamlessly. Although other tools and commercial products allow for integrated solutions to deal with specific issues (e.g. video surveillance and emergency management) the MONICA platform enables the monitoring of both security and acoustic knowledge spaces and processes. It allows for the integration of IoT sensors and addresses incident detection, all of which combine real-time data, visual and audio knowledge spaces, as well as incident response algorithms and strategies.

Each demonstration preparation has been complex in terms of selection of the Use Case groups and the solutions, definition of the requirements, selection of the stakeholders to involve, adaptation of the IoT platform and solutions to the venue and pilot’s needs, calibration, integration with other Smart City applications. The MONICA platform is a cloud-based, advanced, open IoT platform with automated closed-loop actuating functions. The platform dynamically integrates devices and mobile wearables in the physical world with automated closed-loop feedback functions. The platform also integrates humans in the loop by providing situational awareness and dynamic decision support tools. The platform supports multiple IoT applications in a wide usage context focusing on the two most important challenges for organisers of large-scale events in cities and urban areas: unwanted noise in the surroundings and security of the audience. The MONICA IoT platform proved to be highly adaptable, but it took around one month for each demonstration to finalise the whole set-up of platform and solutions. A total number of 25 demonstrations have been organised (see table 2 and 3 for the full list of demonstrations) in two years and 29 exploitable results have been deployed. The adaptability and interoperability of the platform are described in D8.3 Consolidated

[10] Source: https://www.researchgate.net/publication/200553206_The_System_Usability_Scale_SUS_an_Empirical_evaluation

Demonstration Platform Pilot Progress Report 2, D9.3 Replication Reference Book and Roadmaps for MONICA Market Replication and the online version: https://www.monica-project.eu/monica-replication-reference-book/

### 5.2.2 Standards and pre-normative activities

Expected impact from DoA: *The close links between several project partners and standardisation bodies e.g. ETSI and industry bodies and alliances such as oneM2M, AIOTI, IERC, ECSEL will secure direct, and substantial impact in the form of pre-normative activities. The interaction with horizontal support activities will further enhance the impact in a large number of IoT related areas as described in the dissemination plan*.

During the project duration of three years, MONICA partners have always followed any information regarding European harmonized radio communication standards and special EU Decisions related to the solutions to be deployed in the demonstrations.

Partners have succeeded in identifying some existing harmonized European Norms (EN's) for IoT which are recognized by all countries where the Pilot demonstrations of the MONICA capabilities took place.

IoT Standards adopted by MONICA:

- ETSI EN 300 220-2 V3.1.1 for subGHz wristbands (868MHz). subGHz wristbands are mainly used by the crowd. These are low power and low-cost devices (around 10€ each, even less). (position accuracy around 5-10 m).
- IEEE 802.15.4a, ETSI EN 302 065-2 V2.1.1 for UWB wristbands. UWB wristbands are more expensive and provide more accurate localization capabilities (position accuracy around 20 cm). UWB wristbands are mainly used by security staff.
- IETF 6LoWPAN / IETF ROLL / IETF CoAP are standards used by the environmental sensors.
- Data modelling and Validation based on OGC Sensor Things API standard
- The IoT Resources Ontology provides device modelling derived by the W3C SSN standard
- Event Broker is based on OASIS MQTT standard
- ISO/IEC/IEEE 42010:2011 (used for architecture views and doc.)
- AIOTI HLA (Reference Architecture)
- oneM2M NSCL: the external IoT platform connectors allow the communication with external IoT platforms and the integration of data coming from outside (e.g. from the Hamburg Smart City platform). In addition, MONICA integrates the OneM2M Network Service Capabilities Layer (NSCL) allowing the platform to expose the IoT data according to the OneM2M standard;
- Bluetooth BLE / DASH7 / Wi-Fi – IEEE 802.11
- Knowledge Base Ontology based on ETSI SAREF

An important element of MONICA project has been to assess and identify if the European suite of radio frequencies (RF) IoT standards was missing some elements, which might improve the performance and value of the results demonstrated. A possible additional IoT standard or IoT standard upgrade has been identified in order to ensure a more dependable end-to-end latency for synchronized data interlinking of the many sensors applied with the digital MONICA sound field calculations. In D12.5 Report on Standards, Regulations, and Policies for IoT Platforms) proposed technical requirements to an eventual new IoT standard/standards upgrade have been covered and the liaison activities with ETSI TG28 to present and discuss the matter have been presented. A first ETSI meeting took place in May 2019, proposal was presented, and the members are now elaborating on the input.

RING, on behalf of MONICA, identified the requirement for a new standard/update of existing IoT standard, that provide guaranteed low latency and time jitter for RF connected end-to-end communication. RING also achieved to include MONICA in the comprehensive AIOTI study High Priority IoT Standardisation Gaps and Relevant SDOs (the link of the study: https://aioti.eu/wp-content/uploads/2020/01/AIOTI-WG3-High-Priority-Gaps-v2.0-200128-Final.pdf ).

### 5.2.3 The interoperability of the MONICA platform and technologies

Expected impact from DoA: *The interoperability of the MONICA platform and technologies with other Smart City platform will ensure its sustainability beyond the project. The use of open architectures and standards will allow existing Smart City IoT platforms to plug-in to both components and larger parts of the MONICA solutions, such as the heterogeneity and semantic visualisation layer, trust federation schemes, co-creation platforms, and business models*.

Large scale deployments of IoT and Smart City platforms are often hindered by the lack of data accessibility and interoperability standards between systems, devices and the network. Most of the device producers still produce their devices with their own platform for data collection (EC, 2017. P21). IEEE defined interoperability as the ability for two or more components to exchange information and to use the information collected. Achieving interoperability is vital when wanting to interconnect multiple things together across various different communication networks (Elkhodr et al., 2016). Interoperability is also important to support seamless and heterogeneous communications across the IoT Platform (Elkhodr et al., 2016).

The MONICA platform worked with four platforms: the platform of the Torino municipality, used for the IoT sound level meters; the Smart City Platform of the city of Hamburg, the Noise Platform of the Greater Lyon metropolis and the M2M platform of Telecom Italia.

## 5.3 User acceptability

User acceptance includes a stage of User Acceptance Testing (UAT). UAT is the last stage of a testing and specifically looks at whether a system (in this case MONICA solutions) can support day-to-day user scenarios and is sufficient for business usage. MONICA specifically looks at how the solution can assist the user in their day to day tasks, making sure that the solution can streamline the processes of the user and improve their efficiency.

When developing and deploying an IoT device or other technologies, users' perception of the technology has been evaluated both in year 2 and 3 of the MONICA project. However, few standardized and validated questionnaires measuring acceptability are available (Torbjørnsen, 2018). End users' perceptions are important components of the technology assessment when developing and introducing technological devices as a supporting tool in their every-day life.

The acceptability of digital solutions is often used synonymously with the concept of satisfaction, but for the analysis of the user acceptability in the MONICA project more factors have been considered: user satisfaction, comfort of the device, increased security perception in an open air event, and level of privacy of the user following the use of the device.

