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

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

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Index:

1 Executive summary

This document presents a market and business analysis of the exploitable results identified in MONICA which can be exploited. As such, it serves as a foundation for commercial strategies and plans.

The MONICA solutions include: Crowd and Capacity Monitoring, Crowd Management and Communication, Sound Level Monitoring, Adaptive Sound Field Control and User Experience.

Based on publicly available market studies, we have analysed the total markets for products and solutions that are related to MONICA solutions: a) the Creative and Cultural Industry, b) the Sports Industry, and c) the Smart City Management Industry. For each of these market categories, we have tried to isolate the markets that are specifically related to MONICA solutions. This exercise requires a fair amount of guesswork and does not pretend to be accurate. Its sole purpose is to point out approximate sizes of the relevant markets to be used in the market segment prioritisation. The result of this process has led to the following total, potential market sizes for MONICA solutions:

- The Creative and Cultural Industries; subsection 'outdoor musical events with performing artists': €300m annually;
- The Sports industry; subsection 'security of events in permanent sport facility operations': €200m annually;
- Smart City Management subsection 'managing outdoor event and city noise': €500m annually.

The market analysis of the Creative & Cultural Industry (CCI) and the Sport Industry shows that revenues for both music concerts, festivals and sports games continue to grow, with both markets being very important contributors to the European market value. However, the sectors also face challenges with increasing city populations and more sensitiveness towards environmental issues such as noise and congestion. Also, safety issues at open-air events are apparent with challenges in terms of infrastructure, communication and external threats. Finally, increasing competition evokes the need for new innovative offers that can help frame a unique user experience and thus generate a high visitor satisfaction rate.

IoT technology forms a central platform in making events in the city smarter. Inherent in 'smart' is not only the aspect of enhanced entertainment for the eventgoer but also the aspect of efficiency as well as safety and well-being, both for the visitors and the citizens living close to the event. The adoption and acceptance of IoT depend on technical and financial aspects but increasingly also on human issues as the amount of data created and exploited by humans grows.

Thus, the value framework that the MONICA solutions bring to smart open-air events covers: finding the balance between urban uses (attracting visitors while considering residents); ensuring a safe and enjoyable event experience (the safety and enjoyment of the event goer) and framing a sustainable IoT ecosystem (which covers technical, financial as well as human aspects).

The market segmentation and business analysis of MONICA solutions yield the following overall results:

MONICA Crowd and Capacity Monitoring: A comprehensive set of tools to capture and store situational awareness information of crowds and individuals. Unique selling points include: comprehensiveness of the platform, its eloquent design from an IoT point-of-view and integration capabilities. The Performing Arts of the CCI is the most attractive segment.

MONICA Crowd Management and Communication: A reliable web-based overview of event activities and a tailored communication system that supports efficient and mission critical management of incidents. Unique selling points include: comprehensiveness of cloud solution, wealth of features and integration options. The Performing Arts of the CCI together with Smart City Management are attractive segments.

MONICA Sound Level Monitoring: Accurate, real-time sound measurements for precise information about sound levels. Unique selling points: use of accredited sound level meters to document compliance; comprehensiveness of the solution and integrability. The Performing Arts of the CCI, including the owners of permanent concert venues, is an attractive segment.

MONICA Adaptive Sound Field Control: Optimisation of sound experience for concert audience and up to 10dB attenuation of the sound levels for the neighbourhood as well as within "quiet zones" protecting the hearing of audience and staff. The solution is unique in the market and the options present a number of compelling Unique Selling Points in terms of sound field control offerings and sound quality. Another remarkable uniqueness is

the ability to integrate with other MONICA solutions. The Performing Arts of the CCI, including the owners of permanent concert venues is the most attractive segment.

MONICA User Experience: 1. Citizen engagement platform based on open data. Unique selling points: integration ability and data transparency. In the Smart City Management market, the municipalities, the need for investing in citizen engagement and co-creation activities is high and often seen as the hall-mark of a “Smart City”.

2. Enhanced visitor experience from information, communication, engagement to analytics. Unique selling point: Customisable solution with multiple features and functions. The Performing Arts of the CCI including the owners of permanent concert venues, is the most attractive segment.

2 Introduction

2.1 Purpose, context and scope

The purpose of this deliverable is to present a market overview, segmentation and analysis to position the MONICA exploitable results as preparation for commercial strategies. As output of the market segmentation process, a business analysis is performed resulting in the six business models presented in this deliverable. Based on this, project partners can make informed decisions on how to define their individual exploitation plan. The document also serves as a starting point for external stakeholders who have an interest in applying MONICA results in their products and/or services.

The deliverable is part of task T11.5 which develops a business **framework** for the deployment of the MONICA IoT platform embedded in the economic realities of the tourism and cultural event industry. This task also **defines the foundation** for commercial implementation of the MONICA IoT platform across the international Smart City landscape.

Hence, the scope of the deliverable is to present an overall market overview and scene setting, analysis, segmentation and the resulting business models. The markets touched upon include the Cultural and Creative Industry, the Sports Industry and the Smart City management markets. The related markets of the Tourism Industry which are indirectly impacted are covered in *D11.3 Using IoT and Smart City Platforms to Support European Tourism and Culture*.

2.2 Structure and content

The framework for analysis, segmentation and business modelling is presented in Chapter 3. An overview of the IoT emerging markets coming from the hackathon results is provided in Chapter 4 followed by identified exploitable results in MONICA in Chapter 5.

Chapter 6 presents the overall market status and trends in the Creative & Cultural Industry, the Sport Industry and the Smart City management industry, relevant to MONICA demonstration sites.

Chapter 7 covers a segmentation of the market to better prepare the business analysis and is performed using a benefits segmentation.

Based on the analysis of market segments, Chapter 8 performs a business analysis completed by a presentation of resulting six business models to invite further exploration and exploitation.

3 Business framework overview

This chapter presents the business framework for the deployment of MONICA solutions. It covers methods for assessment of exploitable results and Intellectual Property Rights (IPR) issues, market analysis, business analysis and modelling. The partners' individual business analysis, including exploitation and positioning strategy, is presented as part of the confidential exploitation plans in *D12.6 Final Replication, Exploitation and Business Plans*.

3.1 Method for assessment of exploitable results and IPR issues

In order to exploit the identified results, Intellectual Property Rights (IPR) must be determined. This document describes only the overall solutions suitable for publications. The partners' individual plans for IPR exploitation are described in the confidential exploitation plans.

The full framework for IPR management was developed and reported in *D1.4 Plan for Managing Knowledge and Intellectual Property*. The MONICA consortium follows the recommendations for EU research projects, and IPR management handled according to the Grant Agreement[1] with specific rules set forth in the Consortium Agreement. This process has been followed in the exploitation planning process using a tool called the IPR Identification Sheet. The first step focused on identifying beneficiaries who have contributed to the results. Subsequent steps involved negotiations among partners about the ownership of these results.

28 tangible exploitable results have been identified and recorded and joint ownerships have been negotiated and agreed directly between the involved partners. After the identification and description of the result and the optional components, the Project Board unanimously approved the list, the valorisation of partners' work and the distribution of ownership. The results are available in *D1.3 Final Report*.

3.2 Methods for market analysis

For the purpose of market analysis, the exploitable assets have been aligned with three clear and identifiable markets: a) The Creative & Cultural Industry, b) the Sport Industry and 3) the Smart City Management Industry. Each of these markets are relevant to the MONICA demonstration sites and they are all sufficiently well-defined in terms of publicly available market descriptions and market data for the scope and resources available in the MONICA project.

The market analysis aims to identify the attractiveness and the dynamics of each of the three markets. It looks into the size of the market both in volume and in value, the various customer segments and buying patterns, the competition, and the economic environment in terms of barriers to entry and regulation. From these market descriptions, the business analysis focuses on the strengths, weaknesses, opportunities and threats (SWOT) of the MONICA solutions to arrive at adequate business strategies for exploitation.

3.2.1 Market research and segmentation

Desk-top research and expert knowledge within the consortium have been used to arrive at a reasonable cohesive description of the three most important markets. These markets are generally well described in various material publicly available on the internet. The purchase of detailed client studies (costing thousands of euros) and market reports have been deemed to be outside the scope of this market analysis.

In any event, the available public material has proven to be sufficient to provide a realistic business ecosystem and a number of sustainable business models for the partners' individual exploitation plans.

3.3 Methods for business analysis

The business analysis aims to set out a business ecosystem that provides the optimal business strategy for exploiting the market potential in each of the three markets with the MONICA solutions and by the consortium partners. The business analysis encompasses the following steps:

- Formulate Unique Selling Points
- Perform SWOT analysis

[1] Grant Agreement 732350 Section 3, paragraph 3.2.1 Management Procedures defines the rules for handling Intellectual Property Rights, their use and dissemination

- Develop an optimum positioning strategy
- Develop sustainable business models

The result of the SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis and the market attractiveness analysis are presented as the foundation for the individual and joint exploitation plans and for the partners' subsequent product development and marketing plans.

3.3.1 Unique Selling Points and SWOT analysis

In the first step, all the Unique Selling Points (USPs) have been analysed against the competition. Focus of the comparison will be on features, benefits to the customer, ease of use, customer acceptance, etc. As such, a USP is important as it provides more value for money to customers than other available solutions.

In the second step, a detailed SWOT analysis has been performed, analysing the *Strengths* and *Weaknesses* of the MONICA solutions against the *Opportunities* and *Threats* exposed by the market.

The SWOT analysis will be carried out for all exploitable results placed in the green areas of the Market Attractiveness matrix. The USP will be grouped as either *Strengths*, when the MONICA solution is superior to the competition, or as *Weaknesses*, if those MONICA aspects are inferior to competitive solutions. Likewise, all the Opportunities of the market segment are identified and described (price attractiveness, customer behaviour, market size, etc.). All the strengths are matched to the market Opportunities in order to create the foundation for a powerful sales and marketing strategy that fully exploits the superiority of the MONICA solutions. At the same token, the Weaknesses are matched to the market Threats in order to allow for relevant risk mitigation plans.

3.3.2 Market prioritisation

It is now possible to prioritise the different MONICA solutions in terms of the attractiveness of each of the markets. Based on the market analysis and the identified USP/SWOT analysis, each exploitable result has been ranked according to its business strength and competitive situation. The ranking will determine the relative business strength.

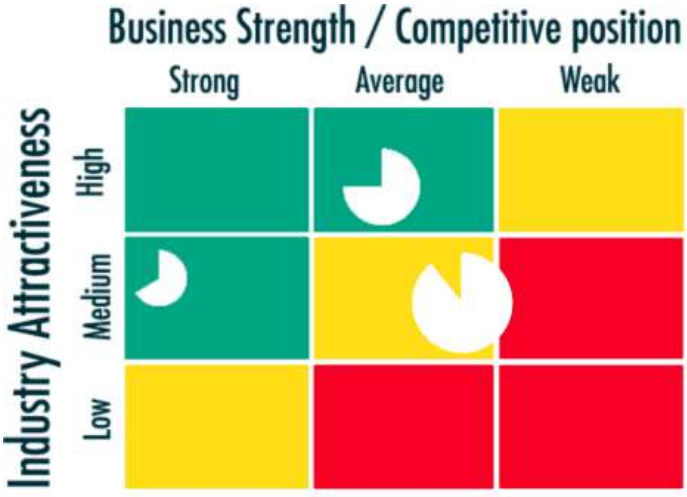


Figure 1: The Market Attractiveness Matrix

The General Electric - McKinsey Market Attractiveness Matrix has been chosen as a benchmarking methodology to analyse the position of the MONICA results and segment the markets accordingly. It is a powerful marketing strategy and product portfolio analysis tool that compares MONICA solutions with respect to market attractiveness and competitive power. It provides a useful guideline as to which results are directly exploitable, where and how, and the MONICA results have been positioned in the matrix for each of the three markets described in the detailed analysis.

The method is displayed is a 3x3 grid[2]. The attractiveness of the market is represented on the y-axis and the competitiveness and business strength of the MONICA solutions are plotted on the x-axis. Both axes are divided into three categories (high, medium, low) thus creating nine cells. The solution is placed within the matrix using circles with the size of the circle representing the volume of the turnover.

[2] https://www.cleverism.com/ge-mckinsey-matrix-how-to-apply-it-to-your-business/

When completed, the Market Attractiveness provides a useful guideline as to which results are directly exploitable. The results in the green areas enjoy excellent positions with a combination of high business strength and attractive market conditions. This is the high priority results that should be pursued immediately.

Any results placed in the red areas should be avoided. They have low competitive strength, and the market is unattractive or difficult. The results need to be upgraded in terms of competitive position and repositioned for a different and more attractive market segment. Even if possible, this may require substantial investments and time.

The results in the yellow zone may be interesting but need to be upgraded vis-à-vis the competition. If they move horizontally to the left and become more attractive in the identified market segment, they may be exploitable.

3.4 Methods for business modelling

3.4.1 Elements of a business model

The basic questions to be answered in the business model are the fundamental questions of any business: What do we offer to the customer, who are they and how do we operate to deliver the product or service so that we can create a profitable and sustainable business?[3] In other words, we need to identify and analyse the value proposition in the intended MONICA solution, to which customer group the solution is targeted and how we organise ourselves to deliver the solution in the most efficient way.

When the three questions have been answered, we can analyse the revenue streams and cost models and derive the financial return and thus evaluate the sustainability of the proposed business.

From the business framework presented in this document, the business concepts of the identified MONICA solutions were further developed in *D9.3 Replication Reference Book*.

Based on the value propositions and customer target groups in *D9.3* combined with the business model framework in *D11.5*, we are now able to lay out specific examples of business models, which will be used to inspire partners when creating their individual exploitation plans.

3.5 The Business Model Canvas

The first step in the process is to identify and analyse the value proposition in the intended MONICA solution, to which customer group the solution is targeted and how the solution can be delivered in in the most efficient way.

The value proposition is an overall view of an organisation's bundle of products and services that together represent a value for its customer. An important reason for the failure of many technology-driven business ideas over the years is the lack of a sound value proposition to customers. It is thus of the utmost importance that value propositions based on MONICA solutions are evaluated and assessed in an objective way.

[3] The methodology and illustrations in this chapter are adopted from Pigneur (2005).

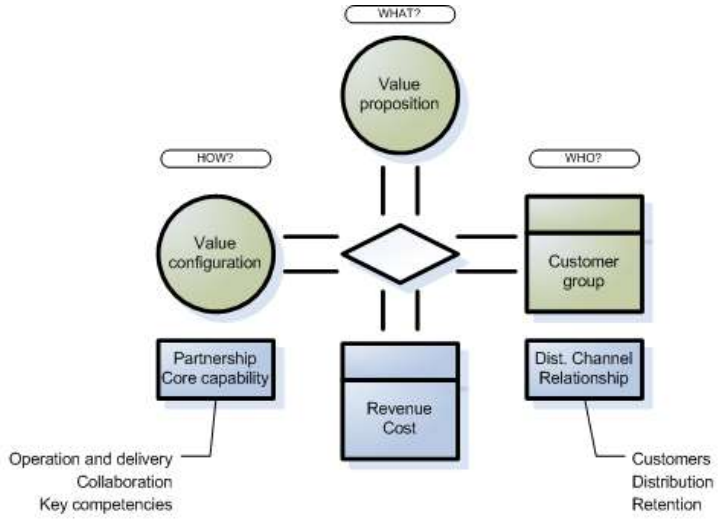


Figure 2 Value Proposition elements

Customer groups are targeted by the actual value proposition. When the customer group has been defined, the next step is to evaluate how the organisation actually can gain access to this target group, i.e. which distribution channel can be activated. A distribution channel can be defined as a set of links or a network via which an organisation "goes to market" and delivers its value proposition. This concept is well known and straight forward for physical products, but MONICA solutions need a whole new thinking in terms of re-defining "distribution channels".

The need for innovation in distribution channel planning is high and concepts like bundling of services, value nets and dynamic value constellations can be successfully incorporated in this process.

The value configuration involves structuring the organisation's or organisation's infrastructure to be able to deliver the value propositions to the target groups. The value configuration is thus closely related to the organisation's core competencies and operational infrastructure.

The value proposition defined in this way, allows us to build a sustainable business model for the exploitation. The process modelling approach is more appropriate to the MONICA cases and will be pursued in the following. The Business Model Canvas methodology is an excellent tool to look at business processes between known stakeholders based on value propositions.

3.5.1 Business model canvas

The Business Model Canvas, developed by Alexander Osterwalder and Yves Pigneur in the context of the Business Model Framework (Osterwalder & Pigneur, 2010), offers a tool to visualise the framework of the specific business model, mapping the different building blocks and making the model easier to communicate and understand. This tool is used to map out all details of the business model and the business ecosystem once the value proposition has been identified. It is a dynamic tool which can be updated and adapted to the business model so that it matches the current challenges and meets the customer demands at all times.

Perspective	Question	Building block
Offer	What?	Value proposition
Client (right side)	Who?	Customer segment Distribution channels Customer relationships
Activity (left side)	How?	Key resources Key activities Key partnerships
Financial	How much?	Revenue stream Cost structure

Figure 3: Business Model Canvas Components

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. This tool is used to map out all details of the MONICA business models based on the value proposition, target groups, the partner constellations, and revenue models outlined in *D9.3 Replication Reference Book*. Figure 3 shows the different building blocks that make up the canvas (Pigneur & Fritscher, 2014).

4 Emerging IoT markets

Before going into detail with the MONICA solutions, this chapter presents a short market overview related to the results from the three MONICA hackathons carried out in 2018.

The hackathons were organised to promote new market openings for start-ups through the use of MONICA data, and the results reflect emerging IoT market trends: hearables for a consumer market and a data-driven behavioural approach to urban planning.

4.1 Smart wearables for consumer markets

According to Statista, the number of connected wearable devices worldwide is expected to go from 722 million in 2019 to more than 1.1 billion in 2022[4] concurrent with the rollout of 5G in Europe[5].

Figure 4 shows a range of wearable technology applications where MONICA primarily covers the security and safety sector (remote monitoring, tracking), serving the B2B market. Two of the hackathon winners approach a B2C market, delivering hearables for the wellness/health/lifestyle sectors.

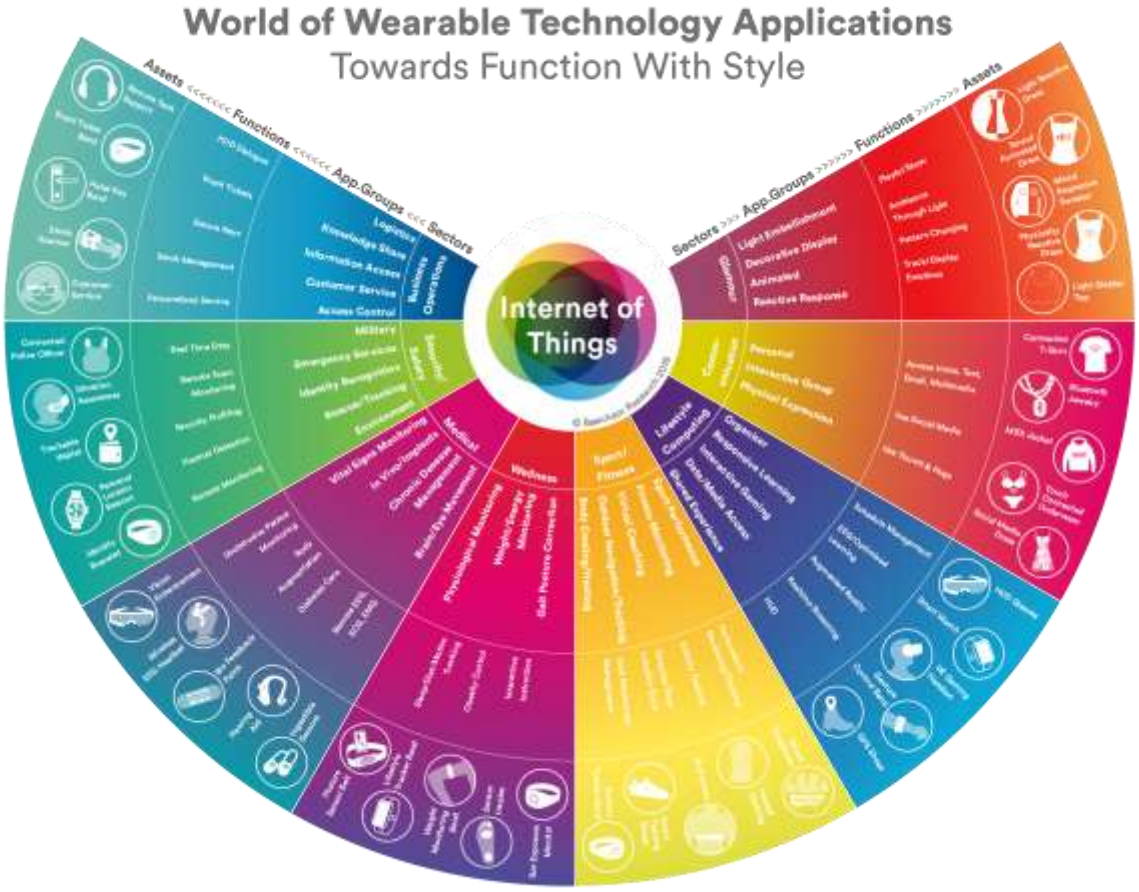


Figure 4: Wearable tech areas. Image by Beecham Research

[4] https://www.statista.com/statistics/487291/global-connected-wearable-devices/
[5] https://www.statista.com/topics/1556/wearable-technology/

In-ear devices ("Hearables") are getting more and more common and are used for multiple purposes such as listening to music or communicating with others. According to IDC[6], hearables were among the fastest growing categories in 2019, covering almost half of the wearables market in the second quarter of 2019.

Meanwhile, sub-segments are emerging such as hearables dedicated to sports (fitness measurements such as heart rate, maximal oxygen uptake etc.) as well as better hearing (conversation enhancement, control of background noise, personalised hearing aid, tinnitus relief)[7].

The winning entry of the MONICA hackathon in Leeds, UK [8] belongs to the 'better hearing' segment as a personal, augmented audio device giving its user control of the auditory environment. In the context of MONICA, stadium visitors are able to control their auditory environment during games thereby making sporting events safer and more inclusive to all.

As opposed to in-ear devices, on-ear devices seek to free the ear canal, thereby enabling its wearer to be more aware of what goes on in the surroundings while listening to some form of sound. The winning entry of the MONICA hackathon in Roskilde, Denmark[9] is such a device. It is a wireless bone-conduction hearable based on sending sound waves in the form of vibrations directly to the human skull so that the user is spatially aware at all times. It is aimed at people wanting to 'listen to their surroundings and the digital world simultaneously in all sound environments of their daily life with superior sound quality for different hearing profiles'[10]. Thereby it also overcomes the negative occlusion effect of in-ear devices and hearing aids whereby you hear yourself louder due to obstruction of the ear canal. In the context of MONICA, three use cases were presented that aim to enhance communications at events:

- Security personnel can be spatially aware at all times, not having to rely on a headset which obstructs the ear canal;
- Sound engineers can perform their operations, such as live sound mixing, and communicate at the same time without it interfering with their sound perception;
- Staff members can use the solution as a regular communications device connected to a body-worn two-way radio.

