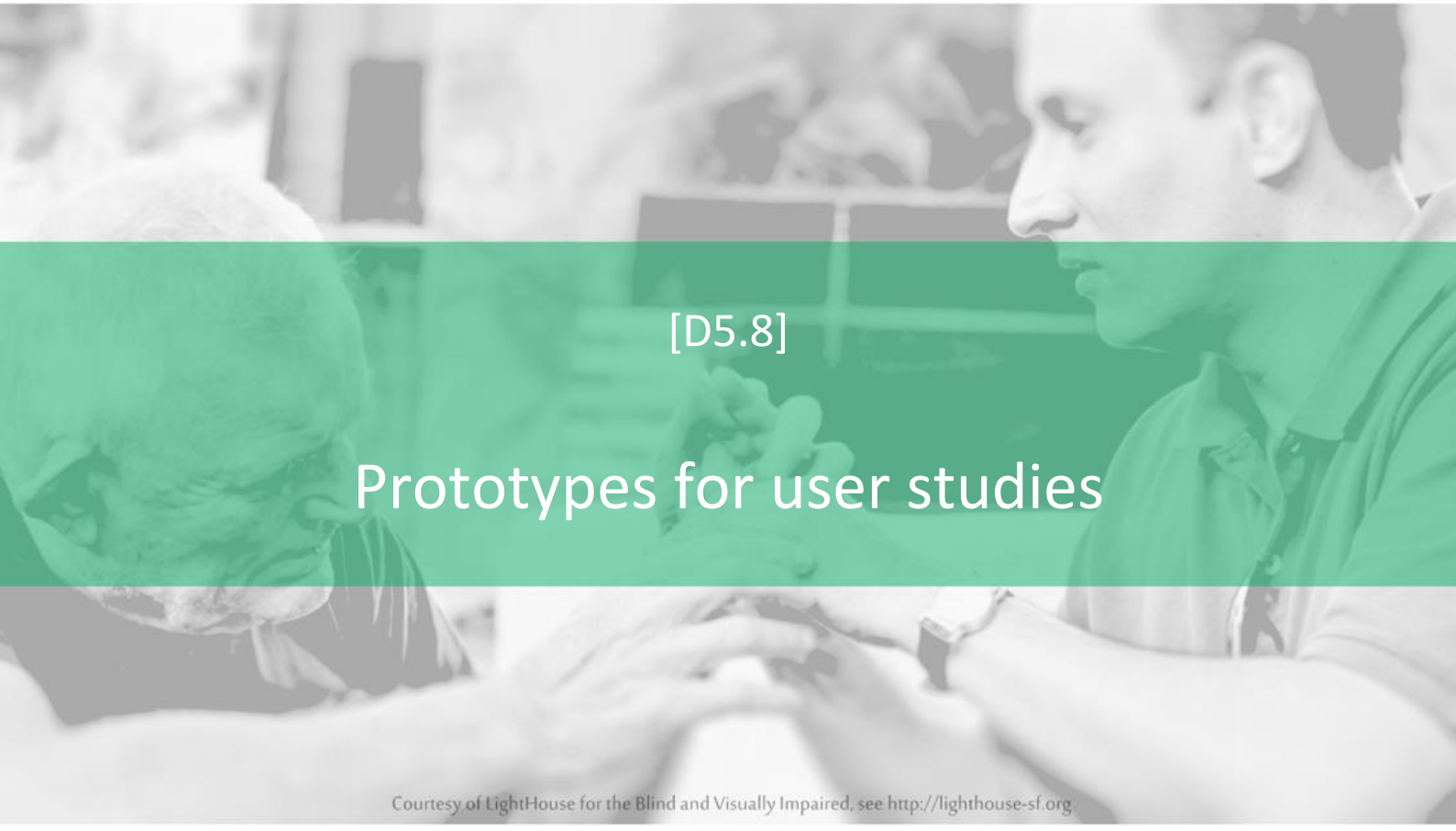
SUITCEYES

1 Jan 2018 - 31 Dec 2020

Smart, User-friendly, Interactive, Tactual, Cognition-Enhancer, that Yields Extended Sensosphere
Appropriating sensor technologies, machine learning, gamification and smart haptic interfaces



Courtesy of LightHouse for the Blind and Visually Impaired, see http://lighthouse-sf.org

[D5.8]

Prototypes for user studies

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Dissemination level		
PU	PUBLIC, fully open, e.g. web	X
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CI	CLASSIFIED, information as referred to in Commission Decision 2001/844/EC.	

