Aalborg University
June 2023

W-meter

Master's thesis, product rapport

Industrial Design, MA4-ID2
Kristoffer Faurby Larsen and Rikke Skov Præstgaard

The team behind the W-meter

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Rikke Skov Præstgaard

Thanks to

This project has been made in a corporation with a lot of different stakeholders which should have a thank you. Thank you to Cacta, the startup we have been cooperating with, for letting us help with the design of a hydration-level device, and giving insight and feedback for the concept. Thank you to the healthcare workers, the elderly, and Bettina Nielsen at Høje Tranders Friplejehjem for observing, testing, get feedback on our concept in their daily life. And lastly thank you to the home care unit Nord Land Øst Aalborg Kommune for letting us be a "trainee" for a day to observe the daily work life of a healthcare worker in public home care as well as feedback on our concepts.

Title page

Title:	W-meter
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Programme:	Industrial Design, AAU
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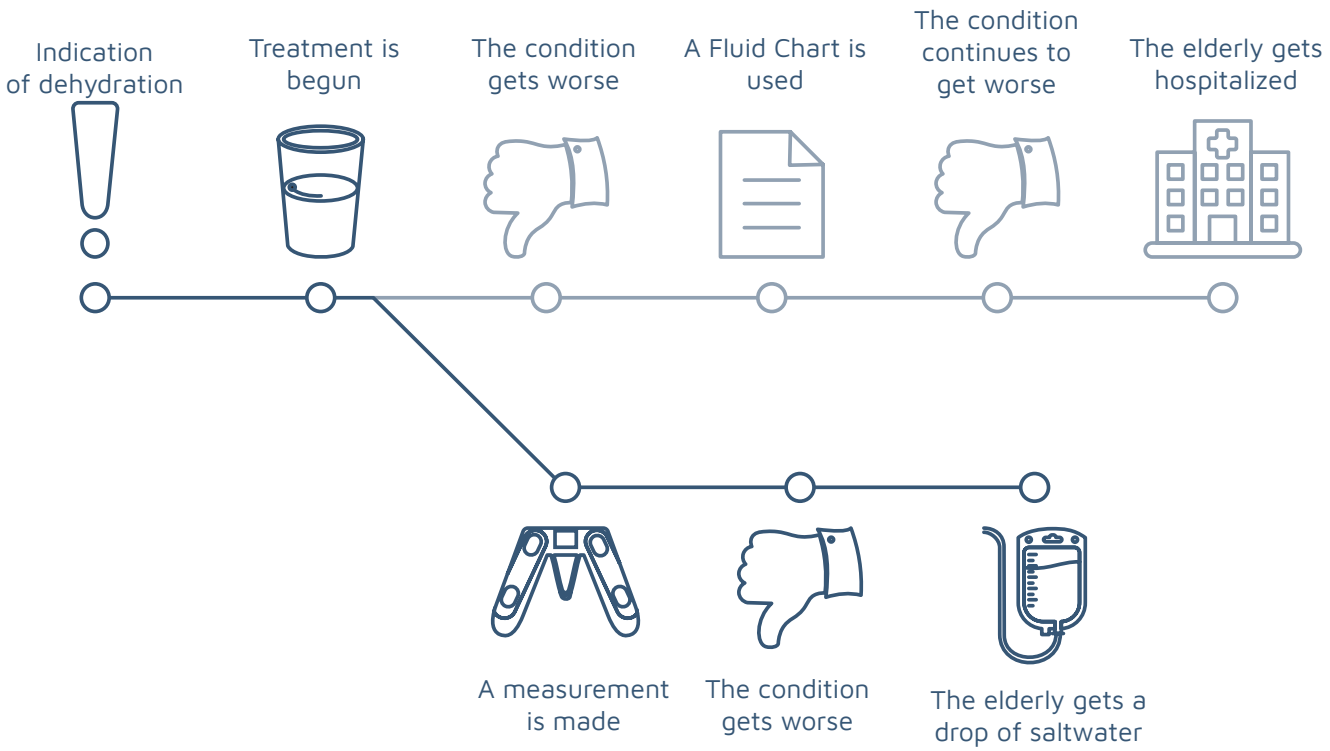
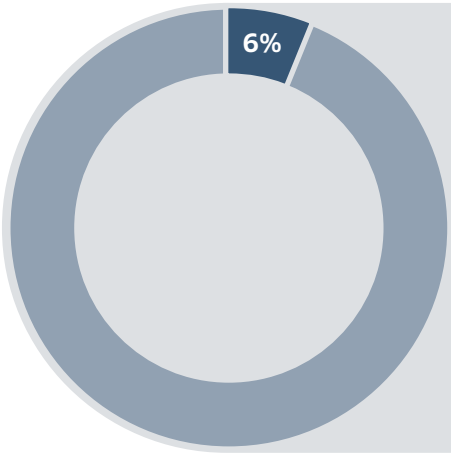
Project group:	MA2-ID2
Main supervisor:	Christian Tollestrup
Co-supervisor:	Mikael Larsen
Pages:	24

Tabel of context

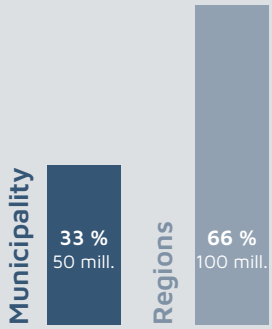
The impact of the W-meter





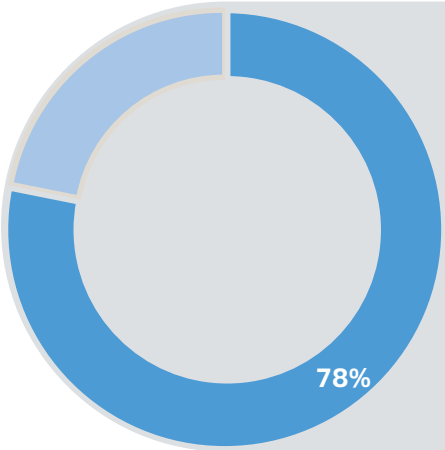
143,000 elderlies receive care and every year.
6% are admitted to the hospital due to dehydration.

The problem begins with the aging of the body. As people get older, their feeling of thirst decreases (Beck & RAvn n.d.). Additionally, the elderly has a lower percentage of water in their body, increasing the risk of becoming dehydrated. This biological problem leads to around 7,500 (Esundhed 2022) hospitalizations of elderlies every year. Dehydration is in itself problematic, but it can lead to side effects such as falling, getting cystitis or pneumonia (Bjørnsson 2007).



The Danish municipalities use 50,400,000 DKK.
every year on hospitalizations linked with dehydration.

The problem starts in home care and in nursing homes, where the dehydrated elderly needs extra care. If the condition of dehydration gets worse, the elderly is at risk of getting hospitalized. Making dehydration evolve into a problem in the healthcare system. When this happens, the municipality has to pay for 33% of the costs while the region pays 66%, respectively 50 mill. DKK and 100 mill. DKK per year. The problems continue when the elderlies get back from the hospital, as they need rehabilitation (Cacta 2023).



The w-meter can prevent 85% of the hospitalizations,
saving the municipality 78% of their cost.

The problem is often seen in the summer. But as the elderlies feeling of thirst is decreased, they often do not get enough to drink. This product will help the healthcare workers in home cares or nursing homes to detect and monitor the course of dehydration. Thereby, the healthcare worker can adapt the treatment to the elderly's needs, preventing hospitalizations.

It is a communication problem between the shifts that affects the relationship with the elderly.

Communication

The problem has its roots in communication as the healthcare workers need to hand over their subjective observation of the elderly's state of dehydration to their colleagues by writing it in CURA, the platform for the elder care sector. The healthcare workers cannot do it verbally, as they do not see the colleague on the other shifts. Furthermore, the healthcare worker must know the elderly to see if they are behaving abnormally. Unfortunately, it is not uncommon to use substitutes in the healthcare sector (Christensen & Kretz 2022).

Relationship

A good relationship between the healthcare worker and the elderly is essential and helps to make healthcare workers' work assignments easier. The healthcare worker uses both logos and pathos to affect the elderly. They can utilize their relationship with the elderly to influence them to drink more. This makes the relationship between the elderly and the healthcare worker an important tool for the healthcare worker.

The current scenario of the elderly experiencing dehydration creates mistrust between the elderly and the healthcare worker. The elderly either lie, as they know more water will entail toilet visits, which for some elders is difficult, or they simply do not remember. Consequently, the healthcare worker does not always believe in the elderly. To ensure they get the right answer, the healthcare worker asks again in a different way or checks in on the elderly more often than usual during the day, which can make the elderly feel mistrusted or under surveillance. Altogether, this is a non-optimal scenario for developing a good relationship between the elderly and healthcare workers.

"Anna was a bit tired today. Gave 200mL water, she drank 150mL"

The aim of this product is to change the scenario to one where the relationship between the healthcare worker and the elderly can continue to grow. This will be created by removing the feeling of mistrust between the two parties, as the product ensures the healthcare worker of the elderly's course of dehydration.

Current tool

Healthcare workers currently have few tools for detecting and treating dehydration. Most of them are based on observations of behaviour change, invasive methods, water intake, urine, etc. When the elderly display mild symptoms of dehydration, like tiredness, headache, or confusion, the healthcare worker will start to nudge the elderly to drink by using different techniques.

If this does not help, the elderly can be prescribed a fluid chart. The healthcare worker will fill out the fluid chart with how much water the elderly is drinking, giving a more precise picture of the elderly's fluid intake. But as the healthcare worker cannot be around one elderly all day to see how much fluid they drink; it is often difficult to know how much the elderly have been drinking. The elderly or another healthcare worker could have filled up the glass again without the elderly remembering, the elderly could have used the water to water their plants, etc. All in all, making it difficult to know their fluid intake. Healthcare workers often describe the use of the fluid chart as a laboratory and difficult to remember as it is not a part of their routines. If the elderly's hydration level is still decaying the elderly needs to be hospitalized.

Become sure of your supposition.
Adjust your treatment methods for recovery.
Improve the possibility of a good relationship.

Indicates the hydration level of the body and gives the healthcare worker the ability to monitor the course of dehydration with the elderly.

W-meter

A tool that enables comparison

01

The healthcare worker has a suspicion of the elderly being dehydrated.

03

The healthcare worker shows the elderly how the w-meter is used.

Off

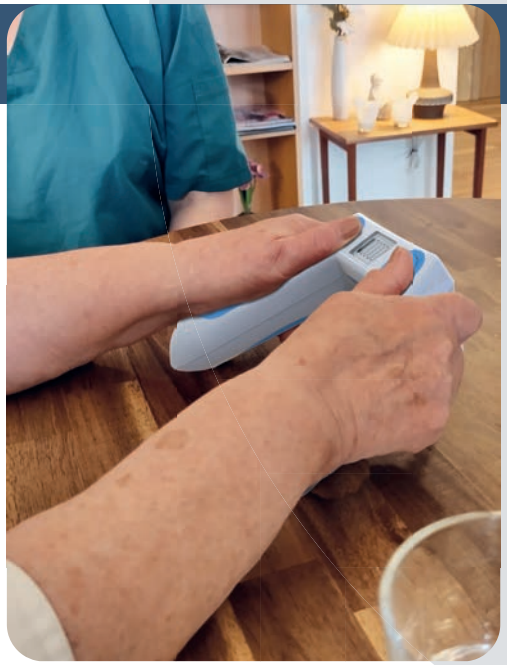
On

02

The elderly receives water to start the treatment right away.

04

The measurement is taken while the elderly is sitting comfortably, with the elbows at the edge giving an optimal position for the measurement to be valid.

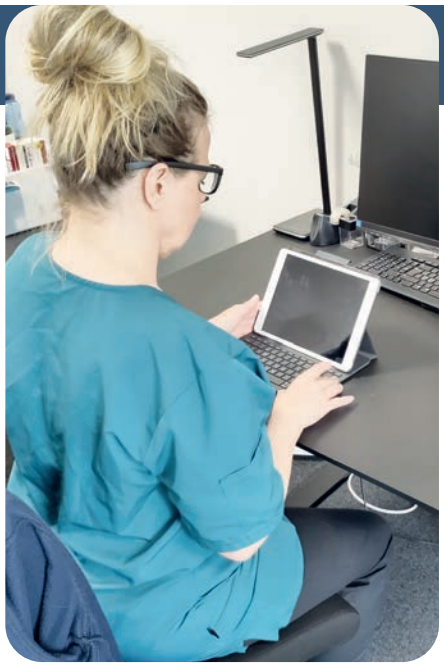


05

The healthcare worker explains the result of the measurement and how the course of using this device will be.

07

The healthcare worker puts the w-meter back in her bagpack.

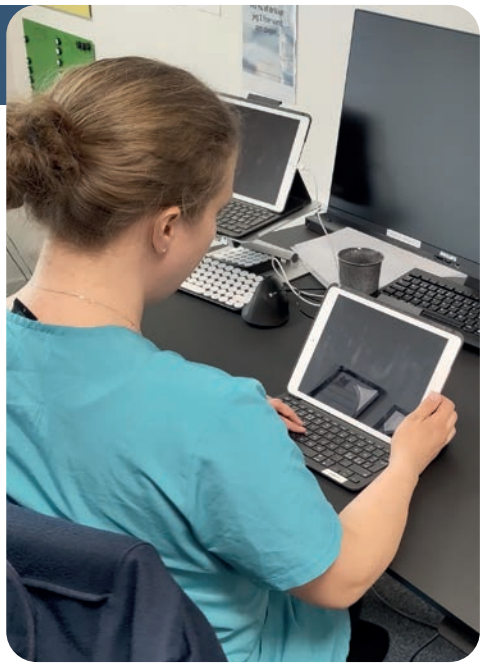


06

The device is cleaned with a cleaning wipe and turned off, but keeps displaying the measurement.

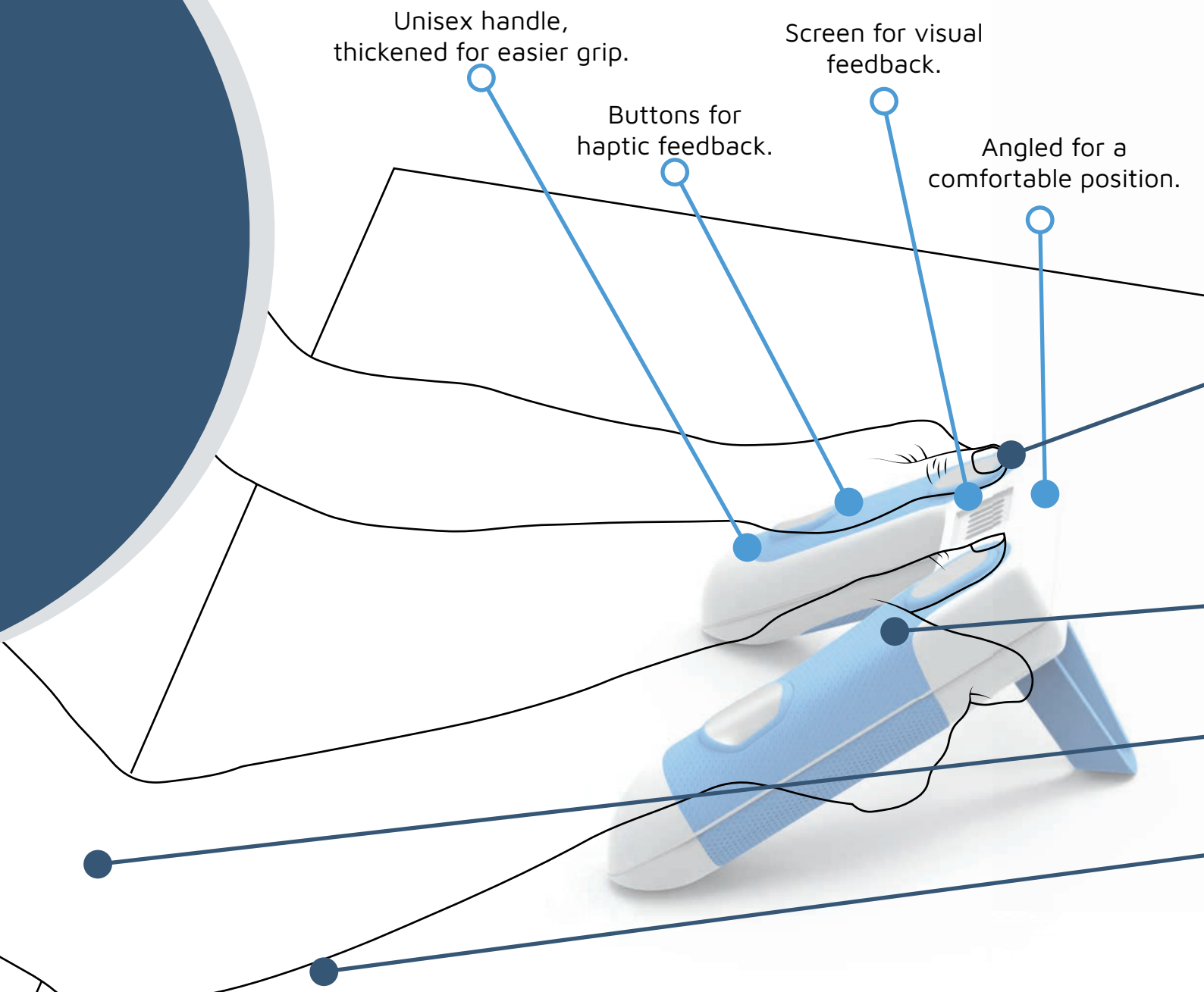
08

The healthcare worker logs the measurement into CURA so the next shift can compare it with the measurement they will take later.



Designed for an elderly user

The elderly population can have disabilities related to their senses and their mobility. The w-meter is designed to be used by the elderly as it has multiple ways of giving feedback and accommodates their mobility.



Designed to ensure a trustworthy measurement

To get a valid measurement, when using bioimpedance, the person who is measured must obtain the same body position every time. The w-meter is designed to help achieving that:

The w-meter is intended to be used as you are sitting at a table, thereby utilizing the still-sitting position of the user. All of the below comes naturally when using the product if the user just focuses on two things: Grabbing the product and having their elbows on the edge of the table.

- The electrodes are also spaced, according to studies, with the optimal distance.

  The electrode button size and the 5N requirement, for it to be punched down, gives the user the optimal connection between skin and electrode,

- The handles and blue area signal how to grip the products with your hands, ensuring a global hand-to-hand measurement that accommodates for the hydration differences in the left and right arm.

- The healthcare worker should instruct the elderly to place their elbows at the edge of the table as this, combined with the angles of the product, gives a position that ensures a valid measurement.

- The use of a table further ensures the same vertical positioning of the arm, as the w-meter indicates it should stand on the table.

A hygienic design

The product is classified as a non-critical device, meaning it must follow the rules stated by ISO 17664-2:202.

Enclosed buttons.

Can be taken off for a deep clean.

Smooth and even form that is easy to wipe off.

No cracks for filth.

Healthcare workers in the homecare drive to several elderly in one shift and normally only bring a tablet with them. When the healthcare worker enters the home of the elderly, they need to take on shoe covers and open doors, so the device needs to be easy to carry with them. This is why the leg is designed to be flipped up, turning off the device, but also now working as a handle. The product has a battery life of 1810 uses before charging is needed, meaning it only needs charging once a year.

Bring it, on your way

What the users think

***Value proposition**: The healthcare sector in the municipalities is estimated to be able to save 78% i.e. 50 mill DKK, while the regions can save the double.*

Manager

"If we can detect dehydration at an earlier stage like 'Whoa, here's an elderly person we have to pay special attention to', then it means a lot less work. If we first have someone who is severely dehydrated, it takes a long time to rehydrate them again and it requires a much greater effort from the staff to rehydrate."

***Value proposition**: The healthcare worker now has a tool that enables them to communicate the state of the elderly's dehydration to their colleagues, making it possible to monitor the course of dehydration for the elderly and alter the treatment as needed.*

Healthcare worker

"This product can help prevent hospitalizations. We will be able to detect dehydration at a much earlier stage than now. Right now, we only detect dehydration when the skin can stand up, and at that point, it is often the case that the citizen is so dehydrated that they have to be hospitalized."

***Value proposition**: The elderly feels safer and included as they are taking part in the measurement.*

Elderly

"Was that everything, well that's all right."

The go-to-market strategy

Stage 2: The Danish municipalities

Potential sale of additional 20,000 devices.

The product is marketed towards all the Danish municipalities, utilizing the approval and professional network of the first-mover municipalities to be of interest to the market.

The product is sold through its own web shop and through the municipalities' platforms like a centre for assistive devices and procurement contracts in the municipalities. Furthermore, the product is represented when welfare technology fairs and courses are held.

At this stage launch B is developed.

Stage 1: The first-mover municipalities

Potential sale of 2,300 to 3,450 devices.

The product will be tested by the first-mover municipalities as the team will use their existing network from the project to convince the municipalities of the potential of the product. After they have approved of the product, the strategy moves to stage 2.

Launch A: W-meter

Start production of 2,500 units.

Stage 3: Northern Europe

Potential sale of 533,147 devices.

After selling to the municipalities in Denmark, the product could be expanded to elder care in northern Europe. This market goal is evaluated to require some adjustment to the business plan since the elder care systems vary compared to the Danish.

Approval

Launch B: Collaboration with CURA

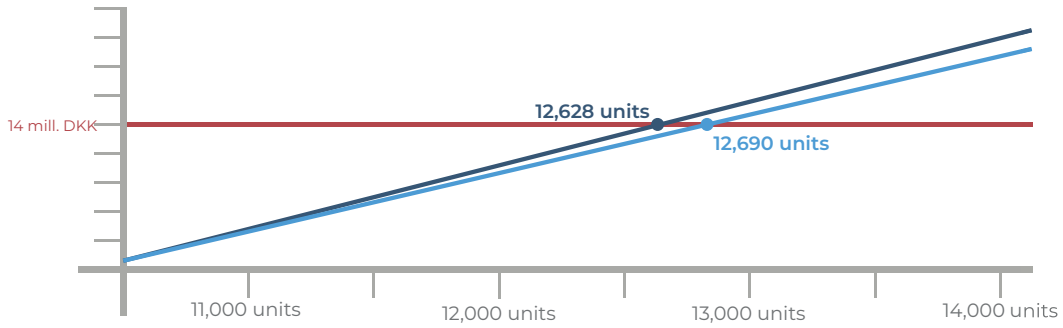
The customers have an additional opportunity to make a subscription agreement. This subscription will give them an improved device that can automatically transfer the measured data to CURA and link it with the elderly. This feature gives them the opportunity to see the development of the elderly's course of dehydration in CURA.

To launch this, software development is required in collaboration with CURA. Furthermore, the CPU needs to be changed to a Raspberry Pi Pico w, which can send and receive data via Wi-Fi.

The finances of the project

In the estimations of project finances, it is assumed that the product will be sold to 44% of the market, meaning the Social and Healthcare Assistants in Denmark and, in the future, northern Europe.

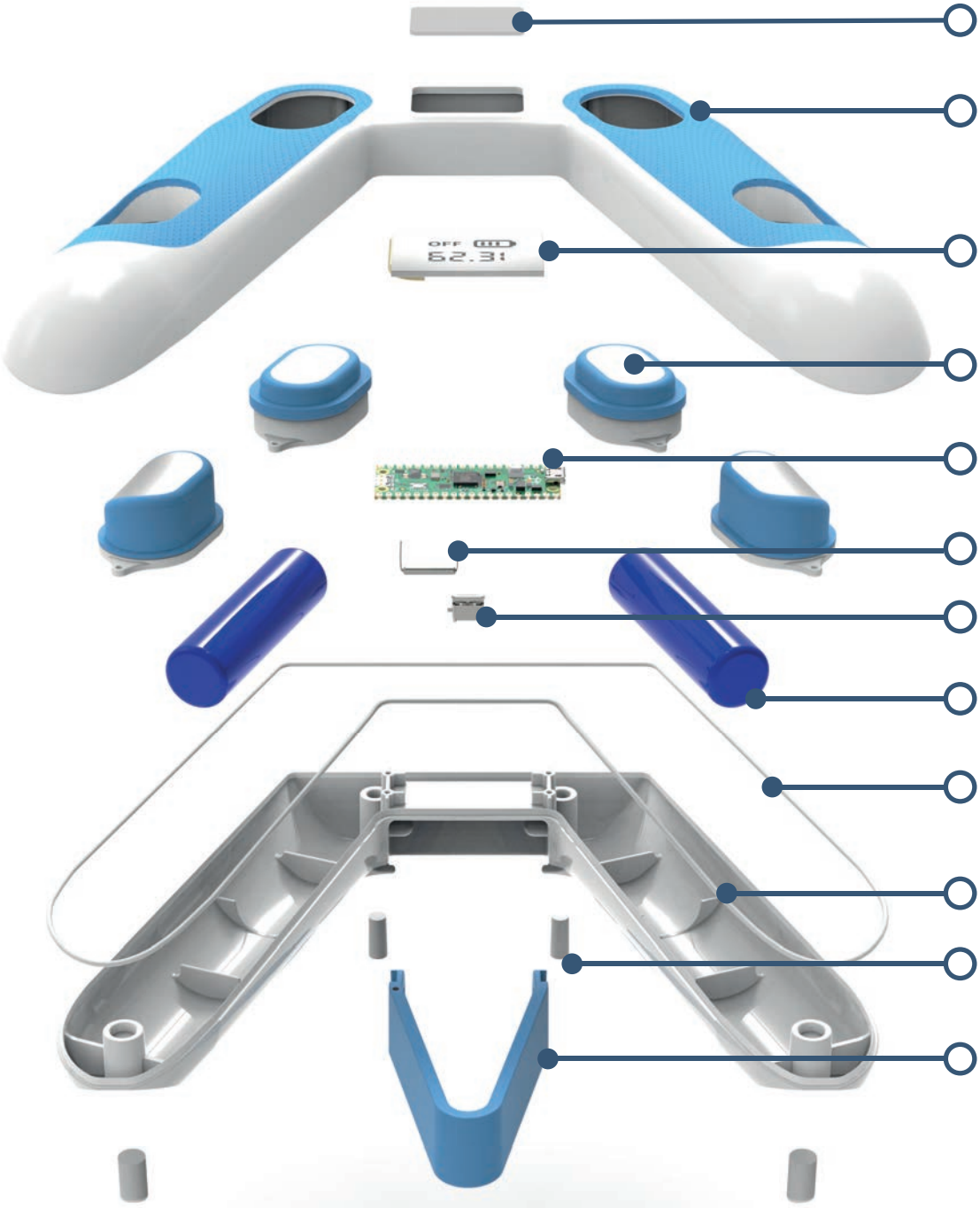
	Total quantity	First-mover municipality *2,500 devices*	The Danish municipalities *23,262 devices*	50.000 unit production *50,000 devices*
	Total cost	Cost per. device	Cost per. device	Cost per. device
Investment (fixed)	10,189,804 DKK	4,076 DKK	438 DKK	204 DKK
Overhead cost sales and marketing (fixed)	4,082,890 DKK	1,633 DKK	176 DKK	82 DKK
Operating cost				
Material and production cost (variabel)		222 DKK	172 DKK	168 DKK
Production salary (variabel)		10 DKK	10 DKK	10 DKK
Overhead costs (variabel)		56 DKK	43 DKK	42 DKK
Total cost (per. device)		5,996 DKK	839 DKK	505 DKK
Sales revenue (per. device)		1,350 DKK	1,350 DKK	1,350 DKK
Operating profit (per. device)		-4,646 DKK	511 DKK	845 DKK
Breakeven [units]		-	12,690 units	12,628 units



The estimations show that the project can reach breakeven at 12,530 units. Following, the 23,262-unit case will give an operating profit of 949 DKK per. unit, and the 50,000-unit case will give an operating profit of 1048 DKK per. unit. Additionally, it should be mentioned that the product is evaluated to last for 5 years.

The components of the product

The product is classified as a 2A Medical Device, meaning it must be produced according to and withstand the tests stated by DS/EN 60601-1:2006 and DS/EN 60601-1-11:2015, thereby having an IP22 - rating.



Screen protection
Logner lasting in a bagpack.

Top shell in ABS
Designed for disassembly.

E-paper screen
Low power consumption.

Electrode buttons
Ensures the correct connect between skin and electrode.

Raspberry pi pico, CPU
Embedded processor

Reed switch
Integrated on- off switch.

USB C charger
Wildly available for the user.

Batteries
Battery lift for 1810 uses.
Charging once a year.

Rubber gasket
Designed for disassembly.
IP22 rating.

Bottom shell in ABS
Designed for disassembly.

Rubber plugs
Designed for disassembly.
IP22 rating.

Leg
Integrated on- off switch.

Aalborg University
June 2023

Master's thesis

Aalborg University
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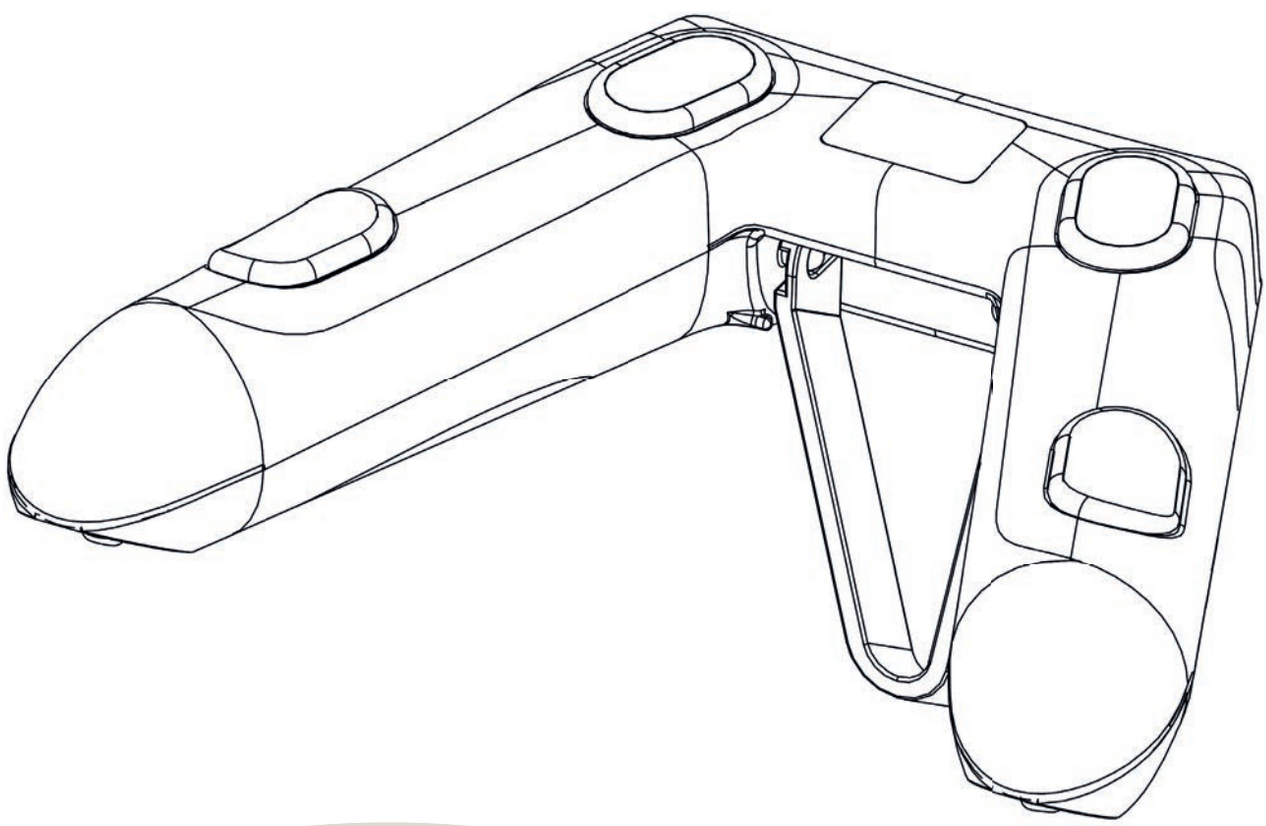


W-meter

Master's thesis, Technical drawings

Industrial Design, MA4-ID2
Kristoffer Faurby Larsen and Rikke Skov Præstgaard

Intro

The parts in this technical drawing folder are primarily produced using injection molding. It is common to finalize the drawings with the company who are to produce the component. In that scenario, the company that owns the product only specifies the dimensions which are important in relation to other parts. This approach has been used for the technical drawings for w-meter. To support these important dimensions there has been made six exemplary dives related to fastening, one related to a principle, as it is a product designed for disassembly:

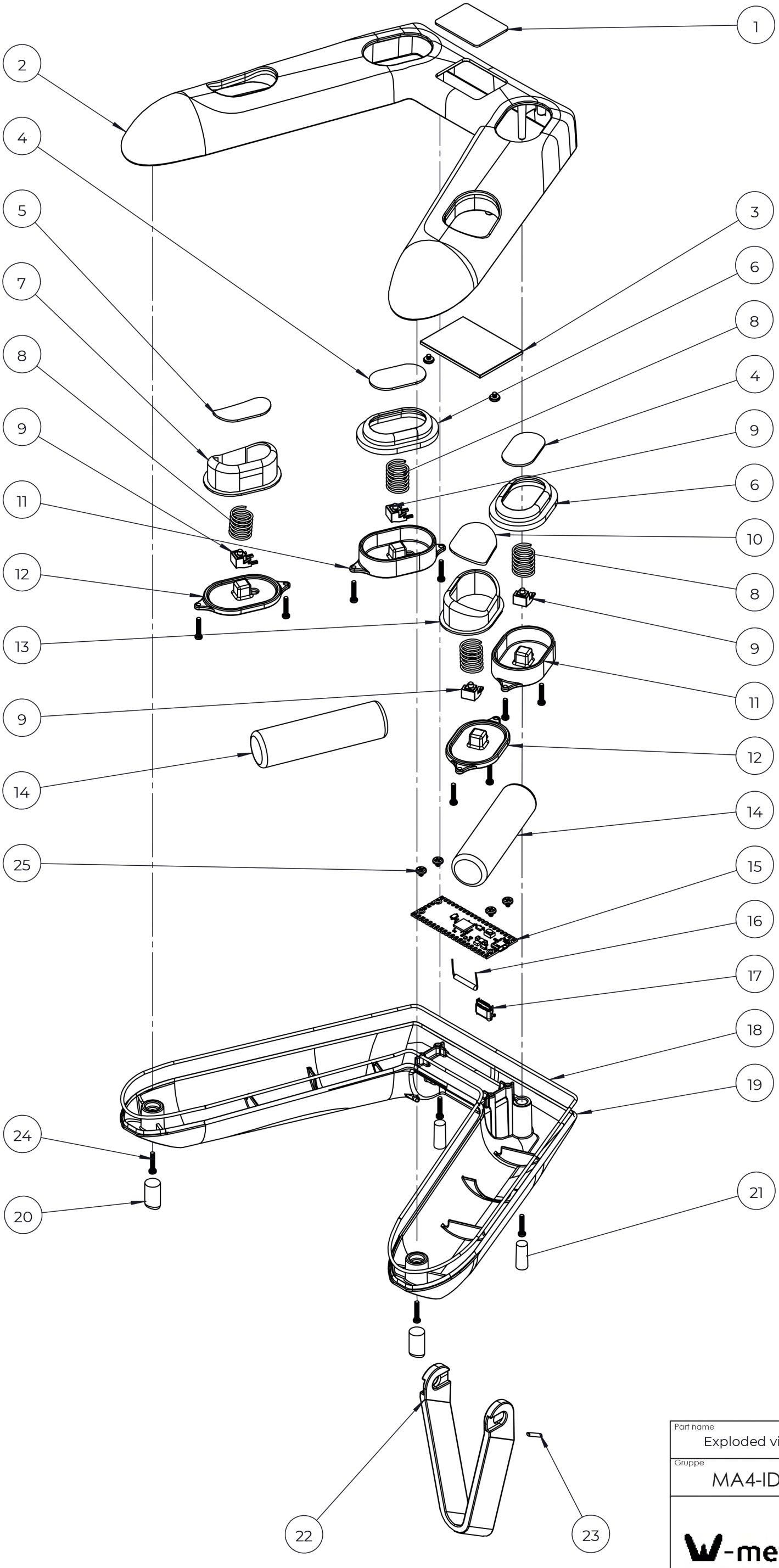
- The leg and the bottom shell need to fit together, relating their tolerances to each other.
- A screw hole related to the top- and bottom shell.
- Fastening of an electrode holder front to the top shell, screw through (gasket in-between).
- Fastening with ultrasonic welding of the screen protector to the top shell.
- Fastening the CPU to the bottom shell, screwed.
- A cut-through of the working principle of the electrode button.