See Appendix A for a Business Environment Value Chain Model for hearables.

4.2 IoT and behavioural change

Smart cities are increasingly using data to understand and change human behaviour as part of the urban planning. The move from monitoring and analysis of data (supply-side data focus) to communication and behavioural change (demand-side people focus) is a necessary next step of the smart city in solving nightlife challenges where public spaces have to accommodate for both partying crowds and residential homes.

The winning solution at the Torino hackathon[11] is an example of using MONICA sound level data to motivate nightclubbers and bar owners in the Torino nightlife to change behaviour. The solution displays monitored sound levels on tablets in bars and media totems in the streets to increase awareness of the noise issues. If noise levels are too high, actions are initiated by the application and again when the crowd manages to reduce the sound levels. To further promote reduction of noise, different economic incentives are also introduced.

[6] https://www.idc.com/getdoc.jsp?containerId=prUS45488019
[7] https://www.idc.com/getdoc.jsp?containerId=prCEMA44834119
[8] https://www.hearablelabs.com/
[9] http://www.auricle.io/
[10] http://www.auricle.io/
[11] https://www.monica-project.eu/the-shhh-project-wins-the-third-monica-hackathon/

5 MONICA exploitable results

To approach a market and plan exploitation, you have to know what you are offering. The project has therefore identified and agreed upon 28 tangible results which can be exploited, either commercially or scientifically.

The MONICA approach has been to deploy IoT technologies that address actual needs and challenges coming from 11 European events with one of the central technologies being smart wearables. Consequently, the technologies have been replicated in three other settings: a conference event, a festival and a street party.

The following is a presentation of the exploitable results from this work. Technologies developed and provided by the supply-side partners have been divided into three solution groups according to their end-use destination: sound management of open-air events; security and safety management of open-air events and user experience at and of open-air events.

The following section describes only the overall solutions suitable for publication. A detailed description of the individual exploitable components, ownership and marketing plans is part of the confidential deliverable *D12.6 Final Replication, Exploitation and Business Plans*.

5.1 The MONICA portfolio of solutions

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 urban settings: Unwanted noise in the surroundings and security of the audience.

The MONICA platform is covered by a portfolio of six dedicated “solutions” that cover specific parts of the closed-loop functionality. The portfolio consists of these solutions as visualised in Figure 5:

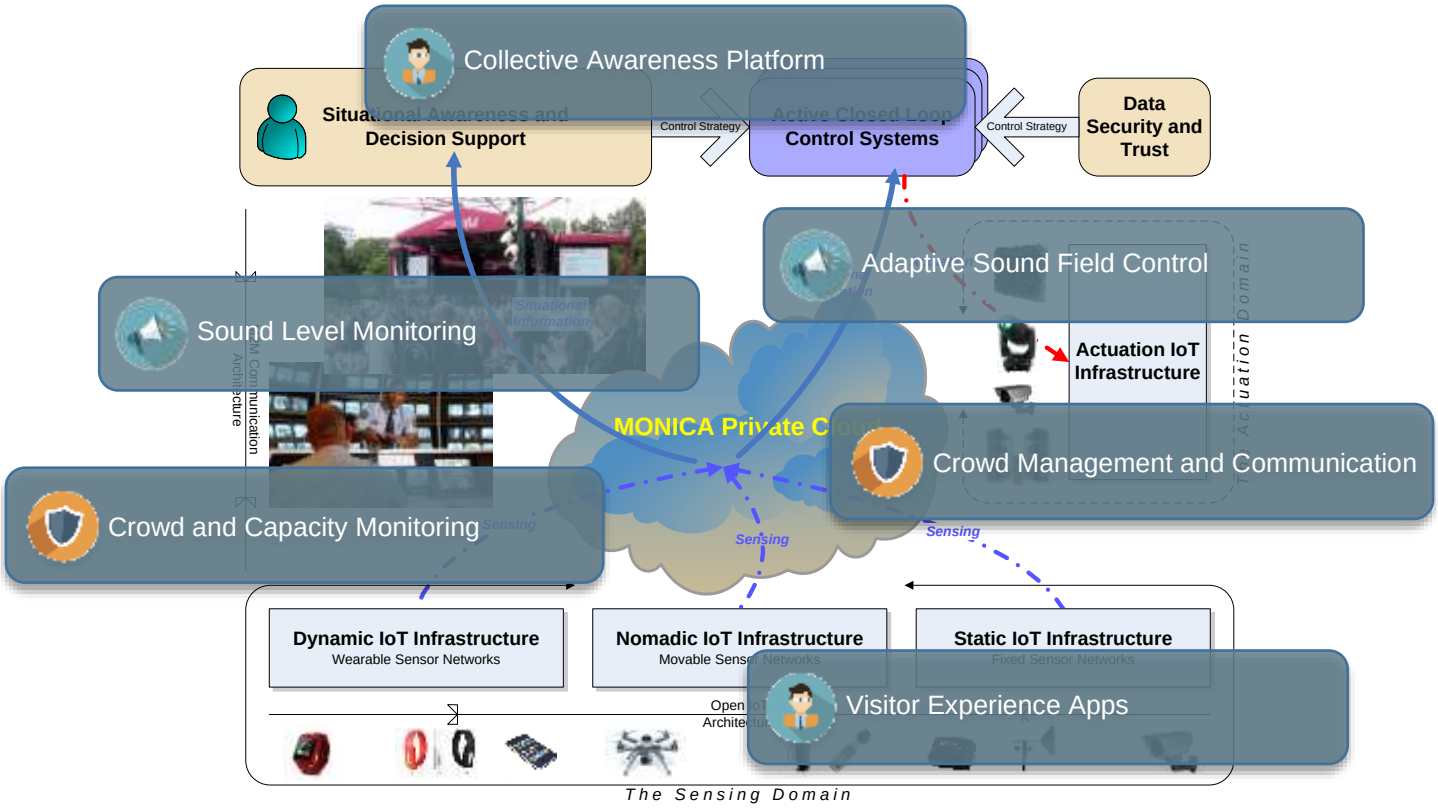


Figure 5: The MONICA platform with its solutions

The MONICA platform is built on several IoT physical world network infrastructures and a closed-loop control system for each application. The components are connected via dedicated communication network and data repositories. Some solutions cover data capture from the physical world with analysis and transmission of information to the MONICA private cloud service. Other solutions deal with providing situational awareness from the information, decision support and feedback/actuation back to the physical world.

During the project, the solutions have reached a Technology Readiness Level (TRL)[12] of 6-8 which means that they are close to being commercially available on the market:

- MONICA Crowd and Capacity Monitoring solution (TRL 8: system complete and qualified)
- MONICA Crowd Management and Communication solution (TRL 7: system prototype demonstration in operational environment)
- MONICA Sound Level Monitoring solution (TRL 7)
- MONICA Adaptive Sound Field Control solution (TRL 6: technology demonstrated in relevant environment))
- MONICA Visitor Experience solution (TRL 8)
- Collective Awareness Platform (TRL 9: actual system proven in operational environment)

5.2 Sound management results

The MONICA sound management results consist of a sound monitoring part and a sound control part.

Sound Level Monitoring

The *MONICA Sound Level Monitoring* solution provides real-time monitoring (measuring and displaying) of sound levels at discrete outdoor locations in the city by the use of high quality, accurate and weatherproof IoT-enabled sound level meters.

The sound level meters collect data in real-time and send them directly to backend databases. It can also perform real-time sound analysis so that sound contribution levels from different sources can be separated.

The result can be displayed as a simple sound map or integrated into a website via a plugin, displaying the time series and the geographical location of each of the sound level meters. The result can also be displayed on a Common Operational Picture (COP) in the control room or through mobile apps to assist sound technicians in the monitoring of sound levels at concerts.

Adaptive Sound Field Control (ASFC)

Based on integration with existing Public Address (PA) systems, the *MONICA Adaptive Sound Field Control* solution enables organisers of open-air concerts to mitigate sound outside the perimeter of the concert area.

The ASFC system is specifically designed to work in outdoor conditions with varying atmospheric conditions, using IoT devices to extract data online and in real-time and run special algorithms calculating *inter alia* the sound mitigating audio.

Quiet Zones are part of the MONICA Adaptive Sound Field Control solution. The zones are established in the concert area and reduce sound levels from the stage. The zones thereby minimise the sound exposure to the staff and the public, providing a ‘sound shelter’ in which security staff can communicate and guests may answer a phone call.

5.3 Crowd management results

The MONICA crowd management results consist of a crowd monitoring part and a crowd management part.

Crowd and capacity monitoring

The *MONICA Crowd and Capacity Monitoring* solution for security and safety management consists of a range of tools based on video cameras and wearables (crowd and staff). It can be divided into two main purposes: monitoring crowd flow and detecting incidents.

[12] 1 to 9 scale used by the Horizon 2020 Programme, indicating the maturity level of technologies.

Advanced video analytics provides improved data processing and advanced algorithms for crowd counting and crowd density. With the concepts of IoT and cloud computing, the video analytics processing is split between edge nodes and cloud infrastructure. The additional computer power offered by clouds and the IoT hybrid processing model enables more advanced algorithms which can still use low-cost, commercial off-the-shelf sensors but achieve high performance for counting and tracking in crowded scenarios.

The system calculates the crowd density based on the output of the crowd density algorithms and displays the result as a heatmap on a graphical interface. Likewise, crowd density based on location data from crowd wristbands can be shown as a heatmap.

From the video streams, it is possible to detect abnormal incidents such as fights as well as to detect and track objects or humans, even under extreme weather conditions.

Precise tracking of staff positions is enabled by smart IoT staff wristbands and trackers. Wristbands used by the crowd can also be tracked for density calculations with tracking being anonymous and less precise.

Finally, wearable sensors (gyroscope and accelerometer) makes it possible to recognise human activity, enabling recognition of general daily life actions such as walking, running, standing, siting and lying down or recognition of specific actions relevant for security or healthcare monitoring such as humans fighting, falling down or waving.

Crowd management and communication

The *MONICA Crowd Management and Communication* solution for security and safety management consists of a range of tools based on video cameras and wearables (crowd and staff). It can be divided into two main purposes: overview of crowd status and decision support with decision support for intervention, and two-way communication with security staff and stewards in the field.

A cloud-based overview display solution provides the control room staff with a Common Operational Picture (COP). The COP provides a real-time updated picture of the security situation, aggregating all the information from the area under surveillance, is displayed on a graphical user interface. It includes live heatmaps of crowd density and capacity and shows the position of various types of staff on the ground and any detected objects or incidents. It thereby enables the control room staff to make decisions on emerging issues and take preventative or responsive action based on accurate information.

A Decision Support System (DSS) is added to the solution in order to provide support for crowd management, intervention strategies and tasks, as well as staff feedback and communication.

Communication and information sharing between control room and field staff is improved by the use of smart glasses, staff trackers or IoT staff wearables. By wearing the smart glasses, ground staff can take pictures and video and send it to the control centre for inspection and then receive directions.

Staff wristbands with Ultra-Wideband (UWB) radio technology provide position and a reliable communication channel relatively insensitive to interference compared to other radio alternatives. The wristband's LCD screen, three buttons, vibrator and buzzer enable bi-directional communication.

The staff tracker is a custom-built GPS tracking device with an alarm button, showing the positions of staff and security personnel on a digital map. It uses LoRaWAN® technology and is thereby independent of commercial cellular mobile networks and WiFi.

5.4 User experience results

Enhancing the visitor experience

The visitor experience results include the MONICA event information app and IoT crowd wristband. The visitor app makes it possible for event organisers to provide key information about the event such as an overview map and information about traffic, parking, attractions and their position, first aid positions, toilet facilities, cash machines, bars etc.

The MONICA IoT wristband enables a variety of features for user interaction which include concert lightshows, attention notifications and social media connection between wristbands wearers.

Engaging the citizen

A collective awareness platform (CAP) enables public authorities to display open data relevant to a certain societal or environmental issue such as noise pollution and thereby engage their citizens in finding solutions to the problems.

The definition of the overall solutions allows us to approach the relevant markets and see how the solutions fit in, which is the scope of the following chapter.

6 Market analysis

This chapter presents the overall landscape and megatrends in the Creative & Cultural Industry, the Sport Industry as well as the Smart City management industry as relevant to the MONICA demonstration sites. The purpose is to identify the attractiveness and the dynamics of each of the three markets, presenting the challenges, needs and size of the industries and extracting the relevance for MONICA. As such, it is the first step in positioning MONICA's exploitable results on the markets.

The approach has been to do desk-top research and use expert knowledge within the consortium to arrive at a reasonable cohesive description of the markets. They are all sufficiently well-defined in terms of publicly available market descriptions and market data for the scope and resources available in the MONICA project.

6.1 Creative and Cultural Industry

European Culture takes many forms and is expressed in millions of ways. MONICA focuses on one of the key aspects of European Culture: The cultural performances in open-air settings, with special focus on musical expression.

Thousands of cultural festivals & live music festivals and concerts take place in Europe every year. So far, 459 live music festivals[13] and 260 arts festivals[14] are registered for 2020 but this is only a snapshot of the real picture. According to a survey conducted by the European live music network Live DMA (Live DMA, 2020), more than 400,000 music events (covering indoor as well as outdoor concerts) are organised annually by its 2597 live music venues and clubs, illustrating an abundance of music performances available. Covering the whole event management industry, one estimation is that 20 million events are organised annually[15].

With regards to music events, ownership is either private, non-profit or public which means that different business models and legal obligations exist (Live DMA, 2020). In the case of the Live DMA venues, the contribution is private 48%, private non-profit 44% with the remaining 8% being public organisations.

That live performances are popular is also evident by the number of spectators: Almost half (46%) of the European population[16] attend live performances (EC, 2015). In fact, revenues for concerts and music festivals have grown since 2010, rendering the European festival market healthy (EY, 2014, p. 49) with festivals being an increasing asset for cultural tourism worldwide (EY, 2015, p. 92).

Young people are highly represented in the Creative and Cultural Industry both in terms of employment and attendance. For music festivals in 2016, almost 70% of the people attending were between 18 and 30 years of age[17].

6.1.1 Challenges

However, the sector also faces challenges with increasing city populations and rising property costs and people expecting to be able to maintain their quality of life, resulting in more sensitiveness towards environmental issues such as noise and congestion.

Sound emissions

Since urban spaces are growing fast and cities are becoming more and more dense, so the issue of the perception of sound emissions outside a venue is increasingly challenging (Live DMA, 2019).

Current regulations for festivals (if existent) are, in many European countries, often based on the international standard International Organization for Standardization (ISO, 2013) and/or the European Directive on noise (EC, 2003) that regulate occupational noise exposure (Tronstad et al, 2016).

Sound regulations vary depending on the implementation, control and penalties linked to the nuisance perception from neighbours. On this regard, there are European, national, regional or local regulations that can be in the form of laws, decrees, edicts or recommendations (Live DMA, 2019). That means that sound is regulated in a strict manner in some countries and only through recommendations in other countries.

[13] https://www.musicfestivalwizard.com/
[14] https://www.festivalfinder.eu/
[15] Source: festivality.co
[16] Covering EU28 member states, Iceland, Norway, Switzerland, FYI Macedonia and Serbia.
[17] https://www.statista.com/statistics/438157/age-distribution-of-festival-goers-in-europe/

Moreover, the sound emissions of a venue i.e. the sound perceived from outside the venue, are regulated differently depending on what hour of the day or night it is. Generally speaking, at night, venues must respect stricter sound regulations than in the day (Live DMA, 2019).

Safety issues

Open-air city events face increased security and safety demands, dealing with challenges in terms of infrastructure (traffic blockage, street bottlenecks, poor access routes and restricted capacity), communication (lack of reliable technology) and external threats (petty theft, terror attacks, attacks on artists, general crime).

If the venue is large and publicly open, the free flow of many people represents a high degree of security threats with both small and large incidents being likely to happen.

Increasing competition

Throughout Europe, festivals and music events have to deal with increased competition and some with a decrease of public funding, threatening especially the existence of smaller, local activities. The situation evokes a need for innovative initiatives which range from advertising-based revenues, digital technology-uptake and more quality-oriented offers (EY, 2014, p. 50) depending on what is legally possible as a commercial, non-profit, or public organisation.

6.1.2 Estimated market size

Open air musical events are not only cultural light-houses; they are also big business. The global Cultural and Creative Industries generate annual revenues of US$2,250bn and provide 29.5 million jobs worldwide (EY 2015).

With revenues of €535.9bn, the European Creative and Cultural Industries (CCIs) contributed to 4.2% of Europe's Gross Domestic Product (GDP) in 2012 (EY, 2014, p. 10). The industry covers 11 cultural and creative markets, of which Performing Arts (live concerts and festivals) is the 7th largest in terms of turnover (EY, 2014, p. 10) as seen in Figure 6.

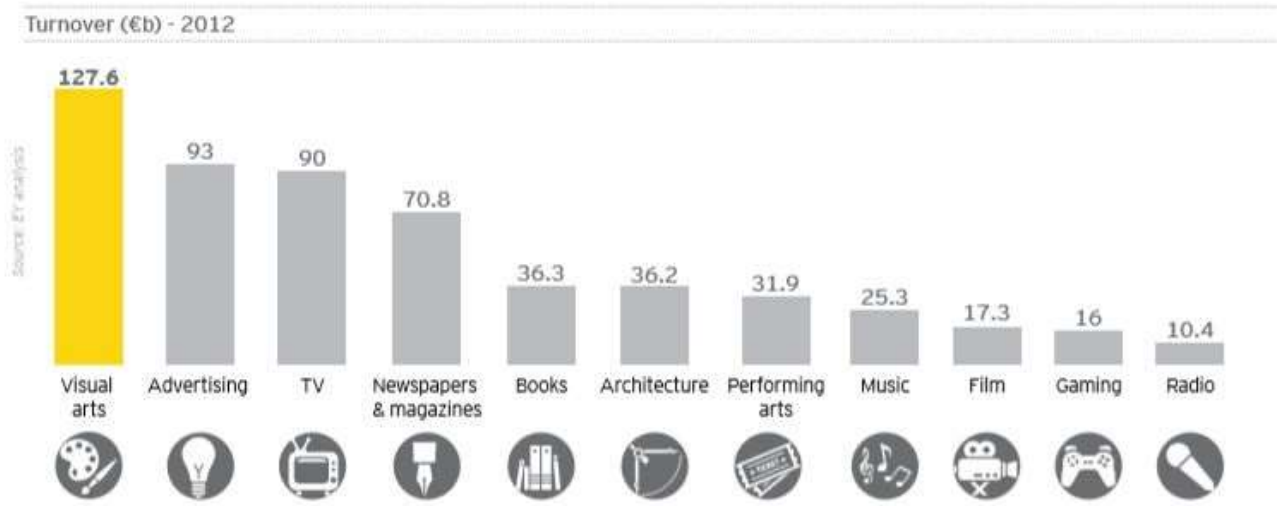


Figure 6: Turnover 2012 for the Creative and Cultural Industry in Europe

More than 7m Europeans are directly or indirectly employed in creative and cultural activities (EY, 2014, p. 10) with performing arts as the market employing most people (1,234,500 million people).

Figures also show that the industry was resilient during the economic crisis. In fact, it grew on average by 3.5% a year from 2000 to 2007 and continued to grow at 0.7% annually between 2008 and 2012. (EY, 2014, p. 16).

The MONICA solutions are mostly related to the subsections 'Performing arts' and 'Music'. But outdoor concerts and events are not entirely 'performing arts' and entirely 'music'. We thus assume that there is an overlap of 10 % between the two groups so that performing music will amount to approx. €6bn annually. But of this, only a fraction is related to outdoor events. On the other hand, outdoor events tend to be larger and more costly than indoor. If we again assume that 1 in 40 events are outdoor and average size is double that of indoor events, we arrive at a total market potential for MONICA solutions for outdoor music events to be

around €300m annually. This market estimate will be used in the ensuing sections on market positioning analysis and in the individual partners' exploitation planning.

6.1.3 Relevance for MONICA – finding the balance between urban groups of interest

The aim for any organiser of open-air music and cultural events in inner cities is to frame an overall positive experience for the one attending the event and the one living next to it. As mentioned, digital technology-uptake is a central element of this framework both in terms of sound, safety and service. The MONICA technology solutions support the preservation and promotion of European culture in the form of safe and enriching inner-city events balanced with a peaceful coexisting and cohabitation of citizens.

The balance is supported by sound level monitoring that ensures compliance of sound level ordinances for outdoor musical events and informs about the actual sound picture of other city activities such as street festivals, open-air markets, restaurants and clubs. Additionally, MONICA sound control technologies can help reduce the sound impact from outdoor music concerts in favour of the neighbouring communities. Through establishment of quiet zones in the concert area, the sound exposure can be minimised for different purposes such as giving visitors and security staff the opportunity to communicate.

Essential is also security and safety for event-goers and local residents. Here, MONICA's crowd monitoring and management tools with decision support and information sharing can help facilitate a smooth and effective run of the event. Paired with sound data, the crowd data can provide important information about the environmental impact of the event for better preparation of intervention.

Digital technology-uptake for enhanced user experience can be supported by mobile apps to market certain events and time schedules and provide exclusive content, integrating also smart wristbands with several features, all of which seeks to improve the overall concert or festival experience.

6.2 Sport Industry

Sport is a significant contributor to Europe´s economy, driving growth and employment (EU Council, 2018, p. 3). That experiencing a game and its atmosphere at a stadium is popular is evident by the numbers: there are 1185 sports stadiums in Europe[18] and an average of 36% Europeans[19] attending live sport events (EC, 2015), which means millions of sports fans supporting their teams by being visible at the stadiums.

Additionally, many stadiums are great historic and cultural flagships for their cities enjoying not only local but also international status and recognition. As a result, infrastructure and construction of sport stadiums are often supported by municipal funding even though the stadiums are commercial entities driven by sponsorship and profit.

Stadiums accommodate all kinds of age groups, embracing the entire family depending on the profile of the sport and game. In the case of cricket which is one of the sports relevant to MONICA, the short-day cricket matches at the Emerald Headingley Stadium have a wide appeal, with a large number of younger people and families attending, and hence a more diverse crowd than the longer games which attract an older segment. International cricket matches also have many international visitors who come to the stadium for the first time as well as bringing further external security, systems and processes.

In the case of rugby, the stadium hosts the yearly finale between the city's two universities, thus accommodating more than 10,000 university students.

6.2.1 Challenges

The sports stadiums face many of the same challenges as with cultural and music events, with security and fan experience being predominant concerns.

Match day experience

As sport has become more commercialised and matches more expensive to attend, competing also with sport streaming services, a high visitor satisfaction rate at matches is pivotal. This can be achieved through a variety of activities, a more personalised fan engagement and/or establishing better facilities at the stadiums such as hospitality areas. To do so, many stadiums are redeveloping their grounds to further evolve and live up to new spectator demands.

[18] http://www.worldstadiums.com/europe/maps/europe.shtml
[19] Covering EU28 member states, Iceland, Norway, Switzerland, FYI Macedonia and Serbia

Crowd behaviour

The visitor experience is also affected by the infrastructure, how easy it is to enter and exit the grounds, find the way and the facilities, avoid queues and get help. Especially games with fixed breaks put pressure on the facilities whereas other games such as five-day cricket means constant entering and exiting for security personnel. Therefore, tools to understand crowd behaviour are sought for since knowing how visitors move and behave means you can better plan.