Questionnaires have been developed by LBU and comparison of results across pilots have been performed. In total, data from 827 participants have been analysed. Of these 827, 50,3% were male and 49,7% were female. The age range was from 18 to +65 years, with:

18-24 years: 46%

25-34 years: 26%

35-44 years: 17%

45-54 years: 8%

55-64 years: 2%

+65 years: 1%

In short, all stakeholder categories in the organisation of a pilot event have been involved in the surveys in order to collect information for the impact assessment related to the rate of acceptance of the end users.
On average the user acceptability is 58%. The result has been calculated by summing up the total amount of % strongly agree and agree, divided the total amount of demonstrations.

### 5.3.1 User satisfaction

The satisfaction of the use has been evaluated through questionnaires distributed to the security staff who used the MONICA solutions (LoRa trackers, Smart glasses, COP) during their shift, and to the event's visitors who used the crowd wristbands and who downloaded the visitor apps.

Crowd Wristband: "*Overall, I am satisfied with the wristband*"

**Table 43 Crowd wristband satisfaction of the use**

| | No of participants | Agree | Neutral | Disagree |
|---|---|---|---|---|
| IoT Week | 51 | 58% | 34% | 8% |
| Woodstower | 233 | 37% | 45% | 18% |

LoRa tracker: "*Overall, I am satisfied with the LoRa tracking device*"

**Table 44 LoRa tracker satisfaction of the use**

| | No of participants | Strongly agree | Agree | Neutral | Disagree | Strongly disagree |
|---|---|---|---|---|---|---|
| Pützchens Markt 2019 | 7 | 43% | 29% | 29% | 0% | 0% |

Smart glasses: "*Overall, I am satisfied with the smart glasses*"

**Table 45 Smart glass satisfaction of the use**

| | No of participants | Strongly agree | Agree | Neutral | Disagree | Strongly disagree |
|---|---|---|---|---|---|---|
| Movida 2018 | 9 | 0% | 45% | 22% | 33% | 0% |
| Leeds Rugby 2019 | 8 | 13% | 62% | 25% | 0% | 0% |
| Tivoli 2019 | 5 | 0% | 40% | 40% | 20% | 0% |
| Leeds Varsity 2019 | 4 | 25% | 50% | 25% | 0% | 0% |
| Fête des Lumières 2019 | 2 | 50% | 50% | 0% | 0% | 0% |

COP: "*I am satisfied with how easy it is to use the COP*"

**Table 46 COP satisfaction of the use**

| | No of participants | Strongly agree | Agree | Neutral | Disagree | Strongly disagree |
|---|---|---|---|---|---|---|
| WinterDOM 2018 | 1 | | | X | | |
| Port Anniversary 2019 | 1 | | | | X | |
| Rhein in Flammen 2019 | 1 | | X | | | |
| Tivoli 2019 | 1 | | X | | | |
| SpringDOM 2019 | 1 | | | | X | |
| Woodstower | 1 | X | | | | |
| WinterDOM 2019 | 2 | | | X | X | |

One limitation of the analysis related to table 46 is the low number of participants. Comparing to the other tables in this and other sections, in table 46 there are no percentages because only one respondent per event participated to the survey. The only exception is WinterDOM 2019 with two respondents. For a better insight to how satisfied the users are, it would be desired to have more users testing the COP and answering the questionnaire.

The satisfaction of the use has been evaluated through one question in the questionnaire distributed to the visitors who downloaded the MONICA event app.

"*Overall, I am satisfied with the APP*"

**Table 47 Pützchens Markt satisfaction of the visitor app**

| | No of participants | Strongly agree | Agree | Neutral | Disagree | Strongly disagree |
|---|---|---|---|---|---|---|
| Pützchens Markt 2019 | 33 | 18% | 36% | 27% | 9% | 12% |

**Table 48 Leeds Varsity satisfaction of the visitor app**

| | No of participants | Yes | Neutral | No |
|---|---|---|---|---|
| Leeds Varsity 2019 | 235 | 95% | 4% | 1% |

### 5.3.2 Comfort of the device

The comfort of the device has been evaluated through questionnaires distributed to the security staff who used the MONICA devices during their shift and to the festival goers who used the crowd wristband.

Staff trackers: "*The tracking device was comfortable to wear*"

**Table 49 Staff trackers: comfort of the device**

| | No of participants | Strongly agree | Agree | Neutral | Disagree | Strongly disagree |
|---|---|---|---|---|---|---|
| SpringDOM 2019 | 1 | 100% | 0% | 0% | 0% | 0% |
| Pützchens Markt 2019 | 7 | 29% | 71% | 0% | 0% | 0% |
| Rhein in Flammen 2019 | 7 | 29% | 43% | 0% | 28% | 0% |
| WinterDOM 2019 | 3 | 0% | 33% | 0% | 33% | 33% |

Crowd wristband: "*The MONICA wristband was comfortable to wear*"

**Table 50 Crowd wristband: comfort of the device**

| | No of participants | Yes | Neutral | No |
|---|---|---|---|---|
| Woodstower | 233 | 65% | 20% | 16% |

### 5.3.3 Increased security perception in an open-air event

As well as being a socio-economic impact, the increased security perception in an open-air event is also important when looking at user acceptance, as it's very important to know what the visitor and neighbour perceptions are of the MONICA solutions. To measure how the security perception of the visitors can potentially change, if the event organisers would adopt new technologies to improve the security measures in the venue, a question has been added in the visitor and neighbour questionnaires.

"*We are testing a new technology on Port Anniversary to improve visitors' safety (sensors that measure wind speed, to alert the event organiser if the speed becomes dangerous). How do you feel about that*?"

**Table 51 Port Anniversary security perception**

| | No of participants | That's excellent, I feel more safer | That's Good | This won't make a difference in the way I feel | I do not find it necessary, I won't feel any safer | I don't like it |
|---|---|---|---|---|---|---|
| Port | 106 | 26% | 37% | 25% | 9% | 2% |

| | | | | | | |
|---|---|---|---|---|---|---|
| Anniversary 2019 | | | | | | |

"*How would you feel at an event if the security guards wear smart glasses to record live videos and take images during the event, to positively contribute to the visitors' safety and security?*"

**Table 52 SummerDOM security perception**

| | No of participants | Very favourable | Favourable | Neutral | Unfavourable | Very unfavourable |
|---|---|---|---|---|---|---|
| SummerDOM 2019 | 132 | 22% | 51% | 13% | 9% | 5% |

"*The DOM is a pilot in an EU project in which new technologies are to be used that increase visitor safety. How do you find that*?"

**Table 53 WinterDOM security perception**

| | No of participants | Very good | Good | Neutral | I don't think it's necessary | I don't like this at all |
|---|---|---|---|---|---|---|
| WinterDOM 2019 | 252 | 18% | 47% | 15% | 10% | 9% |

### 5.3.4 Privacy concern of the user following the use of the device

The privacy issue has been investigated both in 2018 and in 2019 in all the events where there have been devices deployed and technologies that were collecting information on routes of the user within the event venue: cameras, staff trackers and crowd wristbands.

**Cameras**:

Question to visitors: "*How would you feel at an event if the event organisers used cameras to manage and control crowds around toilets, bars and other amenity locations*?"