These six exemplary dives are evaluated to represent the different specification types that are to find in the parts of the product. These will all need to specify before contacting a production company.

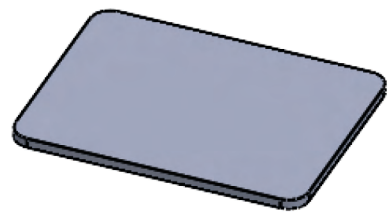
In general, the injection mold is designed with a draft angle of 1 degree and filets of minimum 0,5 mm, to avoid the material cracking in use. Further, all measurements on drawings, that are not specified, are following the standard DS/ISO 2768-1:1993, see the title header of the drawing. The color standard is Pantone. The surface finishes are stated using SPI grades. In general, the injection mold is designed with a draft angel of 1 degree and filets of minimum 0,5 mm, to avoid the material cracking in use. Further, all measurement on drawings, that are not specified, are following the standard DS/ISO 2768-1:1993, see the title header of the drawing. The color standard is Pantone. The surface finishes are stated using SPI grades.

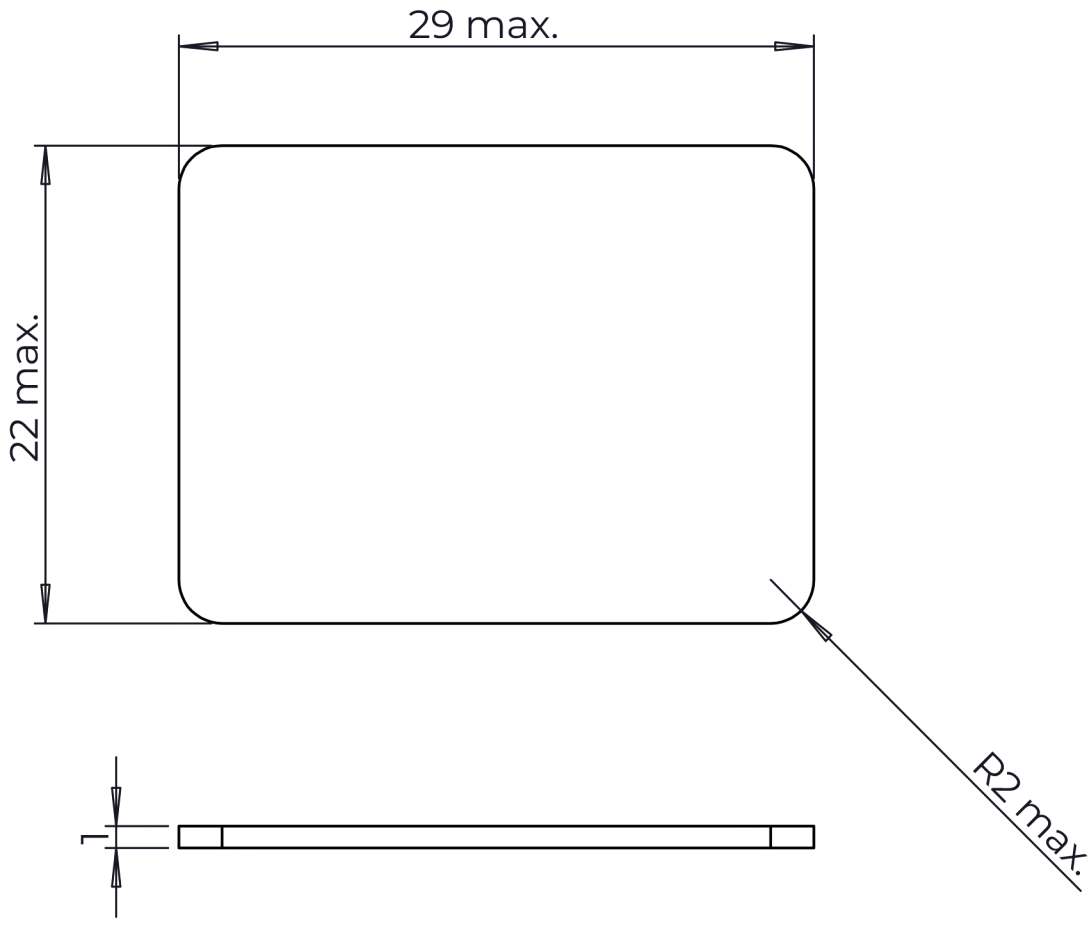
BOM

Part no.	Part name	Qty.	Std. component	Material	Color	Process	Surface finish	Fixture
1	Screen protector	1		ASB - sheet	Transparent	CNC	SPI - A2	Ultrasonic welding to part 2
2	Top shell	1		ASB	292 C and Cool Gray 1 C	Injection molding - regular	SPI - B1 / SPI - D3	Screwed to part 19
3	Screen - Electronic Paper Display	1	x	-	-	-	-	Screwed to part 2
4	Front electrode	2		Gold coated	-	-	-	Fixed to part 6
5	Back electrode right	1		Gold coated	-	-	-	Fixed to gasket for the
6	Gasket for front electrodes	2		Rubber Shore 40A	292 C	Molded	-	Fixed to part 4 and 11
7	Gasket for back electrodes right	1		Rubber Shore 40A	292 C	Molded	-	Fixed to part 5 and 12
8	Compression spring - 5 newton	4	x	AISI 302 Stainless steel	-	-	-	-
9	Momentary Pushbutton Switch (KFC347)	4	x	-	-	-	-	Press fit to part 11 or 12
10	Back electrode left	1		Gold coated	-	-	-	Fixed to part 13
11	Electrode-button holder front	2		ABS	Cool Gray 1 C	Injection molding - regular	As machined	Screwed to part 2
12	Electrode-button holder back	2		ABS	Cool Gray 1 C	Injection molding - regular	As machined	Screwed to part 2
13	Gasket for back electrodes left	1		Rubber Shore 40A	292 C	Molded	-	Fixed to part 10 and 12
14	Battery	2	x	-	-	-	-	Fixed by ribs
15	CPU - Raspberry Pi Pico	1	x	-	-	-	-	Screwed to part 19
16	Reed switch	1	x	-	-	-	-	Press fit
17	USB - C port	1	x	-	-	-	-	Press fit
18	Gasket between top and bottom shell - Ø3	1		Rubber Shore 40A	Cool Gray 1 C	Molded	-	-
19	Bottom shell	1		ASB	292 C and Cool Gray 1 C	Injection molding - core features	SPI - B1 / SPI - D3	Screwed to part 2
20	Rubber plugs front Ø7 x 13 mm	2		Rubber Shore 40A	Cool Gray 1 C	Molded	-	-
21	Rubber plugs back Ø7 x 9 mm	2		Rubber Shore 40A	Cool Gray 1 C	Molded	-	-
22	Leg	1		ASB	292 C	Injection molding - regular	SPI - B1	-
23	Magnet Ø2 mm x -4 mm	1	x	-	-	-	-	-
24	Assembly screws - self cutting M2 x 10 mm	12	x	-	-	-	-	-
25	Screws for screen (extra big head) – self cutting M2 x 3 mm	6	x	-	-	-	-	-
26	Wires	-	x	-	-	-	-	-

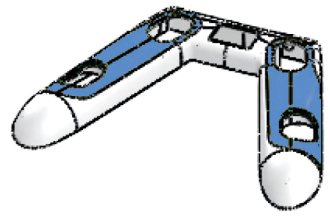


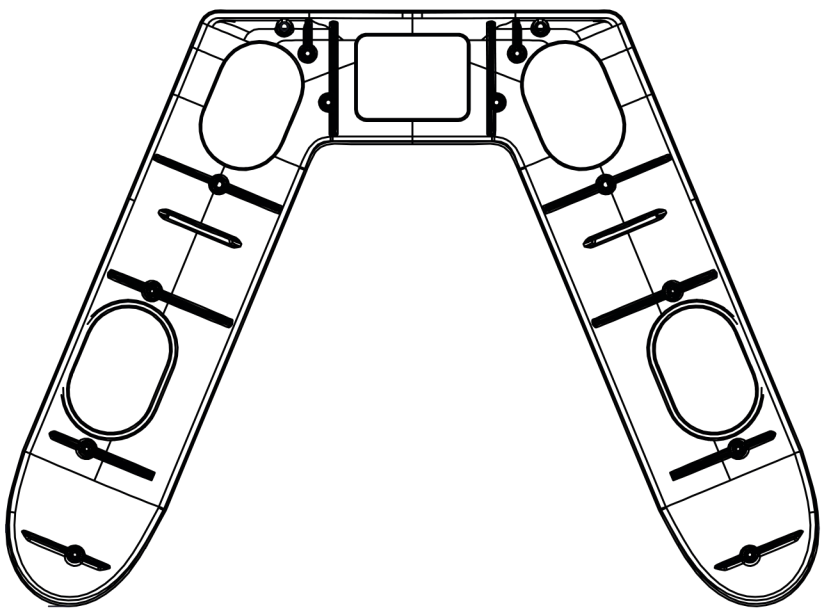
Part name: Exploded view	Project: Master's thesis
Gruppe: MA4-ID2	Scale: -
W-meter	Date: 31-05-2023
	Format: A3
	Page: 3 of 13

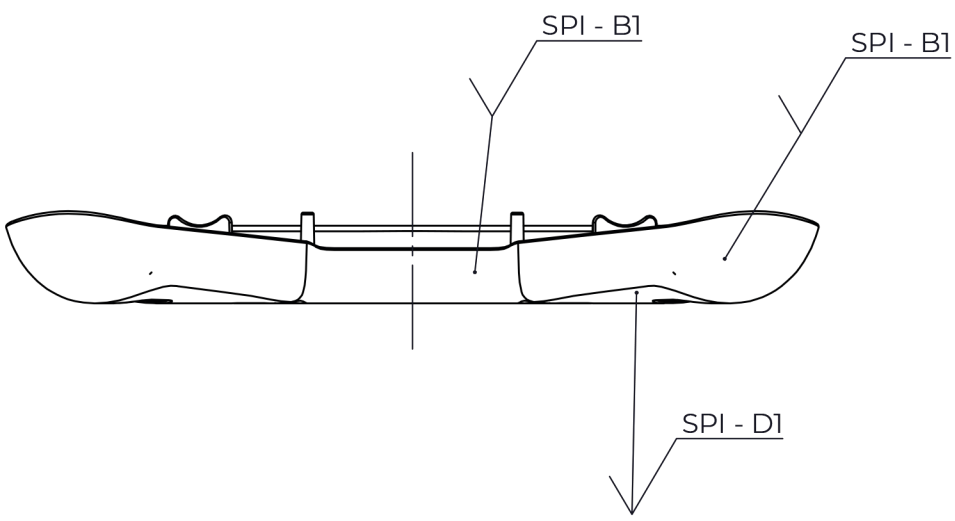


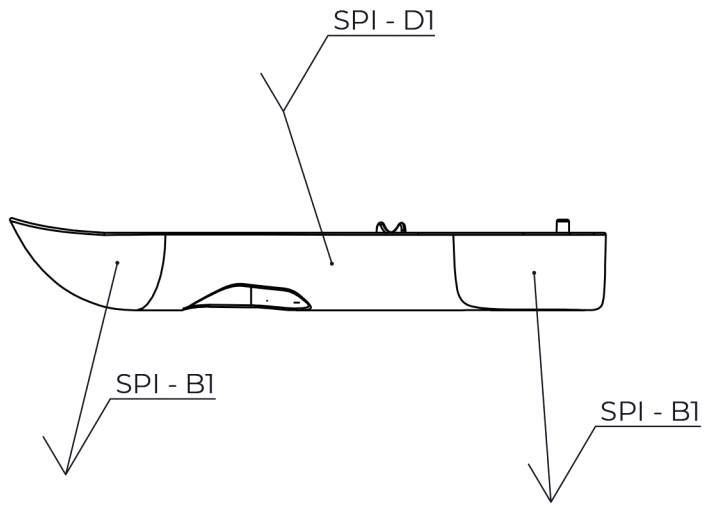


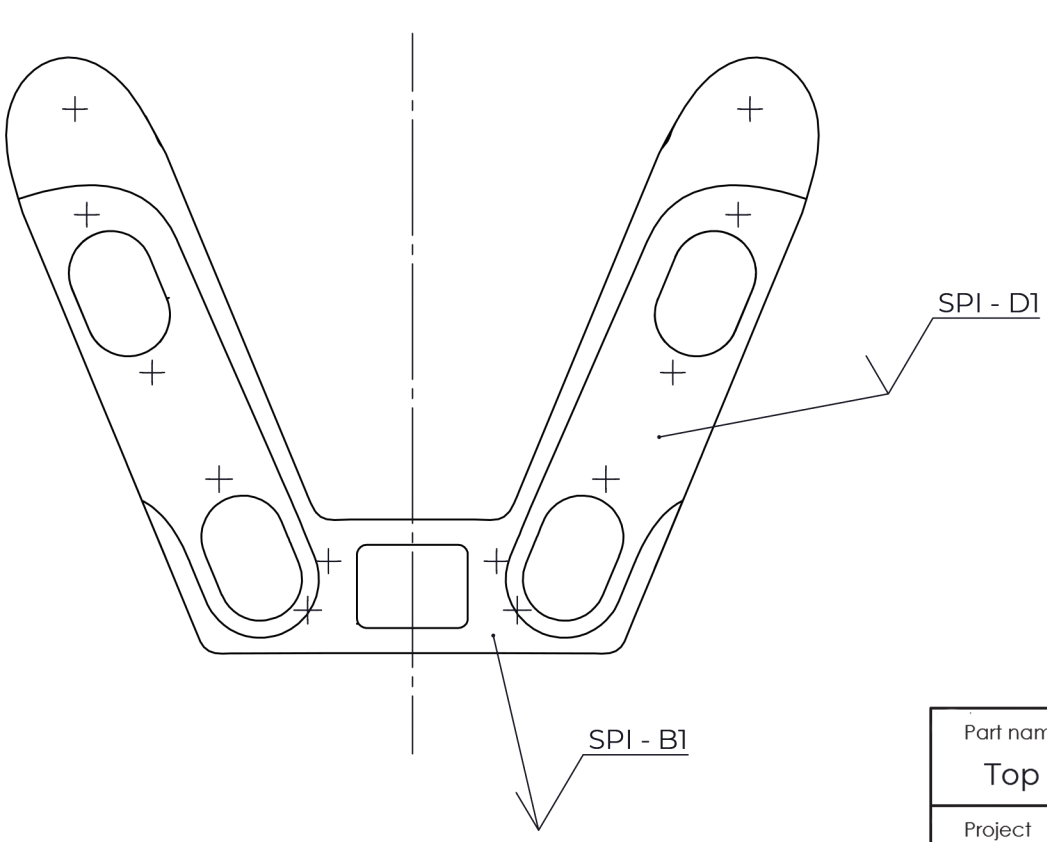
Part name Screen protector	All non-specified tolerance follow DS/ISO 2768-1-c	Part no. 1
Project Master's thesis	Material ABS - sheet	Scale 2:1
Group MA4-ID2	Process CNC - cut	Date 31-05-2023
W-meter	All non-specified surface finish follow SPI - A2	Format A4
	Color Transparent	Page 4 of 13





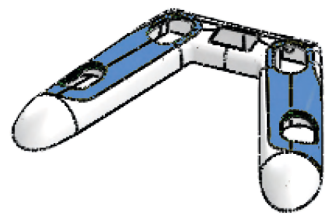


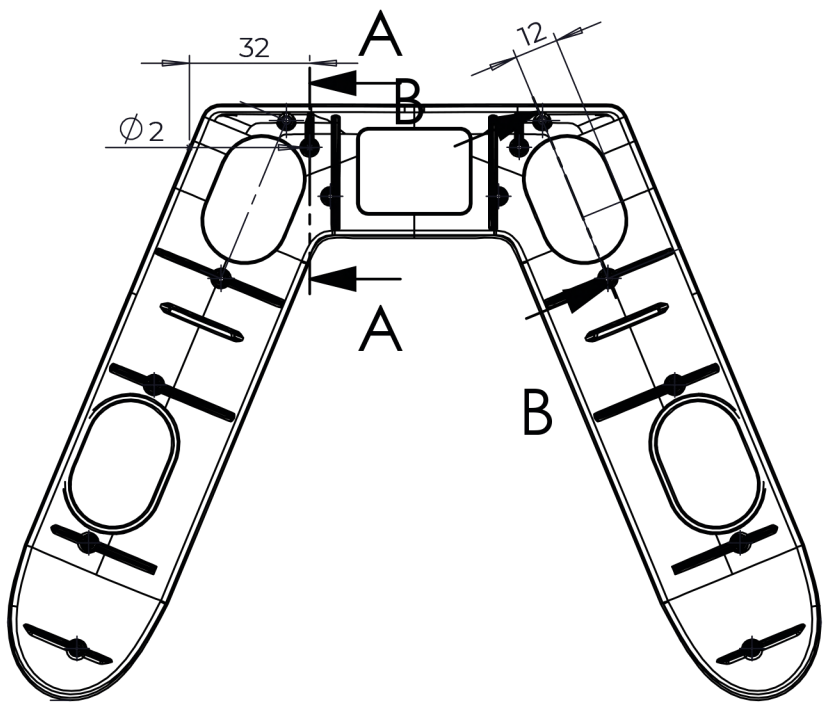




Only showing surface finish

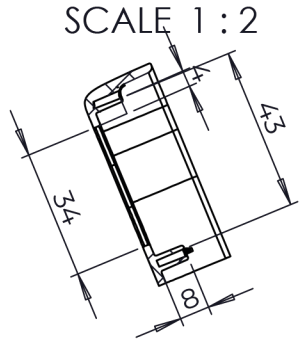
Part name: Top shell	All non-specified tolerance follow: DS/ISO 2768-1-c	Part no.: 2
Project: Master's thesis	Material: ABS	Scale: 1:2
Group: MA4-ID2	Process: Injection molded	Date: 31-05-2023
W-meter	All non-specified surface finish follow: As machined	Format: A3
	Color: 292 C and Cool Gray C1	Page: 5 of 13

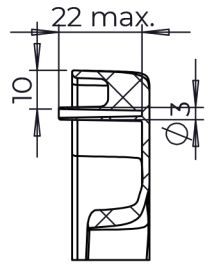




SECTION B-B

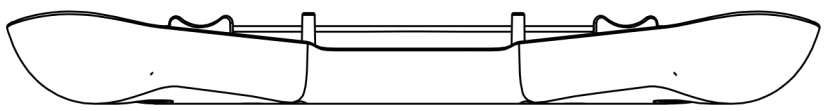
SCALE 1 : 2

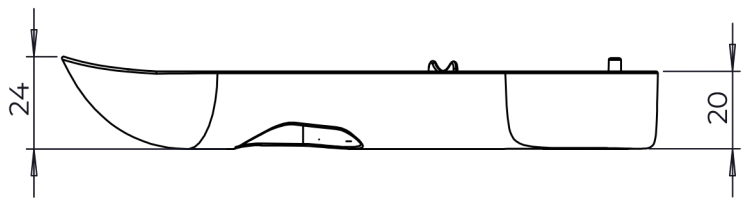


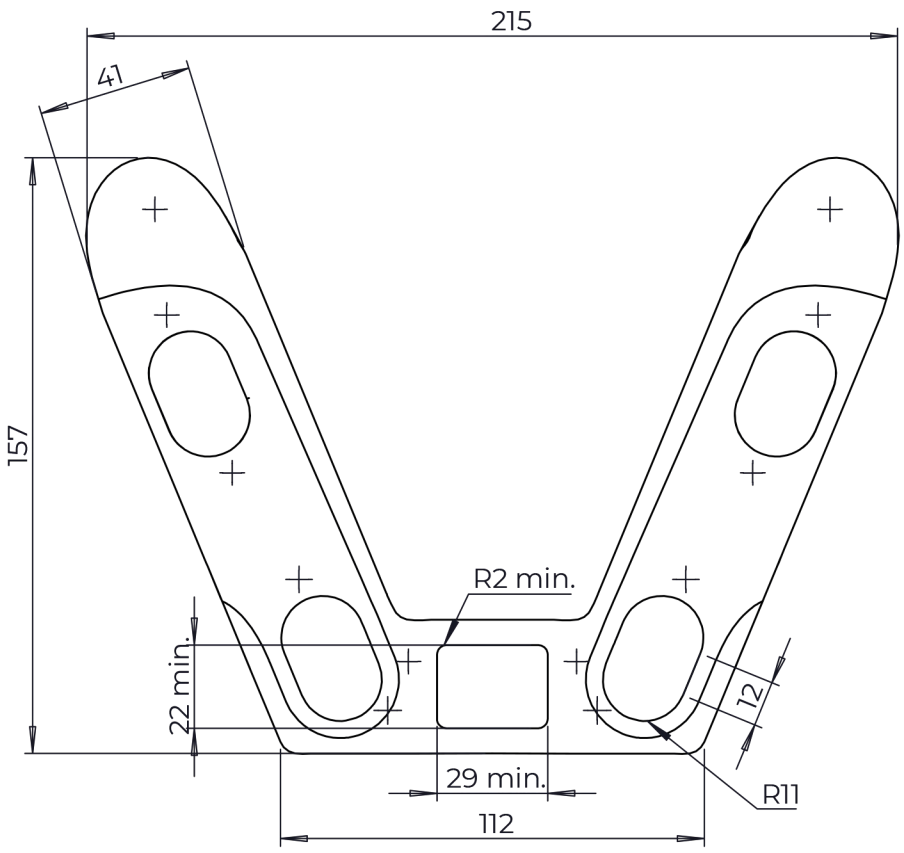


SECTION A-A

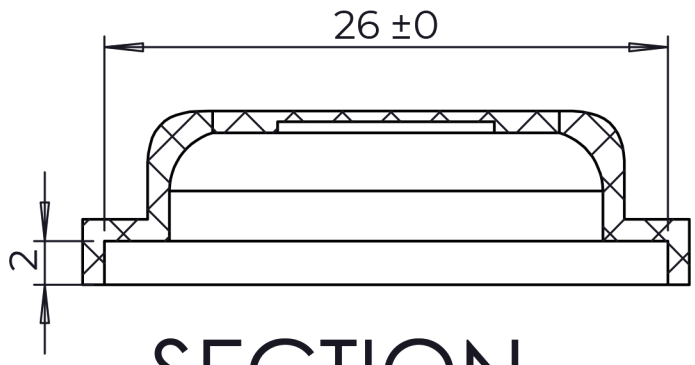
SCALE 1 : 2







Part name: Top shell	All non-specified tolerance follow: DS/ISO 2768-1-c	Part no.: 2
Project: Master's thesis	Material: ABS	Scale: 1:2
Group: MA4-ID2	Process: Injection molded	Date: 31-05-2023
W-meter	All non-specified surface finish follow: As machined	Format: A3
	Color: 292 C and Cool Gray C1	Page: 6 of 13



SECTION E-E

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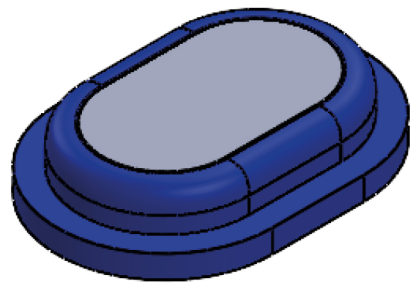
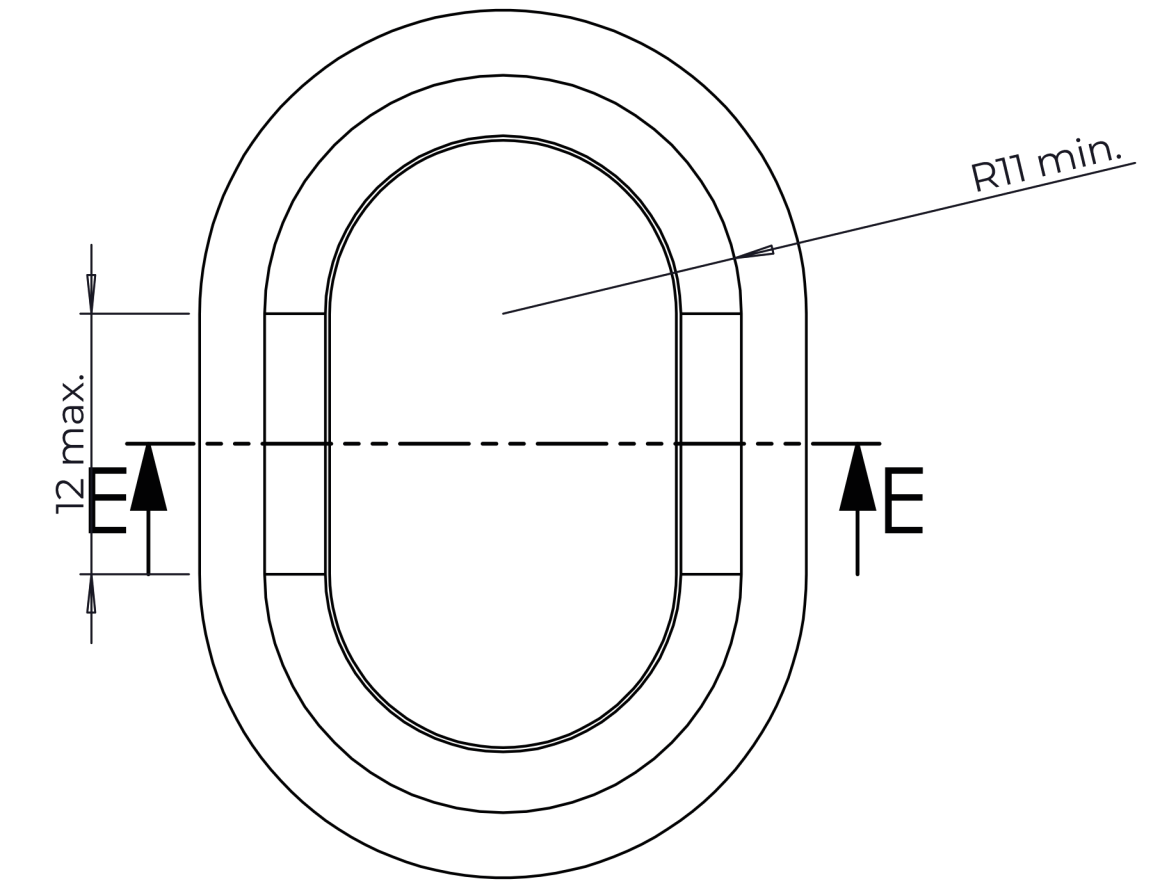
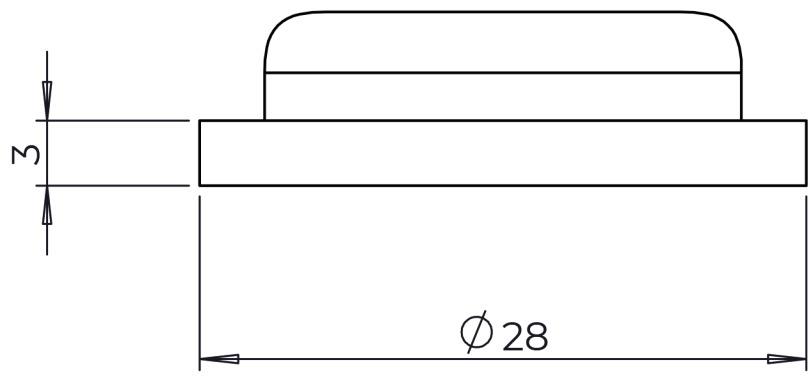
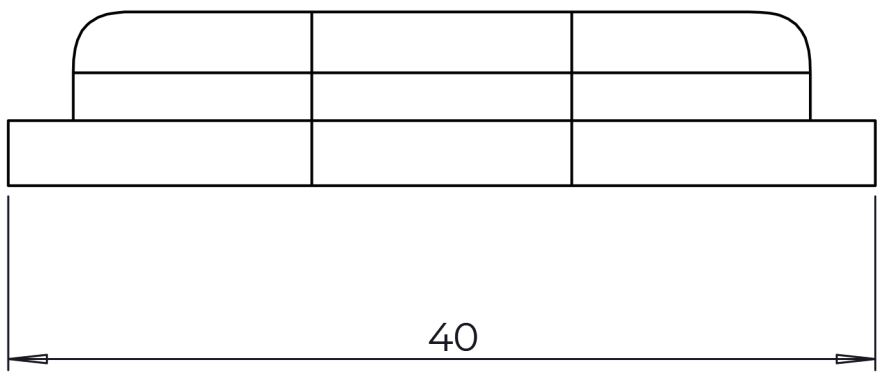
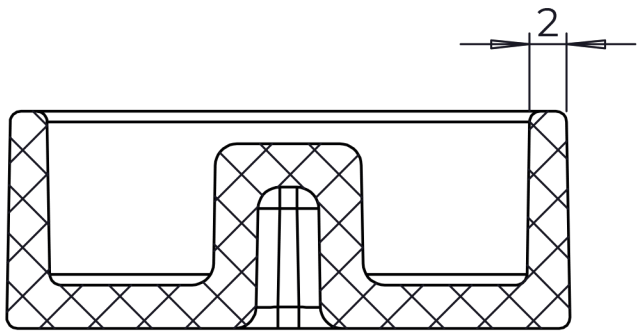


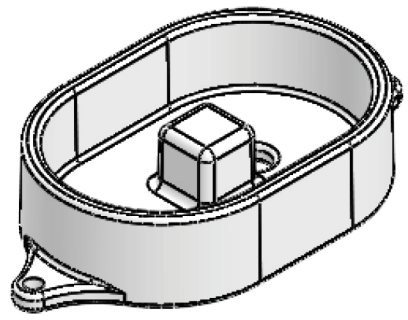






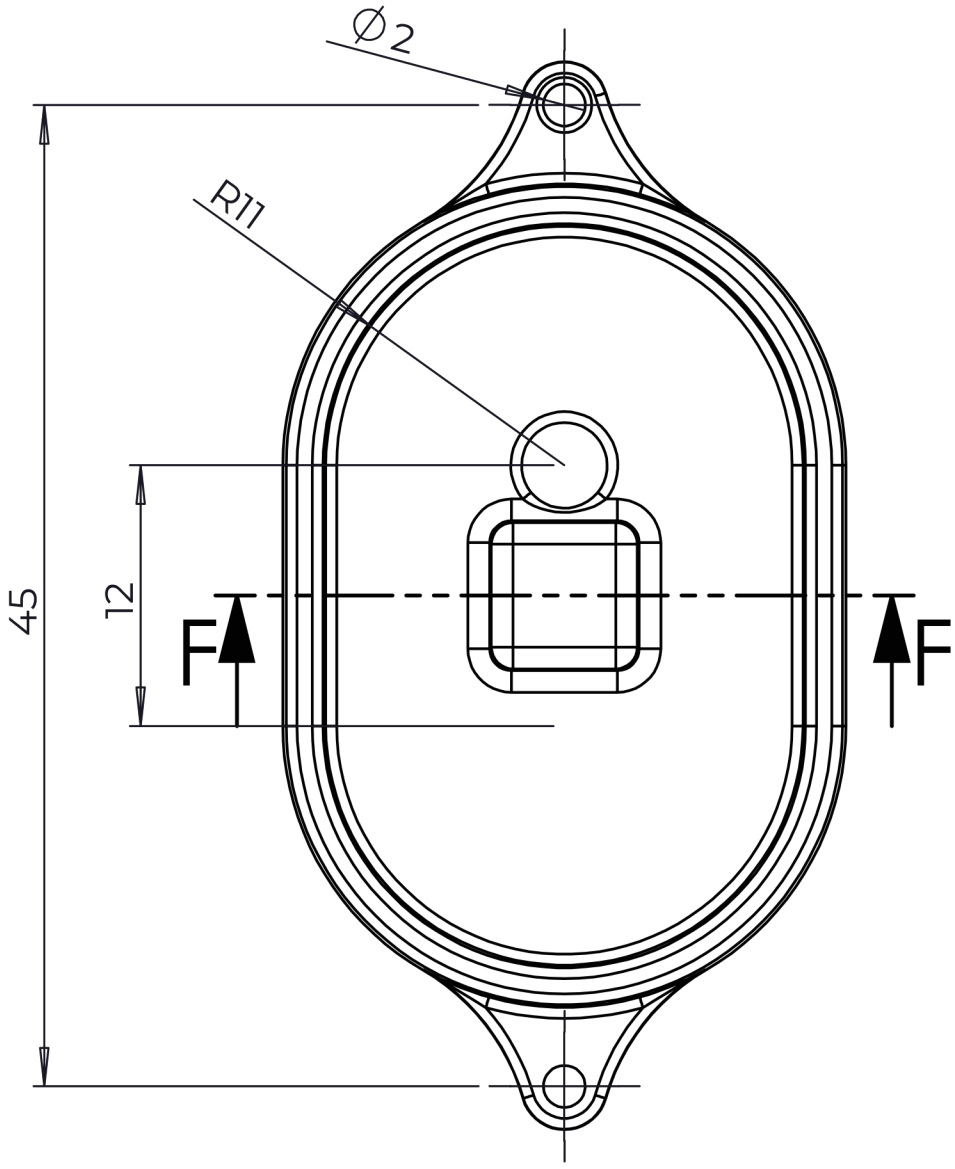
Part name Front electrode + gasket	All non-specified tolerance follow DS/ISO 2768-1-c	Part no. 4 + 6
Project Master's thesis	Material Rubber shore 40A	Scale 2:1
Group MA4-ID2	Process Molded	Date 31-05-2023
W-meter	All non-specified surface finish follow -	Format A4
	Color -	Page 7 of 13