Handling of incidents

Preventing and detecting health and security incidents as well as offenders and providing a timely response are also high priorities for the stadium operator. This includes everything from limiting long lines of queues outside the entrance and exit that could otherwise be a target, screening for forbidden and potentially harmful items and avoiding theft and vandalism onsite.

6.2.2 Estimated market size

The most recent report (EU, 2018, p. 9) shows that in 2012, sport-related activities contributed with 2.12% (€279.7bn) of the total EU GDP (€13,198bn). In addition, 5.67 m employees could be attributed to sport which is a share of 2.72% of the total (€208.55m)[20]. Like the CCI, the sport industry has not suffered considerably from the financial crisis.

The largest sport-related subsectors are education, sport services, public administration, accommodation & restaurant services and retail. Other multipliers (effects on the economic circuit) cover the supply network such as production of food and beverages and key sectors such as construction.

The 'sport services' subsector covers sport facility operations, sport clubs, fitness facilities, and other sport services such as sport promotion or athletes (EU, 2018, p. 16). It constitutes 15% or €42.1bn of the total sport-related GDP contribution and employs 749,000 people.

The subsector 'sport services' is the only one that is specifically related to sport, 'however, even this sector is aggregated with amusement and recreational activities and thus has to be divided into its sport-related and non-sport parts' (EU, 2018, p. 10).

The MONICA solutions are mostly related to the subsection "sport services" which covers sport facility operations, sport clubs, fitness facilities, and other sport services. This market is estimated at a total of €42 bn. However, the MONICA solutions are only relevant to sport facility operations and only for the permanent facilities such as sport stadiums which we assume is 5% of the total. Moreover, only a fraction (security of events) of the cost of operating the stadiums is relevant. We estimate that this is only 10% of the cost per stadium. Hence, we arrive at a total market potential for MONICA solutions for sports events to be around €200m annually. This market estimate will be used in the ensuing sections on market positioning analysis and in the individual partners exploitation planning.

6.2.3 Relevance for MONICA – ensuring a safe and enjoyable experience

Sport stadiums have implemented different measures to ensure a safe and secure environment for all its visitors, such as fixed video surveillance and mobile body-worn cameras carried by security personnel who patrol the grounds. Often this necessitates a constant eye on the streaming video in the control centre as it arrives to detect and manage threats.

The MONICA crowd solutions can support the safe and enjoyable experience by introducing advanced video analytics that supports the control centre by providing information about crowd size and flow (crowd counting) and by detecting incidents such as fights or unusually stationed vehicles near entrances.

The solution also facilitates a quick speed of response based on real-time communication between staff onsite and the control centre, using smart glasses, IoT staff wristbands and staff trackers. The control centre can quickly locate and track staff members in real time for a better coordination of intervention.

With deployment of an event app, the organiser can inform about the venue and security related matters to more people thus preparing the visitor in the best possible way.

The outlook illustrates that the two industries (CCI and sport) are high political priorities due to their growth and employment figures and their importance in the branding of Europe. Even though the industries were not

[20] The economic study is based on national Sport Satellite Accounts (SSA) from Austria, Belgium, Cyprus, Germany, Lithuania, Luxembourg, the Netherlands, Portugal, Poland, and the United Kingdom

heavily affected by the European economic recession, competition, security issues and changing user expectations increasingly demand innovative measures that make the event safe and attracting.

IoT technology is a key platformin making events in the city smarter. Inherent in 'smart' is not only the aspect of enhanced entertainment for the user but also an aspect of safety and well-being, both for the users and the citizens living close to the event.

From the needs of the industry and the city's security and sound challenges, we now turn to the Smart City management market and the areas which provide opportunities for MONICA.

6.3 Smart City management

The European Union (EU) defines the Smart City as a place where traditional networks and services are made more efficient with the use of digital and telecommunication technologies for the benefit of its inhabitants and business (Hämäläinen, 2020).

Sustainable urban development is recognised as a key challenge at the global level and the need for efficiently run cities becomes evident looking at the increasing urban population. According to the Department of Economic and Social Affairs of the United Nations "in 1950, 30 per cent of the world's population was urban, and by 2050, 68 per cent of the world's population is projected to be urban" (United Nations, 2019, p. 1). The growth in the urban population in just four decades will be equivalent to the size of the urban population achieved throughout all prior periods of human history. Almost 3 billion additional citizens will require electricity, clean water and sanitation, efficient transportation, homes, and public services such as health, education, and public safety".

In 2011, 240 of the 468 EU-28 cities with at least 100,000 inhabitants (51% of the total) had at least one Smart City characteristic and can therefore be classed as Smart Cities (EU, 2014).

IoT technology is increasingly being deployed to solve the societal challenges. The rapidly growing number of Smart City platforms enables cities to assemble all their digital applications on uniform communication networks spanning entire cities and delivering diverse applications such as health, energy and resource efficiency, and traffic management that help the city to become more environmentally sustainable and provide quality of life for its citizens.

According to criteria established by Think Tank of the European Parliament, almost all cities in Nordic countries are Smart Cities. Most cities with populations over 100,000 in Italy, Austria and the Netherlands are Smart Cities, as well as half of British, Spanish and French cities. In comparison, Germany and Poland are behind, while the eastern EU member states have the lowest number of Smart Cities (EUROACTIV, 2017).

EU (EU, 2014) defines six elements of Smart City characteristics: Smart Governance, Smart Economy, Smart Mobility, Smart Environment, Smart People, and Smart Living. The most common of the six key features are those associated with pan-European public goods problems - Smart Environment and Smart Mobility, present in 33% and 21% of initiatives respectively. Each of the other four characteristics (governance, economy, people and living) is addressed in approximately 10% of the Smart Cities, reflecting specific local strengths or weaknesses (EU, 2014).

Among the six elements of Smart City characteristics, the MONICA focus is on Smart Living which is strongly related to MONICA, as it is defined as ICT that "enables lifestyles, behaviour and consumption. It implies also healthy and safe living in a culturally vibrant city with diverse cultural facilities and incorporates good quality housing and accommodation" (EU, 2014, p.28). This area includes technologies to integrate and analyse massive amounts of data to provide better living to citizens in the form of childcare facilities, community libraries, entertainment modes and hospitals according to the area needs, etc. Later, the concept of smart events has emerged to specify the application of IoT at open-air cultural and sporting events, see Figure 7.

Figure 7: Smart Events: security, sound and user experience at open-air, cultural and sporting events

6.3.1 Challenges

The challenges of smart city management are related to technical and financial aspects but increasingly also to human issues as the amount of data created and exploited by humans grows.

Interoperability

Large-scale deployment of IoT and Smart City platforms is hindered by lack of data accessibility and interoperability standards between networks, systems and devices. Today, most of the device producers still come to the market with their own platform for data collection (EC, 2017, p. 21).

High cost

The implementation of IoT in terms of infrastructure and investment in sensor devices is often a costly affair necessitating regulatory support from the political side if to be realised (GrowthEnabler, 2017).

Data security and privacy

A wide spread adoption of IoT is also hindered by major concerns about data security and privacy. Today, a large amount of personal data can potentially be shared endlessly, as Smart Cities deploy sensors and devices in several sectors of the citizen life (healthcare, public institutions, transport services, and so forth). Also, the vulnerability of systems and devices remains relevant and data breach is still a major challenge for national and European cyber security agencies (Allied Market Research, 2018).

6.3.2 Estimated market size

Looking at the smart city market size, there are undoubtedly many opportunities for companies providing advanced technology services to Smart Cities.

The global IoT market will grow from US $190 bn in 2018 and is projected to reach US$ 1.102 bn by 2026, at a CAGR of 24,7% in the forecast period (2019-2026) (Fortune Business Insight, 2019). The global IoT market share will be dominated by three sub-sectors: Smart Cities (26%), Industrial IoT (24%) and Connected Health (20%) followed by Smart Homes (14%), Connected Cars (7%), Smart Utilities (4%) and Wearables (3%) (GrowthEnabler, 2017, p.14).

Total spending on IoT solutions in Europe is expected to surpass $241bn in 2022[21]. In a report from the Large-Scale Pilots Programme (LSP, 2019), European Smart Cities spent €16,5bn on IoT technologies in 2018: 6% in connectivity, 38% hardware, 35% services, 21% software. 'Over 50% of Smart City opportunity lies in Services and Software (platforms, applications, and analytics), which are growing their shares' (LSP, 2019, p. 64).

The MONICA solutions are mostly related to what European cities spending on Smart City IoT technologies i.e. €16,5bn, almost equally divided on hardware, software and services. The MONICA solutions have the approximate same composition, so we focus on the share of the total spending on cultural, outdoor events. But again, the cost of managing outdoor event and city noise are only small tasks in the total city budget. If we estimate the cost of the outdoor event to be around 2% (1 in 50 solutions) is for outdoor events and smart city monitoring, we arrive at a total market potential for MONICA solutions for smart city management events to be around €500m annually. This market estimate will be used in the ensuing sections on market positioning analysis and in the individual partners exploitation planning.

6.3.3 Relevance for MONICA – framing a sustainable IoT ecosystem

The realisation and acceptance of IoT depends on multiple technical, financial and human factors which must be accommodated for. To do so, MONICA has developed a framework for deployment of a sustainable IoT ecosystem built around:

- A dynamic IoT platform
    - integrating a large amount of heterogeneous IoT sensor data;
    - enabling data accessibility and interoperability of devices and systems, realised by standardisation;
    - providing secure data integration and sharing from device level, transmission of information to stored information.
- A comprehensive ethical and data privacy framework which includes ethics checklists, data protection impact assessments and compliance reports
- IoT device affordability and regulatory compliance
    - established through open and transparent competition in the device market thanks to application of harmonised standards and radio spectrum bands;
    - Regulatory compliance;
    - IoT-enabling existing devices where possible.

Sustainability is sought achieved not only through interoperability, standardisation and IoT-enabling of existing devices but also through building the solutions from real user needs.

The above overview shows the value framework that the MONICA solutions bring to smart open-air events:

- finding the balance between urban uses (attracting visitors while considering residents)
- ensuring a safe and enjoyable event experience (the safety and enjoyment of the event goer)
- framing a sustainable IoT ecosystem (which covers technical, financial as well as human aspects)

In the next chapter, we will look at the specific benefits that each of the MONICA results offer against this value framework.

[21] https://www.idc.com/getdoc.jsp?containerId=prCEMA44834119

7 Market segmentation

This chapter performs a segmentation of the market to better prepare the business analysis. It provides an overview of the different market segments that MONICA can address, touching upon the competition and the economic environment in terms of barriers to entry and regulation.

The segmentation has the purpose of allowing partners to make an informed decision on how to define their own individual exploitation plans.

Segmentation is performed by mapping the MONICA solutions and products outlined in Chapter 5 against the market analysis in Chapter 6 with benefits as segmentation variable.

7.1 Crowd and capacity monitoring

The focus of the crowd and capacity monitoring solution is on the application of the range of tools based on video cameras and wearables (crowd and staff) in the segment: Open-air festivals, music and sporting events.

7.1.1 Market demand

Sports and entertainment events are a key market for crowd management technologies and sadly, the trend of increased need for event security continues to rise. These events are attended by thousands of people, so crowd management issues arise regularly. The sector covers a broad range of events: music festivals, sports stadiums and outdoor sporting events such as marathons, cultural events, museums, nightclubs, tourist attractions and so on. However, the technologies that can be applied to provide crowd management services at these different venues are broadly the same (GSMA, 2018, p.6).

Thanks to IoT sensors and network data, it is possible to provide event managers with important information for the security planning, such as location of people, the direction of the crowd and the most crowded area in the venue. Moreover, these technologies are able to provide information also to better plan future editions of the event and to plan the layout of the venue to maximise the revenues and the visitors' experience year after year, such as how many people are visiting the food stands, how long the queue for the toilets is, how many people are approaching the site and by what means they are arriving (by car, public transport or on foot) (GSMA, 2018, p.6). This kind of information is useful for sports stadium managers too, so that they can allocate enough staff at security gates and bars.

Local city celebrations involving large crowds in large areas, need different solutions. If the city works with the local network operator, it is possible to use IoT technologies that rely on it. The network operator can provide a real-time data stream of the location of all mobile phones connected to its network within a given area and mobile-enabled IoT sensors installed locally can give a precise view and count of the entire crowd, allowing the crowd manager to monitor the movement of the crowd. Another method of crowd management is to distribute wearable devices to track visitors.

7.1.2 MONICA benefits

The responsible for security, safety and first aid during and after the event will benefit from the MONICA Crowd and Capacity Monitoring solution by having a comprehensive and cohesive set of tools to capture and store situational awareness information of crowds and individuals. It will greatly help them during both post-event investigations and in real-time. The specific benefits of MONICA Crowd and Capacity Monitoring solutions are:

- Provide full overview and control of the crowd levels in different areas
- Prevent the exceeding of capacity limits
- Predict critical situations or high crowd density
- Detect abnormalities within a crowd
- Report abnormalities instantly
- Report abnormalities accurately and with images for specialist advice
- Solidify the safety of the event
- Facilitate entry and exit safely and quickly

- Provide a complete overview of the deployment of staff members

Finally, the MONICA Crowd and Capacity Monitoring solution can be customised for short term deployment (e.g. for a specific concert); for a recurrent event (monthly or seasonal) or for semi-permanent events (night life area, traffic).

7.1.3 Target groups and market players

For the IoT solutions in the crowd capacity and monitoring segment, there are mainly two target groups:

1) Smart city operator: Technologies can help municipalities on several tasks such as planning, designing and controlling the public and private mobility patterns, license plate recognition, abandoned object recognition, counting the pedestrian traffic, organizing automated access control of automobiles to closed areas, tracking objects left intentionally or accidentally in public spaces, monitoring the crowd capacity in a certain area.
2) Event organiser: Both for sport facilities and public events, the IoT technologies can support the people counting (to know in real time the number of visitors), the covering of a larger area under observation in the venue with fewer cameras, a quick spotting of children who are lost during the event, the tracking of suspicious individuals whereabouts, the organising of automated access to cars in the parking lot of the venue.

In the video analytics market, most of the key players are based in North America. Avigilon in Canada, and Cisco Systems, IBM, Honeywell, Agent VI in US. Axis Communication is a Swedish company and Allgovision from India (Fortune Business Insight, 2019).

7.1.4 Market drivers and inhibitors

Drivers:

- Technological market driver: Increasing investment in machine learning technologies and Artificial Intelligence (AI) is pushing the global market of the smart crowd management solutions. A combination of solutions based on cameras, sensors, AI, data analytics, and situational awareness offer a smarter, more efficient approach to crowd management.
- Economic market driver: Efficiently run (smarter) cities. Smart cities can help drive IoT adoption in their events by focusing on investments, building trust, promoting interoperability, supporting crowd management.
- Social market driver: Fight crime and terrorism, control population density. Security staff and smart city managers need to handle a broad range of threats and should be able to effectively and quickly adapt to changing crowd sizes.

Inhibitors:

- Regulation on protection of personal data: Enterprises and end users are unclear about the privacy and security implications of billions of connected devices. IoT technologies need to meet consumers' privacy expectations and suppliers have to adopt adequate data security measures.
- Restrictions on video surveillance: Closed circuit TV (CCTV) systems can help prevent, detect and investigate attacks against the safety of citizens. Under the provisions of the GDPR, video surveillance is considered a high-risk operation requiring particular attention, especially when a crowd is monitored. According to the European Data Protection Supervisor "Any form of surveillance is an intrusion on the fundamental rights to the protection of personal data and to the right of privacy. It must be provided for by law and be necessary and proportionate[22]". As the last sentence indicates, there must be a legitimate reason for implementing surveillance and an assessment of whether such a system is needed in the first place. Secondly, the collection and processing of personal data (i.e. information that relates to an identified or identifiable natural person) must adhere to the GDPR provisions. This responsibility lies with the Data Controller. Uncertainties of the regulatory requirements with regards to data protection and privacy can represent an inhibitor.
- Business case: the investment in the temporary or permanent setup of these technologies for a single event and the maintenance costs can represent a barrier.

[22] https://edps.europa.eu/data-protection/our-work/subjects/surveillance_en

7.2 Crowd management and communication

The focus of the crowd management and communication solution is on the use of tools (Decision Support System - DSS, Common Operational Picture - COP, staff tracking devices, smart glasses) to gather crowd information and present this information as decision support for those entrusted with security management during large events. The segment is music events, outdoor concerts, street festivals, open-air markets and sporting events.

7.2.1 Market demand

There is an increase in demand for security services due to the real and perceived threats of crime and terrorism faced by the population in many countries of the world.

The crowd management and event security market is subject to various challenges such as the ability to communicate and share information with the other stakeholders without any network disturbances. As the number of stakeholders involved is high, including the law enforcement agencies, it requires communication to happen reliably across the entire area of the venue, including outside the venue and even across the entire city.

The market demand is for efficient and timely management of critical incidents during large events. For event organisers, security and first responders, it is critical during the event that the control centre staff have a real-time overview, quantitative data about crowds and crowd behaviour, and advanced detection of incidents and events, for the implementation of intervention strategies. Another element for an effective crowd management plan entails adequate communication among security staff to exchange information on reporting and handling of critical incidents.

The main features needed are:

- From the control room, notify staff/guards about type of incident and related location, for instance, through smart-glasses, staff tracking devices and other wearables;
- Respond back to control room through staff wearables (e.g. smart-glasses, staff trackers).

7.2.2 MONICA benefits

The MONICA Crowd Management and Communication solution provides the event organisers with a reliable overview platform and a tailored communication system that supports efficient and timely management of incidents during large events. Control room overview combined with efficient staff communication is a key factor in handling critical incidents.

Safety and security responsible teams can benefit from improved support in detecting potential critical incidents, as well as in handling and reporting such incidents.

From the control room, security staff can inform onsite personnel of an emerging situation and coordinate the response. Being able to share information with team members, will improve the assessment of a situation and therefore improve the speed of the intervention required at the site. Such timely support can help security personnel prevent a situation from escalating.

The benefits for event organisers are: Being able to support onsite safety and security personnel to detect, report and handle incidents in a timely manner. By combining different applications and devices to collect and transmit relevant data to the COP, the DSS can help to detect potentially dangerous situations. The control room can use the COP to locate onsite personnel and be better able to coordinate a response team to handle incidents.

The benefits for onsite safety and security personnel are: improved support from the control room as their location is constantly known and they can send images, live video and audio to get support from team members in assessing the situation. Should an incident occur, other team members can arrive in a timely fashion to support the handling of the incident potentially preventing it from getting out of hand.

7.2.3 Target groups and market players

Event organiser: The event organisers need a reliable overview platform and a tailored communication system that supports efficient and timely management of incidents during large events.

Onsite safety and security personnel: This group of stakeholders need support in detecting potential critical incidents, as well as in handling and reporting such incidents.

Control room staff: From the control room, security staff need a tool that provides an overview of the crowd to inform onsite personnel of an emerging situation and coordinate the response.

Several market players offer commercial products with integrated solutions that deal with issues such as video surveillance, emergency management, integrating a limited set of sensor types. The market in North America registers the leading market share, owing to higher adoption of technology and huge spending incurred on ICT infrastructure. The key market players are based in North America, Juvare (US), TrackForce Valiant (US), Permar Security Service (US), Genetec (Canada), and Europe, QR-Patrol (Greece), Crowd Dynamics (UK).

7.2.4 Market drivers and inhibitors

Drivers:

- Technology market driver: The emergence of IoT and cloud technology have mainly contributed to the development of the wearables market gaining more and more popularity in many other industries as it fulfils all the requirements for various purposes. Moreover, among the drivers of this growth, wristbands and smart eyewear will remain key drivers in the wearables market.
- Social market driver: the increasing event security concerns drives the IoT industry.

Inhibitors:

- Less privacy of the employees: Although these tracking wearables could be beneficial to employees, contributing to the increase of security in the event, there is a perceived lack of privacy. Clear guidelines for the use and purpose of tracking wearables must be in place and in compliance with the GDPR.
- Personal information security and acceptable use: Certain wearables have the potential to collect detailed and personal data. The use of wearables is therefore subject to the GDPR and only data directly relevant for the use of the solution must be collected. Still, ownership and the ethical use of such data are complex issues that need to be considered.
- Business case: The investment in the deployment of these technologies for a single event and the maintenance costs can still be beyond the budget, especially for small businesses.

7.3 Sound level monitoring

The focus of the MONICA Sound Level Monitoring solution is on sound monitoring in open-air urban areas, covering music events, street festivals and general nightlife.

7.3.1 Market demand

Noise is one of the most common sources of disturbance for humans in the world today, not just impacting hearing, but destructing the overall wellbeing. The most relevant source for acoustic emissions in urban contexts is represented by vehicular traffic. Leisure time activities such as concerts and festivals represent another significant source of noise. However, they are also a source of great pleasure, providing wellbeing and positive social interaction thereby defying the simplified labelling as ‘leisure noise’. As a result, there is a demand for finding a balance which secures the city’s vibrancy and branding potential while safeguarding the health of the people living in it.

Although the specific correlation between health effects and noise is even more documented than other environmental pollutants, the results in addressing noise emissions and planning noise reduction interventions in urban contexts are not impressive. Local authorities are not yet implementing stable noise monitoring policies due to several factors, such as high equipment costs, scarcity of skilled personnel and lack of environmental awareness (Zappatore et al., 2016).

However, in the last years, several technologies such as smart sensors and IoT monitoring systems have been developed to improve the effectiveness in noise monitoring: the solution of continuous noise monitoring and noise mapping enables public administrations to know, in real time, the levels of noise and the areas that concentrate the highest levels, so that local policies for the prevention and reduction of noise can be established.

The market demand is calling for an accurate measurement of sound levels in order to establish a sound map of an event from three perspectives: Regulation (confirm adherence to established noise limits), objective contribution (define noise sources and their contribution) and information (inform about sound levels and analyse components of sound).

7.3.2 MONICA benefits

The MONICA Sound Level Monitoring solution provides accurate sound measurements which are needed to get precise sound level information and from that draw the right conclusions. It can be applied to a specific concert; to recurrent events or to continuous monitoring.

The solution provides sound levels, sound contribution analysis, sound heat map and noise density, supporting the public administration in its dialogue with citizens about noise issues as well as the collaboration between the public administration and the event organiser to achieve a balance between concert pleasure and quiet life.

This way both parties can estimate the impact of sound emissions in audience and neighbour areas, confirm adherence to noise limits and quickly act if thresholds are reached. A clearer definition of sound sources and contribution can also provide a more correct picture of the concert impact and help the sound engineer in the sound adjustments.

By clustering the sound level data with crowd data, the smart city operator can identify patterns on which to act upon and build new strategies of crowd management.

7.3.3 Target groups and market players

The main target groups are public administrations and smart city operators who are responsible for noise monitoring. Event organisers and sound engineers are also interested in the solution as part of managing the sound levels at their event.

The market players mainly consist of sound and acoustics consultancies providing both hardware and software for sound monitoring. Some consultancies are hired by the municipality to provide noise measurements, surveys, noise mapping and reports on qualitative perceptions (SensorTeam, Enfonic, Vanguardia Consulting).

