TALLINN UNIVERSITY OF TECHNOLOGY
SCHOOL OF ENGINEERING
Department of Mechanical
and Industrial Engineering

ESTONIAN ACADEMY OF ARTS
FACULTY OF DESIGN
Department of Design
and Technology Futures

SMART WORKWEAR FOR PEOPLE WHO ASSIST CROWDS

Nutikad tööriided inimestele, kes töötavad rahvahulkadega

MASTER THESIS

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Tallinn 2023

AUTHOR'S DECLARATION

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No academic degree has been applied for based on this material. All works, major viewpoints, and data of the other authors used in this thesis have been referenced.

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Department of Mechanical and Industrial Engineering

THESIS TASK

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Study program: MADM10/18, Design and Technology Futures

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Thesis topic:

in English: Smart Workwear For People Who Assist Crowds

in Estonian: Nutikad tööriided inimestele, kes töötavad rahvahulkadega

Thesis main objectives:

1. Understand the people working with large crowds' needs for workwear.
2. Explore existing solution space and identify possibilities for new solutions.
3. Propose a design concept for better workwear with digital communication options110 between people who manage crowds.

Thesis tasks and time schedule:

No	Task description	Deadline
1.	Literature rewiew	31.01.2023
2.	Field research and analysis	28.02.2023
3.	Concept design finalisation	31.03.2023
4.	Thesis finalisation	27.04.2023

Language: English **Deadline for submission of thesis:** 08.05.2023

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TABLE OF CONTENT

List of Terminology

- TalTech - Tallinn University of Technology (Tallinna Tehnikaülikool)
- D&TF - Design And Technologie Futures (Disaini ja Tehnoloogia Tuleviku eriala)
- PMG - Pirita Economics Gymnasium (Pirita Majandusgümnaasium)
- KKHK TG - Kehtna Vocational Education Center’s Adult Highschool (Kehtna Kutsehariduskeskuse Täiskasvanute Gümnaasium)
- EDT - Estonian Drama Theatre (Eesti Draamateater)
- EDT AA - Estonian Drama Theatre audience assistant (Eesti Draamateatri publiku teenindaja)
- SM - smart textile (nutikangad)
- IM - intelligent materials (targad materjalid)
- PPE - personal protective equipment (isikukaitsevahendid)

PREFACE

Theatre productions, concerts, festivals, sports events, marathons, and basic study work at schools are all crowd gatherings, presumed to offer meaningful, good, and safe experiences to participants.

This thesis is focusing on possible solutions to help people assist crowds on small or big scales by concentrating on a design solution to make their work more effective in communication among each other and designing workwear that reflects their needs. The thesis implements human-centered design practices and merges these with smart textile and intelligent materials solutions to improve crowd manager communication among each other and via that whole service. The Design Thinking Process circles around communication and intelligent materials, the scale of the event, and crowd assistants/managers. With the support of the methodology, implementation knowledge about uniforms, and smart textile solutions, the design concept is developed.

Design proposal Kooz is a multifunctional communication support device integrated into smart workwear for people who work with large crowds to help them manage crowds more effectively. Designed together with the crowd assistant teams and participators of crowdy events with their needs in mind. Kooz digital communication system that is smart material work gear attached to workwear aims to afford fast and effective communication between crowd assistants during the event from the start to the end with stakeholders. The thesis work can be modified and scaled toward various scales of crowdy events.

Keywords: smart textiles, intelligent materials, smart workwear, smart work gear, large crowds, communication, digitalization, master thesis

1. INTRODUCTION

The roots of the original motives of this master's thesis go back in time to the period when, due to my career [1], I came across the task of creating work clothes for audience assistants at the Estonian Drama Theater in Tallinn. People who in their daily work help the audience find seats, assist, react, and help when a visitor needs help. These employees are also the hallmark of the company's customer service, being the first to greet the audience and provide supportive a customer experience around the theater production, concert, or event that people came to enjoy.

Realizing that the work clothes worn by the people who wear them daily in an honorable institution must, in addition to good looks and comfort, have many other qualities that serve the purpose of quality work in the service culture of the organization. The finished outfit, in addition to the solid and classic suit or costume, had to have varied purposes in the form of a durable and ergonomic fabric, and distinctive signs corresponding to the institution, which made the costume a recognizable common part of the EDT. While dealing with aftercare issues and observing usage, I came up with additional solution ideas that this costume could have offered more. To name a few, for example - better visibility in a dark room during the performance they assisted; an extra pocket or fastening system for phones and other extra devices used for communication between employees to be effective in their work. Therefore, the thesis concept found its first development ideas.

Returning to the motives of this master's thesis and having updated knowledge by now after intensive studies in the joint master program Design and Technology Futures at Tallinn University of Technology Department of Mechanical and Industrial Engineering, and Estonian Academy of Arts, Faculty of Design, I see opportunities to improve the topic of workwear via the example of audience assistants at the Estonian Drama Theater. As well as wider the topic around other possible usage areas. The thesis studies possible development proposals meant for employees who manage smaller or larger crowds. The solution is merged with contemporary technological advancements in the smart textiles realm that possibilities were also researched.

The study explores possible alternatives for communication besides phone and radio connection to ease the work which is usually spread out in large landscapes, spaces, or buildings.

As a designer, I see value in applying a co-design approach alongside other design thinking methods. Persons who work with smaller or larger crowds or participants in crowds themselves are experts in their own experiences and helped shape the solutions for the design proposal. Therefore, audience assistants from the EDT were included in the study as initial storytellers. The other groups who helped to shape the final proposal were the teachers and students of Pirita Economic High School (PMG) and the teachers and students of Kehtna Vocational Education Center Adult Highschool (KKHK TG). In addition, the study group includes individuals with various backgrounds of activities that all were connected to safety, large crowds, its management, or smart textiles or smart workwear. Either managers or participants of large events, both groups were in focus as they had a professional or personal connection to this study.

The study was conducted mostly in Estonia, except for one individual from Fort Worth, Texas, USA in the field of smart workwear. The whole number of partitioners who took part in the study is 79 that includes 12 EDT audience assistants, 28 Pirita Economic High School students, 10 Pirita Economic High School teachers, 10 Kehtna Vocational Education Center Adult Highschool students, 5 Kehtna Vocational Education Center Adult Highschool teachers; 4 volunteers from the large event assisting teams; 1 marathon runner with 12 years of international experience; 1 organizer of major events in Estonian Maritime Museum (Seaplane Harbour), Tallinn Treff Theatre Festival Old Town Day’s in Tallinn Festival and Saaremaa Museum; 1 Head of the Textiles Department in TalTech; 1 university professor experience of 40 years; 1 Drilling Fluids Quality Engineer in Fort Worth, Texas, USA; 1 tradeshow partitioner; 4 security team members.

A possible solution is expected as changes in communicational behavior between workers that work with large crowds, and through that in service quality.

2. TOPICALITY

2.1. Problem Space and Owners

Efficient crowd management and control are determinants of the quality of the human experience in these environmental settings, and a critical safety consideration [2].

Therefore most gatherings are secured by various kinds of security teams to support events and large gatherings. All major cultural institutions have designed the safety service around the events they present. In most cases, it is mandatory to follow the framework of laws established by the institution itself organizing the event or the regulations of the event's city [3] or the state [4].

It is generally accepted that preparation alone is not sufficient, meaning that monitoring crowds during an event and anticipating interventions remains essential [5].

We still hear documented cases, such as this recent incident at the Astroworld Festival in Texas, USA in November 2021, where a tragic event led to the death of 10 people [6]. It was obvious that the staff could not handle the situation and the communication between the stage and the audience was limited.
As well as the smaller inconvenience happened at the EDT in March 2016, when there was a power cut in the middle of the performance. A team of 29 audience assistants had to distribute overcoats to nearly 400 people and guide them safely out of the multi-story building in the darkness.

This thesis researches those people's needs who manage crowds in live gatherings. Whose fast and effective work can save lives in unknown difficulties working with crowds. The main subject observes challenges around crowd managers' communication and aims to offer more effective communication options for them and met criteria for safety.

The importance of understanding human behavior in crowds is necessary to ensure that crowd managers are properly supported in the preparation and during a crowded event [7].

The direct problem owners who are the focus of this research paper are people who work with large crowds on any scale and are in need of communication with colleagues

during an event they assist in order to deliver a safe work environment to the visitors who take part in the event. The more distant problem owners, in this case, are involved in organizations and institutions that own the event, and the distant support service teams (first aid, extra security service).

2.2. Focus Groups

People who directly assist the crowd to create a safe and pleasant environment are the main category in research as they are the ones who communicate the set of safety rules of the event to the visitors. To describe it more specifically I use often referring examples from the work of Estonian Drama Theatre audience assistants (ETD AA) as this study consists also of my personal experience of 13 years-long co-working with them in the same institution.

The EDT safety service system consists of 29 audience assistants [8]. These are workers in uniforms as audience assistants who first greet visitors in the event place and directly communicate needful information about the event as well as led the visitor to their place and deal with any kind of situations which include audience well-being (accidents or sudden health issues of the visitors when these occur). These are also the workers who are in contact with an additional security team hired by EDT or ambulance in case of need.

Other stakeholders were largely divided between two main focus areas:

- entertainment - audience managers, ticket controllers, security staff, first aid workers,
- education - teachers, lectors, professors tutors, and trainer

Figure 1. The study Groups and Stakeholders Map, created by the author.

2.3. Mindmapping Employees Who Work with Large Crowds

The direct problem owners who are the focus of this research are the people who work with and assist crowds during events for safety and a good experience. The more distant problem owners, in this case, are workers involved in more remote matters such as extra security, first aid, check-in points, and distance monitoring. The event process affects them in the case of an emergency.
I mapped the possible digital aspects to find out the possible use of intelligent materials in their work clothes. By mind mapping the possible research groups, I pointed out the tasks of the groups, which could also be the object of research into smart work clothes and be included in a possible design solution. I also grouped the tools they use to create effective security strategies. A detailed Research Groups Mind Map can be found in ***Appendix A.***

2.4. Defining Event

To define crowd gatherings in the frame of this study the term event is described as a planned gathering or an occasion that is organized by an institution or a group of people to celebrate, conduct, or led any particular happening or for the purpose of spend that moment with others in a larger social scale than only family or friends [9]. Events are classified according to the features of the event, its purpose, and the audience it is aimed at.

Included events in the paper include:

- Leisure events - held for a positive experience. For example entertainment events, musical nights, and theatre performances.
- Cultural events - events that are organized to celebrate cultural heritage and traditions. Festivals and religious occasions come into the category of cultural events as well. Although religious occasions are not mentioned in this paper.
- Sports events - held for evaluating, presenting, and measuring physical achievements.
- Organizational events - well-organized systematic gatherings that have a specific agenda and interests that are either commercial, sales-driven, political, educational, etc. For example political events, product launches, fundraising, corporate events, and educational events.
- Schoolwork has been considered within the framework of this research as a small-scale public gathering.

- Economic events connected with financial rise. For example events for aiming up marketing and sales, trade shows, grand openings, charity or fundraising, product launches, and events to increase productivity.

Another classification of the event was not researched in this study, although the character of the event allows adaptation of the study design solution on them are:

- Personal events on a large scale - events that are held on every personal level for family and friends. For example birthday parties, wedding events, and anniversaries.

2.4.1. The Scale of The Event

This research reflects experiences from diverse event sizes that population varies from a high school class of 28 students to the Moscow Marathon with approx 50,000+ participants. The design solution is co-designed with people who manage crowd sizes of 28 - 400 people. Final design solution use cases include an event crowd size of 7000 people.

2.5. Event Management

Event management is understood in the research as the process of planning, organizing, decision-making, coordinating, and controlling the human resources, financial, physical, and information resources of an organization to reach its goals efficiently and effectively [9].

Event management as the application of project management that creates and develops small or large-scale events itself is not the primary subject in the study. The design solution is hoped to be adaptable to many existing event management systems but it is referred to and explained as needed. The areas this research includes are event management subjects like coordinating the event staff, planning the logistics, and identifying the audience.

The study describes how to meet large crowd management needs in an integrated framework that details the development of an event management support system.

Crowd management in a broader perspective and crowd psychology is not directly the subject of this research paper but is referenced where necessary.

2.6. Other Areas of the Topic

As a design solution to the study, it is hoped to find a development that combines the achievements of modern workwear and contemporary textile technology, using smart textiles [10], and intelligent materials [11].

Therefore the research is dedicated to finding the benefit of smart textiles and intelligent materials for people who work with large crowds. The aim is to create an efficient application in workwear for communication in crowd management.

The research examines uniforms, intelligent materials, the compatibility of clothing as a means of communication in a defined area of space, and its design and use.

The uniforms are discussed in the environments in which they are exposed to the management of large numbers of people. Different types of possible situations are analyzed in which the work of people who work with large crowds would be facilitated by interactive workwear in order to guide and ensure the safety of crowds. In addition, the possibilities of integrating different means of communication in the development of interactive fibers and fabrics for workwear will be in focus. Setting up new options of communication in the event management groups the resulting positive impact is expected more effective and cohesive behavior during any event. The whole design process was evaluated from the point of view of sustainability in mind *(Figure 2).*

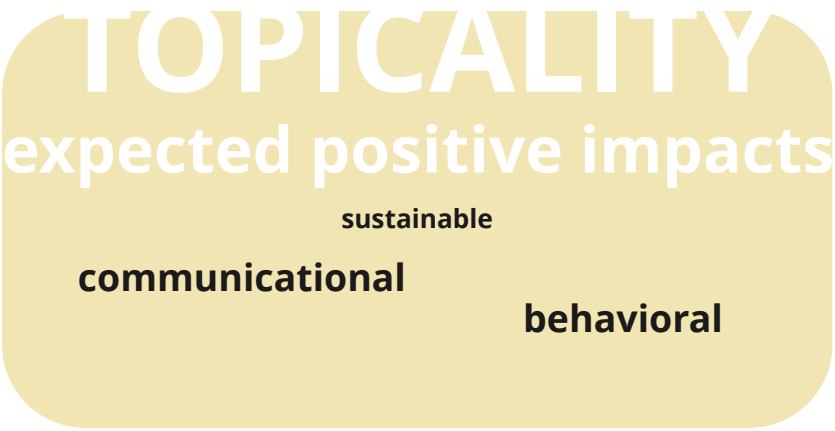


Figure 2.

The expected areas the research design solution could impact positively, created by the author.

3. METHODOLOGY

The thesis methodology demonstrates concepts of the used design approaches. Empirical research based on verified evidence is the overall approach and consists of the following main building blocks such as observation, induction, deduction, prototyping, testing, and evaluation. Empirical research methods such as observations, semi-structured, interviews, focus interviews, and co-design workshops are used to understand different aspects of the subject [12].

3.1. Process Methodology

The design process methods were evolving during the study as the process naturally took its thrive toward more complexity. Therefore using not one method but 3 along the learning process together were used in this process.
The design process was initially started with the **Double Diamond Model** *(Figure 3)* in mind as it seemed to serve its purpose to have all qualities for a framework for the vast research process ahead [13].

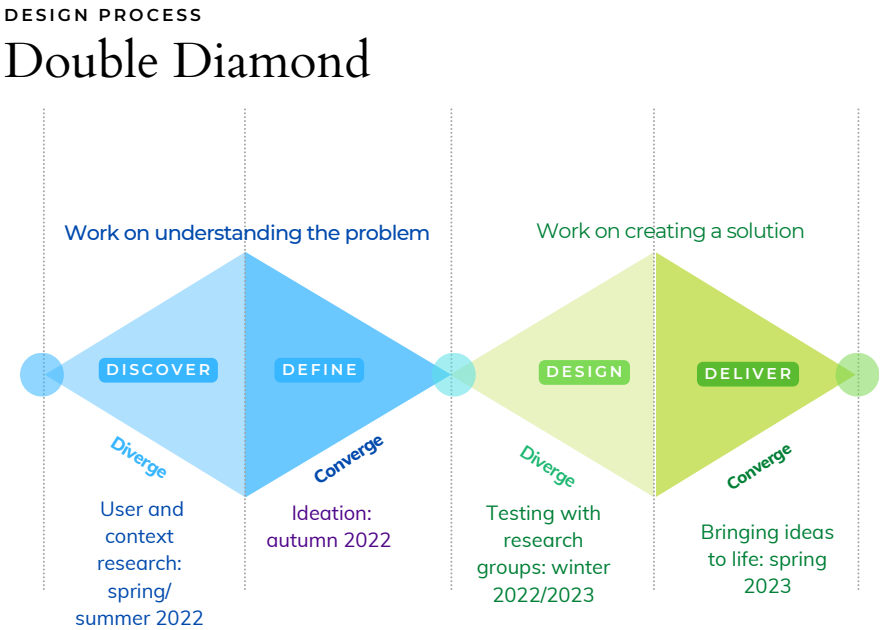


Figure 3. Double Diamond Model, created by the Design Council, modified by the author.

Areas of divergence in the diamond model visualize the exploration and all topics to be included in research while convergence refers to taking focused action based on prior research activity. As well as getting to know the users and finding out their needs. The following definition phase included ideation and arose of selection of the first possible ideas.

As the research developed **The Design Thinking Process** [14] with its five steps of Empathize, Define, Ideate, Prototype, and Test were included parallelly as the process tended to be nonlinear *(Figure 4)*. And the actual action framework the Double Diamond Model Stayed more like the backup model to return from time to time to evaluate the position in the study process. The movement back and forth between the stages was frequently experienced. Returning to the Empathize phase and carrying the insights and learnings was part of the designing process for crowd workers.

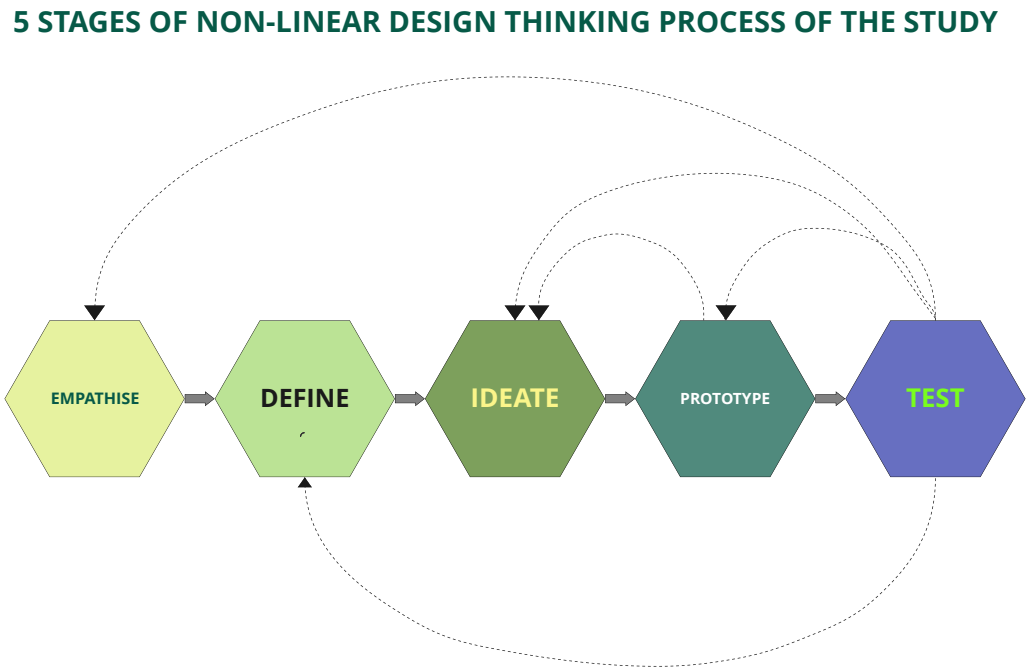


Figure 4. Five Steps of The Design Thinking Process Model, created by H.Plattner, modified by the author.

Developing the process, however, a more accurate representation of the process can be shown through the **Constructive Design Research Model** [15], useful to keep track of the activities by mapping them and organizing the whole process in one bigger structure *(Figure 5).* A more detailed matrix can be found in ***Appendix B***.

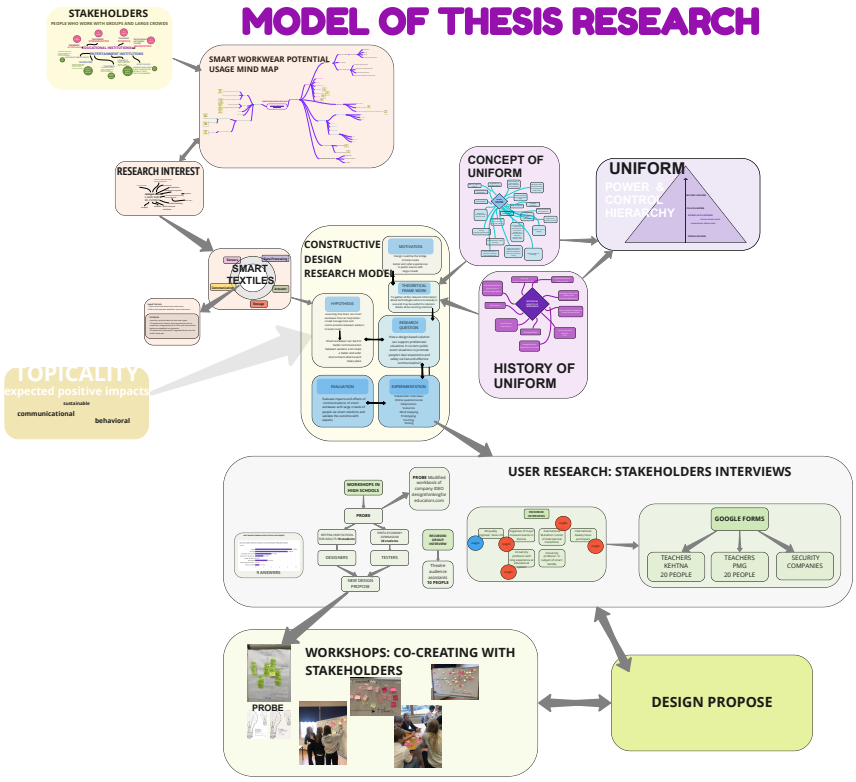


Figure 5. Constructive Design Research Model, created by Bang et al., modified by the author.

The core concept in the Constructive Design Research Model remained solid during the research process and gave the confidence to build the study system around it.

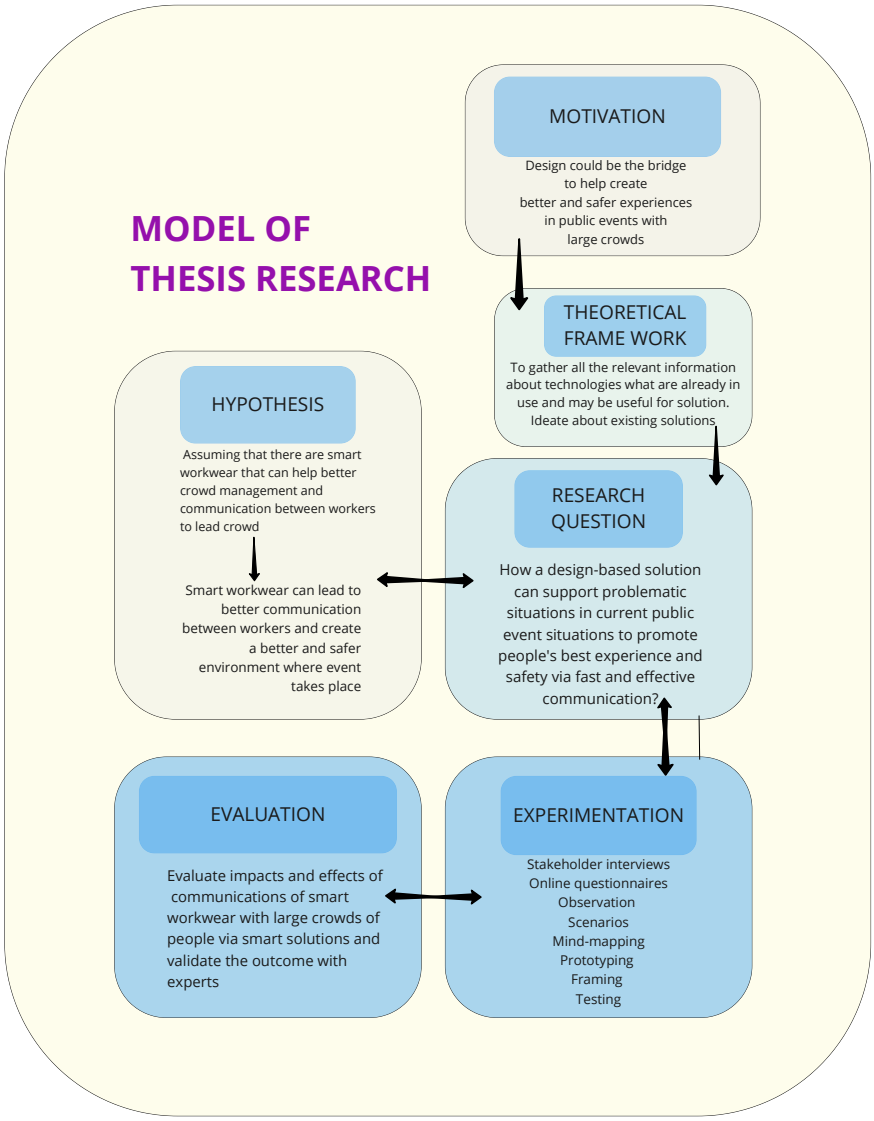


Figure 6. The Core of the Constructive Design Research Model, created by Bang et al., modified by the author.