Deliverable Type		
R	Document, report (excluding the periodic and final reports)	
DEM	Demonstrator, pilot, prototype, plan designs	X
DEC	Websites, patents filing, press & media actions, videos, etc.	
OTHER	Software, technical diagram, etc.	

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Glossary	
Abbr./ Acronym	**Meaning**

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Executive Summary

This deliverable aims at providing a garment for user studies. As studies are to be performed with a variety of persons, all to which the garment to some extent needs to be customizable, not least for good vibration transfer, this garment resulted in a vest that accommodates a span of sizes and placement of actuators and accompanying electronics.

Important improvements from D5.7 were done with regards to

- Making the garment easier to put on and off
- Possible to place actuating elements also on the front of the garment

These were considered important requirements since the D5.8 garment is meant for *user* studies, hence demanding to be somewhat user friendly, whereas the D5.7 garment was considered more of a testing device.

The garment provides the possibility to place the actuating element, with a Velcro solution, on the front and back of the garment at two heights: chest and waist height. The size of the garment can be adjusted by opening or closing separable zippers at both sides of the garment and by the use of elastic fabric as part of the main fabric.

Introduction

The aim of D5.8 *Prototypes for user studies*, is to make garment prototypes for *studies with users*, performed in WP6 and WP7. This deliverable is a continuation of D5.7 *Prototypes for psychophysical studies with two touch dimensions*, where a 'chessboard' vest, see Figure 1a and 1b, was designed and manufactured for WP6. The vest developed in D5.7 was intended for psychophysical studies with non-deafblind persons. The D5.7 vest provided WP6 with the opportunity to test vibrotactile patterns on multiple positions on the back of the wearer of the vest. The key feature of this vest was then 'one size fits all'. The innovative construction of the vest guarantees the simultaneous structural stability and flexibility to fit all (within certain limits) body shapes and postures.

a) *b)*

Figure 1. Chessboard vest, D5.7. a) front of vest with straps that can be individually fitted on the person wearing the garment b) back of vest with multiple placement possibilities, actuators are placed on the inside of the vest towards the person wearing it.

The D5.8 vest for user studies aims for improving the D5.7 construction and providing better performance concerning wearability, comfort and also includes integration of actuators on the front of the garment.

In this text, the term *wearability* refers to the ease of use of the garments, this with consideration to the end user being persons with deafblindness. Comfort is an essential property of garments and a definition of this is made by Kadolph (2013) as "comfort addresses the way textiles affect heat, air and moisture transfer [..] and the way the body interacts with the textile product."

Choice of modality

In previous work (D5.5-D5.7), the modalities chosen are vibrotactile and thermal. The thermal modality is of interest in a general perspective related to textile comfort and of particular relevance in products such as outdoor jacket with e.g. heating elements. However, as thermal stimuli has a long updating time, the consortium decided that within SUITCEYES it will not continue with the thermal modality for the HIPI. Therefore, the modality of choice for this prototype is vibrotactile.

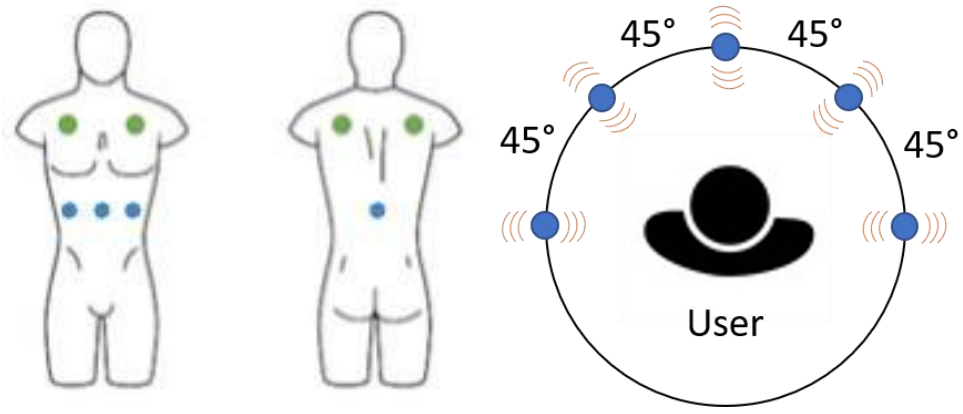
Requirement for the vest for user studies