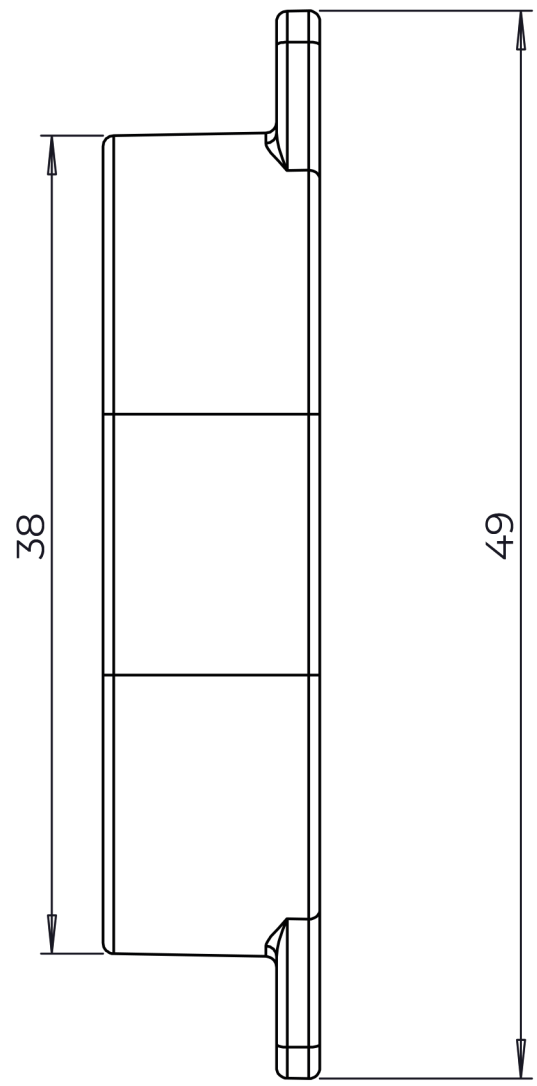


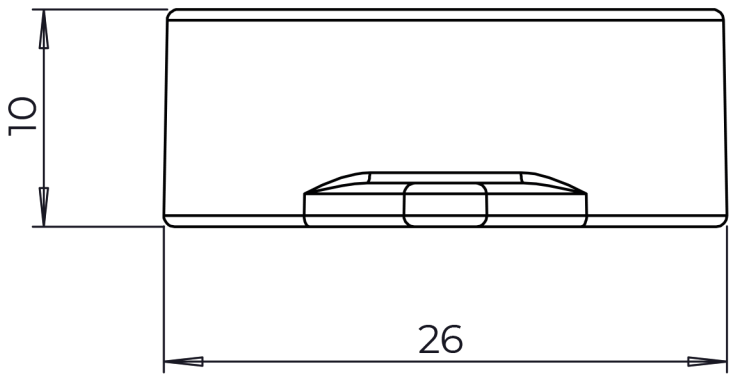


SECTION F-F

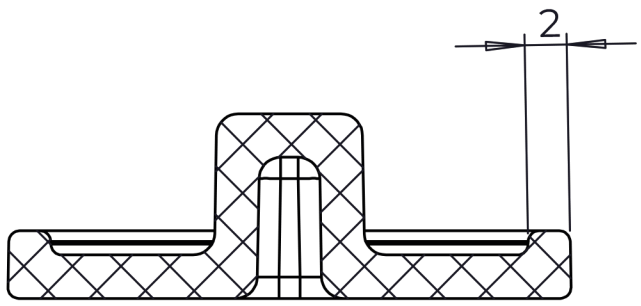
SCALE 2 : 1

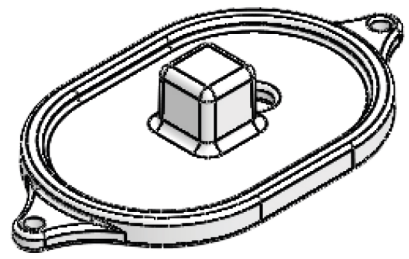






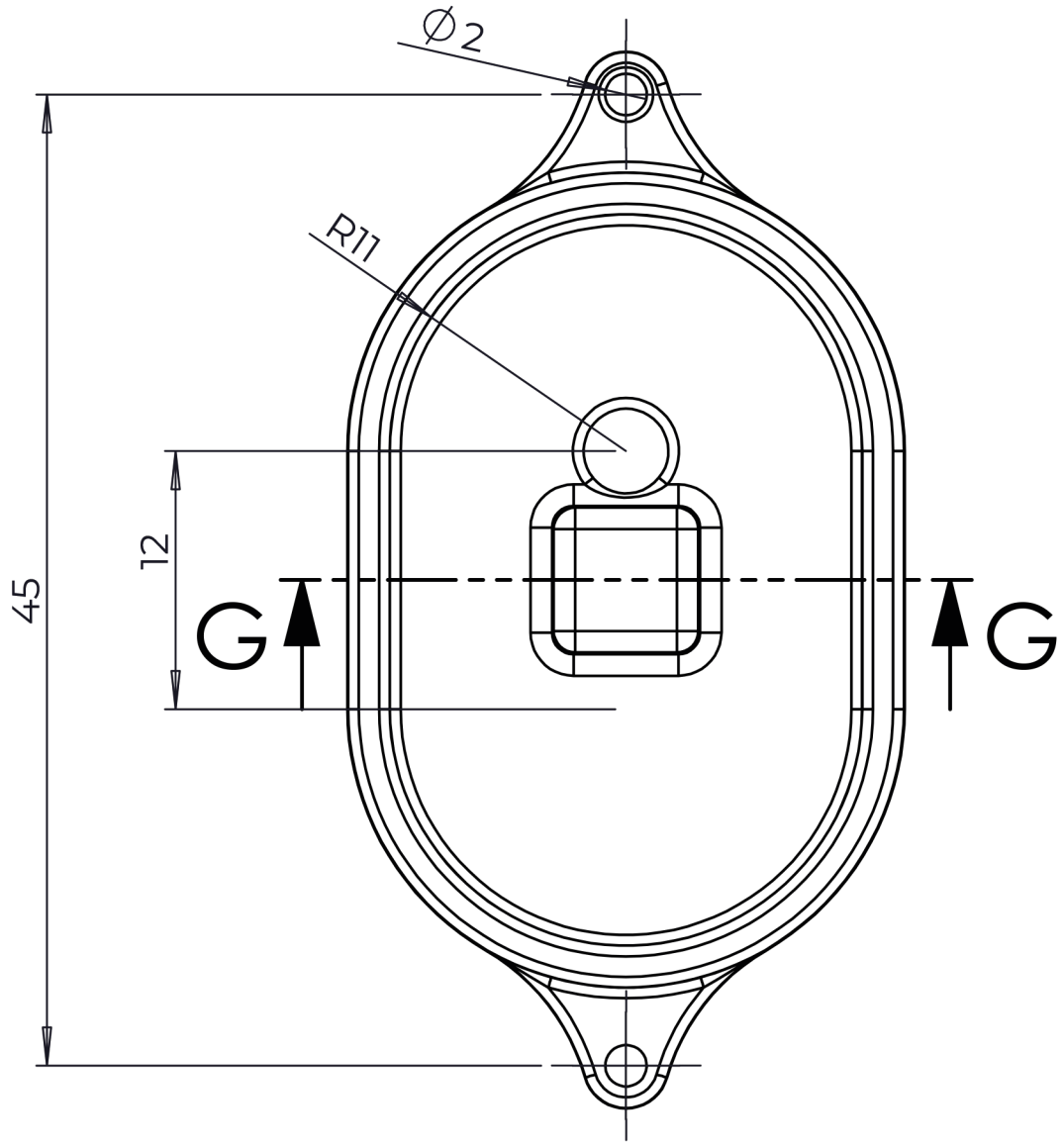
Part name Electrode-button holder front	All non-specified tolerance follow DS/ISO 2768-1-c	Part no. 11
Project Master's thesis	Material ABS	Scale 2:1
Group MA4-ID2	Process Injection molded	Date 31-05-2023
W-meter	All non-specified surface finish follow As machined	Format A4
	Color Cool grey 1 C	Page 8 of 13

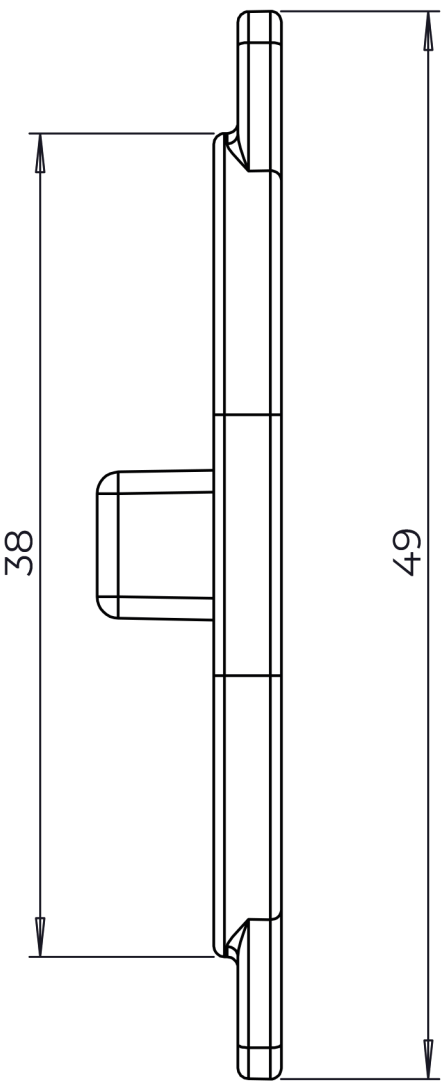


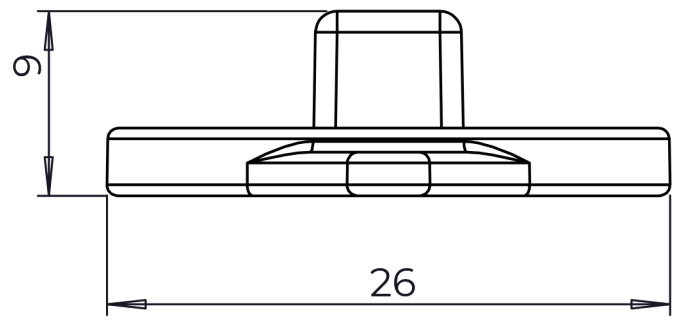


SECTION G-G

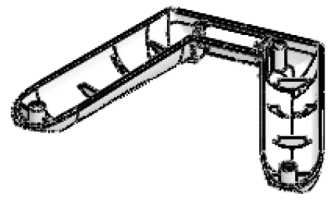
SCALE 2 : 1

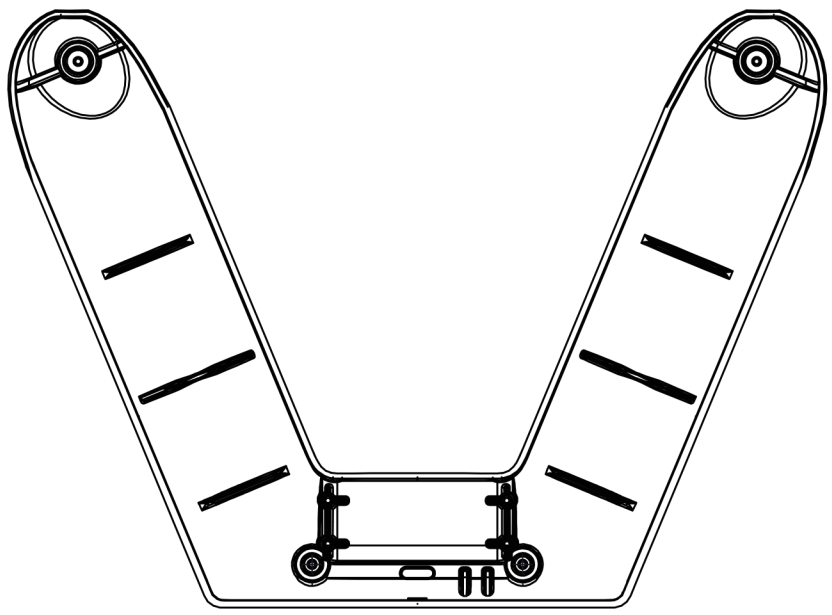


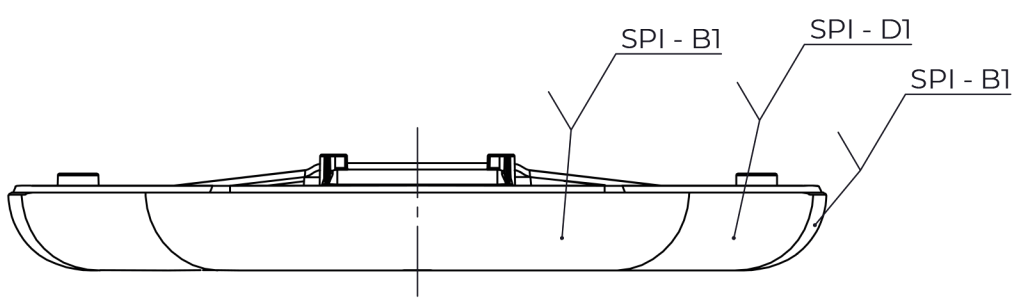


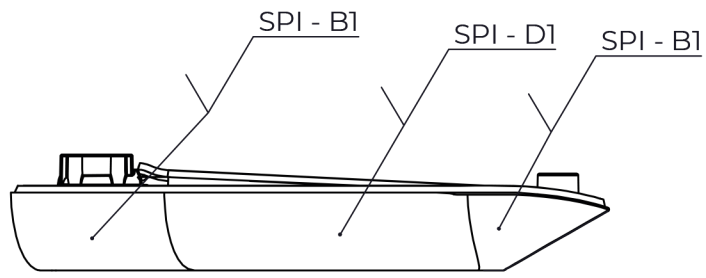


Part name Electrode-button holder back	All non-specified tolerance follow DS/ISO 2768-1-c	Part no. 12
Project Master's thesis	Material ABS	Scale 2:1
Group MA4-ID2	Process Injection molded	Date 31-05-2023
W-meter	All non-specified surface finish follow As machined	Format A4
	Color Cool grey 1 C	Page 9 of 13



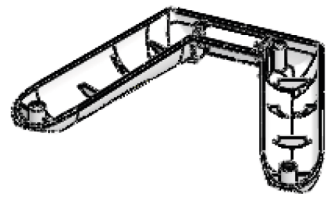


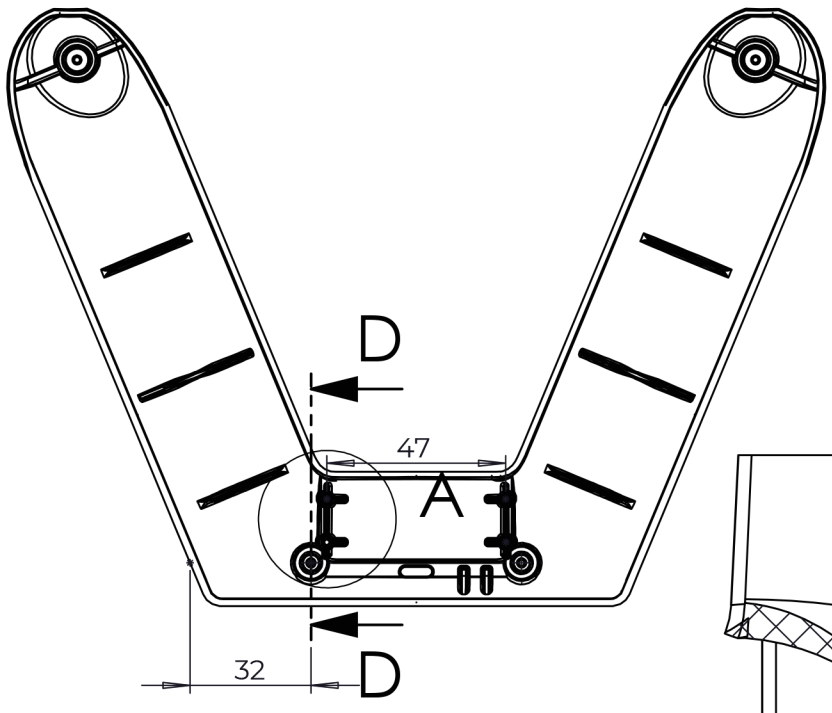


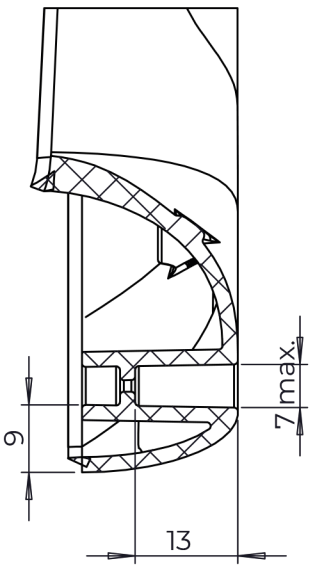


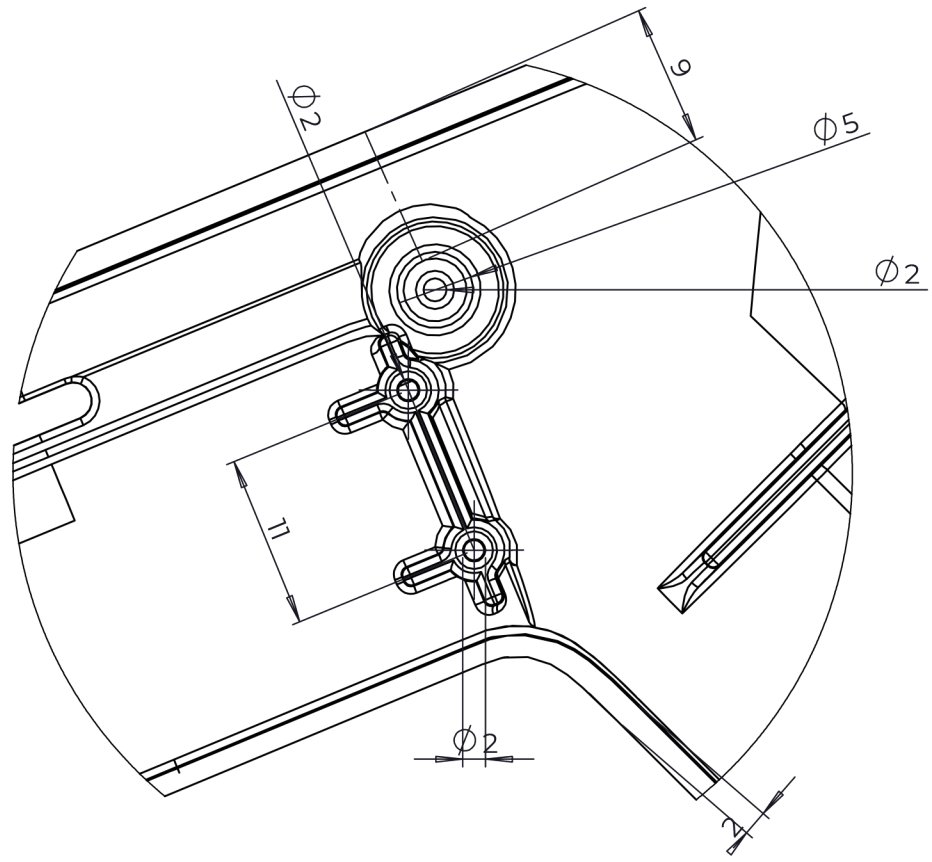
Only showing surface finish

Part name: Bottom shell	All non-specified tolerance follow: DS/ISO 2768-1-c	Part no.: 2
Project: Master's thesis	Material: ABS	Scale: 1:2
Group: MA4-ID2	Process: Injection molded	Date: 31-05-2023
W-meter	All non-specified surface finish follow: As machined	Format: A3
	Color: 292 C and Cool Gray C1	Page: 10 of 13







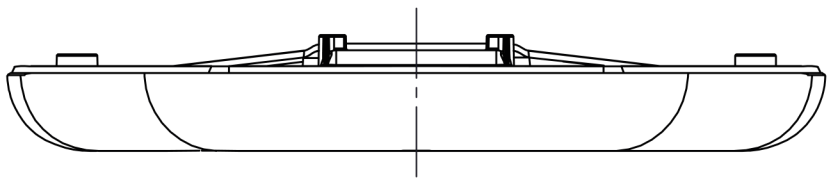


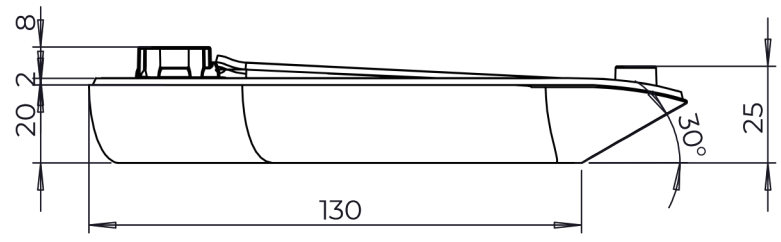
DETAIL A

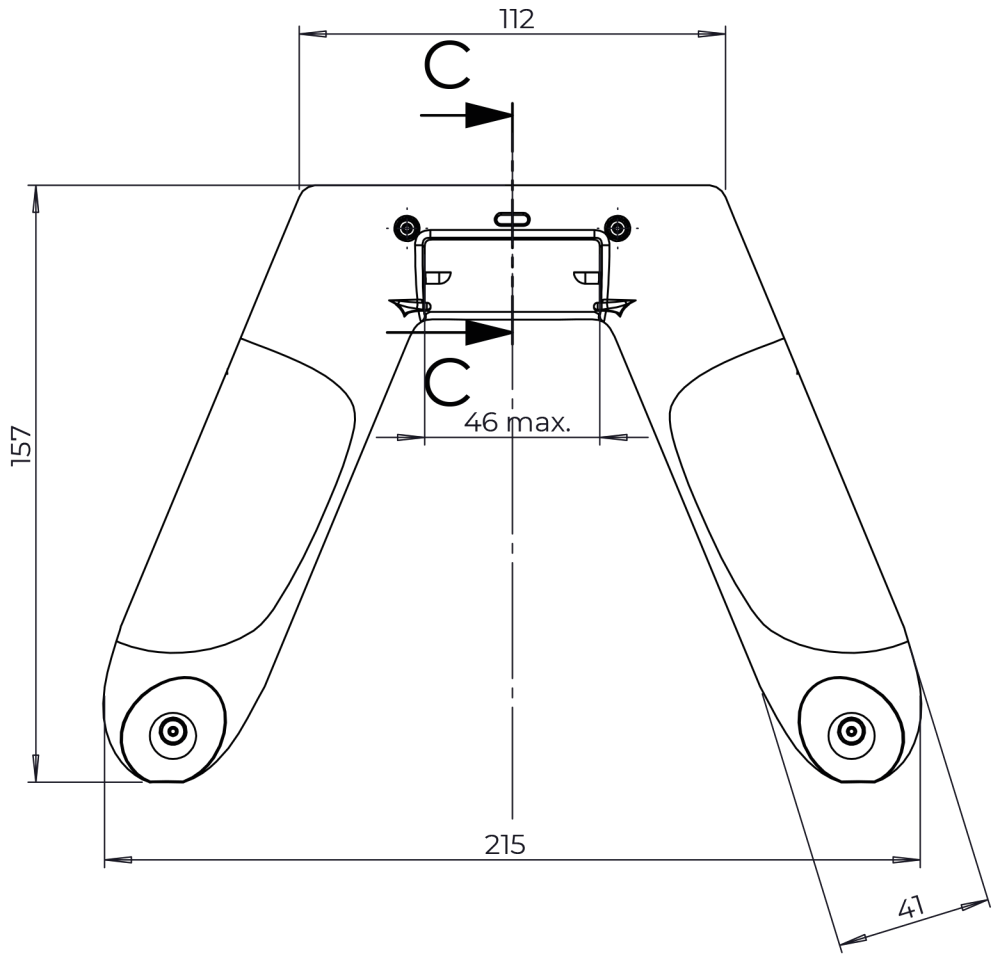
SCALE 2 : 1

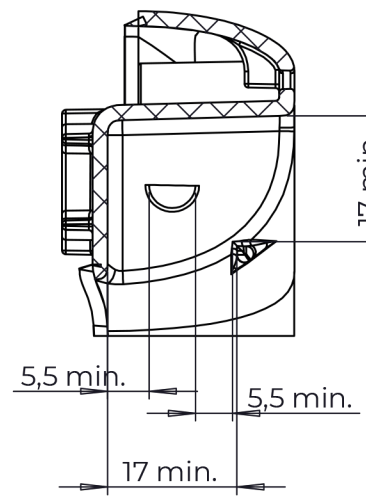
SECTION D-D

SCALE 1 : 1





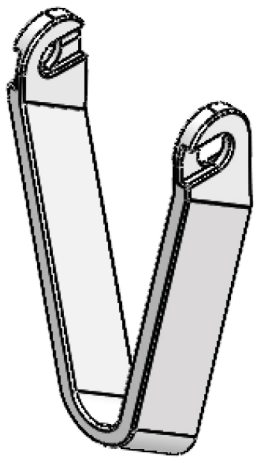


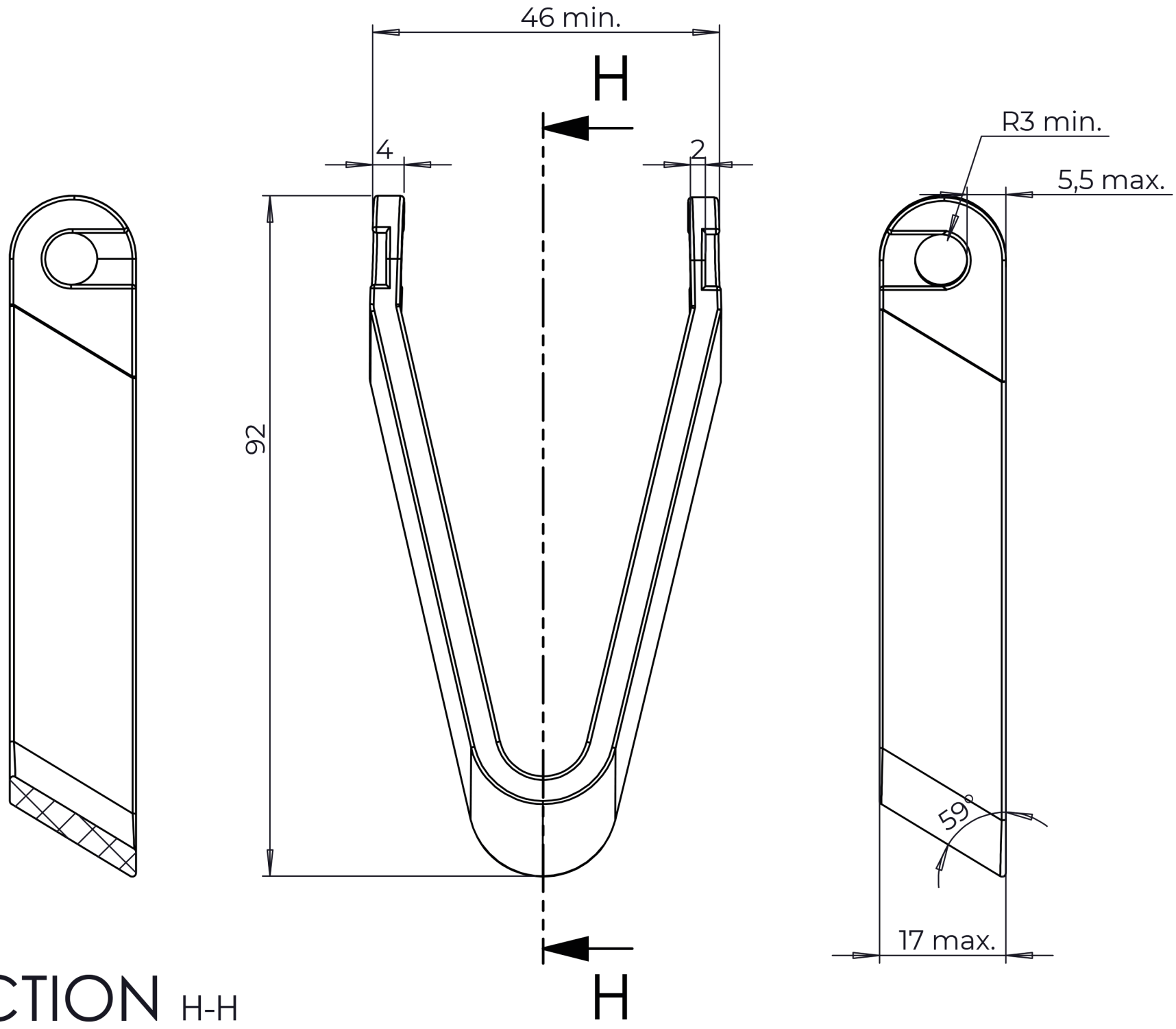


SECTION C-C

SCALE 1 : 1

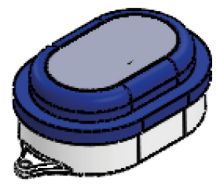
Part name: Top shell	All non-specified tolerance follow: DS/ISO 2768-1-c	Part no.: 2
Project: Master's thesis	Material: ABS	Scale: 1:2
Group: MA4-ID2	Process: Injection molded	Date: 31-05-2023
W-meter	All non-specified surface finish follow: As machined	Format: A3
	Color: 292 C and Cool Gray C1	Page: 11 of 13

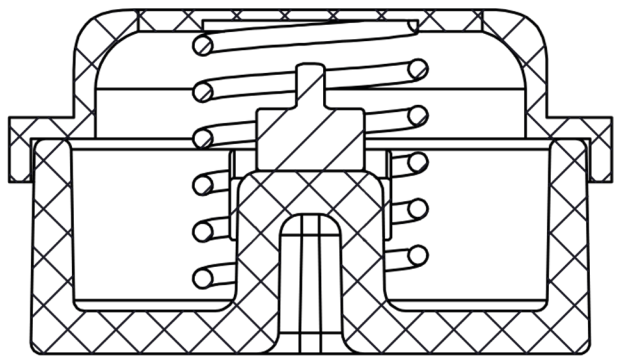




SECTION H-H

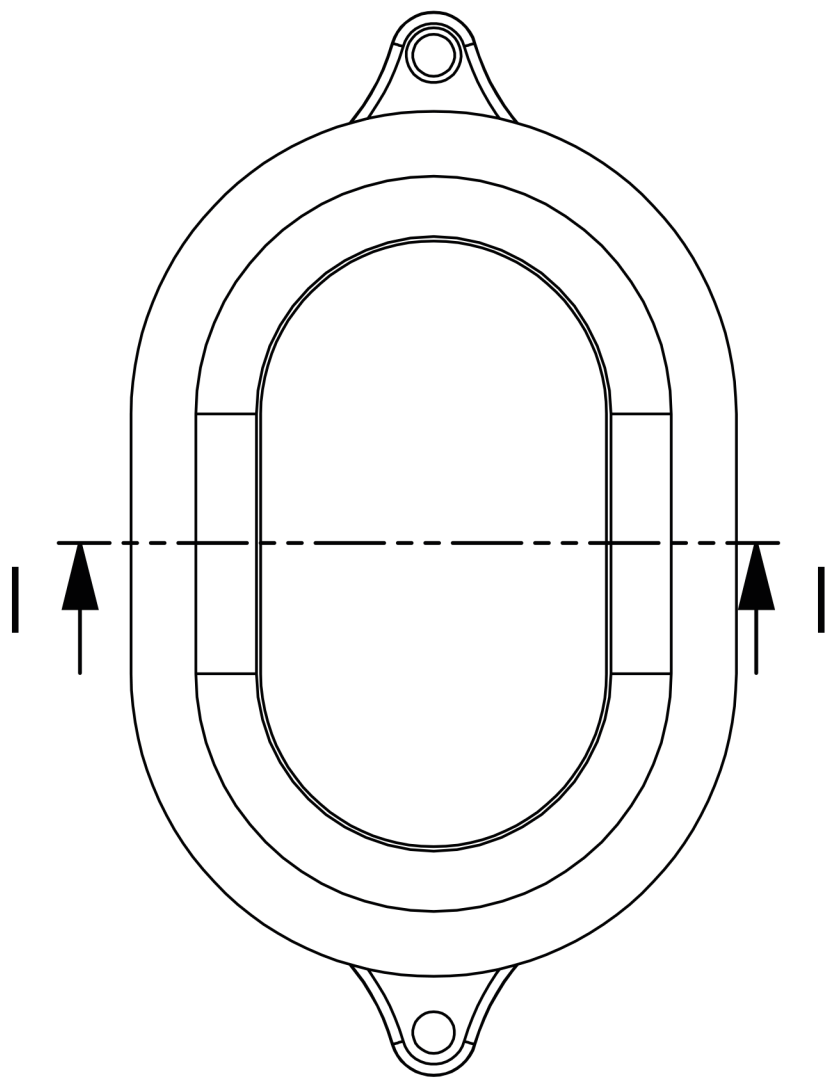
Part name: Leg	All non-specified tolerance follow: DS/ISO 2768-1-c	Part no.: 22
Project: Master's thesis	Material: ABS	Scale: 1:1
Group: MA4-ID2	Process: Injeaction molded	Date: 31-05-2023
W-meter	All non-specified surface finish follow: SPI - B1	Format: A4
	Color: 292 C	Page: 12 of 13

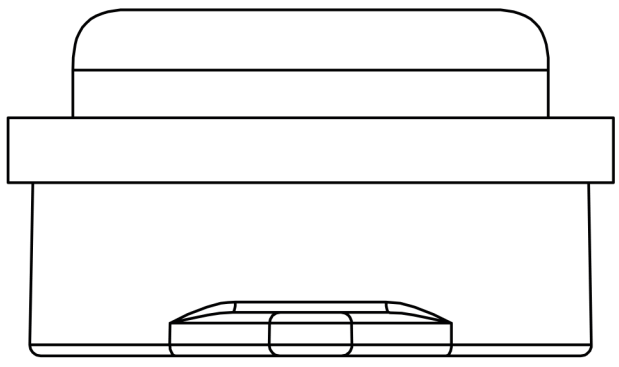




SECTION I - I

SCALE 2 : 1





Part name Cut electrode button	All non-specified tolerance follow -	Part no. 4, 6, 8, 9, 11
Project Master's thesis	Material -	Scale 2:1
Group MA4-ID2	Process -	Date 31-05-2023
W-meter	All non-specified surface finish follow -	Format A4
	Color -	Page 13 of 13

Aalborg University
June 2023











Procesrapport

Master's thesis

Industrial Design, MA4-ID2

Kristoffer Faurby Larsen and Rikke Skov Præstgaard

Table of Content

04 Concept development for HCW

05 Concept detailing

Title page

Title:	Procesrapport
Theme:	Master's Thesis
Programme:	Industrial Design, AAU
Project start:	February 1. 2023
Submission:	May 31. 2023
Project group:	MA2-ID2
Main supervisor:	Christian Tollestrup
Co-supervisor:	Mikael Larsen
Pages:	92

Abstract

Formålet med dette projekt er at udvikle apparat, som kan hjælpe mod dehydrering af ældre i hjemmeplejen. Det er lavet, som et speciale projekt på kandidatuddannelsen Industrielt Design på Aalborg Universitet foråret 2023. Projektet forsøger at takle problematikken omkring ældre, som bliver dehydreret i hjemmeplejen, da det koster de danske kommuner op mod 50 mio. DKK om året.

Projektets endelige problemformulering er: Hvordan skabes et produkt, som kan hjælpe SOSU-medarbejder, til at mindske antallet af ældre, som bliver dehydreret i hjemmeplejen? Med baggrund i problemformulering, er det forsøgt gennem anvendelsen af flere forskellige design metoder fra design thinking at designe et produktforslag, som løser dette.