3.2. Research Methods

In addition to desk research, the main research methods include primary data collection obtaining information directly from the original sources. These primary sources of data collection varied depending on the research subject's ankle as it had many sub-themes to concentrate on.

Secondary data collection is referred to in the study as information gathered from previous experience co-working with EDT audience assistants previously.
In the field of smart textile research, and workwear history, references are presented.
Follow-up interviews and feedback sessions were conducted during the design development phase at the end of the study to improve the solution. This period also included co-design sessions to develop, validate, and improve the concept. All methods are described in the following part.

3.2.1. Desktop Reserch

The analysis of the desk research informed the following qualitative research process. It provided understanding and introduction to the smart textiles and overall intelligent materials topic, including the work which has been done in regions of the European Union, USA, and Asia.
Another inquiry took place on the subject of uniforms - the concept of uniforms, and its historical tendencies were studied. As well as the role uniform plays in public life and private experience in the current moment. The social meaning of uniform in the military, in institutions, in political movements, in the workplace, and in history were the themes and factors in focus that were taken into consideration while moving forward with the study.
The third theme in the desktop study was events and their classification gave the overall scope of this research scale.

3.2.2. Observations

As mentioned, many years of co-working with audience assistants in the same institution Estonian Drama Theatre, and designing the uniform for them as the head designer was the pre-period and secondary data collection time of this study. This time gave an idea of which are these workers' actual needs in order to deliver good customer service. Other observations continued during the study with the following public events like the SEB Spring Marathon in Tallinn, visiting summer and on-place theatre projects, concerts, and festivals. Observations in both high schools PMG and KKHK TG were taken parallelly with co-design sessions during the research process.

3.2.3. Focus Group Interviews

The first research interview method was conducting focus group interviews, which involved a group of audience assistants interviewed at the same time to gain insights

into comparing complementary perspectives. Another reason for that was that focus group participants responded more comfortably and naturally, as the group setting made them feel more supported by each other. Three sets of focus group interviews were conducted. The first set was during the defining phase of the topic, the second set was during the prototyping to add as comprehensive a design solution offer as possible, and the third in the testing phase was to improve the fundamental design challenge, and focused on a viable solution. 15 people participated in this process, lasting 1-1,5 hours.

3.2.4. Qualitative Semi-Structured Interviews

The semi-structured interview method combines pieces of both structured and unstructured interviews and was used mostly on one-on-one interview occasions. Although I as the interviewer followed a general plan and set of questions, often provided the flexibility to make changes as the subject took a turn or brought a new aspect to the theme. This created a more informal atmosphere and helped to get the data that was necessary for research in a more natural manner. 14 people participated in it and that lasted about half an hour each. The interviews aimed to get information that could be analyzed and generalized.

3.2.5. Personal Interview

A one-on-one interaction between me and an interviewee took place several times and helped to gather a direct personal significant amount of accurate data. In the personal interviews, the main focus was on getting as many different perspectives on the topic as possible, in order to get a broad-based result both in understanding the needs of users and in offering a design solution. The number of participants is 10. The length varied from 30 min to 1,5 hours.

3.2.6 Online Interview

Some personal interviews were held as online interviews and provided the option for me and the interviewees to not be in the same location at the same time. This allowed me to collect data from the long-distance interviews. And include one individual from Texas, USA in the research. 4 people participated online and each lasted about half to an hour.

3.2.7 Online Questionnaires

Online questionnaires were held in the beginning mostly to understand the user needs and general emotions surrounding the subject. Also, this provided fast insights into the smart-wear subject and how familiar people are with it. This was also a good way to gain access to a range of research subjects to validate initial assumptions before conducting interviews. All together took part in surveys 23 people

3.2.8. Co-design Workshops

The co-design sessions were used to develop, refine, and later test the intended design concept [16]. The first workshops were used to generate a concept format and generate ideas with stakeholders. Later in the testing phase, the concept was presented to various potential users. A potential user journey was created in advance and walked through with the participant. They provided feedback on what features of the concept and how they would use, what was not necessary for them, and what was missing or out of line. They were asked to conclude how the proposed solution made them feel and whether they thought it would be useful. In the co-design workshops, the Design Thinking for Educators - the workbook of the design company Ideo - a free resource for educational purposes was used to introduce the concept of design thinking [17].

3.2.9. Framing

The method of framing was used to get more creative with regard to the process of accessing the problem and what we wanted to create. Questions such as: what should be the ultimate outcome; which problems am I trying to solve; what will be the meaning that I want to incorporate in the solution; were the questions to clarify the subject.

3.2.10. Personas

Personas as fictional stakeholder characters, which are created based on research in order to represent the different user types.

3.2.11. Use Cases

Use cases were created during workshops and testing to explain and measure a imagine possible situations and ideation of possible outcomes and solutions.

3.2.12 User Journey Mapping

User Journey Mapping is used to understand and visualize the touchpoints, actors, and interactions throughout the user journey. Mapping the journey is key to creating an understanding of the problematic points and what are the causes of these highlighted issues. User journey mapping helped to see both smaller pain points as well as lays out the bigger system which gives an opportunity to make across-journey changes.

3.3. Research question

The starting point of the initial research was thrived by the vast assumption that the design and technology could be the bridges to help create better and safer experiences in public events with a large crowd. Accompanied by the overarching question of how to improve the previous experience of creating the workwear in the EDT to a better, more effective more up-to-date version using contemporary smart materials. I turned back to the people for whom I first created the uniforms as I needed deeply understand these workers' needs and perspectives on the subject that guarantees visitors' safety in the EDT. After the first focus group interview session with EDT, audience assistants became more clear about the ecosystem around the subject.

The knowledge was analyzed and the concept was presented during the interview with Tiiu Plamus, Head of the TalTech Textiles Department TalTech who insured my assumptions that smart technology could give solutions for communications between workers. She directed me toward the already existing solutions co-created by Taltech Textiles Department - Ragnarok Workwear 2.0 [18] which is a smart suit for workers and supervisors exposed to high-risk working environments which prototype has been developed in cooperation with the Taltech Department of Health Technology Sensor Technologies in Biomedical Engineering, and the Department of Computer Systems and Protex Balti AS, Estonian ICT Cluster, and Smart Electronics Cluster ESTRONICS companies. The workwear has been developed in close collaboration with the aquaculture industry of Norway.

Ragnarok 2.0 offers: fall detection; monitoring vital signs; activity monitoring; GPS positioning, and tracking; safety light; speech-to-text notes; recording speech; and saving it as voice clips or text [18].

Accompanied by another desktop research about protective clothing for firefighters [19] suggested by Professor Plamus significant certainty was created for further developments to form in research questions. All the relevant information about technologies that are already in use in smart textile technologies may be useful for the design solution.

With all the information gathered during these research sessions, the following research question was formed based on the gained information:

How can a design-based solution support problematic situations in public events to guarantee people's best experience and safety via fast and effective communication?

3.4. Hypothesis

The research hypothesis assumes that the integration of advanced solutions in smart textiles technologies to crowd assistants workwear can help crowd assistants manage crowds more effectively.

Smart workwear can lead to better communication between workers and create a safer environment where the event takes place conducting in-depth research on the industry and its processes by involving them in co-designing for the communication support service.

3.5. Research Process and Schedule

The research overall period was from September 2021 until April 2023 but was divided into two sessions Sept-May 2022 and Dec 2022 - May 2023 including a break between for personal reasons. The first collaboration for this research with EDT audience assistants began in early October 2021 but overall secondary data collection is referred to in the study as information gathered from previous experience working with audience assistance from 2005-2018 during my position as head artist for ETD. Stakeholder interviews were held across the period including the break period.

Collaboration with PMG and KKHK TG took place in Oct 2021 and Jan-March 2022 and consisted of co-design sessions.

4. BACKGROUND RESEARCH

Next, my research involved background studies in topics hoped to involve in the design solution:

- Understanding the general concept of workwear led back to the concept of uniform and its history.
- Researching the field of smart textiles and the general field of intelligent materials with the aim of incorporating them as an approach to design was the second branch of the study.

4.1. Historical Concept of Uniform

A uniform is a special form of clothing that marks status more visibly than other forms of dress. It represents the power and control of the institution that sets it to work — it is one part of the whole aesthetic system to regulate environments. The way a person's costume represents a person's belief system and how they relate to the world. We can glean information about social status, beliefs or non-beliefs, and political, economic, and cultural views from clothing. Work clothes are one part of the entire aesthetic system that regulates work environments [21].

Uniform work clothes represent the power and control of the institution that implements it. Work clothes are one part of the entire aesthetic system that regulates work environments. In the 19th century and with the rise of modern industrial societies, mass production techniques promoted uniformity and became part of modern culture. The uniform changed from a garment that created a spectacle of mass bodies to one that allowed them to be nationally monitored and even more regulated. Since the middle of the 20th century, work and leisure uniforms have been in use in public life [20], [21].

Historically, officials in military, police, and colonial uniforms were useful in asserting imperial power. In various institutions, uniformity promotes ideas of order, stability, and discipline, but in the colonial context, uniforms had a more precise meaning. In particular, the colonial policeman combined military and civilian roles to become the most visible symbol of colonial power. Uniforms clearly highlighted social class differences in the workplace, and employers were convinced of their value in creating a corporate identity [21].

Figure 7. Historical Aspects of the Uniform Map, created by the author.

4.2. Contemporary Uniform

Workplace uniforms and dress codes were and still are used as a form of social control to indicate rank in organizational hierarchies. The true meaning of modern uniforms lies in the aesthetics of standardization and the attention it brings to the worker's body; it shows a corporate culture that wants to protect reputation and authority. Uniforms are rarely neutral – ideas of honesty, authority, and power are woven into different types of uniforms. Uniforms are now associated with reputation management and brand identity. In an effort to create a science of corporate identity management, many companies have looked to aesthetics to embody their desired corporate image. Employees are shaped and transformed by clothing, grooming, and behavior management to realize the corporate aesthetic. And it raises new questions about the uniform in the corporate environment, which signifies power and control over the micro-territory of the worker's body, turning workers into symbol bearers of the organization. Including the suppression of individual identity through official attempts to hide aspects of gender, sexuality, or race in the workplace. These frequent controversies over workplace dress codes challenge the notion that a uniform is an

idealized form of clothing, with the psychological aspects of belonging combined with symbolism that supports an institution or brand, or identity [21], [22].

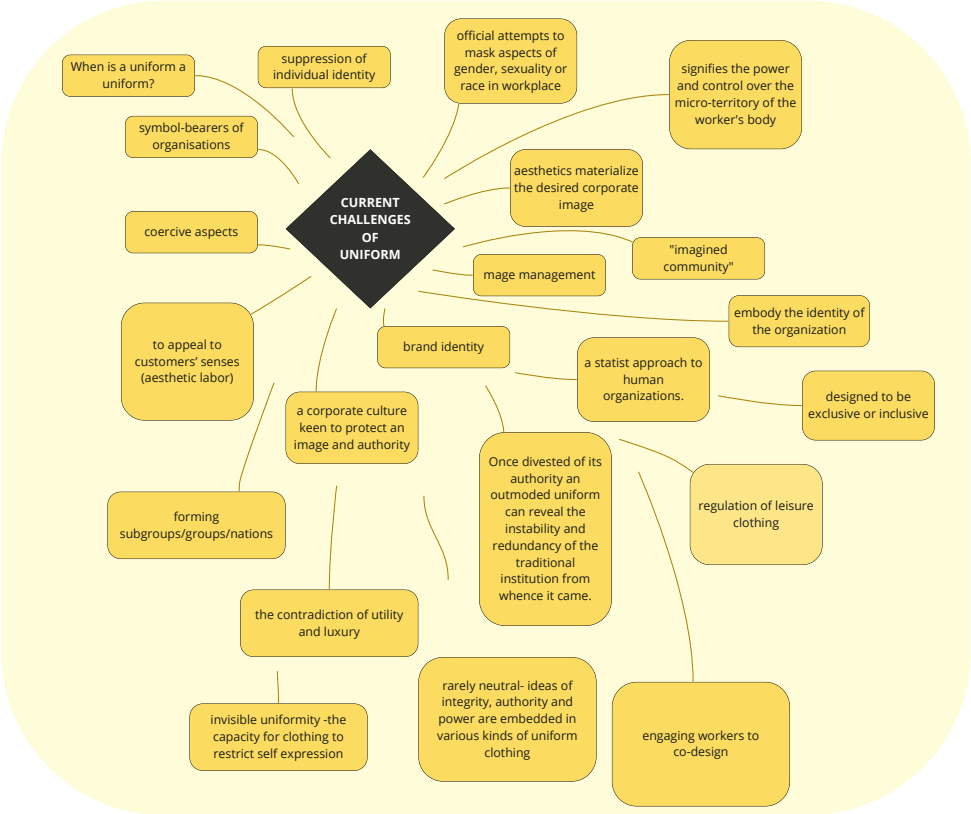


Figure 8. The Socio-Political Implications of the Current Uniform, created by the author.

Regulated clothing is designed to control the wearer. Uniforms can also signify the wearer`s lack of power as the prison uniform reveals. Prison uniform has been a critical part of the system to control inmates to project the power of the penal establishment on the incarcerated body through reform and humiliation [21].

I mapped the location of the workwear, and dress code, on the uniform hierarchical map, based on how much power one or another uniform has in society, assuming the military has the most power and the least power have prisoners. In the military context uniform confers on the wearer the power to perform statehood, but in prison regulation, clothing marks the body as state property. The police uniform is caught between the two: conceived to balance the demand for social control with the needs of public service, the idea of the uniformed constable was conceived to visibly perform state power while also making them subject to scrutiny by the public and the authorities. The map shows the location of the workwear, and dress code, on the uniform hierarchical map, based on how much power one or another uniform has in

society, assuming the military has the most power and the least power have prisoners. In the military context uniform confers on the wearer the power to perform statehood, but in prison regulation, clothing marks the body as state property. The police uniform is caught between the two: conceived to balance the demand for social control with the needs of public service.

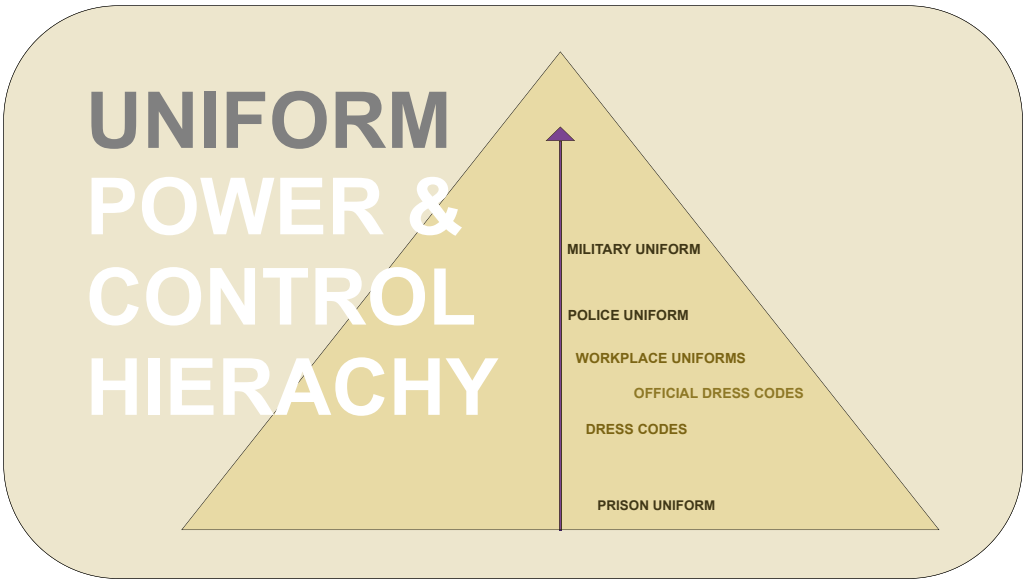


Figure 9. The Uniform Authority Hierarchy Map, created by the author.

4.3. Conclusion from Concept of Uniform

Positive aspects of uniform	Negative aspect of uniform
engaging workers to co-design	coercive
supports and communicates brand identity	suppression of individual identity
helps identify employee	hierarchic, rarely neutral
appeal customers' senses - aesthetic labor	signifies the power and control over the micro-territory of the worker's body

Table 1. Positive and Negative Aspects of Uniform by the author.

4.4. Difference Between Uniform And Workwear

The main difference between workwear and the uniform for a workplace is that workwear could be a dress code supporting a person's individuality.
A dress code is a set of criteria set by business management for dressing in formal, semi-formal, or casual work attire or in according to tasks.
Uniformity is important for recognizability and safety to conduct and provide certain services. The purpose of identification for other people to reach out to them without confusion is the main factor in these cases.
The workwear, uniform, and dress code have their specialized utility depending upon the work environment they work in [21].

Uniform	Workwear
Uniforms make the workers stand out in a crowd, and they are easy to recognize when needed.	The workwear dress code is a flexible option for the employee without enforcing uniformity. They can choose to wear an outfit within the set premise of the the company.
Uniform is a part of the brand identity of business to work for.	A semi-formal dress code helps develop a more flexible work culture and supports individuality.
Uniform provides a sense of collectivism in a team and helps develop a subculture of unity.	The workwear dress code provides the sense of corporation and outlook of a collective yet diverse work environment.
Uniform supports the feeling of pride within the team having a specified identity.	Workwear dress code enables the employee to express his/her personality.

Table 2. Difference Between Uniform and Workwear by the author.

4.5. Smart Textile Definition

Smart textiles also called smart garments or fabrics, have a digital component embedded in them. The technology is incorporated into the fabric through various methods, such as conductive fibers or multilayer 3D printing. The finished structure can be further modified by lamination, coating, and composite methods. Depending on the application, smart fabrics are created from the fusion of fibers and technology. Smart textiles are manufactured and designed to integrate technologies that offer the user greater functionality. The purpose of smart fabrics is to provide added value to

the user, whether for pleasure, performance, or safety. In other words, smart textiles are computer systems that have five functions: sensors, data processing, actuators, storage, and communication. The heightened use of smart fabric is seen in medicine, entertainment, fashion and footwear, sports and fitness, military, safety, and transportation [23].

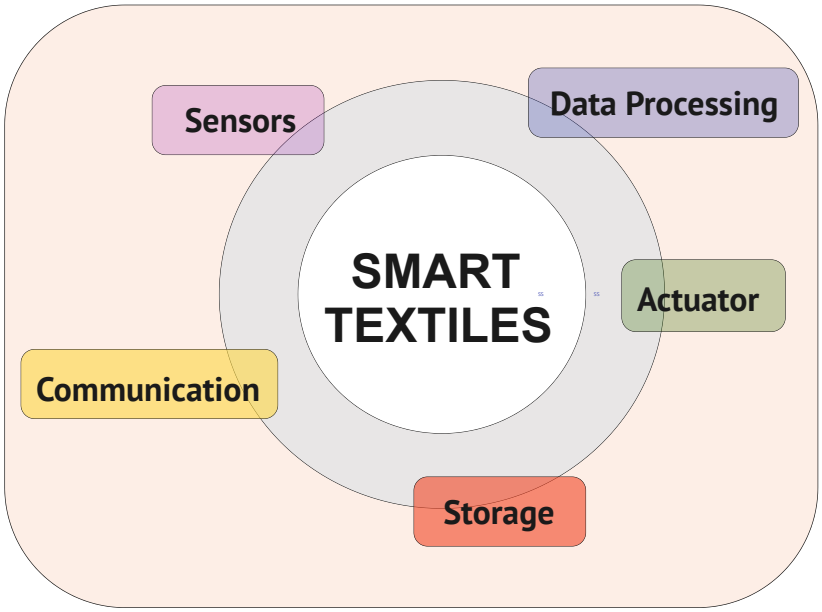


Figure 10. Smart Textile Function Map, created by D.C. Çelikel [27], modified by the author.

4.6. Types of Smart Textiles and Terminology

Boardly smart materials can be divided according to the reaction method into four categories:

- Passive smart materials that primarily sense environmental conditions or stimuli are sensor-based like in UV-protecting, plasma-treated, and waterproof clothing.
- Active smart textiles are able to sense the stimuli from the environment and respond to them. For example, phase-change materials, shape-memory materials, and heat-sensitive dyes.
- Intelligent textiles/materials or sometimes called ultra-smart materials are materials, and structures that can react, sense, monitor, and adapt according to the stimuli and be manually or pre-programmed to perform functions. And give a response to environmental conditions, such as thermal, mechanical, chemical, magnetic, or other

sources. For example, spacesuits, musical jackets, and wearable computers are ultra-smart materials [24].

Via sensors smart textiles are composited they can be divided into:

- **Thermal sensors** detect and collect energy from a heat change, such as a thermistor, which changes resistance due to the heat change.
- **Light sensors** convert light energy into a voltage output, for example, photoresistors.
- **Audio sensors** convert sound into an electrical signal.
- **Humidity sensors** measure absolute or relative humidity.
- **Pressure sensors** convert pressure to an electrical signal. A pressure sensor can be based on operations such as opening or closing a circuit. But also be more sophisticated forms like capacitive or piezoelectric phenomena.
- **Strain sensors** convert strain into an electrical signal and be based on semiconducting materials, strain-sensing structures, or piezoelectric effects.
- **Chemical sensors** are a series of sensors that detect the presence and/or concentration of chemicals.
- **Biosensors** sense biological elements which respond with a property change to an input analyte, for example, the blood glucose levels [25], [26], [27].

An **electronic textile or e-textile** is a fabric that is able to conduct electricity. Combined with electronic components it can sense changes in its environment and respond by giving off light, sound, or radio waves. E-textiles are fabrics that enable digital components such as a battery, lights, sensors, and other electronic components to be embedded into them. Electronic textiles have its root a long time back with the use of conductive materials such as gold or silver in the yarns of the fabric usually around the core of the yarn, but without electricity, it was mainly used for aesthetic purposes. This started the trend towards incorporating more and more minuscule conducting materials into the yarns to make the textile wearable and capable of conducting electricity without harming the wearer. We all know that to complete an electronic circuit a power source is also needed. As of now the most common source of power supply has been through an external battery, but the upcoming technology is planning to harvest energy from multiple sources such as wind, rain, and human movement making the electronic sensors self-powered. All these modifications have one thing in common that is they are designed to be worn without any uncomfortable feeling to the wearer [27].

Nanotextiles are textiles made of small particles that give conventional materials properties such as superhydrophobicity, odor, moisture elimination, increased elasticity

and strength, and resistance to bacteria. Depending on the research focus, a nano fabric can be made from nanofibers, or a solution containing nanoparticles is applied to a fabric. Research on nano fabrics includes biotechnology, molecular chemistry, physics, electrical engineering, computer science, and systems engineering [28].

Biofabricated textiles are materials grown from live microorganisms, such as bacteria, yeast, algae, and fungi root structures. These organisms are fed using substrates turning them into biological fiber factories. Biotextiles include implantable devices such as surgical sutures, hernia repair fabrics, artery grafts, artificial skin, and parts of artificial hearts [29].

Photonic textiles can emit light. They incorporate polymeric optical fibers (POFs), light-emitting diodes (LEDs), and sensors and controls that enable users to interactively personalize their garments and environment by changing the colors, patterns, and emission frequency of the emitted light and creating the possibility of intelligent display for new options of communication [30].

4.7. Examples of Existing Smart Workwear Solutions

Smart workwear potential including wearable technology is a large area. Personal protective equipment is becoming more accessible in everyday work and offers benefits to workers worldwide by enhancing existing safety features. Manufacturers are rapidly developing and employers are adopting smart or intelligent personal protective equipment (PPE), driven by the constant search for better occupational safety solutions. The benefits of smart PPE can allow site managers to know where their workers are and if they are protected and safe. Smart PPE can warn beforehand of potential hazards that could lead to injury.

