

**Digitalizing Performance:**

The influence of wearable technology on costume design and on the work dynamics of interdisciplinary collaboration



Master's thesis for Master of Arts (Art and Design)

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### Abstract

When wearable electronics are used in a costume, they become a tool to expand its basic visual function and explore new, multi-sensory layers. Through technology, the performer's body breaks the conventional frames and pushes the aesthetics and functions of costume design to the foreground of performance making. This thesis investigates the use of wearable electronics in a costume, their functions and influences on various aspects of the performance making process, specifically on costume design and the work dynamics of interdisciplinary collaboration. The work is based on the application of data captured by a 3D position tracking software to different wearables in a live demo performance, and examines the development of a performance dramaturgy around such material and the performer experience in a costume with embedded technology. As this thesis shows, the functions of technology in the costume made for this project upgraded the performer's role in the staging, as the performer became the agent who provoked interactions between the stage elements by simply moving around the space. The location of tags embedded in the performance costume was tracked and the position data was used to generate location-related cues that would trigger interactions with the set, sound, lighting and costume lights without any other mediating operator. An interdisciplinary team of students collaborated on creating such a costume as well as the performance, whose narrative was built around the interactions the embedded technology offered. The creative process and results of the project are used as the case-study for this practice-based, design oriented artistic research, providing insights collected through qualitative methods, such as auto-ethnography, observation, and informal semi-structured interviews. Wearable technologies that are becoming part of the costume design process offer possibilities for a new layer of visual or sensorial effects, encourage wider conversations and create unexpected collaborations. They initiate different approaches to the design of a costume and to make performance from an aesthetic and also practical perspective, as the components provide new functions and expressive possibilities, but need to meet certain safety and comfort requirements when embedded. Taking full advantage of the wearable elements requires the costume to take the lead in the performance making process, affecting the work dynamics as a whole, as the collaboration develops around the costume. Such situation creates an opportunity for interdisciplinary team members to work closer together, proposing the purpose, functionality and design elements of the costume, making it a shared domain that supports storytelling.

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**Keywords** costume design, wearable electronics, interdisciplinary collaboration, interactive performance, digitalizing performance, position tracking technology

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**Front cover:** The beginning of the performance, Kallio Stage (López, 2018)

**Back cover:** The performer dancing with the light objects, Kallio Stage (Hallikainen, 2018)

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## - Introduction

In my practice as a costume designer I have increasing encounters with ideas and demands for something out of the ordinary, something that brings another layer to the costume that expands beyond costume as a visual element that dresses a character. Wearable electronics offer new possibilities and can be used as a tool to accomplish that. The use of wearable electronics has the potential to provide new aesthetic languages, functional roles, but mainly new possibilities to explore and express through costume. As a competent costume designer I need to be able to adapt and understand how to integrate technologies into the costume I design, how this affects the costume, the performer, the wearable components, how they need to be managed and implemented, as well as the functions they provide. In order to explore alternative options and approaches to performance making with wearable technologies integrated into costume, I have undertaken artistic research, which I analyse in this thesis. The aim of this thesis is to investigate the use of wearable electronics in costume, through a specific project as a case study, and, by doing so, to explore how such a technology influences different aspects of performance making throughout the process, focusing on costume design and the dynamics of the interdisciplinary team collaboration.

Nelson (2013:3), whose work has championed “Practice as Research” (PaR) in the performing arts, proposes that:

*“People engage in research from a variety of motives but, ultimately, the rigours of sustained academic research are driven by a desire to address a problem, find things out, establish new insights.”*

The motivation behind this practice-based research is to bring attention to the approach that relates to, and affects costume design, as well as to the development of performance dramaturgy when wearable technology is brought into creative teamwork. To achieve this, I use an example of such a project, in which costume and the technologies incorporated in it affected the creative and practical aspects of collective performance creation. In these, the costume-based process encouraged new creative approaches and led the team to transcend the established roles of their fields of expertise. The final performance of this project – a demo performance – was built around interactions that were not generated directly by the costume material itself, but by technology, embedded in the costume. Hence, the term “costume-based” does not address the frame of the costume only as a physical material or as an object, but also addresses the functions, actions and other possibilities that the costume provided, which are discussed further in this thesis. These happened with the support of wearable devices and instigated visual manipulations, visible mainly through the interaction with the lighting, with great potential for new creative ideas. The technology embedded in the costume in question was programmed to take control from the lighting console and trigger different atmospheric and scenic manipulations directly through the action of the performer’s movement in space and without any other mediating operator. Such transitions are commonly present in theatre, but are usually operated by a technician: light changes, scenery alterations, sound effects and mixing, as well as costume and prop manipulations. The ability to take advantage of such functions without an operator, influenced and enhanced the creative team’s approach to the concept of the final demo performance, which was executed in a way that no technicians were needed behind the controlling console throughout the entire duration of the performance. Moreover, the technology in the costume upgraded the performer’s role in the

staging, as the performer became the agent who provoked such changes. On the account of suddenly gaining complete control over space manipulations, the performer was left experiencing either, or both, certain liberation and additional responsibility.

Through a theoretical framing that departs from the established roles and process for costume design and the costume designer within a creative team, followed by exploration and experiments, this research spans from the start of the collaborative process, to the final demo performance as a result. To illustrate how, when and what happens when the costume, and together with it, the performer, take over the management of mechanical, digital and artistic changes on stage, I approach this research with the following questions:

- RQ1: How does wearable technology influence the approach and the process of costume design?
- RQ2: How do wearable electronics and their features influence the performance-making approach and process?
- RQ3: What does a costume-based approach bring to the work dynamics in an interdisciplinary collaboration?

- **Personal background on the topic**

The first time I was introduced to wearable electronics and intelligent textiles was during a short theoretical course called “Intelligent Textiles”, back in 2013 in my previous Master studies in Engineering Design of Textile Materials at the University of Maribor, Slovenia. I remember watching the video of Hussein Chalayan’s transforming dresses and being fascinated by the dresses altering their shapes, proportions and colours, seemingly on their own, without any visible trigger (Hussein Chalayan Spring Summer 2007). These features sparked my interest, but with the tight time frame and no resources, I completed the course with presenting few enthusiastic theoretical ideas, some more realistic than others. At that time wearables were neither affordable nor easy to come across in the context of my studies, and with little knowledge of how to make things work, or even where to turn for help, I was not able to work in this field much further.

Following, I worked again in this area during the “Wearable Electronics” course as a part of my Master level studies in Costume Design at Aalto University, in the spring of 2017. This time the course was not strictly theoretical, it had a hands-on approach. There I was able to see and learn how things are built and connected, what is needed to make a costume light up, produce sound, detect and react to the physical changes in the body, as well as where to find the needed components such as sensors, resistors, tiny LED lights or appropriate wires. A challenge within the frame of this course was to start from scratch: to explore the electronics, create a concept with them, and present a working design. With an enthusiasm to play with lights in the costume, a team of two costume designers and a lighting designer was formed. The cooperation resulted in the creation of a “Living dead doll”, which was cosplayed by fellow

student Ina Dolk, one of the designers in the team.<sup>1</sup> The costume we created featured a light panel in a shape of a heart and a crinoline framed with electroluminescent wire, both of which had the ability to light up in different patterns; to shine constantly, to flash periodically or, more importantly, to flash to the rhythm of the wearer's heartbeat. For the last one to happen, light features were connected to a small pulse sensor which was masked into a decorative earring, a feather board and of course a power source. The programming code needed to be uploaded to the feather board, which would take the incoming data from measuring the pulse, and transform it to impulses sent to the light components to flash. With a desire to present an illusion of the costume having a life of its own, without being visibly altered, the technological elements needed to remain unseen. With the shape of the costume, they were easily hidden in a pouch under the crinoline, where they remained invisible, while not affecting the enactor's movement. Sound effects were not planned, but flickering of the electroluminescent panel and wire came with a mechanical clicking sound. That enhanced the illusion of an artificial life from inside the costume, and created an eerie atmosphere, portraying the crossover between human and technology. The final outcome created a modest yet captivating visual effect and brought a very new experience for the wearer (who in this case was not only a designer but also an experienced cosplay performer). After a while in the costume, despite being fully dressed, Dolk felt vulnerable and stripped down in front of the audience, because of the fact that the spectators could read her pulse through the light flickering pattern (Dolk, 2018). The feeling of being exposed, despite being fully clothed, is an effect noticed also elsewhere in projects involving sensors that communicate bio-data, e.g. by Pesonen (2013:10-11), who shortly addresses this issue in her master thesis that involves fashion garments producing sound through biosensors. The "Living dead doll" was a small-scale project that resulted in curious findings and in a whole new world to explore.



**Picture 1:** Ina Dolk as The Living Dead Doll, Theatre Academy (Frumen, 2017)

Following these preliminary explorations, when the "Digitalising performance with wearables and software" research project came as an opportunity, I was thrilled to be able to work with electronic components once more, this time with direct support by a computer scientist as a part of the team. This meant working with someone who knows what kind of components are needed when the ideas come, how to wire them, and – more importantly – to know how to write codes according to the wishes and requirements of the team; this is a precious addition to the performance making team. The fact that such a skilled collaborator was going to support the technical part of this project relieved me from thinking about what I am capable to make happen and brought much needed freedom to the project; therefore I gladly dived into the project, head first.

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<sup>1</sup> The team on the "Living dead doll" project included Costume designers: Ina Dolk and Tjaša Frumen and Lighting designer: Essi Santala.

- **Structure of the thesis**

The thesis is structured in the following sections; Introduction, Theoretical framing (Chapter 1), Artistic research (Chapter 2), Observations (Chapter 3), Findings (Chapter 4) and Conclusion. The introduction presents the topic and the aims of the research, the personal background of the author, the motivations behind the research, and the main research questions.

Chapter 1: The theoretical frame firstly covers the general approach to costume design and to collaborative performance making without the use of wearable electronics, and then, as a comparison, continues to address the same approaches when wearables are used. Through a literature review, the wearable electronics are shortly defined and traced back through history in the context of costume, while the thesis topic is related to previous writings. The thesis continues to explain the practical implications of the costume design approach and their connection to the team dynamics, when wearable electronics are a part of the process. Theoretical examples are trailed from the general idea to practicalities of execution and embedding the electronics, to maintenance of the final costume. The new level of collaboration between different design disciplines through costume is addressed, due to which the costume becomes a collective site of collaboration, instead of merely the costume designer's domain.

Chapter 2: The theory is put to practice in the artistic part of the research, which is formed around a case study. This chapter presents the project, the creative team behind it and the technology used. Through the Nelson's (2013) methodological approach of Practice as Research, as well as Arlander's (2011) method of using practice as data for the research, the stages of the artistic work are presented and applied to test the research questions of the specific case. The actual practical work is presented through the collaboration on costume embedding wearable electronics, its functions and data output used in the performance making and creating the narrative.

Chapter 3: Observations consist of practical matters noticed through the working process of the case study project. These observations address the occurrence of technology creating an illusion of a performative character in space, in its interaction with the performer through costume-embedded elements. This section also addresses the performer's experience in the costume embedding wearable technology as well as the performance making process with focus on the functions and roles it provided.

Chapter 4: Findings provide the answers to the research questions set in the introduction. These are analysed with practical knowledge acquired through the overall work process on the case study. The thesis concludes with personal implications for further research development on this topic, as well as reflections on the process and outcomes of the project.

## - Chapter 1: Theoretical Frame

### ○ General approach to costume design in collaborative team dynamics

As the thesis focuses on the use and outcomes of technology in costume and its effects in the costume design and collaborative performance making process, I feel that it is firstly appropriate to, shortly address the conventional, and most widespread, approaches to costume design and the performance making practices of a creative team within an established process. There are no specific rules on how processes do or should happen. Each project as well as every creative team is different; it carries diverse needs, ideas and ways in which designers approach the design and production. Therefore, my theoretical framing is a one-sided process sample written from the viewpoint of a costume designer, based on my personal experience gained through time. It is therefore background and interest-specific and is meant to serve as a generalised pre-existing theoretical context to compare the topic to.

A common process of performance making frequently starts with a collective exchange of ideas. Depending on the starting point of the project, whether it is being developed from a script or not, the levels of conversations vary. Then the team would present their ideas through sketches or mood boards, see how they fit with one another, and after the sense of a world and its atmosphere is established, each team member more or less retreats to complete their piece of the puzzle, their own field of expertise, until the point when it all comes together. The creative contributors from different disciplines would keep each other in the loop during the process, but ultimately everyone takes responsibility of their part of the creative contribution.

Costume is a piece of clothing that the performer inhabits to create a character. It serves the purpose of establishing personality, by revealing the layers of the stage persona (Hočevár, 2012:37). In other words, it influences the viewer's perception of who this character is; are they a part of this world or an outsider, what are the personality traits of this person, what is their social status and are they important, are they a memorable individual or somebody who blends with the crowd. One usually approaches designing a costume from a few influencing inspirations and demands in mind. Sometimes there are specific demands coming from the script or the director's vision and in such cases one tries to work with such input, rather than against it. It can be anything from a tiny piece of jewellery to maybe a jacket, but in any case, something that carries a significant meaning from the character's past. With that, as Pantouvaki (2014:180) writes, the costume becomes *"a tool for storytelling and for creating experiences with multi-layered interpretations."*

The initial ideas either stay as intended or partly change according to the performer's physical features (their body figure, their skin tone, sometimes hair colour) as well as performance features (e.g. the posture and body language they adopt for the character). But what the final design of the costume strongly resonates with is the context of the world and the atmosphere that the artistic team aims to create. A sense of the universe is being created with combinations of colour pallets, textures, materials, shapes and it is also a stage in the process, where the collaboration with other disciplines really shines through. The performer in the costume starts living the story when placed in the space, and this is why in my view (excluding the directors or

choreographers) the collaborations between costume designers and scenographers are the most engaging and comprehensive ones. In bare minimum the use of style, colours and patterns needs to be discussed, so the character does not end up looking out of context.

Lighting design elevates the visual elements, creates the moods and many different kinds of illusions. What lighting designers like to know as soon as possible is, what colours are going to be used in the elements on stage, be it costumes or set pieces, so they can proceed with designing and planning the lighting. As it happens, certain materials and colours can react to certain shades of lights and change their appearance completely. Sometimes this is expected and planned, yet other times it happens completely unpredictably and can disturb the imagined colour pallet. That is why it is very useful to have an opportunity to test the materials on stage before the costume is made, in which case there is still a chance to decide whether to use a different material, as opposed to changing the lights which is the only option left when the costumes are finished and the opening date is close by.

Sound design enriches the experience and immerses the audience (and performers) into the story, but it seldom connects directly to costume design. Occasionally performers get microphones, but these are generally added in the end, on top or under the costume. Because they are mainly used to record speech, microphones are placed in standard positions. Depending on the type of microphone, it would either be located on the forehead, on the side of the cheek or on the upper part of the chest, while the battery goes to the back, inside a microphone belt or pocket.

While the costume is being made and all the aesthetic choices are ideally already decided, the disciplines not actively involved with the costume might begin to feel a bit anxious about getting the costume on stage. They do not always have a sense of how much time the process from sketches to making, fitting, adjusting and finishing of the garment takes. Especially if the costume is complicated and the performance in the making is not the only one in the maker's schedule. Most of the time costumes do not just exist and sit in the wardrobe waiting to be used; they need to be made from scratch. The materials need to be found, ordered, washed, cut to specific patterns, sewn together and get finishing touches such as closings, edges and other details. The more the costume designer knows and understands about this process, the smoother the collaboration with the maker gets. When time comes for the fitting, only the narrowest circle of the creative team is present; the costume designer, the costume maker, the performer, sometimes the director and occasionally the hair and make-up designers. Performers frequently express valuable comments about the costume, mainly concerning the relation between comfort and movement. During the fittings they share their concerns if the neckline or the waist is too tight, if they are able to raise their arms without the shirt moving out of the pants, if they can they squat without any seams tearing, etc. Costumes can either let the performers move as freely as possible within the limits of the choreography or shape the movement by intentionally restraining them in some pre-determined way. In the latter option, costume serves to explore the movement through the use of the costume, and this is the reason why the prototype, if not the final costume, needs to be presented quite early in the process. Firstly, to develop the choreography, and secondly to see whether the costume can last throughout the performance, or if duplicates will be needed throughout the running time. In such cases the costume drives the process of performance making, its aesthetics and narrative, causing the ideas and collaborations to evolve around the frame it is suggesting.

Hair and make-up designers often come in towards the end of the process, when the time comes to complete the transformation of the performer into the character. It is very useful if they are present at the costume tests during the performance making process, so that all the elements can be put together to

see how they fit when there is still time to tweak or improve them if needed. When everything falls into place, especially within the given time frame, it results in a complete performance that everyone is satisfied with.