Det har skabet produktforslaget W-meter, som er et apparat, der kan kvantificere forløbet for dehydrering af ældre i hjemmeplejen for SOSU-assistent. Sådan at de kan yde den rette behandling, når det er nødvendig. Ved at kvantificere forløbet forbedres også samarbejdet mellem SOSU-medarbejderne. Produktforslaget er designet sådan, at det inddrager den ældre i målingen af dehydrering, sådan at det virker mindre indgribende på den ældre. Det opretholder den gode relation mellem den ældre og SOSU-medarbejderen og forbedrer plejen. Det anslås, at produktforslaget vil kunne spare de danske kommunerne omkring 30 mio. DKK om året.

Thank you too

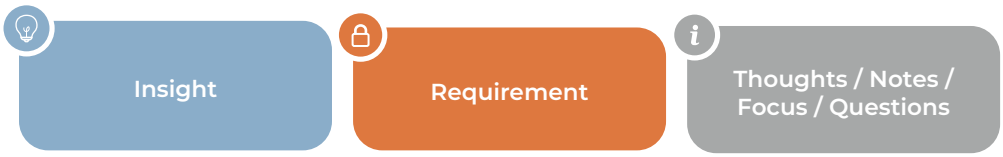
This project has been made in a corporation with a lot of different stakeholders which we would like to thank you. Thank you to Cacta, the startup we have been cooperating, for giving ud the chance of designing a hydration-level device, and further for them giving insight and feedback on the concept. Thank you to the healthcare workers, the elderly, and Bettina Nielsen at Høje Tranders Friplejehjem for letting us make observings, tests, get feedback on our concept, in their daily life. And lastly thank you to the home care unit Nord Land Øst Aalborg Kommune for letting us be a “trainee” for a day to observe the daily work life of a healthcare worker in public home care as well as feedback on our concepts.

Reading guide

The documentation of the project is done in four parts:

The product rapport: A presentation of the product proposal.
The technical drawings: The technical specification of the product proposal
The process rapport: A chronological documentation of the design process and the reasoning behind it.
The appendix: A more detailed and complete unfolding of each action done in the design process. The actions are structured over the worksheet made through the process. Only the most relevant worksheet can be found in the physical submission. The rest can be found in the online submission. Through the process rapport, the worksheet will be referred to as W#.

Through the process rapport these boxes the mark if you as a reader should extra aware of:



The Harvard Method is used as the reference style. On page 93 the list of references followed by the list of illustrations can be found. The list of illustrations only contains references to the illustrations which is not made by the team.

Through the design process, we have made use of many different Healthcare Workers some of them did not want to appear by name and picture in the rapport. They will appear anonymous in theis project, refrenced by with their working title.

Word definitions

Word	Explanation
Social and health care worker	In Danih called social og sundhedshjælper also called SOSU-hjælper. The Social and health care worker is mostly responsible for the care, nurturing, and practical help of the elderly in eldercare (SOSU 2020).
Social and health care assistant	In Danish called Social og sundhedsassistent also called SOSU-assistent. The Social and health care assistant has more responsibility compared to the worker. They can be responsible for the medication of the elderly and the coordination with other healthcare professionals (SOSU 2020).
HCW	Healthcare worker (HCW). We define it as an educated Social and health care worker or assistant.
The technology	When we refer to the technology, we mean the technology needed to measure hydration, which Cacta is currently developing.

Introduction

This project is made in collaboration with Cacta. Cacta is a start-up that is developing a non-invasive medical device to measure under- and overhydration. Initially, they asked us to help design a device that can help monitor the dehydration of elders. There are around 7,500 Hospitalizations per year due to dehydration of elders (Esundh 2022). It costs around 50 mil. DDK per year (see * below). A week into the project, after we made the deal of cooperation, Cacta changed their user group to women who have had breast cancer and thereby risk developing lymphedema due to the removed lymph nodes. According to Cacta, the shift is done because they see a better business opportunity and it is easier to mature the technology for them than an older body.

Ill. 1.

Mads
Co-Founder
Cacta ApS

Ill. 2.

Ida
Co-Founder
Cacta ApS

Cacta is a medical device start-up. It is a spin-out from Biomedical Design Novo Nordisk Foundation Fellowship Program at Aarhus University. Cacta is working on developing a non-invasive medical device to measure under- and overhydration (Cacta n.d.). The start-up consists of Ida Grønborg and Mads Skak, who is our main contact.

Cacta is still developing the technology. This means we are black boxing it in the product, i.e., We consider their data to be accurate, even though they are still under development and not tested fully.

* The number is based on a rule of thumb that is cost 20.000 DDK (Cacta 2023). Pursuant to the Danish Health Care Act §238 should pay ⅓ of that cost (Regeringen og Kommunernes Landsforening 2021). Landspatienstregisteret 2022 regiestered 7.500 hospitalisation due to dehydration of elderly 65+ (Esundhed 2023). This gives a cost for the municipalities around 68 mil. DDK per year.

01 Problem scoping

This chapter will explain the problem scoping of the project. It will be defined whether the project should revolve around dehydration of the elderly in health care or women who have had their breast removed due to breast cancer and have the chance of developing lymphedema. The chapter will end with concluding the initiated framing for the project.

1.1 Dehydration or lymphedema

In the initial state of the project, it is all about conducting field research to understand the problem. We were working on investigating both problems simultaneously. To decide on which one was the best fit for this project, we have tried to summarize our problem understanding from worksheets1 - 7. The summaries will be structured around WWWWWH method (Boeijen et al. 2014), even though it was not the approach used. It does, however, give a good overview. Even though the summary appears simple, it is based on knowledge gathered from a visit at Høje Tranders Friplejehjem, an interview with two lymphedema therapists at Aalborg Universitetshospital, an interview with Niels Kroman Medical Director and professor of breast cancer surgery at Kræftens Bekæmpelse, and an interview with Gunn Ammitzbøll who did a ph.d. in prevention of lymphedema. Also we have used insight knowledge from Cacta and desktop research.

1.1.1 Dehydration

Initial problem: Elders cannot feel thirst, as the level of the "thirst hormone" in the body decreases with age (Beck & Ravn n.d.). The dehydration leads to around 7500 (Esundhed 2022) hospitalizations of elders which costs 50 mill. DDK for all municipalitys and 100 mill DKK for the regions each year.

Who: There are around 153,000 elders who are receiving care in Denmark (Danmarks Statitisk 2022). If the elderly receives care from the municipality, it is the HCW's job to ensure the health of the elders on a daily basis. This means that the product will be used by the HCW and the elders. The municipality and The regions are also involved as they are the ones paying the bills for the hospitalizations and home care.

What: Besides the decreased "thirst hormone", the elderly have a lower percentage of water in the body, heightening the risk of becoming dehydrated. Some take diuretic medicine which increases the risk of becoming dehydrated (Beck & Ravn n.d.). In the worst case, dehydration leads to hospitalization. This can be due to both dehydration alone or some of the side effects such as the elderly falling, getting cystitis or pneumonia, etc. (Bjørnsson 2007).

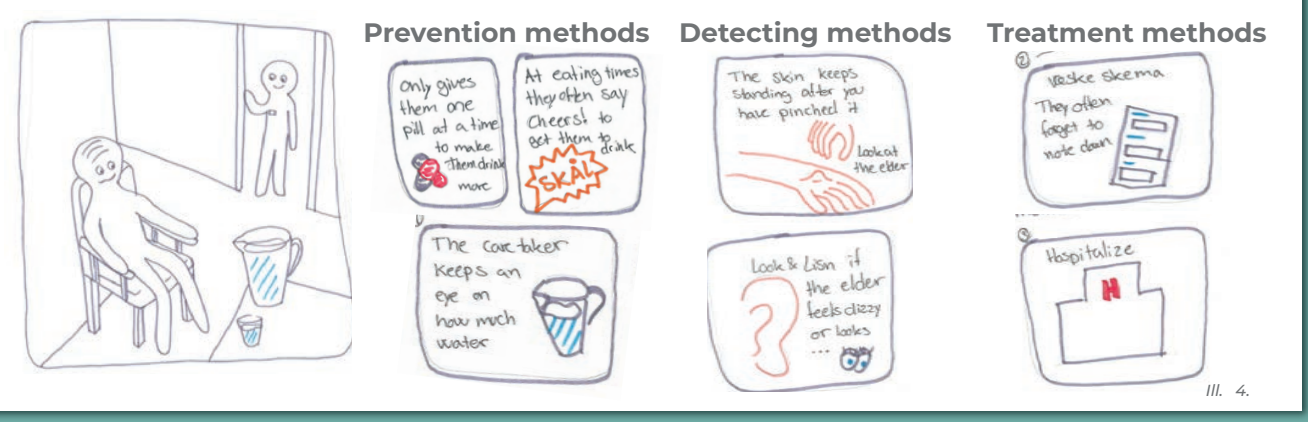
Where: It is primarily a problem for the home care and nursing home, but if the condition worsens, leading to hospitalization, it becomes a problem in the healthcare system. The problems continue when the elderly gets back from the hospital, as they need rehabilitation.1 We see the product being used by the HCW in home care or nursing home, not at the hospital, because they are using a blood test to diagnose dehydration. If the lack of fluid can be detected earlier, it will not become a risk for the elderly and could save society a high expense.

When: The problem occurs when the elders do not get enough to drink. The risk is increased in the summer as heat affects the body's need for water (W02). We see a possibility to develop a product for the HCW in home care or nursing home that can detect and monitor dehydration, so the condition does not worsen.

Why: Right now, there is no diagnostic tool that can detect or monitor dehydration (W02). A lot of the current tools for detecting and measuring dehydration are either based on invasive methods or observations of behavior change, water intake, urine, etc. (W01 , W02, Mayou Clinic n.d.).

How: The current coping strategies are either that the HCW follows a mnemonic rule and their intuition or that they monitor the fluid intake by Fluid chart or Aquatime (W01).

Problem statement: How do we design a dehydration measure device that can help prevent the elderly from hospitalization?



Ill. 4.

1.1.2 Lymphedema

Initial problem: Breast cancer patients have the risk of suffering from lymphedema after a breast removal treatment of cancer. If lymphedema is discovered in the early stage, you can to some degree recover.

Who: Women who have been treated for breast cancer, by removal of their breast, have the chance of developing lymphedema. Every year around 5,100 women get breast cancer in Denmark (Sundhedstyrelsen, 2021) and about 40% will develop lymphedema (Kræftens Bekæmpelse, 2016) The discovery and treatment of lymphedema are done by lymphedema therapists at the hospitals. The product will be used by the women and lymphedema therapists but is assumed to be paid for by Regionen.

What: Breast cancer patients can develop lymphedema after the treatment as there is a risk of damaging the lymphatic system. The system helps in transporting the waste products out of the body. When the system is damaged, it can lead to accumulation of lymph (fluid) in the arms (Kjems 2022a, W06). Lymphedema increases the risk of local inflammation, fever, decreased mobility, and causes cracks in the skin as fluid leaks out (Kjems 2022b).

Where: Lymphedema develops in the patient's arm and can be discovered by the patient at home, at the GP doctor, or by the lymphedema therapist (W06). We see the product being used either at home or by the lymphedema therapist.

When: Lymphedema can develop after the breast removal treatment for breast cancer and for the rest of the patient's life. Lymphedema comes in different stages: The condition is latent in stage 0, and reversible in stage 1 where is it detectable. However, it is already irreversible in stage 2 (Kjems 2022a, W06). The product relies on the assumption that if lymphedema is detected early, it can be stopped from evolving and becoming chronic in stage 2 (W04). The aim would be to develop a device that can discover lymphedema before reaching stage 2 by monitoring fluid levels in the arm.

Why: Right now, there is no tool that can discover it early. A lot of the current tools for detecting and measuring lymphedema are either the pitting technique or based on measuring the dimension of the arm either by measuring tape or submerging the arm into a bucket filled with water (W06). A tool for detecting lymphedema is assumed to make it less stressful for the patient as it will assure them.

How: The current treatment is seal drainage, compression stockings, or special massage from the lymphedema therapists (W06).

Problem statement: How to design a monitoring device, which can monitor if the breast cancer patient develops lymphedema?

1.1.3 Dicusion

For a more detailed view of how we saw the potential between the "design problems levels" of the two problems, look at the design brief in W5. After exploring both dehydration and lymphedema, we had to decide which problem we wanted to tackle.

In our research and discussion with experts, we kept running into: "Why should we measure it if we can't do anything to prevent the development" - Niels Kroman. He directed us to Gunn Amnitzbøll, who has a Ph.D. in preventive treatments for Lymphedema. She said: "There is some evidence that it can help to start treatment in face 0 if you can discover it that early on, but as far as I know is not validated enough so that I'm convinced." The two statements make it difficult to justify developing a product for lymphedema as in Denmark the health sector are not allowed to start treatment if the citizen is not sick. The product is meant to monitor every woman who has had an operation even though only 40 % of them get lymphedema, making 60% of them feel sick without that actually being the case. On the other hand, in the case of preventing dehydration, the stakeholders welcomed such a product.

Additionally, the lymphedema therapists at the hospital only had a very short time to do the interview. This barrier of time was also met when interviewing the other stakeholders who were contacted, making a future corporation difficult. Again, the opposite was to be said in the case of preventing dehydration as the stakeholders had plenty of time to show the context and give feedback.

Lastly, the potential customers for a lymphedema product were fewer than in the case of preventing dehydration of elders.

Further, we see a more Wicked problem in making a product for the elderly. We would have to make a product that suits the elderly in terms of usability, whereas, in the case of lymphedema, the users are more willing to use the product, resolving in fewer barriers to shape the product. In conclusion, preventing dehydration of elders is rather a design problem.

i

The project will revolve around preventing the dehydration of elders in healthcare.

1.2 Exploring dehydration of elderly

To get an initial understanding of the user, stakeholder, and scenario evolving around the problem of elderlys becoming dehydrated, we went to visit Tranders Høje Friplejehjem. In preparation, we made an interview guide and three sketches (W01). We conducted semi-structured interviews with two elders, two HCWs, and the manager. The insights we had gathered were discussed with Mads from Catca, (see W07), on a workshop day where both parties shared their knowledge about the problem. After the workshop, we also went to the home care in Kærby Aalborg where we interviewed an HCW, to get an understanding of the differences between home care and a nursing home, (see W09). This chapter will present the final knowledge we gathered during these interviews.

Visit Tranders Høje Friplejehjem

Ill. 5.

Jeanette
Social and health care worker

Semi-structured interview

- 13 years of experience

Ill. 6.

Lilly
Resident

Semi-structured interview

- 90 years old
- Resident since Sep. 2022
- Claims she drinks enough water
- Lite cognitive deterioration

Ill. 7.

Inge
Social and health care assistant

Semi-structured interview

- 30 years of experience
- 20 years in nursing homes

Ill. 8.

Oda
Resident

Semi-strucutred interview

- 90 years old
- Resident since Sep. 2021
- Aware she does not drink enough water
- Cognitively normal
- Almost blind

Ill. 9.

Bettina
Manager

Semi-structured interview

- Educated as a nurse
- 3 years as manager for Høje Tranders Friplejehjem
- Before many years in public nursing homes

Workshop with Catca

Ill. 10.

Mads
Co-Founder – Cacta ApS

Workshop

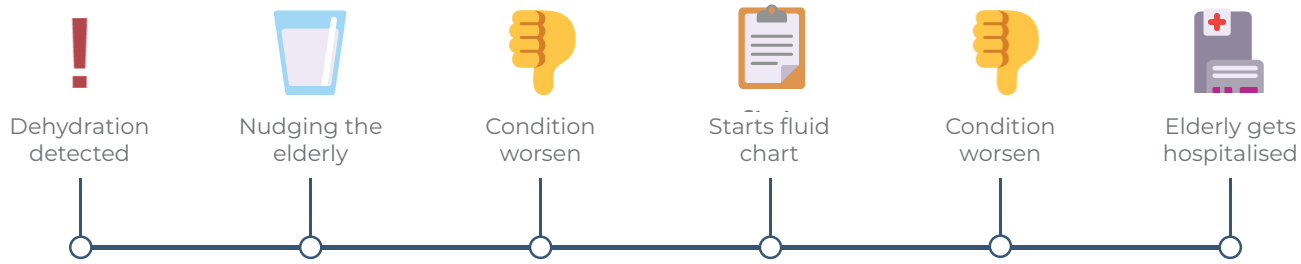
Visit Kærby Home care

Ill. 11.

Trine
Social and health care assistant
& Quality employee

Semi-structured interview

- 18 years of experience
- 10 years as Social and health care assistant
- 50 % Social and health care assistant
- 50 % Quality employee



Ill. 12. Worst case as-is scenario of an elderly experiencing dehydration.

1.2.1 The as-is scenario

From the visit, we identified that the HCWs are good at noticing if the elderlys start to get dehydrated. Especially when the elders are in nursing homes as they can keep an eye on them all day. If the elderly shows mild symptoms of dehydration, like: tiredness, headache, or confusion, the healthcare worker will start to nudge the elderly to drink by using different techniques.

Nudging techniques

Even though the HCWs are around the elderly all day at the nursing home, the HCWs are only overseeing the elderly for a short amount of time during the day. This makes the HCW unsure of exactly how much the elderly drink, as another HCW can come in and give them fresh water and fill up the glass again. The elderly also could pour the water into a potted plant to water it. Their only way of knowing is by asking the elderly:

"*So, have you had anything to drink today?*"
"*Would you mind drinking the water, please?*"
"*Now remember to empty the glass of water you have in front of you, and I'll find you some coffee in the meantime.* "

Hypothesis by the team: This "policeman/ parents behavior" towards the elderly does not improve their relationship.

The HCW working in the home care sector used the same nudging techniques. But they have even less time together with the elderly. A deeper understanding of dehydration in home care will be investigated in section 2.1.

Even though the HCWs identify dehydration and start to nudge, the condition can still worsen, as the HCWs cannot ensure that the fluid they put in front of the elderly is drunk. When this happens, the HCW can start to use a tool called fluid chart. The HCW measures the elderly's intake and outtake of fluid. If the condition of the elderly still worsens, the elderly gets hospitalized.

The HCW has a mnemonic rule, a standard called the ISBAR. The HCW filled this formula out before calling the doctor in all situations where the elders are ill. The team thought: Can the product become a part of this ISBAR list? (W09).

The HCW ensures there is a jug of fluid easy to access for the elderly.

The HCW only gives the elderly one pill at a time, to make them drink more water without them noticing.

At dinner, the HCW often toasts with the elderly to get them to drink more without asking them to do so.

Ill. 13.

The project will revolve around preventing the dehydration of elders in healthcare.

It would make sense to design a measurement device that can help the HCW monitor the hydration level of the elderly. So, if the elderly's hydration level is worse, they can use a more dramatic method like inserting a drip, to avoid hospitalization. As described earlier, this costs a lot of resources

1.2.2 Mapping of the stakeholders

We identified several stakeholders. These are based on our interviews with the elderly, HCWs, and managers at Høje Tranders Friplejehjem as well as our workshop with Mads from Cacta.

Ill. 15.

Healthcare worker
Core user

HCWs are the users who will use the product. They are the ones who need to act on the information given by the product, so they can take better care of the elderly.

"My main task is taking care of the elderly' health."

Ill. 17.

The elderly
Core user

The elderly is the one the product needs to be used on. They are the ones getting the health benefits from using the product. The elders need to give the acceptance of the product being used on them before the HCW can use it.

"I am sure that I drink enough water."

Ill. 19.

The municipality
Direct stakeholder

The municipality is the purchaser /decision-maker and makes decisions based on economics. From their perspective, if the product can increase the quality of either the HCW's job or the life of the elderly and save money, it is worth investing in. Further, their perspective is that the product must be trustworthy.

"The product must be trustworthy."

The next three stakeholders are based on knowledge from the interviews, i.e. our assumptions.

Ill. 14.

Healthcare personnel
Direct stakeholder

The nurse or general practitioner, i.e., the healthcare personnel who do not have daily interaction with the elderly but are responsible for evaluating their health. They are direct stakeholders as they need the information the product provides to ensure the best treatment for the elderly.

Ill. 16.

Relatives to the elderly
Indirect stakeholder

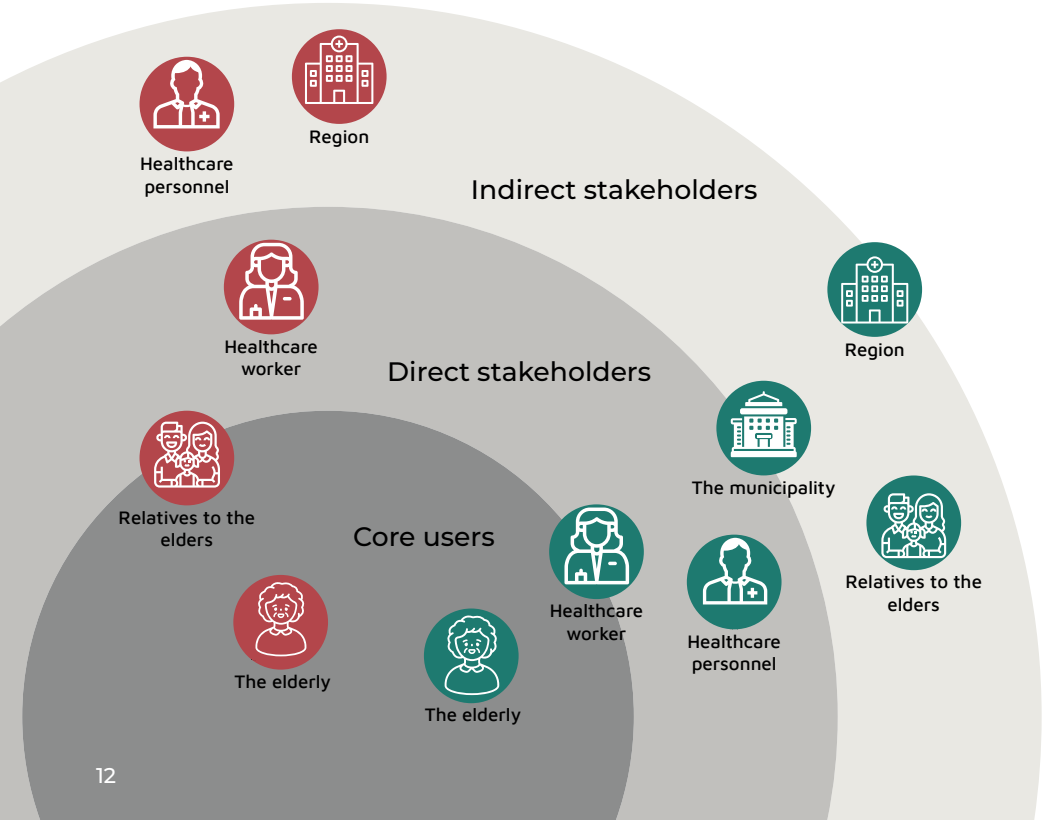
The relatives of the elders want the best for the elders so they can keep enjoying life with them.

Ill. 18.

Region
Indirect stakeholder

They are the ones paying for the dehydration treatment at the hospital. They have an interest in preventing hospitalization to save money.

The stakeholders can form constellations in different ways. Both so it is the municipality who is the purchasers/decision makers, green constellation, or it could be the relatives or the elderly who buy the product, red constellation. The project will be based on green constellations, due to business insurance as the HCW is employed to ensure the health of the elderly, and not all families are close either in terms of place of residence or emotionally. The project will, however, explore whether the product should be targeted at the HCW or the elderly as the main user of the product.



Ill. 20.

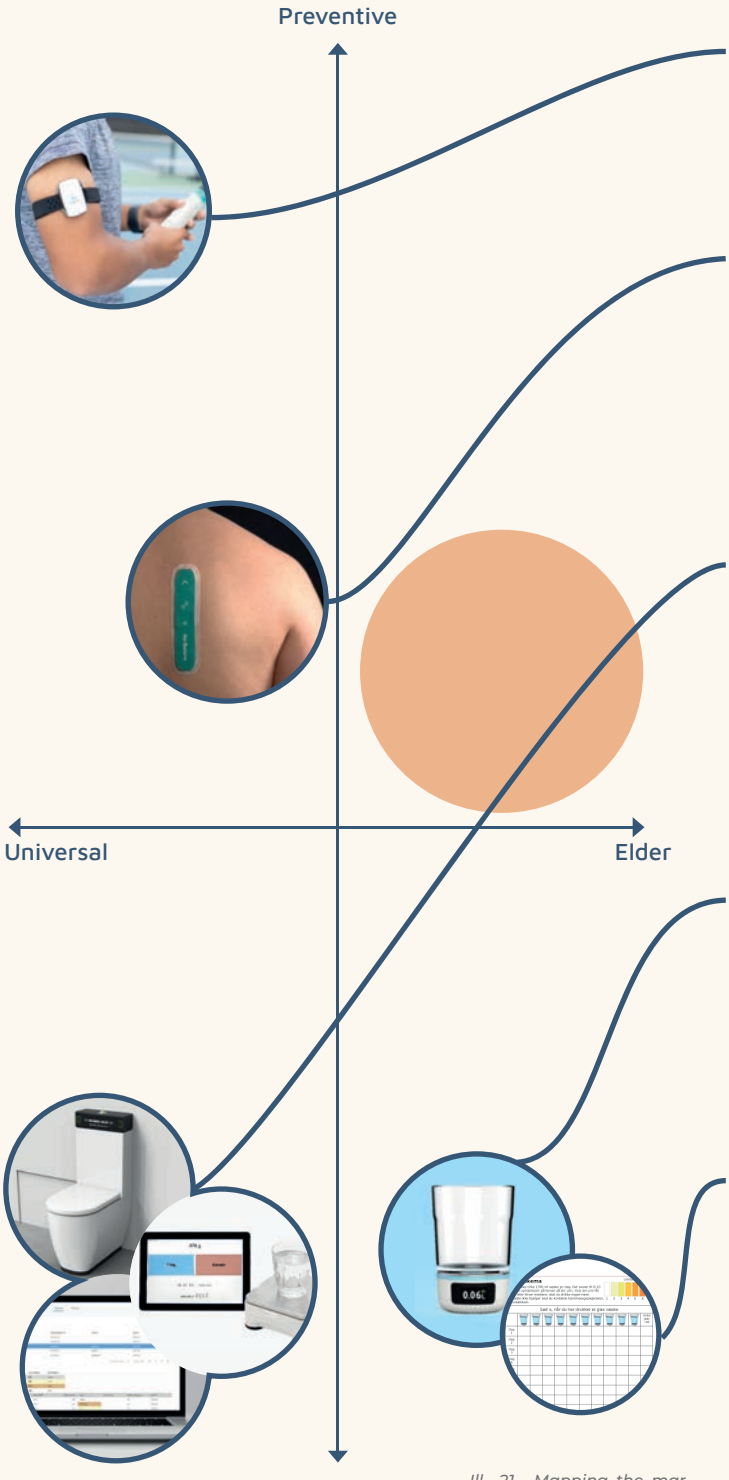
1.2.3 The position in the market

From the visit, we identified that both Tranders Høje Friplejehjem and the home care in Kærby Aalborg are only using the fluid chart when prescribed by the doctor. Most of the products on the market are a digitalization of the fluid chart, like Aquatimes, and Measurelet. There are products like Mode Sensor and hDrop on the market that can measure hydration, but they are not marketed toward identifying dehydration in elders.

Below there is a small selection of the products on the market. There is a short description of how it works. Further below, there are some bullets on how the stakeholder we interviewed saw the products, i.e. what are the barriers of the different products.

Most of the products on the market are reactive, especially the ones targeted to elders. So there is a potential for creating a product that is more preventive and easy to implement in the daily work of the HCWs or the elders' daily life.

Cacta claims that the technology will be the same size as the technology in thermometer.



Ill. 21. Mapping the market of the products for dehydration in elder care

hDrop

hDrop is a wearable product that monitors the hydration level through a sensor facing the skin and analyzes the data in real-time. It is designed for use in a workout setting (hDrop n.d.).

- Not designed specifically for dehydrating elders

Mode Sensor

Mode Sensor is a bandage that is non-invasive and can monitor the hydration level over seven days. It is not on the market yet but soon to come (Modesensors n.d.).

- Bandages will add even more procedures as the HCW need to change them.
- Some elders will take it off because they forget what it is. Mostly those suffering from dementia.
- Not designed specifically for elders
- It is a bit time-consuming to wear a plaster every day

Measurelet

Measurelet automates the fluid chart by having a scale connected to a program that automatically makes the fluid chart. They are developing an integrated solution with the toilet to measure feces as well. It is mostly targeted towards the healthcare industry where they use fluid charts more (Measurelet n.d.).

- It is just an optimization of the fluid chart. It is still time-consuming to apply in daily routines.
- It measures the fluid intake and feces output but does not motivate the elderly to drink. The market segment is primarily sick people where monitoring needs to be done.

Aqua Time

Aquatime is an intelligent cup that measures fluid intake automatically. The cup notes the amount and the time when the fluid is drunk and can send the data into the system used in the healthcare system, Cura (Aquatime n.d.).

- It requires the elderly to only use this cup for drinking.
- It only measures fluid intake, but does not motivate the elderly to drink
- It is just an optimization of the fluid chart

Fluid chart

Fluid chart is a tool used in healthcare where the fluid intake and feces are measured and noted (Lægehåndbogen 2021) .

- It is difficult for the HCW to have an eye on the water intake at all times.
    - The elderly could drink the water or pour it out, without the HCW noting it, resulting in the wrong fluid intake being noted down.
- It is time-consuming to apply this method n daily routines.
- It becomes a random guess how much the elderly drinks.

1.2.4 Feedback on ideas

In preparation for the visit, we made three ideas, which we showed them to gather more latent information about what works for HCW, and what are the pains and gains. The ideas were developed based on different directions the product could take, hoping it would help to shape the direction of the next idea generation.

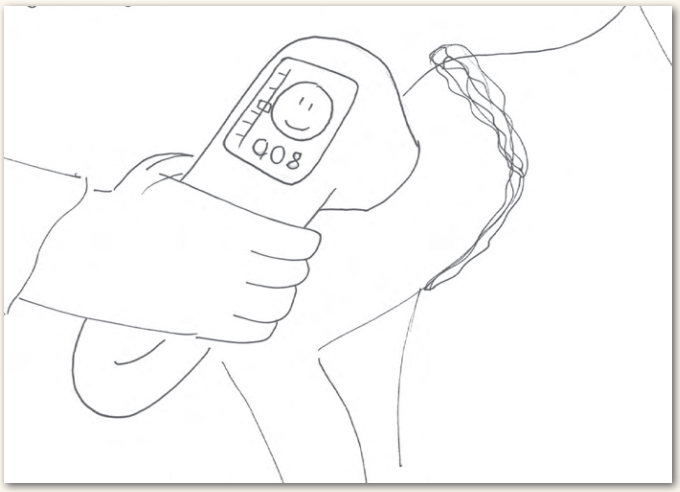
The table below will explain the ideas, and what rejection and hooks the HCW saw in relation to the different ideas.

General notes

"Just a device we need because then we (e.d. HCW) do not have to be the "policemen" the devices can be it" Jeannette – The HCW wants to take care of the elders and have a good relationship. The device can be the reminder instead of the HCW.

From the feedback, it is clear that the HCW mostly saw the product as reactive rather than preventive. They liked the handheld the most, because they thought the elderly will take off any product they do not normally wear, and they cannot remember why they should wear it. The manager was more fond of the smartwatch for home care because she thought the elders are used to wearing a watch and will keep it on. Both the HCW and manager questioned how much responsibility that can be placed on the elderly.

Handheld



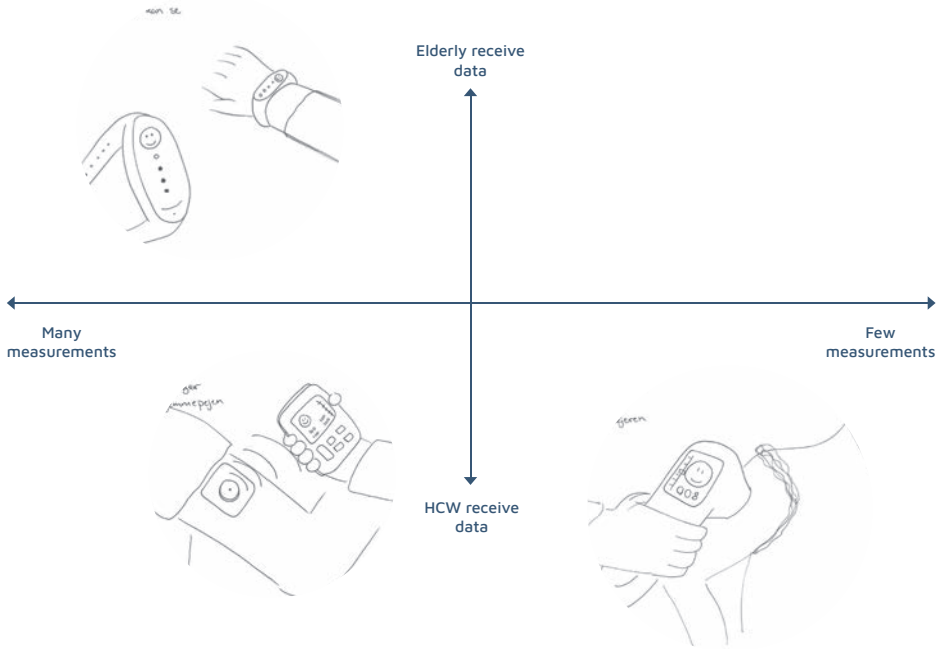
It works like an infrared thermometer. It is just placed on the skin to measure the hydration level.

"It would okay if the HCW comes to take a measurement" Oda - It is not a problem that the HCW needs to come and measure it. It just gives safety to the elderly.

"Perfect it can fit in a pocket" Trine – In home care, they only bring a small bag with they equipment i.e., it should fit in that bag. It is easy to bring along.

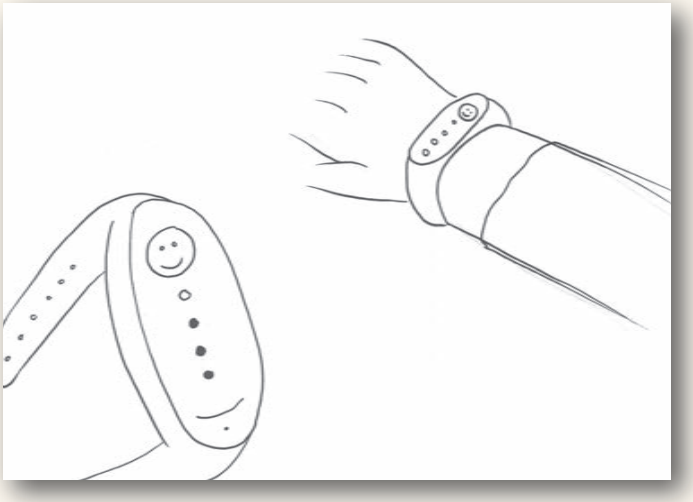
"Another device which needs charging" Janette – They already struggle with charging all the other devices they have like phones, tablets, etc.

"Smarter than the watch since the HCW has the control" Inge – The HCW questions if the elders are cognitively working well enough to manage it.



Ill. 22.

Smartwatch



The technology is incorporated into a smartwatch. It will send data to the HWC at all times and inform if there is a problem. Possibility of also showing the data to the elderly so they can manage their water intake themselves.