**Table 54 Camera: privacy concern**

| | No of participants | Strongly agree | Agree | Neutral | Disagree | Strongly disagree |
|---|---|---|---|---|---|---|
| SummerDOM 2019 | 132 | 42% | 41% | 5% | 7% | 5% |

**Staff trackers**:

Question to security staff: "*In terms of privacy, how did you feel about other people tracking your location?*"

**Table 55 Staff tracker: privacy concern in Rhein in Flammen**

| | No of participants | Strongly agree | Agree | Neutral | Disagree | Strongly disagree |
|---|---|---|---|---|---|---|
| Rhein in Flammen 2019 | 7 | 0% | 0% | 0% | 14% | 86% |

**Table 56 Staff tracker: privacy concern**

| | No of participants | I felt good about it | I don't care/I'm ok | I don't mind (neutral) | I felt a little uncomfortable | I didn't like it at all |
|---|---|---|---|---|---|---|
| SpringDOM 2019 | 1 | 0% | 100% | 0% | 0% | 0% |
| Pützchens | 7 | 43% | 43% | 14% | 0% | 0% |

| | | | | | | |
|---|---|---|---|---|---|---|
| Markt 2019 | | | | | | |
| WinterDOM 2019 | 3 | 0% | 33% | 0% | 33% | 33% |

At WinterDOM 2018, event staff used the LoRa trackers during their shift. The following answers has been collected from 4 respondents working in the event organisation:

- For me it is ok to be tracked at the event site during the work. I even feel a bit safer. I'd like to switch it off after work e.g. on the way home.
- I have no problem or concerns with other people seeing my location.
- When wearing the device only on-duty, i.e. on the event/venue site I didn't have any privacy concerns. For one, the other staff/people were generally aware of my position anyways, and second, I know who is able and allowed to track my position, e.g. using the MONICA COP. However, I would not like to wear such tracking device over a whole day or always, i.e. when off-duty.

At FdL 2018, the following answers from 4 respondents was collected from the event organisation who used the LoRa trackers during their shift:

- I liked the explicit ON/OFF tracking message.
- felt safe being tracked
- wondering about my journey being discussed

**Crowd Wristband**

During IoT Week 2019, crowd wristbands were distributed to around 400 visitors. Range of attendees included Chief Technology Officers (CTO's), Heads of Innovation and Technology, IT Directors, Developers, Start-Up's, Government, Automotive, Operators, Technology Providers, and Investors.

Their level of acceptance of being tracked by MONICA wristbands was measured via a sample of 38 users. The following question was used: "*Although the wristband tracking is anonymous, how do you feel about event organisers tracking your location?"*

More than 86% of the participants were happy for their location to be tracked, with some indicating that's fine as long as it's in the event. Others stressed that the tracking should be for a good reason.

**Table 57 Crowd wristband: privacy concerns in IoT Week**

| | No of participants | I'm ok with this | I don't like this | Other |
|---|---|---|---|---|
| IoT Week 2019 | 38 | 87% | 5% | 8% |

During SummerDOM 2019, crowd wristbands were not distributed to the visitors, nevertheless the level of acceptance towards this kind of technology has been investigated with the following question: "*How would you feel at an event if they used smart technologies, such as wristbands, and your location was tracked throughout the event?*"

**Table 58 Crowd wristband: privacy concern in SummerDOM**

| | No of participants | I like this | I'm ok with this | Neutral | I don't like this | I wouldn't want to wear the wristband |
|---|---|---|---|---|---|---|
| SummerDOM 2019 | 132 | 9% | 23% | 13% | 30% | 24% |

During the large-scale demonstration of Woodstower, in August 2019, more than 6 thousand crowd wristbands were distributed to the festival goers. After the festival, the organisers sent a newsletter to all the visitors with a link to the MONICA survey. In the questionnaire, several questions on the IoT wristbands were asked in order to collect the feedback from the users. One question was about the privacy issue:

"*Although the MONICA wristband tracking is anonymous, in terms of privacy, how do you feel about others tracking your location*?"

**Table 59 Crowd wristband: privacy concern in Woodstower**

| | No of participants | I'm ok with this | I don't like this | Neutral | Other, please explain |
|---|---|---|---|---|---|
| Woodstower 2019 | 233 | 58% | 17% | 13% | 13%* |

* Comments from the participants:

- I do not see the interest as a spectator
- Weird
- If it is to follow friends it may be funny to see it useful to find them, otherwise see the crowd movements but anonymously.
- We prefer to be in anonymity
- It depends, if it is for non-commercial research purposes it does not bother me.
- Do not bother me as long as it remains anonymous

The tracker of people's location is an extremely useful tool in the event management, but the privacy issue has become more and more relevant for the end users. Generally speaking, the results of the surveys show that users have different levels and types of privacy concerns depending on the type of wearable they use. However, the MONICA solutions have been able to prove the implementation of adequate protections and safeguards for individuals' rights. What clearly emerged from the answers of the respondents is that the GDPR implementation has undoubtedly contributed to the increase of awareness of the users' rights in terms of privacy and data management: indeed, the results of the MONICA's surveys reflect the trend.

## 5.4 Key Performance Indicators (KPIs)

The impacts have been described in the previous sections but some of the impacts have been described and quantified in the DoA with a set of KPIs for each area of impact.

### 5.4.1 Socio-economic impacts

In the DoA, for the socio-economic impacts, 11 relevant KPIs have been defined to measure the progress on citizen benefits, safety, comfort, health, public services, economic growth, entrepreneurship, etc.

**Table 60 KPIs for Impact on citizens and validation of socio-economic potential across value chains**

| Impact on citizens and validation of socio-economic potential across value chains | End of the project | Targeted Project KPI |
|---|---|---|
| Approval rate related to noise and security by professional organisers | 33%, 66% | >65% each |
| Minimum rate of the public exposed to MONICA solutions participating in validation surveys | 6,3% | >20% |
| Approval rate related to public participants exposed to the solutions | 68% | >60% |
| Number of value chain actors involved in webinars, workshops and demonstrations | >1.600 | >800 |

**Approval rate related to noise and security by professional organisers**: The WP9 team, with the help of the pilots, managed to get in touch with few sound staff members of Tivoli and Kappa FuturFestival to collect

feedback on the MONICA sound solutions. Unfortunately, due to their busy schedule during the concerts, they managed to take a look at the sound app developed by CNET, which displays on the smartphone of the sound staff the sound levels in real time. It has not been possible to organise focus groups to collect feedback on the ASFC system and the IoT sound level meters. The questionnaire was not the right tool for the purpose. Therefore, the 33% in table 60 is only about the acceptance on the sound app for sound staff. The sample is not representative, and it doesn't cover all the MONICA sound solutions.

About the MONICA security solutions (LoRa staff trackers, smart glasses, COP and the video analytics) a total number of 20 people from security staff of Tivoli, WinterDOM, Fête des Lumières and police officers from the Torino municipality have been interviewed through questionnaires. The 66% of them was overall satisfied with the performance of the security solutions offered by MONICA. Apart from these 2 people, several other feedbacks have been collected in post-demonstrations meetings where pilots have met security stakeholders. So, the 66% is only related to answers from questionnaires, but there are reports with further positive comments that have not been considered here. However, in the exploitation plans of Leeds and Bonn there are information on possible future collaboration between the security staff of the stadium and OPTINVENT (smart glasses) and between the Bonn municipality and FIT (LoRa trackers). See D12.6 Final Replication, Exploitation and Business Plans for more details.