- **Use of wearable technology in costume and how it affects the collaborative team dynamics**

- **Theoretical Implications**

Through the technology in the costume we start to perceive the performer's body differently. Both aesthetically and functionally we cannot help but anticipate how a certain feature will look, transform, what illusion it can create and how this supports the experience. Wearable electronics cover a broad spectrum of items, from accessories with an extra multi-sensory function, to highly purposeful medical implantable devices. They qualify as *"electronic devices constantly worn by a person as freely as clothing to provide intelligent assistance that augments memory, intellect, creativity, communication and physical senses"* (Ko, El-Aufy, Lam, Macdiarmid, 2005:13). In this thesis I am focusing on electronics worn in the costume, therefore the wearable electronics I am discussing are being used for entertainment purposes. These are analysed through a case study performance.

With integration of wearable electronics in the clothing we are able to, as Seymour (2010:54) describes, *"transform traditional fashion elements such as color, texture, and cut to include movement, touch, light, sound, and interactivity as new aesthetic interaction interfaces."* A garment can be recording and transmitting video and audio materials, changing shapes or proportions, generating wind or vibrations, reacting to a number of different factors, etc. There are many possibilities wearable technology can provide, and with sufficient skill and resources, most of them are possible to achieve.

The use of technology in costume design is not exactly a new concept. Early experimentations with illuminating performers through costumes go back to the late nineteenth century. One of the most known examples are the pioneering dance performances of Loïe Fuller. She fascinated the audiences with what looked like *"painting with light,"* by illuminating the flowing draperies of her costume (Pantouvaki, 2014:182). An example dating to roughly the same period, where the technology was actually worn, is Gustave Trouvé's electro-mobile jewellery. With the help of miniature electro-magnets, small figurines on the tie-pins were able to move or light up; effects that would later be featured on the costumes of Folies Bergère performers and ballet dancers (Classic Boat Magazine, 2012).

The means of bringing such effects to life used to be and still are quite ambitious, and can therefore quickly become costly as well as take considerable amount of time to make. Consequentially, this is why nowadays such projects tend to get more attention in high budget projects with longer pre-production times. We can spot exciting visual effects in costumes featured in spectacles such as big tour concerts of Michael Jackson, Red Hot Chili Peppers, U2, Laura Pausini, to Eurovision performances and Olympic Games opening ceremonies. Although the mainstream musical performances get the most recognition for using such features, wearable electronics are by no means limited to large-scale projects. However, to this day they remain present mainly in the commercial and contemporary dance world, as text-based theatre has not yet embraced these means (Pantouvaki 2014). Using electroluminescent wires and panels in



costumes, groups such as Wrecking Crew Orchestra, Light Balance or iON Dance Crew are creating their whole acts around light illusions in the dark (America's Got Talent - Wrecking Crew Orchestra, 2012), (Light Balance Show, 2015), (24ur, 2014). In a *"game-based dance performance"* entitled *Impulse/Control*, triggering of vibrating pressure signals in costumes was used to give an impulse to the dancer to take action (Oliphant, 2011). The effects produced by the wearables do not only need to enhance the effect of the movement, they can also use the movement as data. With a concept that resembles that of the motion capturing technology, the E-Traces pointe shoes were designed to capture movement and pressure of the dancer's feet and provide an option to show the data graphically, interpreting it to the visual art (Draper, 2018).

The creative options escalate with the variety of the electronic components incorporated. The greater diversity in wearables, the bigger the pallet of disciplines involved. The more disciplines are included in creating such costume, the more the costume gets interconnected with different aspects of performance building, and the more the narrative can be built with the costume functions in mind and vice versa. *"The incorporation of technology depends on the context of use and the desired interaction between the fashionable wearable and its surrounding environment"* (Seymour, 2008:15). Technology in costume therefore not only affects the approach to costume design, but also the role of the costume in the process of performance making and choreography. If something stimulating happens on the surface of the costume, it would be enriching for the performance to relate it to the choreography instead of letting the performer ignore it. Performers experience the costume in a different way than the audience, namely in a direct embodied way, and this allows the performer to improvise and react to the costume and its changes immediately, throughout the performance. As Kozel (2007:287) describes, *"the inversions, the hesitations, the desire to be secret and then to reveal: these motivate the choreography of the self and can inspire the design of wearable devices."* The effects however are not visible to the audience, but they do influence the performer. They can be heard or felt by them and be completely invisible to the observer, but they are still just as impactful for the experience. Kozel (2007:40) also suggests that this correlation takes the performance perception to another level and somehow brings a new depth to the world created; she writes that *"The invisible can be seen as a dimension that cannot be isolated from others but permits the existing ones to intersect differently."*

The range of technological capabilities is showing in different aspects of performance making, many of which Pantouvaki (2014) brings to attention in her article about the potential of further exploration of the expressive and narrative possibilities of performance costume through wearable technologies. It applies as much to the aesthetical approaches of the performance, as well as to the technique of building and deepening the meaning of the performance as a whole, when she proposes that *"the intersection of costume and new technologies has the potential to create new artistic concepts as well as new expressive narratives"* (Pantouvaki, 2014:192). She points out that the *"costume can become an interactive interface between the body of the performer and the environment,"* with which she establishes that the manipulations do not need to be limited to the costume being the only transforming factor (Pantouvaki, 2014:192). The wearables embedded in a costume can cause the stage elements to change, be activated or continuously react to the performer's actions while wearing the costume.

Taking in consideration these possibilities, it is essential that the designers have a “*comprehensive understanding of the purpose, the user, the interaction*” of the costume being made and the components being used (Seymour 2010:17). When technology meets costume design, the results can bring along striking and memorable visual, audio as well as sensorial effects.

- **Practical Implications**

When incorporating any kind of electronics in a costume for a performance, there are several things to keep in mind. Wearable electronics do not only influence design choices, but start to gather new decision bearers in the making process of the costume and the performance. Establishing a clear and ongoing communication with all artistic collaborators involved is always the key to successful collaboration, but this should be the self-evident basis of any project. If the general idea of the costume existed before the idea of incorporating wearables, do the newly added technologies affect the look or the shape of the costume? Do they affect the functionality, as in limit the movement or cause discomfort to the performer? Or have the wearable electronics been the part of the concept since the beginning? Are they small, light and flexible enough not to provoke any noticeable effects, or is the choreography being developed with the consideration of their incorporation? What functions should the costume have? Should it change colour, shape, react to something, make sound, light up? Then, it is time to find the means to make it happen.

Let's say, for the sake of example that the costume needs to produce light. What kind of light? Is it one colour, does it change, is it enough that it can be turned on/off, or do you want to change the intensity and the pattern of the light as well? Are the changes triggered, what triggers them and in either case, how are they controlled and what additional components are needed for that? Does the costume need to glow all over, should certain parts get illuminated, and if so, are they close together or wider apart? Conversations between the costume designers and lighting designers will go beyond issues such as “What colour is the fabric going to be?” or “Is it reflective?” Such are usual topics discussed in a traditional performance making collaboration. The lighting designers are the key collaborators in defining, refining and finalizing the aesthetic matters of light components incorporated in the costume; these relate to forms, colours, placements, amount, functionality and use. Here, I am specifically focusing on the light-related examples because the case study project in which I worked has focused mainly on the interaction between the body (costume) and the light.

The options and possibilities depend on the selection of the type of light component, but in order for any of them to work they will need a source of power. If there is more than one illuminated part, are they connected or do they each feed of a separate power source? Is one power source strong enough or do the elements need more than one in order to light up to their full potential? How big (and heavy) do the power sources need to be? How are they going to be incorporated in the costume; can they be visible or should they be concealed? This is also relevant to the light sources; are they visible or hidden when turned off, how do they work with material if covered? What colour is the fabric and how does it affect the colour of the lights, what is the intensity they need to reach in order to be visible through it, do they get diffused by the fabric and if so to what extent? If using LEDs do we see separate illuminated points or should they blend into a beam?

Similar process of questioning applies if a microphone or a speaker needs to be incorporated. Sound designers will have a lot of demands and insights to contribute if, for instance, the objective in focus is sound recorded or transmitted through costume. If recording, the sound designer needs to be able to receive clear sound of what there is to be recorded; be it the speech, the heartbeat, the sound the fabric makes when performer moves, etc. In order to support that from the costume design side, it needs to be discussed what and how is to be recorded. When the objective is clear, it can be decided in mutual understanding whether the fabric can, should or should not make sound that the mic could pick up, is fabric really the main concern or do accessories present the problem when they jingle and how to solve that. Do they get replaced, made from different materials or simply removed? If the costume should transmit sound, the creative team needs to decide where the sound should come from, what kind of noise it is that is complimenting the design of the costume (or vice versa), what is the motivation behind the sound and how is it controlled. Is there a technician controlling it from the audio console, is it pre-programmed, or can the performer control it and how? Is it being triggered by something and if so, what kind of sensor is making it happen and where is it placed? Is it a bending sensor that could get triggered with the performer bending a limb or is it a pressure sensor that gets triggered when the performer steps or leans on it? In the case study project, sound transmissions were discussed to be featured in the costume, but due to time constraints it was decided to transmit the sound in the costume's surroundings rather than coming from within the costume. Anyhow, the sound matrix and the voice tracks used were interactively controlled through wearable technology, reacting to performer's movements.

When the concept questions are resolved, the process continues to technical issues. Like light, the sound devices need to be powered, which results in additional components and connections between them. How far apart are they and how are they connected? Is it with wires, conductive thread, conductive paint or something else? Since the connections are for the most part non-stretchable, yet body changes proportions and distances between certain points with movement, attention needs to go to the lengths of the wires (or other connecting material). They should not be too short, also small tensions can dismantle the connections between different components which are usually soldered together, nor should they be so long that they start to gather in unwanted bulks, when the outline of the body decreases. Only one wire is normally not enough; there needs to be at least one for power, one for grounding, and if there is a wish to control any kind of wearables with an outside command, one to send through the data. The longer the distance between different components, the weaker the feed, so the diameter of the wire should thicken with distance.

Once the full list of components, wirings, their lengths and sizes that are to be used is finally known, the thought needs to go into how to protect and incorporate them properly. It is neither pleasant nor recommended that the electronics are in a direct contact with the skin for numerous reasons concerning safety and general well-being of the performer. Electronic components are made from metal and can be quite sharp. For lot of people a contact with certain metals can provoke an allergic reaction. Salty water is very conductive and with people producing sweat and wearables being under electric current, this presents a likely bad recipe for possible incorrect tampering. If the contacts would be interfered improperly, this could lead to short circuits or even send minor electric shocks to the body. In order to avoid such unwanted occurrences, the wearable components should have any sharp edges concealed when embedded; there should be a layer of fabric or other non-conductive material around them, preventing the possibility of coming into contact with the performer's skin. The components and their wirings should ideally be located on parts of the body that do not bend, secured in their positions to prevent unintentional excessive movement.

In such a process the whole creative team continues to learn more about the possibilities of technologies integrated in costume design, as the costume goes into production. The maker will do his/her best to solve the demands in the most elegant and functional way, following the intended solutions and ideas, while constantly improving embedding options. With practical progress of the project, everyone will learn to adapt to the needs of others as well as the fact that the costume needs to become a fully functional garment. In order to achieve that, the process of fitting gets extended not only in regard to the fitting of the garment, but also to the time which is needed to make sure that electronic components work properly when the costume is worn. No matter the scale or the type of the performance, when working with wearables in the costume, certain strive to make it look effortless is constantly present. Such demands are less difficult to achieve if the electronical components are *“robust, small, consume a small amount of power, and comfortable to wear”* (Ko, El-Aufy, Lam, Macdiarmid, 2005:13). The convenience of wearables is relative and case specific, but the basic goal is to *“create garments that drape and conform as normal”* (Hardy, D.A., Moneta, A., Sakalyte, V., Connolly, L., Shahidi A. and Hughes-Riley, T., 2018:1). If this aim turns out successful, the performer is provided with a functional comfortable costume that provides additional assets, as oppose to concerns and physical limitations. Time needs to be spent on testing the extra features, which shifts the dynamics from needing a performer on stage in costume to see how it works, to programing the costume alone, for which the performer is not needed at all times, while the costume might be.

Through the continuous use of the costume, the metals could ultimately rust due to the longer exposure to moist, which brings us to the problems of general maintenance. It is more or less impossible to wash a costume with electronic components if they are not removable. And when there are many of them, they seldom are. In such cases alternative treatments like using odour controlling sprays and dry cleaning chambers come very handy. When the costume has been over few fittings, rehearsals and performances, the time probably arrives when some malfunctions will occur. Such occasions are not a problem, if the precautions have been considered beforehand. Seymour brings up a valid point;

*“The cut of a fashionable wearable should allow for the incorporation of a modular system to house the supporting computer components. These components need to be able to be easily exchanged or replaced due to changes in standards, failure, or the simple fact that the garment may need to be washed”* (Seymour, 2008:24).

She continues that it would be really useful if the electrical components could be intersected and assembled in separate parts (Seymour, 2008). For example, it is much easier to find and fix or replace the part with an occurring error in different sections of light chain, if each light component or wire can be connected and tested separately.

Costume with additional technological functions does not merely present the means of clothing that transforms the performer into the character anymore. It does not only stay within the costume designer’s domain, but instead provides a possibility for other members of creative team to get involved and bring in elements from their fields of expertise. With such a change in dynamics, a costume-led approach to performance making is spontaneously being stimulated. As if the technological challenges that are always present in the costume design and making become more visible and understandable for other lighting when the electronics are being incorporated. Furthermore, since the extra features easily become complicated, there is a chance to expand the “basic”

artistic team. A position opens for someone new to join the process – e.g. a person who has the knowledge to write the code for wearables to perform the given or imagined tasks.

## - Chapter 2: Artistic Research

### o Digitalizing Performance: The Project as the Case Study

This thesis is based on a case-study project, performed within the frame of the “Digitalizing performance with wearables and software” research collaboration between the major of Costume Design of School of Art, Design and Architecture and Computer Science from the School of Science of Aalto University with the programme of Lighting Design from the University of Arts Helsinki.

Over the summer months of 2018 (June-August) Aalto University gathered an interdisciplinary team consisting of designers, a performer and a computer scientist to collaborate on researching options of a 3D positioning tracking system and explore how the captured data can be applied to different wearables and software in a live performance and how this affects the making of a performance. In this team, I was the costume designer. We were given a timeframe of three months, and resources including the location tracking system, a schedule of available spaces, access to the Aalto Studios and a decent budget to test, research and finally create a short demo performance as a result of the team’s creative collaboration.

The scope was to “employ software-defined elements in live performance, namely, by deploying computing devices on stage as well as through the performer’s body and costumes, to orchestrate the existing support infrastructure” (Appendix I). The aims of the project as a whole were set by the supervising professors and were presented to the team at the beginning of the collaborative process. These were:

- *“To understand viewpoints and characteristics of technological and artistic practices in the project.*
- *To study the technological frame: to understand possibilities and requirements of 3D positioning as well as dmx-control systems, parameters of moving lights; to understand how to embed the technological devices into the performer’s body through design.*
- *To understand the challenges of translating data between standards and the behaviour of light with surfaces and materials.*
- *To create ways to translate location data into standard control data of theatre lighting equipment (dmx)*
- *To find interesting relations between body generated location data and its visual impact translated into light.*
- *To develop relational findings into a selection of specific movement-interaction based visual ideas.*
- *To understand how body position and body visibility affect meaning-making for performance.*
- *To define interesting temporal and spatial structures for rehearsing and presenting the ideas.*

- *To integrate and develop these findings and creative ideas into a whole, through dramaturgical development (work in team).*
- *To present the results of these work in a demo performance.*
- *To document the process and evaluate the demo-performance” (Appendix I).*

Such requirements provided a general research frame and an agenda which we could follow, broaden and upgrade as the process continued. Although the very first intention was to make a spotlight follow the performer without a technician behind the lighting console, both professors and participating students alike were determined from the beginning to create something more performative than a technical demonstration of how things work. The final demo performance narratively presented various performer-led technological interactions that happened with the use of position tracking technology integrated into the costume.

My main role in the project was to design and produce a functional interactive costume with wearable software, trackers (tags) and power sources aesthetically incorporated into the costume, providing an option to take over the commands from the lighting console. Through these wearable technological elements the costume enabled triggering different space manipulations, creating interactions with props, sounds or light changes in the setting or within itself, controlled by the performer’s movement in space.

#### ▪ **Introducing the artistic team**

The project started with the core team of three collaborating students: a computer scientist, a lighting designer and a costume designer. Emilio López with background in computer science came on the project with no previous experience in the performing arts but with a strong wish to explore this field through collaboration. Applying his skills to the technical parts of the project, from computer programming, to connecting wires in the costume, he presented a crucial collaborator. The lighting designer was Mia Jalerva, coming from a background in theatre, live performance and installation art. The costume designer was Tjaša Frumen (myself), with a background in film, animation, live performance and some previous experience working with wearable electronics, as described earlier in the thesis. All three of us were approached and selected to join this project due to our expressed interest in combining electronics and performance making.