Some examples of smart workwear:

- Smart eye protection gives access to data and improves communication and connection with workers. A screen on the lens allows information to be visualized on the surface while worn, allowing users to access sensor data. The display can warn the user of dangers and provide him with needed information.
- Smart helmets use meta sensors to assess situations, providing information and greatly improving their protective function. Integrated accelerometers can detect collisions, free fall, and sudden immobility, while others such as temperature, humidity, and ambient brightness sensors improve communication.

- Smart gloves can integrate Near Field Communication (NFC) chips, allowing users to access information through their digital devices. The gloves can be customized to regulate access to machinery or infrastructure.
- Smart safety shoes use insoles containing smart chips that can detect and assess dangerous situations, such as the risk of slipping, alert the wearer and allow other workers to avoid stress-free. Safety-related features of the footwear can be identified and movement information is collected using intelligent sensors to actively detect potential damage and loss of safety features. For example, the wearer may be notified that their boots were not properly fastened or that they are defective [31].

5. PARTICIPATORY RESEARCH

Participatory research began with questionnaires and semi-structured interviews with crowd event safety volunteers, teachers, and EDT audience assistants.
Questionnaires and semi-structured interviews include questions about current issues related to work clothes, and the main form of qualitative data collection was to highlight problematic aspects of working with crowds. Key recurring findings from the interviews are summarized by deductive reasoning conclusion at the end of the chapter. The structure of the interviews has been prepared in advance but adapted by follow-up questions that organically occurred and developed the theme of the conversation. The purpose of the interviews was to support creativity in the idea-generation process of the project by generating a large number of useful information from the stakeholders, which was then filtered out according to the hypothesis into the, most practical or innovative ones. The purpose of the project is always explained either before the questionnaire or at the beginning of recording the interviews. All interviews are conducted anonymously to protect the individual's personal information, and only their job or activity title is provided.

The decision not to include the interviews in the appendix is based on the fact that the interview data has been analyzed immediately and their different perspectives on the topic have been highlighted.

5.1. Event Safety Volunteer Interviews

Four large outdoor event safety volunteer interviews were conducted (2 men, and 2 women). All of them set up face-to-face physical meeting sessions. All the interviews lasted around 40 minutes to 1 hour. The questions were divided into individual

experience questions and overall questions about communication and management problems and existing workwear.

All four participants highlighted the need for a uniform in addition to comfort, it should conform to the wearer's body and have plenty of fasteners and pockets to carry everything they need for their work. Extra work equipment was needed, the participants listed the following: a radio transmitter (sometimes there was even a need for two of them), a mobile phone, a loudspeaker, special tools for the task included including a screwdriver, a water bottle, charging cables for the phone. When asked how they communicate with colleagues who are further away, the participants mentioned mobile phones, radio transmitters, loudspeakers, hand signals, SMS, Messenger, or some other app that provides calls.

The disadvantages of work clothes were pointed out that they always are not breathable as the materials are made from and sometimes, can be uncomfortable and clumsy. Also, they do not look good on everybody as the object of standardization the uniform is it can´t provide quality to fit everyone.

All the participants were very open to the possibilities of smart textiles that I presented to make their work clothes lighter and easier to manage and supported the idea that communication wise the work gear should be improved. The existing solutions were difficult, clumsy, and sometimes ineffective.

Main takeaways:

- **The importance of comfort - to have less work gear that is bulk and needs an extra fastening system or pocket or hand. Workwear should fit the wearer's body.**
- **The importance of having a quick and effective cleaning method.**
- **To have enough fasteners and pockets to carry everything you need for work.**
- **For remote communication with colleagues, participants mentioned mobile phones, walkie-talkies, loudspeakers, hand signals, SMS, Messenger, or another app that allows calls.**
- **It is essential to have a clear communication system between workers. All team members should know where they are supposed to be and when they should be there and the communication should be effective and on time.**
- **Communication tools to be used during the event should be common for everybody. Having common tools will be an invaluable resource during the event for communication with colleagues and stakeholders.**

5.2. PMG Teachers’ Questionnaires

Next, I contacted and prepared a survey for the teachers of Pirita Economic High School, who in the research represent the part of the employees who work with smaller crowds on a daily basis. The research sought to find out how workwear design could benefit those who work with smaller numbers of people. I concentrated on finding out the teachers' pain points and needs for work clothes. Also, identify how the need for work clothes differs from the large crowds’ of employees. A total of 10 teachers, 6 women, and 4 men, answered the first set of questionnaires.

On the topic of work clothes and their needs, it was highlighted that there should be pockets or attachments for all the necessary things that teachers have to carry with them (phones, keys, textbooks, and other teaching materials when moving from one class to another), card (proof of employment), chalk, wallet, writing instrument, notebook, pen, felt-tip pen, stopwatch, handbag).

Two out of ten people stated that school teachers could have their own work uniform, as the majority did not prefer or did saw the need for a uniform. However, they noted, that there should be special solutions for carrying communication tools and other work tools. The questions revealed the means of communication that teachers use to communicate with each other at school. To do this, teachers use social media apps, email, phone calls, SMS, and face-to-face meetings. The physical education teacher added knocking-whistling and pointed out that SOS (three short and three long equals SOS, save our souls) signals are an important form of communication. Teachers did not see the need in their everyday work wear for communication with other colleagues but 7 out of 10 stated that extra communication device between teachers is needed in case of activities outside the schoolhouse. For example museum visits, and hikes, gatherings outside in nature. The physical activity teacher was most interested in having extra help from smart solutions in her workwear. She offered that in run training in Pirita forest, it would be great to track students in their way and know where each person is. All partitioners stated that teacher workwear should be good-looking and comfortable and easy to manage in means of cleaning and wrinkling.

Main takeaways:

- **should be pockets or attachments in workwear for all the necessary work tools and communication tools;**
- **teachers use social media apps, email, phone calls, SMS, and face-to-face meetings;**

- **extra communication device between teachers is needed in case of activities outside the schoolhouse;**
- **workwear should be good-looking and comfortable and easy to manage in means of cleaning and wrinkling.**

5.3. Interviews with the EDT Audience Assistants

Semy-structured group interviews with audience assistants gave insights that helped conclude the previous ideas that I already had with working with them before. The first meeting had 12 people and the age included a range of 47-78 years old women. First and most important for audience assistants to work in a venerable historical institution like the Estonian Drama Theater is in the context of Estonia that they gain self-confidence and comfort through the work uniform is good-looking and fits their body shape. They pointed out that they occasionally bring flowers brought by the audience to the stage and are the center of attention. Work clothes should also be easy and quick to maintain, as they are used almost every night but as it is 3 piece set (blazer, blouse, skirt) then the cleaning is time-consuming and sometimes they need to wear an unclean uniform as the other set isn't back from maintenance. Dry cleaning tends to worn-out the fabric fast and is not sustainable in its nature. They also considered it important to be able to move freely and quickly in the uniform, since work in large theatre buildings is done on a rotating basis, and in the case of working in the wardrobe, free movement is needed to receive and return people's outerwear. Attendants use phones to communicate with each other. The phones in themselves as a means of communication were considered problematic by audience assistants, pointing out several shortcomings in it. For example, the line is blocked at the moment of need; they forget to turn the phone off during the performance and make unnecessary noise; there is no coverage everywhere in the big old historic house, especially when working in a small hall on the 4th floor of a building.
They pointed out 3 main essential connections they need during work:
- The connection between colleagues at the event site.
- The connection to the security team.
- The connection to first aid.

Main takeaways:

- **To gain self-confidence and comfort through the work uniform is good-looking and fits their body shape.**

- **They also considered it important to be able to move freely and quickly in the uniform.**
- **Work clothes should also be easy and quick to maintain, as they are used almost every night.**
- **It is time-consuming to clean the whole set of workwear in dry cleaning tends to worn-out the fabric fast and is not sustainable in its nature.**
- **The phones as communication tools were considered ineffective.**
- **The need for connection between colleagues at the event site.**
- **The need for connection to the security team.**
- **The need for connection to first aid.**

5.4. Observations of the Summer Events

I observed events during the research process in the spring-summer of 2022. St John's Day was the biggest of them. Music concert Nick Cave & The Bad Seeds in Haabsalu, and Tallinn Marathon in Tallinn were other events I consciously observed. I was paying attention to event structure and safety solutions and of cause mainly what workwear and work gear organizers wore as the events provided a good opportunity to observe. This is not extensively covered in this thesis but provided a backdrop for the process.

Main takeaways:

- **For communication is used using two-way radios, and mobile phones. Organizers provided earpieces in the particularly noisy event areas. Obviously, people who use them were trained previously in the use of communication systems.**
- **It was visible who was in charge, and who is providing information and instructions (via radio, mobile phone, in person, etc) because of recognizable workwear or sometimes sign-in clothes, and work gear.**
- **Useful information was presented in terms to ensure that all parties are able to interpret the information in the same way.**
- **Public information is an important aspect and it was displayed to the audience during the event. Announcements were reinforced by message displays. Important messages were repeated to the audience in an advised manner.**
- **For some parts of the Tallinn Marathon distance, a supportive team or signage was not available and it raised concerns.**

5.5. Online Interviews with the Drilling Fluids Quality Engineer

A drilling fluids engineer with the drilling fluids quality engineer from Fort Worth, Texas, USA means the person who tests the quality of any fluids that would be used to either drill an oil well or test the actual oil that is coming from the well. The interview was conducted with the aim of getting direct feedback from the user of smart workwear. Oil rigs are dangerous places and not open to large crowds. They can accommodate a certain number of workers at a time and mandatory precautions are taken before entering. The dangers would be poisonous gases and falling parts from oil rigs and actual fire. Everything that is dealt with on oil rigs is very flammable. Probably the largest disaster in the United States, that has happened was the Deep Water Horizon catastrophe [32]. That was an offshore platform where several lives were lost due to a fire. Also, it was due to miscommunication between people, the mainland office, the off-shore office, and the drilling areas. The Deep Water Horizon incident offshore on very large platforms had different functions located on it. Different rooms, and office areas, and these were enclosed areas. In this particular area, a drilling rig was troubled and set on fire. Additional poisonous gas made everything much more dangerous. That could have saved people's lives if the communication devices would have been better and faster according to the interviewee.

Workers on rigs work from 6:00 AM to 6:00 PM and that shift is called the tower. And then the second tower comes on and they work from 6:00 PM to 6:00 AM. And that means around 100 hundred people in one location at any given time are on an oil rig. In the context of this research, we can consider it medium crowd gathering.

The presence of smart workwear and proper wearing of protective equipment and the charge of their batteries are checked daily basis. Due to health-hazardous factors, protective suits are made of non-flammable fire-resistant material. Fire-resistant clothing is probably the first and foremost layer of protection as on oil rigs are a lot of flammable themes. Everything is powered by diesel the drilling fluids in use are flammable. The majority of the drilling fluids that we use are oil-based products. Cotton workwear is layered with non-flammable chemicals and has to send it back in to have the chemicals reapply on it every week.

A device monitor that measures the number of dangerous gases in the air or alerts the worker that the gas is even present is carried separately from workwear. These monitor devices measure particle parts per million. It is worn at chest level. The main

gas in the oil industry, the most dangerous gas that workers encounter is called H2S is hydrogen sulfide gas at 100 parts per million and is deadly to humans.
After washing off the layer which protects from fire, a new layer is added the protection. The industry standard is regulated and required by USA Occupational Safety and Health Administration (OSHA).

Main takeaways:

- **Even advanced industries in the Western world are space to improve in order to save people's lives if the communication devices would be better.**
- **Systematical monitoring by industry standards safety protocols to clean and process workwear guarantees better safety for workers.**
- **Modern devices monitoring the purity of air are used daily bases and are at an advanced level although these are not integrated into smart workwear itself.**

5.6. Online Interview with the Experienced Marathon Runner

A marathon runner with 8 years of experience who has participated in 83 races in Stockholm, Moscow, Riga, Helsinki, and Vilnius marathons outside Estonia. As well as participated in all major and minor public runs and marathons in Estonia. The experience of running in a large crowd was frightening at first for her because of the crowd but calmed down after some very well-organized running experiences.
The biggest sources of stress are the bottlenecks in the starting corridors, which occur when passing through narrow areas to the start point. Also, health problems that occur on the running track, both for yourself and for other runners are discouraging. The crowdiest marathons have been the Moscow and Stockholm marathons with around 50-60 thousand participants. The risks of moving in large crowds have been mitigated with different strategies in different marathons. The main strategies are different start times with different levels of runners. People are divided into groups by level, and the numbering system depends on this level. For all races, he pointed out that the human factor, who directs and gives help, is important. There could always be more people in the marathon distance, who guide and give help. She pointed out that the Moscow Marathon was different in that she felt particularly safe there, as the support staff was available and helpful throughout the entire 42 km run. In increasing the general sense of security, she considered an important factor to have a helpful staff, who is recognizable as the organizer of the marathon. Also, the support staff has a means of communication to contact the medical staff or the security services. She

emphasized that the supporting staff should have all the information about the marathon's current logistics, where there are medical stations, how far the finish line or drinking station is, etc. If it seems that the marathon volunteer has not received initial training, the runner feels insecure. The system, which was considered very functional, is an app-based digital platform for every marathon. Positive experience from Moscow Marathon online app with a tracking solution where your family and loved ones can track exactly where you are on the distance, and if you have been at one point for too long, the family can simply go there and notify the organizers and first aid based on this mapping. According to the chest number with the chip, people are divided into larger groups by level. And the runner can be identified by it for the entire run, both to the family and to the organizers. In addition, the interviewee added that the chip on its chest number could have an additional function that sends out an additional SOS sign for help if necessary. Increasing the sense of security was considered important by the helpful staff, who are recognizable as the marathon organizer. Also, these support staff has a means of communication to contact the medical staff. Clear, large signs all over the city and the secured path are important. The good experience was marathons where every 10 meters, a police officer or a security guard along the entire 42 km length of the run was presented.
The main communication tool between organizers is a radio connection.

Main takeaways:

- **The main communication tool between marathon organizers is a radio connection.**
- **An online app with a tracking solution where the runner is trackable during the marathon is helpful security and health-wise and lowers stress for runners and family and for close ones during the marathon.**
- **An online app collecting information from chips placed under the chest number during the marathon is a helpful tool to track runners´ location for all parties - runners and families, the close ones, and marathon organizers.**
- **In increasing the general sense of security is important to have a helpful staff, who is recognizable as the organizer of the marathon. The support staff should be easily obtainable and helpful throughout the entire run.**
- **People divided into smaller groups help manage the larger crowd.**
- **Clear, large signs that communicate marathon information all over the city and the secured path are the most important factors for a good marathon experience.**
- **The biggest stress occurs in "bottleneck" areas there are too many people at one time.**

- **It would be great to have one common understanding about safety rules in masses which could be communicated to the people already at schools**

5.7. Online Interview with the Organizer of Major Events

The interviewee has 15 years of experience organizing large crowd gatherings and major events in the Estonian Maritime Museum (Seaplane Harbour), Saaremaa Museum, Tallinn Treff Theatre Festival, and Old Town Days Festival in Tallinn of up to event size of 10 000 people. She pointed out that the best experience in terms of visitor safety has been in those cases where all safety aspect of the event is managed by the professional security team. To put up the major crowd event the framework of the event is structured by public city and institutional laws and terms [3],[4]. The public event permit is issued with rules, the requirements of which must be met in order to hold the event. Extra safety on top of the term and rules is good to achieve. Strategical planning ahead on how to avoid "bottlenecks" at the entrance or exit during the end of the event is essential. Dividing large crowds into smaller groups is a helpful strategy and is achievable by attracting visitors' attention to additional solutions or actions.

Workwear s recognizable and visible from a long distance and should communicate the aim of the information what that information point provides.

The communication tool is radio transition in large events with security teams who use inside their team other communications systems like smartphones, hand signage, etc.

As the radio device itself is a bulk, heavy instrument the pain point for the interviewee was to carry that with her, and would prefer a better solution for carriage and fastening system on the workwear. Altogether with other tools she had to carry along (chipcard for entrances, keys, etc) she felt overloaded with tools and had extra stress losing or forgetting them on the way.

Main takeaways:

- **The major crowd event is structured by public city and institutional laws and terms framework.**
- **Extra safety on top of the term and rules is good to achieve.**
- **Dividing large crowds into smaller groups is a helpful strategy.**
- **It would be great to have one common understanding about safety rules in masses which could be communicated to the people already at schools.**

5.8. Interview with University Professor

The interviewee has 40 years of experience working with students. The most problematic situation during this time working with the crowd of school class was a fire at university and she was designated to direct a class of 25 people out of a flaming smoky house. She pointed out that there has not been enough training for teachers during her working years on, how exactly to act and direct crowds in problematic situations. A direct call line device to fast connect with an ambulance would add to the feeling of security. Help would be especially needed in situations where teaching takes place outside the school building, because it may be very necessary to quickly call for help. Inside the school building help from colleagues, relieves stress and helps act in a calm manner.

Main takeaways:

- **It is important to have an authority who takes the immediate lead in life-threatening situations that can occur during the study process at school.**
- **Direct, clear, communication is crucial because of possible panic in the crowd.**
- **Not enough training on how to act in cases of life-threatening situations occurs in the education process and how to act wisely to direct crowd out of problematic situations.**
- **Not enough information on how to deal with health situations.**
- **The main communication tool is a smartphone which can be problematic at times.**
- **It would be good if the teacher have a device for direct help with first aid connection.**

5.9. Interview with Experienced Tradeshow Partitioner

This interview highlighted the opinion that the staff responsible for the event should be recognizable. Organizers of beauty fairs are often only recognizable by their work cards, and in an emergency, this is not enough for efficient and quick action. The interviewee pointed out that often the information of his divided safety measurements is not comprehensible or does not exist at all, and in an emergency, it is difficult to know what to do. Prior information about the security of the event should be communicated much better to people, and the security personnel should be in recognizable uniforms.

Main takeaways:

- **Information about the security of the event should be communicated better to people.**
- **The security personnel should be in recognizable uniforms.**
- **It would be great to have one common understanding about safety rules in masses which could be communicated to the people already at schools**

5.10. Interview with Security Team

A focus interview with four security personnel explained their needs for uniforms and work equipment. It is of equal importance to inform the public about their role. A hat or helmet and sunglasses are part of the uniform. These items can protect against blinding, prevent others from seeing who or what the guard is looking at, and even protect them from thrown objects. Another important part of a security guard's uniform is the equipment belt. The sturdy strap holds a variety of items and provides easy access to protection when you need it most. New security guards are advised to practice quickly removing objects from the belt to prepare for a real threat. Flashlight One of the most important pieces of equipment that a security guard carries on their belt is a flashlight. A flashlight can not only illuminate poorly lit parking lots and stairwells but it can also be used for protection against an intruder or other criminal. The security guard flashlight is durable and can withstand drops. Flashlights are not only useful for night guards. Day shift guards can use a flashlight in dark rooms or unlit areas. The smartphone is the main means of communication. A smartphone with a camera is also useful for documenting the area, suspicious people, or criminal evidence. Video footage can be very useful in documenting an argument. In addition, it is convenient to use a smartphone to call the police, fire brigade, or medical personnel as soon as the need arises. A baton is considered a weapon. In most cases, security personnel must complete a training course to carry a baton while on duty. Pepper spray is another tool that many security guards carry for protection. First aid supplies should be readily available and portable in a small package for quick and easy access. Common complaints were that overall safety workwear is bulky and unwieldy, and if some of the workwear features could be converted into lighter, smart versions, that would be great.

Main takeaways:

- **Security workers need a long list of work gear that they fasten on the belt.**

- **The main communication device is a smartphone with a camera.**
- **Overall complaints were that together is security workwear bulk and clumsy but includes useful items for their work. If some of the functions of work gear could be transformed to lighter smarter versions would be just great.**

5.11. Conclusion from Participatory Research

The study of the problem set revealed the main themes on which the further research process focused.

Individuality

All interviewees emphasized the importance of individuality. Workwear should fit the wearer's body type and support each person's individuality to gain self-confidence and comfort and to be able to move freely and quickly in the work clothes. The aspects of representing corporate identity over the body during work hours should not be harassing and balanced without suppressing personality.

Cleaning

Workwear should be good-looking and comfortable and easy to manage by means of cleaning and ironing. Therefore the importance of having a quick and effective cleaning method is essential. It is time-consuming to clean the whole set of workwear in dry cleaning tends to worn-out the fabric fast and is not sustainable in its nature. Systematical monitoring by industry standards safety protocols to clean and process smart workwear in safety means can guarantee better safety for workers.

Communication

The 3 main essential connections pointed out that crowd workers need during work:

- The connection between colleagues at the event site.
- The connection to the security team.
- The connection to first aid.

The main communication device is a smartphone with a camera. The phones as communication tools were considered ineffective at times when an event took place in a big old building where could be phone coverage problems or in the cases of large events where coverage is disrupted because of that many people use a phone in the same location. The need for connection between colleagues at the event site could result in workers being forced to move from their work area to communicate work change or messages about the management of the crowd. And that leads to the

original work area being not assisted and causing an unnecessary commute between crowded work areas that are already full of crowd movement.
It is essential to have a clear communication system between workers. All team members should know where they are supposed to be and when they should be there and the communication should be effective and on time. Communication tools to be used during the event should be common for everybody. Useful information is presented in terms to ensure that all parties are able to interpret the information in the same way.

The other communication tool in use like two-way radios (walkie-talkies), loudspeakers, hand signals, SMS, Messenger, or another app that allows calls can be effective but still need pockets or attachment systems in workwear that makes workwear clumsy. All interviewees brought up the importance of comfort - to have less work gear that is bulk and needs an extra fastening system or pocket or if some of the functions of work gear could be transformed to lighter smarter versions would be just great.
Having common tools will be an invaluable resource for communication with colleagues and stakeholders during the event. Direct, clear, communication is crucial because of possible panic in the crowd.

5.12. Emerging Issues in Workwear

Identified during the first round of interviews, observations, and desktop research, the initial ideation phase was aiming to explore the hypothesis and the research resulted in a broad spectrum of challenges for workwear from people who work with crowds. Speaking with different problem owners from different positions, there were certain topics were brought out and highlighted throughout the talks. The workers interviewed had different perspectives on the workwear and the different experience with the crowd size they work with. The similarities were the communication devices they use and the cleaning methods or systems. Using inductive reasoning further development of the results of "need to look good", "feel comfortable in work clothes" and "be visible in work clothes to the crowd they serve" were left aside as focusing on the issues of communication and cleaning methods merging them with smart solutions should improve overall appearance, comfort, and visibility.
The main points for categorizing research materials and themes are highlighted here:

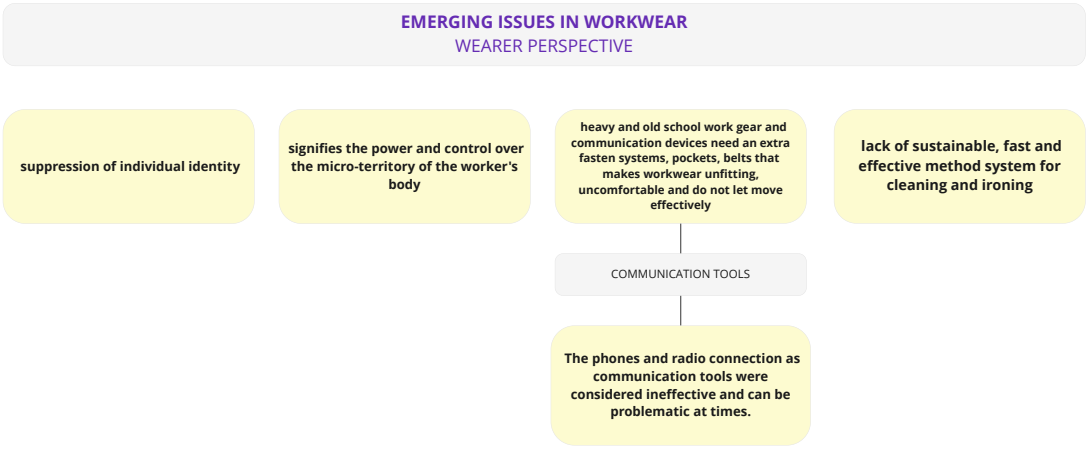


Figure 11. Emerging Issues in Workwear Map, created by the author.

The interviews with the professionals included interesting discussions on the overall mentality, crowd behavior, and how to act in large crowds and many pointed out that they do not know how to act in large crowds if the situation should become dangerous. As it is not generally covered in basic education programs at schools and they have only real-life experiences and street-smart knowledge. The message that stood out was the need for more knowledge about crowd behavior added to the school programs.