"It is nice that it gives a constant picture of hydration level, because right now, if we give the elderly a glass of water. Then when we come back later, we don't know if they drank it or threw it out" Inge – The product removes a sense of uncertainty from the HCW.

"The elderly with dementia would just take it off" Inge – Problematic to give a cognitively bad elderly the control.

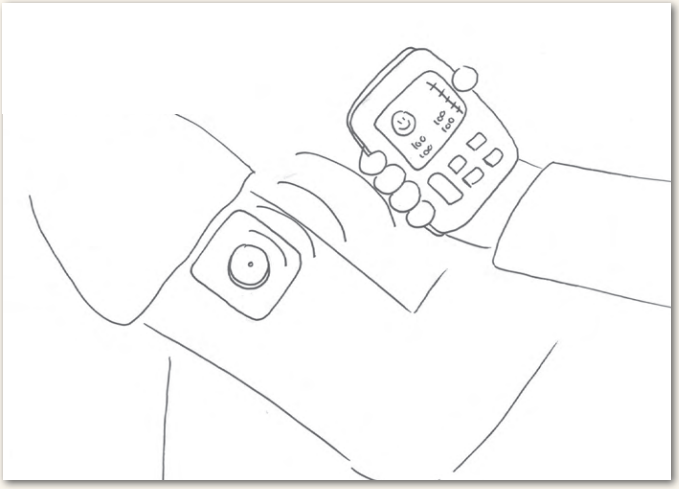
"A lot of relatives are replacing dementia watches with Air-tags because they do have to be charged daily" Bettina – There is a problem with the charging.

"It would work well for the home care because the HCW is only there for a short visit" Bettina – The HCW does not have to come all the way to the elderly to monitor the health of the elderly.

"The cognitively well-functioning elders can manage it themselves" Jeanette – Minimizes the work for the HCW.

"New technology is not necessarily good if it is not really in their interest" Trine – It will only work for the elders that are fond of new technology like a smartphone. *"Maybe it can be combined with the call button."*

Bandage



It is based on the same principle as used for persons with diabetes. The bandage is placed on the arm and measured constantly, but the data are only transferred when a device the HCW is holding is touching it.

"The elders with dementia would take it off because they forget what it is." Bettina – The bandage would not be good for the cognitively bad because it is an object to which they are not used to it.

"It is nice that we can just check without the elderly noticing" Jeanette – The HCW workers see potential in them using just discrete checking of the hydration level. Instead of reminding the elderly all the time to drink.

"It would be great if the data could be transferred to the table which we bring with us all the time" Jeanette – Not adding an extra procedure to their daily work.

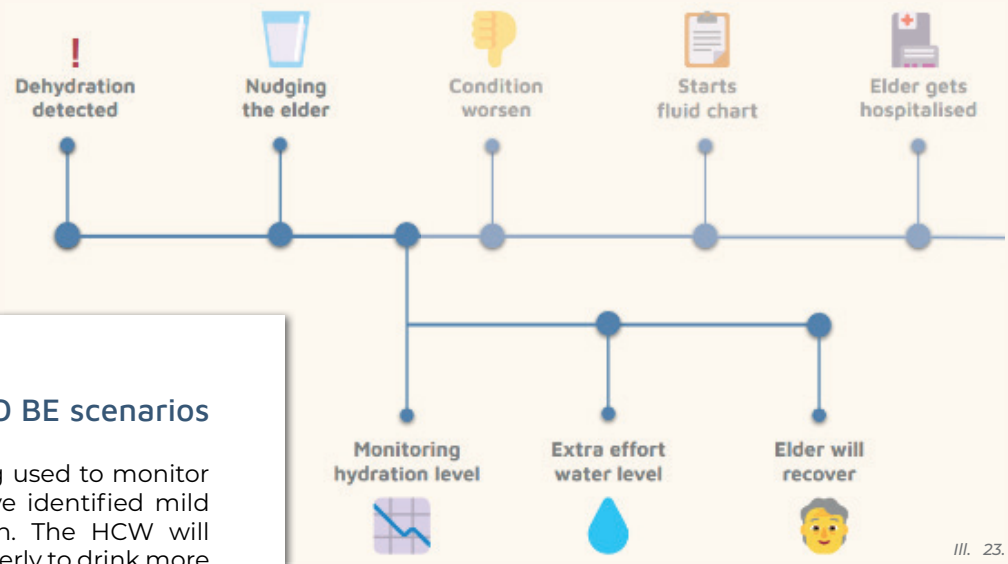
"It just gets placed on them to monitor when we have detected dehydration" Inge does not see it as a proactive device only reactive. The team is not sure if it is because they currently are only dealing with reactive devices to dehydration.

"How often should it be changed" Trine – The product is adding an extra procedure for the HCW to do.

"There is the need for getting consent" Trine – The product will place the elderly under surveillance which is something we have to take into consideration. Trine talks a lot about getting consent from the elderly in general.

1.3 Framing of the problem

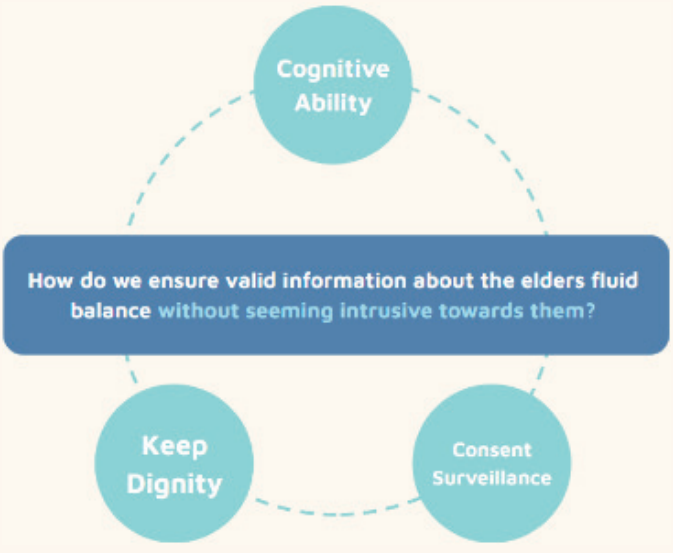
In the previous section, we gathered knowledge of the use context, stakeholders, and market for the problem of dehydration of elders. The following section will summarize the knowledge gathered and display it correlated to the design problem.



Ill. 23.

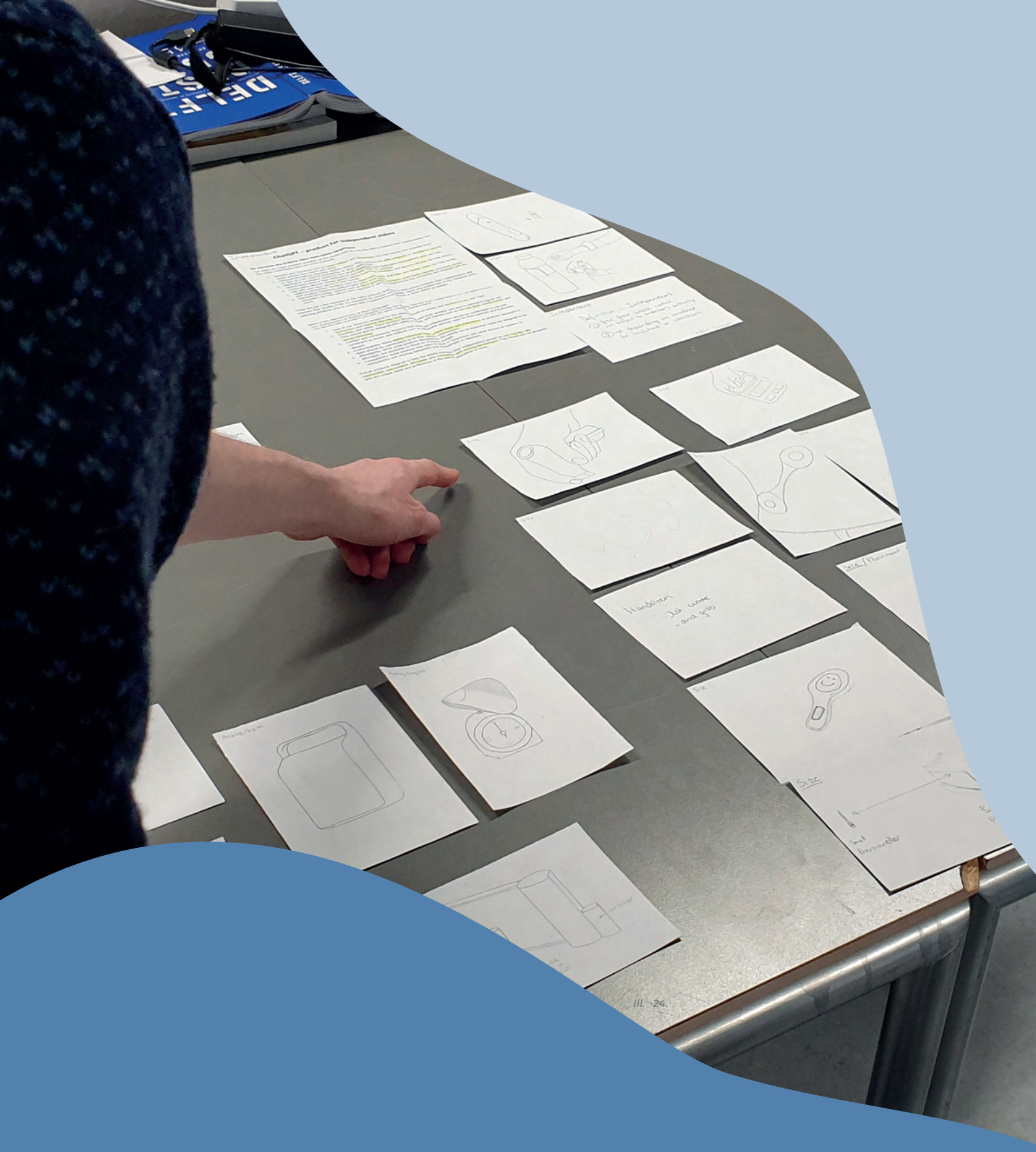
1.3.1 The AS IS and TO BE scenarios

We see the product being used to monitor elders after the HCW have identified mild symptoms of dehydration. The HCW will then start nudging the elderly to drink more water. Hopefully, it will work, otherwise more drastic methods can be introduced like giving the elderly a drip with salt water. They will then recover, and hospitalization will be avoided. This is, compared to the current producers, a less time-consuming solution than doing a fluid chart.



1.3.2 Problem framing

In relation to the problem statement, there are some dilemmas that the project revolves around. It is the cognitive ability of the elderly that influences how the product should function. It is about how to not compromise the dignity of the elders as they are used to doing things by themself. The method of asking them how much they have been drinking can appear intrusive. That can be solved by monitoring the hydration level but how does the product do it without the elderly feeling under surveillance? The elderly should not feel that they are being watched by “Big Brother” but feel safer because they are being looked after.



Ill. 24.

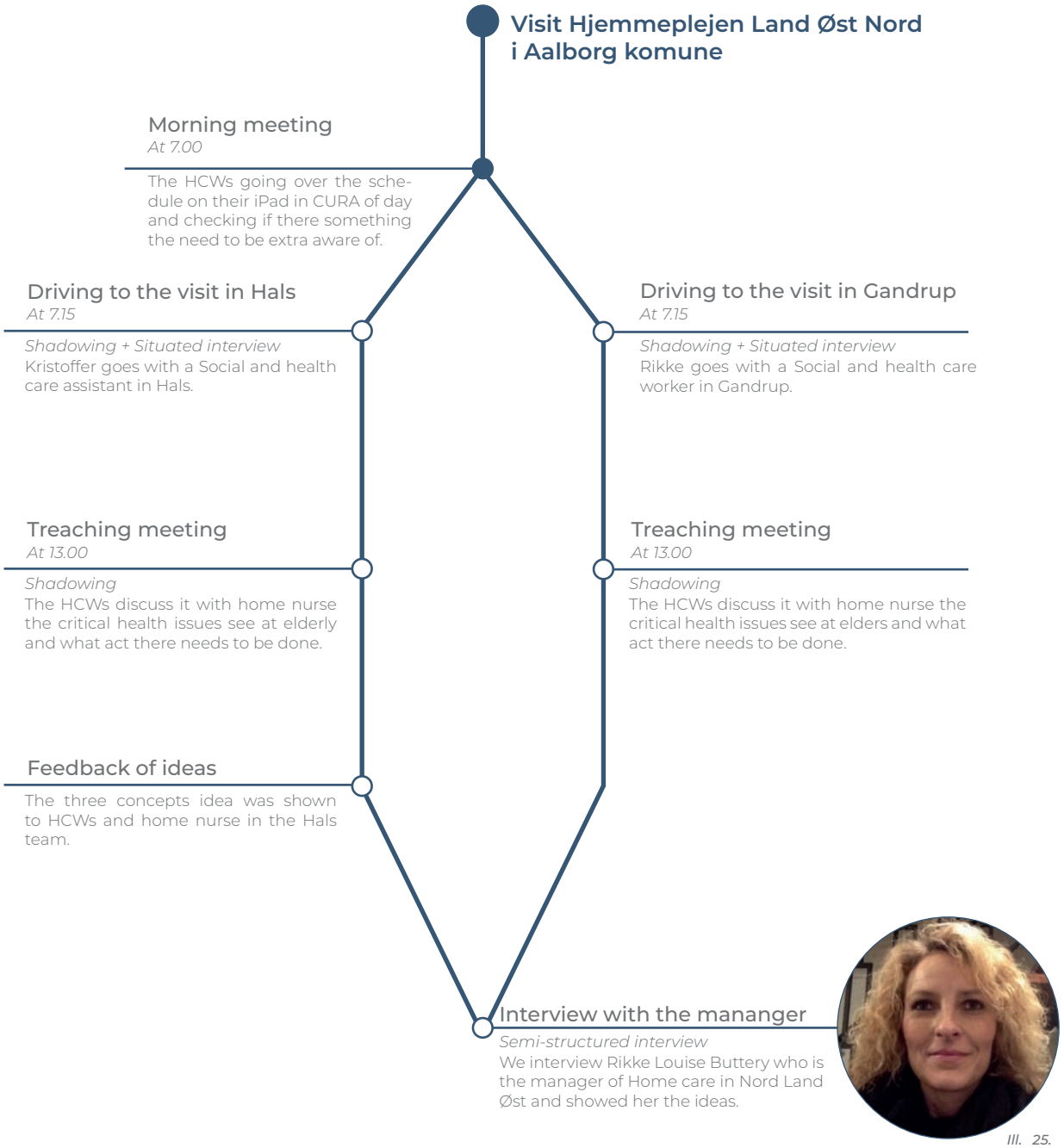
02 Concept direction

In this chapter we will be looking more into who the user is and how to make a product that suits their daily work.

2.1 A day in the work as home care

To understand the difference between the employees' work routines at the nursing home in Tranders Høje and the home care in the public sector, the team went on a day trip to a shadowing (Bagger & Sperschneider, 2003) two HCWs who are working for the Home Care Nord Land Øst in Aalborg Municipality. Each team member followed the HCW on their daily routine from 7 am - 1 pm and asked questions in the car in between the visits, i.e. a situated interview (Bagger & Sperschneider, 2003). Before the visit the team prepared some questions which they wanted to get clarified (see this and the full documentation of the visit in W10).

Each citizen visited was mapped on a scale from 1 to 5, before entering their house, in terms of their cognitive and physical abilities by the HCW. This made the team aware of the elderly's abilities.



Ill. 25.

The elders in home care were better cognitively compared to those living at the nursing home in Høje Tranders. The elderly living in the nursing home were only a bit more forgetful compared to the elders in the nursing home who could not remember who or where they were.

The elderly in home care are cognitively better.

The visit made us aware of the importance of having a good relationship with the citizen. A good relationship between the HCW and the citizen will both helped the HCWs to do their work assignments as the citizen were more cooperative. Especially when the visit was of nutritious focus, the HCW could utilize the relationship with the citizen to encourage them to drink more. They used both logos and pathos to affect the citizen, as the quotes from the visit show.

A good relationship between the HCW and the elders will improve the quality of the HCW job.

"You know it is not good for your stomach to take pills without water."
"You will feel better if you..."
"It will make me happy if you..."
"Can I convince you to..."
- HCW

Having a good relationship with the elderly also made it easier for the HCW to introduce new assistive devices to the elder. In homes where the HCWs did not have as good a relationship with the citizen, they were very aware of how they spoke to the citizen. A quote from the HCW before entering the house:

"I have to be careful what I say here." - HCW

The team is aware of the bias that we possibly only followed the "good" HCW i.e., the only one the manager would let us shadow .

The manager had a different view on the relationship. She knew the importance of it but was more focused on optimizing their resources and services. She called the work assignments they were doing for the elderly. She mentioned that over the next five years, 30% of her staff would stop as they would go on retirement. At the same time, the number of elders would grow as the boomer generation would start retiring. This made her very aware of how she should manage her resources. Due to this, she was very fond of video check-ups with the elders, as this saved time driving to the elderly. The pill-dispenser-robot, Smila, dispenses the pills when the elderly should take the medication. It will notify the HCW if the pills are not removed from the tray within a period.

The manager wants to outsource as much of the work of the HCW to machines which will make the elders self-supporting. Which is necessary due to the lack of man resources.

Ill. 26. Handheld

Ill. 27. Smartwatch

Ill. 28. Bandage

This made the manager fond of the team's idea with the watch (see ill. 26-28). She implied that it could be combined with the call button. It could also measure all the parameters for an ISBAR measurement, (see page 11 for the explanation). The watch could keep an eye on the elderly. The HCW could get a status on the elder's health from the watch and just call them over the tablet, saving time on driving.

During the visit, the team was made aware of the upcoming population growth of elders, as the boomer generation is beginning to retire. This was a deal breaker for choosing either the HCW or the elderly as the main user. While resources decline, the population of elderly grows. It will make sense to make a product that the elders could use themselves. That can also help the HCW to keep an eye on the health of the elders. This ties into a dilemma that revolves around fewer resources and the relationship between the HCW and the elderly. The team would like to unfold this scale further.

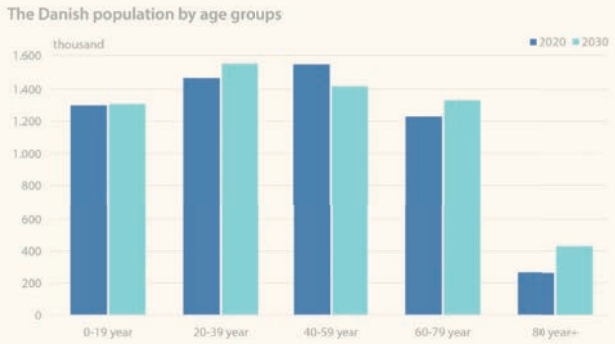
Lastly, the visit further showed an interesting dilemma concerning the elders who need help but do not want it, versus the elders who want help but do not need it. This dilemma will also be explored further.

Reframing

Problem statement: How do we ensure valid information about the fluid balance of elders without seeming intrusive towards them?

Insight:
- Resources in the home care sector are decreasing as the boomer generation is retiring. (This is a political question, as they could just delegate more resources).
- The HCW utilizes their good relationship with the elders to influence their cooperation.

Dillames:
- The elders should not compromise their dignity using the product. (What do we exactly mean by dignity?)
- The elders should not feel surveillance is the product. (What do we exactly mean by surveillance?)



Ill. 29. (Danmarks statestik 2020)

2.2 Idea generation elderly users

The visit to the home care made the team choose the user direction elderly. At this moment, the team had used a lot of time in the problem space. Now the focus moved to the solution space to see what the current knowledge could provide to the solution.

It should be noted that the team wished to speak to the elders on their next visit to Høje Tranders elder care, to get to know the user better. The team expected the elders could have a hard time giving feedback on something that did not look finished, so they prioritized making very realistic products they could present to the elders at the next visit.

To initiate the development of concepts, the team made a brainstorm revolving around: "What is it (the measuring device)", i.e., what can the product relate to, (see W12). Four words were picked from the brainstorming, and four minutes of sketching were used for each word, i.e. we did a Draw to define (Boeijen et al. 2014).

The words were: accessories, good relative/relation, reminder, and Google Home. In the end, the team also made a sketching round inspired by the HCW who said she treated people how she would like to be treated, if she were in their situation. The round was named "If it should be for us".

The sketches below, ill. 30, are the chosen sketches based on the team's evaluation of which ones had the most potential, (see W12 for further explanation). In the discussion of most potential, the team discovered that they were constantly going back and forth between different user types. E.g the teddy bear that could speak to the user and tell them when to drink water was mostly directed towards a user with a low cognitive level. The watch that reminds the elderly to drink by buzzing and showing an icon of water was more directed to a user with a normal cognitive ability.

This made it clear that the user was not defined enough to be utilized as a tool for decision-making. The team decided to dive deeper into defining what kind of user that needs a device that can monitor their hydration level.

Reminder glass | Speaking teddy bear | Calender | Reminder watch | Reminder radio

Ill. 30. The five ideas that the team decided on with the most potential.

2.3 Defining the user

In this chapter we define more clearly which target group of elders we are designing for. These are abilities the team had identified through the visits at Høje Tranders nursing home (W01), and the Home Care Nordland Øst (W10).

The team started by mapping the elders we visited on a scale (to get an understanding of each characteristic, see W13 for the elder's characteristics). The team decided on the following explanation for each characteristic, ill 31.

The definitions are not absolute and there is still a lot of room for interpretation. It is to establish some terms to use further in the report.

We defined the characteristic of the user as visualized in ill. 31. Below the reasons are unfolded.

The team evaluates that the cognitively good elders will be able to use the same product, making the product more inclusive. Thus, the user should be elderly who are a bit cognitively challenged. On the other hand, the elderly should not be so cognitively challenged that they have severe dementia. Since they will receive a lot of services from an HWC, the HCW will keep an eye on their water intake.

There is ambiguity when dealing with a user who does not want help but needs it. It will create more value for the product if that can be solved, i.e., metaphor grumpy old men. This grumpy old man is more likely to end up at the hospital due to dehydration since he believes he is capable of doing stuff he cannot do anymore

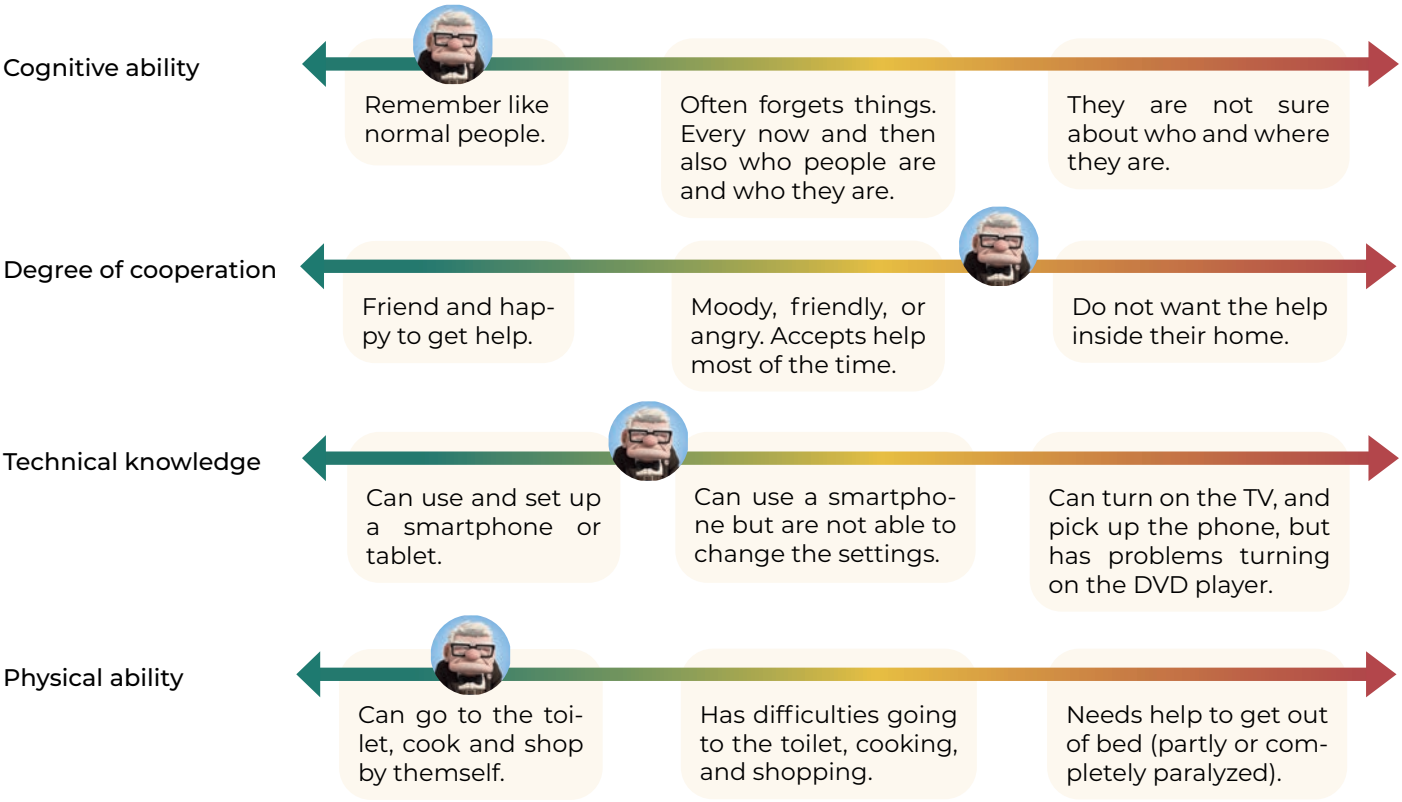
The third characteristic is the elder's technical knowledge. The team evaluated that the elderly should be those who are a bit challenged by technology, as the elders otherwise just can get a regular smartwatch to remind them of when to drink water. The level of their technical knowledge ties into the stories the team had heard on their visits, as the "grumpy old people" in these stories often were skeptical of electronics.

The last characteristic is the user's physical abilities, which the team evaluated to meat average as elders with physical disabilities are assumed to get a lot of help from the HCW.

The vision is to create a product that can assist the grumpy old man in taking care of himself. The reason for choosing this user is that if you design a product for a "red" elder, a "yellow" and "green" elderly will also be able to use the product (ill. 31). In future work, the elders whom the team is visiting will be mapped into these four characteristics, so the team can relate the elders they visit to the target user.

The term intrusive was applicable when we were making a product the HCW should use on the elder. Now we are working with the elderly being the main user. The team needs to explore what will make the grumpy old man use the product. The purpose is to make the elderly healthier as the elderly gets aware of their hydration level.

The main user is a grumpy old man



Ill. 31. The definition of the different characteristics describing an elder.

2.4 Second idea generation

After defining the grumpy old man, the focus of the team was to develop ideas to bring to a second visit at Tranders Høje Friplejehjem. The purpose of the visit was to get answers to the following questions: What appearance should the product have for the elders to want it visible in their homes? Will the elders feel like they are under surveillance if they have a product on them all the time that monitors them? How can we remind the elders of taking the measurements?

After more clearly defining the user, the process went back to product development. Since the previous idea generation, (chapter 2.2), had given little value to concept direction, the team went back to the scale of few to many measurements (chapter 1.2.4). To answer the questions mentioned above, the team developed four concepts: the ISBAR Monitor, the Personal Health Assistent (PHA), the Health Call-Button, and the Health Watcher. (Look in W14 for further information about the development). Furthermore, the team also prepared a series of pictures of watches. The intention was to make the elders rank what they liked, so the team could get an idea of what the elders found appealing.

Feedback from the second visit at Tranders Høje Friplejehjem will be noted alongside the ideas formatted in blue cursive. It is a sum-up of an interview with two HCWs and two elders. To see a full summary of the feedback, see W15.

ISBAR Monitor

A device for the HCW that has interchangeable ends, so it can do all the measurements required for an ISBAR and a hydration measurement, as this should become a part of the ISBAR.

The idea is developed based on the feedback from the home care manager, chapter 2.1: *...maybe also could measure all the stuff for an ISBAR measurement.*

Disclaimer: This idea is developed even though our primary focus is on the elders, since the team had to check the direction. The team thought of it as a handheld version of the Personal Health Assistent.

The HCW thinks it is too complicated for elders to manage, compared to the two other concepts. But it would be a great tool for the HCW.

Ill. 32.

Ill. 33.

Health Call-Button

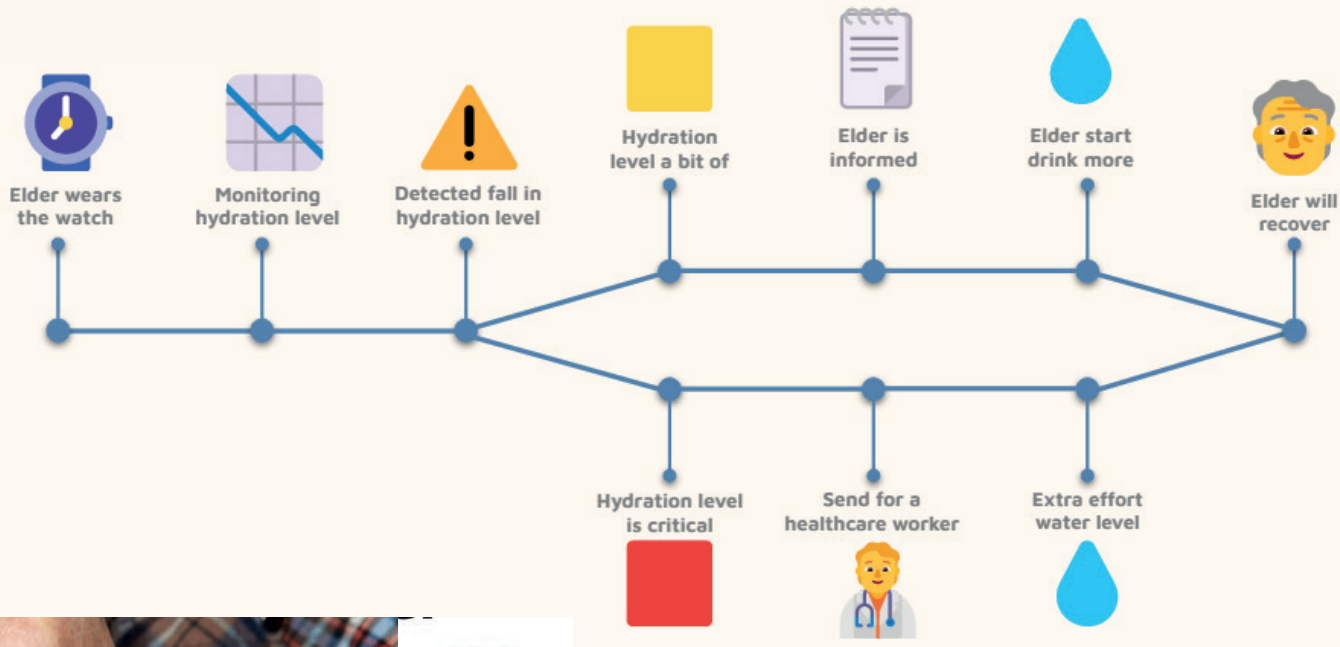
A device that can measure the hydration level of elders and work as the call-button.

The idea is developed based on the feedback from the home care manager, chapter 2.1: ...could be combined with the call button. Further, the team had a vision of an elderly with several wrist devices on one arm, which they wanted to avoid.

The HCW thinks it is perfect because it monitors the elders all the time. e.i. They can pay less attention to dehydration. But the HCW is unsure if the elders would like to wear it due to style.

The elders are fond of the idea as it would remind them to drink. They also assumed they would be able to see how much they had been drinking. But the test with different watches showed that the willingness to wear it was determined mainly by style and it differs a lot.

Ill. 34.



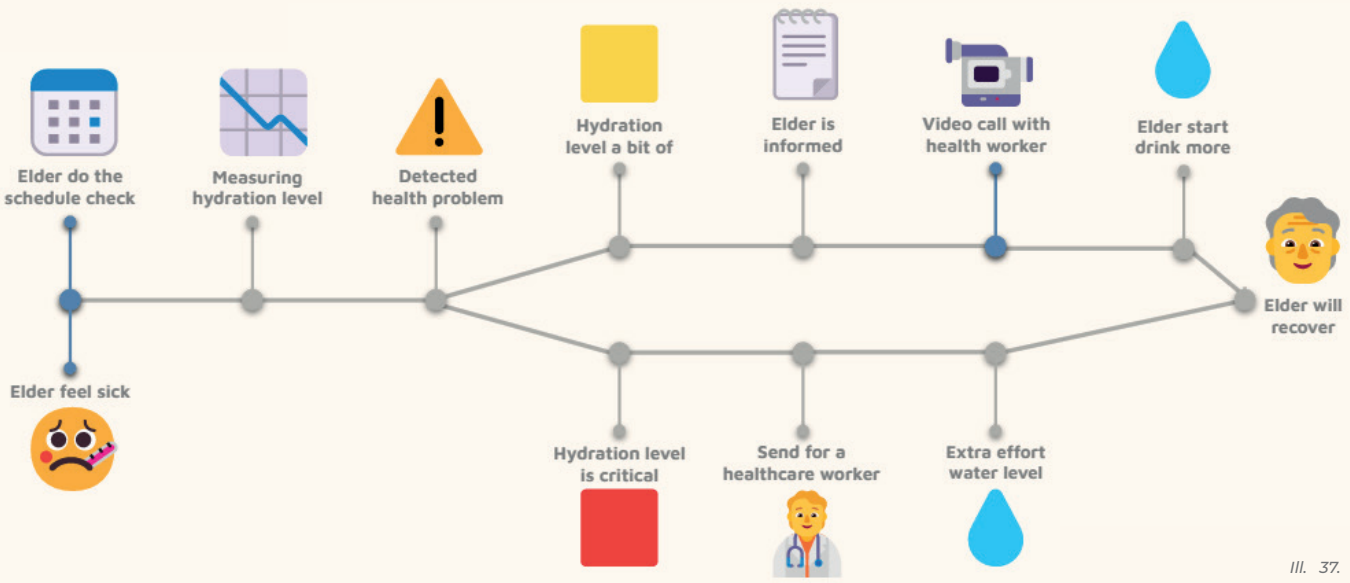
Ill. 35.

Health Watcher

A device that looks like a normal watch but can measure the hydration level and inform the user by lighting up icons, like in an old car when the motor light turns on. The to-be scenario is almost the same as the PHA except this device has no function of calling the doctor itself.

The idea is developed based on the watch idea from chapter 2.2 and the idea direction from chapter 1.2.4, fig 22 where it is the elderly who receives the data, and the product takes many measurements.

The feedback was the same as for the Health Call button.



Ill. 37.

Personal Health Assistant

A device that helps the elders monitor their health when they want to. The product should make the elders able to take all measures necessary for an ISBAR. Depending on the outcome of the ISBAR, the product should give feedback to the elderly and tell them if they should contact a doctor, as the to-be scenario shows.

The idea is developed based on the "missing" idea direction from chapter 1.2.4, fig 22, where it is the elderly who receives the data, and the product takes a low amount of measurements.

Both the elders and HCW think there is potential in the idea, but the question is how the elders are to remember to take the measurements. A HCW mentions that if the product were connected to a routine, it could help the elders to remember.

The HCWs all agree that this idea is the one best fitted for a grumpy elder, as it gives the elderly control.