The task of choosing and engaging the performer as well as the rest of the artistic team was left to the group. We knew, that we want a performer with a dance background because of their movement quality through space. It also needed to be someone with the ability to choreograph and create a narrative, as this part would mainly be on the performer. With the system offering not only 2D but also 3D tracking, we wanted to make sure to take advantage of this possibility and were therefore looking for someone whose skills could take them away from the floor. Aliisa Rinne, circus artist on a rope, tight wire and trapeze came in as a perfect fit for the wishes and requirements the core team had set. With her background in dance, acting and singing, as well as the willingness to experiment with different uses of offered technology, she provided diverse possibilities of where the final demo performance could be taken.

The rest of the team came in “naturally” from our wider artistic contacts. We recruited the sound designer Kalle Rasinkangas, who has worked with positioning and trigger zones before, and would therefore already have the knowledge on how to connect the sound to the technology. Set designer and sculpting artist Oscar Dempsey, or in this project designer of inflatables, was someone who I was interested to work with. Seeing his previous work on inflatable set pieces, I approached him to suggest the collaboration that would result in incorporating inflatables not only in space, but also in the costume. The interest areas and the expertise of the team complimented and complemented each other, which created a starting point for a very smooth creative collaboration that evolved throughout the project.

- **Introducing the system**

To be able to complete the main task of this project, one of the things we were provided with, was the tracking system, consisting of the active monitoring software, the locators and the tags. The locating system was provided by a commercial company (*Quuppa Intelligent Locating System™*) and is based on a position tracking software, which transmits the signal via Bluetooth from tags to locators in real-time (Quuppa, 2018).

We wanted to use tags in the performer’s costume and props, so that we could track her location and use the position data to present the self-controlled follow spot and position related cues that would trigger changes in the set, sound, lights and costume. Luckily, the standard tags are quite small, thin, lightweight and most importantly wireless, hence easy to incorporate or hide.



When the locators are installed in the space and calibrated properly, they serve as antennas which measure the direction of the signal the tags transmit and send the results to the positioning engine, which transforms (outputs) information into data that can be further applied to various software (such as lighting and sound consoles, or computers for example). With only one locator, the system is able to track the positioning of a moving body in 2D. Using two or more, it is possible to track the position also in 3D (Quuppa, 2018). The area covered by receivers is in the shape of a cone, therefore the higher the antenna, the greater the coverage. One tag is visible to multiple locators at the same time, allowing the system to be more accurate and reliable.

**Picture 2:** Quuppa tag (<http://bit.do/eRFLP>)

In our case, we experimented using four locators and five tags. The locators in the final demo were installed on the ceiling toward the edges of the performing area, under the level of other rigged electronics, such as lights or winches, to receive the signal without interruptions. With their coverage, the locators were tracking tags’ positions on the stage part, as well as the audience part. Saltz’s (1997:117) statement: *“Interactive computer art, however, can never exist only as software. The work must reach out into the world in some way,”* in our case, resulted in affecting the performer’s surroundings. Two tags

were placed on the performer's wrist, one inside a prop ball and another two on the edges of a moving scenic element. Not all trackers were active at the same time; the performance area was divided in different zones, and when the performer would move between them, the tags would switch between the tasks they were programmed to do. The cues were timecoded or activated with tags leaving the pre-set zones to change between the different functions they were assigned to throughout the demo. The tags were connected to take control or activate pre-programmed settings of lights, sound and props. For example, the location change of trackers would cause the inverted spotlight to follow the performer (thus, "avoiding" them), control the winches and move set pieces, control the wind machine and inflate props, trigger sound effects and affect the general sound mixing, cause the light effects within the costume, as well as control the overall lighting design of the stage.

- **Research Methodology**

The nature of this artistic research calls for a practice-based, design oriented and interdisciplinary approach. Following Nelson's (2013:26) claim that *"The practice, whatever it may be, is at the heart of the methodology of the project and is presented as substantial evidence of new insights,"* the research focuses around a case-study project, which motivated this thesis. The results of this project provide "evidence of new insights" on my topic, the effects of wearable technologies on costume design and work dynamics in interdisciplinary collaboration. The approach to the practical part is structured around Nelson's (2013) method for using Practice as Research. The collaborative working process and shared findings, conducted through this project, help me present the topics through actual practical examples, as opposed to focusing only on theoretical assumptions. Additional information for the written part was gathered through qualitative methods, such as auto-ethnography, observation, as well as informal semi-structured interviews.

Going into the practical part of the research, not being familiar with the technology, its possibilities, limits and unpredictability, while trying to build a performance with a human factor involved embraced Arlander's (2011:323) philosophy in which she writes that *"most artists are good at exploring the unknown and living with uncertainty in their creation process, and that could be an important asset for research."* Our approach was to get to know the system, explore its possibilities, test how it can work in the hands of the performer, and develop the performance material through the process. The final demo performance of the case-study was originally expected to serve as the conclusion and presentation of the research, but in fact, it offered opportunities for sourcing information and thinking about the topic anew, from several perspectives. Arlander (2011:328) explains:

*"The artwork or performance itself can function as data for research in various ways. Making the artwork or the performance can function as a method of research. The artwork or performance can be the result or outcome of the research. And of course the artwork or performance can function as a presentation or distribution of research outcomes."*

In this case, it was all of the above; the interdisciplinary team set out to create a demo performance based on the material gathered through research, in order to present the research itself. The practical aspect of the project was to develop the interactive performance through a costume-based approach, while



collecting the observations on how such a process influences the role of costume in an interdisciplinary collaboration. To establish a frame for the artistic research, we addressed the aforementioned aims of the project, while also developed own ideas we were interested to try. In order to help contextualize the method of artistic research and break down the phases of the process using “practice as research” (PaR), we turned to the six bullet points, “*Summary of adjustments from practitioner to practitioner-researcher,*” as suggested by Nelson (2013:29):

1. “Specify a research inquiry at the outset” (Nelson, 2013:29)

The extent of the research covers the creative process and work dynamics within the creative team while developing a demo performance within pre-determined frames. The research inquiry includes the use and exploration of provided position tracking technology possibilities through the creative collaboration, as well as designing the functional interactive costume with wearable software through experimenting and meeting the requirements of the extra features integrated in the costume. As this was an interdisciplinary artistic project, the creative process is through thesis compared with situations, where design choices develop from narrative and movement, not necessarily from technical requirements and possibilities the software offers, as they did in this case.

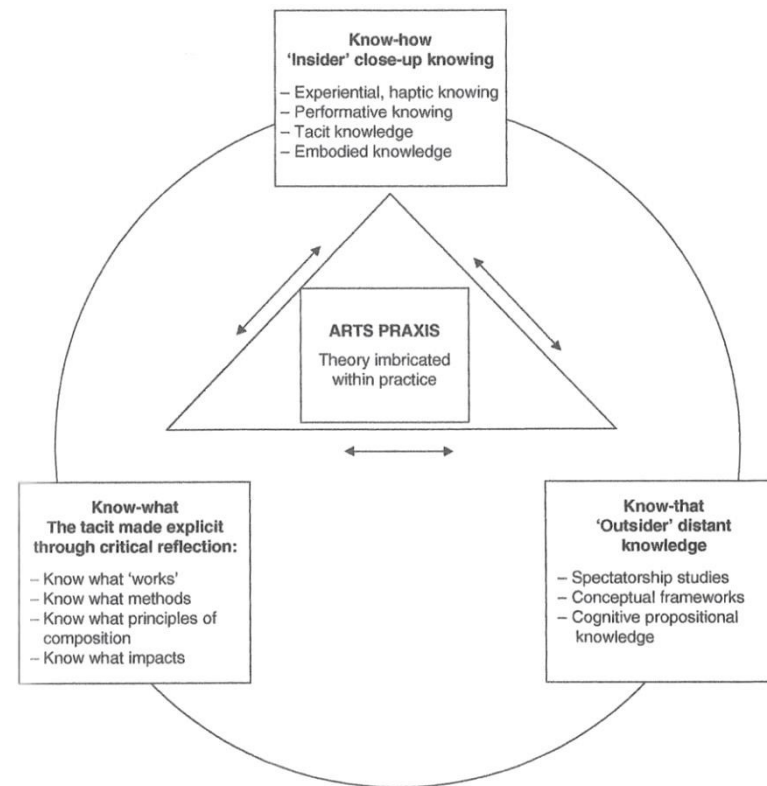
2. “Set a timeline for the overall project including the various activities involved in a multi-mode inquiry” (Nelson, 2013:29)

Just as the basic frames of the project were given, so was the timeline for the practical part. The creative and exploring parts of the process as well as the presentation took place from early June, to early September 2018.

As for the multi-mode inquiry, it refers to an important approach used in project. We would experiment and try out each idea thing that crossed our minds, see how it works, reflect on it, edit the material and return to more try out more. With that we engaged in an ongoing process of “*know-how, know-what and know-that*” (Nelson, 2013:37).

**Diagram 1:** Nelson’s multi-mode epistemological model for Practice as Research (Nelson, 2013:37)

Achieving scenic manipulation with the help of technology incorporated into a costume consisted of the above indicated stages. Our plan was to think of elements that could be manipulated with the technology performer was wearing, and then



explore the ways in which they could be affected. The first step (know-how) was to test if the certain manipulation works mechanically. If it did, the following challenge was to make it work technically. When this was achieved, the performer would improvise with the certain manipulation, to develop performance material. The second step (know-what), was to smoothly include such a manipulation into a performance narrative. Smoothly, in this case, meant with an illusion as if it is “happening on its own”, while the performer would have complete control over it. For this part to appear natural, movement improvisation, repetitions and creating the “choreography” were very important. Conveniently enough, to help with the editing of the experimental material, we quite early set out to hold short small-scale in-between demos, open to outside visitors, between random stages of the process. This would not only provide feedback from external spectators (know-that), unrelated to the project. Because the demos would be documented, it would also allow the creative team as well as the performer to step back and experience the material as observers, which would provide yet another depth to the insights. With that we would be able to learn what worked (know-what), what was or was not understood, what needed development, what else could be done, and decide on material that would be used or discarded. Based on the initial material, as well as new ideas that emerged from small-scale demos, we would further develop the approach (know-how) which was used to create the final demo, whose main objective was to present the research.

The concrete work ended with the final demo, but in the spirit of Nelson’s (2013:37) scheme, just as the small-scale demos were serving as learning opportunities, so did the final one. Testing within the given timeline was completed, but the ideas kept evolving. We could continue to discuss how things were achieved, what worked, what could be developed and what more can be accomplished.

The moments between feedback and reflection after the demos are already mentioned here, but they also strongly relate to the following phase.

3. *“Build moments of critical reflection into the timeline, frequently checking that the research inquiry remains engaged and evidence is being collected”* (Nelson, 2013:29)

Throughout the process, the creative team would follow the performer’s improvisation with different materials she was given by the team and give her immediate feedback or direction on tested sections. The performer, in the moment after the tests, would provide insight from the viewpoint of the embodied experience of the materials. The tests and the performances were documented, to allow going back to them when needed. This documentation not only provided visual data base for designers, but a way for the performer to be able to see herself, analyse the performance from the spectator’s point of view, learn from it and build further. On the path to the final demo performance, as well as after, this helped us separate individual elements and make notes about them on the spot, while we analysed and discussed them in detail. Such notes are not based only on the team’s reflections, but also on feedback from outsiders that experienced the demos.

4. *“In documenting a process, capture moments of insight”* (Nelson, 2013:29)

Throughout the project, attention would be given to documenting the process, in order to have all notes and memories supported with visual references. This helped to follow the progress of performance building with providing visual notes on experimentation with the equipment, spotting fortunate “mistakes,” articulating unexpected developments and following the performer’s choreographing through movement improvisations.

The process of the project was additionally recorded and analysed through auto-ethnography and ethnography. For this purpose the notes taken after the demo session were reviewed and short semi-structured interviews with team members were conducted in the weeks after the final demo. The initiative was to gain first-hand insights on how different the process was from start to finish, what were the new things that needed to be considered, or if there was anything special getting simplified or becoming more complex due to the newly developed technical part.

5. *“Locate your praxis in a lineage of similar practices”* (Nelson, 2013:29)

Looking into similar projects, we found ourselves labelling this one as an Interactive live demo performance, which set out to explore multiple levels of interactions.

The interaction happened between the performer and the tactile stage elements (objects) as well as non-tactile elements (light, sound). Different levels of interaction between both tactile and non-tactile elements take place, when the performer controls them through the use of software as well as when they are being controlled by other means, or not controlled at all. The interaction between the software and the tactile stage element happens through self-control; when the movement of the object is manipulated by location data, provided by the moving object itself. And lastly, the interaction between the audience and the software through a tactile prop.

6. *“Relate the specific inquiry to broader contemporary debate (through reading and exposition of ideas with references)”* (Nelson, 2013:29)

This stage has initially been done with the beginning of the research but got extended and more closely attended through the additional research for the written theoretical part of this thesis, more accurately in Chapter 1: Theoretical Implications.

- **Creative team dynamics in the performance making**

The overall work process on this project was performed within collaborative, devising frames. Our roles and responsibilities were loosely defined, and while mainly working within our fields of expertise, we would assist one another with practical matters, whenever such situations occurred. We would often help each other with technical things, e.g. rigging lights or locators, setting up larger props, or calibrating the system when installed or moved. On other occasions, we would fill-in for disciplines beyond our own, either before the full team was assembled or if someone was not present. For example everyone would take on the role of the performer in the early stages of the process, when the system and the manipulations would need testing. This enabled everyone to get familiar with the system’s possibilities not only from a theoretical concept, but also by experiencing how the spatial elements could be manipulated through the movement, understanding the speed of their reactions and discovering the flaws. With such knowledge we could direct or advise the performer from experience, offering realistic suggestions when creating performance material. For example we wanted to explore the interaction between the performer and a stage element, and we started with manipulating the basic theatrical element, the follow spot. We began with testing how fast and accurate the light

could follow the location of the performer wearing a tag. The main task of a spotlight in any performance is to follow the performer and keep them in the light; however, if a light is not being operated by a skilled operator, but as in our case depended on the software, its task might not necessarily be performed well. From examples like this, the dramaturgy of the performance started to form, and ideas would develop; instead of moving slower, the position of the spotlight would be inverted (meaning it would be moving to the opposite direction as the performer wearing the tag would), and the performer would get a “task” to try and catch up with the light. Such approach would present the element of light as a mischievous second “character”, not wanting to cooperate with a “planned” performance. Whenever a thought or idea was shared, it was tested, reviewed and analysed from different approaches, evolved and re-tested. When decisions were being made, they would be discussed within the team and for the large part agreed on unanimously. Such approach initiated an ongoing flow in creative (and practical) exchange of ideas throughout the process. Working with a computer scientist with no previous experiences in the making of a performance piece as a part of the creative team, we would pay extra attention to the clear and defined communication, as well as providing him explanations of all process steps in detail. Such clarity and openness turned out to be beneficial for everyone involved, as we were able to dissect and understand each other's approaches, processes and needs, attend to those when needed, as well as become aware of our own.

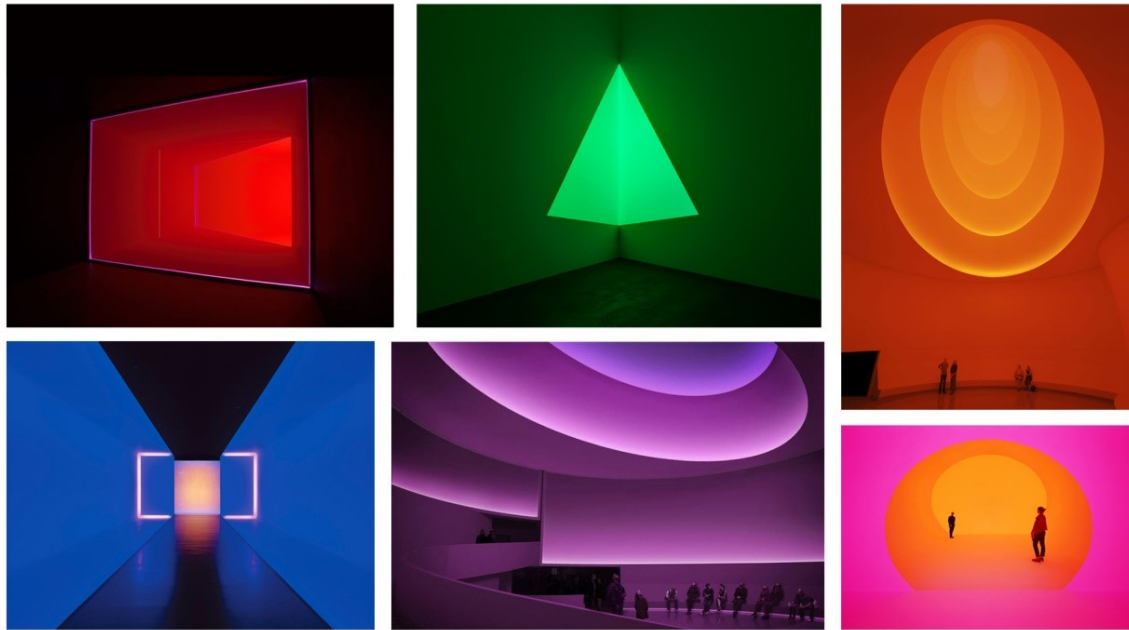
Prior to working on technical parts and creating the narrative from explored elements, the creative site of the project needed to be established. It offered a tool for the core team to get to know each other artistically and gain insights to the kind of aesthetic we were inspired by at specific moment of time, which could be brought to this project. The aim was to create an idea of a mood board that would unconsciously drive, inspire and direct the performance atmosphere.