The garment

The garment for user studies is intended to be used for a larger scale study with individuals having deafblindness. The users for the study are anticipated to be a normally scattered population in terms of length, body weight, body shape, body type, sex etc. It is not possible to make many different garment sizes within this task due to time and cost. Therefore, the 'one-size-fit-all' requirement was kept from D5.7. Adjustments were also done so that it was easier to put on and off compared to earlier versions.

Actuators placement

Like the D5.7 vest, the D5.8 vest also needs to provide placement of actuators, batteries, control units etc. Actuators are placed at two heights, at chest level and waist level, Figure 2, which is why flexibility in placement of actuators, sensors and other hardware components were needed. The other hardware components could be placed on either of these locations.



a) *b)*

Figure 2. Placement of micro-servo motors a) on front and back of garment on upper chest, shoulder blades (green) and vibrotactile actuators placed around the waist (blue), b) around the waist (blue), also on the sides (not all showed in a)). Figures from HSO, Offenburg.

The actuators intended to use are vibration motors, cylindrical in shape and approximately three cm long and one cm in diameter (around the waist) with an addition of micro-servo motors providing a tapping sensation on shoulder blades and chest.

Design and prototyping

Choice of fabric/material used

The D5.7 showed one way of creating a 'one-size-fits-all-garment' that was made from non-elastic fabric. Yet, this resulted in a garment that was quite demanding to put on. Further evaluation of the D5.7 was that it was a garment that when worn for some time made the wearer quite warm. This is thought to be in part due to the interweaving of the back that results in several layers of fabric, since every strap consisted of two layers of fabric. Then when interweaved making a total of 4 layers of fabric placed tightly to the body with limited ventilating of air.

To make a 'one-size-fits-all-garment' the easiest and most intuitive solution would be to make a garment made out of some kind of very elastic material. However, if the material is too elastic, it will not be able to hold the weight of the electronic components of the prototype.

The other important factor that needed consideration when choosing the fabric was that of how to adhere the actuators to the garment. Analogous to the D5.7 vest, which has been used with satisfaction, the solution of placing the actuators with the help of a Velcro fabric was used also here. The Velcro fabric provides little to none elasticity. Velcro fabric is a weft knitted fabric with loops on the face side of the fabric.