5.13. Available (Smart) Solutions for Emerging Issues

Issue	Avable (smart) solution
Suppression of individual identity.	Personalisation is nowadays common in most modern services and service-product combination systems. Many employers have taken the liberal view that even dress code is a uniform requirement; being freer to express the employee's own identity and at the same time to follow a formal clothing requrements.
Signifies the power and control over the micro-territory of the worker's body.	Some businesses integrate the collectiveness through the uniform and keep it personalized by custom-designed badges, logos on the uniform etc. The formal or semi-formal dress code helps develop a workplace culture with more flexibility and endorses the individual streak.
Heavy and old school work gear and communication devices need an extra fasten systems, pockets, belts that makes workwear unfitting, uncomfortable and do not let move effectively.	More and more functions are integrated through different technologies - lamination, sewing or weaving into textiles, making the fabric multifunctional. Integrating work tools into fabrics would reduce the amount of work tools to be carried and make the work form more comfortable and attractive for the wearer.

Issue	Avable (smart) solution
The phones and radio connection as communication tools were considered ineffective and can be problematic at times: 1) carring them needs extra pocket, 2) no wifi connection due to circumstances 3) unwanted sound in silence needed moments when worker has not switch it off	**Textiles perform like displays:** Scientists from Fudan University have developed a smart fabric with a display system that allows users to turn their clothing into a digital screen [33]. **Electricity-generating textile:** Scientists have incorporated piezoelectricity, which uses movement to generate power, into clothing. The body heat coming from body movement of any kind, and the difference between that heat and the colder temperature of the surrounding air could be transformed into thermal power. The heat is by using the thermoelectric effect, which converts temperature differences into electric voltage. If two conductors are connected and one side is heated, electrons start to move over to the cooler side, creating a current that flows through the circuit [34].
Lack of sustainable, fast and effective method system for cleaning and ironing.	**Self-cleaning textiles:** Self-cleaning textiles researchers at the Royal Melbourne Institute of Technology, have developed a cheap and efficient new way to grow special nanostructures, which can degrade organic matter when exposed to light [35].

Table 3. Available (Smart) Solutions for Emerging Issues by the author.

5.14. Reframing

The research resulted in a wide range of challenges for people who work with large crowds. Having chosen a more defined problem space, focusing on bettering

communication solutions, cleaning, and personalized workwear, leads to the following design research question:

What features and components of smart workwear would support fast and efficient communication leading to better-managed crowds?

6. DESIGN PROCESS

The design process started with co-design sessions with PMG and KKHK TG students and teachers. And feedback sessions with EDT AA-s. In parallel, desktop research took place to check the scientific background of the ideated solutions.
The purpose of selecting these two schools was to include people from as diverse a demographic background as possible. If PMG represented young people aged 16-17 living in the city environment, KKHK TG represented a wider age group, including people whose ages varied from 17 to 52 years, who live outside the urban environment in countryside areas. By including EDT AAs as primarily older workers from a demographic perspective, the study covers a wide age range of people from the working-age population.
This exercise aims to corroborate conclusions made from previous research and get a sense of what kind of solutions would pique people's interest.
To give a broader overview and introduction to the topic for the students the help of the Design Thinking for Educators Toolkit by the design company IDEO was used [17]. The main insights from the workshops are used later as a base for generating themes for the design concept. The goals and referred actions are described to frame the ideation and clarify the priorities of the concept.

6.1. Co-design Workshops and Sessions

The ideation part started with brainstorming by students and teachers at both schools, followed by feedback from potential users of EDT AA. Ideation began by setting various constraints to organize ideas and encourage creativity and unexpected results that would span different categories. "In order to map the possibilities and focus on opportunities, asking a "what if?" question is a helpful brainstorming exercise to start with. The "what if?" -s are based on the previous research, interviews, and questionnaires to take the previously highlighted problem points and wonder about solutions through asking questions." [36]. Sessions with PMG and KKHK TG teachers and EDT AA-s represented crowd worker (potential users) perspectives on the issues. Sessions were conducted in the form of discussions.

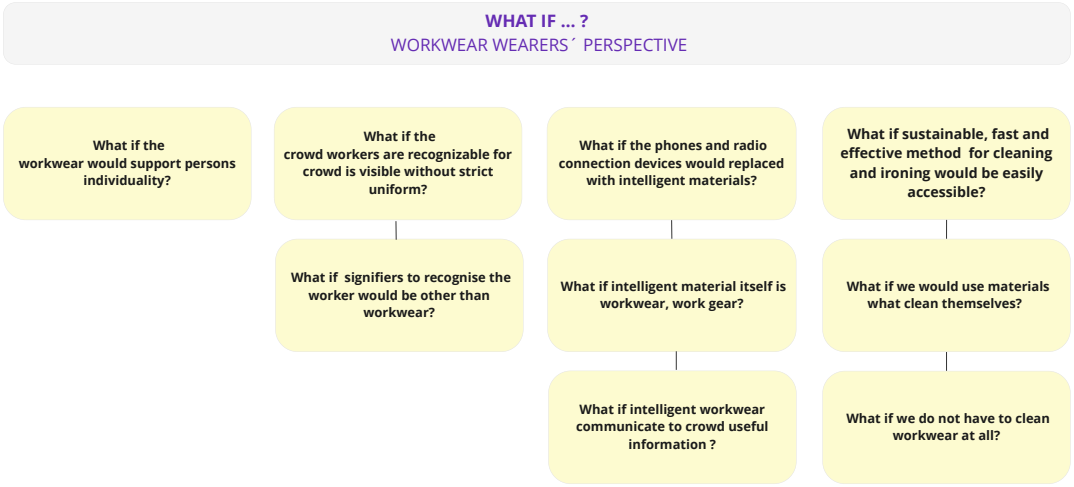


Figure 12. „What if?" Workwear Wearer Perspective Exercise, by the author.

Sessions with PMG and KKHK TG students represented the crowds or audience's perspective on the problems. Sessions were conducted in the form of school classes. In PMG were conducted 2 x 45 min, classes. And in KKHK 5 x 45 min, classes.

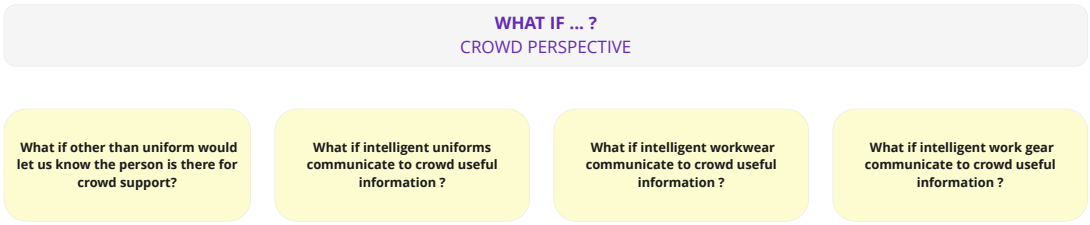


Figure 13. „What if?" Crowd Perspective Exercise, by the author.

Photos 1-2 from the co-design workshops from PMG by the author.

Photos 3-4 from the co-design workshops from KKHK TG by the author.

The questions can be categorized into three subtopics:

- workwear's overall appearance, individuality, and recognizability;
- communication system
- maintenance.

Workwear's overall appearance, individuality, and recognizability

Key to this category is the aspect of employee recognizability as essential to the audience. The proposed solution ideas supported the concept of workwear as a set of clothing options established by the institution. Many times stated that the uniform was considered too conservative in today's world. The concept of workwear as a set of options for items of clothing supports individuality as the employee has the choice to combine the favorite items and create the work costume by this framework including a personal expression to it. Support each worker's personality was seen as a valuable feature and
overall opinion leaned rather towards the more personalized set of work clothes than the strict set of one unified uniform.
The ideas for recognizability ranged from ideas of smart glasses for worker identification to overall blinking costumes and screen-like suits to ordinary name tags to add to workwear.

Communication system

When creating the design concept, the main questions revolved around communication. In a previous study, the devices used as a means of communication were found to cause unnecessary problems in their current state, requiring additional fastenings or additional pockets to the work uniform, thereby making the uniform more cumbersome. The set of problems revolved around the additional questions: where to put the communication tool; how to confirm it; how to be notified when voice notification is turned off, as it may interfere with an ongoing event; how do you get a timely message from a colleague who needs help, while you are busy directing and helping people? How to contact other parties (first aid, Security team)? What are the basic functions of the communication device?
For communication to be successful, the starting point would be to replace the object with something that does not require an additional means of attachment. Focusing on the possibilities of intelligent materials was found to be helpful, placing the smartphone screen on the employee's uniform so that it is easily visible on the uniform, and the employee is always aware of the incoming information by visible

change on workwear during other activities and at the same time can continue the work activity. When discussing industrial wearables as intelligent screens, is need to consider that we are dealing with low throughput, low power, small size, and specific locations. The idea of attaching the smart solution around the wrist came up repeatedly. The human hands are areas that are easy to observe and move. We use watches, smartwatches, and other aids by attaching them to them. In everyday communication, people use hand gestures as extra emphasis for information. In traffic, there is a hand gesture signal system to regulate traffic. The main focus in crowd-worker smart workwear remained in the hand and wrist area as possible additional smart solutions space for the design solution.

To analyze specific cases in a school with groups of students or an audience in a theater, parameters such as environment (outdoor/indoor), coverage, power consumption, scalability, cost, and accuracy should be reviewed before integrating them into the working form.

It was also found that the means of communication should not include communication with non-work factors and could be set only for the necessary functions. As an example, the device could connect an additional security team or an ambulance to a designated location with a simple push button. And do not provide connection options outside the work environment.

Many times was emphasized that the connection should include a visual overview of the venue that provides information about the location where the problem situates. Another brought out was the need for a counting and tracking system to understand how many people are in location; how they are situated and moving.

Maintenance

Options for cleaning have various solutions, but they are not the main focus of the work. Rather the cleaning issue is seen to be solved through technological innovation.

The current concepts in this study include cleaning system providers, cleaning schedules, and workers who are responsible to follow the schedule and set up rules. The aim of the study was to cut off the cleaning system and replace it with smart self-cleaning options for fabrics and materials. It needed to consider the crowd workers´ involvement in the process. That was discussed during sessions and the overall opinion was that extra attention to setting the workwear and gear in the right conditions for cleaning would not be seen as an extra task to avoid.

6.2. Conclusions from Workshops and Feedback Sessions

The main ideas that tried to solve emerging problems such as:

- direct communication during the event between the other parties - the ambulance and the security team is essential.
- Self-cleaning of work clothes would alleviate the problem of handling their cleaning.
- There is a need for a visual plan of the venue where the event occurs.
- The possibility to determine its own location on the plan and an overview of the movement of the crowd and number of the participants would alleviate the emerging problems.

For the feedback session after brainstorming, the most relevant ideas were shared and 10 out of 22 were presented to a potential user PMG and KKHK TG teachers and EDT AA-s.

The "How? Now! Wow!" matrix was used to rank relevance. The feedback giver (potential user) was asked to comment on each idea and give a final opinion on the originality and relevance of the idea.

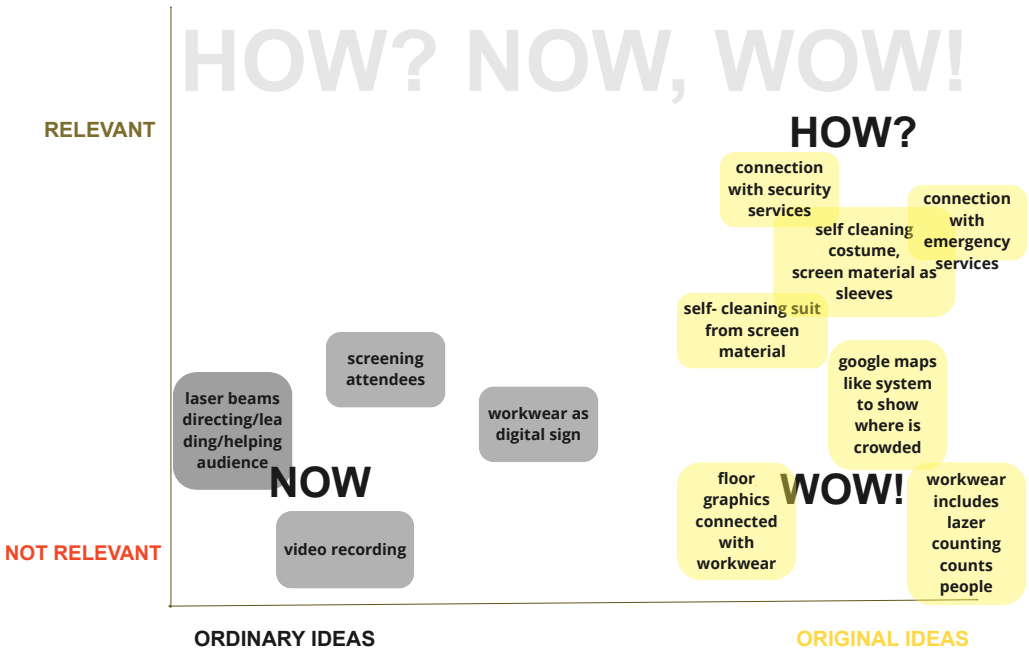


Figure 14. HOW? NOW! WOW! Matrix, by the author.

Using this as a base and combining insights gathered during the interviews, the following parameters were identified that played an important role in designing workwear for crowd workers: **a supportive communication system between workers themselves, and security and first aid teams; self-cleaning option for workwear; recognizability; application software should include concurrent on-screen event venue floor plan; worker and event participant location detection; event participants counting option.**

With the current approach, the solution seemed to lie in integrating existing smart solutions into workwear and designing a communication system around it with the help of a separate device built up from intelligent materials as well. The workwear should provide a connection with essential parties - the connection between workers themselves, and security and first aid teams. As well as a concurrent overview of the event venue and participants. The gathered information formed a resulting question:

Can we design self-cleaning workwear based on smart textiles and intelligent materials that provide recognizability; an on-screen event venue plan; worker location detection; participant's location detection; participant's counting option; while offering a supportive communication system between workers themselves, and security and first aid teams?

6.3. Design Brief

The design brief focused on the results of the study to date and describes the goals and expected results of the development phase by providing a framework and scope for concept development with guidance on what the design solution does and doesn't offer.

6.3.1 Design Development

The design development phase started with depicting smart workwear's components to see where the design process needed to concentrate on for further development. To see its component fragmentations more precisely to intervene in the process.

Also, preparing for co-creating exercises for future second co-design sessions with PMG students and teachers was necessary based on the information map provided.

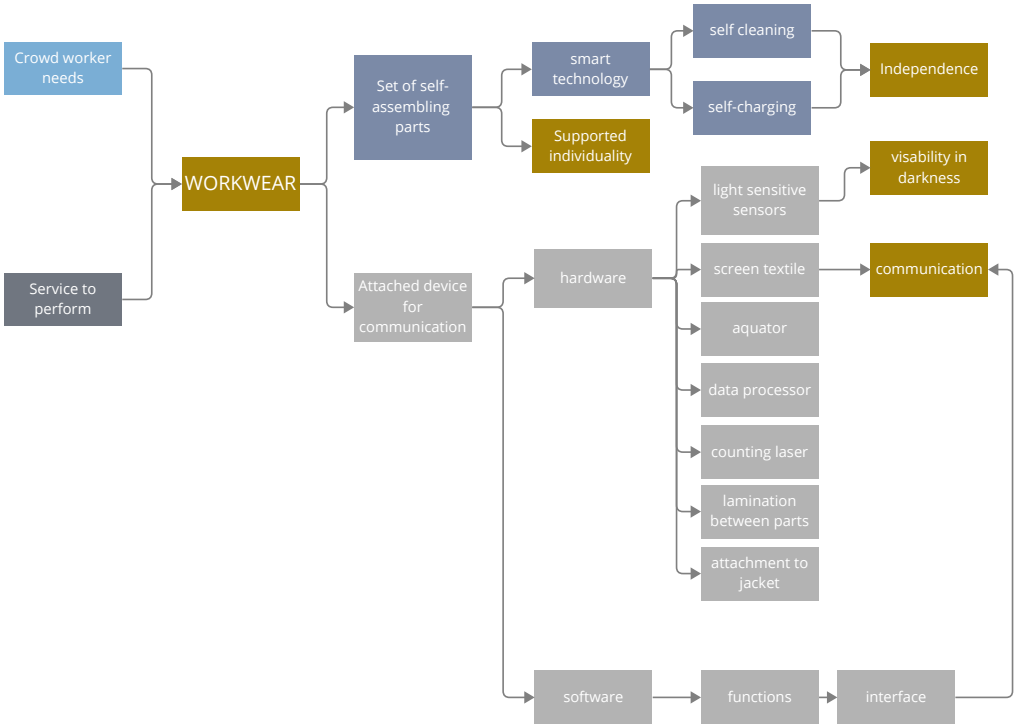


Figure 15. Smart Workwear Components Map, created by the author.

6.3.2. Service-Product Eco-System Map

The service-product ecosystem map was created to depict the interaction with the involved parties of the design to understand direct interactions with each other and distant interactions:

The largest layer number 4 is visualized in the ecosystem of people who are the event's initiators. They should be informed on ongoing situations and are not involved with direct action with the crowd but should be informed if needed. The 3 layer describes the people who should be involved in cases where urgent professional intervention is needed for safety or health reasons when just assisting the crowd would be not enough. The 2 layer shows the on-site interaction between visitors and audience assistants.

And the 1 layer of interaction between the core users - audience assistants themselves.

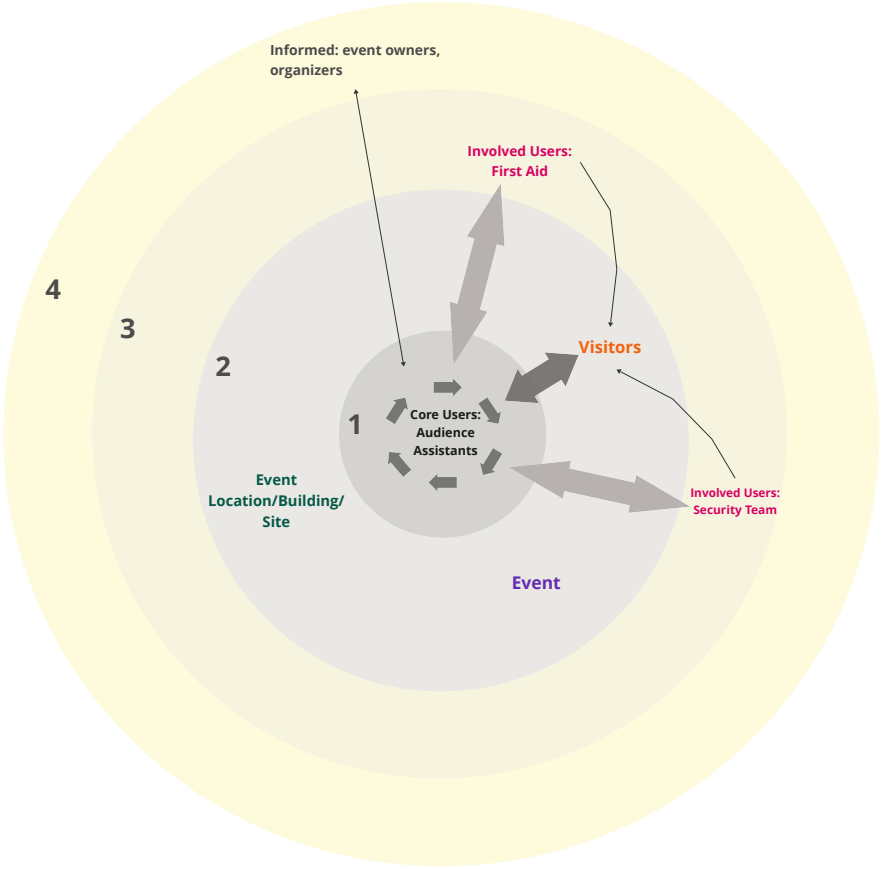


Figure 16. Service-Product Eco-System Map, created by the author.

6.3.3 Design Goals and Actions

Next was to concentrate on the goals and actions of the actual design case. For that visual, a division map was created with its design components involved in the solution. The following shows the components of design into which research results are divided and how they can be useful in the design development process.

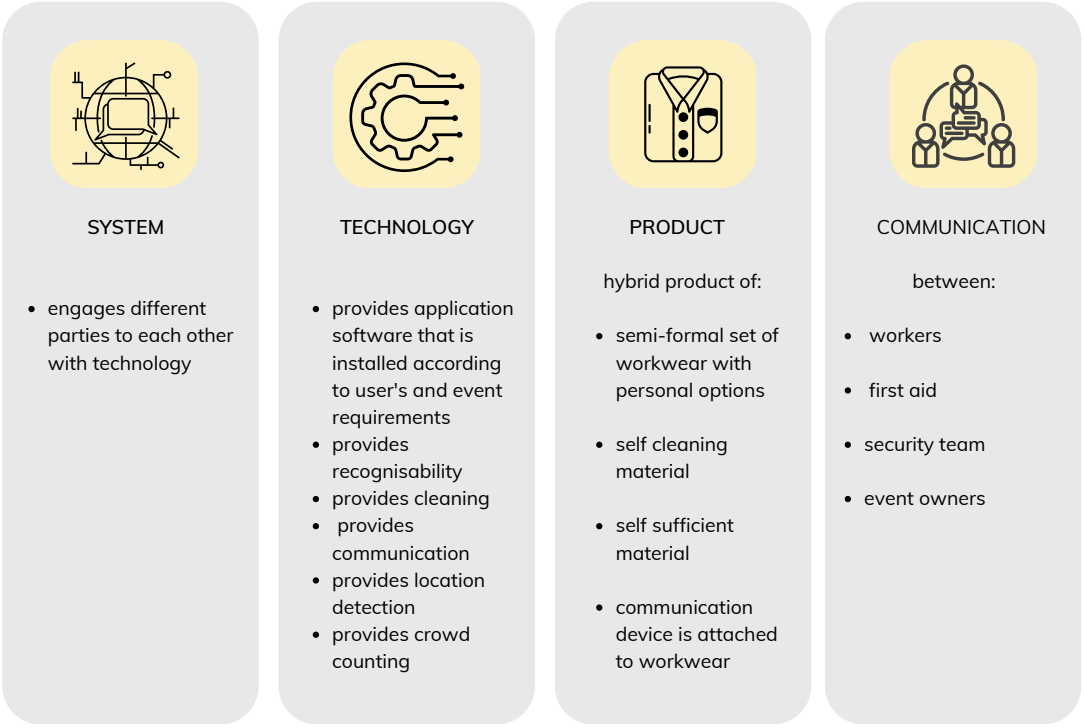


Figure 17. Design Components Map for the Idea Development, created by the author.

The goals and actions of each design component are presented in the table below.

System

Goal	Action
• The system is the basis for ongoing information change during the event between parties at the work site and supportive teams in an interactive way.	• The system ensures communication between different parties at the event location: security team and first responders and engages employees with each other through technology.

Technology

Goals	Action
• To set up digital communication application software between workers, first aid and security team.	• To provide communication between workers, first aid and security team.
• To determine of the location of workers as well as event visitors via technology.	• To provide determination of the location of workers as well as event visitors via technology.
• To determine smart workwear materials that provide self-cleanse.	• To provide smart workwear self-cleanse.
• To determine smart workwear materials that provide self-charge (self-sufficiancy).	• To provide smart workwear self-charge.
• To determine interactive screen materials for digital application.	• To provide interactive screen for digital application.
• To determine attaching material for digital application.	• To provide attaching material fo digital application.
• To determine recognication materials for digital applications.	• To provide recognication materials for digital applications.
• To create connection from crowd counting system to digital screen	• To provide information from crowd counting system to digital screen.

Product

Goals	Action
• To support workers' individuality through the created option set of workwear that workers can combine themselves within the framework of the institution's visual identity.	• Provides self expression inside institution's visual identity frame.

• To reduce the discomfort caused by extra work gear by integrating it into the workwear.	• Direct communication with essential parties via device attached to workwear.
• To reduce stress in workwear maintanace	• Provides workwear self-cleanse

Communication

Goals	**Action**
• The core tasks of the communication application are to ease the communication between workers in large buildings or venues, get help on time and use data for an overview of the workers and crowd movement.	• The communication between crowd workers, first aid, and the security team is set up.
	• The communicational application should be clear about what information is shared with each party.
	• The user should have the ability to add and edit information concurrently with real-world action.
	• The communicational application is not meant as a news feed, with varied information. It should be used to connect with the parties that support the event and workers to support each other.
	• Wherever possible, the use of the device should fade into the background and enable more effective interactions in the real world.