Ill. 36.

As the ISBAR-monitor was intended for the HCW and not the elders, it is deselected. But the feature could be implemented into a smartwatch. The watch does not help build up relationships with the elders which we have identified as a key factor for getting the elders along. It can also make the elders feel under surveillance.

If the elderly has control over the measurement, they will feel less under surveillance.

Surveillance is a dilemma in terms of the law as there is the need for the elderly's consent. But more important is the need for the elderly not to feel under surveillance. An HCW also told us about an elderly who had put a towel around the call button and shoved it in the back of a drawer as he felt like he was under surveillance. The product should find the right balance.

This scenario is to be avoided, which is the reason why the team is going with the Personal Health Assistant. Furthermore, the feedback from both the HCW and the elderly support the insight about surveillance above, as they agreed with this idea being the best for the grumpy elderly. This is because it would be the user who decided when to take the measurements, so they assume the user would be less suspicious of surveillance. But even the elders who are not suspicious about surveillance do not use the call button. The story below explains these aspects.

Dignity, e.g. with call button: Lillian experiences falling from time to time, but did not use the wristband call button. When we asked why, she explained that it was ugly. Instead, she had placed it on the lowest shelf in her bookcase, so she could reach it when she fell. Thereby the call button is not used as intended.

The product should not compromise the dignity of the elderly.

From the visit the following question arises: How do we make sure they want to use the product, so they do not risk losing their dignity with their workarounds?

Before the visit, the team had a hypothesis that the elders' willingness to use a product was linked to the appearance of the product, which is why the team asked the elders to rank some watches in terms of which ones were most appealing to them. The team learned that the elders would only use the ugly call button if they validate the function over the aesthetic (See W15).

The function is more important than the aesthetic. Remember to accommodate elders' disabilities.

In our visits we asked the HCW how they manage a "I can do it by myself"-type, since the product could use some of the same approaches. They answered that they either try to convince them with logic or kindness, like "It would be best for your body if you" or "It would make me happy if you could". They also kept mentioning their relationship with the elder. The same three things as the HCW from the home care are mentioned in chapter 2.1.

None of the elderly thought that they needed help with dehydration; they did not see the product intended for them. This the team sees as a link to the problem scope of "helping elders that do want help".

The next step will be to elaborate on whether the feedback 'routines could be of help to remind the elders and see which routine the PHA fits best into. Further knowledge on how many and how often measurements are needed needs to be researched, as the team assumes it will have an impact on which routine the PHA fits best into.

2.5 Measuring of dehydration

$$\frac{\text{body weight [kg]} * \text{fluid in body [\%]} * \text{fluid you may lose before you experience dehydration [\%]}}{\text{body weight[kg]} * \text{rule of thumb of fluid intake per day related to weight [L]}}$$

$$\text{awaken hours [h]}$$

$$= \frac{\text{time bedore the body shows symptoms of dehydration [h]}}{\text{houres in a day [h]}} = \text{number of times a measurement is needed in 24 hours.}$$

The purpose was to get an idea of whether the measurement was to be done every hour or just once a day to narrow the solution space. The team did desktop research and made a very vague calculation of it, (see W17).

The team found no formulas for how fast dehydration can happen, so we made a formula on knowledge gathered from the desktop research. As the team cannot qualify if all the necessary factors are taken into consideration, the output should be considered as a vague guess.

The result was that the user should make a measurement 1-4 times a day. Further, the team has identified the following influencing factors on the body's hydration level. The factors are named in random order: temperature, activity level, the number of carbohydrates you consume, body mass (as the fluid percentage in the body decreases in bigger bodies), age (as the fluid percentage in the body decreases with aging).

To avoid dehydration a measurement should be done 1-4 times pr. day.

2.6 Elaboration of the user

Elders' routine

Elaborating on the feedback "Routines could be of help to remind the elders" from the HCWs. By introducing it with a routine, it does not need to remind the elders by utilizing alarm noise or flashing lights.

To define elders and maybe get information on their routines, the book "Fra Vugge Til Krukke" was used, as it has a description of the 17 life stages. (Kongsholm 2020) The elderly this project revolves around is in the categories of "Hjemmegående-" or "Afhængig senior", which is described as:

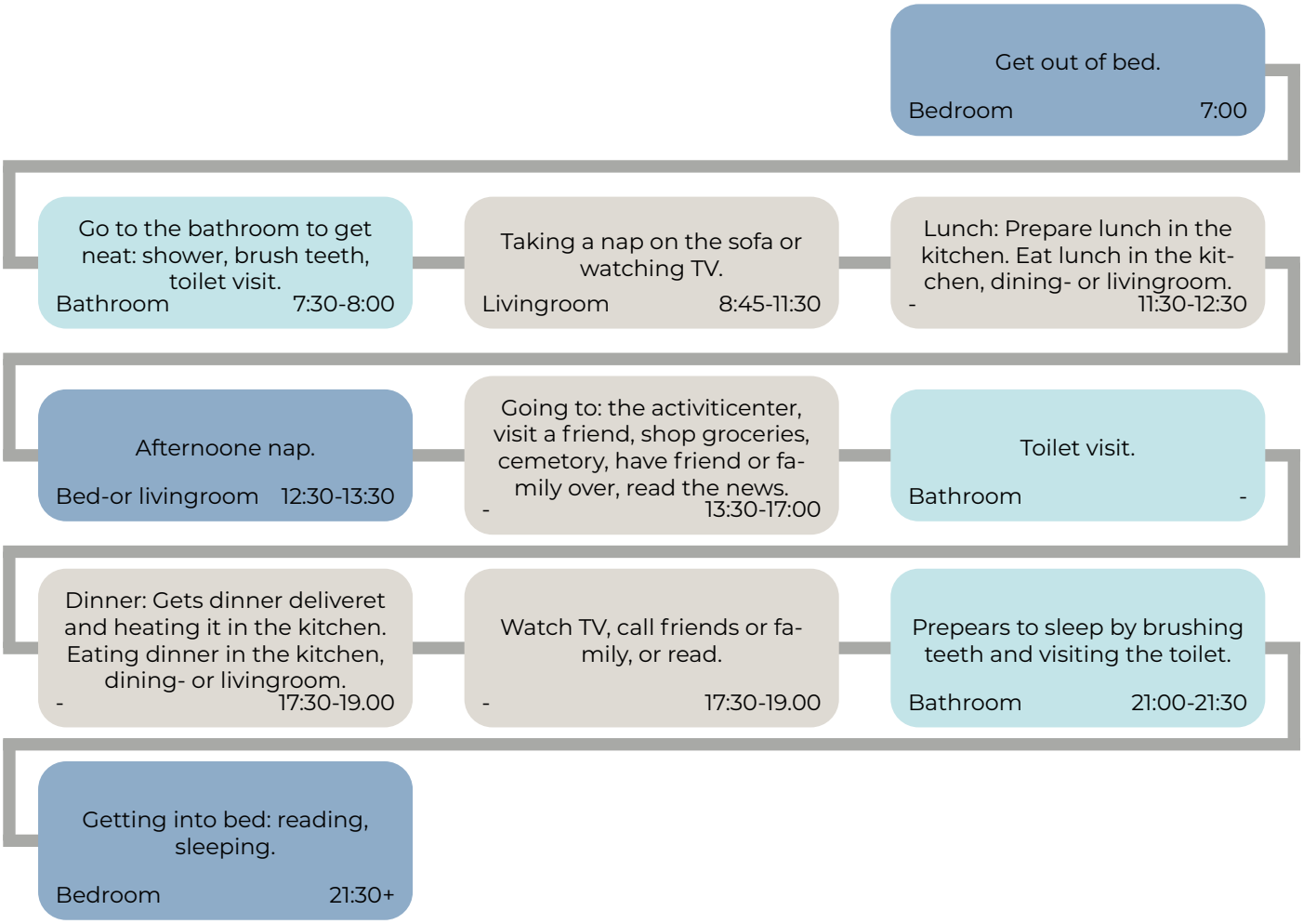
- Some live in sheltered housing (beskyttet bolig)
- Self-supporting
- Start to forget things
- It is harder to multitask or do complicated tasks
- The municipality tries to make them self-supporting for a longer time as possible
- Most of their life is at home
- Next step in life is to get help by HCW
- The cognitive process is slowing
- Most money goes to daily necessities, medicine, and family

The routine mapping is done with the knowledge from our visit at Tranders Høje Friplejehjem, (W01 and W15), and our visit at the Home care, (W10).

We assume that the activities made between breakfast, lunch, dinner, and after dinner can change from day to day and from elderly to elder. Read the illustration from left to right: Activity, Location, and Time.

The activities done in the bedroom, bathroom, and kitchen are routines you need to do every day. The living room has many more activities. The bedroom is taken out as we do not want the elderly to drink right before sleeping, as that would result in a night visit to the bathroom. Furthermore, the living room is common for guests. The users have earlier expressed a wish for putting the device away for when guests are coming. Therefore, we will not consider the living room.

The device should be a part of a routine in either the bathroom or kitchen.



Elders' pains and gains

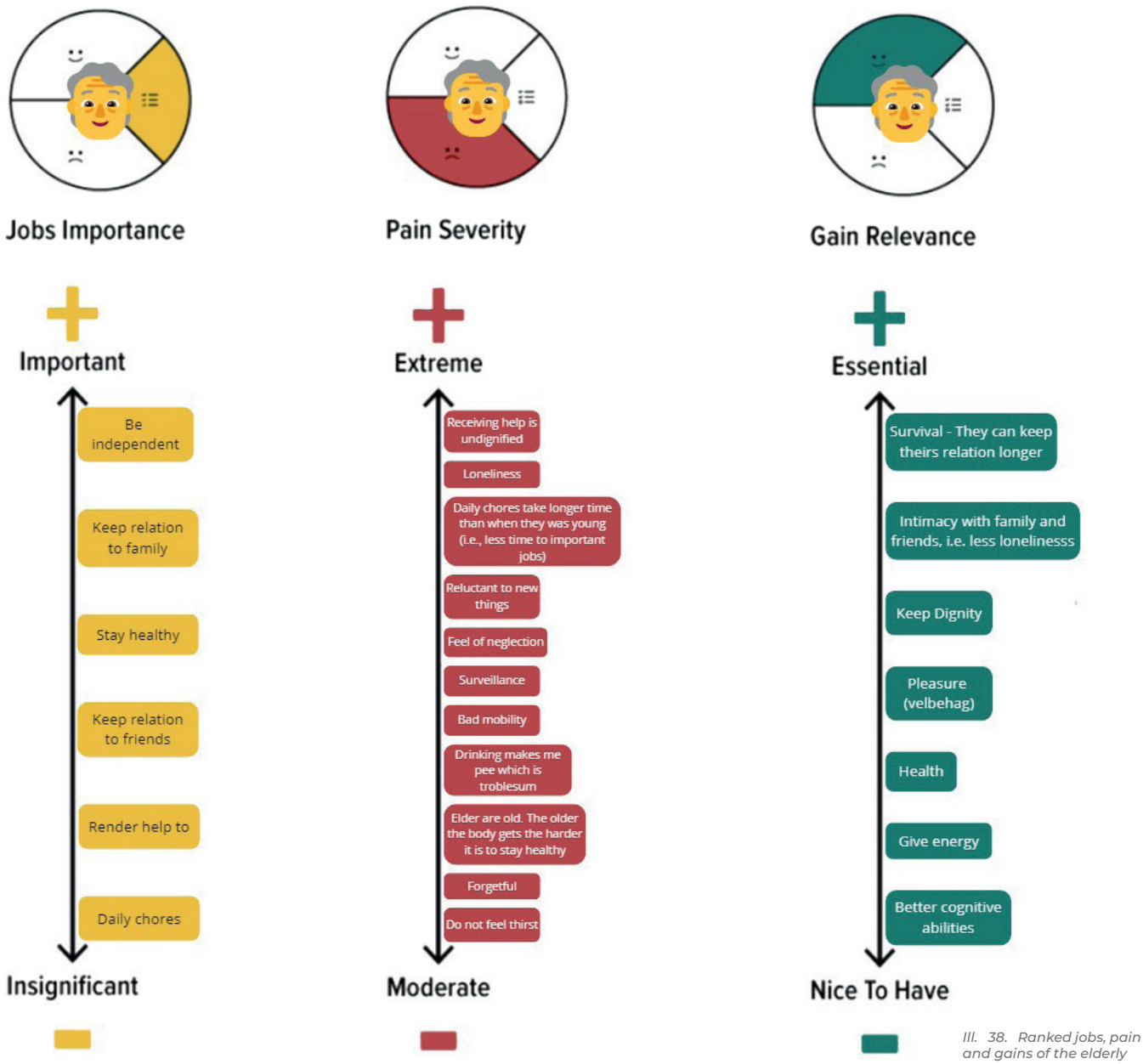
From visiting the elders (in section 2.4) the question 'How do we make sure the elders want to use the product?' arises. To answer this question, the elders have been mapped into the customer profile from the Value Propositions Canvas (Bernarda et al. 2014) along with the other stakeholders: Manager and Health Care Worker, (see the full work in W19).

The ranking shows the top two main drivers of both the pains and gains are to keep relationships and not be lonely. In the case of the grumpy old man, the aspect of being independent is also visible. The knowledge of relations being important for the elderly was also established earlier in chapters 1.2 and 2.1 as well as mentioned in the book 'Fra vugge til krukke' where it is stated: That relationships with family and friends are a large part of the elderly's enjoyment of life (Kongsholm 2020).

The ranking also shows that the pain of 'not feeling thirst' is ranked as the lowest pain. It is ranked as such because many of the elders during our visits said: "I'm certain that I drink enough, but I'm sure many of the other elders don't". These statements tell us that the customer segment is not aware of the problem and probably will not be interested in buying the product. To make the product more appealing to the customers, the team will try to give the product increased value by incorporating their highest gain, relationship, into the product.

The product should make the user more independent to keep the relationship with relatives.

As the symptoms of mild dehydration are reduced performance and fatigue, exhaustion, and confusion. The elders will have less energy for being social. The mission is, therefore, to utilize the elders' want for socializing to motivate them to use the product.



Ill. 38. Ranked jobs, pain and gains of the elderly

2.7 Concept development

After being in the problem space and defining the user more clearly, the team now starts to develop the concepts. The following section will provide a quick overview of the concept development. The goal is to create mock-ups that can be tested the next time we visit Høje Tranders Friplejehjem.

To kickstart the concept development and to narrow down the solution space, the principles from How-tos (Boeijen et al. 2014 page 175) were used. The How-tos headlines were divided into the space areas: placement of measurement of the body, size, context placement in the kitchen, context placement in the bathroom, digital versus analogue, and independent. After sketching the ideas on paper (W22), the team chose five concepts which were made into mock-ups.

The five concepts were evaluated based on seven parameters identified from all the previous visits: bad mobility, space for technology, visibility, hearing, long measurement, short measurement, and ease of even pressure. The ideas were ranked from best to worst for each parameter.

The ranking showed a big difference in the parameters 'long measurement' and 'short measurement', as these parameters affect what concept would be most suitable.

How long does it take to do the measurement?

The following shows the path from the initial drawing conducted by the How-tos to the mock-up and the consideration for each concept chosen. The developmen were focused on the folowing:

- *Fit size of technology (thermometer)*
- *A part of routines*
- *The elderly mobility*

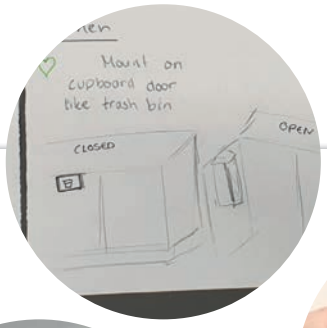
Ill. 40.

Handheld
Short measurement

Handle of Handhelds made it difficult to "press" the measuring points against the skin.

The Handheld has potential as it is not locked to a specific area and you can take it with you around the house.

The placement by the toothbrush mug is convenient, as you will see it when you are brushing your teeth.



Cabinet
Short measurement

The handle from the Cabinet form was better than the Handheld, as Handheld was easier to do motor-skill-wise, and easier to apply even pressure to.

The team will consequently apply the form from Cabinet to the Handheld.

Ill. 39.

Fridge
Short measurement

As forearms can vary a lot in size the product can have problems in fitting all people, as the electrodes used for the measurement may not reach.

Further, the team is concerned about how the product will get power and be mounted on the fridge, as not all fridges have a metal cover (not magnetic).

But it is a good placement, as you will see it when you are cooking, reminding you to drink and eat at the same time.

Ill. 42.

Around arm
Long measurement

Around arm does not hinder the mobility of the hands, and thereby can be used in both routines i.e. brush teeth, cooking.

Ill. 41.

Finger
Long measurement

Would only be usable in the routine of brushing teeth and not in the making lunch scenario as it hinders the mobility of the hands. Also small for elderlies to use.

Ill. 43.

The evaluation alone did not lead to a choice of direction but facilitated a discussion. From this discussion, the team ended up choosing the concepts of Handheld and Around Arm and the locations fridge, toothbrush mug, and cabinet.

2.7.1 Interaction test at Høje Tranders Friplejehjem

After choosing the Handheld and Around the arm, the mock-ups were developed for a visit to Høje Tranders Friplejehjem. The mock-up was refined into the following four mock-ups. These were tested on six different elderlies (for a full description of the approach, ranking of the elderlies, and documentation, see W23). During the visit, the team showed the elderlies how to use each mock-up and asked them to rank the mock-ups from best to worst.

Before the visit, the hypothesis was that the Handheld Foam would be the most intuitive to use. This was rejected during the visit as the Handheld Cardboard was better. The elderly instantly knew how to place it on the arm, even the blind ones. A second hypothesis was that the elderly would have difficulties using around-arm cardboard. This was proven. The visit also showed us that Around Arm Foam worked better than expected.

We chose to refine the Around arm Foam and Handheld Cardboard.

> **i** All the elderly are still saying it is only a problem for their neighbours

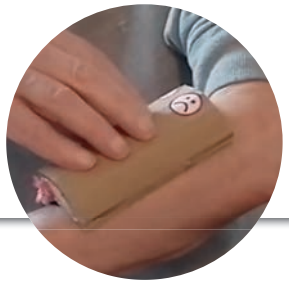
Ill. 44.

Handheld, foam

None of them used the handle as we intended. They used more time to decode the use of the product than the other concepts.

"It is easier because it has a handle."

Ill. 45.



Handheld, cardboard

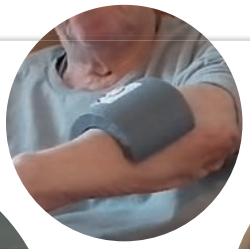
A lot of them just place it on the arm without having to think about how to use it first. They have to remove it from their arm to read the screen.

"It is just right."
"This one is the easiest."

Around arm, foam

It is too small for their forearms, so they were unsure if the electrodes reach the arm correctly.

"It (i.e. Handheld cardboard) is more difficult."



Ill. 47.

Ill. 46.

Around arm, cardboard

For elders who are not used to doing blood pressure measurements by themselves, it was very difficult to tighten.

"Do you have to do it yourself?"

2.7.2 Which routine

At the visit at Høje Tranders Friplejehjem, we asked the elderlies which location in the house and which routine the product would fit best into e.g. kitchen, bathroom. (identified in chapter 2.7 and 2.8.). Here are some quotes from the interview with the elderlies:

"I think it should be in the bathroom then you can just take a test when you are there" - A woman aged 87.

"Nice if it could be removed when you have a guest." - A woman at the age of 92. She did not want it in the kitchen, because then guests could see it when they visited.

"Would be okay if it was in the cabinet in the kitchen." - A woman aged 92.

"It could become a habit" - A woman aged 85.

"It makes the most sense to place it in the bathroom because it is a habit to brush your teeth." - Woman aged 97

The interviews showed that it should be placed in the bathroom because it can become a part of the routine of brushing teeth and it is more discreet in that room if the elders have guests, compared to the kitchen.

Measurement should be a part of the routine in the bathroom.

Disclaimer: The test was done at Høje Tranders Friplejehjem, meaning the test subjects were older than our target group. On the other hand, the cognitive abilities of the elderlies were good. We also only tested one man, It was difficult to find test subjects that were in the range of our users. This could indicate the test result is vague.

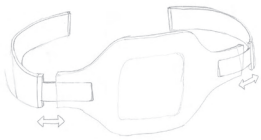
2.8 Refining

After choosing the two interaction principles (i.e., Around arm Foam and Handheld Cardbaord). The next step was to visit and get feedback from Cacta. But before that, we made finished concepts to present to them to get better feedback. The following section will provide a brief overview of the process and the thought behind it (W24).

Around arm

Ill. 48.

Ill. 50.



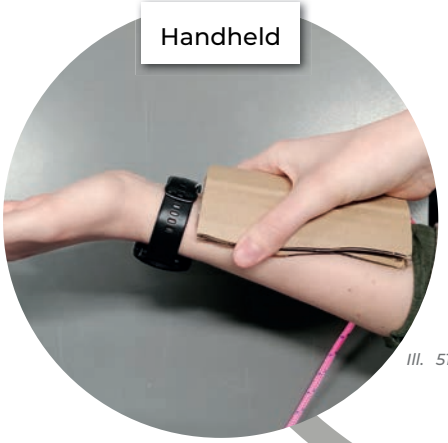
It is assu
can put
and pres
in, like w
headpho
the grip.

Ill. 49.

The inspiration was a textile rubber band.

Maybe the elderly can pull this over just as easily as they pressed the model of stay on arm on their arm.

Handheld



Ill. 51.

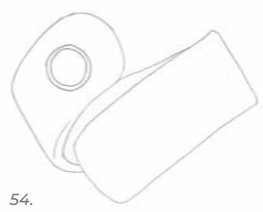
Ill. 53.

Assumption: A charging stand makes it easier to charge the phone than plugging a small cord into a small charging hole.

Ill. 52.

An indent to affort where to put the hand.

- *Correct pressure feedback.*



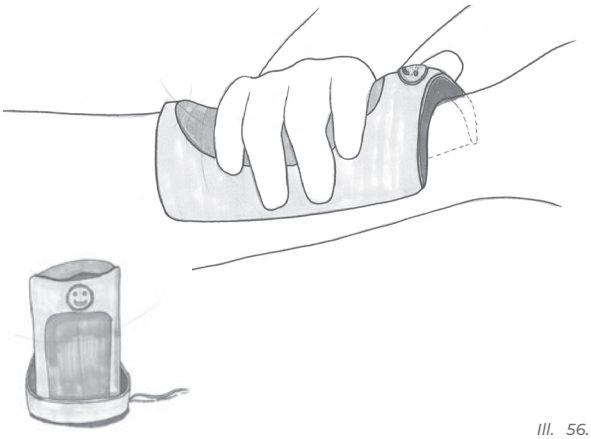
Ill. 54.

Assumption: The shapes are too futuristic for the elders and hard for them to understand. We want a straight forward product.

umed that they the product on ss the extenders with an over-ear ne, to tighten

Ill. 55.

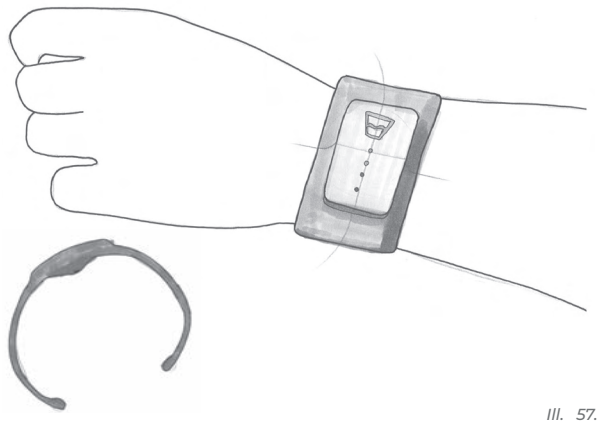
Assumption: A bump under the display, the metal plates can be placed there, providing a tighter connection. Two bumps at the bottom as well to make it further secure.



Ill. 56.

The concept is a half-cylinder shaped to fit the underarm. A colored cut-out is made to indicate where to place your other hand. The start button is placed on top, close for the other hand's thumb to reach it as the hand holds the product. The smiley face on the button lights up red, yellow, or green depending on your hydration level.

The product is intended to be placed in the bathroom, in its charging stand when not in use as this ensures it is easy to grab, easy to place, and always charged.



Ill. 57.

The concept is a bracelet that measures your hydration level on the go. The concept has two parts, a non-flexible and a flexible part, which should have color differences.

In the noon-flexible part, the electronics are placed. Small lights are blinking with a measurement taken to indicate the process. The water icon indicates the measurement with a red, yellow, or green color.

How should the interface be?

- A smiley or a glass of water?
- Tell how many glasses of water you need to drink or just to what degree you are hydrated?
- How do we signal overhydration?

2.9 Workshop with Catca

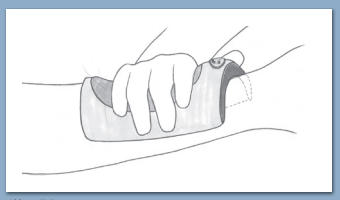
For the workshop with Cacta, we made a presentation with the knowledge that we had gathered up until that point and the two new concepts. This was the entry point for discussion. The goal of the visit was to get feedback on the current concepts and get more insight into what technology Cacta is developing, i.e., more specific requirements from the technology. The following part will go through essential feedback from the workshop (the documentation can be found in W25).

There are new rules in the Danish healthcare system which allow the stakeholders to use much more money on products that can spare human work hours. I.e., it is okay if it costs some money if we can save a visit from the HCW.

We should take a look at Middelfart Municipality which is a ”frikommune” (they decide themselves where they use their money; school, elders, etc). They have worked with relation and self-support in elder care, using the Dutch methods.

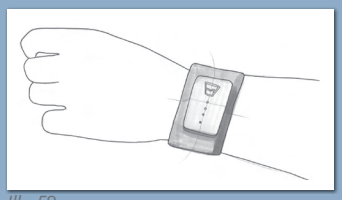
Concept feedback

Handheld



Ill. 58.

Around arm



Ill. 59.

Mads

What does the elderly get out of doing the measurement?

Adding a motion sensor that can detect if the elderly moves to make sure that they do not move.“

Should the product do gamification to motivate the elderly to make the measurement? “ e.g. Duolingo or Brain Training App

Ida

How is it connected/where is it sending data to? Is the device saving the data?

i

How can we make a device which accommodates more different body limbs?

Could it be a glove, so the fit over the thumb makes it easy to place at the same spot every time?

i

Investigate the scale from sports device to diagnosis tool (medical device) to find out where our product should be placed?

If the product can save the data from the previous measuring, then it can just measure the delta.

Feedback on the business case

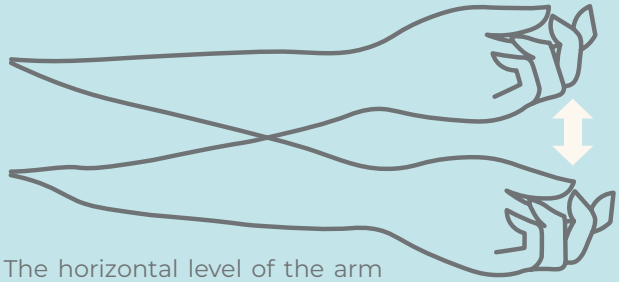
It makes sense that you focus on the grumpy elderly because the rest of the stakeholders who can be interested in the product can still use it.

It is smart that we start the B2C because the way to the market will be shorter. Because if it becomes a diagnostic tool there are many more regulations which are needed to follow. A guess is that it would take around five years extra to develop. It can be discussed if it should be categorized as a diagnostic tool or a “sports” wearable. It is a lot faster to get to market if it is a “sports” wearable, but if it is in that category the doctors will never use it.

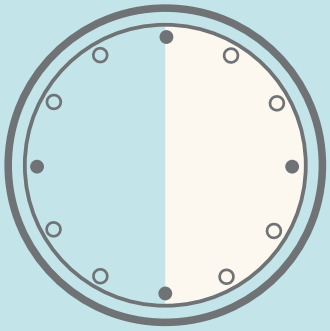
If you start B2C e.g. say you can sell to 5% of the elderly people in Nordic countries, after showing that products can be sold and the elderly will use them, then it is possible to get the municipalities interested.

“ If the elderly need to pay for it themselves it would be skewed and only help the economically strong elderly. “ - Ida

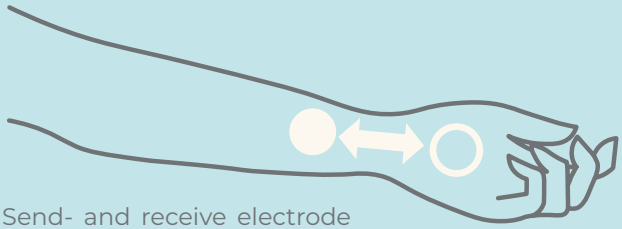
On the other hand, this could be enough elderly to provide solid data, so the municipality should be interested in altering the business from B2C to B2B.



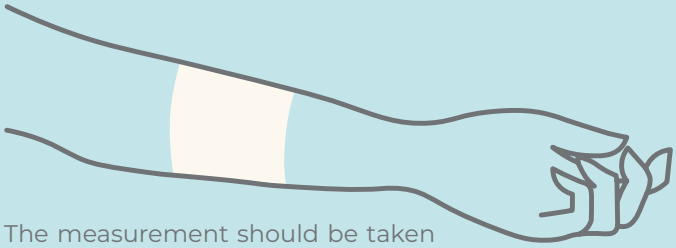
The horizontal level of the arm affects the hydration level.



The measurement takes 20-30 sec to conduct.



Send- and receive electrode must be spaced 5 cm.



The measurement should be taken in the same spot every time.

III. 60.

The technology is based on bioimpedance. Cacta gave us the following requirements for the technology.

- In total there should be four electrodes: two measuring electrodes, and two electrodes for sender power. There should be 5 cm from the electrode which sends power to the measuring electrode. The distance between the two electrode pairs is the measured area. It is assumed that a longer distance between the electrode pairs will provide more valid measurements.
- The distance and placement should always be the same if the results should be comparable.
- They assume the measurement would take between 20-30 sec. But they have discussed it with an expert who claims it only takes a second.
- If the measurement is done on the arm, the position of the arm will influence the result. If one has one's arm over the head there is a chance of the result saying one is dehydrated even though one is not, as the fluid runs down.
- There will be a difference in the result depending on whether one measures on the primary or secondary arm.
- Should the measurement be done locally or globally? Global measurements will be more valid.
- We should remember that the current will always take the shortest path. E.g. if it is arm to arm the armpit cannot touch because the power will always take the shortest path.
- The procedure for the measurement of water with bioimpedance is almost the same as with blood pressure measurement.
    - You need to sit still.
    - It should be done in the same spot every time, to be able to compare.

i We should look into how we ensure a correct measurement, i.e., redo the concepts so they will follow the rules.?

i There is a dilemma between "locking" the elderly to make the perfect measurement and making it easy for the eldely to use the product, so that they want to use it.

These questions will be elaborated on in chapters 3.1 and 3.2.

After the visit we chose to continue with the direction of the Handheld since the user has to sit still while the measurement is done. Thus, there is no need for the mobility of the user.

Ill. 61.

03 Concept development for the elderly

In this chapter we gather knowledge about the technology from Catca and incorporate it into the concept.

3.1 What is bioimpedance?

At our workshop with Catca, we got the information that the technology they are using is bioimpedance. We need to investigate what bioimpedance is to get an understanding of what requirements it will give the product.

Bioimpedance - bioelectrical impedance analysis - is a method used to measure blood flow and body composition. The method is non-invasive as it uses a current it sends through the body. Living organisms will respond to this, telling the composition of the body (GreenFacts, n.d.).

There are other methods to measure the composition of the body. Dilution methods require a blood sample. Dual-energy X-ray absorptiometry (DXA) exposes the patient to radiation, and air displacement plethysmography (ADP) is slower and less convenient than bioimpedance since it just requires the correct placement of two electrodes on the body. In comparison, bioimpedance is non-invasive, safe, portable, inexpensive, and repeatable, making it ideal for tracking changes (Aldis et al. 2022).

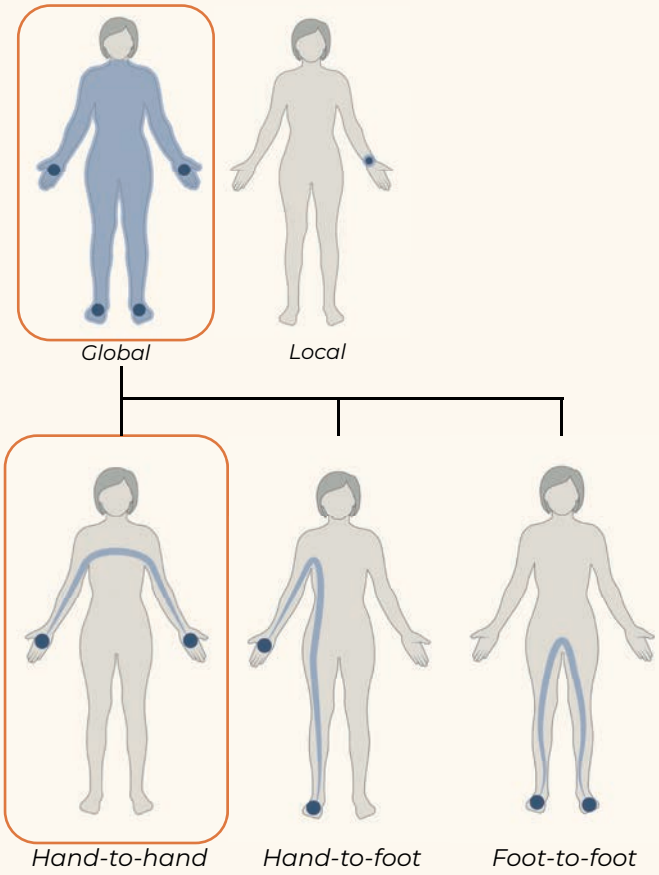
Local or global measurement?

Local measurement refers to a single point measurement, i.e. one that can be implemented in a smartwatch. But this measurement is shown to only be able to measure severe dehydration, not mild, and to be less accurate (Khalil et al. 2014). This discards the local measurement.

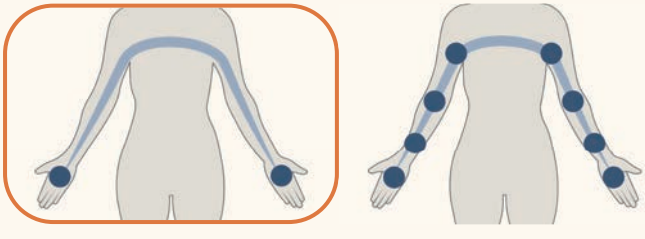
Global refers to the most common methods of estimating the composition of the body. Here the measurement is either from hand to foot, foot to foot or hand to hand, where hand to foot is the most common (Khalil et al. 2014).

During the team's visits to the elder care and care homes, it has been concluded that the arms and hands are the easiest areas of access to do measurements. Furthermore, there is a problem of excessive water in the legs when you are older as the system returning the blood from the legs is weakened. Due to this, some elders wear compression socks which are difficult to take on and off. As the article be Khalil et al. 2014 does not state that one measurement method is more valid that the other, the team decided to develop upon the hand to hand method.