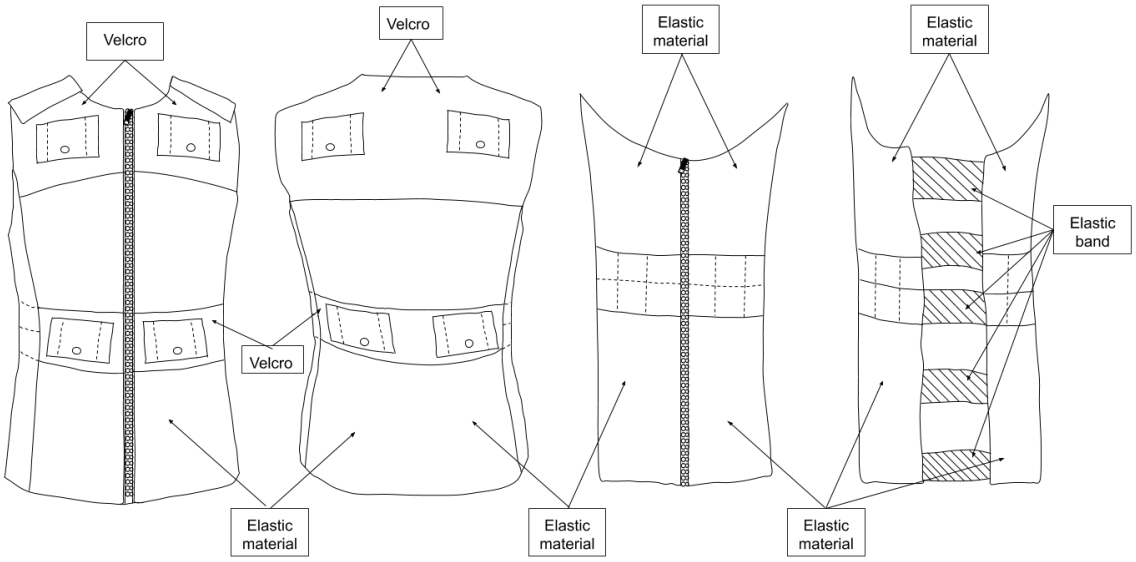


Figure 3. Sketches of user studies vest with material choice.

Taking the given requirements of the vest into consideration the material of the vest was chosen to be Velcro fabric on the places of the fabric that are supposed to hold actuators, and the other parts made out of an stable but still somewhat elastic knitted fabric so provide a wider range of fit. See Figure 3 for sketch of vest and choice of material. The pockets for the actuators (vibration motors) were made 4,5 x 5 cm to make it easier to handle and to be able to also use different kinds of actuators if wanted. This vest improves wearability with the zipper-closure instead of the closure that was used in D5.7. Though the closure of the vest for D5.7 provided a "one-size-fits-all-solution" it would not be

as appropriate for user studies since it is both time consuming and to put on the wearer has to find and place the right strap at the right height so that the straps does not get tangled up and crossed.

The comfort of D5.8 is also improved by fewer layers of fabric and more comfortable front piece of the garment compared to D5.7.

Pattern construction

Taking all requirements into consideration, the garment resulted in a vest that, in comparison, provided better ease of use when putting it. Simultaneously the flexibility to fit to various body sizes was somewhat decreased. In comparison to D5.7, actuators and sensors can also be placed on the front of the vest, compare Figure 3a and 1b.

Sketches of the vest and the pattern construction solutions for fit are shown in Figure 4. Balancing the requirement for ease of use, to put on the vest, and the demand on 'one-size-fits-all' a compromise was made with a solution with separable zippers on the sides that can be completely opened, see Figure 4 c) and d). Since large parts of the vest are made of an elastic material, the vest already has some generosity in fit. We call this 'one-size-fits-most'.

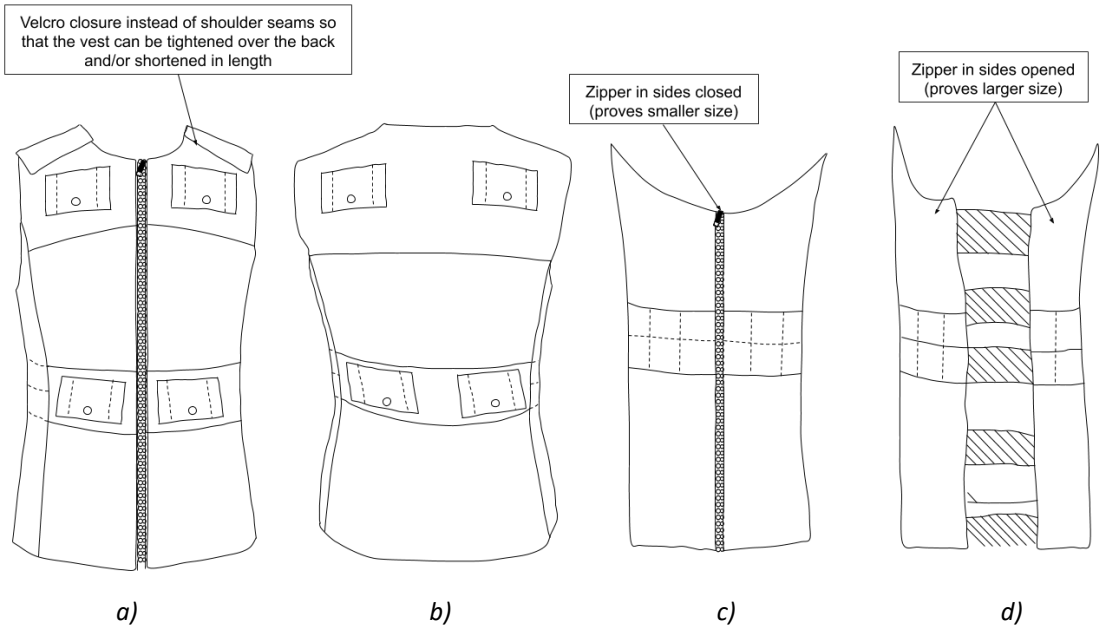


Figure 4. Sketches of prototype vest with sizing solutions, a) front piece with zipper closure, b) back piece c) side piece with closet zipper d) side seam with opened zipper