Table 4. Design Goals and Actions by the author.

6.3.4. Value Creation

The data based on the research results of this paper suggest that new approaches to combining work clothes and work gear lower the employee's stress, provide an opportunity for quick communication with each other, as well as for calling in support teams, making the work tasks of crowd-workers at crowded events smoother, faster and more efficient.
The value created by the assembly can be measured by perceived workwear user value. Value for users is hoped to create through the following features:

- The use of digital communication part of the workwear is hoped to increase the feeling of support from the team via an overview of the concurrent course of the real-life event. Also, the direct communication system between other stakeholders of the service eases and smooths the workflow and creates a better event experience for visitors. An effective communication solution is created according to the user's requirements to simplify crowd workers' workflow and avoid unnecessary movements.

- Personal work clothes through a set of personalized clothing options support the employee's individuality and visibility.

- The self-sufficiency created via electricity-generating textiles is hoped to cover some of the need for energy.

- The self-cleaning textiles create value by easing maintenance and environmental protection because of reduced cleaning efforts. Lesser mechanical or chemical cleaning makes textiles longer-lasting as well. Time, material, and energy reduction are consequently causing cost-efficiency.

6.4. Co-Designing Prototype

In the next development phase of the research, a 2 x 45 min workshop was held with PMG students. The Smart Workwear Components Map *(Figure 15)* previously created, indicated that focus is needed to direct software functions to understand that the service would be covered help for acquiring issues. Therefore, the workshop's second

session aimed to create a function for the attached device and touch on the issues of its overall appearance and interface structure. The overview of the workshop build-up is visible here in the Second Session Workshops Map.

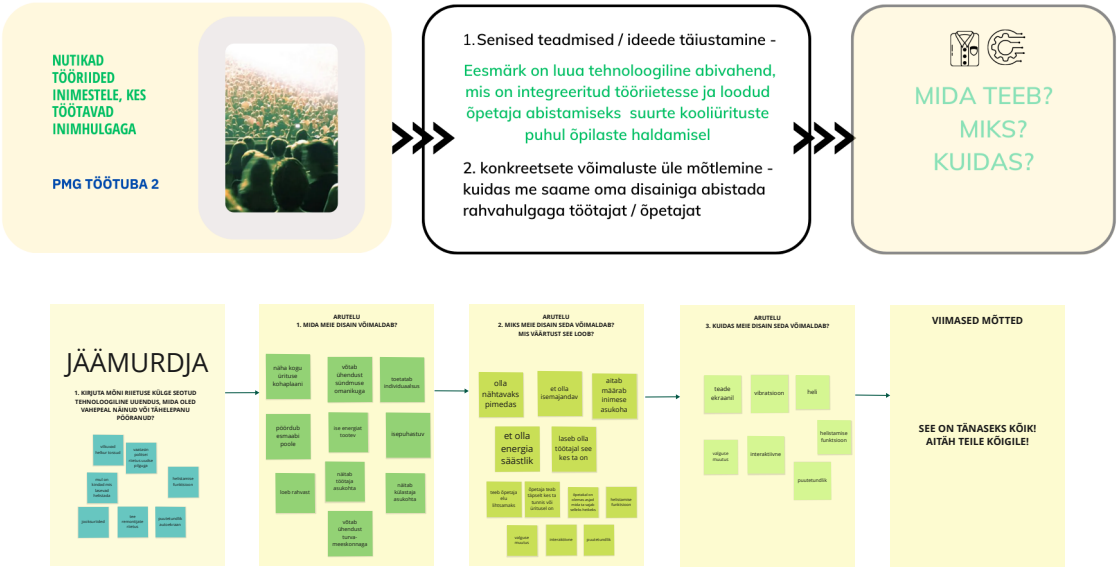


Figure 18. Second Session Workshops Overview, created by the author.

For the first 45 min, the students built the first physical mock-up prototypes with possible solutions considering the previous results considering results of the previous workshops that needed to locate sleave areas on workwear. The initial examples of the interface were also created in this phase with the first prototypes. The main development was to include an event venue plan in the communication system as in the first interface sketches it appeared organically during discussions. Became obvious that without an event venue layout, map of the rooms, or map of the landscape where the event takes place, it would not be possible to create the communication part.

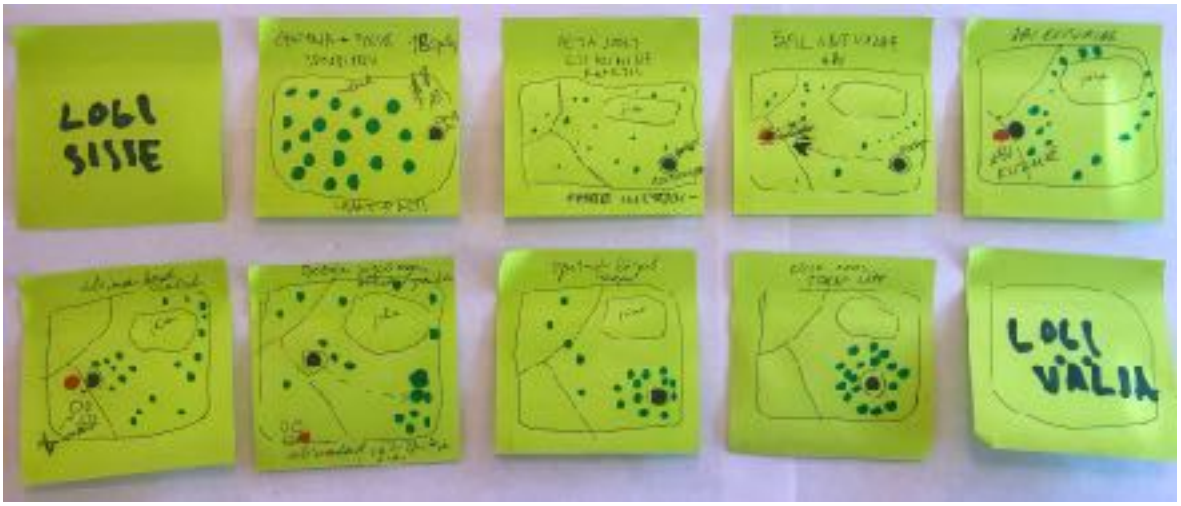


Photo 11. First Interfaces by author.

The rest of the time of the workshops was dedicated to developing the functions of the device. The tasks discussed by the students were set up in a layering system so that the previous task establishes the next topic, knowledge, and system building, starting with the simplest and going more detailed and deeper.
Also, the of discussions on how the crowd counting system should work and whether should it be included in the application or solved with a separate counting system that is not attached physically to the workwear but set up in strategic places in the event venue, and information would be available from the different data processor to the device's software.

6.5. Testing and Feedback Sessions

After that, testing took place with PMG teachers and EDT AA-s. The student's prototypes were presented and analyzed.

6.5.1. Testing PMG Teachers

The PMG teachers gave feedback on comprehensibility, comfort, and a sense of a supported digital community.

Photos 5-6 from the feedback and testing from PMG by the author.

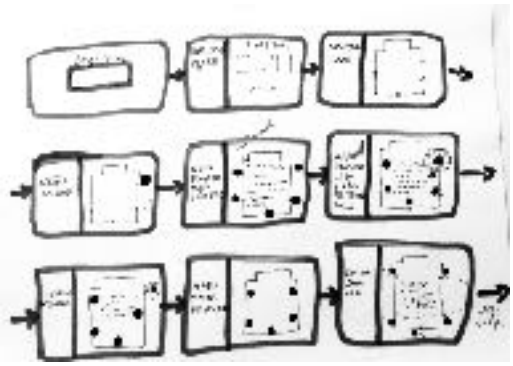
For the feedback session, the potential user-teacher was presented with 2 prototypes of the device. The user was asked to comment on each idea and end their thoughts with something they liked about it and something they wished was different "I like, I wish" exercise by IDEO was used for the feedback session [37]. This exercise aimed to corroborate conclusions made from previous research and get a sense of solutions that would pique people's interest. Most feedback was as expected and confirmed and clarified the assumptions that can help teachers on crowdy events outside the classroom. The ideas were described as practical and useful and compared with an existing alternative - the smartphone and its options. With the current approach, the solution seemed to lie in combining existing capabilities into one supporting system to have a place where people could enter their location and share it with other employees. The system would curate the available location map options, creating a result where it is possible to locate and track employees and respond to the situation as needed. As most of the teachers are familiar with different kinds of technologies the overall design approach did not raise any hesitation that it could be too difficult to use or incomprehensible. It was founded as an interesting alternative to a smartphone in that it concentrates only on work tasks and includes only involved parties and fast help in need. The idea is described to support safety and an increased sense of community between involved parties.

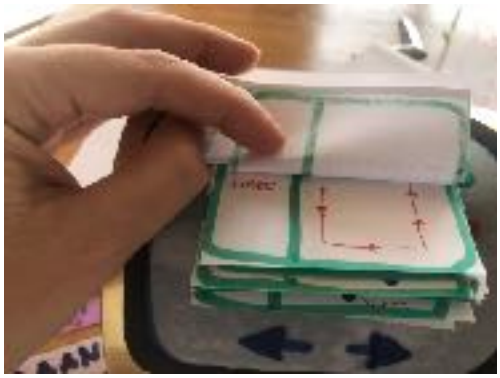
6.5.2. Testing with EDT AA-s

Testing with EDT AA-s was essential because nobody can know the different sides of the problems as well as useful opportunities better than the ones who are facing them daily. Testing consisted of 2 sessions.

Testing Session 1

The testing group of 10 individuals aged 47-78 years raised a certain level of excitement when asked if they would be interested in testing the prototype of the developed design. The consideration is that not all potential users are tech-savvy and not used to digital devices, especially if we consider the given age group. For the first meeting simple interface examples were created based on previous co-design sessions and verbal explanations were helpful to go through all devise functions phases of the design.





Photos 7-10 from the feedback and testing from EDT by the author.

A positive side effect was that the experiment gained curiosity and created a discussion about the effectiveness of EDT AA-s in their work tasks between themselves. The results indicated that the visual explanation combined with a slow verbal explanation of the tasks is an effective way to raise their interest. Discussions concluded with the agreement that they would have to physically move less in cases of using the design and do not need to use their smartphones. As well as the connection from first aid or security teams was found to be effective and create a sense of psychological support. Personal preferences and attitudes about the exact place the device should locate on the body arise once again. It was discussed that it could be on the cover side of the blazer. But still, the overall discussion resulted in the preference for the sleeve location. The prototype was left for a couple of days for them to contemplate. The concept of creating a digital supportive community for them seemed a bit far in the first session.

Testing Session 2 - Use Case Scenario and Design Exercise with EDT AA-s

It seemed needful to build trust by empathizing with them and creating more explanatory material so that the next tasks would be more understandable and fluent. Therefore were created visual layouts with theatre building floor plans; worker locations on them; and worker movements for the second testing session with EDT AA-s.

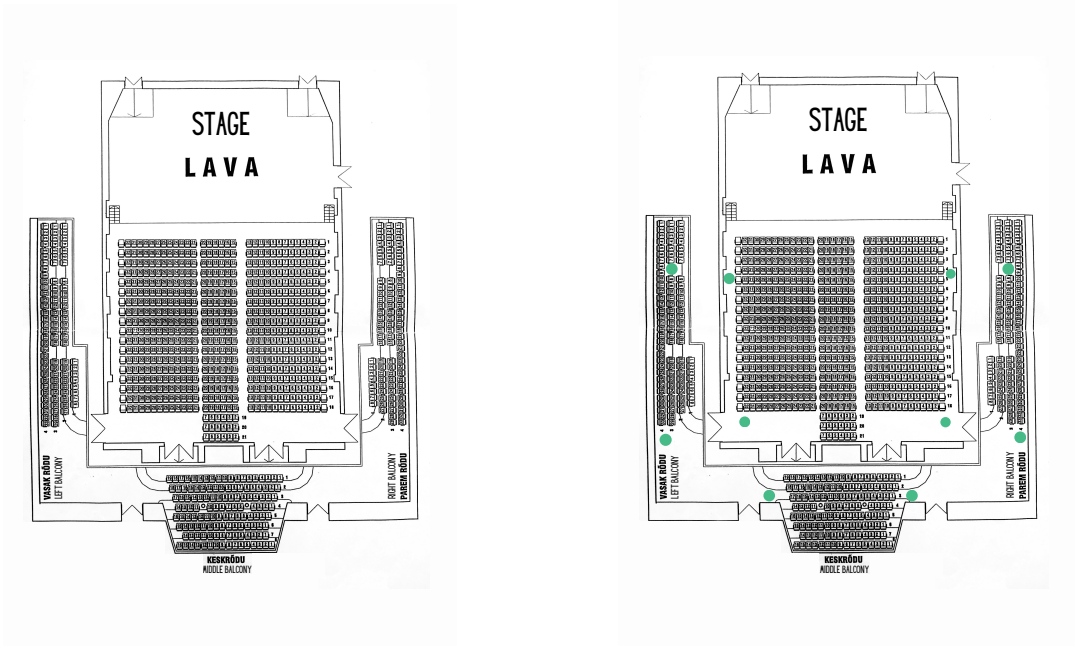


Figure 19. Theatre Floorplan without and with Audience Assistants Locations, created by the author.

The layouts illustrate the use-case scenario and represent the communication device interfaces.

The use case scenario was presented to the EDT AA-s with the following visualization:

Mare is an audience assistant at the theater. She was the first to arrive to assist with the evening performance. She went to the dressing room, takes her set of work clothes, and checks the device's battery level, which is full from last night's movement of generating power, into the clothing set communication device. She dresses in her workwear and goes to her work location in the large building. When she arrives, she logs in to the device attached to her workwear and sets on her location in the theatre building, where she will be helping and guiding people that evening. Logging in colors her location and assisted area green on the device interface floorplan.

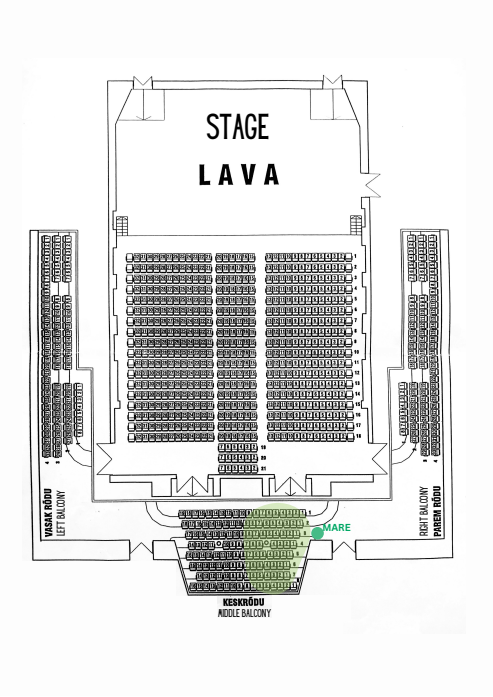


Figure 20. Floorplan with the Location of Mare, created by the author.

Soon after all other audience assistants arrived and turned on their locations as well. Performance began.

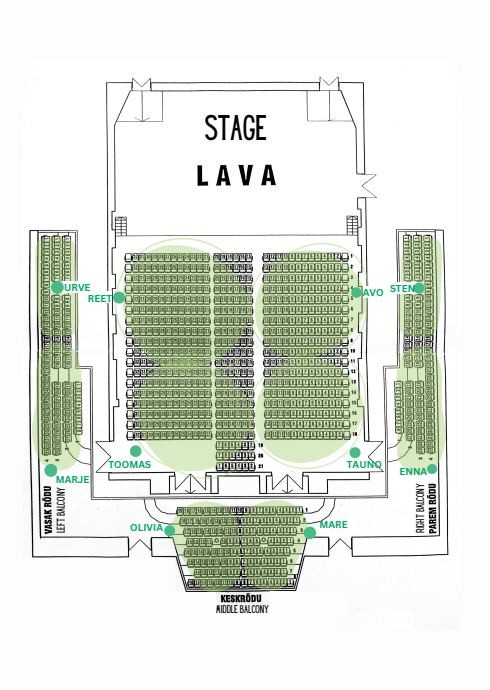


Figure 21. Floorplan with the Location of All Audience Assistants, created by the author.

During the first quarter of the performance, an older lady began to cough loudly in the area of audience attendant Reet's area and she obviously needed help. Reet quietly assisted the woman and her companion out of the hall to the theater's corridor and tried to relieve the health situation with first aid techniques. Reet informed the others that he left his location through a communication device. The input colored her area red on the floor plan map. This means that the other assistants must act accordingly to cover her area.

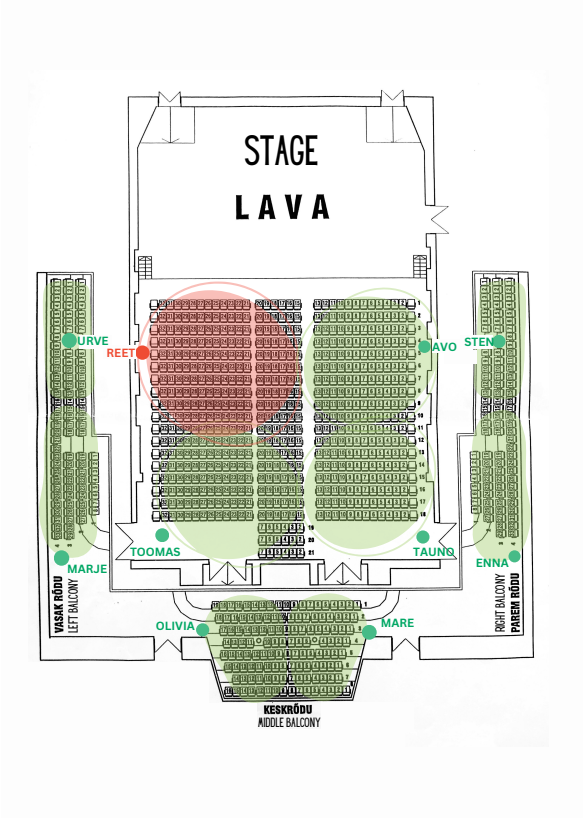


Figure 22. Theatre Floorplan with Status Change of Reet, created by the author.

After Reet left the hall, Toomas moved closer to Reet's previous position, knowing that when Reet left the hall, he would now also be responsible for Reet's area. Toomas informed others through his communication device which made the change visible to other assistants. In layout, it colored his new location yellow. With Toomas' movement to Reet's position, the system automatically moved Tauno's and Avo's positions to larger green areas so that the entire audience area would be covered and the areas would be equal in size for 3 of them without Reet.

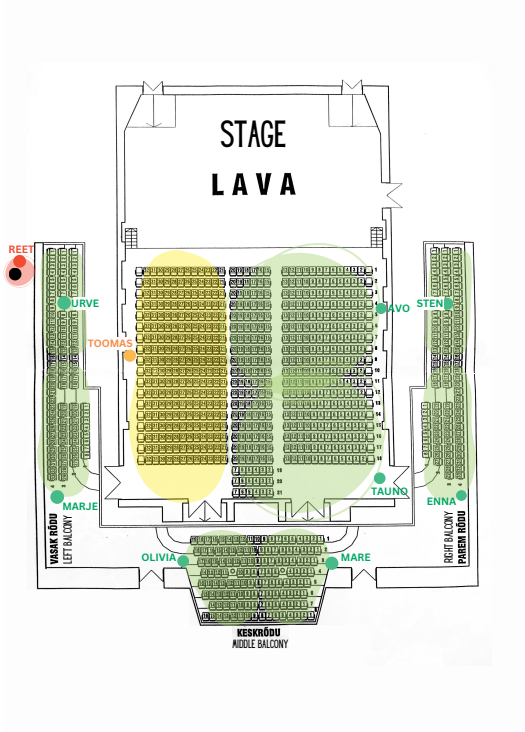


Figure 23. Theatre Floorplan with Location and Status Change of Toomas, created by the author.

On the central balcony, in the area assisted by Mare, in the middle of the performance, a man started to disturb the performance loudly with rude gestures and behavior disturbing other spectators. Mare managed to get the man out of the middle balcony, but the man's behavior in the corridor continued and became even more aggressive. Mare informed the others through the device that she was not in the hall and called the theater's security team to the scene. According to the location plan of the incident transmitted to the security team through Mare's input information, it was easy for them to determine the location of the incident in the theater building and they arrived at the right location in the theater quickly.

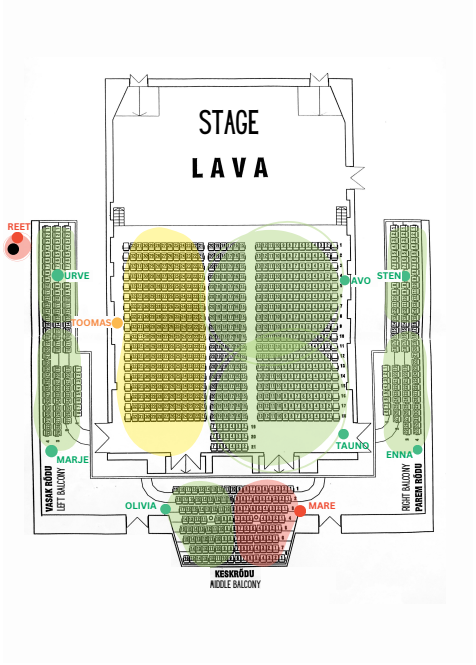


Figure 24. Theatre Floorplan with Additional Status Change of Mare, created by the author.

While Mare was dealing with the aggressive man, Olivia moved her location larger to cover Mare's former position and let the others know about this change by turning her location yellow.

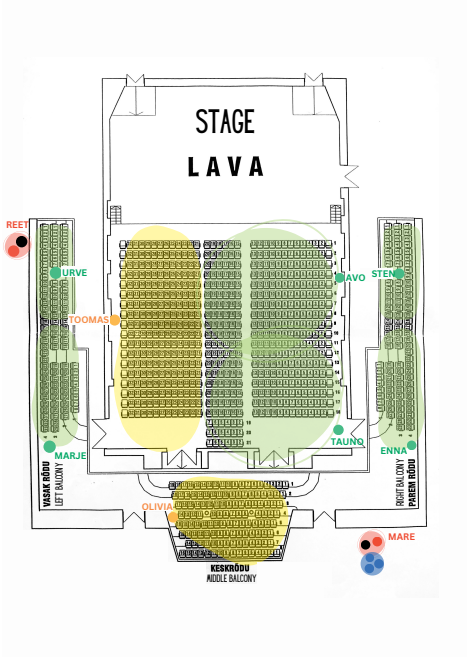


Figure 25. Theatre Floorplan with Location and Status Change of Olivia, created by the author.

The woman being assisted by Reet felt better, and she and her companion were directed by Reet back to their places in the hall. The security team that rushed to Mare's aid led the aggressive man out of the theater building. As the situation calmed down, everyone moved back to their positions and changed their locations back to their original.

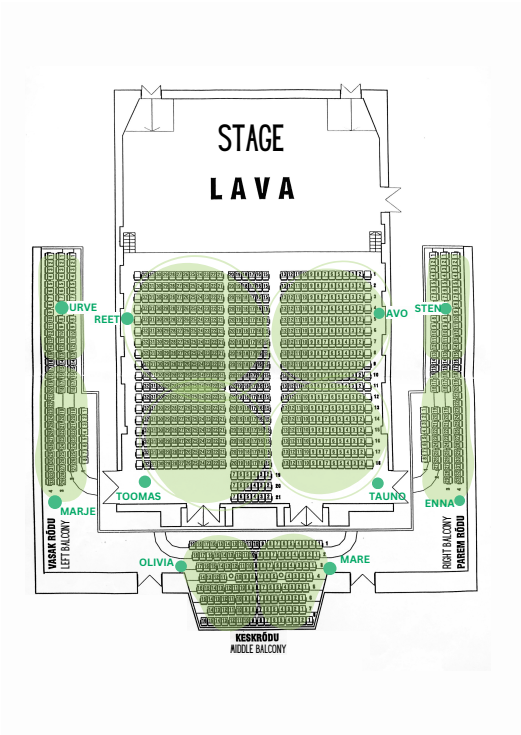


Figure 26. Floor Plan with Restored Status and Locations of Audience Assistants, created by the author.

The visualization helped EDT AA-s comprehend more deeply the meaning of design aid and its functions for them as they described.
After going through the visualization, on the same night, the actual working day continued for EDT AA-s. For that, I asked them to take notes on 2 occasions:

1. Notice and mark down when they needed to use a smartphone during a work night. After completing the task I asked them to think and evaluate whether they could have used the design solution instead of using the smartphone and note it down as well.