Other consultancies specialise in music events, also from the point of view of the event organiser where they bridge the regulatory demands (noise assessment and license compliance) with the audio professionals and organiser (audio view, alerts) such as Vanguardia Consulting.

Finally, consultancies also offer a complete event package covering both sound monitoring & noise control reports together with safety concepts customised according to the specific national regulations (Event Safety Consult).

7.3.4 Market drivers and inhibitors

Drivers:

- Environmental and social market driver: Continuous number of cultural activities drives the demand for environmental supervision for sustainability of the city.
- Political and legal driver: Adherence to noise regulations drives the demand for monitoring solutions.

Inhibitors:

- Social and ethical responsibilities: If the sound levels exceed the recommended or legal levels, there would be an ethical and/or legal responsibility to act accordingly. Uncertainties as to who would be responsible for such actions and the consequences can act as an inhibitor.
- Surveillance: If the solution is combined with CCTV surveillance it may raise concerns about increased surveillance practices and how these affect citizens' rights to privacy. There is a very small risk that, given the right circumstances, a sound level can be associated with an individual. If a user has doubts as to what this risk means in practice, how likely it is and how to assess it may act as an inhibitor. To address this inhibitor, it is advisable to have detailed information on how the solution works and what it does, e.g. measure sound levels rather than origins or the nature of a sound itself. Also, by conducting a Data Protection Impact Assessment the risks to the rights and freedoms of individuals will become clearer.

7.4 Adaptive Sound Field Control

The focus is on the use of the Adaptive Sound Field Control System in the segment: Outdoor, rhythmic and amplified concerts in inner cities.

7.4.1 Market demand

Outdoor concerts have become commonplace in many European cities. These events bring revenue and tourism with benefits for the local economy. But there are also negative effects of these events on the local community: traffic jams, parking problems, anti-social behaviours and noise impact on residents. It is important that the comfort and health in the neighbourhood is maintained and protected and the local authorities have to set rules and regulations that the event organisers should comply with. Nevertheless, according to Live DMA these are “extremely strict and hard (sometimes even impossible) to implement day to day”[23].

Organisers of concerts want to give their performers and audiences the best music experience but they also wish to comply with local regulations on environmental sound exposure. The challenge for regulators therefore lies in balancing the need for entertainment and for support of the local economy against the impacts of outdoor music on the surrounding population.

The market needs to address the challenges of sound regulations from a technical perspective, improving the visitor’s sound experience through the control and adjustment of the sound levels in specific areas of the venue defined by the organisers. The goal is to manage sound exposure of the audience and/or reduce the noise annoyance of the neighbours.

7.4.2 MONICA benefits

The MONICA Adaptive Sound Field Control solution is an IoT solution with closed-loop feedback that addresses sound challenges during concerts and musical events. It offers a multitude of innovative benefits related to the execution of open-air music performances in a public space.

Benefits include:

- Optimisation of the sound experience with respect to both the performers and the concert audience in terms of loudness, directionality and quality. At the same time, the ASFC system can perform dynamic adjustment of the secondary source loudspeakers so that neighbours of the concert venue can enjoy up to 10dB attenuating at low frequencies of the sound levels in their neighbourhood, where it is unwanted and annoying;
- Analysis of the composition of sound level data so that sound levels from the music can be separated from background noise.
- Publication of sound data as Open Data so that citizens can monitor the compliance of the City Ordinance. This will allow the city authorities to engage in constructive dialogue with the citizens and other actors on a factual basis and can provide data for research on environmental health impact.

Combined with the establishment of quiet zones, the organiser can ensure communication between security personnel and staff close to the audience area.

7.4.3 Target groups and market players

The target groups of the Adaptive Sound Field Control (ASFC) system are event organisers, public authorities and PA (Public Address) system manufacturers involved in the planning of outdoor concerts or as a supplier of sound systems.

Many systems on the market are designed for indoor use with stable atmospheric conditions. There are commercial systems for Wave Field Synthesis (WFS) in, e.g., cinema theatres (Genuix, IOSONO, etc.). Moreover, for sound perception and hearing research is it common to use Ambisonic[24] or similar techniques.

Some market players offer sound control systems for outdoor venues that enable a full-volume concert experience while eliminating unwanted sound emission in nearby communities, making adjustments possible in real time as the size of the audience changes (Canadian PK Sound).

[23] http://www.live-dma.eu/wp-content/uploads/2019/03/REPORT-WG-ANTWERP_PUBLIC_201802.pdf
[24] http://www.ambisonic.net/

7.4.4 Market drivers and inhibitors

Drivers:

- Technology market driver: the ability of the ASFC system to adapt to the direct sound and reduce the annoyance, plus improving at the same time the sound experience, is a major growth driver for the segment. Sound Control systems are expected to witness steady growth due to advancements in their manufacturing process and the digital audio technology development.
- Social market driver: the increasing number of festivals and music events in urban areas is driving the demand for active sound control systems.
- Regulatory: Adaption to the actual sound-regulatory code will be of growing significance for competition in the market
- Economic market driver: The introduction of sound control systems has a business potential since more concerts can be arranged.

Inhibitors:

- If Sound Level Meters are used to also record audio for further processing, there is a very small risk that, given the right circumstances, a sound level can be associated with an individual. If a user has doubts as to what this risk means in practice, how likely it is and how to assess it may act as an inhibitor. To address this inhibitor, it is advisable to have detailed information on how the solution works and what it does, e.g. measure sound levels rather than origins or the nature of a sound itself. Also, by conducting a Data Protection Impact Assessment the risks to the rights and freedoms of individuals will become clearer.
- Financial challenges: Controlling sound over a large open area can be expensive. It requires a considerable amount of technology roll-out, such as sensors for sound field characterisation, on-site signal processing and distribution of appropriate secondary source signals and associated secondary loudspeakers that create the mitigating sound fields.

7.5 Quiet zones

The focus is on the use of Quiet Zones in the segment: outdoor, rhythmic and amplified concerts in inner cities.

7.5.1 Market demand

The World Health Organisation (WHO) is working on the development of a general WHO standard for sound exposure in and around entertainment venues worldwide. The provision of retreat areas at concerts such as a quiet zone could be a possible option.

There is hence a demand for local quieter zones within and close to the amplified event area, to give to the visitors and the security staff the opportunity to communicate.

7.5.2 MONICA benefits

The MONICA Quiet Zone solution can provide silent areas for those who need to communicate close to the concert area. The Quiet Zone is an acoustic noise barrier which makes use of active elements to cancel out low frequencies and passive elements to block high frequency noise. The goal here is to obtain the highest possible attenuation of the sound pressure level across the whole listening spectrum. The Quiet Zone system can function independently from the Adaptive Sound Field Controller but will perform best together with it.

7.5.3 Target groups and market players

Target groups are event organisers, local authorities and PA providers.

About the market players, Silentium Ltd. is a high-tech company from Israel specializing in developing innovative noise reduction products and solutions for the automotive, home, industrial, medical and IT industries. Silentium has developed unique Active Noise Control (ANC) technology. QSC is a US company that has developed the technology and solutions for live performance and reduce noise pollution.

7.5.4 Market drivers and inhibitors

Drivers:

- Political driver: Management of a high sound pressure level is a critical issue because the trend is to organise outdoor events in urban areas. Therefore, new technologies will increasingly push the market of the sound control solutions.
- Environmental: The demand to establish quiet zones at concerts to allow staff to work more efficiently in emergency situations close to the concert area.

Inhibitors:

- If Sound Level Meters are also used to record audio for further processing, there is a very small risk that, given the right circumstances, a sound level can be associated with an individual. If a user has doubts as to what this risk means in practice, how likely it is and how to assess it may act as an inhibitor. To address this inhibitor, it is advisable to have detailed information on how the solution works and what it does, e.g. measure sound levels rather than origins or the nature of a sound itself. Also, by conducting a Data Protection Impact Assessment the risks to the rights and freedoms of individuals will become clearer.
- The costs of complying with new regulations can be considerable for the event management budget, both in the private and public sectors.

7.6 User Experience

The User Experience solution consists of two digital and independent applications: The MONICA Collective Awareness Platform (CAP) and the Visitor Experience solution. The following segmentation deals only with the latter solution since it is relevant to the demonstration sites in MONICA. However, the business potential of the CAP is included in Section 8.6.

The focus of the visitor experience solution is on the use of mobile apps and smart crowd wristbands in the segment: Open-air festivals, music and sporting events.

7.6.1 Market demand

In an increasingly competitive consumer event and tourism landscape, the demand is for events that stand out and offer unique and personalised visitor experiences, bringing people closer to the events they attend. However, this does not only include providing the frame for an enhanced experience of the actual performances, sports game or event content but also for an overall good experience of the event before and after which also means ensuring the security and safety of the crowd.

Smart mobile apps

Mobile event apps play an increasingly important role in digitising the event experience, providing interesting contents and real-time event performance insights to a large number of people simultaneously. Apps provide a blend of information, engagement, and interaction features for the attendees, and event planners can better understand what the visitor values the most. Currently trending are new ways to engage and facilitate more individualised experiences with attendees.

Browsing the market, an abundance of possible app features exist which can be classified according to three main layers: Event information & communication, audience engagement and event intelligence, meeting the demand from attendees as well as organisers[25]. Management of the apps is performed through a web-based dashboard.

The event information & communication layer provides all the necessary information about the event, such as traffic and travel, schedules, maps, facilities, presentation and streaming of content, sponsors, news etc which can be more or less dynamic (provided live / in real-time). The communication aspect covers push notifications (alerts, updates, offers).

Further enrichment of the event experience is provided by a more personal approach with features such as cashless payment, targeted messages based on your profile, location-based augmented reality and user-generated content.

A third intelligence layer provides key insights into crowd behaviour through the geo-location data, supporting decisions on security. It is also possible to send messages to app-users based on their exact geographical location.

[25] Example: https://www.greencopper.com/

Smart crowd wristbands

Wearable technology is transforming events and according to GrowthEnabler, more than 173 million wearable devices will be used by consumers by 2020 (GrowthEnabler, 2017, p. 7). The reasons for introducing smart crowd wristbands at festivals, music and sporting events vary. They can be deployed to make the audience part of the show as in the case of Coldplay[26] and Taylor Swift who have distributed interactive LED bracelets to create light shows at their concerts. They can also incorporate additional functions that make it simple and easy to pay at festivals.

Smart crowd wristbands thereby carry many of the same functions as the mobile app due to built-in RFID and NFC technologies. At the 2014 and 2015 editions of the Tomorrowland Festival[27], 375,000 smart wristbands were supplied to the festival-goers, enabling access control, music-synchronised lightshows, crowd heatmaps and brand activations through scanning of the wristband. As opposed to the mobile app, a wristband conveniently stays on you the whole time. Nevertheless, in many cases, the wristband needs to be connected to an app for registration and identification purposes.

7.6.2 MONICA benefits

Providing an event app and an IoT wristband can help to improve the quality of an event and to boost visitor engagement and interest. Additionally, the organiser can communicate important information, gain insights into crowd behaviour and needs that help optimise content and procedures and thereby make the event smarter.

The MONICA app has been developed from the needs of three pilot events; two festivals and a rugby match who have not had any previous, designated mobile apps. The app mainly focuses on an information layer which:

- Provides relevant event information such as time schedules, advice on public transport, traffic, parking, maps, facilities, emergency services etc.;
- Communicates security related information such as guidance to the correct entrances;
- Adds interactive content such as exclusive offers and invites feedback from visitors to further improve the event.

The engagement and intelligence layers can be added through integration with smart wristbands with the possibility of several audience features such as lightshows and cashless functions and tools for analysis such as crowd heatmaps.

Benefits include:

- Smooth entry and exit as well as easy orientation and navigation at the venue;
- Relief of emergency services such as police, fire brigade, regulatory office and paramedics, by referring inquiring visitors to the app;
- Optimal use of infrastructure such as parking lots, shops and toilet areas by displaying and navigating to the nearest location;
- Prevention and reduction of incidents and queues e.g. means entries being less busy;
- Possibility of new revenues by recruiting sponsors and offering stand operators the option of self-promotion through the app or brand activation through scanning of the smart wristband;
- Creation of a smarter and more unique event experience.

The MONICA app can be customised to fit the event and thus be simple and cheaper for smaller venues or public events with limited resources. Today, use of mobile solutions at consumer events is still hindered by financial issues and cost-revenue uncertainty.

For more commercially oriented, major events who are very design and feature aware, the app can either be enriched with more functionalities, such as connecting to the smart wristband for more features or integrating its features into existing event apps.

[26] http://xylobands.com/
[27] https://www.sendrato.com/test-project/

The app can be customised for visitor use but also staff use so that for example sound technicians can monitor the sound levels from their mobile phone.

7.6.3 Target groups and market players

The target group is event organisers, who are in charge of small or large, public, non-profit or commercial events.

Some market players cover the whole spectrum of the event experience (information & communication, engagement and analytics), while other prioritise one aspect such as the engagement aspect or the access/payment aspect, in combination with a smart wristband.

The largest providers of premium app solutions to organisers of music festivals and sports events come from North America (Greencopper, Eventbase, Aloompa). Other organisers team up with technology partners such as mobile communications companies (EE for Glastonbury Festival) or general event management software providers.

Some market actors provide app solutions with the strategy to make smart mobile apps available for all festivals and events (Festivality) based on the estimation that less than 2-3% of the consumer events industry currently integrates mobile solutions[28] despite the general growth of the market for event management software.

7.6.4 Market drivers and inhibitors

Drivers:

- Technology market driver: Wearables and smartphones are a fact of life, enabling many features and functions. Smart wristbands are a key driver in the wearables market.
- Economic driver: Digitising consumer events with apps and smart wristbands enables additional revenues such as sponsorships and brand activation
- Environmental driver: Organisers are environmentally aware which drives a demand for paper-free solutions
- Social driver: The demand is for unique and safe event experiences

Inhibitors:

- Liability in a security and safety context: Concerns related to liability if the app malfunctions and sends people to crowded entrances/exists causing overcrowding and subsequently safety incidents may represent an inhibitor.
- Environmental inhibitor: Environmental concerns about the production and waste issue of wristbands might inhibit market uptake.
- Privacy concerns: The solution can be extended to include the collection of personal data if the user has a profile linked to the wristband and/or app e.g. for location or social media connection. In this case, it may prevent some users from wanting to use it. Such extended functionalities should be optional and provide precise information on purpose, protection of personal data etc. as required by the GPDR. This in turn may act as an inhibitor for adding these extended functionalities to the solution.

Based on the segmentation performed in this chapter, looking at benefits of the MONICA solutions in the segments: open-air, music, sporting and festival events, we now turn to analysing the business potential of the solutions.

[28] Source: http://www.festivality.co/

8 Business analysis

8.1 Introduction

The output from the market analysis and segmentation is the starting point for the business analysis which focuses on the business solutions, the Unique Selling Points and the strengths, weaknesses, opportunities and threats (SWOT) in order to arrive at realistic business strategies for exploitation that partners can use in their individual exploitation and business planning.

For each solution, the business analysis presented comprise the value proposition offered to the customer (business solution), how it is positioned towards the market and a generic business model (how the value is delivered). The opportunities are analysed in order to establish an optimal positioning strategy and a realistic business model canvas.

8.1.1 Overview of the MONICA business solutions

- MONICA Crowd and Capacity Monitoring
- MONICA Crowd Management and Communication
- MONICA Sound Level Monitoring
- MONICA Adaptive Sound Field Control
- MONICA User Experience

8.1.2 Target groups

An overview of the main target groups for investment in or development of MONICA solutions are presented in Table 1 and further specified in the analysis of the individual business solutions. They comprise:

Event organiser: plans and manages every aspect of an outdoor event such as festivals, sports events and music concerts. The organiser can be commercial, a public/private collaboration or non-profit organisation.

Smart city operator: A local authority or municipal organisation that wants to use Smart City or Smart Community solutions to address societal challenge in the city life, collect data and use insights gained from that data to manage assets, resources and services efficiently.

Solution & service provider: Entity interested in adapting/integrating the selected MONICA solution(s).

Event organiser	Smart city operator	Solution & service provider
Commercial actor	Local authority	Hardware, software, network and platform providers
Public/private collaboration	City organisation	Consultancy companies (security, noise)
Non-profit organisation	IoT Smart City integrators	Other IoT industries (building, construction, infrastructure, healthcare, entertainment)

Table 1: Target groups

Additional stakeholders include: event authorities (police, fire brigade, first aiders); event crew (staff, artists, technicians, security personnel), visitors, neighbours, investors and sponsors.

8.1.3 Value propositions

The business concepts of the identified MONICA solutions were further developed in *D9.3 Replication Reference Book*.

Based on the value propositions and customer target groups in D9.3 combined with the business model framework in D11.5, we are now able to lay out specific examples of business models, which have been used to inspire partners when creating their individual exploitation plans.

8.2 Crowd and Capacity Monitoring

8.2.1 Business solution

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, IoT 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. Providing this information to the MONICA Crowd Management and Communication solution allows security staff to obtain enhanced, contextual real-time oversight and decision support for interventions.

It is used by Smart City organisers, event organisers, security staff and first responders in order to monitor crowd behaviour and manage security at large events, e.g. to mitigate security and safety risk or annoyance.

This MONICA solution complements the MONICA Crowd Management and Communication solution. Combined they represent a comprehensive, closed loop solution for gathering information on crowd behaviour and event risks in real-time and presenting such information in the relevant context as decision support for those entrusted with total management of large events.

All aspects of this business solution are comprehensively summarised in the *D9.3 Replication Reference Book*.

8.2.1.1 Features

The specific features of the MONICA Crowd and Capacity Monitoring solution are:

People counting: CCTV cameras incorporating advanced video analytics accurately count the number of people entering and leaving a specific area through one or more gates. It is primarily used to identify the potential risk of overcrowding, but can also be used for statistical purposes, timelines of crowding, etc.

Crowd density: Advanced video analytics estimates crowd size and density from the CCTV footage and results are shown as a real-time heat map on the MONICA Common Operational Picture (COP) in the control room. The information can be used to locate high density areas, so that the event organiser can take precautionary measures to avoid unattainable crowd build-ups during the event. Crowd density can also be accomplished by having visitors wearing low-cost wristbands which allows for anonymous localisation of visitors in the event area.

Human and object detection: Computer-based object detection algorithms are used to identify and detect more than 100 different kind of objects in real-time, including humans and vehicles. It can be used for intervention, elimination of security threats and/or redirection/elimination of potential, emerging security threats.

Vehicle detection: This component provides real-time detection and tracking of vehicles in order to support the security staff handling of unauthorised vehicles in the event area.

Crowd flow: Using the crowd density and object detection algorithms, early warning of security threats, such as overcrowded, high-risk queues, fights or health incidents, can be achieved and immediate actions can be initiated by the security staff and first responders e.g. using the MONICA Crowd Management and Communication solution. Interventions can be in the form of security or first responders' interventions or redirection of visitors to safer areas.

Staff tracking: The positions of stewards and other staff deployed in the event area can continuously be tracked and reported to the MONICA COP. Control room staff can then, at any moment, view the different positions of staff on the ground and obtain an overview of available resources in case of incidents or other interventions. Tracking can be performed with staff wristbands or with dedicated GPS or Gallileo tracking devices.

Mobile video and audio recordings: Smart Glasses, worn by the staff in the field, are able to record video and audio incidents directly from the scene and send them, in real-time, to the control room for decision support and intervention. The glasses have two-way communication capabilities.

8.2.1.2 Product structure

The MONICA Crowd and Capacity Monitoring solution consists of a core product with a number of options available. The structure is visualised in Figure 8.

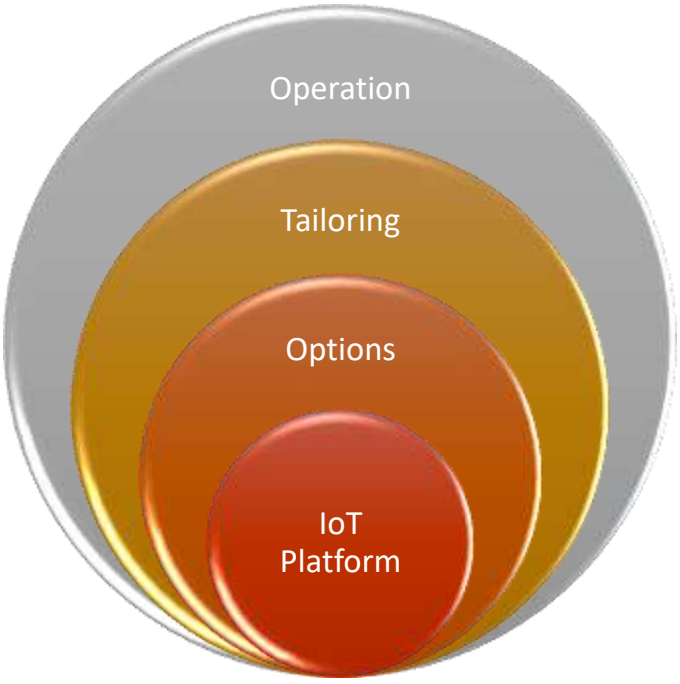


Figure 8: Crowd and Capacity Monitoring product structure

Core: MONICA IoT Platform with MONICA Data Source Open Application Programming Interface, Distributed Middleware, IoT Device Manager, Event Manager, IoT Semantic Manager, Data Security and Trust Framework and the MONICA Network Infrastructure for UWB, 868Mhz short-range device bands, WiFi, and 3G/4G.

Options: People counting, crowd density, human and object detection, vehicle detection, crowd flow, staff tracking, mobile video and audio recordings, on-the-ground staff communication, sound level monitoring.

Tailoring: Customisation of the platform to the customer's specific needs, integrating the IoT platform in the MONICA or customer's own cloud solution, training of detection algorithms, design of wristbands and smart glasses, design of network infrastructure for crowd density measurements.

Operation: Consultancy services in planning phase, site surveys, development and follow-up up on implementation plans, installation, commissioning and testing of platform, operational support.

8.2.1.3 Application areas

The application areas include:

- Gate in/out flow counting, crowd size estimation and congestion monitoring
- Crowd capacity level compliance monitoring
- Crowd density display
- Detection of high-risk queues
- More than 100 categories of objects (including humans and vehicles) detection and tracking
- Fight detection
- 'Falling down' event detection
- Annoyance and safety of visitors

8.2.1.4 Customers

The main customer target groups are: event organiser and smart city organiser. Other stakeholders include event crew (onsite safety and security personnel) and event authorities (police, fire brigade, first aiders).

8.2.1.5 Regulatory and privacy aspects

Since many aspects of the MONICA Crowd and Capacity Monitoring solution involves the collection and processing of personal data (images, position, speech), A *Legitimate Interests Assessment* and a *Data Privacy Impact Assessment* should be performed as part of each planned installation

On this background, the MONICA project has developed a comprehensive framework and guidelines for making the solution compliant with the GDPR as well as international and national technical and performance related regulations and standard.