Jalerva, the lighting designer on the team was captivated by James Turrell's light installations. She liked the idea of a hidden light source and the same sense of timelessness, weightlessness, softness, out of space and context feeling conjured by the installations that also inspired me in the feeling of floating. The softness and indeterminacy also resonated with my idea of merging the boundaries between the costume and the body, between skin and cloth. Another contrasting thing I was drawn to, were the clear lines of shapes and almost architectural structured forms and textures that would create a defined element in space. The rest of the team related to our inspiration, each of them adding their own aspects to it, enriching the overall concept. The overall collaboration on the project ran smoothly, and the part I relate to the most, was the dynamics of working on the costume. Bringing wearables to the table opened the possibilities of exploring, designing and developing ideas between the various design disciplines with costume design as a connecting thread. Kozel (2007) claims, that the poetic aspects of using wearable electronics are initiated by the earliest design choices. She argues that *“The conditions for a particular poetics are set in place by decisions to make the circuitry and wiring softer, pliable; to create degrees of responsivity and configurability; to make the wearables subtle or even hidden”* (Kozel, 2007:286). The design choice to conceal the wearable components was in fact decided in the early stages of the process. As the costume designer I wanted to accommodate the electronical components in the most convenient way for all parties involved, attending to the following requirements. Firstly, the embedding should be accomplished in a way that the technological components are secure. Secondly, the performer in the costume should be safe and comfortable with them. And lastly, the devices should be placed and embedded so that they would be able to perform their functions optimally, regarding intention and result, while fitting the aesthetic aspects of design decisions. All above mentioned properties influence the costume design decisions, but the integration of different disciplines in the process helps develop not only the design of the wearables, but also the

functionality of the costume, and with that enhances its role in the performance making. The collaborative process of performance making in such occasions can be developed around the costume.

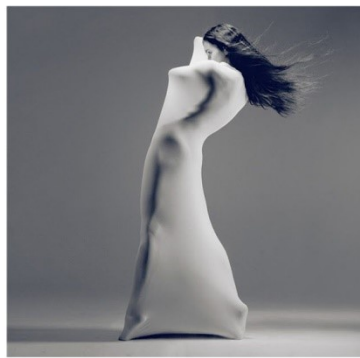
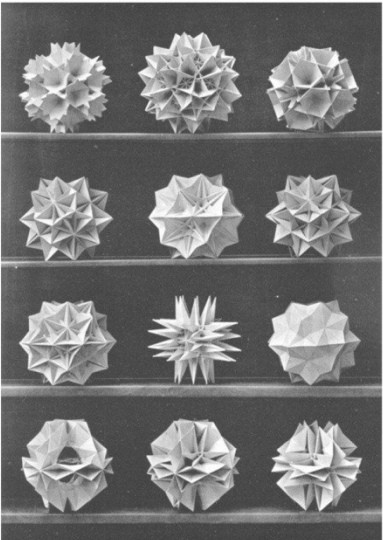
Wearable technology embedded in the costume of the case study inspired the approach to performance building, due to the unique situation, where the performer and the stage elements controlled through the software became equivalent partners in the testing and development of the performance. This happened not only because of the interaction enabled between them, but mainly because of occasional inconsistencies in location tracking which caused the manipulated elements to react with different delay or intensity each time. These elements appeared as if they are “behaving” in a certain manner, and therefore created an illusion of different co-performing characters: the performer as one character and the stage elements/lights as another. The costume enabled the performer to take charge of elements otherwise controlled through the lighting and sound consoles. With such ability, the performer became

something like a conductor of the performance; with the assistance of location tracking technology embedded in the costume, she was able to manipulate light, sound and prop changes through movement.



**Picture 3:** Collage of James Turrell’s installations (Frumen, 2018)

**Picture 4:** Inspirational mood board (Frumen, 2018)



- **Creating Dramaturgy**

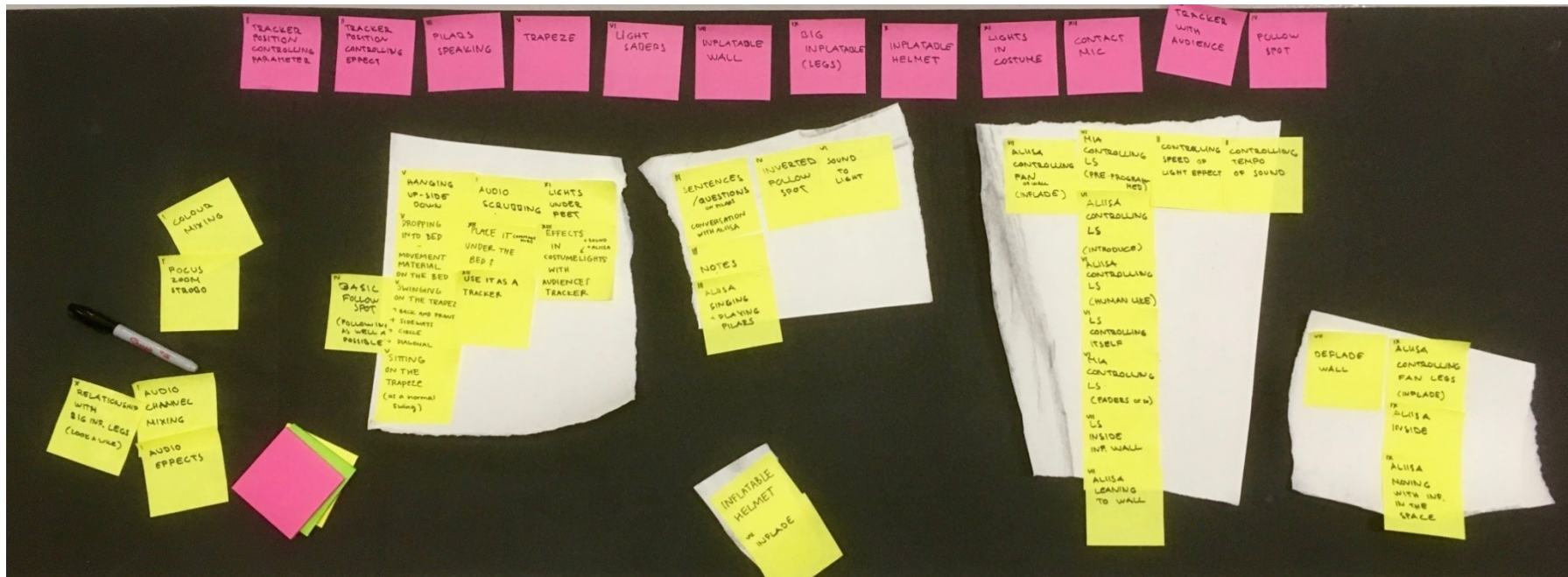
Through the constant testing of ideas, limitations and capabilities of the location tracking software and the interaction that could be created between the performer and the objects connected to the software, a significant amount of information, ideas and performative material was collected. The interactions were not only based on technological settings, but sensorial experiences that create communication. Different elements interesting to the creative team, as well as the ones that evoked positive responses in the test audiences were selected and analysed. Shaping the dramaturgy was an essential part of the process where the creative team collaborated collectively.

Our artistic collaboration started with listing the types of interactions, transitions, and functions the wearable electronics would provide for spatial elements and costume. Then, we discussed how these could be used and developed. We grouped them to separate sections of elements that could be used together. Big part of the chronology in performance was constructed based on the practical aspects of using certain props. For example, a large inflatable set piece was used, and since we wanted the inflating to be performative, it had to be deflated and laid out in the beginning of the performance. Deflating it during the performance would take a lot of time, and the shape in which it would deflate could not be controlled. It was simply more practical to use it the first way and leave it inflated. With all practicalities in mind, the sequences started to be interpreted to create a meaningful content.

In the beginning of the performance the character is introduced in her world, alone. As she moves from her initial position, she encounters the first element with which she develops a relationship with; the spotlight. As the spotlight moves, the light and the performer start to get to know each other, interacting and intersecting. Eventually, they form a verbal conversation which gradually turns into a fight resulting in them parting their ways. As the spotlight leaves, the new elements enter, shaping the performer's new environment which she explores through interaction. She gets lost in a big inflatable object and dances with the moving light elements, taking one of them away. She returns with a new smaller inflatable object, which changes shape during their interaction, causing the character to transform herself before leaving the stage yet again.

The movement and interaction caused by tracking technology inspired the narrative inside the scene sequences and vice versa; once the storyline was created, the choreography and communication between "characters" developed further. The full content of the performance was eventually mapped out through rough mini scenarios, describing events in separate scenes, all connected to one bigger narrative. Throughout the demo we follow the performer facing different stages of developing relationships through various layers of interaction, of achieving communication with "other" characters in space. The first active encounter begun with the performer trying to gain the "cooperation of" the spotlight, that would not move from the fixed spot. When the light started to wander, it appeared to be "interested in" the performer, but almost scared to follow her. The two, the performer and the spotlight, slowly started "getting to know each other," gradually forming a connection. As a spotlight without the use of haze in the space is visible only by the bright circle on the surface, this relationship happened rather on a conceptual level than in a tangible way. To enhance its actuality, we added another non-tangible layer, speech. The performer used live voice, whilst the lighting changes were accompanied by pre-recorded phrases; this way a verbal communication between the two characters developed, and each of them had their own verbal presence. As the conversation gradually turned into a fight, they both leave their separate ways. This left the performer to explore the new environment, some of it manipulated through her actions. Until this point, the "other character"

was visually limited to two dimensions; it was a spotlight projected on the flat surface (stage floor). With the new environment however, new elements were introduced. They were actual three dimensional objects, which also enabled the tactile interaction outside of the technical frames. As the linear light elements entered the space, she started interacting with them through dance. They were framing the space she was moving in and she was reacting to them. Lastly, she formed a bond with a new, this time tactile, inflatable element, evolving through a tactile interaction that changed the outlines of the object. The change in the element motivated the performer to transform into a like-wise creature herself, interacting with the object through her new form before leaving it behind.



Picture 5: The process of building dramaturgy (Jalerva, 2018)



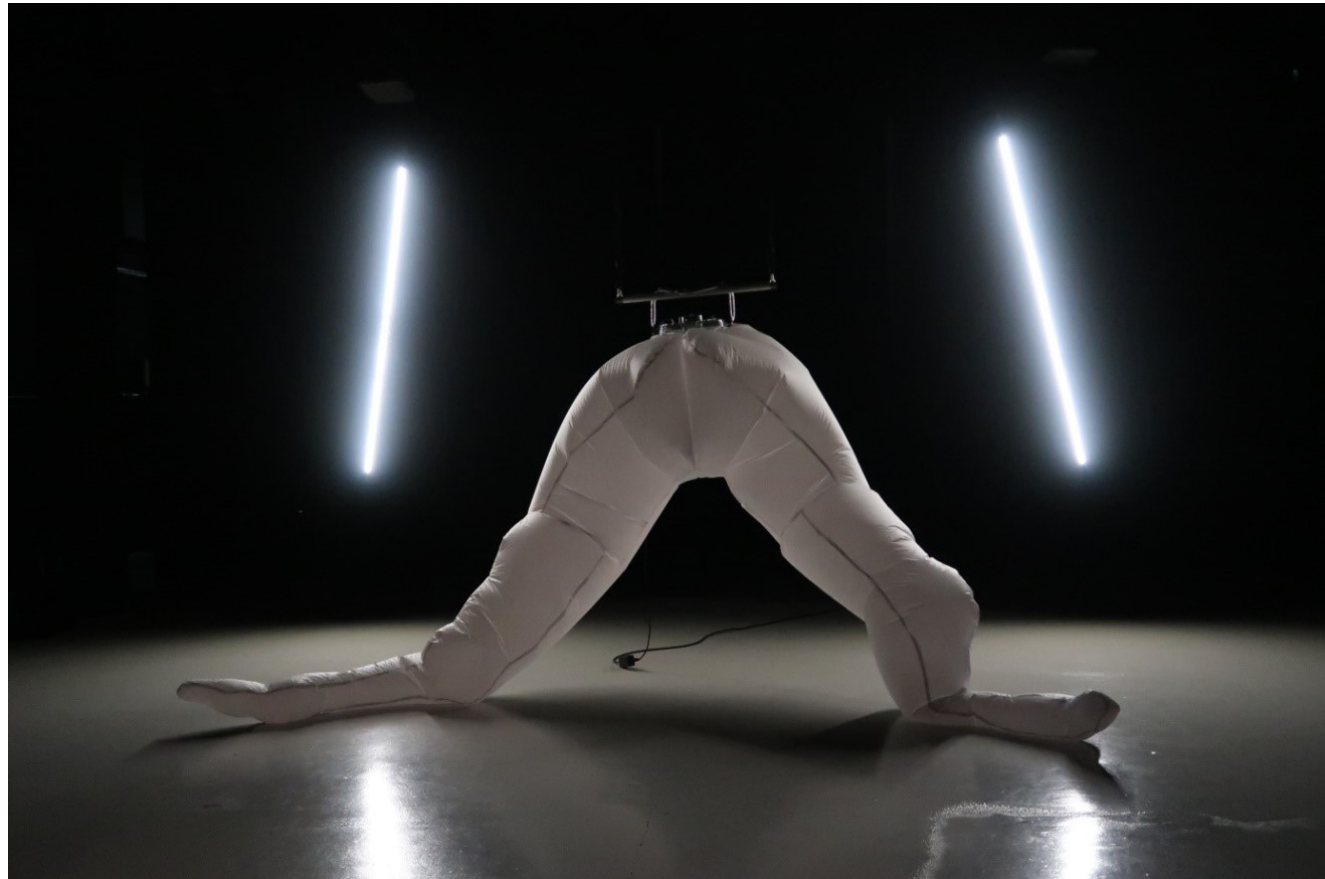
- **Creative team dynamics through the costume**
  - **Creating a World**

The world we invented for the final performance, was inhabited by a humanoid character, expressing her life signals through the illumination of her body. Adapting to the environment, she developed the ability to transform herself into a creature-like being. Being the only “living” character however, she was not alone. The world was filled with a number of other entities, which she encountered on her path. Appearing still and mechanic, these entities (or elements as referred to elsewhere in the text) revealed their “personalities” through their movement, when reacting to the performer’s actions. Exploring her world, the character interacted with these elements and gradually gained control over space manipulations happening around her.

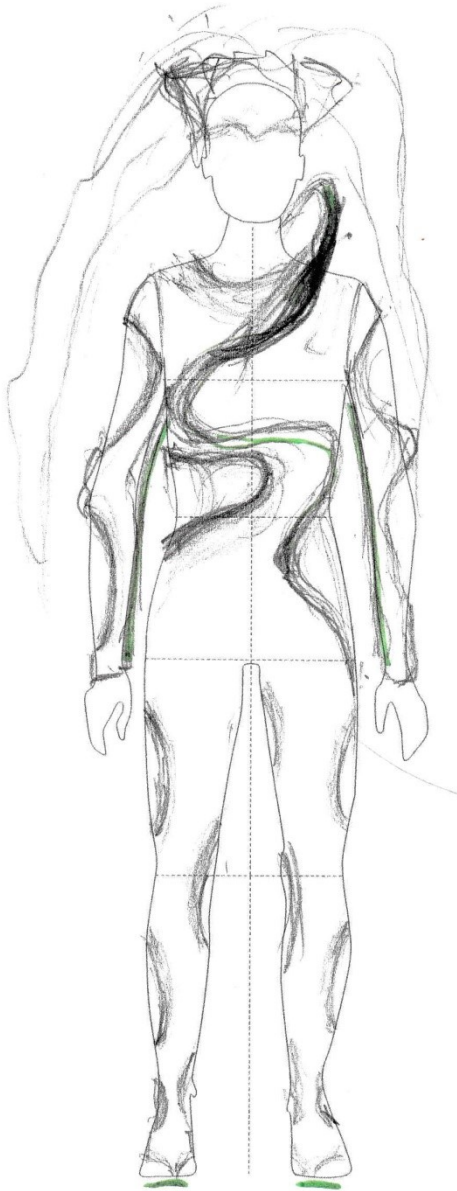
The aesthetics of the world created by the interdisciplinary team was pieced together from various influences. The main visual inspirations came from the mood board materials and brought with them the undefined sense of space and context. Another influence came from the very technical approach to the performance making that our team initially adopted. Inspirational photographs collected by our team members had one thing in common; most of them had in focus one element, defined with clear lines. These shapes, moods and aesthetics inspired our visual elements and their depiction in the performance; the trapeze, the spotlight (with and without audio), the scenic/light objects, the large inflatable wall, the smaller inflatable object, the inflatable headpiece and of course, the performer in the costume. Each of these elements had a clear, defined form and was used one at a time. They were all presented through interaction with the performer. Wolf (2012:249) explains that *“Interactions, [likewise,] tell us about the behaviours of things, the way things react and interact when prompted by someone”*, and as the audience was introduced to these performance elements, as well as to the performer, through the dynamics that weaved between them.