2. Notice and mark down when they needed to move from her location that was different from her location for this workday. (Secondary data collection: theater audience assistant work is based on changing the location from one location to another has the purpose that every worker is familiar with every corner of the venue building and knows the whole building well. Rotation is consensual and based on the floor plan to cover the essential areas for help and direction for the crowd). After noting the activity that took place, the second task was, whether would have changed their location if they had known the position of the other workers in the building and their situation based on the design solution.

The results were gratifying as 8 out of 10 would have used the design solution instead of a smartphone. And 6 out of 10 would have used the location detector. Asking why 2+4 of them would not use the design aid, they express similarly that they need more time to get used to new devices or solutions and they wanted to be sure to perform the task.

According to the Transtheoretical model of change (TTM), people have different readiness levels to change (stages of change): pre-contemplation (not recognizing the need for change), contemplation (becoming aware of change needed, but haven't made a commitment yet), preparation (having strong intentions and taking initial steps toward change), action (freshly started the new behavior), and maintenance (done the new behavior for more than six months). To create a durable habit of behavioral change, it is helpful to remember that people go through the stages at their own pace, and for best results, smaller steps are recommended for more permanent results [38].

Their feedback on the sense of a supportive digital community was positive as found to increase the sense of support from others and described in the following sentences:

- *…" Then I know exactly where others are and what their situation is and know how to act next…", (ETD AA Eve-Mare).*
- *" … I have an overview of what is going on in the whole 3 floors of the building…",*
- *(ETD AA Reet).*
- *"…I do not have to go to find out how the situation is solved but can see it on screen…", (ETD AA Marje).*

6.5.3. Feedback from Event Safety Volunteers

The same 4 safety volunteers (2 men, and 2 women) who gave interviews in the development phase described their feelings about the proposed design as useful and clever. It was an age group of 27-34 years and they did not express any apprehension about the use of new technological communication devices. The same use case floorplans that were presented in 2 testing sessions with EDT AA were used to explain the communication tool. Further was noted that every time they are not familiar with the area where the event takes place and this makes it difficult to go to help a colleague or to ensure quick help to a colleague who is in a difficult situation. Prior familiarization with the site location and walking through it was considered necessary.
The power of personal choice of clothes was seen as an extremely positive development as well as the self-charge and self-cleanse features.

6.5.4. Feedback from with Security Team

The security team's feedback on the design solution discussed the area of the light-transmitted smart fabric, the size of the area, and the possibilities of connecting it to the existing function of the stabbing vests' ability to transmit digital signs on it. Regarding the digital platform, it was found feasible in a specific location. If the location is undetermined, which often happens in the work of security personnel, the meaning of the connection device is questionable.

6.6. Conclusion of the Design Process

After the workshops, and testing the results with developed software function parts were integrated into the Workwear Component Map.

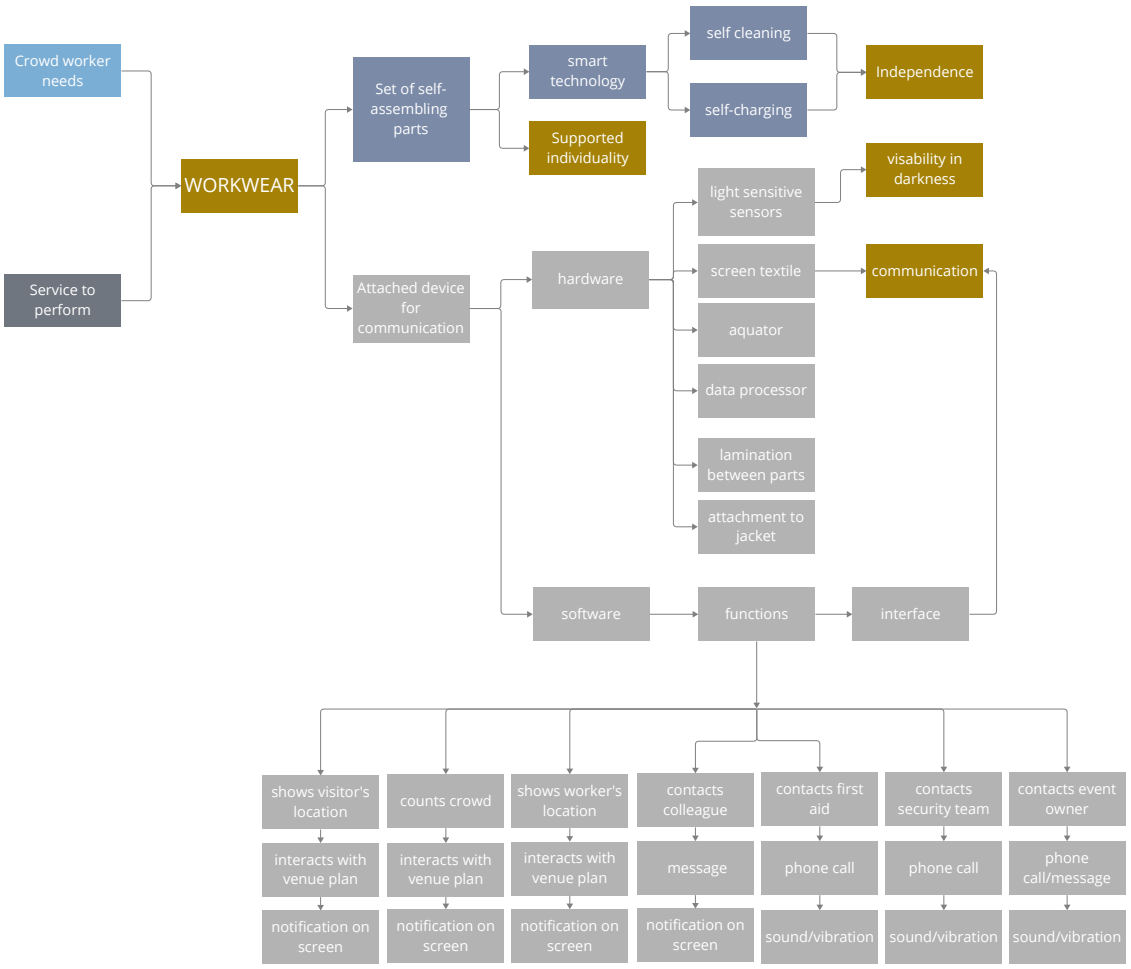


Figure 27. Developed Smart Workwear Components and Function Map, created by the author.

Also, the results of the need for the outside crowd-counting system were marked on the map. The integration into the design solution seemed to be unreasonable as the counting system solution depends on each event situation and is not adaptable for all

events. For example in large events with thousands of participants counting is reasonable to be fully automated and adapted to the event location architecture options while a wearable counting system can work better for small events in the school contacts.

As the self-cleaning topic needed extra desk research to control self-cleaning options, I concluded that there are many developed nanotechnologies whose safety studies on the use of nanoparticles indicate incomplete, indirect, or conflicting risks to human health and/or the environment. Therefore cleaning concept changed from the previously proposed cleaning method based on silver and copper nanoparticles in a previous explanatory user case as it turned out to be harmful to people and the environment in additional desk research. It is replaced with environmental-friendly research results, which changed the design solution of semi-self-cleaning [39].

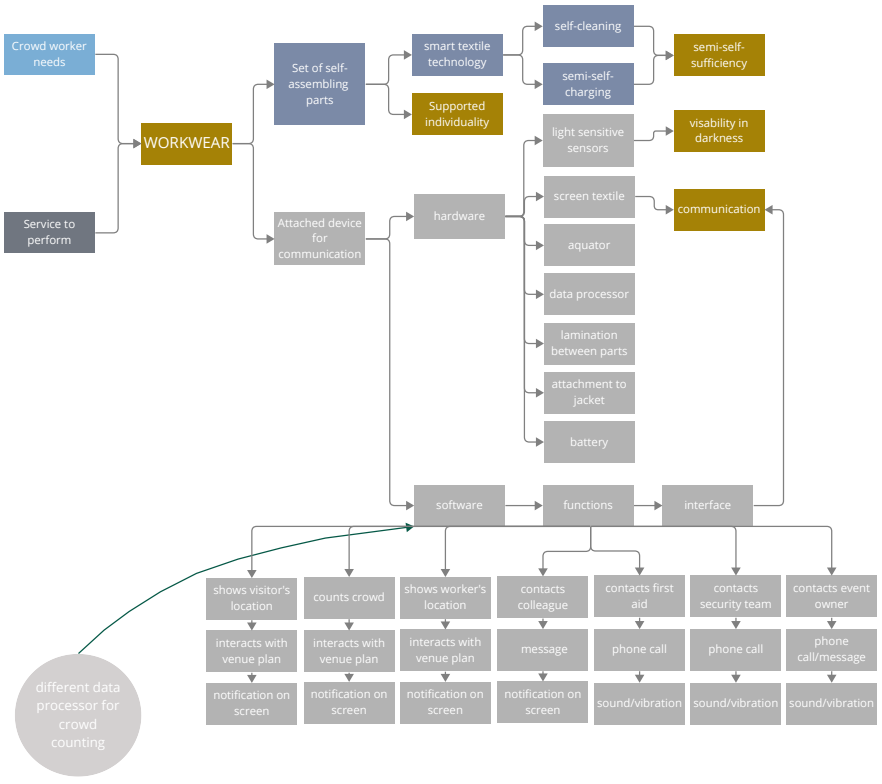


Figure 28. Developed Smart Workwear Components and Function Map 2, created by the author.

Digital prototypes of workwear were created by the author after co-design workshops and feedback sessions:

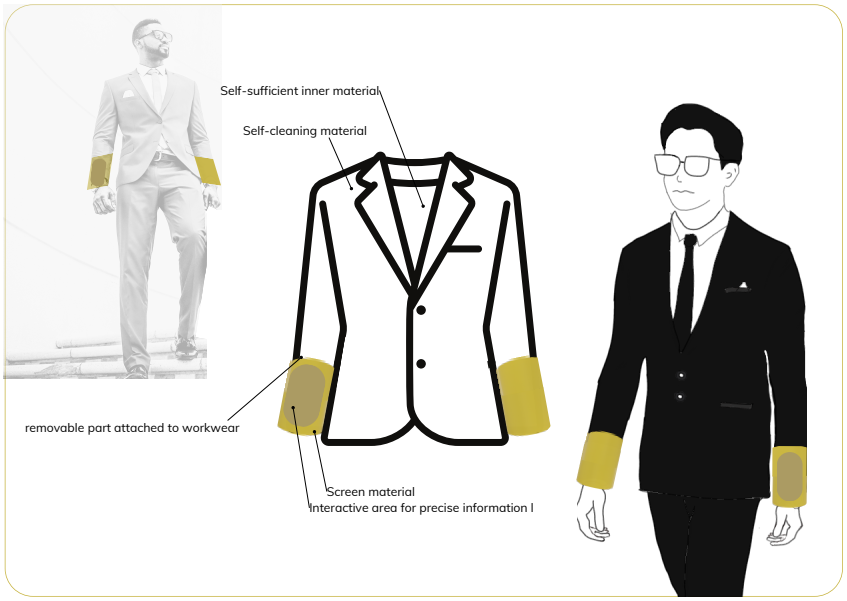


Figure 29. Digital prototype of workwear after 2. co-design workshops and, created by the author.

Figure 30. The developed digital prototype of workwear after testing, created by the author.

Through design practices, concept generation moved forward to propose a positive change in the simultaneous supportive communication system, sustainable workwear,

and support workers' individual expression for work clothes. The main insights from the workshops and testing sessions are used as a base for the design concept.
The design research testing and feedback part led to the conclusion that a wider user base would benefit from a design solution in this area than theatre audience assistants or teachers of a school class of size 28 students.
The target users of the project expanded to include any institution dealing with assisting or managing crowds in areas, buildings, and sites where is possible to determine a location plan or floorplan.

7. DESIGN CONCEPT KOOZ

Chapter 7 describes the conceptual design solution of the thesis. The goals and activities to achieve described in the previous chapters are realized as a conceptual design. The proposal is described through both functionality and layout from digital visual prototypes, user stories, and an overview of the system using the Kooz workwear structure mapping.
The Kooz name refers to the Estonian word "koos" in translation means "together". The title conveys the meaning of shoulder-to-shoulder support, which is perceived as a positive term for being with someone or in the community. The shoulder-to-shoulder feeling that is supported by direct communication between the involved parties in the digital environment to support real-life activities is at the root of its design. "Z" at the end of the Estonian word "koos" refers to an informal alteration, adding a humorous modern sense to the contemporary vocabulary, which is full of Anglo-American adaptations.
Based on the previous research the design concept proposal is **the customized garments set with semi-self-sustaining and semi-self-cleaning solutions with attached work gear designed to work together as one ensemble. However, it is possible to use work gear independently without workwear. The smart work gear is a soft screen communication device that allows crowd workers to communicate with each other and stakeholders, accurately reflecting the user's location on the preloaded map.**

The platform includes a connection with the coworker's network in order to determine the location and status of being and get direct help from the first aid or security team.
The proposal can be described in two bigger parts: **a custom smart workwear clothing set and a digital communication system**, consisting of physical and

digital touchpoints, aiming to increase crowd workers' communication on-site for better service.

- The Kooz workwear garment part consists of an optional set, which the employees can assemble themselves according to their individuality and physical characteristics. The option varies by institutional visual identity and established forms of the social hierarchy of workwear, yet offers a solution for personal choices that support individuality. The research does not define specific choices of parts of the smart garment and leaves assembling to the user to create according to each institution and its corporate identity, giving only directions about the smart possibilities of the materials. General appearance should look professional, clean, and neat to represent any institution.

- The garment set self-cleaning properties use scientific research that is developed on cotton fabric consisting of methyltrimethoxysilane (MTMS)-modified silica aerogel (Ormosil) followed by a polydimethylsiloxane (PDMS) post-treatment [39]. The superhydrophobicity of the developed coating is described to be stable even after one day of immersion testing in water, 5 cycles of accelerated laundering, and 100 cycles of abrasion testing. The design solution for cleaning is not 100% self-cleaning but was chosen to design solution because it still supports sustainability - reduces washing times and saves water. The cleaning concept has changed from the previously proposed cleaning method based on silver and copper nanoparticles [35] as it turned out to be harmful to people and the environment in additional desk research. It is replaced with environmental-friendly research results, which changed the final design solution of semi-self-cleaning.

- Kooz's self-sufficient solution relies on piezoelectricity [34], - a phenomenon where specific types of materials and also textiles produce an electric charge proportional to the mechanical stress applied to them. The solution is supported by additional backup batteries. The potential of the piezoelectricity phenomenon and the possible inclusion of clothing as a power producer for our wearable digital gear has big [40] potential. Therefore I didn't want to completely abandon the concept of piezoelectricity so the final proposal is to equip the Kooz solution concept with additional batteries in case of need, which makes the final solution semi-self-sufficient.

- Kooz's soft digital screen intelligent function of the apparel is created by flexible organic light emitting diode (OLED) flexible structure where the connection to transport information is made via Bluetooth [41]. In addition to the communication

between stakeholders, the screens-sleeves work to attract attention in situations where it is necessary to give people directional information. In dark rooms, it is possible to adjust the light of the sleeves to be noticeable to the person in need of help, but at the same time not to attract too much attention, so that it interferes with watching the show. The sleeve is attached to the work clothes' long sleeves by means of magnets, which are embedded between the outer garment and the lining of the jacket and laminated to the sleeves. Fit with the sleeve is adjustable with magnets as well. Whether the screens are on both hands or only one depends on the nature of the work. An important aspect of screen sleeves is that they can communicate larger messages for visitors besides communication with stakeholders. In many cases of events, the screen-sleeve of one hand is probably enough.

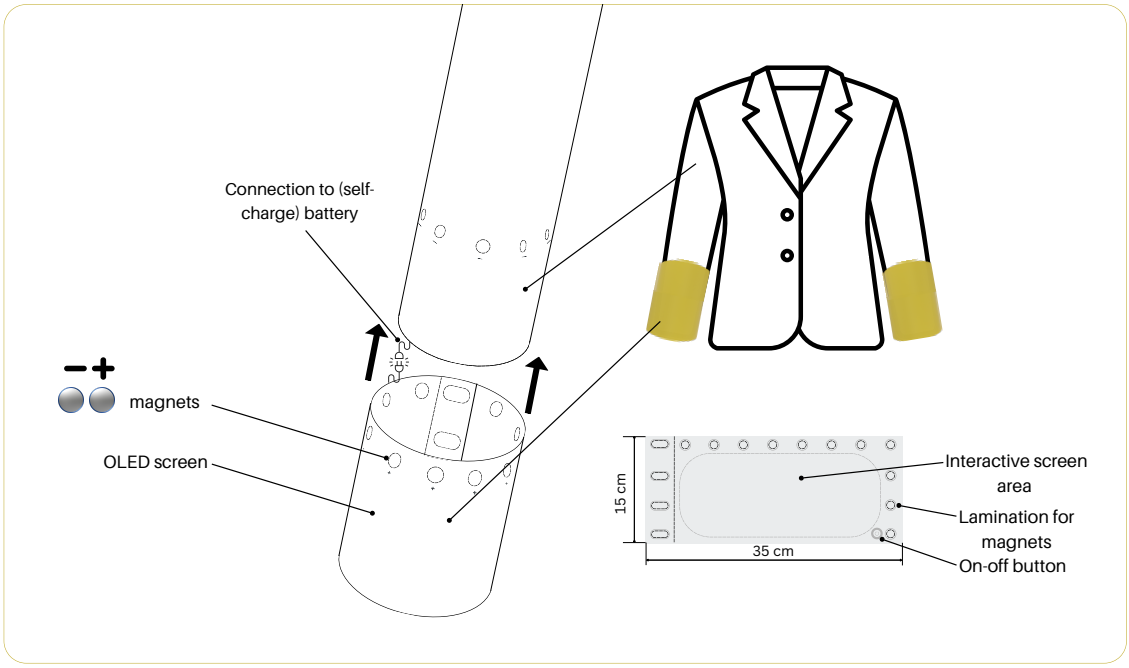
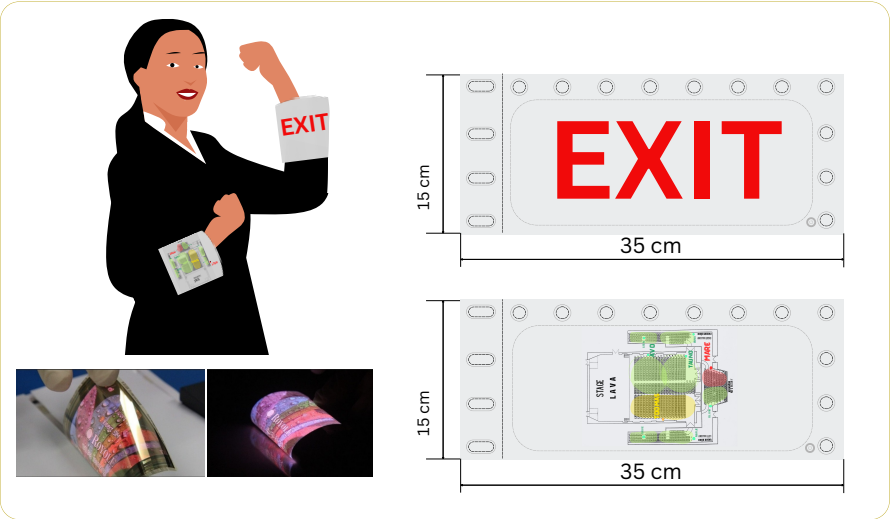


Figure 31. The plan and attachment of the Kooz smart-sleeve, created by the author.



Photos 12-13. Royole Develops 0.01 mm Full-Color Flexible Display.[42]

Figure 32. The plan and screen use of the Kooz smart-sleeve, created by the author.

- Kooz Workwear's digital communication platform includes all crowd workers on the event site as well as involved and informed parties and gives their location state and status at the moment. Kooz's digital part of the design is a platform that hosts the interactions about location movements from user to user and user to security service and first aid service. The digital communication system supports actual physical service on-site. The Kooz digital platform allows the user to monitor the location and status of other employees, determine their own status and location, communicate the necessary messages between workers on site, and call an ambulance or security team at a predetermined location in a large area of land or in a building. In case of outdoor events is possible to use the GPS to download the map. In digital systems, the information that is shared needs to consist of mutually understood building blocks. Users create one base profile, which can be customized every time it is shared by location on the work site. Users can indicate three levels of status in the system: green as taking the work position and working on the determined area, yellow when the user has taken over a colleague's position and area in order to help, and red indicates leaving the position to solve the issue.

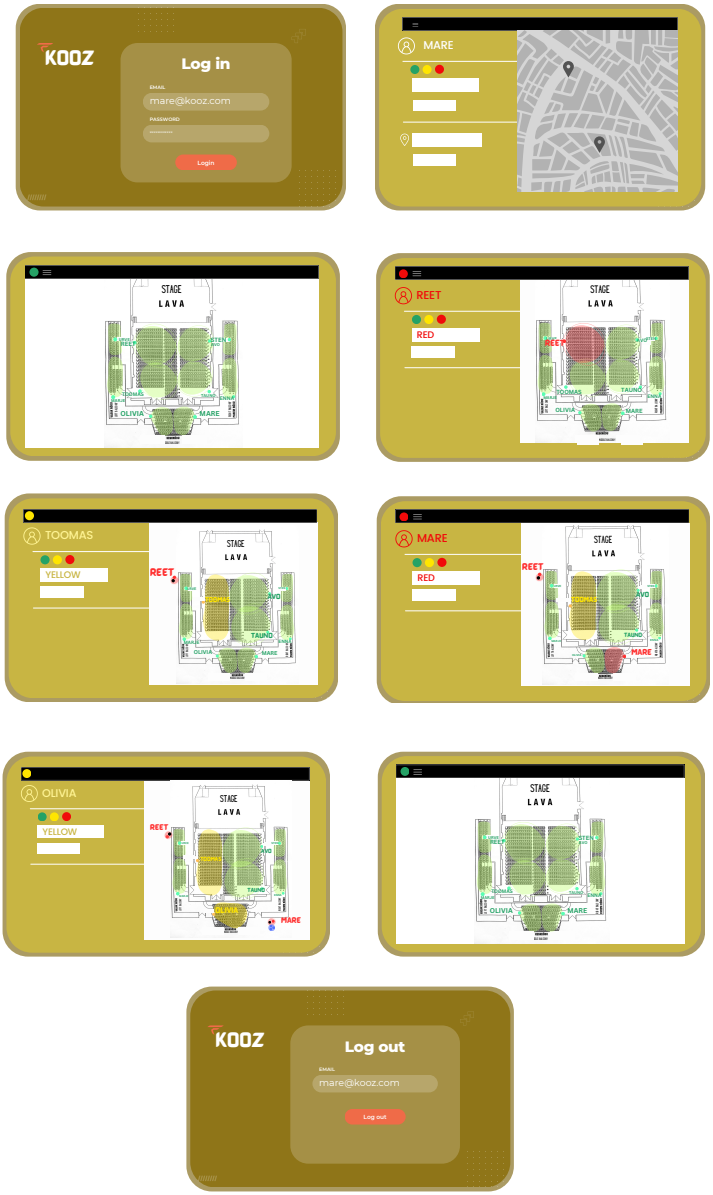


Figure 33. Use Logic for Interfaces, created by the author.

- The crowd-counting system set up in the event building or location collects data in a separate system and sends them to the Kooz digital system. By counting the visitors, it is possible to determine the location and movements of visitors in the building or space of the event.