The privacy related aspects are:

- Internal procedures must be developed to protect personal data

- Internal procedures to protect the rights of data subjects must be implemented
- A Data Processor Agreement must be drafted and signed by the parties
- Data Processor Agreements with third parties must be in place if relevant.
- A Data Management Plan is required which established the intended processing of personal data and the purpose of such processing
- A Data Protection Impact Assessment must be carried out based on the Data Management Plan and special areas of vulnerabilities towards protection of personal data must be identified and resolved.
- Standard CCTV signs must be placed by the cameras following the applicable rules for CCTV signage including the following information in a concise language

Moreover, the IoT elements of the MONICA Crowd Management and Communication solutions making use of radio frequency spectrum must adhere to the various European regulatory provisions as laid forth by CEPT/ECC and some relevant Decisions. For further information see *D12.5 Report on Standards, Regulations, and Policies for IoT Platforms*.

The regulatory aspects are:

- The IoT elements of the MONICA Crowd Management and Communication solutions making use of radio frequency spectrum must adhere to the various European regulatory provisions as laid forth by CEPT/ECC in conjunction with and some relevant EU Decisions. For further information see D12.5 Report on Standards, Regulations, and Policies for IoT Platforms. The cameras including all devices making use of Radio Frequencies must comply with the Radio Equipment Directive 2014/53/EU (RED);
- The staff wristbands comply with ETSI EN 302 065-2 V 2.1.1[29] (publ. in the Official Journal of the European Union - 15.12.2017 - (2017/C 435/05)), including the EU Commission provisions 2014/702/EU[30]. The UWB communication is compliant with the IEEE802.15.4-2011 standard;
- The crowd wristbands are built to comply with ETSI EN 300 220-2 V 3.1.1[31];
- The hardware must comply with the Waste Electrical and Electronic Equipment Directive (WEEE 2012/19/EU);
- The hardware must comply with the Restriction of Hazardous Substances in Electrical and Electronic Equipment Directive (RoHS 2011/65/EU).

8.2.2 Market positioning analysis

8.2.2.1 Unique Selling Points

The MONICA Crowd and Capacity Monitoring solution provides solutions to a number of challenges facing the target groups. Individually, the options display a number of Unique Selling Points in terms of features, service offerings, quality and resilience as well as ease of use. However, the most striking uniqueness is the comprehensiveness of the platform, its eloquent design from an IoT point-of-view (as a first ever complete IoT platform for security and crowd monitoring applications), and its integrability into the MONICA Cloud service and hence to the feedback loops offered by the MONICA Crowd Management and Communication solution.

Overview of the individual needs and challenges related to security and safety at open-air events exemplifies the Unique Selling Points:

Crowd monitoring features uniquely address:

- Circulation: Narrow streets, bottlenecks, large crowds and very poor access/exit routes to and from an area pose the risk of overcrowding and road blocking which hinder emergency services to respond;

[29] https://www.etsi.org/standards-search#page=1&search=EN300%20392&title=1&etsiNumber=1&content=1&version=0&onApproval=1&published=1&historical=1&startDate=1988-01-15&endDate=2016-10-10&harmonized=0&keyword=&TB=&stdType=&frequency=&mandate=&collection=&sort=1
[30] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014D0702
[31] See https://www.etsi.org/standards-search#page=1&search=EN300%20392&title=1&etsiNumber=1&content=1&version=0&onApproval=1&published=1&historical=1&startDate=1988-01-15&endDate=2016-10-10&harmonized=0&keyword=&TB=&stdType=&frequency=&mandate=&collection=&sort=1

- Capacity: When maximum capacity is reached, panic can easily and rapidly spread and danger occurs. In numerous occasions, crowd panic has caused deadly and less severe incidents;
- Crowd count and overcrowding: knowing exactly how many people are present is essential for security, planning, scheduling, and prevention, among others;
- Free flow of people in open events: Large venues with large crowds represent a high degree of security threats - both small and large incidents are likely to take place;
- Traffic: It is important to avoid blockage, dangerous situations on roads, on train tracks etc. as they can cause serious incidents and also create frustration, impatience, which again can cause other smaller and larger issues;
- Lost child: Children can get lost and / or friends can come apart due to the large crowds, the movement of people and noise;
- Vehicle registration: Unregistered vehicles that need access to a restricted zone should pass a smooth and effective registration process. Traffic issues create frustration, time issues, and security issues, among other, and can largely be solved with technological solutions. It also frees time to deal with other more security relevant issues.

IoT technologies uniquely address:

- Communication of security related information to crowd, staff, authorities, press: the most used tools, radio and phone, are both unreliable (signals can be weak or non-existent, system breakdown possible if large crowd use the phones). The lack of technology to communicate creates security risks, as communication can become slower, more unclear, less people can be communicated with simultaneously. It is especially important if the venue has high crowd and staff numbers;
- Mobile apps as a means of near-to-real-time communication between the visitors and the event organisers/police/other stakeholders are valuable. An app can be an essential tool to give practical information, communicate emergencies, schedule and marketing certain events and time schedules;
- Wi-Fi should be available for security and safety improvement, especially for security staff;
- Drones: Despite strict regulations in Europe and large penalty fines, drones are becoming an increased risk factor. It is easy to make unlawful intrusions with a drone, especially at outdoor venues.

Locations are uniquely addressed:

- The location can represent a large security risk, for terror attacks, general crime and petty theft;
- Crime: There are events where visitors can pay by cash only as there are no Point of Sale or other electronic services available at the event, making the event a more attractive target for theft and robbery due to the large amount of cash available.

Performing artists are uniquely served:

- Artists and VIP guests can be targets. Some groups can be provoked by the artists mainly for either religious or political beliefs.

8.2.2.2 SWOT analysis

A generic SWOT analysis for the MONICA Crowd and Capacity Monitoring solution is shown in Table 2. The SWOT analysis is performed by analysing the Strengths and Weaknesses of solution against the Opportunities and Threats exposed by the market.

Table 2: SWOT analysis for the Crowd and Capacity Monitoring solution

Strengths	Weaknesses
• Easy integration of new sensors • Real-time information captured using IoT sensors • Uniquely advanced analysis tools for crowd monitoring • Easy to integrate into the MONICA Cloud services or other control platforms • Highly customisable with many options available • Secure communication and transactions	• Relative high basis investments required if only few sensors are used • New product, not excessively tested; efforts are needed to commercialise • Risks of technical problems; a malfunction may have negative consequences in all aspects of the event • No official quality product certification
Opportunities	**Threats**
• Solution for crowd monitoring in very high demand in some markets • Safety and security for events cannot be compromised • High growth market for IoT technology platforms • Large potential market size • Competitor products are few and not so well integrated	• There may be less functional, but more mature and accepted/established solutions, may be more appealing for critical one-off events • Local regulations for surveillance and aesthetics may hamper the design, layout and installation of solutions

8.2.2.3 Positioning matrix

As described in section 3.3.2 Market prioritisation, the Market Attractiveness provides a useful guideline as to which results are directly exploitable on which markets. The partners can analyse their strength and weakness on each of the markets, analyse the attractiveness and develop their exploitation strategy accordingly. The diagram below shows which markets are the most attractive for the MONICA Crowd and Capacity Monitoring solution. The analysis is performed by comparing the market descriptions (size, drivers, competitors) with the Unique Selling Points of the solution. The results are shown in Figure 9.

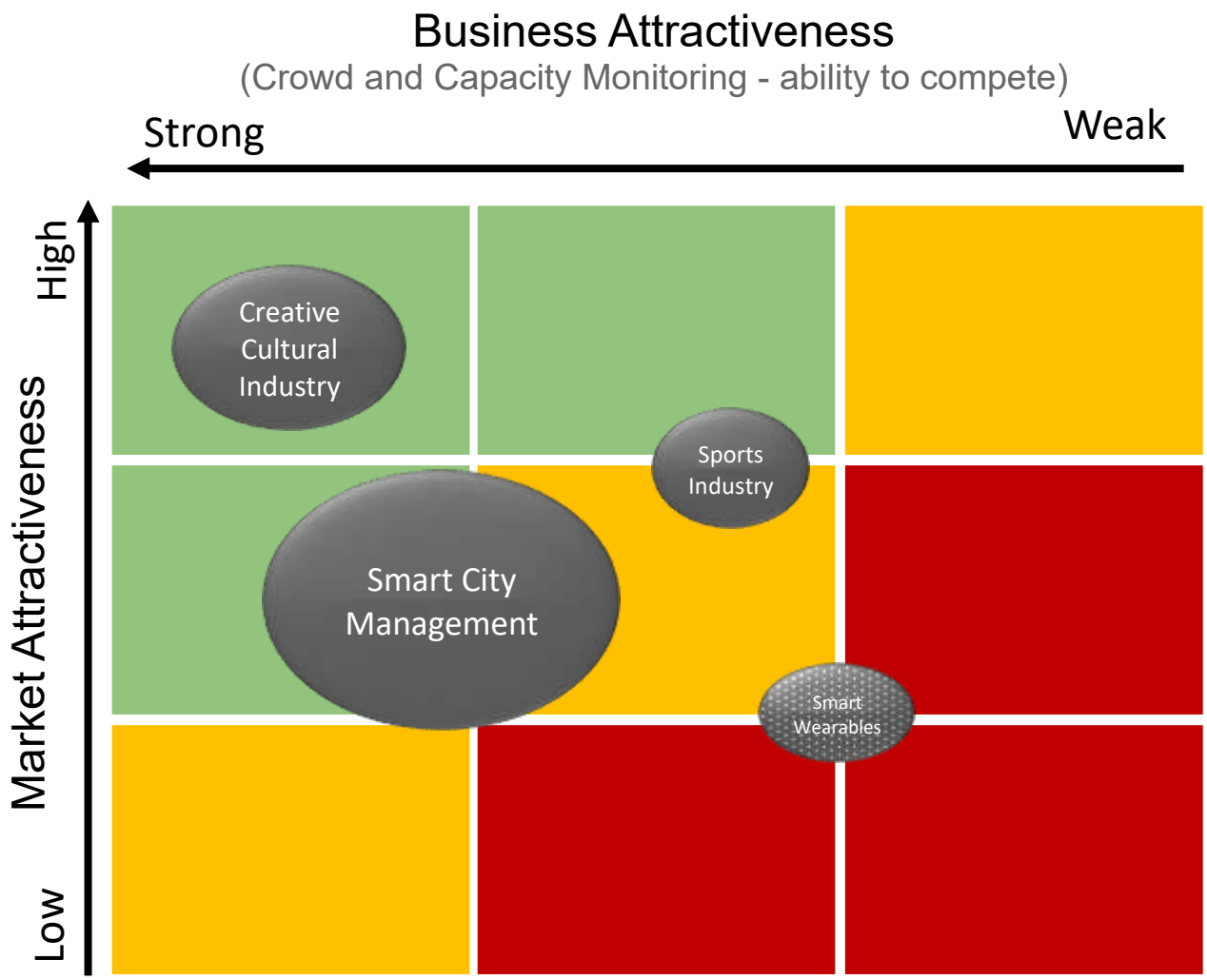


Figure 9: Market Attractiveness Analysis for the Crowd and Capacity Monitoring solution

The Performing Arts of the Creative and Cultural Industry (€300m) is the most attractive segment with a strong position of the MONICA Crowd and Capacity Monitoring solution. The market has real needs (annoyance, risks, safety) and is pressed for coming up with innovative solutions. The market position is strong with most of the Unique Selling Points driving a good market position. Both the noise and the security aspects of the MONICA Crowd and Capacity Monitoring solution are appealing to the Smart City Management segment (€500m), in particular when it comes to urban concerts and night-life noise. However, the market is somewhat more difficult to enter due to installation challenges, public fear of surveillance, political preferences, and the ad-hoc nature of events. The Sports Industry is attractive (€200m), but has already highly advance security installations in place, which could pose barriers for rapid market entry. The solution is not optimally positioned in its present form due to the nature of sport events, i.e. gated, extremely crowded areas during the events and partly indoor or covered venues makes performance and installation of the MONICA Crowd and Capacity Monitoring solution difficult. The Smart Wearables is an emerging market and it is not fully clear how attractive this market will be in the future, as many of the Smart Wearable features and functions will be available in smartphones,

8.2.3 Business model canvas: Crowd and Capacity Monitoring

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. This tool is used to map out all details of the MONICA business models based on the value proposition, target groups, the partner constellations, and revenue models outlined in *D9.3 Replication Reference Book*.

Table 3: Business Model Crowd and Capacity Monitoring

<table>
<tr>
<td rowspan="2"> 
Key Partners

<u>MONICA partners</u>
• VCA Technology Ltd
• Kingston University, Computer Science & Mathematics
• CERTH Information Technologies Institute
• Dexels BV
• Optinvent
• Fraunhofer FIT
• Telecom Italia
• Digsky s.r.l.

<u>External partners</u>
• Hardware (cameras etc.)
• Network components
• On-site Installation
• Sound equipment</td>
<td> 
Key Activities
• Cloud operation
• Algorithm training
• Software development
• Firmware development
• Wristband design
• Network protocols
• Blimps operation</td>
<td rowspan="2"> 
Value Proposition
A cloud-based IoT platform supporting components that can be used to monitor, record & analyse the environment and detect emerging episodes
Options for video analytics, wearables, wind speed, noise.
Capable of collecting information about crowd size, flow, object detection as well as early warning of security and safety threats.
Used for variety of purposes related to crowd behaviour, security and safety of visitors.</td>
<td>Customer Relationship
 
• Provide information about crowd size, density and flow in real-time
• Detect abnormalities and report objects
• Facilitate safe and quick entry to and exit from the event area</td>
<td rowspan="2">Customer Segments
 
• Organisers of musical events, outdoor concerts
• Organisers of street festivals, open-air markets
• Organisers of sporting events
• City authorities for restaurant and night-life areas
• City authorities for streets and areas with heavy traffic
• City authorities responsible for noise control in the city</td>
</tr>
<tr>
<td> 
Key Resources
• Software developers
• Cloud operation
• Network specialists
• Image processing do.
• Hardware designers
• System integrators</td>
<td>Distribution Channels
 
• Direct event organisers
• DIrect city authorities
• Through system integrators</td>
</tr>
<tr>
<td colspan="2"> 
Cost Structure
• Standard cost of cloud services
• Cost of network services
• Cost of hardware
• Cost of development, customisation, training
• Cost of operation
• Cost of commissioning and de-commissioning
• Electricity and rental cost for long term installations</td>
<td colspan="2">• Cloud integration component and services as consultancy services
• Cost of hardware with embedded firmware.
• One off-licenses fees for software and firmware per installation
• Configuration, algorithms training, custom. services
• Installation and commissioning services</td>
<td> 
Revenue Streams</td>
</tr>
</table>

8.3 Crowd Management and Communication

8.3.1 Business solution

The Crowd Management and Communication solution provides a complete, web-based overview of event activities in real time as well as means for feedback 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 COP provides real-time overview, quantitative data about crowds and crowd behaviour, and advanced detection of incidents and events.

As an extension to the COP, 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 tracker. Onsite personnel can report the incident to the control centre by sending live video stream and images, staff wristbands and GPS staff trackers make it possible to locate and track staff members in real time for a better coordination of intervention.

Combined with the MONICA Crowd and Capacity Monitoring solution, they offer a total, closed loop security solution for gathering crowd information and presenting this information as decision support for those entrusted with security management during large events. The solution also complements the MONICA Sound Level Monitoring solution. All together they provide a comprehensive solution for monitoring and managing security and sound during large scale events.

All aspects of this business solution are comprehensively summarised in the *D9.3 Replication Reference Book*.

8.3.1.1 Features

The specific features of the MONICA Crowd and Capacity Monitoring solution are:

Common Operational Picture (COP): The COP is the main interface for providing human professional operators knowledge on the event in order to take informed decisions on environment and crowd control. The COP can combine crowd monitoring with sound monitoring to give event managers a complete overview of the situation. It can be connected to any number of large-screen displays in the control room. Working as a webserver solution, it can be combined with most existing types of control room monitoring infrastructure.

Decision Support System (DSS): Provides recommendations and proposes actions for the human operator based on camera and Sound Level Meters' data as well as from input from other IoT devices such as wristbands. The DSS can solve problems and make interactive decisions by analysing massive streams of data in real time. The DSS supports use security cases such as to crowd incidents, sound management (sound limits, sound contribution, annoyance level), missing persons and locating security personnel. The DSS can also handle sound management, such as sound limits compliance, sound contribution analysis and annoyance levels.

Two-way communication between staff: The staff wearable wristbands contains a UWB radio that provides a reliable communication channel relatively insensitive to interference compared to narrow- or broadband alternatives. A MONICA protocol supports bi-directional communication with other staff wearables.

Alerts: The MONICA Crowd Management and Communication solution simplifies coordination between staff members and the control room for faster reaction to remedy any situation in the field. High-risk queues or other crowd incidents detected by the MONICA Crowd and Capacity Monitoring are reported via the COP and the DSS to control room personnel. The staff can then direct on-site personnel to proper intervention and send selected information from the COP to support the interventions. Further, onsite staff can via the two-way communication network acknowledge the commands and send reports back to the control room on the situation as it unfolds.

Staff communication: As an extension to the COP, 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 tracker. Onsite personnel can report the incident to the control centre by sending live video stream and images, staff wristbands and

Staff wristbands: Staff wristbands makes it possible to locate and communicate to staff members in real time If there is an incident, the staff can press a button on the wristband to ask for assistance and thereby

automatically call upon the nearest available colleague. A LCD screen, 3 buttons, vibrator and buzzer can be programmed for input and output. The UWB radio infrastructure captures the position of the wristbands using triangulation techniques and it is possible to view all staff locations on a map layer on the COP.

Smart glasses: On-site safety and security stewards can use smart glasses to report incidents to the control centre. They can send live video stream and images to support the team in evaluating the situation and whether additional security personnel should be directed to the scene. GPS coordinates are automatically captured by the smart glasses to show the exact position of the reporting steward on the COP.

Staff real-time positioning: Resilient GPS staff trackers using LoRa communication networks make it possible to locate and track staff members in real time in large areas for a better coordination of interventions. The positions can be showed on the COP as a digital map overlay.

8.3.1.2 Product structure

The MONICA Crowd Management and Communication solution consists of a core product with a number of options available. The structure is visualised in Figure 10.

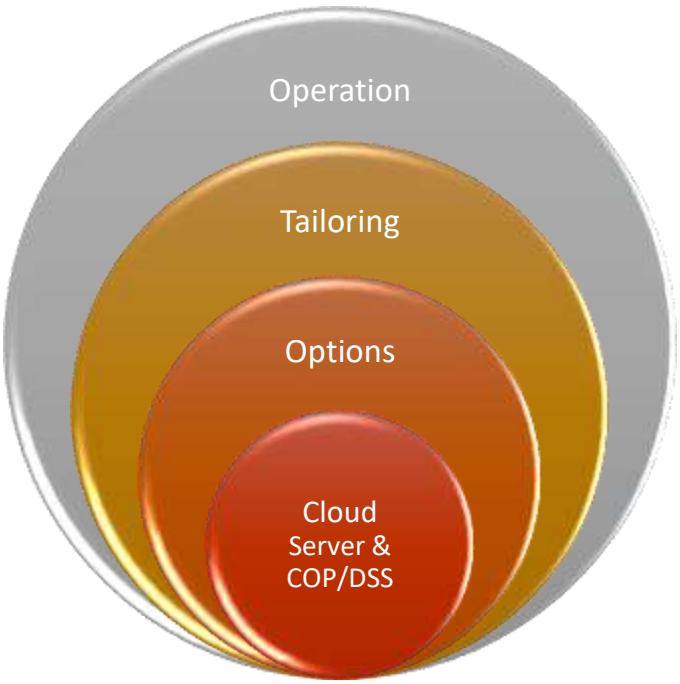


Figure 10: Crowd Management and Communication product structure

Core: The solution is based on a MONICA Private Cloud structure. The cloud services include the MONICA Common Operational Picture (COP) with COP Dashboard, COP Database and COP Updater. Further, the core includes the MONICA Decision Support System (DSS) and the MONICA the Security, Privacy and Trust Framework.

Options: Staff wristbands edge layer, crowd wristbands edge layer, smart glasses edge layer, and staff real-time positioning edge layer.

Tailoring: Customisation of: the cloud service, the COP and the DSS to the customer's specific needs, integrating the MONICA IoT platform or customer's own IoT solution, setting up of customer specific COP, DSS with user interfaces, security roles and rules.

Operation: Consultancy services in planning phase, site surveys, development and follow-up up on implementation plans, installation, commissioning and testing of platform, operational support.

8.3.1.3 Application areas

Application areas include:

- Operational picture of the environment in real-time
- Overviews of crowd size and density across the entire event area
- Decision support for interventions
- Intervention support during events with large crowds
- Communication between control room and field staff

8.3.1.4 Customers

Event organiser: plans and manages every aspect of an outdoor event such as festivals, sports events and music concerts. The organiser can be commercial, a public/private collaboration or non-profit organisation.

Other stakeholders include event crew (onsite safety and security personnel, control room staff) and event authorities (police, fire brigade, first aiders).

8.3.1.5 Regulatory and privacy aspects

Since many aspects of the MONICA Crowd and Capacity Monitoring solution involves the collection and processing of personal data (images, position, speech), A *Legitimate Interests Assessment* and a *Data Privacy Impact Assessment* should be performed as part of each planned installation

On this background, the MONICA project has developed a comprehensive framework and guidelines for making the solution compliant with the GDPR as well as international and national technical and performance related regulations and standard.

The privacy related aspects are:

- Internal procedures must be developed to protect personal data;
- Internal procedures to protect the rights of data subjects must be implemented;
- A Data Processor Agreement must be drafted and signed by the parties;
- Data Processor Agreements with third parties must be in place if relevant;
- A Data Management Plan is required which established the intended processing of personal data and the purpose of such processing;
- A Data Protection Impact Assessment must be carried out based on the Data Management Plan and special areas of vulnerabilities towards protection of personal data must be identified and resolved;
- Standard CCTV signs must be placed by the cameras following the applicable rules for CCTV signage including the following information in a concise language.

The regulatory aspects are:

- The staff wristbands comply with ETSI EN 302 065-2 V 2.1.1[32] (publ. in the Official Journal of the European Union - 15.12.2017 - (2017/C 435/05), including the EU Commission provisions 2014/702/EU[33]. The UWB communication is compliant with the IEEE802.15.4-2011 standard;
- The crowd wristbands are built to comply with ETSI EN 300 220-2 V 3.1.1[34];
- The UWB communication is compliant with the IEEE802.15.4-2011 standard;
- The hardware must comply with the Waste Electrical and Electronic Equipment Directive (WEEE 2012/19/EU);
- The hardware must comply with the Restriction of Hazardous Substances in Electrical and Electronic Equipment Directive (RoHS 2011/65/EU).

Moreover, the IoT elements of the MONICA Crowd Management and Communication components making use of radio frequency spectrum must adhere to the various European regulatory provisions as laid forth by CEPT/ECC and some relevant EU Decisions. For further information see *D12.5 Report on Standards, Regulations, and Policies for IoT Platforms*.

8.3.2 Market positioning analysis

8.3.2.1 Unique Selling Points

The MONICA Crowd Management and Communication solution provides solutions to a number of challenges facing the target groups. Individually, the options display a number of Unique Selling Points in terms of features, service offerings, quality and resilience as well as ease of use. However, the most striking uniqueness is the comprehensiveness of the cloud solution, its' wealth of features (as a complete closed-loop, IoT enabled platform for security, crowd and noise monitoring applications), and its integrability into the MONICA IoT platform.