**Minimum rate of the public exposed to MONICA solutions participating in validation surveys**: The MONICA solutions have been deployed in three years in 25 demonstrations. Most of the events where MONICA platform has been deployed gathered hundreds of thousands of visitors: the smallest event is Movida with an estimated crowd of 2.000 visitors and 5.000 neighbours, and the biggest event is the DOM in Hamburg where in the busiest days there are up to 250.000 visitors. With the limited resources allocated for the impact assessment activities, it has been not possible for the WP9 team and the pilots to better target hundreds of thousands of people in the survey activities.

6,3% is the result of the total amount of respondents and the total amount of users of crowd wristbands, LoRa trackers, smart glasses, sound solutions, visitor apps in 24 demonstrations in 2018 and 2019.

The survey response rate in the questionnaires has been calculated by:

Response Rate = (Responses Received) / (Survey Distributed) * 100

Each test includes testing the solution and responding to the questionnaire. For example, if 10 smart glasses were distributed, 10 questionnaires were also distributed. If 10 were distributed and only 5 participants responded, then the result would be: 5/10 *100= 50% survey response rate.

Nevertheless, the result is in line with the available literature: research shows (Fryrear, 2015) that internal surveys (for example, to employees) receive a generally higher average response rate (30-40%) compared to external surveys, which have an average response rate of 10-15%. Motivation is a key factor in survey response rates, and so particularly with internal surveys, the participants are most likely to respond because decisions (which could directly impact an employee) can be made based on their personal responses. Whereas external surveys often do not reach the right type of respondents, especially if sent out in masses. Furthermore, response rates can also drop below 2% when the respondent population is less targeted and contact information is not available (Fryrear, 2015). It's further suggested that follow-ups (which would be possible with contact details) and often incentives are successful in improving response rates in surveys (Smith et al., 2019). Compared to internal surveys, there is less motivation or little incentive for participants to respond to external surveys.

**Approval rate related to public participants exposed to the solutions:** 68% has been obtained considering 8 demonstrations in 2018 and 2019 where public used MONICA's solutions (visitor apps, crowd wristbands) or where event's neighbours have been affected by the sound control solution (ASFC system).

**Number of value chain actors involved in webinars, workshops and demonstrations**: More than 1.600 people are estimated from conferences, events, workshops in Y1, Y2 and Y3 where MONICA's partners organised and made presentations. Moreover, due to open-source technologies used in the demonstrations, thousands of people have been actually involved. The value chain's actors involved are mainly people from the security business, researchers, start-uppers, politicians.

**Table 61 KPIs on Impact on new industry and business processes and innovative business models**

| Impact on new industry and business processes and innovative business models | End of the project | Targeted Project KPI |
|---|---|---|
| Number of sustainable, validated | 6 | 10 |

| | | |
|---|---|---|
| business models showing the potential from IoT platforms | | |
| Demonstrations of cloud interoperability with public services for business and private purposes | 2 | 4 |

**Number of sustainable, validated business models showing the potential from IoT platforms**: The MONICA platform is covered by a portfolio of six dedicated solutions that cover specific parts of the closed-loop functionality: Crowd and Capacity Monitoring, Crowd Management and Communication, Sound Level Monitoring, Adaptive Sound Field Control, Visitor Experience Apps and the Collective Awareness Platform. Therefore, six business model canvas have been produced and they can be found in D11.5. The Business Model Canvas is used to give a high-level overview of the contents in the value configuration and in the customer group side related to a specific value proposition. 28 tangible exploitable assets have been identified and recorded and joint ownerships have been negotiated and agreed directly between the involved partners. Business Model for the MONICA Crowd and Capacity Monitoring solution, one for the MONICA Crowd Management and Communication solution, one for Sound Level Monitoring solution, one for the Adaptive Sound Field Control solution, one for the Visitor experience solution and one for the Citizen engagement solution.

**Demonstrations of cloud interoperability with public services for business and private purposes**: Public data from the MONICA project has been made available on two occasions, in Torino and Copenhagen.

In the Torino Collective Awareness Platform (https://torino.monica-project.eu/ ), MONICA created an open data repository that enables Torino municipality to make MONICA sound and video based data available to the public. The Open Data repository (https://torino.monica-project.eu/#opendata) has been created by IN-JET with the data provided by the Torino Municipality on noise pollution, crowd, security, trade, business and culture. The aim was to provide factual information as a basis for better decision-making and enable use of the results for new smart city applications.

The data are here: https://torino.monica-project.eu/monica-open-data-portal/. The concept is to create awareness about urban nightlife and its impact, also supporting a hackathon organised by the city. The environmental focus is on noise and security. The purpose of the Collective Awareness Platform (CAP) is to present knowledge through a focused data access point on nightlife in a new way that reveals the complexity and increases the awareness of innovative and smart approaches to problem solving, and thereby gain insight to be used to identify potential solutions.

Thus, it might invite entrepreneurs to develop new solutions based on the data, it might point to new knowledge benefitting city planning, and it might facilitate new citizen initiatives on improvement.

The expected MONICA solution for Movida in San Salvario should also be able to offer to the Movida-goers a 360° experience of the district's nightlife, as if they entered a theme park with presentation and reviews of local businesses, cultural programmes, special offers, interaction with IoT and wearables, reward or loyalty programmes, payments, access to information provided by the city administration, amongst other ideas.

In the Copenhagen CAP (https://copenhagen.monica-project.eu/ ), CNET will keep on working with the municipality on the "Bike as a Sensor" project, after MONICA, to install on renting bikes sensors to collect data and make them available to the citizens: the goal is to have a noise and air quality map of the city with the support of the citizens who rent the bikes.

**Figure 5 Bike as a sensor**

With the CAP, the City of Copenhagen expects to create awareness among the citizens about MONICA and what new technology can do for the city in general. Copenhagen wishes to show the citizens that the city continuously works for a better city to live in, and that the city tries new methods to keep Copenhagen in the top league of cities to live in. Furthermore, the city expects to make the citizens aware of problems, and thereby also interested in potential solutions. The City hopes to inspire citizens to act.

**Table 62 KPIs on impact on citizens quality of life in the public and private spheres**

| Impact on citizens quality of life in the public and private spheres | End of the project | Targeted Project KPI |
|---|---|---|
| Reduction of noise levels in low frequency octave bands in selected neighbouring areas | 11 dB | 10 dB |
| Satisfaction rate related to noise by neighbours, professionals and musicians | 45%, 50%, - | >50% |
| Number of citizens using the Collaborative Awareness Platform | N/A | >1.000 |

**Reduction of noise levels in low frequency octave bands in selected neighbouring areas:** DTU deployed the Adaptive Sound Field Control System in two pilots in 2018, in Torino at Kappa FuturFestival and in Tivoli Gardens in Copenhagen during a Friday Rock concert. In 2019 DTU worked on the 2019 edition of the Kappa FuturFestival. In three demonstrations the system was able to decrease the noise levels for less than 9 dB, mainly because of the complex environment of the event sites and for the very short measurement time that the event organisers gave to DTU to get enough data to test the adaptive part of the system. After that experience, the system has been further improved. With MONICA tests in open terrain without adjacent activities and buildings complicating the sound attenuation, DTU achieved a reduction of up to 20 dB.