The orange boxes indicate what will be used in product



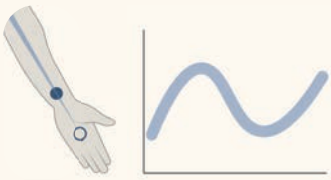
Ill. 62. Global or local measurement



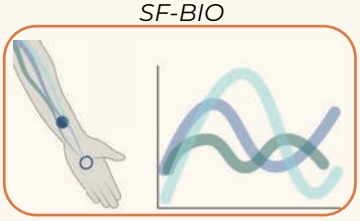
Ill. 63. Whole body or segment measurement

An article by Khalil et al. 2014 explained that Body Segment Bioimpedance Measurement is the method with the most accurate results. But as this will require more measure points, making the device more laborious to use due to e.g. accurate placement of electrodes and removing long sleeves clothing, it is discarded.

Which frequency method?



SF-BIO



MF-BIO

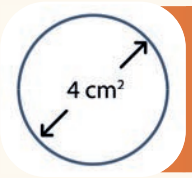
Ill. 64. Types of frequency methods

Single Frequency Bioimpedance Analysis (SF-BIA) is, as the name explains, where you send a single frequency often 50 kHz through the body. This can determine the total body water (TBW) using the derived equations. The method is valid for bodies with normal hydration but is not valid for bodies with significantly altered hydration (Khalil et al. 2014). As elderly have between 40-50% water in their body, compared to a normal body which has 60% (Claros & Collins 2011), the SF-BIA is not valid to use on elderly.

Multiple Frequency Bioimpedance Analysis (MF-BIA) is when you are sending more than two frequencies. A study showed that elderly subjects measured with MF-BIA were less sensitive in detecting fluid shifts (Khalil et al. 2014). This indicates to the team that elders are difficult subjects, but also that MF-BIA is the most valid method to use.

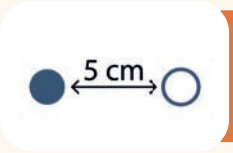
Requirements for the technology

The MF-BIO method requires at least two electrodes: One for sending the current through the body and one for receiving the current, measuring the voltage drop. The two electrodes are most common to see in a circular or rectangular shape with a contact surface of 4 cm2 or larger. Furthermore, the electrodes should be placed at a 5 cm distance (Khalil et al. 2014).



he electrode should be 4 cm2 or arger.

Ill. 65.



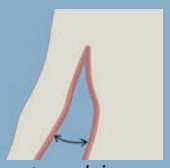
5 cm in distance between the electrode pair.

Ill. 66.

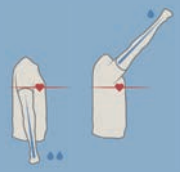
Elements that affect the measurement

The study by Aldis et al. 2022 showed that the results were to be considered poor estimations if they were not compared to the body measurement: temperature, movement. The article by Khalil et al. 2014 claims that gender, age, ethnic group, posture, and measure protocol effects the measurement. We will keep this in mind in the design process, as we are aiming for the most valid result.

The difference between left and right arm also contributes to the decision of measuring across both arms.

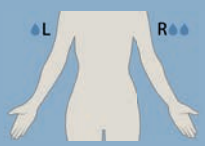


Same touching area or no touching.



Same vertical arm position.

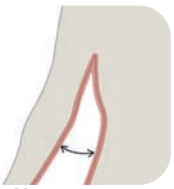
Hold the position still.



Hydration difference between L and R arm.

Ill. 67. The position for the body

All these requirements for getting the most valid results are relying on the person's mobility. Generally elderlies do not do not enjoy a high degree of mobility, so the development must focus on making it possible for the elderly to keep the measuring position still.



Ill. 68.

As the current design scenario is the elderly using the device in their bathroom at home, we can't be sure the elderly has clothes on while doing the measurement. Due to this, the requirement of "Same touching area or no touching" is perceived as "area must not touch".

3.2 Designing for the elderly

Until now the team had gathered information about how to design for the elderly, by testing mock-ups of the ideas on the elderly at a nursing home. The team investigates if there are some standard design principles when designing for elders, as this could speed up the development process.

In the book "The Design of everyday things", Don Norman has written a chapter about 'Design for special people'. The quotes underneath are from the book. They are quoted as they describe well the stigmas around designing for the elderly (Norman 2013).

"I don't want to go into a care facility. I'd have to be around all those old people." (Comment by a 95-year-old man.) Many devices designed to aid people with particular difficulties fail. They may be well designed, they may solve the problem, but they are rejected by their intended users. Why? Most people do not wish to advertise their infirmities. Actually, many people do not wish to admit having infirmities, even to themselves (...) Most of these devices are ugly. They cry out, "Disability here." Why not transform them into products to be proud of? Fashion statements." (Norman 2013 page 244)

Norman further describes what other designs had done to accommodate the user's need for not signaling disability.

"Some companies are making hearing aids and glasses for children and adolescents with special colors and styles that appeal to these age groups." (Norman 2013 page 245)

"Even though the peeler was designed for someone with arthritis, it was advertised as a better peeler for everyone" (Norman 2013 page 244)

Norman rounded off the chapter by introducing the correct term to use, when designing for elderly.

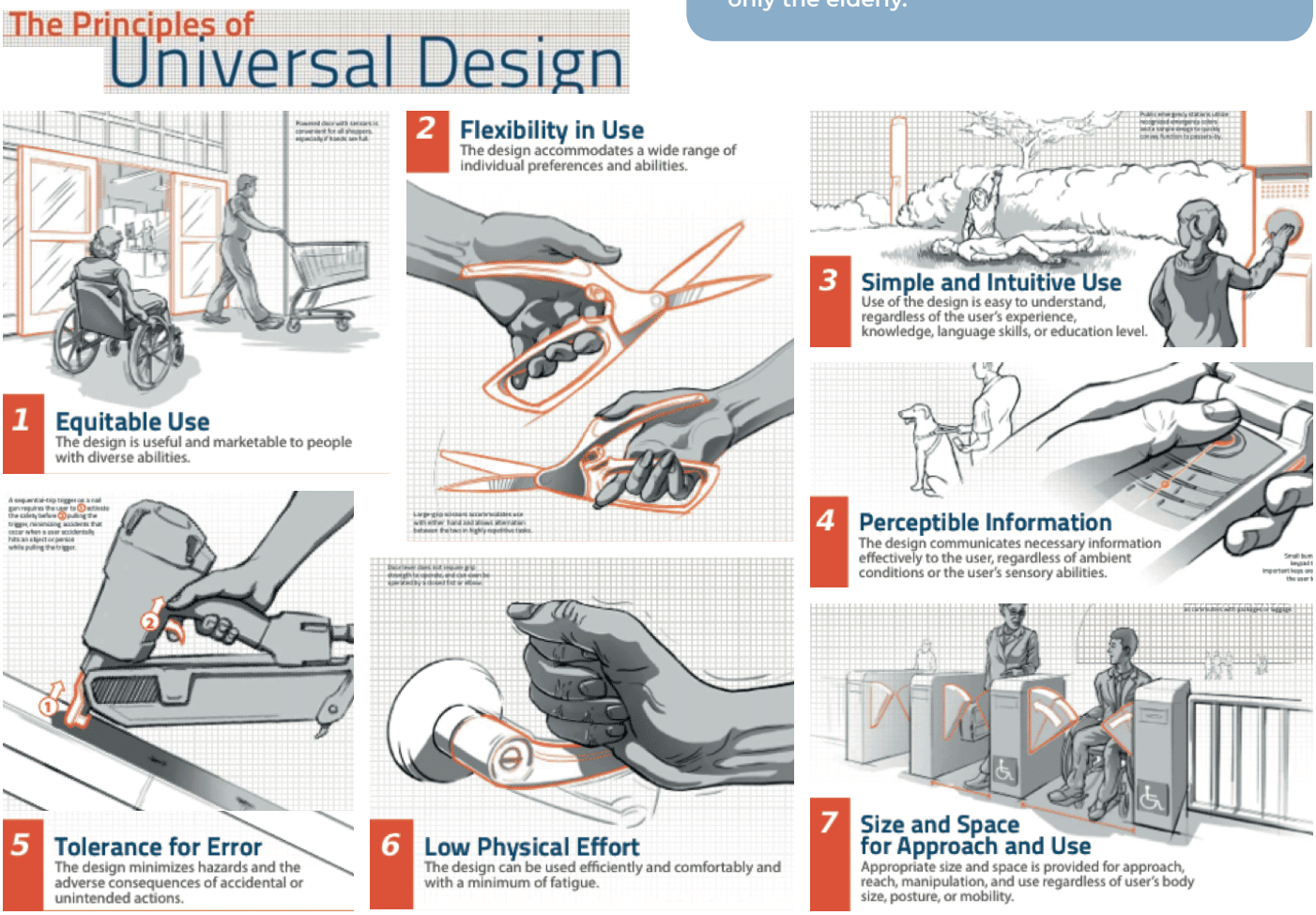
"Designing for people with special needs is often called inclusive or universal design. Those names are fitting, for it is often the case that everyone benefits. (...) The best solution to the problem of designing for everyone is flexibility." (Norman 2013 page 246)

By searching for universal design 'the seven principles of universal design' (Persson et al. 2015) was found. Shown in ill. 69.

Don Norman's statement is that disabled people do not want to be looked at as disabled people. This ties into the team's discovery that the elderly do not want the HCW to be acting like the police or a parent towards them. The elderly want to be respected and seen as normally functioning. Therefore, when designing for them, we should accommodate their disabilities but make it so that people without disability also want the device, as this makes the disabled not feel disabled.

The seven principles of universal design will be implemented in further development as a rule set to evaluate the idea.

The design should be universal and apply to not only the elderly.



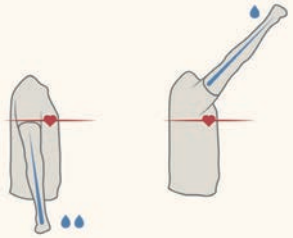
Ill. 69. The Principles of Universal Design

3.3 Fusing the technology with the ideas

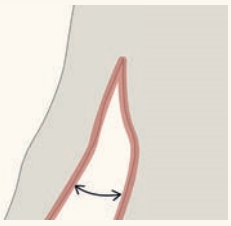
In this chapter we will go from the problem space to the solution space. Evaluating the interaction test that was conducted at Høje Tranders Friplejehjem (chapter 2.8.1) made the team wonder if any better principles could solve the requirements for the product. To explore this, the team used a Morphological Chart (W30) (Boeijen et al. 2014 page 171.) In this exploration, the knowledge about bioimpedance was fused with the tested ideas. The focus was to develop a device that measures hand to hand and ensured a "correct position":

The Morphological Chart leads to six principles in terms of guiding the user into the correct position.

These were the leading requirements for the development at this stage

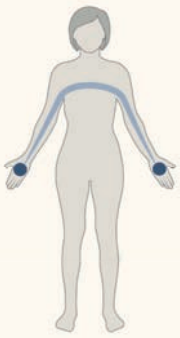


The same vertical arm position.



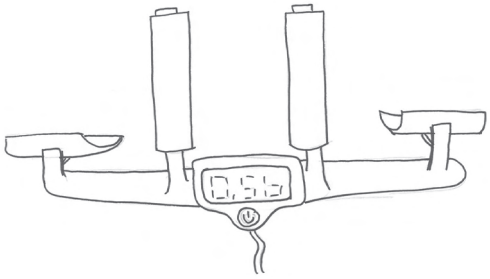
Same touching area or **area must not touch.**

Hold the position still



Whole body, hand to hand.

Ill. 70.



Ill. 71.

Guide with hand and wrist

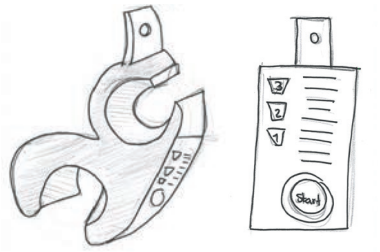
Gets the user in the correct position, but looks very medical, not something an elderly wants in their home. Furthermore, it is not easy to hide away when friends come to visit.

Ill. 73.

Guide with fingers

Finger sizes vary a lot making it difficult to find one hole that fits all. This assumption is based on the existence of different ring sizes.

The screen is very small preventing the elderly from having a clear view.



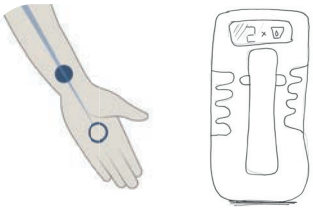
Ill. 72.

Guide with wrist

The wrists lock more than the hands do. As we only need to measure one place, it could be done around the wrists.

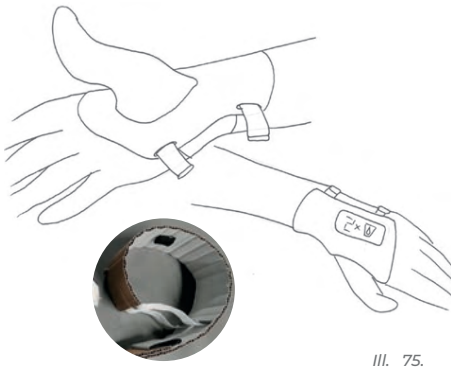
This is based on the existence of bracelets and handcuffs that can fit multiple sizes. How can we accommodate more wrist sizes?

The ideas were made into models to test the usability, correct position, comfort, and "hideability" of the product. By comfort it is meant that the product should not put the elderly in a "correct position" in which they cannot sit still for 30 seconds.



Ill. 74.

In the process of building the model, it was tested if the electrodes could be placed only in the hands. This would require the handle diameter to be almost ⅔ as big as the book Measures Of Man (book, ref) recommends. It was discarded.

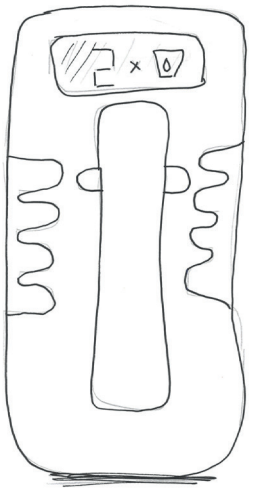


Ill. 75.

Guide with thumb

We like the idea of guiding the placement of the product with the thumb. Thumb sizes vary, but the device can hook onto or around the thumb.

Too complicated to tighten as the test in 2.8.1 showed the elders have difficulties tightening the mechanism used in a sphygmomanometer.



Ill. 76.

Guide with hand

Unsure if the hands are enough to nudge the user into the correct position. Maybe there could be a hole for the thumb to lock the position of the hand more.

Ill. 77.

Guide with wrist thickness

The thickness of the wrist differs from person to person.

We think the elastics can make it difficult to put on, as we are unsure of how much pull force and grip the elderly have.

Ill. 78.

Guide with a wrist

Usability: A bit difficult to take on, but we assume the right material will make it easier.
Correct position: Yes
Comfort: Yes, it is okay.
"Hideability": Yes

As the guide with the wrist is the most compact and therefore easy to hide, its development is continued.

Ill. 79.

Guide with hand and wrist

Usability: Yes, easy to take on.
Correct position: Yes
Comfort: Yes
"Hideability": No, it is big

> These mock-up tests made the team wonder what position had the best middle ground between comfort and *correct position.*

> Due to the new information about the technology, the team ended up wondering how big of a battery this technology would require, as this would influence the size of the product.

The two questions above will be explored in the following chapters.

3.3.1 Testing which correct position had the most comfort

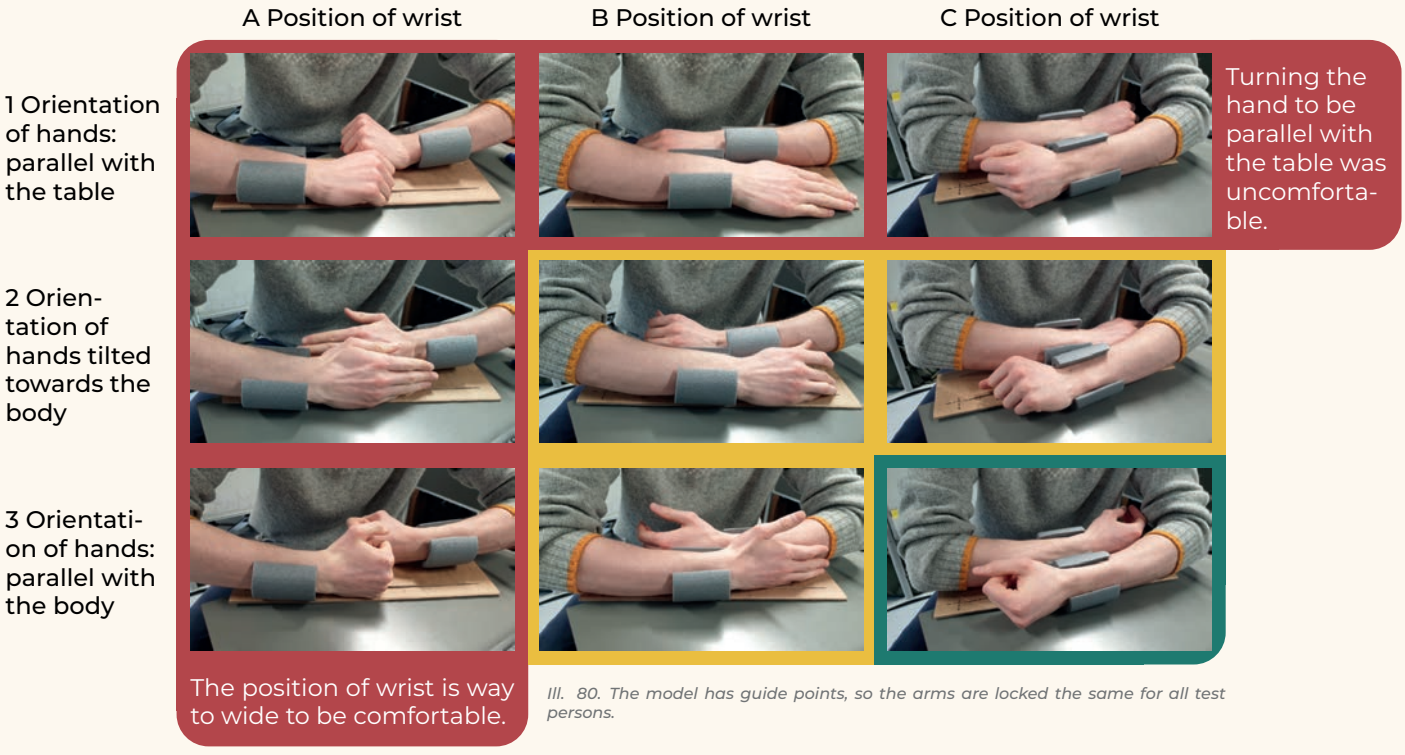
After choosing the guide with the wrist, nine positions were tested to identify the most comfortable one. The test was conducted on six test subjects. Each test subject ranked all the positions and at the end named their favourite of all (see full description in W31).

The test showed that a wide position of the arms (position A) and hands parallel with the table (orientation 1) are uncomfortable. The positions marked with yellow had an equal ranking, and the one marked with green had both the most points. These positions were applicable to the idea guide with wrist, confirming the choice of further developing this idea.

Ill. 81.

Ill. 82.

During the test, it was noted that the test subjects' watches were in the way and that a couple of them mentioned it was more comfortable if the bottom plate was leaning against their stomach as shown in ill. 81.



Ill. 80. The model has guide points, so the arms are locked the same for all test persons.

3.3.2 The influence of the battery on the size

A critical part of the technology is how much space the batteries will need since the rest of the components are relatively small. An approximation of the appropriate battery size was based on finding similar products like body fat scales which use the similar technology of bioimpedance. Based on the quick research, it will be suitable with battery packaging between 2-4 AA batteries. As these products use the simplest version of the bioimpedance technology, one could argue that a bigger power supply is actually needed. On the other hand, these products are set to last a year on their battery.

The research ensured the team that there was no need to worry about the battery enlarging the product substantially.

The battery size will be equal to the size of 2-4 AA batteries

3.3.3 Idea development

An evaluation of the idea, guide with wrist, compatible with the user, the grumpy old man, easily led to association with handcuffs. As this association would not be beneficial for convincing the grumpy old man that this product is something he wants, the team will try to rethink the concept in a way that it should be less like handcuffs. To explore it, the structural aspects of how the idea could be placed on the arm and to move away from the ring shape, the team made a 45 min. brainstorm with wires as 3D could give a better understanding of the possibilities. The most interesting ideas are shown below (the rest can be seen in W34).

After the brainstorming the ideas were evaluated based on the following focus points:

- ☐ The shape and how to use it should be easy to understand.
- ☐ As it is a 30-sec. measurement, the product should be quick to put on and take off.
- ☐ We need a secure fit to ensure that the electrodes get full contact with the arm.
- ☐ The shape should ensure that each user has the same position every time.

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- ☑ As it is a 30-sec. measurement, the product should be quick to put on and take off.
- ☐ We need a secure fit to ensure that the electrodes get full contact with the arm.
- ☐ The shape should ensure that each user has the same position every time.

Utilizes the hand grip to ensure the same placement of the measure points. But the grip can rotate in the hand making room for the arm to move and thereby locking the measure point less.

But how does it look for a left- and right hand? And further, how does it ensure the correct position of the whole body?

Ill. 83.

- ☑ The shape and how to use it should be easy to understand.
- ☑ As it is a 30-sec. measurement, the product should be quick to put on and take off.
- ☑ We need a secure fit to ensure that the electrodes get full contact with the arm.
- ☐ The shape should ensure that each user has the same position every time.

Utilizes the thumb to ensure the same placement of measure points in the U-shape.

Again, how does it look for a left- and right hand? And further how does it ensure the correct position of the whole body?

Ill. 84.

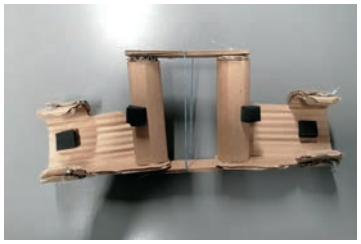
- ☑ The shape and how to use it should be easy to understand.
- ☑ As it is a 30-sec. measurement, the product should be quick to put on and take off.
- ☑ We need a secure fit to ensure that the electrodes get full contact with the arm.
- ☑ The shape should ensure that each user has the same position every time.

Utilizes the hand grip to ensure the same placement of the measure points. The grips are connected to a shell that curves around the wrists securing them. The whole idea is to bend, so one can lean the back side against one's stomach.

As this concept ensures the correct position of the whole body, its development is continued.

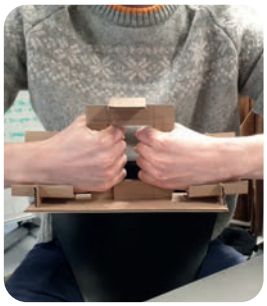
Ill. 85.

The wrist and the thumb will be used as guides to ensure a correct position every time.


Ill. 86.

The idea was mocked-up to understand the possibility of it better: A handle insures the user knows where to grab, and the U-shape is known for fitting around the wrist, as the shape is used in bracelets. The shape locks in an angle that hugs the body so the user can relax the arms on the stomach as the measurement is taken. The relaxed fit on the stomach makes it possible to utilize the stomach as a surface to lean against to ensure that the electrodes get full contact with the arm and further when taking on the u-shapes.



Ill. 87.

In retrospect, this idea looks like a merging between the guide with hand and wrist where the insight from 3.3.1 *"the bottom plate was leaning against their stomach it was more comfortable"*

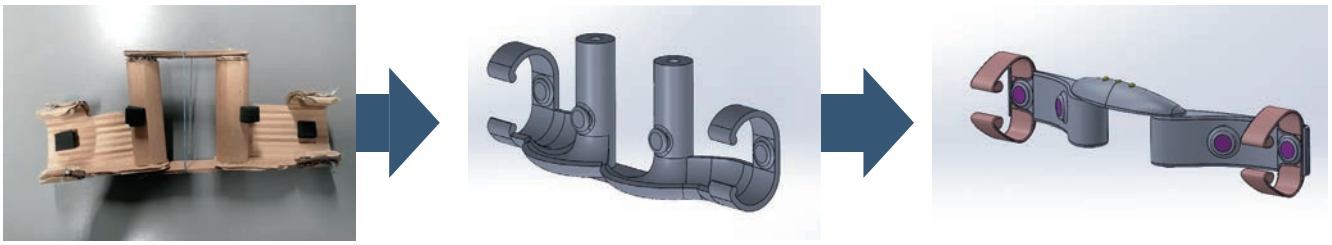
3.5 Adaptation to the anatomy

The further development was conducted in a 3D program as this allowed for more details and precise placement of the measuring points in relation to the hand. In the development, the book Measures of Man was used to find the dimensions of the hand. Further, the concepts were 3D-printed and tested on persons with small, medium, and large hands, which the team found in their building (see W37 for the full process of the concept).

The focus of this development was to make a matured form, as the form of version 0 had elements that could be unnecessary e.g. the plate under the hand in version 2, should align the hand, but this could be done with less material. Furthermore, the U-shape should be designed to fit all wrist sizes, but it was discovered not to be possible. Instead, a locking mechanism was made for the wristband that made it possible to change between three sizes.

i It is still unclear how much we need to secure the arm to make a good measurement i.e. how tight the wrist should be.

i Unsure if this concept is different enough, the grumpy old man does not feel like they are locked.



Version 0 *Version 2* *Version 5*

Ill. 88.

3.6 User interactions

Simultaneously with the 3D maturing the user scenario was thought through since it affects the architecture of the product.

The device is designed for the elderly. They grew up in an age where all devices got power through a cord. Therefore, the team decided that the device will be charged by a docking station. By doing this, the device will have to be on display in the bathroom making an appearance to remind the elderly to use it. The device will need to be small, so it can be put away when guests are over. A requirement identified in chapter 2.8.2. But before thinking about a docking station, development of the interface for the product was begun (W35).

3.6.1 Interface

The development was started by sketching different ways of communicating data to the elderly. Through the sketching process, the placement of the interface was discussed. The team could see a benefit in the interface being placed on the docking station, as the measuring device then would require less power. The measuring device should only take the measurement and then the elderly will place the product back in the docking station where the data would be transferred, processed, and displayed on the docking station.

The sketching process was summed up and evaluated:

Words: Not as quick to understand as the others.

Smiley: Quick to understand, but does not say if you are about to tilt over to one of the other two categories.

Scale: You can see your current categories and how close you are to changing to one of the other categories. Makes it possible to display overhydration.

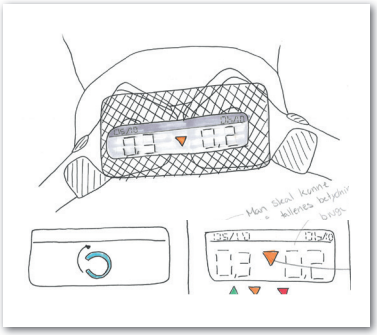
Numbers: you need to understand what the number refers to in order to understand if it is bad or good.

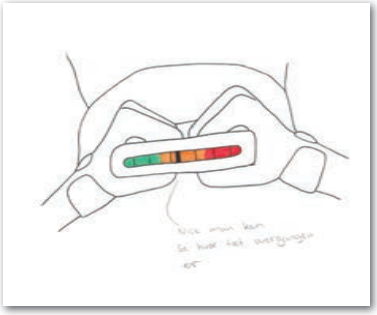
Arrow: Gives a good indication of whether it is better or worse than last time, but does not say a lot about the current measurement.

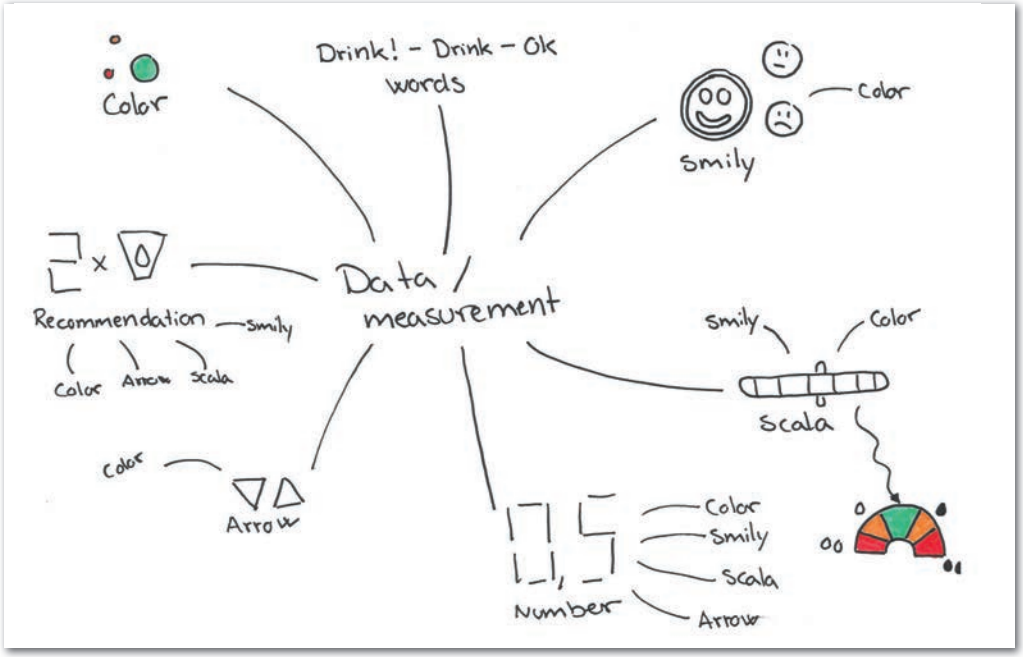
Recommendation: Not sure we can collect the data necessary as weight and temperature come into play.

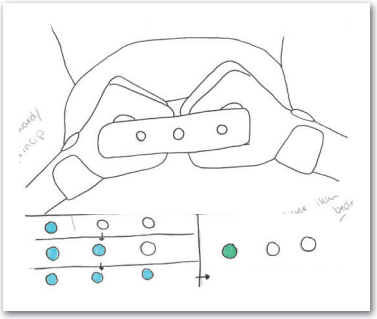
Color: Colour emphasizes most of the above information displays. Red, yellow, and green are commonly known from traffic lights to represent stop/danger, be aware, and all good.

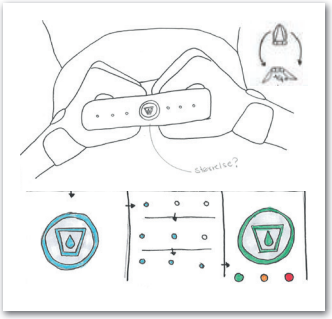
The team **chose to use a scale with colour indication** since it simply makes the elderly aware of which level of hydration they are at.

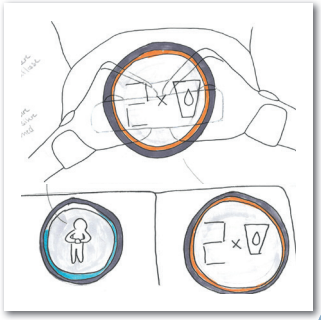












Ill. 89.

3.6.2 Interaction

To develop the docking station the team went to a bathroom and positioned the mock-up in different ways as they each time acted out the interaction required for taking a measurement. The positions were evaluated based on accessibility and ease of initiating the measurement.

Position 2 was chosen, as it made it possible for the user to pick up the device and put it on, without having to turn the device in their hands, making it quicker and easier to take a measurement. Furthermore, the position gives easy access from the top complying with the fact that one is possibly standing up in the bathroom.

Sketches were made based on this position and evaluated based on “hideability”.

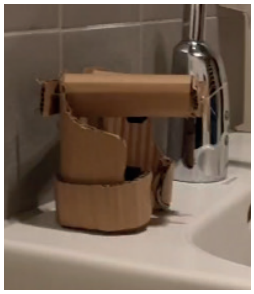
The team chose to make a docking station for the device. On the docking station there should be a scale with colours that will indicate what hydration level the elderly is at.

Ill. 90.

Position 1
+ Easy to grab the handles

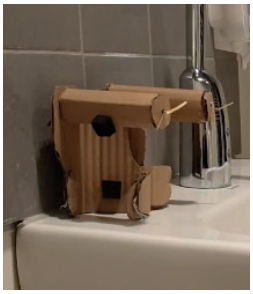
Ill. 91.

Position 2
+ Easy to grab the handles
+ Complying with standing up



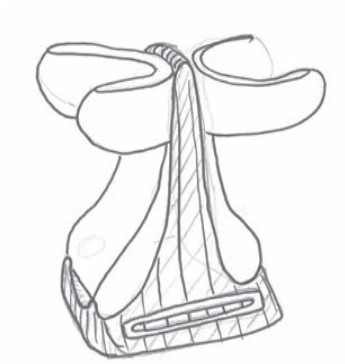
Ill. 92.

Position 3
+ Easy to grab the handles
- Turn the device in hands



Ill. 93.

Position 4
+ Easy to grab the handles
- Turn the device in hands

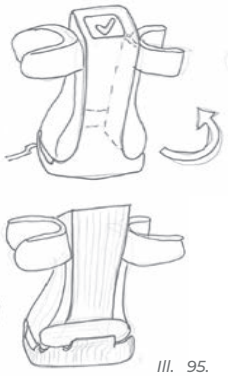


Ill. 94.

+ The device to lean against something.

+ Hole at the bottom so you can grab the device.

+ Visible display at the bottom tilted towards the standing user.

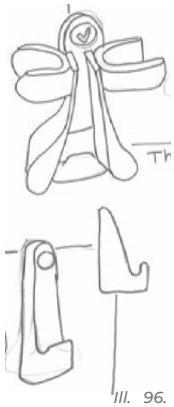


Ill. 95.

+ Visible screen tilted towards the standing user.

- Big compared to what is necessary.

- Looks a bit like a skyscraper.

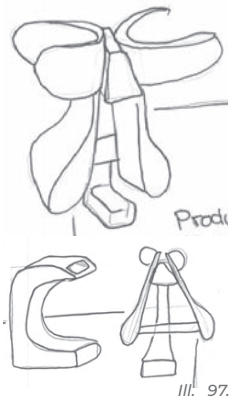


Ill. 96.

+ Looks like a smartphone stand or charger.

+ Visible display at the top.

- Could be difficult to balance.



Ill. 97.

+ Would be easy to grab when nothing is underneath the handles.

- The device needs to be able to be locked in this position so the “handles” do not fall outwards, but then how does it then fold outwards when it is necessary to initiate the measurement?

3.7 The price point for a visitator

With the main user being the elderly, i.e. the product being in their homes, the regulation around the budget of getting a product referred to the elderly is to be investigated. If the price of the product is under 500 DKK, then the elderly should pay for the product themselves, and if it is over 500 DKK then it can be referred from the municipality, meaning they will pay for it (Ældresagen 2023).

i These are the rules, but how much is the elderly and the municipality willing to pay for such a product?

3.8 The business case

The possible sales opportunities influence the best-fitted production, and since we soon are looking at production an estimation of how many we can sell a business is needed. We need to know how many we can sell and what price point is realistic for our customers to be interested in the product.

3.8.1 Number of elderlies in the population

The team believes in a business plan that involves starting in Denmark and expanding to similar countries in Europe, meaning we both need to know the number of people over 65 years in Denmark and the other countries.

In Denmark, there were 1,156,000 Danes over 65 in 2020. The Danish Ministry of Health and Elderly has estimated that this number will increase by 5% by 2050 (Sundheds- og ældreministeriet 2020.

The table below lists the similar countries that were referred to and how many elderly they have over the age of 65 years. In total 27,473,230 citizens are 65 years and above in these six countries (The World Bank 2022).