The trapeze, not directly interactive, was used as a tool for movement material when interacting with the spotlight. The spotlight was used to set the scene, and it was the first element that the performer interacted with by controlling it. Firstly, not reacting, then timidly following the character, evolving as a second “character” through speech, and finally leaving. The light objects entered with a pre-programmed “choreography,” then started interacting directly with the performer’s movement. After a while they obtained control over their own movements. Changing their altitude and angle they were used to create the geometrical shapes in space. These changing shapes would frame the character’s new environment to inhabit. The world we created also included a big inflatable object resembling a wall when inflated; this started off deflated and was activated after the performer’s interactive dance with the light devices. The intensity of the fan attached to the inflatable, and therefore the speed of its inflating depended on the performer’s position. Its movement when being inflated resembled the waving of the sea, that spread over the space with the shapes and the sound it produced, providing a new habitat for the character to explore and get lost in. Returning in the company of a smaller inflatable object, the transformations were initiated. Interacting on a tactile level, without the use of software, the performer induced the inflatable object to evolve and eventually change its shape, letting out two long pieces. Motivated by the shape, the character went through a costume and character transformation, using an inflatable headpiece to make herself resemble the silhouette of the inflatable object, changing her body posture and movement as she did so.

With this demo performance and the world it was set in, the artistic team wanted to show different levels of interactions between the performer and their environment, their relationship, growth and transformation. We explored how visual perception of such encounters, combined with a technical approach used to create them, inspires the narrative language that the audience is seeing. Many interactions were carried out through the costume embedded functions, and therefore through the costume design; as Pantouvaki (2014:187) writes, costume design then becomes “*essential not only in creating an abstract embodied experience, but also as a meaning-making creative tool in the context of a performance narrative.*” The costume concept evolved together with the performance. It was designed to portray a life inside a humanoid character, merging the boundaries between the costume and the character. This character, when triggered, could reframe into another type of character, resembling an insect-like creature. The combination of the world, elements and the character depicted a still and timeless, somewhat abstract world, giving the impression of a weightless deep sea or space atmosphere.



**Picture 6:** The smaller inflatable and the light objects, Kallio Stage (Pantouvaki, 2018)



#### ▪ The basic costume

The costume and the performer are often considered two separate entities; the character in the clothing. Even when it changes the performer's body shape or posture, it is still considered that the "costume is a body that can be taken off" Monks (2010:11). I approached this project with the idea to play with the boundaries between the two performative bodies; the body that the costume offers and the performer's body which inhabits it. My aim was to merge the fabric of the costume with the body of the performer in a way that would create an illusion of them sharing the same surface. The effect of the costume appearing as if grown on the performer was to be achieved with transitions between the material and the skin.

With Rinne being a trapeze artist, it was expected that she would be using the trapeze during the performance. However, without the continuous access to the actual performance space and being unable to functionally rig the trapeze in other rehearsal spaces, we could not know in advance to what extent that would happen. When she eventually started using it, my intention was for her to be comfortable in the basic costume, so I worked with her to make sure the design would allow her to twist and turn to every pose and not block or diminish her sight in any way. During movement improvisation exercises, when testing the use of the system and the position of the tags in different parts of the body, I was inspired by Rinne's flexibility and her versatility of expression through her body and movement. She was able to position herself in shapes not necessarily resembling a person, and with that she inspired the idea of character transformation into something other than human.

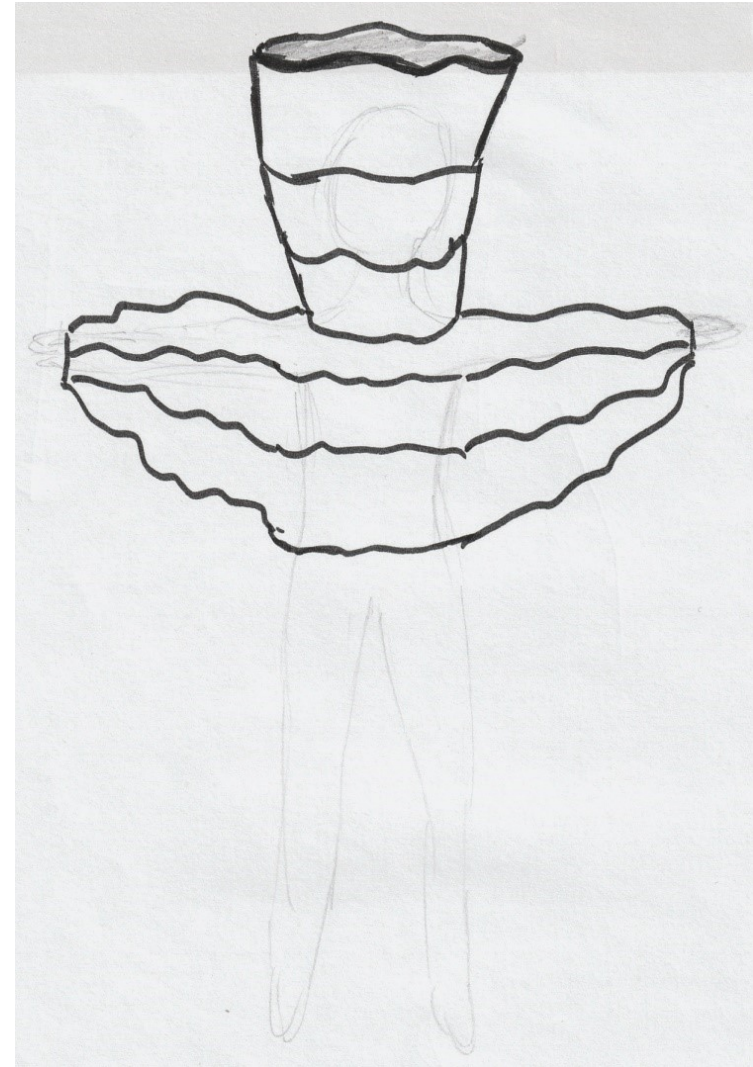
The basic costume would be used for the full length of the performance and would consist of a full length form fitting bodysuit with prolonged leggings to conclude in dance paws. The general idea behind the costume was to portray a humanoid character, with the basic part of the costume to be perceived as her body, not a separate garment. To create an illusion that the skin and the cloth are sharing the same surface, the cut-outs would be designed into the garment, providing the points of transition between the two. Every such transition would be smoothed with a dying technique, where the colour of the performer's skin would be matched at the every edge of the costume, slowly transitioning to the colour of the costume fabric.

**Picture 7:** Costume sketch 1 (Frumen, 2018)

Embedded in the basic costume would be two trackers and a strip of LED lights. With the intention to illuminate the character and offer the possibility for them to express through the light, use it, or react to it, while the light pattern would be portraying a lifeform from within the costume (character). Besides the basic – grown on the

character – body suit, there would be two removable parts of the costume; a voluminous pullover-like garment with an oversized layered collar and an inflatable headpiece. The voluminous upper part of the costume inspired by the wavy lines and folding structures, was designed to change the silhouette of the basic costume and provide a way for the character to feel secure, shielded. The giant collar of the garment was designed to provide another function; when pulled up it would cover the performer’s face, and combined with the inflatable headpiece, completely change the perception of the character. At a specific point during the performance this character would undergo a transformation, changing their appearance from a humanoid, to a creature-like being. The inflatable part of the headpiece was shaped in two long elements, repeating the wave lines of the voluminous top part of the costume, and when inflated, the performer would use them as feelers to explore the world around them in a new manner.

When looking for the fabrics to make the costume, I was drawn to two white samples. The first one was a stretch fabric with a very distinct relief texture that (not only in my view, but also by the provided name) resembled the shape of splashing water. The second one was a soft, semi-thick, elastic foam-like material that could be easily shaped and maintain a structure. Both were used for the final costume. The texture of the first fabric really came to life when stretched upon the surface, and with all demands in mind, I decided to use it in a body suit that would look like being drawn on the performer. The idea was to make it look like a texture of the body, rather than a piece of clothing. To enhance the effect of the second skin, I wanted more costume-skin transitions along the length of the costume (later limited to hands and legs), rather than to have a full leotard transitioning only to neck, wrists and ankles. To provide additional transitioning locations, the cut-outs would be designed into the garment. It was planned that the basic costume would serve as a blank canvas for incorporating the wearables, but what kind, size and how many components was still left to be decided. The look would portray a humanoid character that exists in the abstract, undefined world created for her. With the help of an inflatable part of the costume, a headpiece designed and built in collaboration with Dempsey, the character was planned to undergo a transformation.



**Picture 8:** Costume sketch 2 (Frumen, 2018)



Making a first prototype of the costume, using nude coloured Lycra, different sizes and placements of the cut-outs in the costume would be tested to see how they behave, before cutting them into the real fabric. Because I imagined the holes to be quite big, the costume maker and thesis advisor suggested using nude fabric inside the holes, instead of leaving the cut-outs empty, or cut out smaller surfaces, as such big holes might disfigure the way the fabric holds the body. This would however contradict my idea of merging the cut-outs' edges with the performer's skin. Nonetheless as it turned out, bigger holes actually worked better than smaller ones, both aesthetically and functionally. With distance, the effect the smaller holes create weakens. They also cause much more wrinkling and loose fit of the garment around the edges of the cut-outs, than the larger sized ones. The process of testing and controlling the cut-outs in the costume to keep shape and stay in place lasted considerable amount of time. The holes were drawn and then adjusted and cut one by one. When needed (especially lower down the legs and around elbows), the fit of the sleeve or the legging would be adjusted not to wrinkle or get loose. The combination of carefully thought out placements of the cut-outs and a time-consuming fitting, resulted in the form fitting body suit covered in cut-outs, and no additional darts, apart from the already existing side seams. The costume, especially on the performer's legs, already appeared as painted on with a brush, but in order to make the colour of skin slowly transition to the white of the fabric, I proceeded to test few ideas.



The dip-dye technique was used on all the edges of the costume, namely the transitions from costume to skin, to achieve the fading effect. The task to match the colour's effect on the white fabric to the performer's skin tone was very demanding, since the pigments are not monochrome, but exist as the mixtures of various colours. Having to mix and match the exact shade of the colour required a considerable amount of time, effort and testing, but with the help of the costume workshop supervisor, the match was finally achieved. A situation predicted and bound to happen, but could not be controlled was that the performer's skin tone might slightly change between the dying tests and the actual performance, as the summer was coming to an end. An additional idea to support the transition was to continue the texture of the fabric to the skin. For this purpose textured prosthetic pieces were created from silicon, which we applied during the make-up test. Even though achieving what was imagined, the texture suggested an illusion of a damaged skin, so we decided to not use it. Instead, a thicker silicon replica of the texture was created, which the make-up artist then used as a stamp.

**Pictures 9 and 10:** Make-up test: Skin texture detail (prosthetics and stamp) (Frumen, 2018)

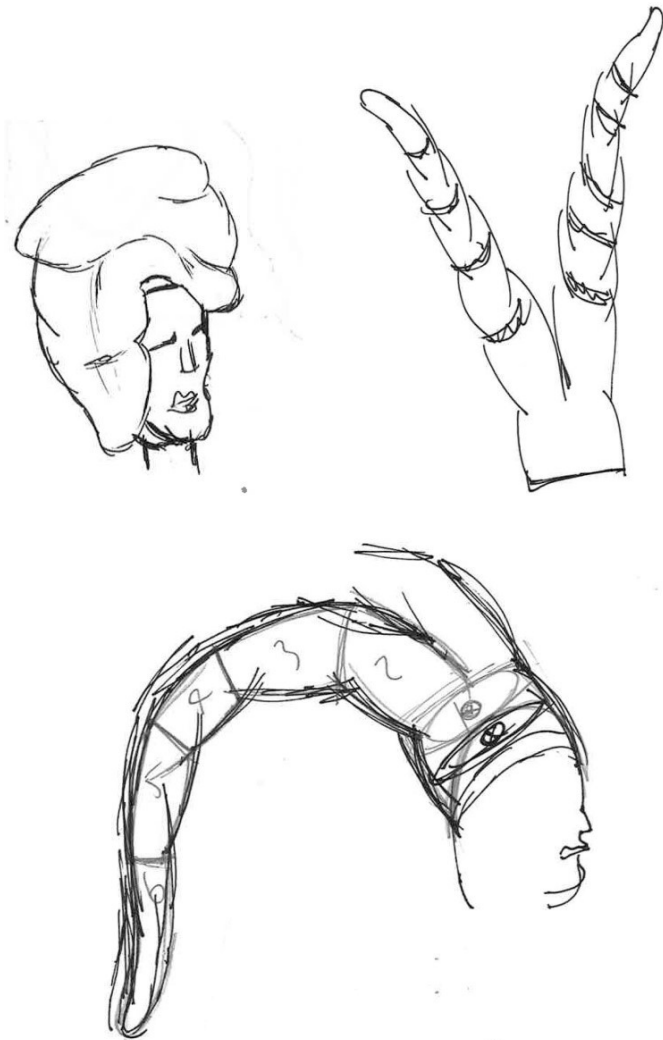
The second, foam-like fabric was used to create a removable voluminous upper part of the costume, changing the silhouette of the form fitting body suit. I liked the idea of big sleeves connecting to the torso, but with the initial tries of cutting the flat shapes and seeing how the fabric behaves, it became clear that a way for the sleeves to fold accordingly needed to be invented. Inspired by the mood board pictures of architectural shapes and the lines of fabric floating in the water, I designed the structural pullover-like garment. The foam would keep the shape, the curves could be manipulated in terms of being turned in or out and the sleeves would stay in place even if the performer would take her arms out. This material also turned out to be a soft and comfortable option for padding the electronics, smoothening the edges of the costume, as well as a great light diffuser and was therefore used as such wherever a LED strip would be incorporated.

While the body suit allowed the performer to maintain the freedom of movement, it did also not suggest any specific frames. The voluminous upper part and the headpiece were designed not to constrict the movement either; however, because of the appearance and sensation when worn, they did inspire the performer to move and posture herself in a different manner. Through such visual changes in the costume and performer's embodied perception of the appearance, the character transformed from a humanoid, to a creature-like being. This influenced the narrative of the performance making, as it provoked an evident character development. With the basic part of costume designed, it was time to design, embed and connect the wearables, which are subjects addressed in the following sections.

- **Fitting the inflatables**

Seeing Oscar Dempsey's previous work on inflatable set elements, I was interested to see something like this incorporated in the costume. It seemed intriguing to explore how the body proportions could be altered, how the perception of the body would change when a part would be enlarged or added through an inflatable element. Such an element would not only affect the visual impact, but also the performer's experience and embodiment of such feature. My main condition was that the inflatable part needs to look like a part of the costume, designed with it, and when deflated, either not be visible or be designed to look in a specific way as part of the overall costume design. As a costume designer (myself) and scenographer/sculpture artist (Dempsey), I knew we would be approaching the concept from different perspectives. The visual aspect was important for both of us, but while Dempsey was concerned about the technical requirements, I was worrying about the comfort and the frame of movement it would provide for the performer.

A few technical facts we needed to keep in mind were, that whatever we would inflate, it would have certain requirements and follow the basic laws of physics. First thing the inflatable would need to be able to inflate was a fan. The fan, no matter its size, needed to be attached to a solid base with a space underneath it to be able to suck the air in. It also needed a power source. The inflatable would fill up at a certain speed and would deflate with the same speed, as the area where the air could flow in or out was the same, and the process could not be forced faster. The rules also apply to the way of filling up; if not perfect geometrical shape, the object might be partially deflated in some parts and more inflated in others. Whenever a specific feature has its requirements and rules of behaviour it is easier to embrace and work with them, instead of attempting to working against them at all cost.