Thanks to the lessons learned in the previous demonstrations and with the tests, DTU decided to deploy the system in a different venue, with the needed requirements:

- not in urban environment but in an open terrain instead,
- for thorough and complete testing of the ASFC system, it is essential to have a dedicated a 4-hour timeslot without interruptions.

The selected venue was in Roskilde, a town outside Copenhagen, in occasion of the Sound Summit organised by the Roskilde Festival Højskole at the Sound Summit in November 2019. The insertion loss

(reduction) was about 11 dB in the controlled low-frequency range in the dark zone, and the adaptation was working. In the days before the demonstration, another test was also done, including testing using an alternative adaptive algorithm. Also, this version was working well, with the insertion of around 15 dB. For the validation results description of the ASFC system, see section 4.6. For more details on the Sound Summit demonstration, see D8.3 Consolidated Demonstration Platform Pilot Progress Report 2.

**Satisfaction rate related to noise by neighbours, professionals and musicians:** Neighbours of the Kappa FuturFestival have been interviewed through questionnaires in 2018 and 2019 to assess the satisfaction level after the deployment of the ASFC System from DTU. The result is 45% because the system has been deployed in one stage only out of four, so the decrease of dB has not been very decisive in the neighbourhood. Moreover, the residents are every year more exasperated because of the noisy Festival, so the only acceptable solution for most of them would be to move the event in another area of the city. Still, 50% of the respondents in 2019 said that the nuisance has been lowered meaning that the MONICA solution deployed for the sound control has contributed to solve the issue. According to the professional feedback, the satisfaction rate is 50% but it's fair to say that the sound staff interviewed mainly commented on the sound app, not on the sound solutions. Given the very hectic events where the sound solutions have been deployed, it has been very difficult to reach the sound staff to have their feedback on the MONICA's solutions. In regard to the performers, the pilots decided not to involve them in the MONICA's survey.

**Number of citizens using the Collaborative Awareness Platform:** Two MONICA Collaborative Awareness Platforms (CAPs) have been developed during the project to address the challenges of urban life: An Urban Spaces CAP for Torino, centered around the city's nightlife Movida and a Copenhagen platform focusing on the sound levels in the inner city.

The Torino CAP is presenting the impact of nightlife and was a part of a MONICA hackathon event on urban spaces in 2018. The environmental focus is on noise and security. The CAP displays factual noise data and information about the nightlife in the San Salvario district in Torino. The platform is publicly available: http://torino.monica-project.eu/

In Torino, the CAP has been used mainly for the hackathon (October 2018): 191 is the number of users who accessed the CAP during the competition in Torino.

The Copenhagen CAP is looking at the environmental impact that sound has on city life. Sensors mounted on electric city bikes create awareness with citizens. The data collected is visualized in the CAP, in order to gain insights and use these to identify potential solutions based on the data, to point to new knowledge benefitting city planning and to facilitate new citizen initiatives on improvement. The platform is publicly available: http://copenhagen.monica-project.eu/

The Copenhagen municipality has been very interested in testing the CAP first for internal use. Istegade festival in September 2019 took place as a new MONICA replication and replicated the deployment of the easy-to-install IoT enabled Sound Level Meters in Copenhagen. The idea was to use the SLMs to collect and download certified noise data for the purpose of using these in non-compliance cases. Places of interest were identified for bikes and organizing how to display the data was conducted by partners. Ten bikes running in Copenhagen had an example map, but there were unfortunate issues with the bikes and vandalism of the bikes occurred.

Nevertheless, Copenhagen Municipality is still working with CNET and with the official bike sharing service Bycyklen[11] with electric bikes made available to commuters and tourists by subscription. Each bike has an integrated tablet, making it the first bicycle hire system where all bookable bikes have an online connection as well as motor assistance. As an IoT device and as a green mobility option to complete the last mile commute and thereby reducing congestion, the bike option fits well with MONICA and the awareness campaign of the CAP as an example of a sustainable solution to a city challenge. As a starting point, the users will be anonymous, but opportunities to engage them as part of their subscription could be investigated if this option is chosen.

In conclusion, the CAPs in MONICA attempt to make data meaningful by presenting them in a context that is relevant to many citizens, engaging them in the creation of value (collecting data on bikes, in Copenhagen) and in developing new solutions to city challenges (participating in hackathons, in Torino).

**Table 63 KPI on impact on opportunities for entrepreneurs**

| Impact on opportunities for entrepreneurs | End of the project | Targeted Project KPI |
|---|---|---|

[11] https://bycyklen.dk/en/

| | | |
|---|---|---|
| Acceptability of the toolbox and guidelines through validation in incubator environments | 74% | >95% |

**Acceptability of the toolbox and guidelines through validation in incubator environments**: The MONICA Development Toolbox developed in WP7 is meant to enable companies to easily develop IoT applications. In March 2020 six developers have been recruited to test the toolbox and evaluate the usability. A questionnaire has been distributed among the testers and 74% is the result obtained analysing the answers from the following question(s):

1.) I think that I would like to use this system frequently
2.) I found this system unnecessarily complex
3.) I thought the system was easy to use
4.) I think that I would need the support of a technical person to be able to use this system
5.) I found the various functions in this system were well integrated
6.) I thought there was too much inconsistency in this system
7.) I would imagine that most people would learn to use this system very quickly
8.) I found the system very cumbersome to use
9.) I felt very confident using this system
10.) I needed to learn a lot of things before I could get going with this system

To request the perceived user friendliness of the system which was rated as “good” the developers were asked to answer the following question:

“*Overall, I would rate the user friendliness of this product as*”

### 5.4.2 Technological impacts

In the DoA, for the technological impacts, 6 relevant KPIs have been defined to measure to measure the progress in scalability and resilience, the applicability of different kind of wearables, integration of heterogeneous IoT enabled sensors and actuators (including professional measuring equipment and drones), simultaneous support for many, real time closed-loop applications, and interoperability with legacy IoT platforms and cloud services, including social media.

**Table 64 KPIs on Impact on several IoT important technology areas and IoT ecosystems**

| Impact on several IoT important technology areas and IoT ecosystems | End of the project | Targeted Project KPI |
|---|---|---|
| Total number of users that uses connected wearables in the entire project | 7.500 | >40.000 |
| The number of applications that integrate different wearables and other sensors | 29 | 20 |
| The total number of applications running simultaneously on the same platform during live event | 41 | 15 |
| The largest number of simultaneous communication sessions during the events on one pilot | 6.231 | 8.000 |
| Number of interoperability hooks to Smart City platforms | 4 | 4 |

| | | |
|---|---|---|
| demonstrated | | |

**Total number of users that uses connected wearables in the entire project**: The demonstration of crowd wristbands at large scale in real events have been particularly challenging, as all pilot partners that were initially interested in this technology stepped out.

Moreover, the number of available wearable production ready prototypes was limited (max 10 pairs of smart glasses, 45 units of LoRa trackers and - most of all - 10.000 single-use crowd wristbands).