[32] See https://www.etsi.org/standards-search#page=1&search=EN300%20392&title=1&etsiNumber=1&content=1&version=0&onApproval=1&published=1&historical=1&startDate=1988-01-15&endDate=2016-10-10&harmonized=0&keyword=&TB=&stdType=&frequency=&mandate=&collection=&sort=1
[33] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014D0702
[34] See https://www.etsi.org/standards-search#page=1&search=EN300%20392&title=1&etsiNumber=1&content=1&version=0&onApproval=1&published=1&historical=1&startDate=1988-01-15&endDate=2016-10-10&harmonized=0&keyword=&TB=&stdType=&frequency=&mandate=&collection=&sort=1

Overview of the individual needs and challenges related to security and safety at open-air events exemplifies the Unique Selling Points:

- Visualisation: It can visualise data on a dedicated dashboard like the MONICA COP in the control room and thus provide a complete overview of the venue, the crowd's position, movements, and behaviour.
- Detection: It can issue alerts of potentially critical situations related to crowd management and control. It can also be used to document incidents and incident handling
- Intervention: It can be used with the MONICA DSS to help control room and operation managers to make the right decisions at the right time. It enables also safety and security teams to evaluate emerging incidents
- Communication: It can support onsite staff communication, coordination and management. It can support security personnel in the reporting of health, safety and security incidents
- Flexibility: It can be used and extended with a variety of devices such as smart glasses, staff trackers, crowd wristbands and CCTV cameras with easy IoT interfaces.

8.3.2.2 SWOT analysis

A generic SWOT analysis for the MONICA Crowd Management and Communication solution is shown in Table 4. The SWOT analysis is performed by analysing the Strengths and Weaknesses of solution against the Opportunities and Threats exposed by the market.

Table 4: SWOT analysis for the Crowd Management and Communication solution

Strengths	**Weaknesses**
• A complete closed-loop, IoT enabled platform for security, crowd and noise monitoring applications • Visualise data on the MONICA COP in the control room and provide overview of crowd behaviour • Detect potentially critical situations and provide decision support for interventions • Two-way communication with onsite staff improves coordination and management • Extendable with a variety of devices	• Relative high basis investments required if only few devices are used • New product, not excessively tested; efforts are needed to commercialise • Risks of technical problems; a malfunction may have negative consequences on security • No official quality product security clearance
Opportunities	**Threats**
• Solution for crowd management in very high demand in all markets • Safety and security for events cannot be compromised • Large potential market size • Competitor products are few and not so well integrated	• There may be less functional, but more mature and accepted/established security solutions, that may be more appealing for critical events • Local regulations for surveillance and security levels may hamper the rollout of solutions • Communication not integrated with the standard communication networks used by public security forces

8.3.2.3 Positioning matrix

As described in section 3.3.2 Market prioritisation, the Market Attractiveness provides a useful guideline as to which results are directly exploitable on which markets. The partners can analyse their strength and weakness on each of the markets, analyse the attractiveness and develop their exploitation strategy accordingly. The diagram below shows which markets are the most attractive for the MONICA Crowd Management and Communication solution. The analysis is performed by comparing the market descriptions (size, drivers, competitors) with the Unique Selling Points of the solution. The results are shown in Figure 11.

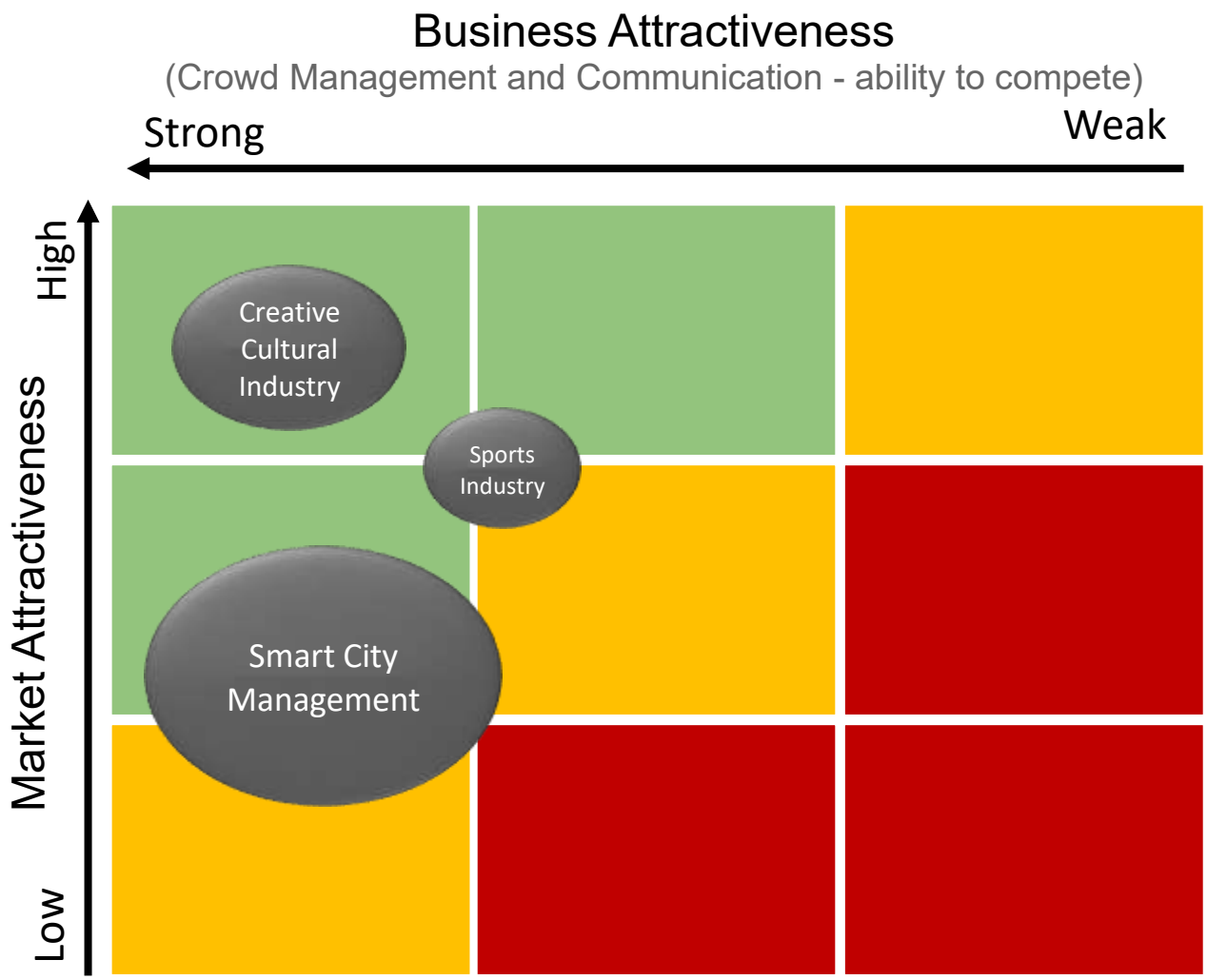


Figure 11: Market Attractiveness Analysis for the Crowd Management and Communication solution

The Performing Arts of the Creative and Cultural Industry (€300m) together with Smart City Management (€500m) are attractive segments for the MONICA Crowd Management and Communication solution. The need for massive, but ad-hoc communication solutions during entertainment events makes the Creative and Cultural Industry slightly more attractive because of the flexibility and scalability of the solution. In the Smart City Management market, the need for localised (not city-wide) communication functionality are more specialised and the MONICA Crowd Management and Communication may be too complex, if it is not delivered together with the MONICA IoT Platform. The Sports Industry is attractive (€200m), but has already highly advanced security installations in place, which could pose barriers for rapid market entry. The Smart Wearables is an emerging market and it is not fully clear how attractive this market will be in the future. It depends on the need for wearables to connect to central cloud solutions.

8.3.3 Business model canvas: Crowd Management and Communication

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. This tool is used to map out all details of the MONICA business models based on the value proposition, target groups, the partner constellations, and revenue models outlined in *D9.3 Replication Reference Book.*

Table 5: Business Model Crowd Management and Communication

<table>
<tr>
<td rowspan="2"> 
Key Partners

MONICA partners
• LINKS
• CNet Svenska AB
• Atos
• VCA Technology Ltd
• Dexels BV
• Optinvent
• Fraunhofer FIT

External partners
• Hardware
• Network components
• On-site Installation</td>
<td> 
Key Activities
• Cloud operation
• Cloud systems
• Software development
• Firmware development
• Network protocols
• Cybersecurity analysis and mitigation</td>
<td rowspan="2"> 
Value Proposition
A Private Cloud structure including the MONICA Common Operational Picture (COP) the MONICA Decision Support System (DSS)
Visualise data in the control room and provide an overview of crowd’s position, movements, and behaviour
Decisions support system to make the right decisions at the right time
Two-way communication supports onsite staff, coordination and management</td>
<td>Customer Relationship
 
• Provide overview of crowd size, density and flow in real-time
• Detect abnormalities and objects for interventions
• Enhance communcation with on-site staff</td>
<td rowspan="2">Customer Segments
 
• Organisers of musical events, outdoor concerts
• Owners of venues for large events such as stadiums, concert arenas
• City authorities for safety of large events
• City authorities responsible for noise control in the city
• Organisers of sporting events</td>
</tr>
<tr>
<td> 
Key Resources
• Software developers
• Cloud operation
• Network specialists
• System integrators
• Cybersecurity experts</td>
<td>Distribution Channels
 
• B2B event organisers
• B2B city authorities
• Through system integrators
• Through cloud operators</td>
</tr>
<tr>
<td colspan="2"> 
Cost Structure
• Standard cost of cloud services
• Cost of network services
• Cost of hardware
• Cost of development, customisation, training
• Cost of operation
• Cost of commissioning and de-commissioning</td>
<td colspan="2">• COP and DSS provided as an up-front customization and installation charge plus recurrent software licenses
• Cloud integration component and services as consultancy services
• Security framework as a recurrent license plus one-off configuration charge
• Configuration, installation commissioning service costs</td>
<td> 
Revenue Streams</td>
</tr>
</table>

8.4 Sound Level Monitoring

8.4.1 Business solution

The MONICA Sound Level Monitoring solution provides real-time monitoring (measuring and displaying) of sound levels at discrete outdoor locations in the city. It is enabled for use in Internet of Things applications and is easy to deploy in the urban space. It collects data in real-time and sends them directly to backend databases. It can also perform real-time sound analysis so that sound contribution levels from different sources can be separated and pre-defined sound events can be detected.

The solution uses professional Bruel & Kjær IoT Sound Level Meters to measure instantaneous broadband sound levels and 1/3 octave spectrum. In addition, the Sound Level Meters can provide GPS positioning. Data are exposed on a gateway and may be transmitted to cloud servers or the user's proprietary servers or CMS platforms.

The solution complements the MONICA Adaptive Sound Field Control solution and combined they represent a total, closed-loop sound monitoring and control solution for event and concert organisers during large open-air events. The solution also complements the MONICA Crowd and Capacity Monitoring solution where it is combined with crowd monitoring IoT devices. All together they provide a comprehensive solution for monitoring and managing sound and noise during large scale events.

All aspects of this business solution are comprehensively summarised in the *D9.3 Replication Reference Book*.

8.4.1.1 Features

The specific features of the MONICA Sound Level Monitoring solution are:

Sound levels: Historical Sound Level parameters measured at the location of the Sound Level Meter(s) can be retrieved within a specified time interval. Intervals can be specified in steps of one second. The Sound Level Meter can measure basic parameters like Leq, Lmax, Lmin, Lpeak, L10 and L90 with up to two simultaneous frequency weightings (available weightings: A, B, C and Z). It can measure with up to three simultaneous time weightings (Fast, Slow and Impulsive) for the exponential averaging. Read about definitions here: http://www.gracey.co.uk/basics/***Sound contribution analysis***: Measuring the Sound Level in the vicinity of an outdoor event like a concert will also include the sound from other sources, like cars driving by. By placing one or more Sound Level Meters close to the concert, this service enables that the contribution from that concert can be separated at any other location where a Sound Level Meter is placed, and the Sound Level caused by the concert at that location estimated.

Sound event detection: The Sound Level Meter Gateway can be trained to detect specific pre-recorded sound patterns, like gun shots, screaming people and accelerating cars, from the captured sound picture in real-time. Relevant stakeholders can subscribe to receive alerts of interesting events that are detected.

Sound heat map: A simple sound heat map module has been developed using LAeq measurements of the MONICA IoT Sound Level Meter to compute a 2D map of noise density across a pre-defined area. A more complicated Sound Heat Map is calculated in the MONICA Data are collected to the MONICA cloud and presented at the MONICA COP. Combining the sound levels recorded by the Sound Level Meter with a computational sound propagation model, the signals from the MONICA Adaptive Sound Field Control System solution and the weather conditions measured (wind, temperature and humidity), the sound field is calculated. The map covers the area of the venue and the surrounding neighbourhoods, giving an overview of the levels during the concert.

Collaborative Awareness data platform: A simple WordPress plugin to display data on e.g. a city's CAP (Collective Awareness Platform) or standard website. The plugin collects data obtained directly from one or more MONICA IoT Sound Level Meters and send to a CMS platform. The plugin displays the time series and the geographical location of each of the Sound Level Meters.

8.4.1.2 Product structure

The MONICA Sound Level Monitoring solution consists of a core product with a number of options available. The structure is visualised in Figure 12.

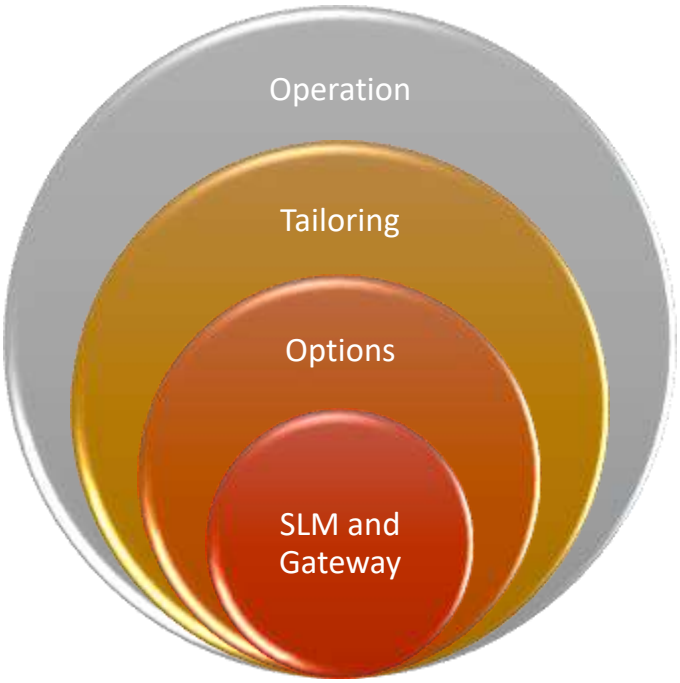


Figure 12: Sound Level Monitoring product structure

Core: The solution is based on a MONICA IoT enabled Sound Level Meter. The sound level meter measures accurately sound pressure levels in different places of the venue and transmit data to the MONICA cloud solution in real time.

Options: Sound heat maps, sound contribution analysis and acoustic event detection using the MONICA Cloud solution.

Tailoring: Customisation of: the cloud service and the COP to the customer's specific needs, integrating the Sound Level Meter into the MONICA IoT platform or customer's own IoT solution, setting up of customer specific COP with user interfaces.

Operation: Consultancy services in planning phase, site surveys, development and follow-up up on implementation plans, installation, commissioning and testing of platform, operational support.

8.4.1.3 Application areas

Application areas include:

- Noise level compliance during events
- Sound level monitoring in nightlife areas
- City noise level mapping
- Noise level recording in work areas

8.4.1.4 Customers

Main customers are: event organisers, local city administrations responsible for ensuring compliance to noise limits and handling citizens' complaints and noise consultancy companies.

8.4.1.5 Regulatory and privacy aspects

The MONICA project has developed a comprehensive framework and guidelines for making the solution compliant with the GDPR as well as international and national technical and performance related regulations and standard.

The privacy related aspects are:

- The solution may raise concerns about increased surveillance practices and how these affect citizens' rights to privacy, particularly if also CCTVs are in operation enabling audio to be coupled with video.
- The solution may reveal facts about actual sound levels which may require the city to inform citizens hereof and take action.

The regulatory aspects are:

- The analysis in the MONICA IoT Sound Level Meter must conform to the international standard IEC 61672-1 (Class 1) and has implemented frequency and time weightings as specified in the standard.
- Sound Level Meters must comply with the Radio Equipment Directive 2014/53/EU (RED).
- The hardware must comply with the Waste Electrical and Electronic Equipment Directive (WEEE 2012/19/EU).
- The hardware must comply with the Restriction of Hazardous Substances in Electrical and Electronic Equipment Directive (RoHS 2011/65/EU).

8.4.2 Market positioning analysis

8.4.2.1 Unique Selling Points

The MONICA Sound Level Monitoring solution provides solutions to a number of noise challenges facing the target groups. Individually, the options display a number of Unique Selling Points in terms of features, service offerings, quality and resilience as well as ease of use. However, the most striking uniqueness is the comprehensiveness of the solution together with the MONICA Adaptive Sound Field Control solution (as a complete closed-loop, IoT enabled platform for sound and noise management), and its integrability into the MONICA IoT platform.

Overview of the individual needs and challenges related to security and safety at open-air events exemplifies the Unique Selling Points:

- Ease of operation: The Sound Level Meters are made to professional standards and may be used for compliance measurements. They are light-weight and easy to install.
- Connectivity: The Sound Level Meters can operate on WiFi or 3G/4G wireless internet and can operate on battery (up to 14 hours) and on permanent power (if available). The Sound Level Meter Gateway contains processing capabilities, which enable services that uses input data from several Sound Level Meters.
- Functionality: The Sound Level Meter will measure a range of useful technical sound level parameters. The Sound Level Meter Gateway may also detect pre-defined sound patterns such as gun shots, screams, braking noise, etc. It will also be able to analyse noise contributions from different sources (music, crowds, entertainments, traffic)
- Integration with cloud: The Sound Level Meter exposes data for other applications in the cloud services through simple web interfaces. It may also be interfaced to the city's Open Data platform

8.4.2.2 SWOT analysis

A generic SWOT analysis for the MONICA Sound Level Monitoring solution is shown in Table 6: SWOT analysis for the Sound Level Monitoring solution. The SWOT analysis is performed by analysing the Strengths and Weaknesses of solution against the Opportunities and Threats exposed by the market.

Table 6: SWOT analysis for the Sound Level Monitoring solution

Strengths	Weaknesses
• A complete closed-loop, IoT enabled platform for sound and noise monitoring and control • Provide real-time sound level data for the Adaptive Sound Field Control system • Visualise sound and noise data on the MONICA COP in the control room • Determine contribution to total sound picture form different sources • Scalable with a variety of Sound Level Meters	• Relative high basis investment required if only monitoring devices are used without the Adaptive Sound Field Control solution
Opportunities	**Threats**
• Solution for sound management in urban areas is in high demand in all markets • Performers are unwilling to reduce the sound level from their performance and cities are eager to get musical events in the cities • Large potential market size • Competitor products are few and not so well integrated – no sound reduction product exists	• Local regulations for surveillance and security levels may hamper the rollout of solutions • Cheap hand-held sound meters are sometimes seen as sufficient for screening purposes

8.4.2.3 Positioning matrix

As described in section 3.3.2 Market prioritisation, the Market Attractiveness provides a useful guideline as to which results are directly exploitable on which markets. The partners can analyse their strength and weakness on each of the markets, analyse the attractiveness and develop their exploitation strategy accordingly. The diagram below shows which markets are the most attractive for the MONICA Sound Level Monitoring solution. The analysis is performed by comparing the market descriptions (size, drivers, competitors) with the Unique Selling Points of the solution. The results are shown in Figure 13.

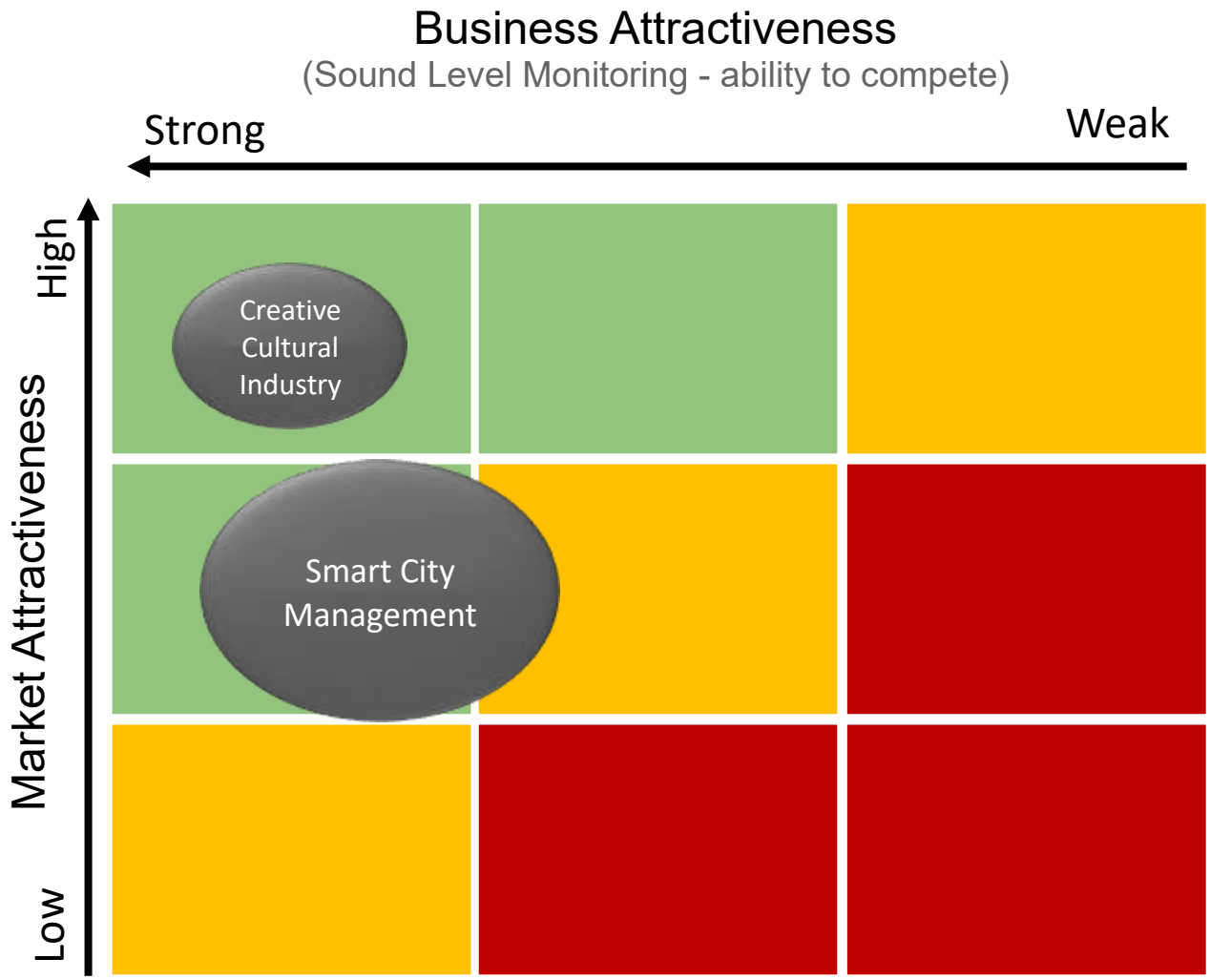


Figure 13: Market Attractiveness Analysis for the Sound Level Monitoring solution

The Performing Arts of the Creative and Cultural Industry (€300m), including the owners of permanent concert venues, is a very attractive segment for the MONICA Sound Level Monitoring solution. The need for sound reduction in connection with the increasingly popular musical events in inner cities increase the market need for also a solution for acquiring the accurate, real-time sound level data. The mere size of this market makes the Creative and Cultural Industry slightly more attractive than others.