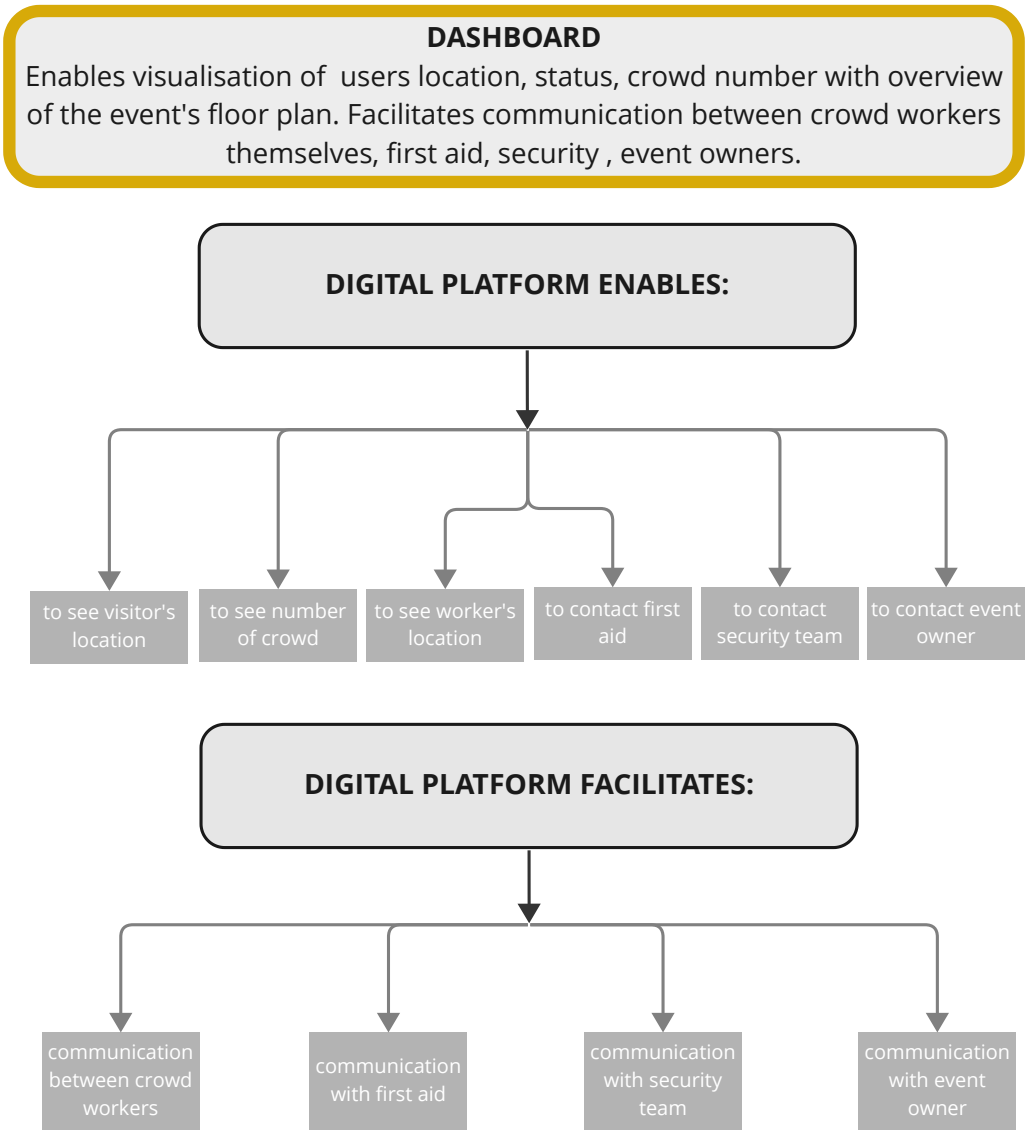


Figure 34. Overview of Goals Set for Kooz Digital Platform Map, created by the author.

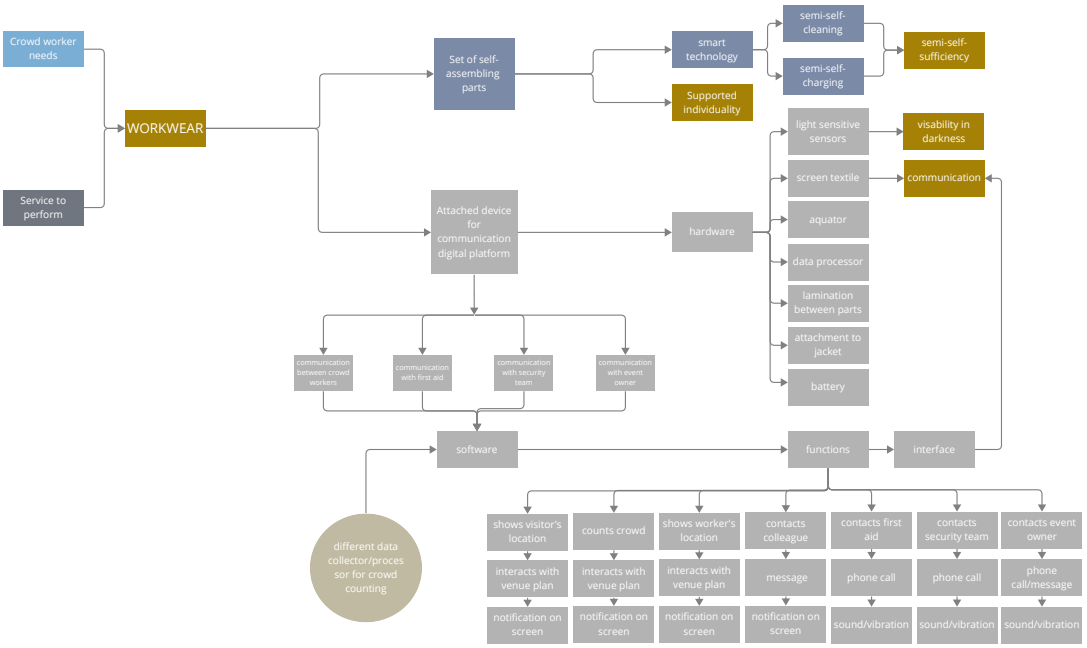


Figure 35. Kooz Workwear Components and Function Map, created by the author.

The bigger overview of the Kooz workwear structure is in ***Appendix C.***

7.1. Users

For a comprehensive sense of what Kooz aims to achieve, I created fictional users - personas - and user stories with them in order to describe how the users interact with Kooz workwear or its communication part. There are different ways how individuals are connected to Kooz and how the concept is perceived. Kooz is told by 3 user stories – a security team member of a large concert, an event owner/organizer, and a physical education teacher.

Use case of Alex at the large outdoor concert (Alex is in this case a crowd assistant, not the distant involved party):

Figure 36. Persona Alex, created by the author.

Alex is a security guard at a rock concert with approx 7,000 people that takes place in the evening. The company owners he works for investing in Kooz workwear. He took part explanatory course and he uses it now in every event he assists.
Using Kooz's communication tool, he as well his colleagues have an overview of people's movement by looking at the map of the land area. Alex is connected with others by seeing their location, status, and movement through Kooz. The counting of the crowd is done at the entrance gate ticket controllers by the QR code of the ticket and the counting laser attached to the entrance gate. The counting system automatically transfers the ticket code to the system that transfers the visitor to the

map of the Kooz interface as a black dot and prints a wristband to the visitor. Via the ticket QR code, Alex sees the movement of the visitor on the Kooz interface.
In the middle of the concert, the density of the crowd in front of the stage becomes tighter and the behavior more aggressive. An incident with an aggressive group of people happens in front of the stage where Alex secures the mass. It takes the attention of two other colleagues attention as well. They change their status in red and deal with the situation. One young male got injured and they call the ambulance team via Kooz. They lead the injured person out of the mass and meet the arrived first aid team. The incident subsided because the security guards reacted on time and everyone moved to their original places and changed their statuses back to green.
Then a group of concertgoers turned towards Alex as they recognized him via luminous sleeves and asked what is the fastest exit from the concert area. Alex gave them instructions and the group left.
At the concert's end, Alex directs the crowd toward the exit with enhanced direct and instructional hand gestures that are well visible because of luminous Kooz sleeves.
After the concert, he changes workwear to his own clothes, and this time he knows he needs to do nothing with that in means of cleaning as they all deliver workwear for cleaning every 2 weeks.

Use case of event owner Rebecca (event owners have informed users with looser ties to the digital platform and overall Kooz workwear. Their main interest is the financial and artistic success of events. Kooz provides them with a direct phone or message connection in case of need.):

Figure 37. Persona Rebecca, created by the author.

Rebecca has been organizing big concerts for almost 20 years. She is familiar with the process of building up concerts and she also owns a security company that provides security services for these concerts. When she got acquainted with Kooz's design solution, she liked that it offered her versatile solutions: communication with all parties involved in the service and the optimization of cleaning and, if necessary, enabling connection with her smartphone as a concert organizer. For the upcoming concert, she decided to invest in Kooz solutions.

On the day of the concert, Rececca was available via smartphone, but there were no notifications from the concert venue. She already thought that everything would go smoothly. However soon after, she received a message from a security team member via Kooz in his smartphone message box that a visitor broke his leg in a scuffle in the exiting crowd, but the situation was resolved with the involvement of an ambulance, and since the visitor was clearly under the influence of alcohol, which was also confirmed by the emergency workers, it is unlikely that somehow the organizers will be blamed for the incident.

Use case of concert-goer Madis.

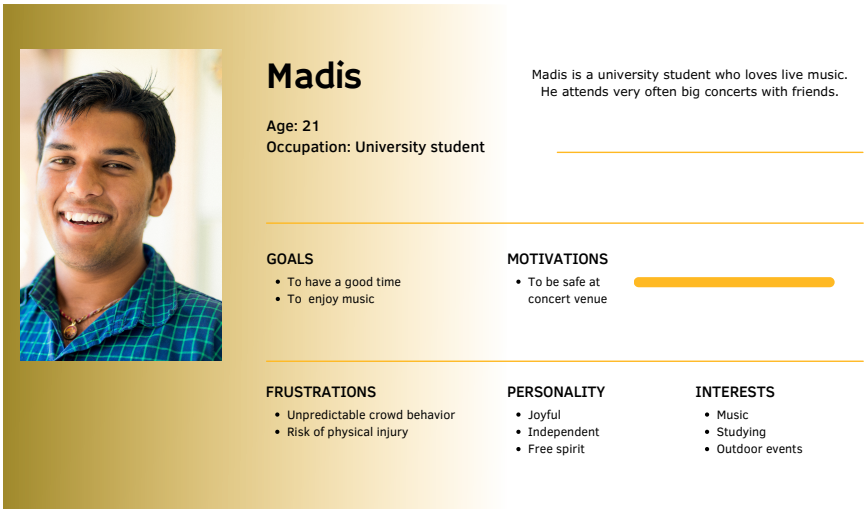


Figure 38. Persona Madis, created by the author.

Madis likes concerts and often attends with friends. Before the concert the same night they all meet in a bar and have a beer or two. Arriving at the concert place they head to the front of the stage to be close to the band performing.

The concert started and everyone joins in. The crowd continues to gather and there was a scramble for space. Someone aggressively hit Madis on the back, and then a fight broke out between Madis and the hitman. The scuffle turned into a fight and the security guards quickly intervened into the incident. In the scuffle, someone fell on Madis' leg and he felt great pain. The security team helped the rioters away from the concert site, and the ambulance that was called in advance arrived immediately. Madis got help but the injury seemed to be serious because he could not walk properly. The ambulance took Madis for more examination at the hospital and that was the end of the concert for Madis.

User Journeys Maps were created synchronically with the following cases and presented a bigger version in ***Appendix D.***

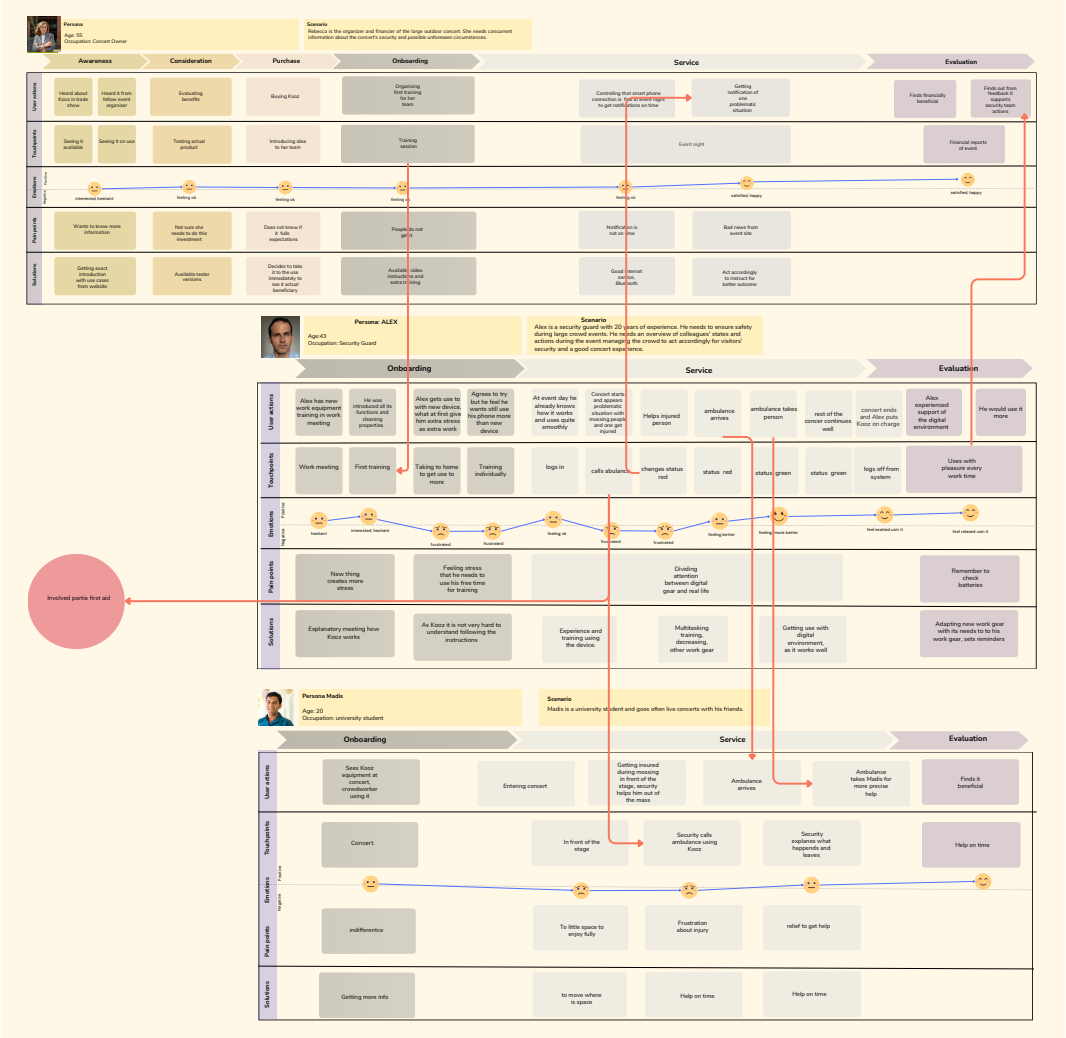


Figure 39. User Journey Maps.

Use case of high school physical education teacher Katie:

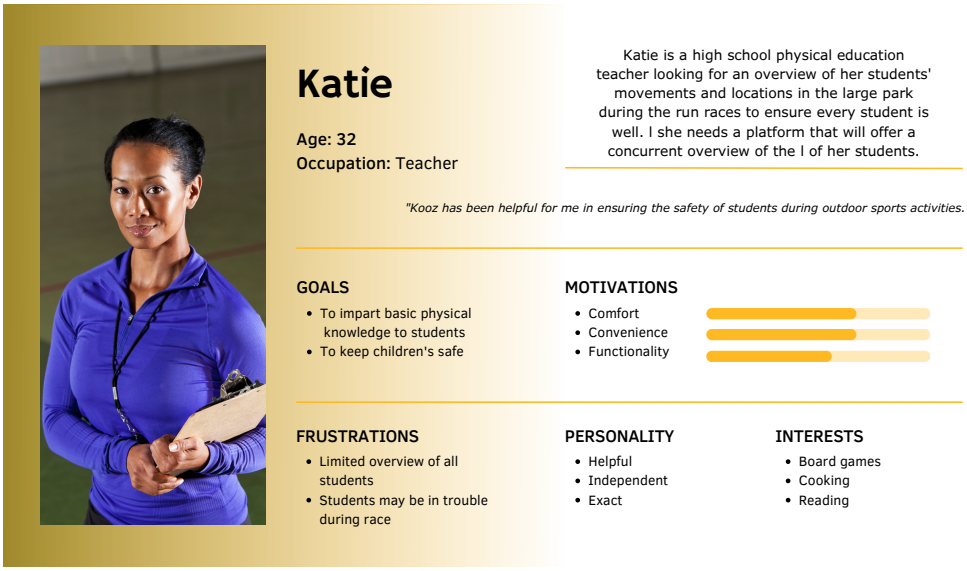


Figure 40. Persona Katie, created by the author.

On the high school day, the task of the two parallel 10th-grade physical education classes with a total of 40 students is an orienteering run in a large park. The aim of the physical education lesson is to cover a given distance according to the instruction card. Physical education teachers Katie and her colleague Stuart meet the students in the hall of the school building at the beginning of the lesson, where the wristbands are distributed to the students. The wristband has an OR code, which teachers enter into the Kooz system using a laser reader to record the total number of students and monitor their movement during the run in the park. The teachers then fasten the pre-loaded Koos around the sleeve of their jackets. Afterward, they go together to the big park next to the school for a physical education class. Two meeting places are agreed and one of the teachers moves to meet place no. 2. The purpose of the meeting places is to divide the distance in half and, if necessary, to help the students by reaching them faster in case of need. Then the children start running according to the instructions.

Katie and Stuart monitor students from the Kooz's soft screens displays where the trajectory of the distance is also marked on the pre-loaded map of the park. Everything is going perfectly - students are moving in the right direction.

Then Katie notices a non-moving student point that has deviated from the general trajectory, and instead of moving, it has been standing in one place for several minutes. He informs Stuart about this via text and they agreed that Katie will move toward the student and Stuart will monitor the screen alone. Katie changes the status to red and also changes red the stationary student point. Since the distance is not

long, Katie reaches the student quickly, and when she arrives, she discovers that the student is crying by the side of the road, because a tree branch had torn a hole in the sleeve of his new jacket, and this made his emotional situation sad. Together, is decided that it can be fixed by an expert and they go back to track, and since the student is still disturbed, Kaite decides to take him with her to the agreed meeting place and not force him to run. When the situation is resolved, Katie sends a message to Stuart that everything is fine and changes the status to green. The run ends at the agreed finish and all students and teachers go back to the school building together.

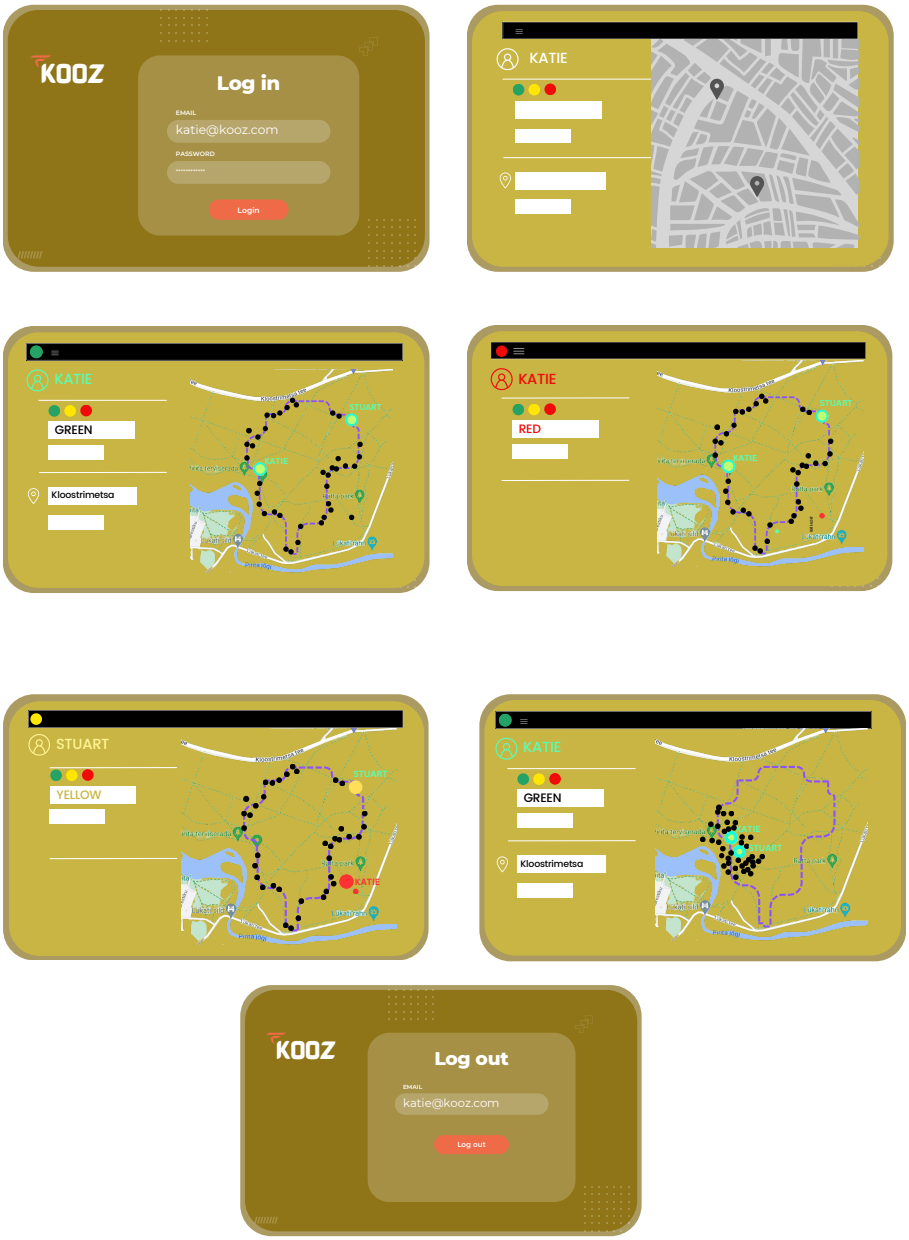


Figure 41. Use Logic for Interface "Case Katie", created by the author.

7.2. Other Applications and Services

Kooz communicates with involved parties (first aid, security team) similarly to applications that can call and send messages to the receiver's smartphone, and they can call or message back. Kooz does not support any social media app because the connection service is meant to be real-life event-oriented supportive communication. Connection is created via Bluetooth. For maps, the GPS service option is used but in most cases, preloaded maps of building floorplans or event areas are used.

7.3. The Benefits of Kooz Stakeholders

The benefits lay on all the main problem owners and stakeholders. In these cases, the users, the event owner and security teams, and the first aid teams are the key stakeholders. The design proposal, if implemented will change the system towards crowd assistants empowerment throw better collaboration.

The assistants will have a sense of community and belonging, a feeling that the special digital network and other members of the community support them. The user of Kooz has the possibility to observe the whole event and be an active member of the concept.

The event owners will have a loose connection with Kooz, being only a provider of the design solution not active users of it during the event. Having a direct message only if the problem occurs as the communication network works professionally with the crowd assistant on the specific topic of need.

The involved parties do not have much difference in their work activities or communications as the Kooz connects with their emergency phone number as in any other case of need.

8. CONCEPT EVALUATION

The reaction to the thesis design concept was generally positive. Different functionalities of the Kooz platform appealed to different users, but most people agreed that a workwear overall concept with the integrated digital platform into the workwear and semi-self-cleaning solution would be a beneficial concept for work clothes to develop.

For a more formal evaluation of the concept, the product-service map digital prototypes and interface layouts were presented to 3 large event volunteers who also were the participants in the interviewees. This presentation took place over a video

session, where it was easy to share the digital research developments. In this evaluation session, they all mentioned that phones replaced by Kooz would make their attention more work-orientated because it does not allow other attractions like looking at social media apps and communicating with people from outside the system. The feedback towards usability and comprehensibility was positive also as they describe it as easy to understand as it has only necessary functions including work. But they mentioned that first time they probably would like to have a smartphone with them as a backup solution for possible accruing unforeseen circumstances though. They all found the functions of the app to be understandable and learnable fast as it has quite basic functions. The user journey was then walked through during the session covering the user's motivation, needs and preferences, actions on the communication platform and in their physical environment, reactions, and potential emotional gain while using different situations. The main thing that was brought out was when going through the user's journey, that a certain frustration arises at a moment when it is simultaneously necessary to enter information on the platform for other employees and to deal with a critical situation in real life. It would take some extra training and get used to it. But since there are few options for entering messages, it was found that it should still be possible to do it at some point, when there is a calmer moment as soon as possible.

8.1. Communicational Change

Changes and improvements in communication can be highlighted through the following aspects. The simultaneous overview of the event provided by the digital communication tool allows you to see everything that is happening and transmit the user's status and movements.

A user can connect with another user as well as privately with one selected user. Direct connections with the organizers of the event are established on the basis of a phone call or SMS, and security teams and emergency services on the basis of a phone call. All this connectivity in the workplace is strictly work-oriented for its current event and does not support distractions such as communication on social media or other non-work activities.