We started figuring out which part of the performer's body we wanted to inflate, thinking how the narrative would be shaped with it. Would the feature be constantly present or something separate and detachable from the costumed body? We wanted to create a reason or motivation for the transformation that would happen when the feature would inflate, because it would not only cause the performer to perceive herself differently, it would also influence her posture and movement quality, and with that change the character. With the fact that a trapeze was going to be used in a final demo, we decided to provide the option to easily put on or remove the piece to not get in the way, if that would be the case. The aesthetic perception of enlarging the body or a part of it tends to imply swelling (or pregnancy), which led to the decision to design an inflating shape that would develop a new shape of the silhouette, rather than enhance the outlines of existing one. After a few ideas, sketches and considerations where this new part could be and how it could affect the perception of human body, we set out to create a headpiece. When deflated and prepared for reveal it was designed to look like a hat or a crown, but when inflated, two long pieces cascaded from it. Their shape was not meant to immediately implicate any specific association, but depending on their use they could vaguely resemble hair, tentacles or insect-like feelers. It was meant to provide a character with a chance of transformation, which combined with the costume, it did.

**Picture 11:** Inflatable headpiece sketches (Dempsey, 2018)

When fitting technology in the costume, we wanted to see just the effects and not the parts that are doing the trick, so just like for other wearables, we chose the smallest inflating tool that would successfully perform the task; a computer fan. This also meant that a large power source was not required, and two PP3 batteries were enough. The base for the fan was raised above the top of the head to provide enough space for the air suction, and the lower side was secured with a net, to protect the hair from getting tangled inside. The form provided a big enough slot for the placement of batteries, for which purpose we created easily accessible pockets under the base, to provide the option of detaching and replacing the batteries. The on/off switch was, for convenience of the performer, embedded in the side frame of the structure.

**Picture 12:** Inflatable headpiece in the making, Aalto Studios (Frumen, 2018)

For the prototype we built a cardboard frame for the structure, which was later replaced with an adjustable helmet headband that provided proper fit and grip of the headpiece and finally, the headpiece was dressed to match the rest of the costume. The actual inflating part was made of lightweight windproof material, which enabled the air to be captured inside and the element to stay inflated despite the initial concerns about the powerfulness of the fan. The inflatable part was in a shape of two long elements, mimicking the shape of an inflatable set object (used in the final demo), and repeating the wavy shapes of the voluminous top part of the costume.

As planned, the use of the headpiece served in character transformation. Worn without being activated, it appeared as a crown. When turned on, two inflatable pieces would cascade down from it. The structure did not weight much, but the sensation provided enough awareness for the performer that her head is being extended, and this stimulated her to change the way she perceived and moved her head and consequentially, her whole body. At this point the LEDs in the performer's feet were turned on, which gave the illusion of her floating instead of walking. With the change of the posture, the nature of the character changed and the narrative was made. The performer reframed into an insect-like creature, using headpiece parts as feelers.

**Picture 13:** Completed headpiece, Kallio Stage (Frumen, 2018)

- **Embedding wearable electronics**

Trackers were the first piece of technology that we intended to embed in the costume. By the time they needed to be embedded, it was already decided on how they are going to be used, how many will be featured in the costume and what would be the best placing for them considering their use. The functions of trackers widened the possibilities of the performer's role and the aftermath of her actions. Causing scenic, light and sound elements to change with movements extended the function of performer's body. With no technician behind the controlling consoles, the performance developed through the direct interaction between the stage and the performer; this created the illusion of stage elements coming to life. Though the two trackers in the costume were active throughout the duration of the demo, they were controlling different things in different stages of the performance. The part





where they were being used in a most dynamic way was when the performer was controlling the movement the scenic/light object with changing the altitude of the trackers. The most convenient placement on the performer's body that would allow to move the tags from highest to lowest point, create the largest distance between them and, consequentially, provide ability to control each one separately, were the performer's hands. The tags fit nicely on the insides of the wrists, where special pockets for them were made on the inside of the costume. Embedding the trackers invisibly did not cause any trouble; they are small, lightweight and above all, wireless.

Having so swiftly settled the basic part, we were tempted to undertake another technical challenge and therefore decided to bring to the costume the element of light. With the given amount of time, budget, only one performer and interested lighting and costume designers, as well as the computer scientist to offer a hand, it seemed like a too good of an opportunity to dismiss the idea. As already established in the mood-boarding, the lighting designer and I discussed that we prefer diffused, indirect light that creates soft image without sharp shadows, and so we agreed that the light sources in the costume should be hidden. We liked the mystical idea for the audience to know something is there, without revealing how it works. Lights in costume are often used to draw the frames of the body in the dark, or to create a sparkling fairy tale-like effect in the skirts, but we wanted to explore grounds beyond the basic visual impacts and see if a costume could actually function as an independent light source. The aim was to design the lights to make them feel as a part of the character, and with that show another layer of the character coming to life and expressing through them. At the same time, the lights offered another element that could be interacted with and controlled through the system.

In the initial tests, I was trying to create a texture with sewing the lights inside narrow fabric tunnels and achieve an illusion of a life under a costume, sort of like a venous system. For this purpose I was using Electroluminescent wires, but friendly and adaptable as they are to work with, they are not very bright, can only be in a specific length and colour, cannot be dimmed and in addition to that, they produce a high pitch sound when turned on. The light sources we decided to use in the final costume were flexible NeoPixel LED strips. The single LEDs are very small and almost flat, and the whole strip is covered by a silicon tube, which protects the strip and at the same time provides comfort for the wearer if they were to put weight (*step or lean*) on it.<sup>2</sup>

With the use of Arduino circuit board or a similar component, such as Adafruit Father, the light colours, patterns and intensities of the LEDs could be pre-programmed or controlled from afar, and if desired, each LED manipulated separately. This function enabled us to have a complete control over the lights in the costume, as they could be tampered with from the lighting console and, because of this, also by the trackers.

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<sup>2</sup> The NeoPixel LED strips come in the full length of 4 meters, but can be cut on the marks to an exact length or even extended with another strip if needed, which is exactly how they were used in our costume. The base of the strip can be black or white (we chose white), and the light colour options are unlimited due to the fact that they not only come with RGB LEDs, but also RGBW, meaning the "pure" white light can be achieved.

**Picture 14:** The performer (Aliisa Rinne) and the big inflatable, Kallio Stage (Hallikainen, 2018)

When Jalerva, the lighting designer, suggested using costume as the only light source for a part of the performance, I did not want the performer's face to disappear. Hence, I used a part of the tube-like structure that was coming out of the costume to frame the LEDs that would illuminate the performer's face. A few tests needed to be done before achieving the desired effect. First of all, the direction of the LEDs in a light strip needed to face certain way to shine the light in the right direction. Second, once embedded inside a tube and covered with fabric, the positioning of the tube need to be adjusted to make sure the face would be illuminated. And last but important, the highest level of intensity of light that does not disturb the performer's sight needed to be determined. . While the need for the upper part of the tube firstly came from the practical reason, it was designed with the idea of portraying life of the character inside the costume. Its shape would create an organic feel when a light impulse would travel through it, and provide a relatively long path on which this would happen, for the effect to last a while. To provide the performer with an option to intentionally illuminate something with the part of the costume she could easily control, the light strips were placed also on the inside parts of her forearms. Another beautiful effect Jalerva suggested, which I was instantly intrigued by, was to have lights under the soles of the performer's feet. This provided a nice challenge, as I did not intend for the performer to wear shoes. The latter option would have been much easier, as footwear would provide many options of where to embed the lights, as opposed to bare feet. Were we to equip each foot light separately however, they would each need their own power source as well as feather board that would allow them to be controlled from the distance, and the code for this parts would have to be written separately. I originally wanted to expose more of performer's legs, but came up with the idea of



prolonging the lower part of the costume to continue into dance paws, which allowed for her to stay barefoot, while providing a good option for embedding the lights in the arches of her soles. To relief the pressure on the LEDs when being stepped on, I originally tried supporting them with custom made silicone pads, which turned out to be unnecessary. They ended up being replaced with the lining made of foam-like material that was also used in other places around the LEDs and served not only to soften the strip, but also to hold it in place and diffuse the lights. Not using shoes and having a form fitting costume eliminated the option to embed the rest of technological components around the lights in the feet. With the performer rolling around during the performance, legs can be a tricky place to comfortably host anything but a cloth.



Although all costume lights worked during costume try-outs at first, the strips in the arms started causing technical problems which we were unfortunately not able to fix before the deadline of the final demo and due to that, some ideas could not be realized. Anyhow, the lights and feather boards needed a connection to a power source, which brings us to a new development, analysed in the next section.

**Picture 15:** Aliisa Rinne as The creature, Kallio Stage (Hallikainen, 2018)

- **Connecting wearables with power sources and wires**

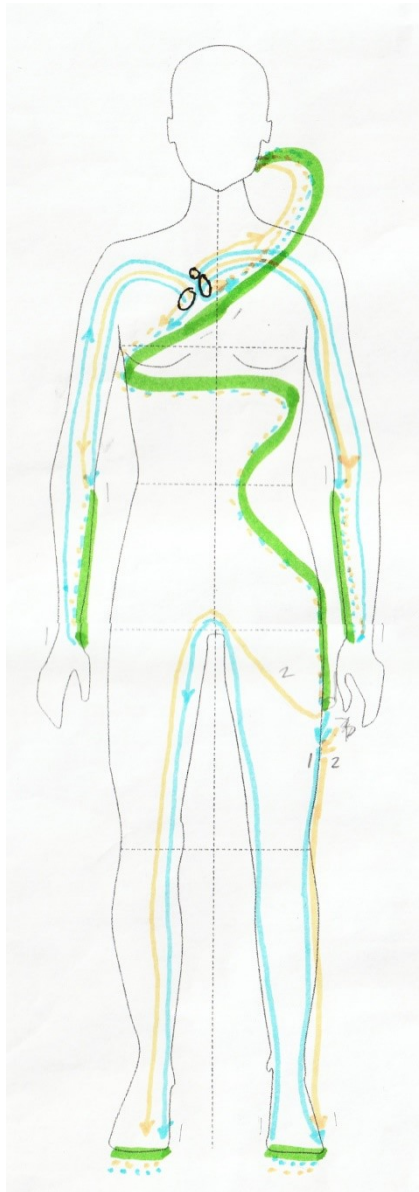
The decision to use power banks as power sources was taken quite early in the process, as they are relatively small in relation to their capacity, rechargeable, convenient to connect and more importantly, come in various shapes and sizes. As the total length of the LED strip used in the costume was planned and estimated to be around three meters long, the calculations suggested the use of three power banks would be ideal.<sup>3</sup> Again, the power sources as any other piece of wearable electronics would need to be either hidden or aesthetically incorporated in the features of the costume and should not limit the performer's movement.

When testing different shapes around the bending body to see what fits more naturally, it was decided to use the three cylinder shaped power banks, which were initially considered to be removable. The plan was to place them on a reachable place in the performer's lower back, where she felt most comfortable carrying them in the first tries. After establishing that they would remain in the costume for the whole time, the placement needed to change, as it was not comfortable for the performer to lie on her back when wearing them. The most convenient placement in terms of comfort as well as accessibility, turned out to be in the bosom area. A structured sports bra was used, as it was able to hold the weight of the power banks attached to it with pockets made of elastic material. Two power banks would fit underbust and one in between. In theory that would be a good placement, but with the costume being fitted to the body and power banks not being as small as one would hope them to be, they would create lumps in the shape of the body and required a bit of padding to conceal. With an attempt to minimise the amount of items that do not visually add to the effect, only two power sources were used. Two of them were much easier to conceal and ended up being nearly invisible when placed inside the pockets between the breasts. The shape of the body also provided an area on the chest, where the costume would not touch the skin and this space was used to successfully hide the wire connections going from power sources into LEDs and in the feather board that was placed into a separate pocket. The deduction of power sources however, brought another matter that needed to be negotiated between the costume designer and the lighting designer. The powering with only two instead of three power banks meant that the full capacity of the LED strip could not be reached, because this would need more power than the two power sources could supply. If all the lights in the costume would be on at the same time, they would smoothly work on only 56% of their full intensity, brighter if the white LEDs were not used and even brighter when only a small number of LEDs are on at the same time, for example like an animation going through the strip. Since LEDs in their full capacity are in fact very bright, it was a compromise we agreed upon.

The part which presented the main challenge in the functionality of the costume was connecting all the wearable components in the right way and order, while keeping the connections secure and organised. The initial idea, aiming to achieve the minimization, was to use the conductive paint or thread where possible. The conductive paint did not work well enough, as the resistance was higher than conductivity. The conductive thread was very thin, which would be practical on one side, but on another, it would also wear and tear easily. On top of everything, there was a fact I did not realise prior to sketching the

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<sup>3</sup> The actual number of needed power sources would vary depending on the output current rating of a power bank; in our case the realistic options were to either use two large (and more powerful) square shaped power banks, or three somewhat smaller cylinder shaped ones.



connections, which was, that one connection does not necessarily mean only one wire. The wearables in the costume were designed in such a way that required three or even four connections, which should not interfere between themselves to be present on same locations. There was the need to attach the LEDs and the feather to the power source with connecting power, grounding, data input and in some cases data output on the other side of the strip.

The costume contained two main sections of LED lights, separated approximately in two equal parts, which would be split between (initially three, later two) power banks. These would share a connection to the feather board, which would also be powered from one of the power sources. The first section of the strip would cover the back part of the tube, starting from the chest area where it would connect to power. The second section would consist of five smaller sections, connected in the following order: left arm, right arm, front tube, right foot, left foot. In order to provide functional, durable and safe connections, the final decision was to use wire, and the softest type that would regain its form when bended was the silicone covered wire. From the very beginning I wanted as much electronic components in the costume to have an option to be removable, if not during the performance, at least for the maintenance purposes. For that reason every connection that needed to be made between the LED strip and the wires was added a two-piece connector that would allow assembling and disassembling components when needed.

The wire could not just connect two components across the shortest length but needed to be led along certain lines of the body, where the length would not change and the wire would not get caught, for example, in the knee or elbow joints. As some of the distances between the locations of the LEDs that needed to get connected were pretty long, the total length of wire used in the costume added up to 16 meters that needed to be embedded in a single costume. For this purpose, carefully planned and positioned tunnels were sewn on the inside of the costume, in which the wires would be inserted. With up to four wires in the same tunnel and multiple dressing and undressing of the costume, the wires eventually started to roll around each other and create tiny lumps. This was to some measure expected, and in order to minimize this effect, some of the tunnels were separated to hold the wires in combinations 2+1, 2+2 or 3+1. Another helpful practical trick was to leave tiny spaces in the curves or intersections of the tunnels. This allowed for easier insertion of the wires, but more importantly gave them the opportunity to adjust their shape to outside of the limits of the tunnel, as well as be pulled back inside when the section of the costume got stretched.

**Picture 16:** Positioning of wearable technology in costume (Frumen, 2018)

The costume on which all the placings and methods of embedding were tested was originally meant to serve as a prototype, but with the precise work of everyone involved, it was decided to be used as the final costume.

- **Demo (); - Interactive Performance**

The main objective behind the final demo was to demonstrate the various uses of the location tracking system in live performance and especially to indicate how such a technological element would enable an artistic creation. The technology embedded in the costume was coded in a way that it enabled the performer to take control from the lightning console and trigger different set, prop, sound and light manipulations with the simple action of moving in space. To make visible for the audience that there is no operator behind the controlling consoles the technical station was turned towards the stage and placed in the middle of the sitting area, so the audience could see no one was pressing the buttons when changes were happening on stage. The demo was performed on 6<sup>th</sup> of September 2018, at Kallio stage, twice in the same day. Only the first performance was recorded on video (Final demo – Digitalizing performance with wearables and software, 2018: <http://bit.do/eSPwg> ), while both shows are documented with photographs.



**Picture 17:** The costume (worn by Aliisa Rinne) in the performance, Kallio Stage (Hallikainen, 2018)

## - Chapter 3: Observations

### ○ Demo-related observations

#### ▪ How technology created narrative

Since the very beginning the creative team intended to make the final demo interactive, to make it seem that the performer is not the only character on stage. Little did we know; the software had the same plan. The Quuppa system we were working with was not entirely accurate, and because it was sending and receiving data constantly, elements connected to it, appeared somewhat unstable. Constant shaking, noticeable mainly in the spotlights and lifting of winches, were the cause that the team (as well as the audience) started to perceive the technology as an element with a “will and mood of its own”, and such associations created another character in the space. Recalling the experience, Rinne (2018) shared her impressions:

*“The elements what we used created interaction between me and them. For me it felt that I wasn’t alone on the stage. There was different light, sound and prop “co-performers” with me.”*

The analyzation of experience goes deeper when trying to compare different sizes of follow spots. With a tiny spotlight, the diameter is smaller, the spot’s edges are sharper, the movement seems larger, and it never actually illuminates anyone, so it starts to be perceived as a small jumpy animal following people around. The larger spotlight, on the other side, is softer around the edges and it has an option of illuminating a person. It is bigger to begin with, and because of that its movement does not appear as excessively active as the one from the smaller spot; it comes across as a calmer a light with an idea to occasionally staying behind when it should follow. Noticing such properties when interacted with, the narrative started to invent itself through performer’s improvisation and response to it, as the technology personified a character.