In the Smart City Management market, the need for localised (restaurant and nigh-life city sectors) makes the IoT solution for sound monitoring. The data can be captured for compliance or just for monitoring and send directly to the city's own databases, which is a great benefit. The Sports Industry (€200m) is not relevant yet for sound monitoring.

8.4.3 Business model canvas: Sound Level Monitoring

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. This tool is used to map out all details of the MONICA business models based on the value proposition, target groups, the partner constellations, and revenue models outlined in *D9.3 Replication Reference Book*.

Table 7: Business Model Sound Level Monitoring

<table>
<tr>
<td rowspan="2"> 
Key Partners

<u>MONICA partners</u>
• B&K
• DTU
• ATOS
• CNET
• CERTH

<u>External partners</u>
• Hardware
• Network components
• On-site Installation</td>
<td> 
Key Activities
• Cloud operation
• Cloud systems
• Software development
• Firmware development
• Network protocols
• Cybersecurity analysis and mitigation</td>
<td rowspan="2"> 
Value Proposition
Manage noise levels and compliance during events
Provide sound monitoring platform for the Adaptive Sound Field Control solution
Monitor noise levels in restaurant and nightlife areas
Map city noise levels in traffic zones & work areas
Send accredited noise data directly to the city database for later analysis</td>
<td>Customer Relationship
 
• Organisations responsible for regulatory compliance during concerts
• Departments analysing noise data in the city
• Sound engineers with concert operators</td>
<td rowspan="2">Customer Segments
 
• Organisers of musical events, outdoor concerts
• Owners of venues for large events such as stadiums, concert arenas
• City authorities for noise from large events
• City authorities responsible for noise control in the city</td>
</tr>
<tr>
<td> 
Key Resources
• Software developers
• Cloud operation
• Network specialists
• System integrators
• Cybersecurity experts</td>
<td>Distribution Channels
 
• B2B event organisers
• B2B sound engineers
• B2B city authorities
• B2B system integrators</td>
</tr>
<tr>
<td colspan="2"> 
Cost Structure
• Cost of hardware
• Cost of development, customisation, training
• Cost of operation
• Cost of commissioning and de-commissioning</td>
<td colspan="2">• Sound Level Meter provided as a one-off commercial product
• Contribution analysis provided at a recurrent license fee
• CAP integration provided at a recurrent license fee
• Configuration, installation, service costs</td>
<td> 
Revenue Streams</td>
</tr>
</table>

8.5 Adaptive Sound Field Control

8.5.1 Business solution

The MONICA Adaptive Sound Field Control solution is an advanced sound control system that can impact the sound field outside the scene layout through active and adaptive sound field control. The system can provide an optimised sound field in the audience area (bright zone) while reducing the sound levels in neighbouring areas (dark zones) with up to 10dB at low frequencies.

In other words, the music can be louder for a better concert experience at the front of the stage, whereas sound levels can be reduced outside the concert area for less annoyance. To this end, the sound levels are dynamically controlled adjusting for changes in weather or audience, which impacts the propagation of sound waves. The system can work in any kind of environment, open air or closed space or urban area.

The Sound control system can be expanded by the establishment of Quiet Zones in certain areas which gives visitors and staff the option to retreat to a quieter place.

All aspects of this business solution are comprehensively summarised in the *D9.3 Replication Reference Book*.

8.5.1.1 Features

The specific features of the MONICA Crowd and Capacity Monitoring solution are:

Sound level reduction: Overall, the ASFC depends on additional loudspeakers pointing towards the area where noise reduction is needed. This part is integrated with the venue's overall sound (PA) system. The ASFC enables a high sound pressure level in the bright zone relative to the sound pressure level in the dark zone thereby creating the impact of sound level reductions. Moreover, the additional loudspeakers to control the sound in the dark zone do not negatively impact the sound experience in the audience area, the bright zone. The software for sound field optimization algorithm and sound propagation model is configured and tuned specifically for each venue.

Adaptable sound field control: Two important prerequisites for the ASFC system to perform well in a practical situation are: 1) obtaining an accurate sound propagation model for the venue and 2) providing a suitable controlling signal through the secondary sources (loudspeakers).

1. The propagation model is enabled using various environmental sensors and microphones in and around the concert area. Sensors for wind speed, humidity and temperature provide data for the propagation models and "heat maps" for the venue areas. IoT enabled Sound Level Meters are easy to mount and place in correct places around the venue. All sensors are IoT enabled, i.e. they use standard ethernet protocols for communication with the ASFC system.
2. The control signal is obtained by converting the entire PA system output to a control signal for the secondary sources. The control signals have been modified in order for the desired effect to take place in each observation point in the dark zone. The modification takes place in fast computer algorithms based on so-called "forward models" that models the sound propagation through atmospheric air from the secondary loudspeakers to the observation point in the dark zone. The forward model is continuously updated using input from the environmental sensors in order to adapt to changes in atmospheric/weather conditions during the concert.

Crowd and sound heat maps: Audience absorption and scattering is of high importance. To estimate these effects, a mapping of the density of the spectators, and notification of significant changes, is done using video cameras and image processing as provided by the MONICA Crowd and Capacity Monitoring solution. A sound heat map of the area is obtained by Sound Level Meters in a relatively dense network of calibrated IoT enabled Sound Level Meters which may be supplemented with additional data from cheaper uncalibrated sensors from available wearables. A mathematical propagation model, which estimates the transfer-functions, could be used to compute a map of sound level distribution in the dark zone around the convert venue. This will provide a much better adaptability of the forward model. However, this feature is not yet available at the time of writing.

IoT enabled Sound Level Meters: Type-approved, accredited and calibrated IoT enabled Sound Level Meters, which measure correctly under changing environmental conditions like temperature and humidity. They are enabled for use in Internet of Things networks and are easy to install and move around the convert venues as necessary in order to provide proper input for the adaptive algorithms. Sound level data needs to be collected in real-time and send directly to the ASFC with minimum latency.

Quiet Zone: A Quiet Zone is a noise barrier that allows staff on the field to have a small physical space where they can speak without the overwhelming sound from the concert performance. The Quiet Zone principle is to make use of active elements (ASFC) to cancel out low frequencies and passive elements (sound blocking screens) to block higher frequencies using a passive noise barrier. The aim is to obtain the highest possible attenuation of sound level across the entire listening spectrum without disturbing the sound field from the primary sources.

8.5.1.2 Product structure

The MONICA Adaptive Sound Field Control solution consists of a core product with a number of options available. The structure is visualised in Figure 14.

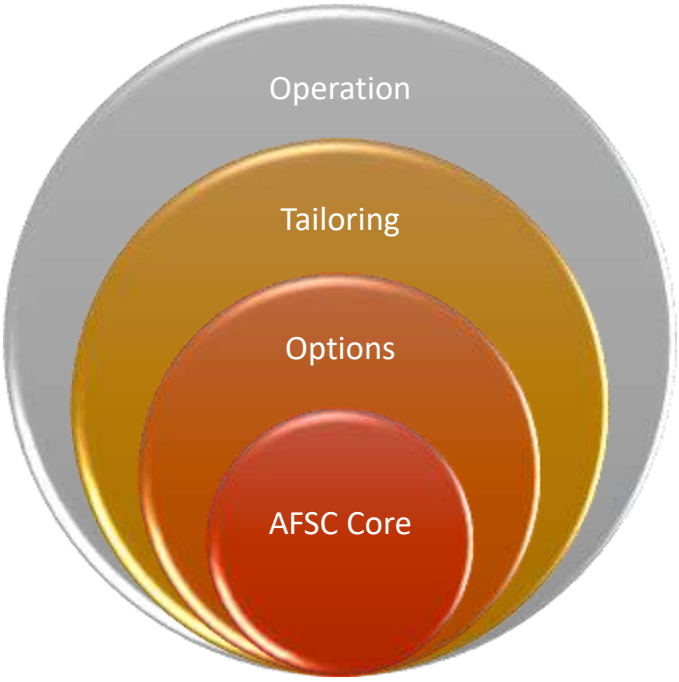


Figure 14: Adaptive Sound Field Control product structure

Core: The core of the product is the Adaptive Sound Field Controller which receives audio signals from the concert's PA console and converts it into a noise reduction signal that is transmitted to the region where the sound levels are to be reduced. It is a highly complex system that consists of signal router, audio interface, ASFC Core Digital Signal Processor multi-channel amplifier and loudspeakers.

Options: Different sound propagation models that adhere to venue geography and weather conditions, sound heat maps, and Quiet Zones.

Tailoring: Optimisation of the Adaptive Sound Field Controller and the sound propagation models as well as speaker layout. Configuration of a Quiet Zone

Operation: Consultancy services in planning phase, site surveys, optimization and development models, implementation plans, installation, commissioning and testing of platform, operational support.

8.5.1.3 Application areas

Application areas cover:

- Increase of sound levels inside the concert venue without surpassing established thresholds
- Reduction of impact of loud music on neighbourhoods
- Compliance to work and health regulations with the establishment of Quiet Zones.

8.5.1.4 Customers

The main customer target groups are event organisers, public authorities and PA (Public Address) system manufacturers involved in the planning of outdoor concerts or as a supplier of sound systems.

8.5.1.5 Regulatory and privacy aspects

There are no personal data captured or handled in the MONICA Adaptive Sound Field solution. Hence, the GDPR regulation does not apply to this solution.

The regulatory aspects are:

- The hardware must comply with the Waste Electrical and Electronic Equipment Directive (WEEE 2012/19/EU).

- The hardware must comply with the Restriction of Hazardous Substances in Electrical and Electronic Equipment Directive (RoHS 2011/65/EU).

8.5.2 Market positioning analysis

8.5.2.1 Unique Selling Points

The MONICA Adaptive Sound Field Control solution provides solutions to the number one noise challenge facing organisers of open-air concerts in inner cities or urban settings. The solution is unique on the market and the options present a number of compelling Unique Selling Points in terms of offerings, quality and closed-loop features. Another striking uniqueness is the ability to integrate with other MONICA solutions such as the MONICA Sound Level Monitoring (to capture accurate sound level data from the venue), the MONICA Crowd and Capacity Monitoring (to provide a standardised IoT network for connecting Sound Level Meters) and the MONICA Crowd Management and Communication solution (for providing a cloud based server solution with COP facilities).

Overview of the individual needs and challenges related to security and safety at open-air events exemplifies the Unique Selling Points:

Benefits for the performers and organisers:

- The sound experience can be optimised with respect to both the performers and the concert audience in terms of loudness, directionality and quality. At the same time, the ASFC system can perform dynamic adjustment of the secondary source loudspeakers so that neighbours of the concert venue can enjoy up to 10dB attenuating of the sound levels in their neighbourhood, where it is unwanted and annoying.
- Real-time display of noise levels on ground plans in 2D can be displayed based on easy to install IoT enabled Sound Level Meters.
- High sound levels can be dangerous to the health of concertgoers; some will prefer to have a lower sound level at the expense of the ultimate artistic quality. For these spectators, the application will make it possible for the organisers to offer different classes of sound levels (maybe with different prices). An app on a Smartphone will advise the concertgoer of the actual zone and the sound levels.
- Quiet zones can be created close to the audience area. These spots can be used for security personnel and the organizers' staff. They can in principle also be created for other people a distance away from the primary audience area (e.g. restaurants, ticket offices, etc.). The number, size and location of the Quiet Zones are specific to each concert and can be moved for different venue layouts.

Benefits for the public authorities:

- Public authorities can use the IoT layer with IoT enabled professional Sound Level Meters to correlate a large amount of sound level data so that sound levels from the concert are separated from background noise.
- The sound data can be published by the municipality as Open Data and the MONICA Collective Awareness Platform solution will allow the citizens to access these data and monitor the compliance of the City Ordinance. This will allow the city authorities to engage in constructive dialogue with the citizens and other actors on a factual basis, and can provide data for research on environmental health impact.
- Citizen Engagement widgets can be developed that can be installed on public authorities' websites and display e.g. real time and cumulative data on noise levels and crowd sizes obtained from the city's Open Data repositories. This can be part of a cooperation and co-creation activity launched by the city.

8.5.2.2 SWOT analysis

A generic SWOT analysis for the MONICA Adaptive Sound Field Control solution is shown in Table 8. The SWOT analysis is performed by analysing the Strengths and Weaknesses of solution against the Opportunities and Threats exposed by the market.

Table 8: SWOT analysis for the Adaptive Sound Field Control

Strengths	Weaknesses
• A complete closed-loop, IoT enabled platform for sound reduction control applications • Reduces sound levels with up to 10dB outside the audience areas • Different sound propagation models for different venues and weather conditions • Sound Heat Map for monitoring sound levels	• High basis investments required • Requires very detailed planning and site surveys including testing; not suitable for one off events • Secondary source loudspeakers are bulky and difficult to place in the optimum position due to geography • New product, not excessively tested; efforts are needed to commercialise • No permanent official reference site
Opportunities	**Threats**
• Solution for sound management in very high demand in all markets • Sound quality for events cannot be compromised • Large potential market size • Competitor products does not exist	• The value proposition is mostly attractive to those who are struggling to meet demands • City may find it unnecessary to invest in sound level reductions since they can force organisers to bear the costs

8.5.2.3 Positioning matrix

As described in section 3.3.2 Market prioritisation, the Market Attractiveness provides a useful guideline as to which results are directly exploitable on which markets. The partners can analyse their strength and weakness on each of the markets, analyse the attractiveness and develop their exploitation strategy accordingly. The diagram below shows which markets are the most attractive for the MONICA Adaptive Sound Field Control solution. The analysis is performed by comparing the market descriptions (size, drivers, competitors) with the Unique Selling Points of the solution. The results are shown in Figure 15.

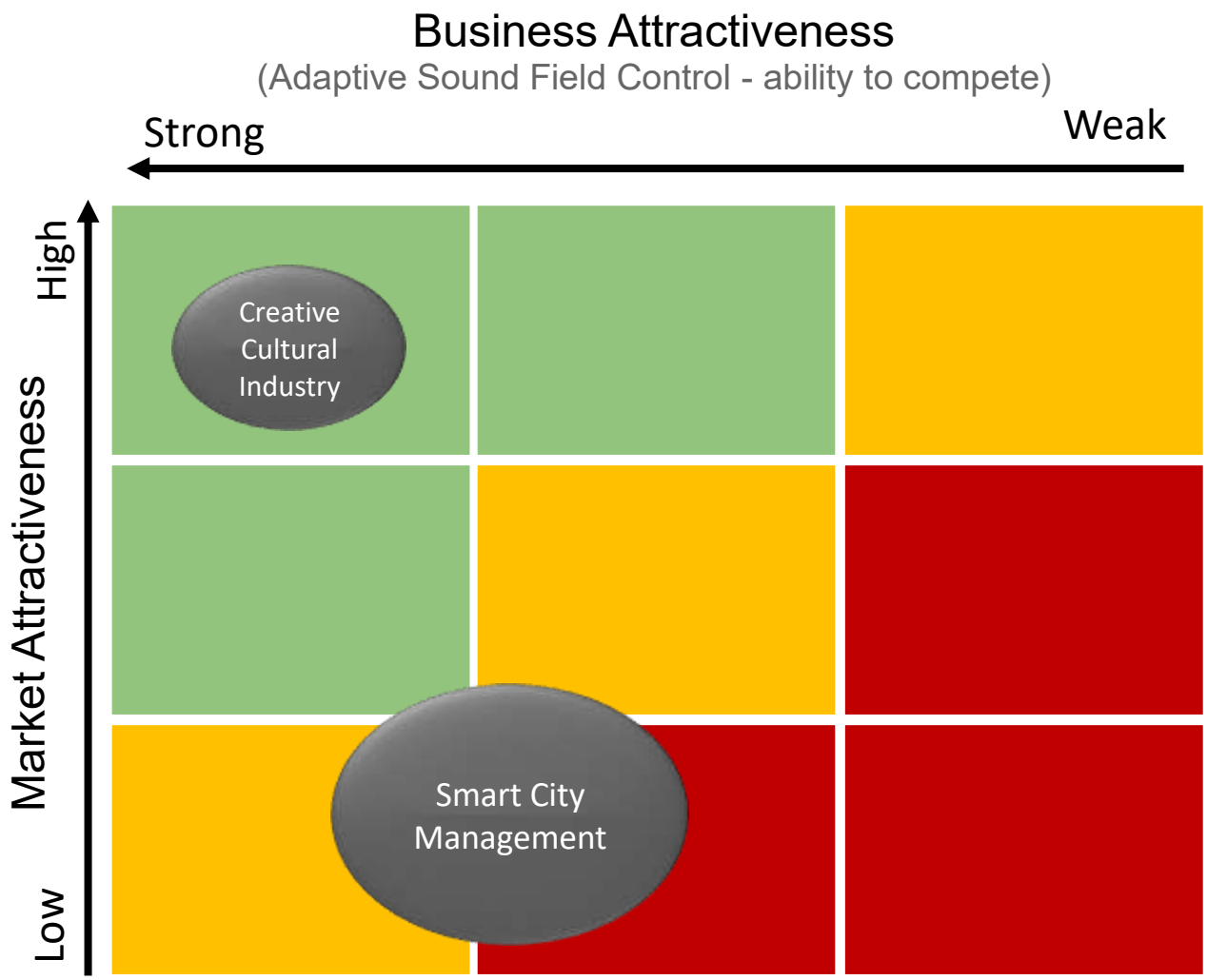


Figure 15: Market Attractiveness Analysis for the Adaptive Sound Field Control solution

The Performing Arts of the Creative and Cultural Industry (€300m), including the owners of permanent concert venues is by far the most attractive segment for the MONICA Adaptive Sound Field Control solution. The need for sound reduction in connection with the increasingly popular musical events in inner cities increase the market need and the MONICA solution is the only available solution on the market. The mere size of this market makes the Creative and Cultural Industry much more attractive than others.

In the Smart City Management market, the need for investing in sound level control solutions is not very pronounced because cities mostly order the organisers to comply with city ordinances. The Sports Industry (€200m) is not relevant for sound level control.

8.5.3 Business model canvas: Adaptive Sound Field Control

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. This tool is used to map out all details of the MONICA business models based on the value proposition, target groups, the partner constellations, and revenue models outlined in *D9.3 Replication Reference Book*.

Table 9: Business Model Adaptive Sound Field Control

<table>
<tr>
<td rowspan="2"> 
Key Partners

<u>MONICA partners</u>
• DTU
• B&K

<u>External partners</u>
• Hardware
• Loudspeakers
• Network components
• On-site Installation</td>
<td> 
Key Activities
• Propagation model optimisation
• Software development
• System integration development
• Sound field analysis</td>
<td rowspan="2"> 
Value Proposition
Manage noise levels and compliance during events
Provide Adaptive Sound Field Control
Establish Quiet Zone for event staff</td>
<td>Customer Relationship
 
• Organisations responsible sound quality during events
• Sound engineers with concert operators
• Concert venue owners</td>
<td rowspan="2">Customer Segments
 
• Organisers of musical events, outdoor concerts
• Owners of venues for large events such as stadiums, concert arenas
• City authorities for noise from large events</td>
</tr>
<tr>
<td> 
Key Resources
• Acoustics
• Software developers
• System integrators</td>
<td>Distribution Channels
 
• B2B event organisers
• B2B sound engineers
• B2B city authorities
• B2B system integrators</td>
</tr>
<tr>
<td colspan="2"> 
Cost Structure
• Cost of hardware
• Cost of propagation model optimization
• Cost of development, customisation, training
• Cost of operation
• Cost of commissioning and de-commissioning</td>
<td colspan="2">• System integration package including site survey, design and planning, installation, test and operational support during the event
• Single use license for each customised version of the model (i.e. for each event)
• Rental or sale of loudspeakers and necessary cabling</td>
<td> 
Revenue Streams</td>
</tr>
</table>

8.6 User experience

8.6.1 Business solution

The MONICA User Experience solution consists of two digital applications for greater enjoyment and quality:

1. The MONICA Collective Awareness Platform (CAP) solution where users can see a city's or even organisers' Open Data and engage in co-creation activities stimulated by factual information presented in the CAP.
2. The MONICA Visitor Experience solution which includes Smart IoT wristbands, interacting with users during concert and other events and an event app.

The two solutions are quite independent of each other.

8.6.1.1 Features

The specific features of the two solutions are:

MONICA Collective Awareness Platform: is an online citizen-oriented platform that promotes collective awareness about societal challenges by gathering and displaying all related data and information. In MONICA, the challenge is to find solutions to the split between cultural attractiveness and community nuisance when organising events in the inner city, next to residential areas. The starting point is creating awareness of these challenges and from this, engage the stakeholders in identifying and developing solutions.

The platform typically consists of two layers: an awareness layer and an engagement or co-creation layer, inviting people to interact and/or participate. In some cases, crowd funding and donations are also part of the platforms.

The awareness layer outlines a particular challenge by presenting factual information and data. Based on this, participation is encouraged either through the platform functionality or in separate forums. Based on this informed knowledge, the CAP invites or unites people in creating solutions which can help improve the situation. Awareness is created through the display of open data, made available by the city's users and presented in a way that is understandable to a wider, general public. As such, the co-creation of value takes place in collaboration with the city's users as collectors of data.

MONICA Visitor Experience solution: uses wristbands with remote controllable LED lamps to create lightshow effects at festivals or at events with features like polls, attention notifications and connecting through social media. Another solution is an event app, enabling visitors to access and negotiate the event more easily. The event app can used together with the wristbands for enhanced visitor experience during and after the event.

The specific features of the MONICA Visitor Experience solution are:

Event App: The event app is customised to the specific event and provides event-related information and guidance, enables communication of important happenings or security situations with the choice of offering exclusive content and feedback-options. It can be integrated with the IoT wristband for location service and friend connect features.

Light shows: The two RGB LEDs on the crowd wristband can be controlled by a management console available for operators wishing to synchronise the LEDs with the music from the stage

LED alerts: The two RGB LEDs on the crowd wristband can be used to guide people based on colour codes. A venue can have "coloured exits". The LEDs of the wristbands can be controlled by individual base stations. A wristband will give priority to LEDs command from the base station that is nearest; based on this proximity characteristic the wristbands can be guided to the nearest exists indicated by a colour command of the LEDs.