Such strictness is designed so that audience servants and other crowd workers concentrate on the current event as much as possible and keep their attention on it.

The employee in the crowd can immediately enter the necessary information into the digital platform and it will be visible to colleagues who are working in other areas of the event location at the same time and behave accordingly.

Communication between the parties takes place in a digital environment and does not require any other additional means. The environment helps the employees when

receiving information about the changes happening with the audience, and based on this, gives additional instructions for further behavior.

8.2. Growth in Sustainability

Although the ambitious idea of creating self-sustaining workwear, the research results showed many great innovations in that direction, it is always necessary to put people's safety first. As the topic developed, I came to the conclusion that there are many developed nanotechnologies whose safety studies on the use of nanoparticles indicate incomplete, indirect, or conflicting risks to human health and/or the environment.
Therefore final research included the study offers safe solutions for health and the environment by adding dirt protective coating on it still needs cleaning but in a reduced volume which in turn reduces the water usage and increases product lifespan.

The piezoelectricity phenomenon has the potential to the inclusion in clothing as a power producer for wearable digital gear. While the final proposal is to equip the Kooz solution concept with additional batteries and makes the solution semi-self-sufficient it is still a step towards improving sufficiency and overall sustainability.

8.3. Behavioral Change

According to the Transtheoretical Change Model (TTM), ten processes have been identified that must be implemented for the desired behavior change (TTM) [38].
Processes are viewed in the context of Kooz's capabilities, goals, and functions.

Kooz features that support the experiential processes of change:

- **Consciousness Raising:** increasing information - overview of information sharing in the collaborative digital environment; access to others.
- **Dramatic relief:** experiencing and expressing feelings - the Kooz solution supports self-expression through personal clothing choices (supported self-expression); the color combination of red, yellow, and green in the digital environment describes workers' state of being and aiming to let others know of it:
  1. red - I am in the middle of the accrued problem, please take over my work area.
  2. yellow- I took over a colleague's area, please pay attention to your enlarged area
  3. green - I am fine in my position.

  A supported system for expressing emotional states ensures general stress level stabilization.

- **Environmental Re-evaluation:** assessing the impact of behavior on the physical environment - a revaluation of needed activity and movement based on digital overview, and acting accordingly leads to increased work efficiency.
- **Self-re-evaluation:** assessing one's feelings and thoughts - indicators of progress can be measured when everyone reacts according to the one person who entered digital information about the circumstances, and the problems occurring at the event are managed together. Assessing one person's success depends on cooperation with others.
- **Social liberation:** - increasing alternative behaviors - dashboard provides a digital overview of the users' states supporting alternative behavior to act accordingly, to not move physically to get information or call in the case of a problem. Certainty of actions relies on digital information.

Kooz features that support the behavioral process of change

- **Counter-conditioning:** choosing available alternatives - the use of the Kooz digital environment is encouraged by functions focused on solving only work tasks and problems; merging gear with workwear frees the worker from carrying the additional gear; less attention to cleaning.
- **Helping relationships:** creating a digital workgroup, experiencing the support of a digital community, and working on cooperative decisions in a group can lead to stronger relationships and greater trust in real-life.
- **Reinforcement management:** progress overview – seeing achievements in financial and artistic statistics; seeing less expense in workwear cleaning statistics; seeing fewer security teams included cases; visualizes effort being made and highlights positive change.
- **Self-liberation:** believing in the capability to change - positive work experience, positive real-life feedback from colleagues (shoulder-to-shoulder feeling); positive feedback from visitors and event owners.
- **Stimulus control:** combating stimuli that provoke negative behavior - collaboration, contribution, support from other group members, and quick help in case of a problem are all reducing friction and facilitating making positive choices.

8.4. Data Management and Privacy

The digital network that Kooz wants to create between employees is not based on the sharing of personal data other than a person's name. In the case of both smaller and larger events, personal data is also not processed. The ticket code is entered or the wristband is issued only to count the total number of visitors and to track the general crowd movement.

CONCLUSION

The hypothesis focused on improving crowd assistants' communication problems aiming to solve them with new smart technologies. Using co-design methods the design proposal was significantly developed, including the people who work with crowds through the co-designing. The thesis research deals with the question of how a design-based solution can support problematic situations in public events situations to guarantee visitors' best experience and safety via fast and effective communication.
Through selected methodology, active desk research, listening to interviewees' subjects from different angles and corners, and throw visualizing complex problems there was a possibility for problem-solving and also innovation. The motivation behind the design process remained the same throughout – aiming to help workers who serve visitors during crowdy events.

The purpose of the design proposal Kooz is to be a set of smart workwear consisting of a personal choice, with semi-self-sufficient and semi-self-cleaning solutions, and in which a communication tool is integrated. The communication tool can also be used independently without workwear. Smart work equipment includes a digital platform that allows workers to communicate with each other and stakeholders by accurately reflecting the user's location on a preloaded map. Currently, the proposal is co-designed with people who manage crowd sizes of 28 - 400 people. Final design solution use cases include a crowd size of 7000 people.

People's individual choices and physical characteristics are supported by choosing their own clothing set from several options. The design solution presents the possibility of an ensemble of products by combining varied innovative materials and solutions into workwear. That allows crowd workers to exchange information with their colleagues about arising problems during work effectively. Workers are relieved from the stress of where to place the work tool - smartphone-, as it is replaced with integrated smart materials solutions into their workwear. Also, they are relieved from the stress of not knowing what is happening in another part of the event locations. The design solution shows possibilities to create a real-time digital environment based on smart soft-screen material innovations integrated into workwear, to give an overview of the event. By having an overview in the digital environment, unnecessary movements of employees in the large location of the event for the purpose of obtaining information are avoided, which was done before because it was not possible to use the phone in the absence of coverage or the employee had forgotten it to silent mode.

Although the final prototype of this research work has not been completed in reality, it shows the possibilities and potential of the field, based on the scientific works of the field. Seeing new possibilities in combining smart textiles and intelligent materials based on scientific experiments and merging them with workwear was a challenging journey to the final result. Several times the approach had to be changed because innovations fulfilled only one need and created problems with a solution from another angle.

In conclusion, the field possibilities are endless and created great respect for those people who have dedicated their lives to researching innovative textiles and materials and as well as for those who assist all of us in public events.

SUMMARY

Most people love public events that offer well-organized experiences. In addition to the artistic, cultural, emotional, or physical experience of the event, visitors assume and wait for supportive and consistent service throughout the event. People in different roles deal with the successful delivery of the event - organizers, performers, visitors and audience attendants, security, and first aid service providers. Valuable and up-to-date event assisting services can only be created together with the service providers, concentrating on their needs.

The master's thesis focuses on improving workwear and gear-related challenges for audience assistants through co-creation. The master's thesis uses co-design methods, looking at the topic through an ecosystem view and involving various stakeholders.

Following the design thinking process, the work process focuses also on empathy.

The main focus topics in the design proposal are the modern smart workwear of the crowd assistants and the communication tool integrated into it, which supports the simultaneous service of the event in the digital environment. The field use of smart textiles and smart materials in the area of work clothing has been discussed more broadly by introducing additional smart technology functions such as self-cleaning, self-sufficiency, and light sensitivity. The purpose of the design proposal Kooz is to be a set of smart workwear consisting of a personal choice, with partially self-sufficient and partially self-cleaning solutions, and in which a communication tool is integrated. The communication tool can also be used independently without workwear. Smart work equipment includes a digital platform that allows workers to communicate with each other and stakeholders by accurately reflecting the user's location on a preloaded map. The design solution Kooz has been co-designed together with people who work with crowds in everyday life and taking into account their needs. Kooz will assist the crowd worker from the start of the event to its end. The solution of the master's thesis is created in such a way that the development of the design offer can be further expanded in various ways, both by improving the digital communication platform and the set of smart workwear.

EESTIKEELNE KOKKUVÕTE

Enamus inimesi armastab hästi korraldatud elamusi pakkuvaid avalike üritusi. Lisaks ürituse kunstilisele, emotsionaalsele või füüsilisele elamusele eeldavad ja ootavad külastajad toetavat ja sidusat teenust läbi kogu ürituse. Ürituse õnnestumisega tegelevad erinevates rollides olevate inimestega – korraldajad, esinejad, külastajad ja publiku teenindajad, turva- ja esmaabi teenuse pakkujad. Väärtust pakkuvaid ja ajakohaseid külastajatele mõeldud toetavaid teenuseid saab luua vaid koos asjaosalistega, keskendudes nende vajadustele.

Magistritöö keskendub publiku teenindajatega tööriietega ja töövahenditega seotud väljakutsete parendamisele läbi koos-loome. Magistritöö kasutab koos-loome meetodeid, vaadates teemat läbi ökosüsteemi ning kaasates erinevaid seotud osapooli. Läbi disainmõtlemise protsessi liikudes keskendub töö empaatiale.

Põhilised fookusteemad disainiettepanekus on töötajate kaasaegne tööriietus ning sellesse integreeritud kommunikatsioonvahend, mis toetab digitaalses keskonnas samaegset ürituse teenidust. Nuti tekstiilide ja nutimaterjalide kasutusvaldkonda tööriietusalal on käsitletud laiemalt tuues sisse lisafunktsioonid nagu isepuhastuvus, isemajanduvus ning valgustundlikkus. Disainiettepaneku Kooz eesmärk on olla personaalsest valikutest koosnev nuti-töörõiva komplekt, millel on osaliselt isemajandavad ja pooleldi isepuhastuvad lahendused ning millesse on integreeritud kommunikatsiooni tööriist. Kommunikatsiooni tööriista on võimalik kasutada ka iseseisvalt ilma tööriieteta. Nutikas töövarustus sisaldab digitaalset platvormi, mis võimaldab töötajatel omavahel ja sidusrühmadega suhelda, kajastades täpselt kasutaja asukohta eellaaditud kaardil. Disainilahendus Kooz on kaasavalt disainitud igapäeva elus rahvahulkadega töötavate inimestega ning nende vajadusi arvestades. Kooz on abiks rahvahulga töötajale alates ürituse algusest selle lõpuni.

Magistritöö lahendus on loodud viisil, et disainipakkumise arendust saaks edasi laiendada erinevatel viisidel, nii täiustades digitaalset kommunikatsiooni platvormi kui ka nutikat töörõiva komplekti.

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LIST OF FIGURES

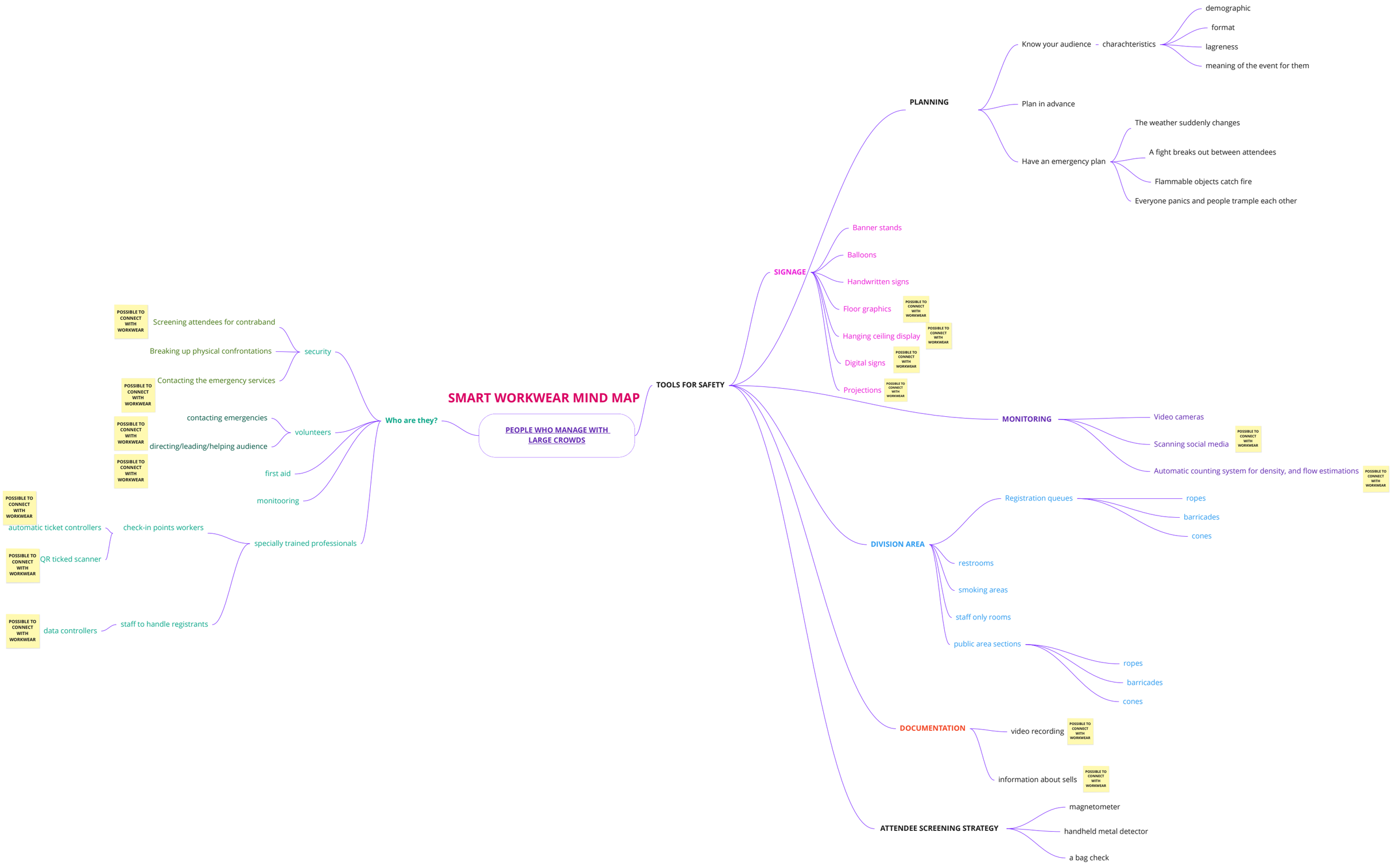
LIST OF TABLES

LIST OF PHOTOS

APPENDICES

APPENDICES

Appendix A. Research Groups Mind Map



Appendix B.
Constructive Design Research Model

MODEL OF THESIS RESEARCH

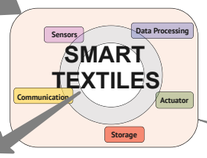
STAKEHOLDERS

PEOPLE WHO WORK WITH GROUPS AND LARGE CROWDS

SMART WORKWEAR POTENTIAL USAGE MIND MAP

RESEARCH INTEREST

SMART TEXTILES



SMART TEXTILES
1.Fabric with textile-based sensor electronics
2.Fabric that envelopes traditional sensor electronics.

E-TEXTILES
e-textiles can be divided into two main types:
1.E-textiles with classical electronic devices such as conductors, integrated circuits, LEDs, and conventional batteries embedded into garments.
2.E-textiles with electronics integrated directly into the textile substrates.

CONSTRUCTIVE DESIGN RESEARCH MODEL

MOTIVATION
Design could be the bridge to help create better and safer experiences in public events with large crowds

THEORETICAL FRAME WORK
To gather all the relevant information about technologies what are already in use and may be useful for solution. Ideate about existing solutions.

HYPOTHESIS
Assuming that there are smart workwear that can help better crowd management and communication between workers to lead crowd

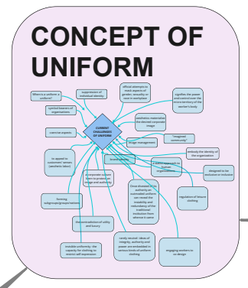
Smart workwear can lead to better communication between workers and create a better and safer environment where event takes place

RESEARCH QUESTION
How a design-based solution can support problematic situations in current public event situations to promote people's best experience and safety via fast and effective communication?

EVALUATION
Evaluate impacts and effects of communications of smart workwear with large crowds of people via smart solutions and validate the outcome with experts

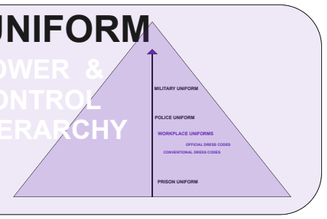
EXPERIMENTATION
Stakeholder interviews
Online questionnaires
Observation
Scenarios
Mind-mapping
Prototyping
Framing
Testing

CONCEPT OF UNIFORM



UNIFORM

POWER & CONTROL HIERARCHY



HISTORY OF UNIFORM

TOPICALITY

expected positive impacts

sustainable

communicational

behavioral

USER RESEARCH: STAKEHOLDERS INTERVIEWS

WORKSHOPS IN HIGH SCHOOLS

PROBE Modified workbook of company IDEO designthinkingforeducators.com

PROBE

KEHTNA HIGH SCHOOL FOR ADULTS **10 students**

PIRITA ECONOMY GYMNASIUM **28 students**

DESIGNERS

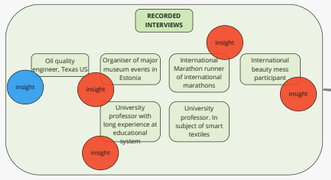
TESTERS

NEW DESIGN PROPOSE

RECORDED GROUP INTERVIEW

Theatre audience assistants **10 PEOPLE**

RECORDED INTERVIEWS



GOOGLE FORMS

TEACHERS KEHTNA 20 PEOPLE

TEACHERS PMG 20 PEOPLE

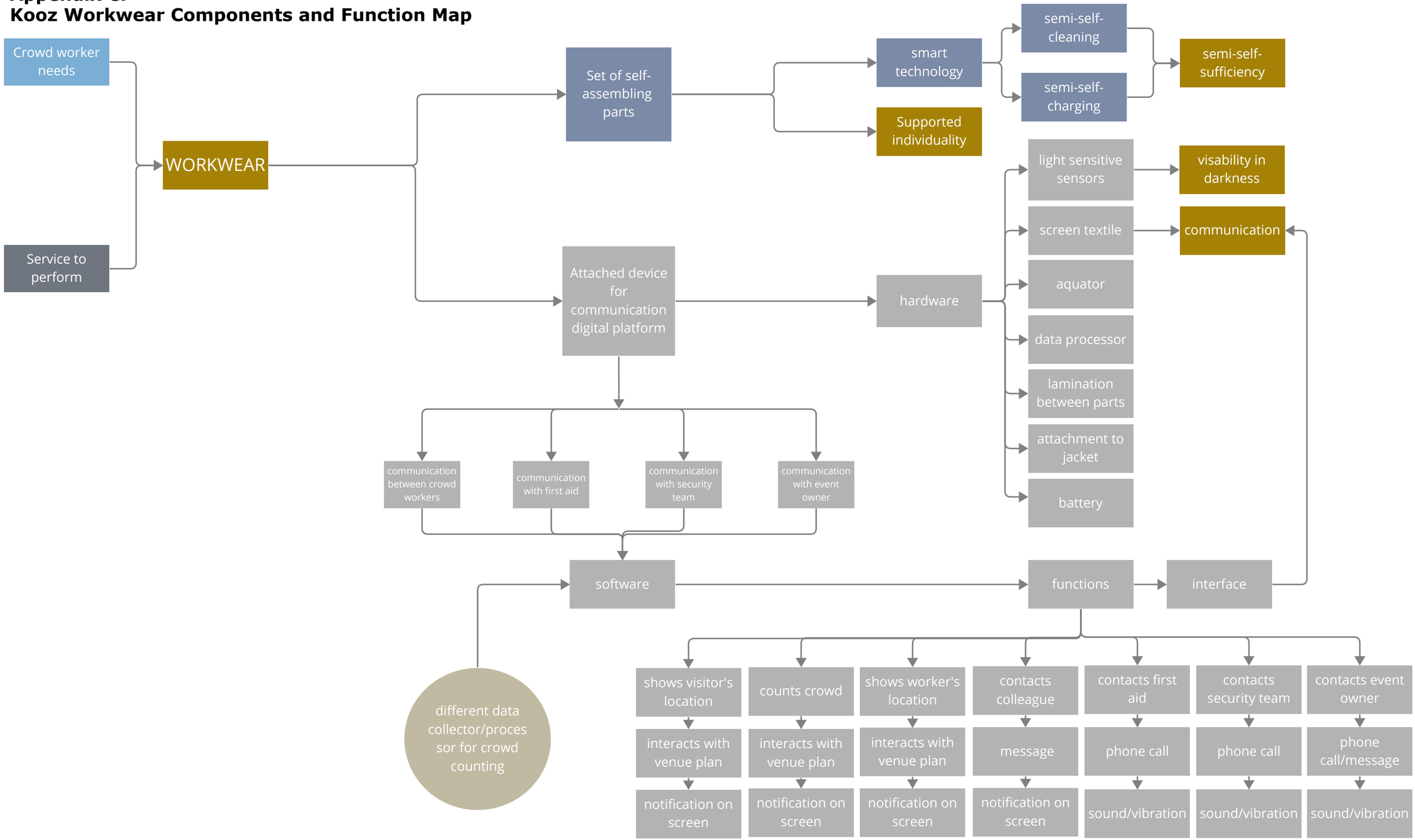
SECURITY COMPANIES

WORKSHOPS: CO-CREATING WITH STAKEHOLDERS

PROBE

DESIGN PROPOSE

Appendix C.
Kooz Workwear Components and Function Map



Appendix D. User Journey Maps

Persona

Age: 55
Occupation: Concert Owner

Scenario
Rebecca is the organizer and financier of the large outdoor concert. She needs concurrent information about the concert's security and possible unforeseen circumstances.

	Awareness	Consideration	Purchase	Onboarding	Service	Evaluation
User actions	Heard about Kooz in trade show Heard it from fellow event organiser	Evaluating benefits	Buying Kooz	Organising first training for her team	Controlling that smart phone connection is fine at event night to get notifications on time Getting notification of one problematic situation	Finds financially beneficial Finds out from feedback it supports security team actions
Touchpoints	Seeing it avaliable Seeing it on use	Testing actual product	Introducing idea to her team	Training session	Event night	Financial reports of event
Emotions (Positive / Negative)	interested, hesitant	feeling ok	feeling ok	feeling ok	feeling ok	satisfied, happy satisfied, happy
Pain points	Wants to know more information	Not sure she needs to do this investment	Does not know if it fulls expectations	People do not get it	Notification is not on time Bad news from event site	
Solutions	Getting exact introduction with use cases from website	Available tester versions	Decides to take it to the use immediately to see it actual beneficiary	Available video instructions and extra training	Good internet service, Bluetooth Act accordingly to instruct for better outcome	

Persona: ALEX

Age:43
Occupation: Security Guard

Scenario
Alex is a security guard with 20 years of experience. He needs to ensure safety during large crowd events. He needs an overview of colleagues' states and actions during the event managing the crowd to act accordingly for visitors' security and a good concert experience.

	Onboarding	Service	Evaluation
User actions	Alex has new work equipment training in work meeting He was introduced all its functions and cleaning properties. Alex gets use to with new device, what at first give him extra stress as extra work Agrees to try but he feel he wants still use his phone more than new device	At event day he already knows how it works and uses quite smoothly Concert starts and appears problematic situation with mossing people and one get injured Helps injured person ambulance arrives ambulance takes person rest of the concer continues well concert ends and Alex puts Kooz on charge	Alex experienced support of the digital environment He would use it more
Touchpoints	Work meeting First training Taking to home to get use to more Training individually	logs in calls abulance changes status red status red status green status green logs off from system	Uses with pleasure every work time
Emotions (Positive / Negative)	hesitant interested, hesitant frustrated frustrated feeling ok frustrated frustrated feeling better	feeling more better feel exatied usin it feel relaxed usin it	
Pain points	New thing creates more stress Feeling stress that he needs to use his free time for training Dividing attention between digital gear and real life		Remember to check batteries
Solutions	Explanatory meeting how Kooz works As Kooz it is not very hard to understand following the instructions Experience and training using the device. Multitasking training, decreasing, other work gear Getting use with digital environment, as it works well		Adapting new work gear with its needs to to his work gear, sets reminders

Involved partie first aid

Persona Madis

Age: 20
Occupation: university student

Scenario
Madis is a university student and goes often live concerts with his friends.

	Onboarding	Service	Evaluation
User actions	Sees Kooz equipment at concert, crowdworker using it Entering concert Getting insured during mossing in front of the stage, security helps him out of the mass Ambulance arrives Ambulance takes Madis for more precise help		Finds it beneficial
Touchpoints	Concert In front of the stage Security calls ambulance using Kooz Security explanes what happends and leaves		Help on time
Emotions (Positive / Negative)	indifferentce To little space to enjoy fully Frustration about injury relief to get help		
Pain points	Getting more info to move where is space Help on time Help on time		
Solutions			