Especially the crowd wristbands which were designed and produced in the first year of MONICA based on three assumptions:

1. stable data delivery and positioning
2. one design, fits all, assuming that crowd wristbands may be used at multiple events
3. cost effective

During year 2 of MONICA the pilots previously interested in testing crowd wristbands in large scale (5.000 plus) were facing several hindrances:

- Nuits Sonores (Lyon): it turned out that the event organizer (outside MONICA's consortium) already used a payment system with wristbands and agreed in MONICA participation only for UC Sound Monitoring.
- Fête des Lumières (Lyon), Pützchens Markt and Rhein in Flammen (Bonn), Port Anniversary and DOM (Hamburg): these are unfenced events so the distribution/recollection of the wristbands would have been logistically challenging and resource consuming for the available budget of the pilots.
- Three MONICA partners considered a large-scale crowd wristband test: Tivoli, Movement and Leeds Stadium.
- Tivoli: After several meetings with the Tivoli management and a small-scale test run in year 2 (400 wristbands tested), Tivoli decided to reject a large scale test, due to the mismatch of the simple design of the prototype vs. the protection of their brand image.
- Movement: The organisation of Kappa FuturFestival was interested in the use of crowd wristbands as a combination of cashless payment system and crowd management but due to the limited time available and the partners budget planning for having a "one size fits all" prototype DEXELS and other technical partners were unable to redesign such product by the beginning of 2019.
- Leeds: The stadium was totally renovated so the base stations could not be installed.

Finally, in year 3 Acoucité proposed to cooperate with a music festival (Woodstower) in Lyon where the project's crowd wristbands could be deployed. For more information about the demonstration, please see D8.3. Thanks to the efforts of MONICA's consortium and the volunteer staff of Woodstower, more than 6.000 wristbands were distributed and used during the festival by the visitors.

**The number of applications that integrate different wearables and other sensors**: The highest number obtained comes from the last MONICA demonstration Fête des Lumières in 2019. 8 demonstrations out of 25 exceeded the threshold of 20 established in the DoA

**The total number of applications running simultaneously on the same platform during live event**: The highest number obtained comes from the Fête des Lumières demonstration in 2019. 19 demonstrations out of 22 exceeded the threshold of 15 established in the DoA.

**The largest number of simultaneous communication sessions during the events on one pilot**: The best result has been obtained in the Woodstower demonstration with the deployment of the crowd wristbands.

**Number of interoperability hooks to Smart City platforms demonstrated**: The MONICA platform worked with four platforms: the platform of the Torino municipality, used for the IoT sound level meters: the Smart City Platform of the city of Hamburg, the Noise Platform of the Greater Lyon Metropolis and the M2M platform of TIM.

**Table 65 KPI on contribution to standards or pre-normative activities**

| Significant and measureable | End of the project | Targeted Project KPI |
|---|---|---|

| contribution to standards or pre-normative activities | | |
|---|---|---|
| Contributions to ETSI, oneM2M and radio spectrum regulations | 1 | 1 |

**Contributions to ETSI, oneM2M and radio spectrum regulations:** MONICA has identified the requirement for a new standard/update of existing IoT standard, that provide guaranteed low latency and time jitter for RF connected end-to-end communication. The Industrial IoT segment is also in need for Low Latency and time jitter. Moreover, MONICA also achieved to be included in the comprehensive AIOTI study High Priority IoT Standardisation Gaps and Relevant SDOs.

### 5.4.3 Quantification of User Acceptance

In the DoA, for the user acceptance, 2 relevant KPIs have been defined to measure privacy, security, vulnerability, liability, identification of user needs, concerns and expectations of the IoT solutions.

**Table 66 KPIs on User Acceptance**

| User acceptance validation addressing privacy, security, vulnerability, liability, identification of user needs, concerns and expectations of the IoT solutions | End of the project | Targeted Project KPI |
|---|---|---|
| Number of users involved in the social media and Collective Awareness apps and sharing data | 500 | >1.000 |
| Acceptability of data protection, privacy and trust schemes | 59%, >98% | >98% |

**Number of users involved in the social media and Collective Awareness apps and sharing data:** Since it was not possible to keep track of all the interactions that the pilots had with their visitors, the total amount of 500 has been calculated considering the Torino CAP users and those giving feedback through the visitor apps.

**Acceptability of data protection, privacy and trust schemes:** The result of 59% has been obtained interviewing a total amount of 779 respondents, and considering two kind of questions in the questionnaires distributed to users of LoRa trackers (security staff) and visitors who used the crowd wristbands or were monitored by cameras.

For the LoRa tracker, the question was: *In terms of privacy, how did you feel about others tracking your location?*

For the crowd wristband, the question was: *Although the MONICA wristband tracking is anonymous, in terms of privacy, how do you feel about others tracking your location?*

For the cameras, the questions were two: *Would you like the event organisers to use cameras that capture and control the crowd around areas such as toilets, booths and attractions?*

*How would you feel if the organizers used cameras to better manage security and health related incidents?*

The >98% in the table above is due to the fact that all the people approached in the MONICA pilots, accepted voluntarily to use and test the devices (smart glasses, LoRa trackers, staff wristband) during their shift after having read the informed consent form provided with the questionnaire.

# 6 Conclusion

MONICA is committed to the effective assessment and validation of the outcome of its innovation and technologies, as part of its mission for evidence-based impacts. Through the validation process, we asked ourselves; have we built the right system? and via impact assessment, the relevance, performance, efficiency and impact of MONICA IoT technologies have been examined in relation to its stated objectives and wider strategic goals.

This document reported the results of the impact assessment and validation process of MONICA innovation activities. The methodology followed was informed by well-established practices and guidelines from prominent bodies such as the G8 Social impact and investment Forum, REF2014, REF2020, and RCUK. The framework dimensions represented impact planning, data collection and validation, implementation and refinement of the process. Collaboration and engagement with the stakeholders were key elements of the success of the process. Seeking demonstrable excellence with impact is a core value of the MONICA project and the context within which impact is taking place is broad beyond research in the realms of society, economy, health, the environment, and quality of life for 100,000+ end users.

The impact assessment and validation process has also faced a number of challenges. For example, the uniform of certain staff was a hindrance to deploying some of MONICA technologies. For instance, Leeds police officers were unable to test the smart glasses because of their police officer hats. Another big challenge the consortium faced, was the busy environment of the events where the technology was deployed. Given the large-scale pilots where MONICA was tested, the staff at such events were extremely occupied managing hundreds of thousands of people, and hence it was very hard to take them out of their busy schedule to give us their feedback about the deployment of MONICA technologies. Accordingly, this affected the number of individuals participating that the project was aiming for.

Nevertheless, the MONICA impact assessment and validation process ensures that impact is implicitly of benefit for society drawing on the ethical principles of privacy and data protection. The report shows the impact MONICA had on the neighbours, visitors, and staff at the events where the IoT technologies where deployed with more than 64% of visitors in some events stating that they would definitely come back to attend future events if MONICA technology was deployed. For example, the use of mobile apps helped the audience check sports matches results and events nearest facilities. The use of crowd wristbands made the audience feel part of the performances in entertainment events. CCTVs and video analysis systems made them feel safe and secure. The more people attending events the more cultural and economic enrichment for the society. Similarly, staff using the technologies felt in more control of the security of their events, with the ability to remotely check the recording of the cameras, and to use smart glasses to search bags at gates and detect suspects, and managing the flow of the crowd was of great benefit to the events' employees.