The side pieces of the vest, Figure 4c, that could not be in the Velcro fabric since it needed to provide elasticity, was instead given pockets for holding vibrotactile actuators.

Sizing

It is common knowledge within the clothing and fashion industry that the matter of appropriate size and fit is a multifaceted issue (Hernández 2018). In a population there is always a distribution of sizes. The girth sizes for example have been found to follow curves like Figure 5 (Eberle 2014), more or less a normal distribution. The mean value of chest girth here is 94,4 cm and a standard deviation of 7,6 cm, given this, it shows that about 95% of the given population (males) are within the span of 30,4 cm. (Eberle 2014).

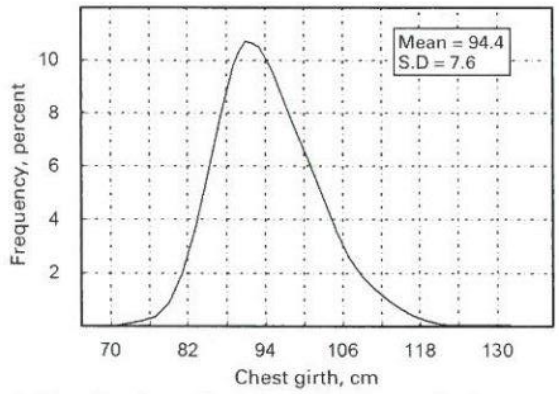


Figure 5. Distribution of adult male chest girth (Eberle 2014)

The anthropometric surveys that constitutes the foundation for all sizing systems contain many measurements. To use all of this in the development of sizes would make the process very complex. Therefore, a few measurements, so called *control dimensions*, are chosen to represent the main different body types that are present in the given population (Eberle 2014). Figure 6 shows how, for an upper garment, these control dimensions are chest and waist circumference. For every chest girth, the waist girth may vary by up to 20 cm depending on body type. The difference between chest and waist girth is also called drop value, which simultaneously indicates body type. Examples of drop values can be seen in table 1 (Eberle 2014)

Table 1. Example: Men's whole body outerwear garment (Eberle 2014, p. 232)

Body Type: Name	**Athletic**	**Regular**	**Portly**	**Stout**	**Corpulent**
Mean drop value (chest-waist), cm	16	12	6	0	-6

The pattern construction decides the actual measurements of the garments, hence determining the size. The fabric of a garment can be either elastic or non-elastic, if very elastic people with different measurement and sizes can wear the same garment, if not elastic the garment is 'locked' to the size determined by the pattern construction. With the solution of having Velcro closure instead of shoulder seam and the addition of a zipper solution in the side seams the vest provides two different sizes and the elastic material provides a span of sizes due to its elasticity.

Figure 7 schematically shows the relationship between garment *length* and garment *circumference* and the dependency on *garment pattern construction* and *choice of fabric* for this vest. The 'default' measurement of the vest is called σ in the diagram. The highlighted area in blue state are the range of

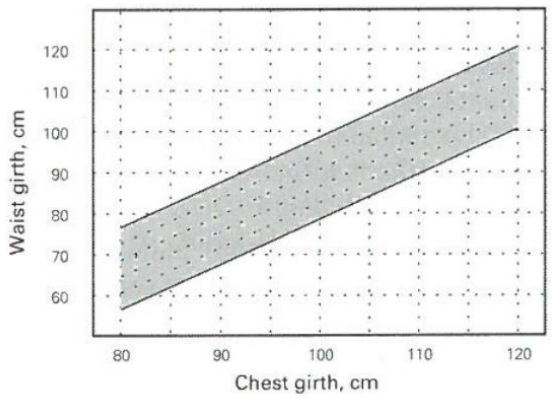


Figure 6. Adult male waist girth versus chest girth (Eberle 2014)