Friend-Connect: A friend is connected by exchanging personal information (which is enabled during registration) by holding the button for 2 s until the LEDs light up blue. By holding the wristbands in close proximity of each other, the LEDs flash green and a connection is made (in the cloud database).

Like-option: When the button on the wristband is pushed for a moment, the location and time will be registered.

Crowd density: leveraging the bi-directional 100 m range radio that is integrated in the wristband. The crowd density feature can be used to create heat maps of the crowd, showing where visitors are gathering.

Location Service: Since there is an approximate location for every wristband in near real time, every few minutes, this feature can be leveraged to implement a Location Service for visitors. In case a visitor needs to be found, the last known location can be queried from the COP in the MONICA cloud.

8.6.1.2 Application areas

Application areas cover:

- Citizen engagement
- Enhancement of the visitor experience
- Interaction with and between visitors
- Safe entrance and exit
- Sponsorship and brand activation

8.6.1.3 Customers

Customers include local administrations and event organisers. Other stakeholders are citizens/visitors/ fans/concert goers.

8.6.1.4 Regulatory and privacy aspects

Since some aspects of the MONICA User Experience solutions involves the collection and processing of personal data (names, addresses, emails, images, position, opinions, access to social media accounts, etc.), a *Legitimate Interests Assessment* and a *Data Privacy Impact Assessment* should be performed as part of each planned installation

On this background, the MONICA project has developed a comprehensive framework and guidelines for making the solution compliant with the GDPR as well as international and national technical and performance related regulations and standard.

The privacy related aspects are:

- Internal procedures must be developed to protect personal data
- Internal procedures to protect the rights of data subjects must be implemented
- A Data Processor Agreement must be drafted and signed by the parties
- Data Processor Agreements with third parties must be in place if relevant.
- A Data Management Plan is required which established the intended processing of personal data and the purpose of such processing
- A Data Protection Impact Assessment must be carried out based on the Data Management Plan and special areas of vulnerabilities towards protection of personal data must be identified and resolved.

Moreover, the wristbands in the MONICA Visitor Experience solution making use of radio frequency spectrum must adhere to the various European regulatory provisions as laid forth by CEPT/ECC and some relevant EU Decisions. For further information see *D12.5 Report on Standards, Regulations, and Policies for IoT Platforms*.

The regulatory aspects are:

- The staff wristbands comply with ETSI EN 302 065-2 V 2.1.1[35] (publ. in the Official Journal of the European Union - 15.12.2017 - (2017/C 435/05), including the EU Commission provisions 2014/702/EU[36]. The UWB communication is compliant with the IEEE802.15.4-2011 standard;
- The crowd wristbands are built to comply with ETSI EN 300 220-2 V 3.1.1[37];

[35] See https://www.etsi.org/standards-search#page=1&search=EN300%20392&title=1&etsiNumber=1&content=1&version=0&onApproval=1&published=1&historical=1&startDate=1988-01-15&endDate=2016-10-10&harmonized=0&keyword=&TB=&stdType=&frequency=&mandate=&collection=&sort=1
[36] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014D0702
[37] https://www.etsi.org/standards-search#page=1&search=EN300%20392&title=1&etsiNumber=1&content=1&version=0&onApproval=1&published=1&historical=1&startDate=1988-01-15&endDate=2016-10-10&harmonized=0&keyword=&TB=&stdType=&frequency=&mandate=&collection=&sort=1

- The UWB communication is compliant with the IEEE802.15.4-2011 standard;
- The hardware must comply with the Waste Electrical and Electronic Equipment Directive (WEEE 2012/19/EU);
- The hardware must comply with the Restriction of Hazardous Substances in Electrical and Electronic Equipment Directive (RoHS 2011/65/EU).

8.6.2 Market positioning analysis

8.6.2.1 Unique Selling Points

MONICA Visitor Experience solution: There are several products on the market using wristbands for enhanced event experience, but the MONICA Visitor experience offers very unique features:

- The communication anchors can be used for anonymous positioning of the wristbands thus allowing the event organisers to create a real-time heat map of visitor density. This can be useful for dispatching stewards to specific areas and for redirecting queues to facilities with less waiting times, e.g. food and drink stands, toilets, etc.
- The MONICA Visitor Experience app is unique in its ability to use the wristband to connect to social media accounts or similar identifications.
- The wristband's "connect" feature (using RFID) can be developed into a cash payment feature to be used e.g. for paying rides or certain consumables.

The MONICA Collective Awareness Platform: The uniqueness of the CAP is its ability to integrate Open Data about the physical environment in the city with a co-creation platform for discussion and collaboration of citizens with the city administration about sustainable solutions. The CAP can be integrated with any Content Management System such as WordPress, SiteCore, Joomla etc. It can also be integrated with Participatory Budgeting platform such as Consul. The unique selling points are also evident from the clear benefits for stakeholders:

- The benefits for Smart City Operators are that they are able to engage citizens in co-creation activities with real, factual information. This gives unique opportunities for in-project assessment purposes, but also for longer term involvement in sustainable societal solutions.
- The benefits for citizens are that they are able to benefit from online, relevant information and data and are able to take that information in to co-creation activities and to make better, informed decisions about the city's environment, economy, infrastructure and consumption. Moreover, this makes citizens' voice heard, and makes the city's ICT portals more inclusive.

8.6.2.2 SWOT analysis

A generic SWOT analysis for the MONICA User Experience solution is shown in Table 10. The SWOT analysis is performed by analysing the Strengths and Weaknesses of solution against the Opportunities and Threats exposed by the market.

Table 10: SWOT analysis for the User Experience solution

Strengths	Weaknesses
• A complete closed-loop, IoT enabled platform for enhanced user experience • Allows visitors to connect, receive and send messages during the event • Provide a live heat map of visitor density during event • Engage citizens in co-creation activities with real, factual information • Integrate with CMS or Participatory Budgeting	• Visitor Experience requires detailed planning and site surveys including testing • No permanent official reference site • A CAP is resource demaning on city adminstrations • A CAP requires continuous political support
Opportunities	**Threats**
• Solution for visitor experience is in very high demand in all event markets • IoT solutions for events is attractive • Local authorities need increasingly to connect with the citizens	• The cost-benefit of the CAP value proposition is difficult to assess • Cities may find it uninteresting to invest in CAP solutions due to the possible ramification of engaging citizens in hot political topics

8.6.2.3 Positioning matrix

As described in section 3.3.2 Market prioritisation, the Market Attractiveness provides a useful guideline as to which results are directly exploitable on which markets. The partners can analyse their strength and weakness on each of the markets, analyse the attractiveness and develop their exploitation strategy accordingly. The diagram below shows which markets are the most attractive for the MONICA User Experience solution. The analysis is performed by comparing the market descriptions (size, drivers, competitors) with the Unique Selling Points of the solution. The results are shown in Figure 16.

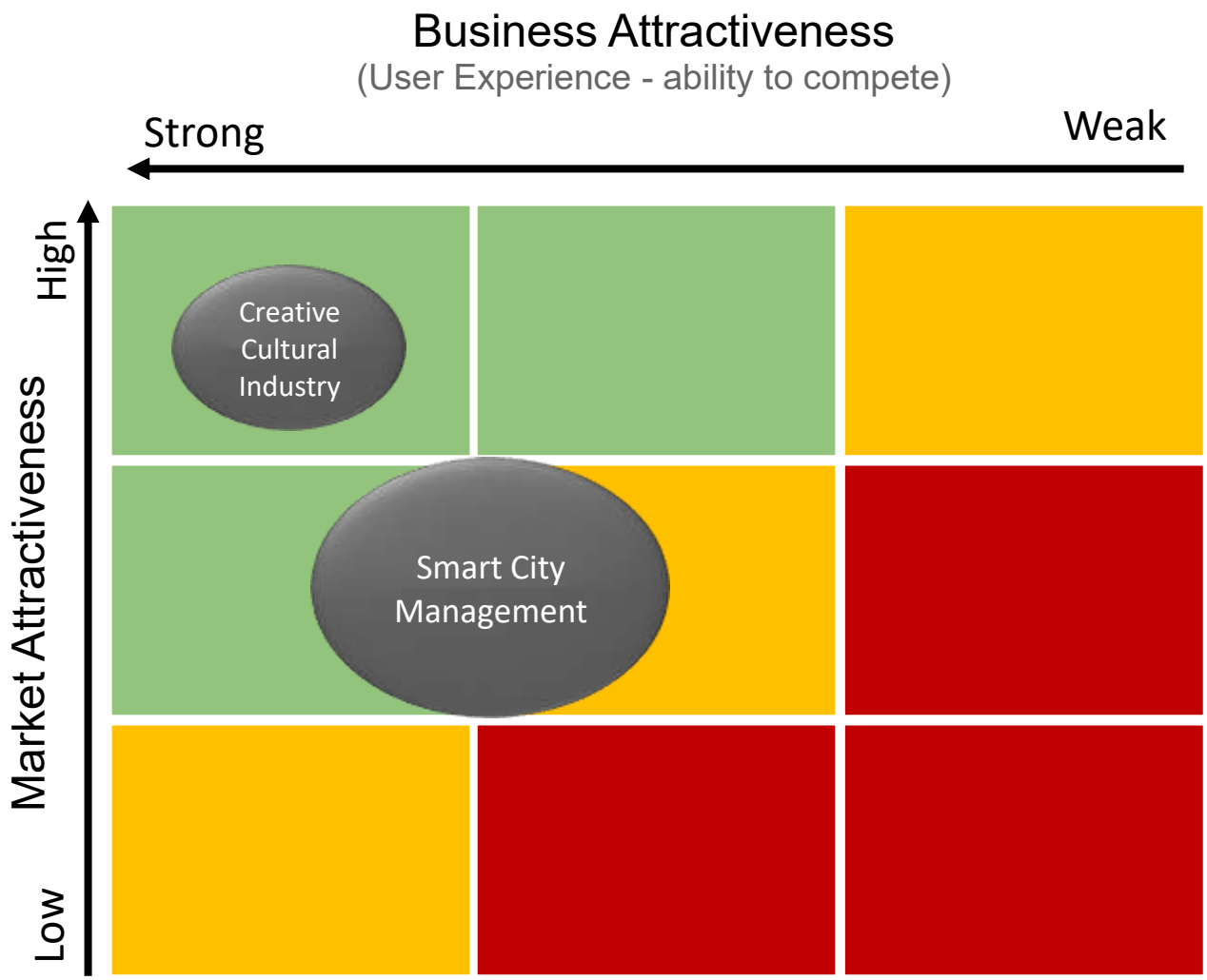


Figure 16: Market Attractiveness Analysis for the User Experience solution

In the Smart City Management market (€500m), the need for investing in citizen engagement and co-creation activities is high and often seen as the hall-mark of a "Smart City". However, there are both practical and political implications that often create barriers for wide spread uptake. Firstly, the management of a co-creation platform can be very resource demanding. In order to be effective, the citizens must feel that the city administration takes their answers and solutions seriously. The experience from participatory budgeting, which is used in quite a number of European cities and metropolises, underpins this barrier. Secondly, there must be full political support for such intensive engagement of citizens in sometimes high profiled cases (such as night-life or traffic noise). The political support must persist event with changing political regimes in the city. This makes the Smart City Management a slightly difficult market to enter. However, when the door is open, The MONICA Collective Awareness Platform with Open Data and perhaps Participatory Budgeting a very attractive solution.

The Performing Arts of the Creative and Cultural Industry (€300m), including the owners of permanent concert venues, is an attractive segment for the MONICA Visitor Experience solution. The market is developed with similar solutions already available, both in terms of wristbands and visitor apps. The Unique Selling Points for the MONICA Visitor Experience solutions gives a strong market position.

8.6.3 Business model canvas: Collective Awareness Platform and Visitor Experience

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. This tool is used to map out all details of the MONICA business models based on the value proposition, target groups, the partner constellations, and revenue models outlined in *D9.3 Replication Reference Book*.

Table 11: Business Model Collective Awareness Platform

<table>
<tr>
<td rowspan="2"> 
Key Partners

<u>MONICA partners</u>
• IN-JET
• CNET

<u>External partners</u>
• Hardware
• Cloud solutions
• Open Data
• On-site Installation</td>
<td> 
Key Activities
• Cloud operation
• Cloud systems
• Software development
• Cybersecurity analysis and mitigation
• Citizen engagement</td>
<td rowspan="2"> 
Value Proposition
Provide a co-creation collaboration platform where different actors can develop new solutions together using Open Data
Integrated with any Content Management System such as WordPress, SiteCore, Joomla etc. and Participatory Budgeting platform such as Consul
Used with the MONICA Sound Level Monitoring to create Open Data with sound levels from streets and areas with heavy traffic, temporary building and construction sites</td>
<td>Customer Relationship
 
• Departments involved in citizen engagement
• Political members of city councils
• Department responsible for infrastructure and the environment</td>
<td rowspan="2">Customer Segments
 
• Smart City Operators
• City authorities responsible for engaging citizens
• City authorities responsible for city infrastructure and urban living</td>
</tr>
<tr>
<td> 
Key Resources
• Software developers
• Cloud operation
• System integrators
• Social science experts
• Communication experts</td>
<td>Distribution Channels
 
• B2B city authorities
• Corporation with system integrators and smart city solution providers</td>
</tr>
<tr>
<td colspan="2"> 
• Cost of development, customisation, training
• Cost of operation
• Cost of commissioning

Cost Structure</td>
<td colspan="2">• CAP integration provided at a recurrent license fee
• Configuration, installation, service at costs</td>
<td> 
Revenue Streams</td>
</tr>
</table>

Table 12: Business Model Visitor Experience

<table>
<tr>
<td rowspan="2"> 
Key Partners

<u>MONICA partners</u>
• Dexels BV
• IN-JET
• CNET

<u>External partners</u>
• Hardware
• Network components
• On-site Installation</td>
<td> 
Key Activities
• Wristband design
• Network protocols
• Cloud operation
• App development
• Software development
• Firmware development</td>
<td rowspan="2"> 
Value Proposition
Create lightshow effects at festivals or at events using wristbands with features like polls, attention notifications and connecting through social media
Enable visitors to access the event offerings and real-time data more easily.
Enhanced visitor experience during and after the event and create connections and likes using the wristbands</td>
<td>Customer Relationship
 
• Provide information about event organisation
• Provide enhanced visitor experience</td>
<td rowspan="2">Customer Segments
 
• Organisers of musical events, outdoor concerts
• Organisers of street festivals, open-air markets
• Organisers of sporting events</td>
</tr>
<tr>
<td> 
Key Resources
• Software developers
• Cloud operation
• Network specialists
• Hardware designers
• System integrators</td>
<td>Distribution Channels
 
• B2B event organisers
• Through system integrators</td>
</tr>
<tr>
<td colspan="2"> 
Cost Structure
• Standard cost of cloud services
• Cost of network services
• Cost of hardware
• Cost of development, customisation, training
• Cost of operation
• Cost of commissioning and de-commissioning
• Electricity and rental cost for long term installations</td>
<td colspan="2">• Cloud integration component and services as consultancy services
• Cost of hardware with embedded firmware.
• One off-licenses fees for software and firmware per installation
• Configuration, algorithms training, custom. services
• Installation and commissioning services</td>
<td> 
Revenue Streams</td>
</tr>
</table>

9 Conclusion and next steps

The result of the SWOT and market attractiveness analysis is the foundation for the individual and joint exploitation plans and for the partners' subsequent product development and marketing plans provided in the confidential deliverable *D12.6 Final Replication, Exploitation and Business Plans*.

10 List of Figures and Tables

10.1 Figures

10.2 Tables

11 References

(Allied Market Research 2018) https://www.alliedmarketresearch.com/smart-cities-market (accessed 2019)

Beecham Research — Image by http://www.beechamresearch.com/article.aspx?id=20 (Accessed 05.12.19).

(EC, 2003) — European Commission. Directive 2003/10/EC of the European parliament and of the council of 6 February 2003 on the minimum health and safety requirements regarding exposure of workers to the risks arising from physical agents (noise) Official Journal of the European Union, 2003.

(EC, 2015) — European Commission, Eurostat 2015 EU-SILC module on social/cultural participation and material deprivation.

(EU, 2014) — European Parliament, Directorate-General for Internal Policies (2014) Mapping Smart Cities in the EU.

(EU, 2018) — EU (2018). Study on the Economic Impact of Sport through Sport Satellite Accounts, Luxembourg: Publications Office of the European Union, 2018.

(EU Council, 2018) — EU Council (2018). The economic dimension of sport and its socio-economic benefits - Draft conclusions of the Council and the Representatives of the Governments of the Member States, meeting within the Council.

(EUROACTIV, 2017) — https://www.euractiv.com/section/digital/infographic/how-many-smart-cities-are-there-in-europe/ (accessed 2019).

(EY, 2014) — EY (2014). Creating growth: Measuring cultural and creative markets in the EU.

(EY, 2015) — EY (2015). Cultural times: The first global map of cultural and creative industries.

(Fortune Business Insight, 2019) https://www.fortunebusinessinsights.com/industry-reports/internet-of-things-iot-market-100307 (accessed 2020)

(GrowthEnabler, 2017) https://growthenabler.com/flipbook/pdf/IOT%20Report.pdf (accessed 2019).

(Hämäläinen M. 2020) — Hämäläinen M. (2020) A Framework for a Smart City Design: Digital Transformation in the Helsinki Smart City. In: Ratten V. (eds) Entrepreneurship and the Community. Contributions to Management Science. Springer, Cham.

(ISO 2013) — ISO. International Organisation for Standardization. Acoustics: Estimation of Noise-induced Hearing Loss (ISO 1999:2013) Geneva: ISO Technical Committee; 2013.

(Live DMA, 2019) — Live DMA (2019) Report Live style Europe Working Group - Music is not Noise. Publication February 2019.

(Live DMA, 2020) — Live DMA, The Survey, Live music venues & clubs in Europe - facts and figures, Publication January 2020.

(LSP, 2019) — IoT European Large-Scale Programme (2019), The European Large-Scale Pilots Programme – Driving IoT Innovation at Scale in Europe.

(Osterwalder & Pigneur, 2010). Osterwalder, A., & Pigneur, Y. (2010). Business model generation: a handbook for visionaries, game changers, and challengers. John Wiley & Sons.

(Pigneur, 2005) — Pigneur, Y. (2005) e-Business model ontology for improving business/IT alignment, Interop, CAISE-EMOI'05, 2005.

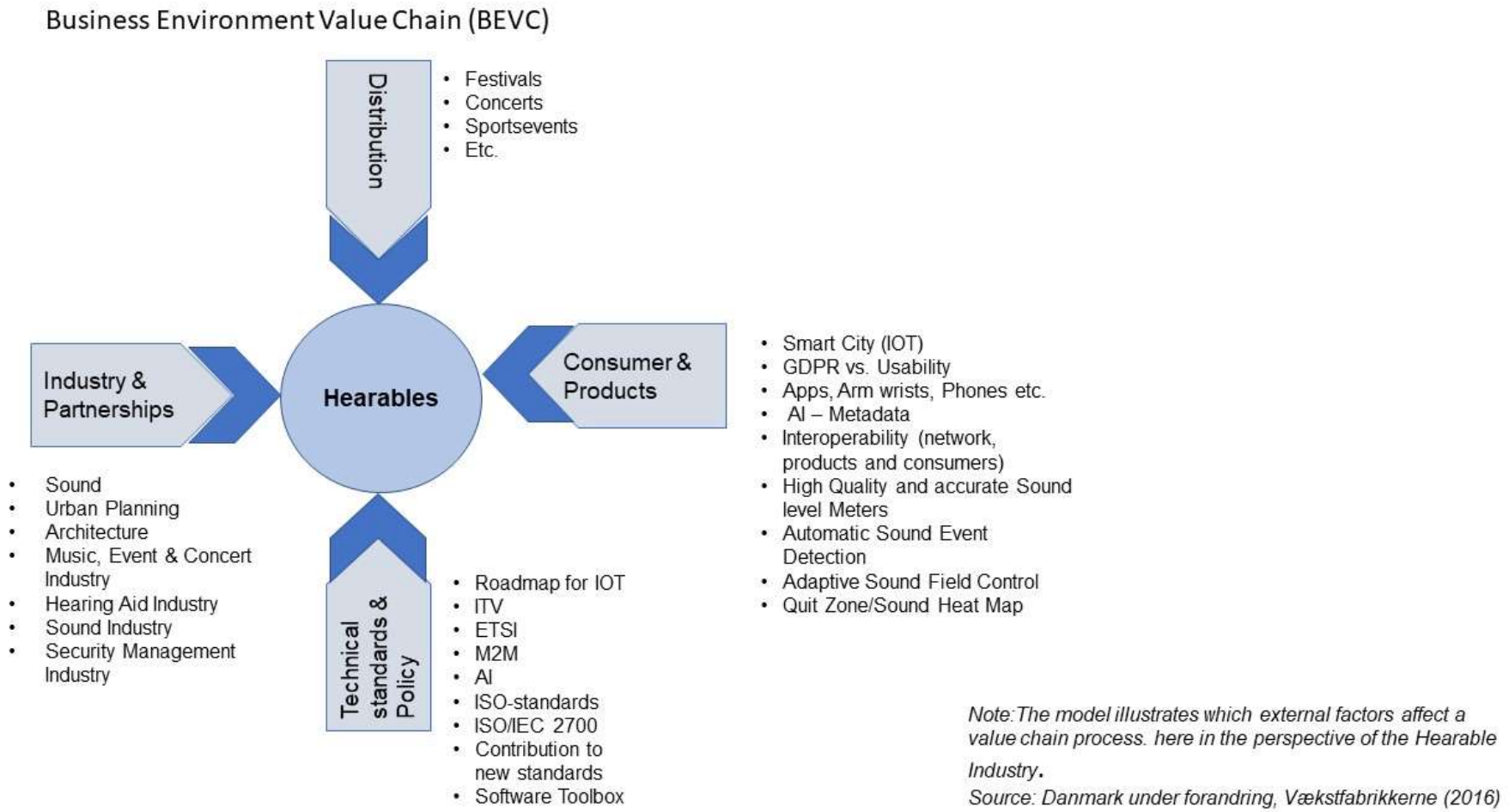
(Pigneur & Fritscher, 2014) Pigneur, Yves & Fritscher, Boris. (2014). Business Model Design An Evaluation of Paper-based and Computer-Aided Canvases. Lecture Notes in Business Information Processing. 220. 236-244. 10.5220/0005426602360244.

(Tronstad et al. 2016) — Tron V. Tronstad, Femke B. Gelderblom, Sound Exposure During Outdoor Music Festivals. Noise Health. 2016 Jul-Aug; 18(83): 220–228.

(United Nations, 2018) — United Nations, Department of Economic and Social Affairs, Population Division (2018). The World's Cities in 2018—Data Booklet (ST/ESA/ SER.A/417).

(Zappatore et al. 2016) Zappatore et al, Smart City 2015, LNICST 166, pp. 885–897.

12 Appendix A: Business Environment Value Chain - Hearables



Note: The model illustrates which external factors affect a value chain process. here in the perspective of the Hearable Industry.
Source: Danmark under forandring, Vækstfabrikkerne (2016)