The report also shows the impact MONICA has on changing people's perception towards IoT technology. However, it shows that the level of technology trust, especially in relation to tracking devices, still depends on the background of the individual, with IT professionals more trusting and willing to use the technology than lay audience.

Finally, the methodology followed showed that the impact assessment approach developed in MONICA is replicable for other projects to plan, implement and evaluate their technologies for impact assessment and validation.

# 7 List of figures and tables

## 7.1 Figures



## 7.2 Tables

# 8 Acronyms and abbreviations

| Acronym or Abbreviation | Meaning |
|---|---|
| AIOTI | Alliance for Internet of Things Innovation |
| ASFC | Adaptive Sound Field Control |
| COP | Common Operational Picture |
| CAP | Collective Awareness Platform |
| CCTV | Closed-circuit television |
| DoA | Description of the Action |
| DSS | Decision Support System |
| ETSI | The European Telecommunications Standards Institute |
| GDPR | General Data Protection Regulation |
| KPIs | Key Performance Indicators |
| IoT | Internet of Things |
| LiPS | Live Positioning Information System |
| SLM | Sound Level Meter |
| UC | Use Case |
| UWB | Ultra-Wide Band(width) |
| WHO | World Health Organisation |

# 9 Appendix

## 9.1 Appendix A Post – demonstration report template

The goal of this document is to collect feedback, results and lessons learned from the coordinator of the demonstration and from the technical partners in relation to the solutions and the platform deployed.

**Demonstration**

*Place and date of the demonstration*

**Main outcomes (to be filled in by the coordinator of the demonstration)**

| **Describe whether the deployment was successful, what the obstacles were.**<br>**Remember that we are interested in numbers and data (i.e. actual numbers of the crowd compared to the estimated numbers from the video analysis)** |
|---|
| |

**Project KPIs**

*Please write down the numbers related to these KPIs for this demonstration:*

| KPIs | Demonstration | DOA |
|---|---|---|
| Number of value chain actors involved in the demonstrations[12] | | >800 |
| Reduction of noise levels in selected neighbouring areas of (in low frequency octave bands) | | 10 dB |
| Total number of users that uses connected wearables in the demonstration | | 40.000 |
| The number of applications that integrate different wearables and other sensors | | 20 |
| The total number of applications running simultaneously on the same platform during live event | | 15 |
| The largest number of simultaneous communication sessions during the event | | 8.000 |

**Solutions and technologies deployed during the demonstration.**
Name of the Use Case Group (i.e. Sound Levels Monitoring and Control)

List of solutions deployed:

- XXX
- XXX

[12] The value chain actors are those from a specific industry who are involved in a set of activities to deliver a valuable product or service from supplier to customer. This should cover all those involved including manufacturer of the hardware, producer of the software, etc. (examples MONICA Smart glasses manufacturer, MONICA Servers. Other examples: Apple, Phillips, Samsung, Vodafone, IBM, Google, SAP. Oracle, ...)

- XXX

In the following tables, please describe whether the deployment was successful, what obstacles there were and the lessons learned.

| **Effectiveness of solutions (i.e, did the solutions work as expected? Did they solve problems? Should they be improved and how?)** |
|---|
| |

| **Practical pilot deployment aspects (e.g., on-site calibration, Internet connectivity)** |
|---|
| |

| **Other Aspects (i. e., impacts of weather conditions)** |
|---|
| |

| **Lessons Learned** (what have you learned, what knowledge/experience have you gained?) |
|---|
| |

| **Replicability** (Property of an activity, process, or experiment that allows it to be duplicated at another location or time) |
|---|
| |

| **Regulation Compliance** (i.e., what kind of authorisations from authorities were needed prior to the event?) |
|---|
| |

| **Scalability** (the capability of a system, network or process to handle a growing amount of work, or its potential to be enlarged to accommodate that growth) |
|---|

## 9.2 Appendix B Questionnaire for visitor app

**Leeds Varsity App**

The information collected will help us to understand how easy it was to use the Leeds Varsity APP and how it can be improved for 2020.

The App has been provided by the MONICA project in partnership with both universities and Leeds Rugby.

MONICA is a European project that aims to improve cultural events via the use of technology, such as an APP.

Personal information like age and gender will also be sought. All personal data will be stored until the end of the project (December 2019) on secure servers controlled by the project consortium. Only authorised project partners will have access.

By filling out this questionnaire you agree that we will process your data in line with our privacy policy.

Thank you for completing this survey and if you have any questions or change our mind, contact our Data Protection Officer Representative: Helen Whitrod Brown, helen.whitrodbrown@yorkshireccc.com

1. The app. improved my Varsity experience

- Yes
- Neutral
- No

2. The app. was easy to use

- Yes
- Neutral
- No

3. I'm more likely to attend next Varsity event if the app. will be available.

- Yes
- Neutral
- No

4. My average spent in Varsity (including tickets):

- Less than £20
- Between £20 and £30
- More than £30

## 9.3 Appendix C Questionnaire for the crowd wristband users

The goal of the questions below is to understand how easy it was for you to use the wristband provided by MONICA project, and the impact it had on your activities.

MONICA is a European project that aims to improve cultural events via the use of technology.

In addition to your opinion we are also going to collect some personal information about you like gender and age.

All personal data will be stored until the end of the project (December 2019) on secure servers controlled by the project consortium. Only authorised project partners will have access. After the project ends all personal data will be deleted.

By filling out this questionnaire you agree that we will process your data in line with our privacy policy.

If you have any questions or change our mind, contact our Ethical Manager: Trine Sørensen, Tel: +45 3160 7365, tfs@in-jet.dk

Gender: Male Female Prefer not to say

Age: 18-24, 25-34, 35-44, 45-54, 55-64, 65+

1. The wristband was comfortable to wear

- Yes
- Neutral
- No

2. The wristband was easy to use

- Yes
- Neutral
- No

3. Comparing to previous years, I prefer the event with the wristband

- Yes
- Neutral
- No

4. In terms of privacy, how do you feel about other people tracking your location?

-It was fun, and helpful for my friends to easily find me

-I do not like it.

-Else: Please comment:

5. Using the app and the wristband, I was able to successfully find a friend

- Yes
- Neutral
- No

-Did not try it (skip to question 7)

6. Using the wristband reduced the time to find a friend

- Yes
- Neutral
- No

7. On a scale of 1-5 (1 terrible, 5 excellent), how would you rate this app?

1 2 3 4 5

## 9.4 Appendix D Questionnaire for the visitors

The goal of the questions below is to understand your perception on the technologies provided by MONICA project for WinterDOM.

MONICA is a European project that aims to improve cultural events via the use of technology.

In addition to your opinion we are also going to collect some personal information about you like gender and age. We will use this data to analyse the answers and to understand the impact that these technologies had on the event.

All personal data will be stored until the end of the project (December 2019) on secure servers controlled by the project consortium. Only authorised project partners will have access.

By filling out this questionnaire you agree that we will process your data in line with our privacy policy.

If you have any questions or change our mind, contact our local representative of the Data Protection Officer: Julie-Ann Shiraishi, julie-ann.shiraishi@sk.hamburg.de

1. We are testing a new technology at WinterDOM to improve visitors' safety (sensors that measure wind speed, to alert the event organiser if the speed becomes dangerous). How do you feel about that?