Another example related to the inconsistencies of the tracked data in the system, created sort of a glitch in the movement of winches the light objects were attached to, and the effect with its unpredictability again portrayed an illusion of a character. The performer played around with the light object during the testing period a couple of times. When preparing the act for one of the in-between demos, she only had one full run-through before the day of the demo. Doing exactly the same thing on rehearsal and on the actual demo, we were all surprised by the way the object interacted with her on separate days. Everything seemed different; its speed of reaction and rhythm of jumpiness in the movement changed completely. The visible variations were not spotted only in the part when the object was reacting to the performer’s movements, but also when it was reacting to itself. The switch to self-interaction happened in approximately the same height and position of the object, yet every time it was impossible to predict how it was going to react. Sometimes it would continue changing position and orientation, sometimes it would lift itself up really fast and stay there, while other times it would move slowly and gradually. At a certain point Rinne (2018) expressed:

*“It was like dancing with another person with a completely different energy.”*

Through such associations, the core of the narrative slowly began to be formed with the help of options of interactions and instability that technology offered, creating the new “character” with its inconsistencies. Wolf (2012:220) suggests that *“an interactive world does not require a predetermined narrative,”* while claiming that *“the structure of a world is often more robust when it comes to the user-led exploration.”* We realised very early in the process that it will be easier to accept the glitches and be prepared for a certain amount of improvisation, as opposed to working against it, or worse, pretending it is not there. It is true that the user, in this case the performer creates the narrative through the interaction, but they can only shape it within the pre-determined frames that are offered to them. The inconsistencies in the system created a certain challenge for the performer trying to practice or repeat the scenes, not knowing which “personality” she is getting to perform with each time. In the final demo this scene served for the performer discovering new environment and elements after parting ways with the spotlight. The variations in behaviour of the elements did not change the narrative per se, but allowed the performer to expect the unexpected and constantly approach the scene as the first time.

The visual dynamics created between the performer and the light objects through the use of position data formed strong geometric compositions, and the movement of the light objects was causing the perception of the space to change with their nonlinear movements upwards and downwards. When hanging horizontally they presented sort of a ceiling, the end of the frame, and when they positioned themselves diagonally they opened up the space and created a new frame for the performer to explore. And while the dance was compelling to watch, the different terms of interaction between the performer and the light object were not always obvious to the eyes of the audience.

In the first part, the interaction only worked one way, and that’s why we labelled it as an apparent interaction. The objects’ choreography was pre-programmed, while the performer moved around it, reacting to its movements. The second part demonstrated an actual mutual interaction, with the performer in charge of both her and object’s movements. The altitude changes of each side of the light objects were connected to the altitude changes of the two tags situated on performer’s wrists. With moving her hands, the performer was triggering the winches to raise or lower the light objects, and with the change of their position, she was reacting to them with her movement, causing her hands to follow and continue sending new data to the system, which kept moving the light objects. In the third part light objects were self-interacting without performer’s involvement. The trackers placed on the sides of the middle object were sending the position data to the system, which according to the one side’s altitude caused the reaction of the winch on the other side, and vice versa. So if the left side of the light object got lower than specific point, it sent the command to the right winch to lower the right side of the object, or the other way around. Because of the inconsistencies of the tracking, the light objects would never stay in the same position. Instead, they would constantly move up and down, sometimes more, sometimes less, depending on the actual position of the edges, as well as the deviation of collected data.

While each section felt like a much different experience for the performer, it might not have been perceived so from the observers’ viewpoint. In a conventional performance it is assumed that lights, set and other objects are controlled from the lighting console (or similar). Hence, the audience often accepts interactions to be apparent or pre-programmed. The commands for direct interactions in our case were being communicated through the Bluetooth



and WiFi and trying to show that no operator was needed during the performance, the controlling consoles were placed in the middle of the audience, turned towards the stage area.

- **Costume-related observations**

- **Placing the performer into costume and costume into space**

Already on the fittings, Rinne was very excited about the costume and the functions it would provide. She was constantly working with the trackers that would be embedded in the sleeves, but the light features, the power sources, the feather and the wires were new to her when embedded in the costume. The electronics were well incorporated in the costume in terms of comfort, safety, and convenience and she immediately embraced the costume as her second skin character.

The costume was finished quite late in the process and therefore Rinne started using it mainly during the final run-throughs and the performances. She was surprised how comfortable she felt wearing it despite the amount of embedded electronics. She remembers how:

*“The costume itself set simple frames in my movement quality. For example I couldn’t comfortably lie on my stomach because the power banks were hidden into my chest. Obviously those details changed something but it didn’t disturb me at all. I actually didn’t think of them while I was performing” (Rinne, 2018).*

The influence of the technology on the concept of the performance, and especially while building the performance, was however stronger. The performer’s role in this specific project was extended and became more complex as she took on a responsibility to be in charge of every change happening on stage. Her presence in the performance space was a catalyst for everything that happened; she not only undertook an expressive role as a “character” through her performing body – a part of performance normally assigned to the performer, but was also (and especially) in charge of manipulating all the elements that are usually controlled by the technicians behind the consoles. The nature of some of the technical changes created an idea of “another character”, and while controlling the technical commands of such specific elements, she was also interacting with them. At the same time however, the movement of the performer through this interaction sent the commands to the elements on how to react back, again and again, until such function was active. In theory, the command and reaction steps were clear and location-wise pre-set through the software. The performer was well aware, for example, that the spotlight would follow her position towards and away from the audience, but would be on the opposite side of the stage, meeting and intersecting with her only in the middle. In practice however, working with technology, there is always a chance for something to not go as planned. In this case there would be no technicians to help to solve the errors, the performer alone would be left to react on the spot and continue the performance. Because of this, most content within the separate scenes of the demo was open to improvisation. Nevertheless, there were certain things the performer had to pay close attention to.

*“I had to constantly be aware of the trackers and stage space while I was performing. I knew that only taking a few steps to the wrong direction can start the next scene, light or sound order,”* Rinne (2018) commented on performing with trackers.

Even though she was fully aware of her control over the system, at times Rinne (2018) felt like the technical elements would be controlled by the rest of the team and not her. The reason behind this might have been that the performer only had the control of everything inside the limits that were set for her. When it comes down to it, the decisions were made beforehand and many terms of how the changes would happen were pre-programmed, which left the performer in charge of triggering them. In other cases she had more control and could influence the happening directly; for example, this refers to where the spotlight would move, which way should the light object go, or what sound responses (sentences) would be activated, all depending on her position. Two big factors that we could not effectively control were the timing and the accuracy of the system; we could make the delay longer, but not shorter. This brought certain unpredictability to the reaction-time in the performance, but with time the performer became used to it.

*“The truth is that you can never fully trust technology. However, since technology on stage was the discipline we were researching, it was not possible to replace it with something else. At the end I was able to put almost all my concentration into what I was presenting on the stage. I could let go of thinking about the trackers and be interactive directly with the elements in the performance”* (Rinne, 2018).

What is worth mentioning here is that the performer did not consciously think of the tags as a part of the costume, as for most of the testing period they were taped on her wrists and not inserted in a costume just yet. Although once we determined the placings of the tags, the wristbands with pockets were made to hold them in place (before we had the actual costume), the trackers in her mind became a separate piece of technology. Should the costume have been provided sooner, with tags already inserted, the perception might have been different.

#### ▪ **Practical matters**

The costume was finished a week before the final demo, but it did not get to be used much on the rehearsals, due to the glitch that appeared in the functioning of the lights. While the full LED strip would work in the beginning of rehearsals, after a while, the front part would not behave as instructed. Therefore each day after the run-throughs, López and I would try to locate and fix the glitch. The problem would always appear at the same point of the circuit; after the arm strips, before connecting to the front tube. Despite the attempts on improving the quality of soldering, changing the wires, installing the resistors, or cutting off single LEDs on the edges to create new connections, the same problem would re-appear the next day. At this point it was very fortunate that all the separate parts of the LED strips were not connected directly to the wires, but had connectors in between. These connectors made it possible to connect each small section of the strip directly to power and data sources, and see where the problem was appearing. They also provided the option to connect the costume lights in different order, meaning regardless of the glitch, they could still be used in the final performance. With the deadline closing in and the ideas on fixing running low, we decided to simply leave out the arm parts and connect the power and data cables directly to the front strip.



Due to the range of Bluetooth connection between the feather in the costume and the commanding console on stage, dressing the performer could not be completed in the dressing room. The walls between the stage and the backstage were blocking the signal, and if the feather was already connected to the power in the dressing room, it needed to be re-set when brought on stage, to be able to connect to the console. Longer use of feather would make it overheat, and with that it was decided not to store it inside the designed compartment, but let be placed outside of it to reduce the heating, making sure it does not come in contact with the performer's skin.

Dressing the performer always felt delicate, because of the amount of wearable electronics that were incorporated in it and the tight fit the costume was designed to have. Even more delicate however, was taking it off after the performance, as the performer got warm and the material somewhat stuck to her skin. Even after multiple changes, the fit of the costume remained the same and additional tailoring was not needed. A new texture start developing on top of the tunnels embedding the wires, as with each dressing and movement, the wires got somewhat twisted.

**Picture 18:** Wires inside tunnels creating texture in the costume, Kallio Stage (Pantouvaki, 2018)

The costume in theory is washable; however, during a tight schedule and constant glitches, there was little opportunity to wash and more importantly dry it. The LED strips are removable, and so are the wires. The wires are attached to connectors whose diameter is larger than the tunnels, and while getting them out of the stretchable costume should not be a problem, fitting them back through the tunnels without damaging either the costume or the connections might be. During the working period, the costume could therefore not be washed due to the practical reasons. The odour control spray was used for basic maintenance, while fully washable under-costume and undergarments were being used underneath the basic costume. After the final demo, the LED strips were removed and the costume was treated with a dry-cleaning procedure which did not affect the wires.

## - Chapter 4: Findings

This chapter serves to and answer the research questions set in the beginning of this thesis. The following findings and described situations are related to the performance that served as a case study of this practice-based, design oriented artistic research. The material was collected using various qualitative methods. First section, the effects of wearable technology on the costume design process, is based mainly on auto-ethnographic notes collected during the process. The following two, addressing Influence of wearable electronics and their features on the performance-making process and What the costume-

based approach brought to the work dynamics of the interdisciplinary collaboration, are based on personal observations, supported by the insights of the creative team members involved in the project, collected with informal semi-structured interviews.

- **The effects of wearable technology on the costume design process**

Designing of the costume is usually approached with certain requirements. The costume needs to serve the character, support the story and contribute to the stage atmosphere, while fitting the performer in a desired way enabling their performance. It provides either freedom of movement or creates a frame for it. When wearable technology is added to the design, it expands the possibilities of costume, by adding an extra layer to the functional and expressive aspect of the costume. Wearable technology brings new areas for the costume designer to research and understand, as it opens new options on what, how and for what effect it could be used. The functions can manipulate the costume directly (e.g. change the colour of lights embedded in the costume), or have an effect on the costume's surroundings (e.g. change the position of the spotlight). In this section I focus on the costume only, as the costume's surroundings are discussed under the following topic of how wearable electronics influenced the performance making process.

Wearable technology can add to the visual aspect and enhance the expression of something; maybe with revealing something underneath the surface of the costume, changing the colour, the shape or the size of it, bringing attention or enhancing certain parts of the costume and altering the proportions. In our case, the lights in the costume were used to draw illuminated shapes traveling through the performer's body, as well as to serve as a light source when no other sources were used to light the performer. The LED strips could be lit in different colours and when diffused with the upper part of the costume, their colour could influence the perceived colour of the costume, which was made from white material. They had the option to be controlled in sections, be lit, turned off, animated, and controlled through the system. Every time the animation would run through the strip, the light would give an impression of a life within the costume. Another part of the costume designed in a way to offer a narrative aspect to its use was the inflatable headpiece; used in different stages, it led the character to undergo a transformation. It was designed to change the outline of the performer's body and influence her to modify her posture and movement. Covering her face (and with that blocking her sight) while the two long pieces were inflated, inspired her to use the inflated parts as her new sense to detect and explore the environment. Several set and light objects were used to create an environment for the performer to interact with through the commands of the system in the costume, or simply by a tactile experience. The big inflatable piece for example also offered the option for the performer to go inside, providing a potential space for a costume change, which we did not end up taking advantage of.

Non-visual features in the costume which influence the performer's actions or motivations behind them can also be explored through the use of wearable technology. Such features are not necessarily visible in the aesthetics of the costume, but are definitely considered when the costume is designed, especially their positioning and embedding components, depending on the effects they will create. During this project the audio triggered by technology in costume had been played in the costume's surroundings.

*“The performer controlled the sound all the way through the performance. She could affect the effects in sound, do crossfades between sounds etc. Also the flow of the “scenes” was controlled by the performer by performing certain actions to “move” the sound design forward” (Rasinkangas, 2018).*

The overall sound design for the performance was quite subtle and while most of the effects the performer had the control over went unnoticed, there was an “apparent” feature performed through the verbal dialogue. When the performer moved along each side of the stage, the pre-recorded sentences were triggered depending on her location, to which she was also responded with speech. Because the conversation between the two was a very concrete part of the narrative, the sentences were used to move the plot forward. To connect the sound with a visual aspect, the position of the spotlight would move and imply where (which speaker along the length of the stage) the sound is coming from. Depending on the function assigned to the spotlight by the system embedded in the costume, it was either still, moving alongside the performer, “avoiding” her and finally, leaving, causing the interaction between the two to create a full story arch of a relationship. Another option, which was also discussed but not used in the final performance, would be for the sound to come from within the costume. The use of sound could vary from actual sentences triggering verbal responses, to specific commands or even abstract effects to which the performer would react to. The sound could be recognised by everyone, or it could be heard only by the performer, in which case it would make the command source invisible to the audience. This would lead to a situation where the costume would inspire the content of the performance from within itself by subtly triggering only the performer’s senses, rather than from its surroundings as it did during the final performance.

Regarding the material design and making of the costume, there are practical aspects that need to be considered and functionally achieved; the embedding of the newly added components. No matter their size, weight and extent, everything needs to be incorporated with safety measures for the sake of the electronics as well as the performer. The weight of the embedded components might affect the fabric choice for the costume, as for example highly elastic or very thin materials might not be able to keep their structure or shape when certain weight is attached to them. If the light sources are being embedded under the surface of the costume, they might influence the material choice as well; their intensity, effect, and colour will depend on texture, thickness, translucence and colour of the fabric. The outline of the design might also get influenced based on the incorporated wearables. If the components are either being visibly incorporated or are relatively large, they will most likely create certain silhouette shapes. Ideally, electronics would be embedded in the costume in a smooth and comfortable way, suiting the chosen aesthetics, being either fully or partly visible or completely invisible, depending on design needs and decisions.

Although they open up a conversation, encourage brainstorming, offer new effects and create wider collaborations, I am by no means claiming that the wearable electronics are suitable for every occasion. To be used to full potential, they should not be added on top of an existing work; the idea of their use should be evolving along with the concept, during the performance-making process. The costume with wearable electronics still serves as a garment to dress the performer, but also generates the interaction and takes on a “character” through which this interaction is shown. With this new role enabled by wearable technology, the costume no longer only supports the narrative; it actually creates content and new performance dramaturgy.

- **Influence of wearable electronics and their features on the performance-making process**

This case-study project was built around the location tracking technology and a challenge of applying it throughout the performance in various ways. The features of wearables embedded in the costume not only influenced the costume design process, but also led the general approach to the performance making itself. With costume design discussed in the previous section, I would here like to focus on how the rest of the creative team experienced that their processes were influenced by the use of wearable technology and especially what type of functions the location tracking system provided to them on creative level.

The first known task for the core team to achieve was to have a spotlight follow the performer on its own (without the technician manually operating it) and from there, the ideas quickly escalated. From freeing one position behind the lighting console, we attempted to pursue the idea to the fullest. Therefore, we extended this challenge to both light and sound designers, by deciding to work on self-operating interactions without any operator for either these elements. Rasinkangas (2018) notes:

*“Usually it’s pretty clear that the sound designer will be behind the desk controlling sounds during a performance. This was known not to happen with this performance from the start of the project. Everything had to be adjusted to that. For me this was more interesting approach than me sitting in the dark and pressing buttons.”*

Once we connected the software to the controlling consoles, we were able to program stage elements to be fully controlled through the system itself. “Fully” in this case meant to the best of the system’s abilities, and though the e.g. light was following the performer, due to certain inconsistencies it was doing so in its own way, giving an illusion of a character, almost a “mood” in which this following was performed. Visual features of wearable technology provided certain aesthetics for the performance, but several functions assigned to embedded tags made costume a tool for creating the content. Lights inside the costume, stage lights, sound base and effects, wind machines, fog machines, winches moving props, everything could be manipulated through movement of the tags embedded in the costume, a prop and a moving set piece. The performer’s words spoke for most of the creative team when she said it was a “*new, interesting and special experience to make a performance which is fully technology based. It was about [artistic] research, none of us couldn’t know exactly what we were getting into*” (Rinne, 2018).