adjustability due to pattern construction. It is the length set by the pattern construction, but adjustable due to the Velcro closure in the shoulder seams of the garment (appendix 1 b) and the circumference of the garment is with the pattern construction divided into two circumferences (the zippers in the side opened or closed, appendix 1, d and e). The highlighted area in orange states that in regards to the length the choice of material does not provide further flexibility, but in regards to circumference, the choice of fabric gives a broader span in fit. As can be seen in Figure 7, the 'give' from the fabric in the garment fit is mainly concentrated in the circumference of the garment. On the other hand, not as much flexibility in size is needed in the length direction of the garment compared to the circumference.

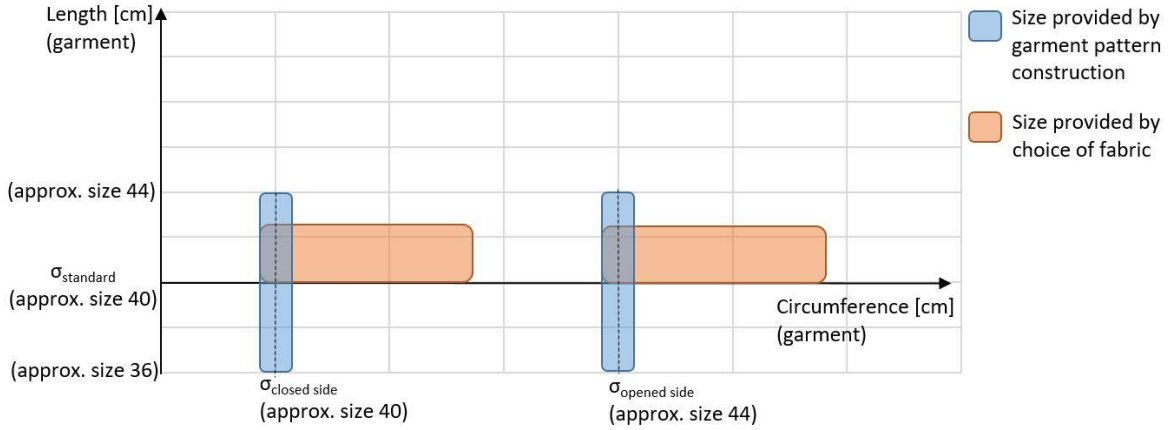


Figure 7. Schematically overview of the adjustability in size of the prototype garment used. Adjustability in size is provided both from the garment pattern construction (blue) i.e. the cutting of fabric and the choice of fabric (orange).). The pattern construction mainly gives adjustability in length of the garment (Velcro solution at shoulder and zippers at the sides). The garment pattern construction provides adjustability in length of the garment (Velcro solution in shoulder seams) thus, its range of impact is prolonged in the y or length direction but limited in impacting circumference. The garment can be made shorter (smaller size in length) or longer (larger size in length) thus spanning from above $\sigma_{standard}$ to below. The choice of fabric mainly providing adjustability in circumference of garment thus being prolonged in x or circumference direction. There are two separate circumference options, zippers closed and zippers opened.

References

Kadolph, S. (2013). *Textiles: Pearson New International Edition*. Pearson Education M.U.A.

Eberle, H., & Ring, W. (2014). *Clothing technology : ...from fibre to fashion* (6th ed, 10th German ed.). Haan-Gruiten: Europa Lehrmittel.

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Appendix 1 Finished prototype

a)

Finished prototype from the front. Black fabric is the Velcro fabric for attachment of actuators and other electronic devices.

The mobile pockets on the upper chest gives ability to place the actuators according to Figure 1.

b)

The shoulder seams are constructed with Velcro and can tighten the garment to fit over the back.

c)

The vest has a lining, between the outer fabric and the lining fabric

d)

Due to the demand that the garment needs to fulfil several sizes, elastic fabric was needed for the side pieces. Since the Velcro fabric was not elastic, pockets were made for these sidepieces so that they also can hold actuators when needed.

e)

When the side zippers are opened, another size is provided. The bands are elastic bands.

f)

The upper yoke offers the possibility to place actuators according to Figure 1