-That's excellent, I feel more safer

-That's Good

- This won't make a difference in the way I feel
- I do not find it necessary, I won't feel any safer
- I don't like it

2. Are you more likely to come again in the future, if these safety and security technologies are used?

- Definitely Yes
- Yes
- It won't affect my decision to come
- No

3. What is your average spending during the event?

- Up to 10 €
- 10 – 24 €
- 25 – 50 €
- 50+ €

## 9.5 Appendix E Questionnaire for the neighbours of the Woodstower Festival

1. What do you think about Woodstower festival?

- I love it
- It's fine
- Neutral
- I don't appreciate it much
- I don't appreciate it at all

2. Do you feel any discomfort or disturbance caused by the event?
- Yes absolutely
- Yes a little bit
- Neutral
- No not much
- No not at all

3. What are the main causes of discomfort or inconveniences? (Please select all that apply)
- Noise
- Waste
- Insecurity
- Other (please state)

4. How is the noise compared to last year?
- Better than last year
- No change since last year
- Worse than last year
- This is my first year
- I don't know / can't remember

5. Over the three days of the event, when is the noise level at its highest?
- -Thursday's night
- Friday's-night
- Saturday's night
- Equal Throughout

6. What type of sound do you hear? (Please select all that apply)
- High-pitched (cheering, whistles, music)
- Low-pitched (bass, vibrations)
- Both
- No sound at all

7. Are you more annoyed by high-pitched or low-pitched?

- High-pitched (whistle, cheering)
- Low-pitched (bass, vibrations)
- Both
- Sound levels do not bother me

8. In relation to the noise, it annoys you:
- At certain times
- Continuously
- Not bothering at all

9. During the festival, does your sleeping pattern continue as usual?
- Yes
- Not at all (my sleep pattern is affected)

10. Do you leave your windows open during the festival?
- Yes
- No
- I close the window despite the heat, because of the noise

11. Do you feel the need to leave your apartment because of the festival noise?
- Always
- Sometimes
- Never

12. How would you rate your noise annoyance on scale from 0 to 10?
(0 = not annoyed at all, 10 = extremely annoyed)

13. The event organisers are involved in an EU project where innovative technologies are used to monitor the sound level of the music at Woodstower festival, how do you feel about that?
- Very satisfied
- Moderately satisfied
- Neutral
- Moderately dissatisfied
- Very dissatisfied

15. What kind of acoustic insulation do you have?
- none
- old double glassed windows
- recent double glassed windows

16. Code postal

17. Floor (0 for the ground floor):

18. Gender:

o Male

o Female

o Prefer not to say

19. Age:

o 18-24

o 25-34

o 35-44

o 45-54

o 55-64

o +65

20. Do you want to add anything about the questionnaire or the festival?

## 9.6 Appendix F Questionnaire about the LoRa trackers

The goal of the questions below is to understand how easy it was for you to use the LoRa tracker, how easy it was and the impact it has on completing your tasks and normal job. The tracker is provided by the European project MONICA that has the goal to improve cultural events via the use of technology.

In addition to your opinion we are also going to collect some personal information about you like gender, age and job title. All personal data will be stored until the end of the project (December 2019) on secure servers controlled by the project consortium. Only authorised project partners will have access.

By filling out this questionnaire you agree that we will process your data in line with our privacy policy.

If you have any questions or change our mind, contact the local representative of the Data Protection Officer: Malik Dine, telephone +49 228 - 77 3288, malik.dine@bonn.de

Gender: Male Female Prefer not to say

Age: 18-24, 25-34, 35-44, 45-54, 55-64, 65+

| Question | Strongly Agree | Agree | Neutral | Disagree | Strongly disagree |
|---|---|---|---|---|---|
| 1.The tracking device weight was suitable | | | | | |
| 2.The tracking device was easy to use | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 3.The tracking device was comfortable to wear | | | | | |
| 3.The tracking device was comfortable to wear | | | | | |
| 4.The tracking device stopped me from doing my normal daily job | | | | | |
| 5.The device battery lasted the whole day | | | | | |
| 6.I needed to restart the device (switch off/on again) in the middle of the event to regain connectivity | | | | | |
| 7.The tracking device met my expectations? Why/Why Not? | | | | | |

Please say why here:

8. I feel safer wearing the GPS Tracker

9. Overall, I am satisfied with the LoRa Tracking Device

10. How long was the device active for?

- Less than 1 hour
- 1-2 hours
- 3-4 hours
- 5+ hours

11. In terms of privacy, how did you feel about others tracking your location?

- I am happy with my location being tracked
- I am ok with my location being tracked
- I don’t mind (neutral)
- I don’t like it
- I am completely against it

12. What additional functionalities would you like to see on the device?

## 9.7 Appendix G Questionnaire on the COP

Usual introduction about the privacy and the MONICA data management.

Date:

Time:

Stage:

Gender (optional): □ Female □ Male N/A

Age (optional):

Function/occupation:

About sound levels, would this COP system be able to help you comply with the current legislation?

□ Yes, absolutely. □ Rather yes □ Rather no □ No, not at all.

Did the display of sound levels measured at local residents help you to adjust the sound level?

□ Yes, absolutely. □ Rather yes □ Rather no □ No, not at all.

Do you find the system understandable (help provided/ functions installed)?

□ Yes, absolutely. □ Rather yes □ Rather no □ No, not at all.

Do you find the acoustic information displayed by the COP relevant? (e.g. decibels A/C weighted)

□ Yes, absolutely. □ Rather yes □ Rather no □ No, not at all.

Do you find the COP system fluid? (display speed / refresh levels rate?)

□ Yes, absolutely. □ Rather yes □ Rather no □ No, not at all.

Is the COP system correctly displayed on your phone?

□ Yes, absolutely. □ Rather yes □ Rather no □ No, not at all.

How many times / for how long have you being used the system? (if second interview or after a completed day of festival)

Do you have any comments or suggestions about this system or this questionnaire?

## 9.8 Appendix H Focus Group Questions for the security staff using Smart Glasses

Gender: Female Male

Job position:

| Question | Strongly Agree | Agree | Neutral/ NA | Disagree | Strongly disagree |
|---|---|---|---|---|---|
| 1. I am satisfied with how **easy** it is to use the smart glasses | | | | | |
| 2. I can **effectively** complete my work using the smart glasses | | | | | |
| 3. I can complete my tasks **quickly** using the MONICA smart glasses | | | | | |
| 4. I feel **comfortable** using the smart glasses | | | | | |
| 5. It was **easy to learn** how to use the smart glasses. | | | | | |
| 6. Whenever I make a mistake using the smart glasses, I recover easily and quickly | | | | | |
| 7. I feel the MONICA smart glasses helped/ can help me to **detect** safety/ security incidents | | | | | |
| 8. I feel the MONICA smart glasses helped/ can help me to report safety/ security incidents (explain how): | | | | | |
| 9. Overall, I am satisfied with the MONICA smart glasses | | | | | |

10. In your opinion, what's the most important thing about the MONICA smart glasses you liked or felt helped you in?

11. What additional functionality you expected the MONICA smart glasses to have?

12. What are the two things you did not like about MONICA smart glasses?

13. Anything else you would like to add:

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