The general instincts and drives of our artistic research process were pretty similar to a standard practice for creative collaboration. Even though there was a lot of technology the performer was interacting with, when stripped to its essence, the process was a familiar one for everyone except our computer science partner who was introduced to performance making by the rest of the team. The environment was created for the performer to explore and get familiar with the technological means, and through that explore what kind of performative material would be produced. To achieve variations she alternately improvised while having complete freedom, or at other times, she was given a task or was directed by other team members. The objective of the final performance after all was to demonstrate different uses of the tracking software in live performance. The concept behind it was always to play with different levels of interactions between the performer and the stage elements. Every element used in a performance, tangible or not, was introduced with the intention of

being interactive. Light, sound, and inflatables, they each had their unique relation to the performer that evolved through the interaction. The content of the performance developed from the practice-based collaboration which involved exploration of software with movement research and numerous discussions. To this López (2018) acknowledges that *“when one starts building the tech first, and then has to build a story, one ends up adjusting it to the possibilities and limitations of the developed tech,”* which in our case, because research started from getting acquainted with the technical frame, was in fact the case.

We established the list of elements with which the performer was working during the rehearsals and discussed the various options of their use and controllability. Based on practical issues we arranged the use of these elements into initial chronological order, which we interpreted to form a sense of dramaturgy, giving meaning to separate sections through the movement or level and quality of interaction. Certain sections within the planned performance which were known to have to be improvised, due to the previously experienced glitches in the system, so it was interesting to try and create a narrative with this in mind. The software, as it is, is still in development and at the moment not completely accurate in the location of small-scale movement in indoor spaces, which was from time to time causing unexpected developments which we tried our best to work around.

*“Because we didn’t control it, we had to make a simpler frame for it to work within, so that we could see the effects. For example the sounds on the pillars [in the final demo], we had to cut down the amount of sound effects and also broaden the area range that the performer could interact with them. I think this made it more complex for us as a team, but maybe not more complex for the audience to understand”* (Dempsey, 2018).

Achieving concrete aims through the use of such technology can quickly become demanding not only from the programming part, but also from the realisation aspect of execution. With the idea of simplifying the control over space manipulations for the performer, a lot of other aspects can get more complex and can therefore take several attempts before they are achieved, if in fact they ever are. Rasinkangas (2018) points out that in such case:

*“The technology starts to dominate the artistic project. Because things are a lot slower to test when you have more complex technology (which usually is still in development or not perfectly understood by the designers) it takes a huge chunk of the working time just to make some tests. Then again, this allows totally new ways of thinking and creating art, and by making mistakes, new, unplanned opportunities rise.”*

Beginning from a blank page, the ideas, the content, the aesthetics and the story of the performance will change and develop several times, as if the starting point would be a script, or at least the outline of the plot. As such was also the case for our process, Lopez (2018) noticed a relation between such an approach to performance making with the computer science practice:

*“Typically in the software industry, requirements are set from the start, and that guides the development process. However, when requirements are driven by aesthetics, they are subject to change on short notice. This is often undesirable, as depending on the requirement, it could imply considerable rework on the software.”*

The technology with its functions was used during this project to the extent that was possible to achieve within the given timeframe. Due to the time constrains some possibilities the team was working on had to be left out, as we could not manage to get them working well enough to be presented. This,

unfortunately, can be the case also in performances not depending on technology; certain features sometimes need to be developed, however within the restricted time frames, the choice is either to simply them, use them in an unpolished version or discard them altogether.

- **What the costume-based approach brought to the work dynamics of the interdisciplinary collaboration**

As already established in the introduction of the thesis, the “costume-based” approach refers to the functions and possibilities the costume would provide due to the embedded wearable technology and location tracking software, as oppose to the costume as an actual garment with only a visual and physical dimension. The project therefore started as a technical exploration of the software, discovering ways and possibilities how to integrate the software in the various elements of performance making as well as the final performance. The tags that were going to be incorporated in the costume offered the possibility to take the commands from the lighting console, meaning the performer’s movement could influence the lighting, while also sound and prop changes would be enabled on stage. The idea behind such an approach was new for the performer, who suddenly had to rely on herself and on the technology to achieve the desired interaction through which the performance developed:

*“At the beginning of the process, it was difficult for me to trust that the technicalities will really work. It was hard for me to understand how the system functions and I needed time to understand what all is about. During the project I learned to trust it more and I was able to try new things and play with it” (Rinne, 2018).*

The project was an open collaboration from beginning to the end. Being built around the possibilities the embedded wearable technology offered, it resulted in a free exchange of ideas, concerning the functions and the effects that the costume could trigger or control within itself, the space, the light, or the sound. The amount of elements programmed to be manipulated without the technician behind the console, gradually pushed the costume and the performer wearing it to the core of performance-making. López (2018) observed a departure from the conventional dynamics:

*“The performer gets to become an integral part of the design team when this happens. Typically the performer is thought of more like a means to an end, but when they get the tools to influence how their environment acts, reacts and looks like, they get an even greater opportunity to shape the performance to their liking through their actions.”*

The costume, due to embedded wearable technology, did not only lead the creative approach to the costume’s functions, but also on the scenic objects and their functions. The LEDs meaning to be embedded in the costume inspired the team to use them and create the moving light objects. The movement of these objects was controlled through the tags, which from their original intention to be embedded in the costume also appeared in the mentioned light piece, making it possible for the object to control itself at a certain point of the performance. The costume had therefore an impact on the whole work process, from approach to performance building, to creating the atmosphere and constructing the dramaturgy. Without actually setting physical or aesthetic



frames for the choreography, the costume instructed certain guidelines that led to exploring different levels of interactions through the movement, which strongly influenced the development of the narrative.

*“There were different relationships weaved around the costume. There was the interaction between performer and costume, the interaction between costume and electronics, and the interaction between electronics and controlling software” (Dempsey, 2018).*

Moreover, these elements influence the teamwork. Various possibilities of the costume and its extensions offered the option as well as the need for other disciplines to take part in the creative decisions as well as the execution of the costume. Depending on the creative discipline of the added function, it opens a position for the specific designer to join the process. Coming from different perspectives of the interdisciplinary team, the ideas were often offered with an immediate plan for execution, which is not always the case when only the costume designer is working on the costume. In our case, collaborating on specific design features and aesthetics of the costume together with the costume designer were the lighting designer and the designer of inflatables. Electronic additions to the commonly fabric-made costume often induce the requirement for collaborators not commonly involved with wardrobe to join the process of costume making. Specific works such as programming, wiring or soldering are needed for the electronics to work, which were in this project executed by the computer scientist, making him also the direct collaborator in the making of the costume.

The time management of the team got shifted, as everyone was dedicating their portions of time to collaborate on costume either in theory and/or in execution. Due to the use of wearable electronics, a fair portion of time also needed to be reserved for testing, to ensure the desired interactions would actually work as planned. Wearable electronics in the main focus, established certain urgency for the costume with all additions to become a fully functional garment. Furthermore, they connected the character with the world we created, as they expanded from the costume into the space. This created an opportunity for interdisciplinary team members to not only work closer together to achieve the result, but also caused them to directly face, support, understand and learn from each other’s skills and contributions.



**Picture 19:** The performer (Aliisa Rinne) interacting with spotlight, Kallio Stage (Hallikainen, 2018)

## - Conclusions

This research was initiated by the task to practically explore the use of a location tracking system and its various application possibilities in a live performance. The aim was to investigate the use of the system related trackers and other wearable technology embedded in the costume and the effects they would have on the costume design itself as well as on the collaborative process and especially the team dynamics during the performance making approach based on such technology. For this purpose a case study project was carried out, which concluded in a short demo performance to demonstrate the findings. The collaboration of the creative team developed around the functions and expressive possibilities that the embedded system provided to the costume, which led both the costume design process and the approach to the performance making. Initially set research questions are addressed through this thesis from the perspective of a costume designer, supported with selected insights from the rest of the creative team acquired through interviews.

Wearable electronics in costume are usually used to enhance visual features, to create a further narrative or to stimulate the performer's actions; however, the functions of technology in the costume made for this project also upgraded the performer's role in the staging as a whole, especially in creating the dramaturgy of the performance. The use of the software provided the possibility to manipulate the changes in scenic elements through the performer's movement in space, supplementing the more conventional way, when these changes are managed by the technician behind the controlling console. Through the location tracking system, the performer's body then became not only a visual tool to tell the story through movement; her movements became a tool to move and control various stage elements. The costume was designed considering various aesthetic but also practical intentions, and incorporated several electronic components, such as LED strips, power sources, an inflatable headpiece and 16m of wire; these components needed to be embedded safely.

The costume with embedded technology providing complete audio-visual manipulation options placed the costume to the foreground of the performance making process. Through this expanded role, the group's work dynamics was impacted as the collaboration developed around the costume. The performance was approached through the costume's integrated functions provided by combining its traditional role (to dress the performer and provide a stage presence) together with the system and the software. Such approach caused a variation to the conventional time management and the overall collaborative process, as the whole team worked on the costume along with its functions, and also time needed to be reserved to test if the features would work as planned. The technology embedded into the costume and the ability to not include an operator provoked different levels of direct communicative interaction between the controlled stage elements and the performer. While this interaction created the content around which the performance and its dramaturgy were developed, the technological properties and the responses of the controlling devices inspired the narrative. The use of technology brought a factor of unpredictability that was used to its best advantage, transforming the changing elements into a second character, giving the performer a partner, which she controlled, and was able to perform with. The performer in such a situation became the agent who provoked interaction with her movements around the space, which resulted in her gaining certain freedom, but also additional responsibility. In our project there was only one performer who constantly needed to be aware of her steps and motions, were there more of them, the obligations could divide between them.

Through theoretical ideas as well as through the case study as a specific and practical example, the thesis demonstrated that when designing a costume using wearable electronics, a lot of attention that needs to go to the smallest details. These range from wanting a simple light, to having to provide power, control options, having the knowledge to wire everything together properly and program it to work, to have it embedded safely, comfortably and in an aesthetically suiting way. The interactive performance created through this research encouraged the interdisciplinary team to collaborate on the execution of the performance through a costume-based approach and offered a possibility for new technical positions amongst designers to join the process. The whole design process of such a garment, as well as the performance weaved around it, initiated an open invitation for all the members of the creative team to think about the purpose, functionality and design elements of the costume. The costume, instead of being just the costume designer's contribution to visually support storytelling, became a collective effort of the interdisciplinary group of people instead.

The control over transitions, which were used to move the "acts" (stages of dramaturgy) forward in this project, could specifically be useful in immersive performances, where performers feed of the audience's responses. It would give the performers ability to interpret timing to serve the audience's experience. My personal interest would be to further explore the interaction between the space and the performer (as well as the audience as the performer), without them knowing that the trackers are embedded and where they are embedded, what effect they have and where the trigger zones are. This was something we initiated, yet did not have time to further explore in this specific project. It would be interesting to create a storyline, which would give impulses to the participant on how to move it forward.

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## - Appendix

### Appendix I

#### Digitalizing Performance with Wearables and Software - Description of Project

##### Background

During the performance, a technological infrastructure supports the performance designer in achieving their artistic goals. However, the solutions and practices in the state of the art are rather primitive, limited or too expensive. For instance, a commonly used case for live performance involves directing a light to one of the characters on stage (e.g., the lead singer in a concert), accomplished in many cases by a dedicated operator manually moving a spotlight to follow characters as they move on the stage. Even though there are some semi-automated and fully-automated solutions to achieve the same result, they usually rely on dedicated hardware and are very expensive, thus, affordable only by multimillion productions. A different option consists, instead, in combining off-the-shelf electronically controllable equipment and computing devices to deeply embed intelligence “on stage”. This paradigm – following the trend of the Internet of Things – offers performance designers the flexibility to incorporate complex multimodal elements in their art pieces through the performer’s own body, by means of wearable devices and software components, without having to worry about the availability of skilled operators or expensive instrumentation.

##### Description of work

This project takes a radically different view for realizing digital environments, offering performance designers new tools to easily accomplish their goals without worrying about the technological aspects involved.

A multidisciplinary group of students from the fields of Computer Science, Costume Design and Lighting Design will work together to study possibilities of 3D positioning system data to control theatre lighting fixtures and its visual impact on the performer’s body through costume. Based on experiments, the student’s artistic research group will develop a short demo-performance in a studio space. The group will work together over a period of 3 months to build and integrate the wearable software set up according to the performance needs. They will collaborate to develop a dramaturgy that will create meaning and narrative through the interaction of movement, space, and visual design (with emphasis on body/costume and lighting), free from the constraints of manual operation. The work consists of developing the wearable software, finding ways to embed it into the performer’s body as a wearable device embedded in a costume, and using it as a tool for meaning-making. The work will conclude with a short demo ‘performance’.

## Goals

The scope of this project is to employ software-defined elements in live performance, namely, by deploying computing devices on stage as well as through the performer's body and costumes, to orchestrate the existing support infrastructure.

Concrete phases in the process:

- To understand viewpoints and characteristics of technological and artistic practices in the project.
- To study the technological frame: to understand possibilities and requirements of 3D positioning as well as dmx-control systems, parameters of moving lights; to understand how to embed the technological devices into the performer's body through design.
- To understand the challenges of translating data between standards and the behaviour of light with surfaces and materials.
- To create ways to translate location data into standard control data of theatre lighting equipment (dmx)
- To find interesting relations between body generated location data and its visual impact translated into light.
- To develop relational findings into a selection of specific movement-interaction based visual ideas.
- To understand how body position and body visibility affect meaning-making for performance.
- To define interesting temporal and spatial structures for rehearsing and presenting the ideas.
- To integrate and develop these findings and creative ideas into a whole, through dramaturgical development (work in team).
- To present the results of these work in a demo performance.
- To document the process and evaluate the demo-performance.

**Project dates: 5. June – 7. September 2018**

## **Appendix II**

### **Interview questions to the members of the collaborative team.**

#### **General questions:**

What happens when the costume takes over the control of mechanical and artistic changes in the space?

How is a design process with such technical requirements different from how the creative team usually approaches a project? What new possibilities does this open?

Try to compare the process with the “usual” situations, where the design choices come from the narrative, pre-thought concept and/or movement, not necessarily from the technical requirements and a pre-determined task.

How different was the process from start to finish, and what are the new things that needed to be considered?

Was there anything special that got simplified or more complex due to the newly added technical part?

From your point of view (of your own area) how did the costume affect the interaction?

#### **Performer:**

What was your role in this collaboration?

How was it similar/different from other collaborations/projects?

How was it like building a performance around all of technology?

Did you know what you were getting into?

How did it feel taking on such a responsibility; having control of everything that happens on stage, including the parts that are usually controlled from the consoles?

Did it bring more freedom or constrains to your movement/to your performance?

(I know it came quite late, but) What did the costume itself bring to your movement quality? Did anything change when you had it on vs. when you were wearing your training clothes?

What new did you discover from the moment you started wearing the costume?



Is there something specific you'd wish to have more time to spend on, and what development do you think it would bring?

If we were to develop this project further, what new would you be interested in experimenting with?

**Lighting designer:**

How was your role extended/relieved on this project?

I know we didn't have a lot of time with all the technical problems, but how was it playing with the lights in the costume? Is it something you've done before?

How did the lights in space affect/relate to the lights in costume?

To what extent do you feel like you're responsible/in charge of the changes and happening in space that the costume/performer is triggering, and what happens sort of unplanned?

Were there features that needed to be considered in this project that are not usually something you need to concern yourself with?

How was it like building a performance around these technicalities? Obviously every performance is different, but what were the main differences and similarities of how did you approach this one? Did you know what you were getting into?

Is there something specific you'd wish to have more time to spend on, and what development do you think it would bring?

Is there something we didn't touch that you'd be interesting to see in action?

If we were to develop this project further, what new would you be interested in experimenting with?

**Sound designer:**

Obviously every performance is different, but what were the main differences and similarities of how did you approach this one? Did you know what you were getting into?

How did the performer interact with your work as a sound designer?

I know you've worked with trigger zones (?) before, but what was different this time?

Is there something specific you'd wish to have more time to spend on, and what development do you think it would bring?

**Computer scientist:**

How did you feel applying your skills and knowledge to the performing arts?

What did you learn from working with a costume designer?

How challenging was to adapt/respond to the needs of costume and performer (aesthetic and functional)?

We started with quite technical things and created the performance out of material we build during the play-time; would it make a difference for you if we'd start with a story and build technical requirements from there?

**Scenographer / designer of inflatables:**

Were there any challenges that appeared when you learned your set pieces should be interactive? Did you design them with that in mind, or is it something that came after?

Obviously every performance is different, but what were the main differences and similarities of how you approached this one?

What did you learn from working with a costume designer in this project?