Land:	People over 65 years:
Germany	18,444,791
Netherlands	3,498,092
Sweden	2,094,024
Finland	1,268,422
Denmark	1,189,085
Norway	978,816

3.8.2 The elderly´s economy

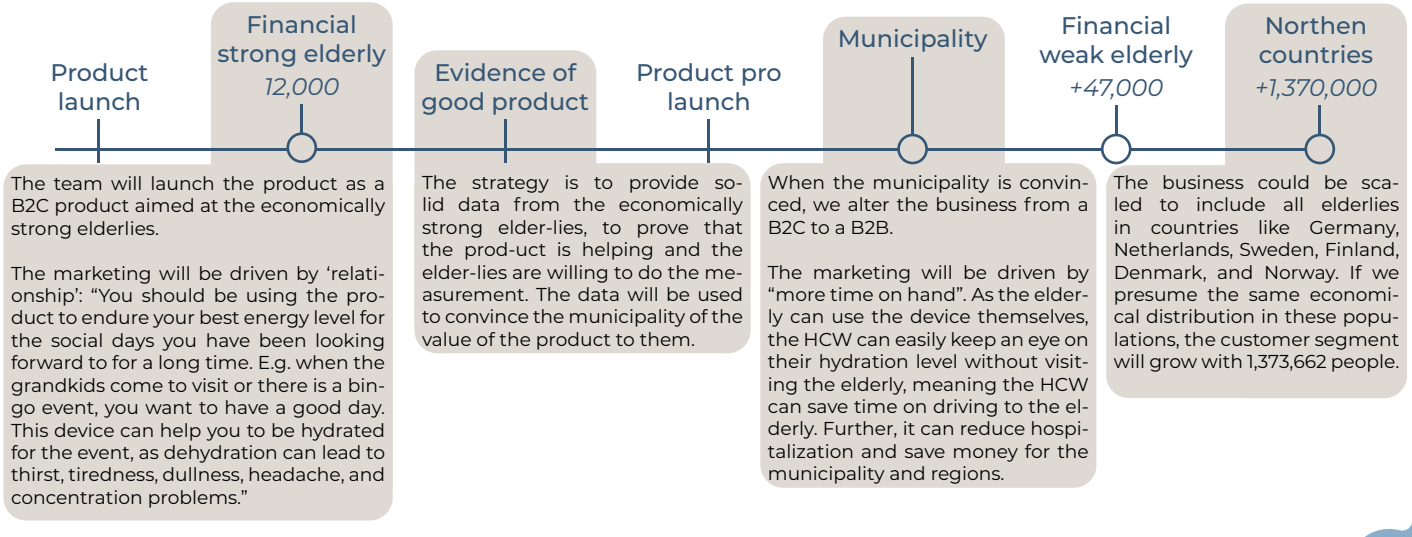
In total 950,337 people get paid public pensioners. ~75% of these are in the lower half of the income distribution (Danmarks statistik 2021).

3.8.3 The business plan

We set the sales price to 500-1000 DKK since products in the same product category are in the same prices range. This price point is suspected to be too high for ¾ of the elderly, as they only have between 7-21.000 a month. The price point will mean that the product will be skewed and only be available for economically strong elderlies. If we estimate that 5% of these economically strong elderlies will buy the product, we can sell 12.364 products. As the vision for this product is to be available to all elderlies, the business plan, taking 5% of the market, is proposed to be: (see timeline below).

When switching the business from a B2C to a B2B, it would be beneficial to accommodate the feature needs of the HCW e.g. sending the data from the device to the organization, so they can keep an eye on the elderlies' hydration levels without needing to be present in the elderlies' homes. This feature could be under development while the product is sold as a B2C product on the market, making a profit for the business while the B2B product, which is estimated to take five years, is under development (look in W36, to see the extended description of the business plan).

i Leaps-of-faith assumption for this business plan is: The grumpy old man is interested in buying a device to monitor the hydration level daily.



3.9 Making the product desirable for the elderly

In order to make the product desirable for the elderly, the principles of 'Nostalgia' (W39) and 'Empowerment' (W38) were explored.

3.9.1 Nostalgia

There are 4 types of nostalgia. The interesting one for the product design is cultural nostalgia because that tells more generally about a group of people's nostalgia (Almeida & Xue 2011). This type of nostalgia is, according to the article, the most difficult nostalgia to identify. Given that the project was under time pressure and the interview conducted at an activity center (Aktivitetscenter) (3.10.1) did not lead to anything. The team chose to end the exploration of using nostalgia to make the product desirable for the elderly.

3.9.2 Empowerment

The research is based on academic papers about 'the psychology behind fitness brands' and identified three recurring themes of motivation (W38):

- A goal-directed activity that brings a sense of accomplishment.
- The ability to compare yourself with others. e.g. games are inherently fun, or we wouldn't play them.
- Social support through collaboration was the primary motivator.

Further, a study discovered that the main concerns of the older generation were to do with the comfort of wearing such devices and the ease of reading visual feedback (Maslakovic 2022).

The above standing principles found by exploring nostalgia and empowerment were made into, respectively, questions and use scenarios for the products, and tested during the visit to an activity center (Aktivitetscenter).

3.10 Evaluating the business case

Throughout the development process the product is developed into a "grumpy elderly" as this person it difficult to make them want a product. This user puts extra focus on what the elderlies got out of the measurement and ended up leading the team to understand the importance of relationships when wanting a grumpy elderly to do something. The choice of the grumpy elderly lies in the Faith of Assumption: If we can make the most difficult elderly want the product, then the others will follow.

To test the assumption, the team went to visit an activity centre (Aktivitetscenter) in Aalborg, as the customer segment was available there. Compared to elderly visits at Høje Tranders Friplejehjem, an activity center is a place where seniors meet for different activities to maintain their level of functioning and social relations (Aalborg Kommune n.d.).

Two of the six elderlies we interviewed had experienced symptoms of dehydration and were aware that it was due to dehydration. Only one of them was interested in buying the product. The others were only interested if the product was free i.e. not interested. Evaluating all the interviews we have had with elderly, most of them think that dehydration was not a big issue for them. This disproves the faith of assumption letting the team to pivot and focus on developing a product for the HCW (W40). The following table sums up possibilities for each direction.

We have, through the process, heard the elderly say it is only their neighbours who have the problem, so it will be difficult to sell the product to them. Meanwhile, the HCW are aware of the dehydration problem, and they can introduce the product to the elderlies. In conclusion, the team pivot to the HCW as the core user.

	Elderly *Live in their own home and are over 65 years*	HCW *Homecare employee*
Functions:	Measure, display and save data.	Measure, display, save data, (and send data).
Placement:	Places in their home, properly the bathroom.	Places in the elderly's home, as this can make the elderlies take more measurements, without the HCW needing to be there. This means less driving for the HCW, but how do we then utilize relationships?
Quote about their view on the problem:	*"I do not have a problem with dehydra-tion, but I am sure my neighbour does."* *It is too little a concern for the elderly to do something about it.*	*It is a problem, and even though the elderly are aware of it, they have a difficult time drinking more."*
Pro- or reactive:	Proactive	The product could replace the Fluid Chart and save work time for the HCW and still be more precise. Reaktiv: HCW detect dehydration • illness affected by dehydration • tendency to dehydration Proaktiv: • medical check

Ill. 98.

3.10.1 Additional feedback from the elderlies at the activity centre

During the visit to the activity centre, the team brought along three concepts to test on the elderlies. They brought three as they were *'unsure if the concept of HydroSure is different enough, so that the grumpy old men do not feel like they are locked'* (chapter 3.5)

The team will continue developing Grab and Curve. Curve ensure the "correct position" but was difficult to use, whereas Grab was intuitive to use but lagged on ensuring the "correct position".

The team also tested different scenarios displaying the data from the measurement e.g. sharing by speaking, sending data to the app, comparing data, or paper. But as the business plan changed, this had little impact on the further development of the product (see W40 for feedback on data viewing/sharing).

Ill. 99.

Grab, 5 votes
Feedback: Do not take up much space.

Observation: Somewhat intuitive in terms of how to grab the product and where to place the fingers. But difficult to "assemble".

Ill. 100.

Curve, 2 votes
Feedback: be easier to use than Grab if your hands are shaky.

Observation: difficulties in the orientation of the product - left or right hand on top?

Ill. 101.

HydroSure, 0 votes
Feedback: It is difficult to put on and looks like handcuffs.

Observation: The watch is in the way

Ill. 102.

04 Concept development for HCW

In this chapter we are going back to the HCW as the main user but will still try to implement the knowledge from the periode we had the elderly as the main user, as we aim to make a tool that does not worsen the relationship between the HCW and the elderly.

The new framing

The trip to the activity center killed the vision of making a product for the 65+ that they could use to ensure they were hydrated i.e., they did not need to cancel plans because they were tired or had a headache as they had not drunk enough water. The team chose to pivot so the customer for the product is the healthcare industry (B2B) and not the elderly(B2C). The main reason is that the elderly do not see it as a problem for them, i.e., they would not buy the product.

The team went back in their process to get an overview of which requirements and insights no longer were relevant. From the overview, the following keywords were identified:
Keyword (its use)

- Relationship (The best tool for HCW. A way to introduce the product)
- Authority (The elderly trust doctors. A way to introduce the product)
- Dignity (Important to retain for the elderly)
- Independent (Important for the elderly to feel independent)

And the following questions, which we still should try to answer:
Question (current answer or assumption)

- What is it? (The product is a monitoring device like a blood pressure monitor. Only used when there is detected a problem.)
- Is the product proactive or reactive? (Reactive)
- How much do we need to secure the user to make a good measurement? (Chapter 3.5)
- What product appearance will be appealing to the elders? (It is assumed the device is always in the home of the elderly)
- How do we get the user to use the product in their home when they do not see drinking enough water as a problem? (Strategies have been the product should be comfortable, handy, and easy to use. The product should create more value than measuring the hydration level)

The use case is now with the HCW. The product should be used when: the HCW identifies dehydration if the elderly has tendencies to dehydration, or in special cases where the elderly has a disease that is affected by the hydration level of the body.

The product will be placed in the home of the elderly when dehydration is identified, so the elderly can measure themselves i.e., they need to be able to use the product themselves. The product will send the data to the HCW automatically, so the HCW does not need to visit the elderly to check their hydration level i.e., saving man-hours in healthcare.

Instead, the HCW will have the possibility of calling the elderly if they forget to do the measurement, i.e., the HCW know as they haven't received data from a measurement.

The product will replace the fluid chart by reducing man-hours and being more accurate. Benefitting both the elderly, the HCW, and the Manager.

4.1 The precision of the concept

With the shift in focus on developing the product for the HCW, Cacta was called to settle the question from chapter 3.5. How much do we need to secure the user to make a good measurement? We know the position can vary from user to user but should ideally be the same for each user from measurement to measurement. Afterward, a test was conducted to see how much control the product needs to apply to ensure the same position.

4.1.1 Feedback from Cacta

The team presented the three same concepts to Cacta as brought to the Activity Center. Their comments matched the feedback from the Activity center. They further noted that the most important requirement for the technology is the insurance of the same distance between the two end electrodes as this determines how far the current is traveling. This becomes more important when there are few measurements. Mads continued explaining the importance of the contact between the skin and the electrodes. This is something Cacta has not explored yet, but they hope to achieve a valid result without using gel, a substance applied to the measured area to get better contact (W44).

The product needs to insure the best possible contact between the skin and the electrodes

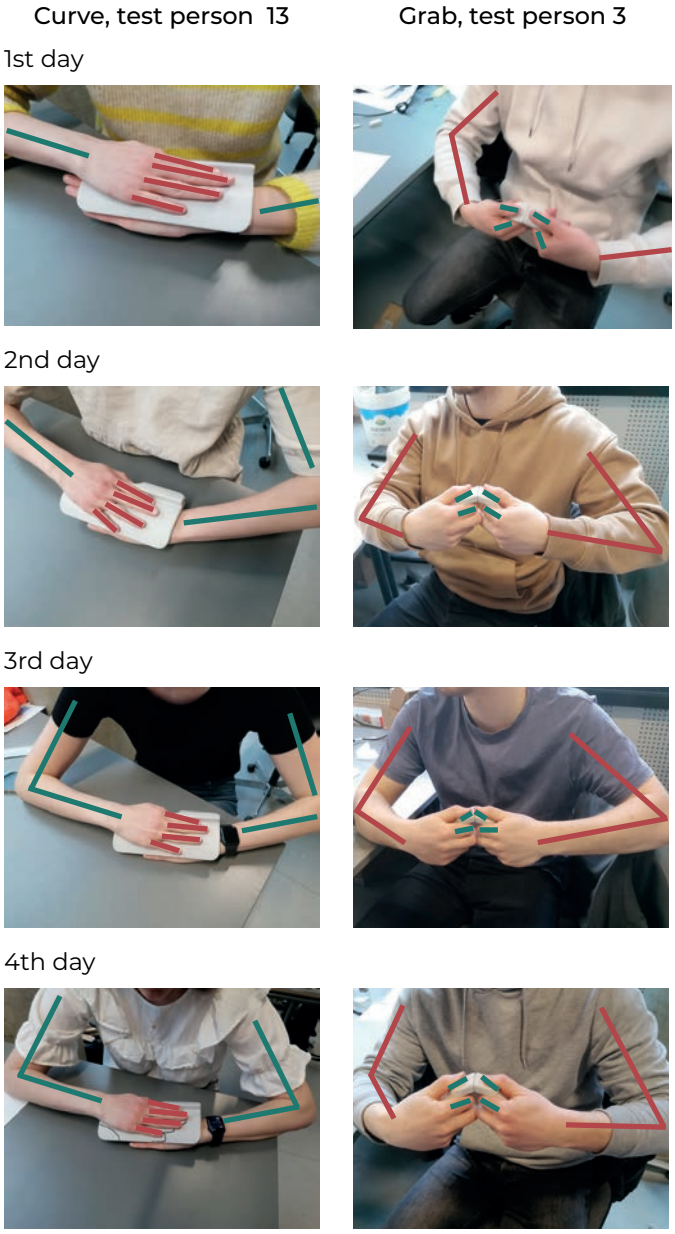
Maybe we should introduce a tension spring element or something that ensures that the user has the necessary contact.

4.1.2 Testing how much control is needed

The Hydrosure seems to be too restricting for the user to be comfortable while using it, but it ensures the “correct position” every time. The principles of Curve and Grab seem more comfortable to use, but the team is unsure if they ensure the “correct position” every time as they are less restricting. To test if Curve and Grab ensure the “correct position”, a test was conducted: On day 1 the subjects were instructed on how to use the devices, then the test subjects used the device, and a picture was taken to document their position. During the following days, the test subjects were only given the devices, without instruction, and pictures of them were taken. After four days the pictures were compared to see if there was a difference in the subjects’ positions (A thorough documentation of the test in W45)

The test was made on fellow students, as it was assumed that the result of the test is not dependent on age, but on intuition and habits of the user. Hence we could test it on any age group.

The test tries to mimic the use scenario of the HCW giving the device to the elder, instructing them how to use it, and leaving the device with the elderly to make more measurements during the day, so the HCW do not need to be there but maybe only need to call the elder.



Ill. 103. Examples from the test to visualize the position changes for each concept.

The test was conducted over four days with eight test subjects. Illustration 103 shows an example from the test; on the same person respectively for four days straight, for both concepts. The conclusion (see pictures above) of the test was: The concept Curve had small changes in the arm position and a few test subjects changed their finger position. Grib ensured that all the test subjects had the same wrist and finger positions, but only two did not change their arm positions. It seemed there was no continuity in the position of the arms. Furthermore, every time a subject had to use the Curve, they had to look at the device before they could tell how the device should be oriented, a problem that did not occur with the Grab.

Ill. 104.

Grib

Ill. 105.

Curve

	Grib	Curve
Arm position:	Changes	Small changes
Wrist position:	Same	Same
Finger position:	Same	Small changes
Intuitive use :	Yes	No
Other: *(W47)*	Can the same function be obtained with a simpler form? Not good, it is two parts, and a part can go missing.	A surface can be utilized to make sure the user stands or sits still while the measurement is done. Good that it is one object, as parts cannot go missing

A surface can be utilized to make sure the user stands or sits still while the measurement is done.

Can Curve be made so that it has affordance to how it should be used?

The team chose to continue developing the concept Curve.

4.2 Revisiting the vision

The team has been working on the lower levels of the Lerdalh pyramid (Tollestrup 2004), i.e., Story and Product principal. Since both the business case and the user had changed, an evaluation of the vision was required.

The team formulated a new vision based on the previous knowledge gathered in chapters 2.1 and 2.4 (See W46 for a more in-depth review of the thinking). The current scenario of the elderly experiencing dehydration creates mistrust between the elderly and the HCW. The elderly either lie, as they know more water will entail toilet visits, which for some elders cause difficulties, or they do not remember how much they have been drinking when the HCW asks them. As a consequence, the HCW does not always believe the elderly. To ensure they get the right answer, the HCW asks again in a different way or checks in on the elderly more often than usual during the day, which can make the elderly feel under surveillance. Together, these result in a non-optimal scenario for developing a good relationship between the elderly and HCW.

Ill. 106.

The aim of this product is to change the scenario to one where the relationship between the HCW and the elderly can continue to grow. This will be done by making the elderly feel independent in the use scenario and allowing them to not compromise their dignity as the HCWs do not think they are lying to them. The product must ensure the HCW that they are acting appropriately in cases of dehydration. As the elderly can take the measurement on their own, the HCW now has more time on hand to provide care to the elderly (W46).

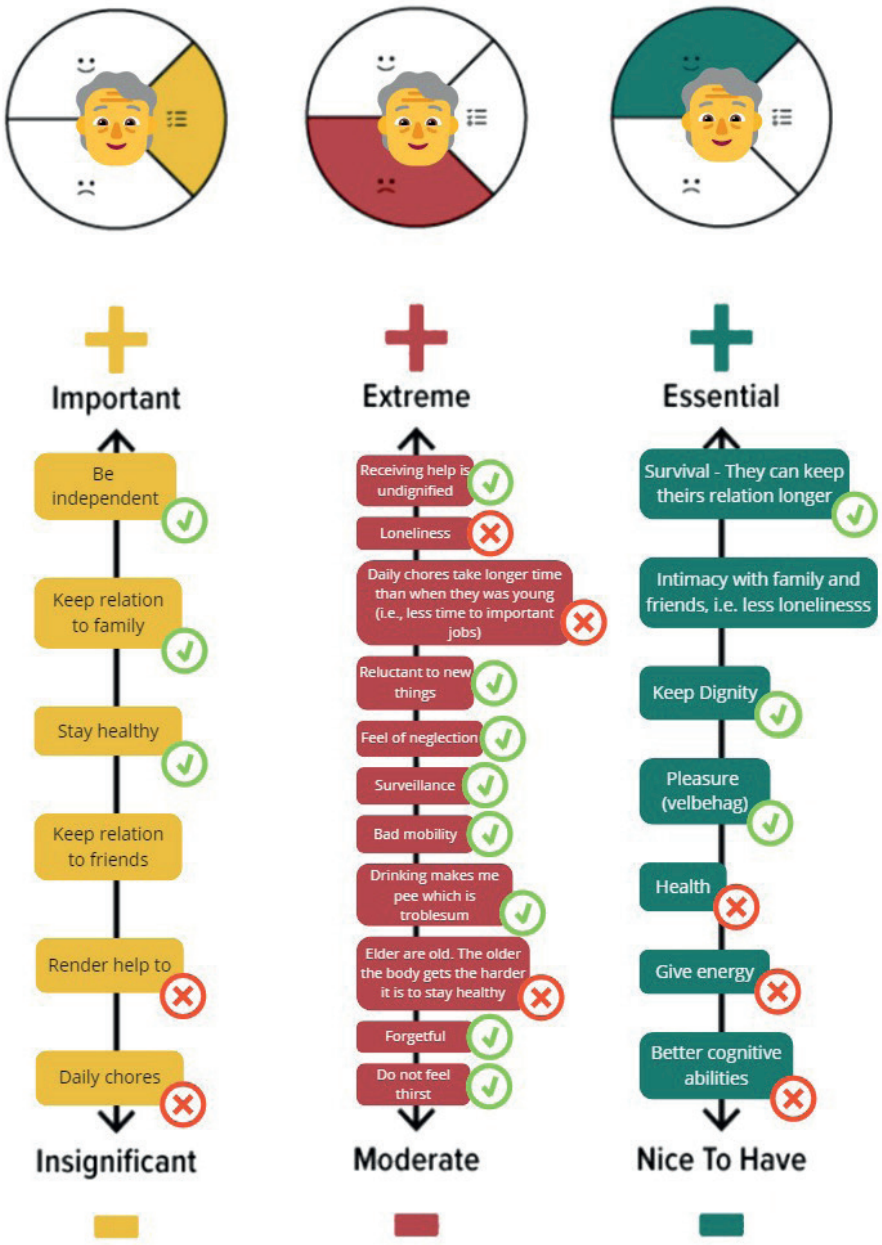
Ill. 107.

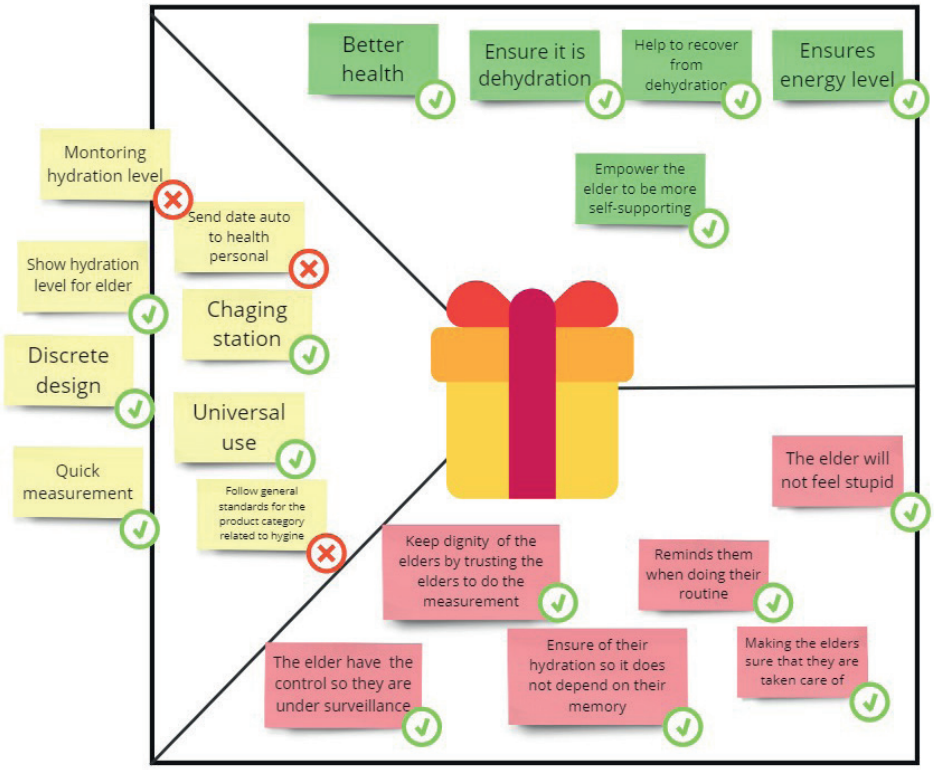
To ensure the product fulfills the users' gains and solves their pains, Customer Profiles for each user were filled out, ranked, and compared to the Value Map of the product (Bernada et al. 2014) (see W48).

Green check marks mean they are fulfilled, red crosses mean they are not, and if they do not have a mark, we assume it might fit.

Filling out the Value Proposition Canvas gave the team an overview of the connections of the products to the customer's needs and a clear image of the values the products give the customers. In the process, no pains or gains were identified that were not already solved or could have been implemented to solve with the product.

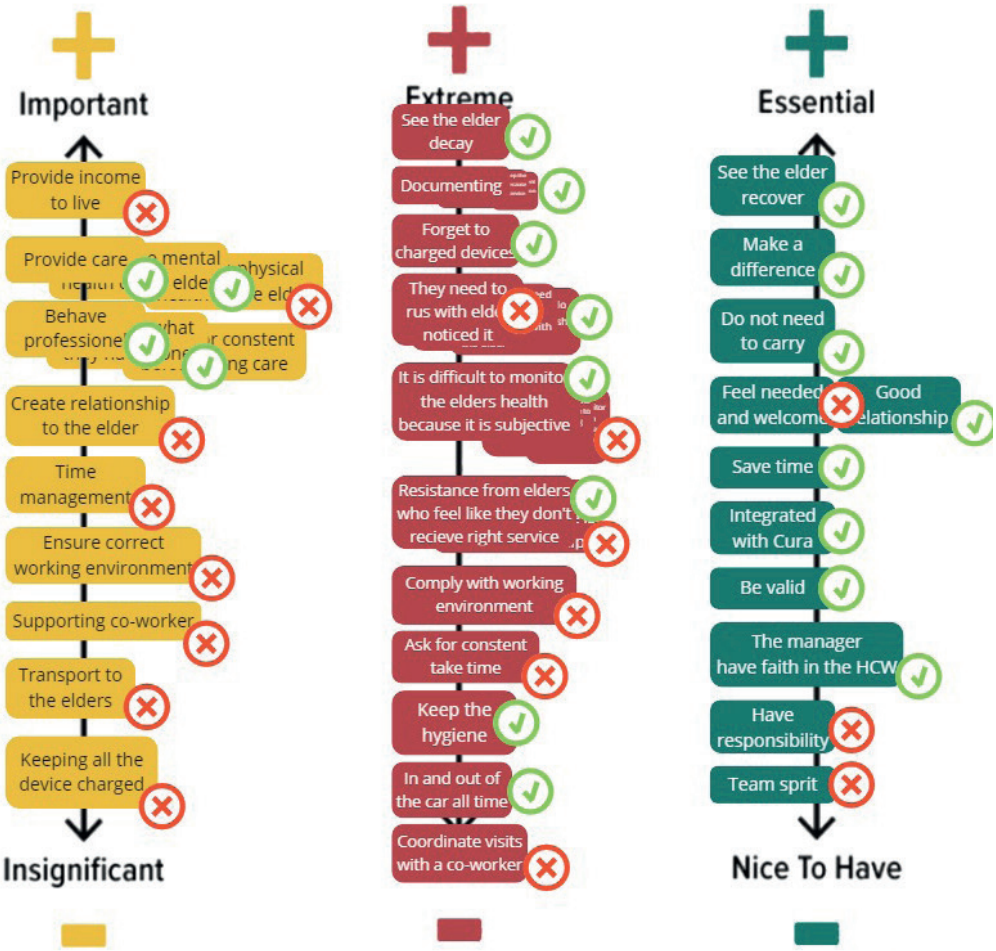
Elderly





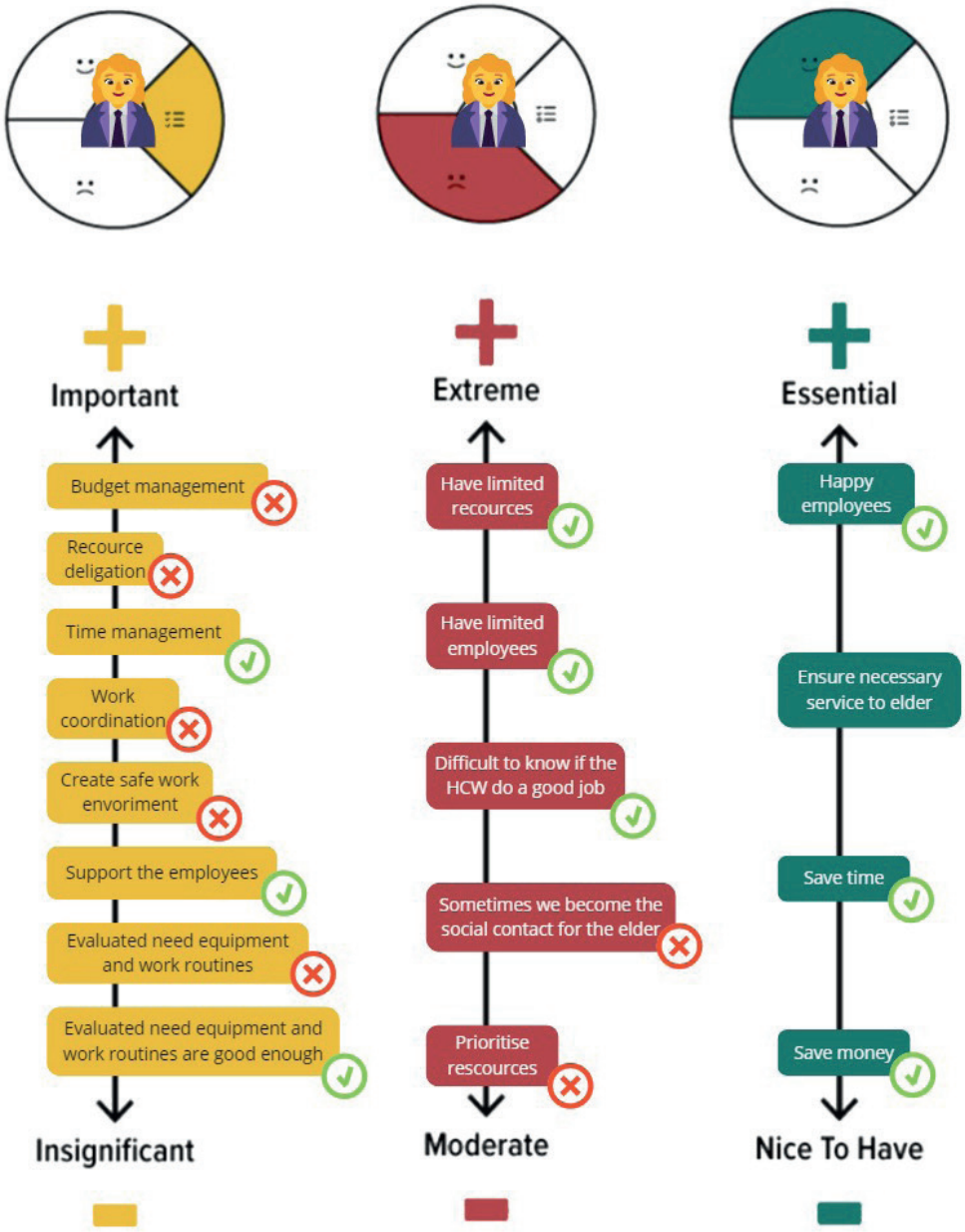
Ill. 108. The Value Proposition for the product and the ranked Customer Profil for the elderly

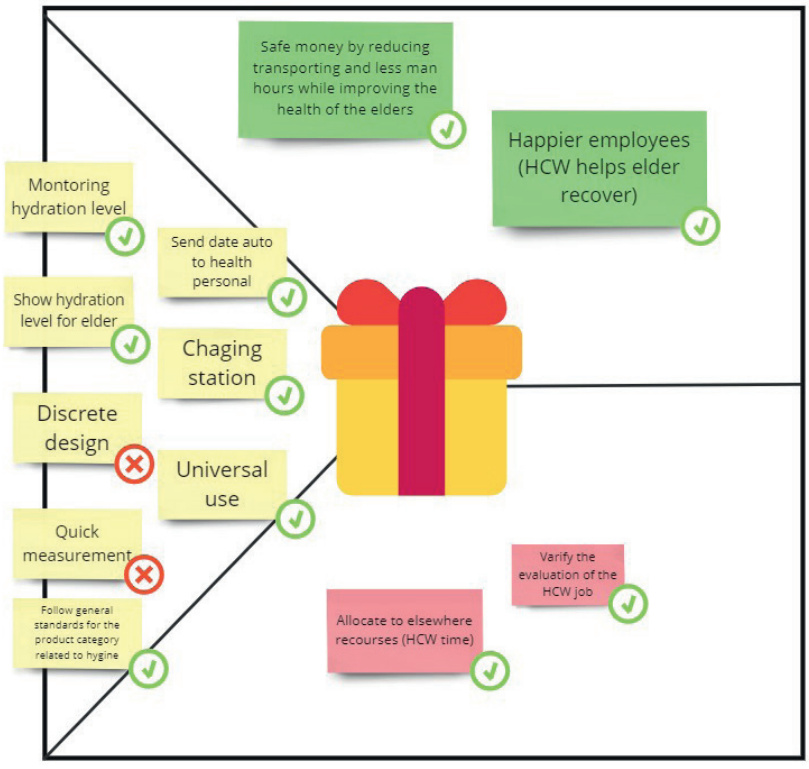
Healthcare worker



Ill. 109. The Value Proposition for the product and the ranked Customer Profil for the HCW

Manager





III. 110. The Value Proposition for the product and the ranked Customer Profil for the manager

4.3 Concept development

After revisiting the vision, the team starts developing the concept to tackle the identified struggles with the Curve.

4.3.1 Make "curve" intuitive

According to our testing at the Activity Center and the fact that we ourselves often orient the product the wrong way, it was concluded that Curve did not have the affordance to understand how to use it. In this chapter the question raised in 4.1.2, "Can Curve be made so that it has affordance to how it should be used", will be explored. The approach will be to develop forms by sketching and mock-ups and test these mock-ups to see if the affordance was improved (To see exhaustive documentation of the approach, see W49).

The second day, the test, without instructions, showed that "Grab the curve" was more intuitive than "Slides against the wrists" as people forgot this variation. Unfortunately, this affordance leads to the fingertips touching the skin on the other hand. The test also showed that the "Angled" was just as difficult to read as its previous form "Curve". Furthermore, the thicker end in "Angled" was supposed to ensure a lineation of the hands, but as it can be seen, this affordance was not read by any of the users (see ill. 116).

The aim was to make the affordance of "Curve" better. As this did not happen, the team pivoted and will try to make 'grab' a still position.

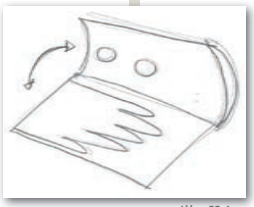
Grib

Ill. 111. Concept gib

Curve

Ill. 112. Concept curve

Ill. 113.



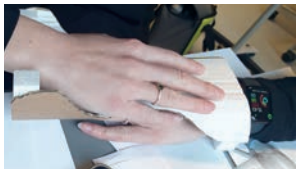
Ill. 114.

Ill. 115.

Ill. 116.

Duble curve affordance test

Ill. 117.



Ill. 118.

Ill. 119.

Ill. 120.

Angled affordance test

Ill. 121.

Ill. 122.

Ill. 123.

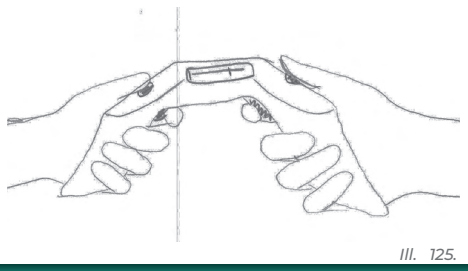
Ill. 124.

These versions of the Curve didnt afford the intented userinteraction better than the original.

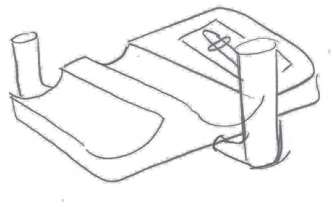
The team will pivot and try to make Grib afford a more still postition

4.3.2 Make the affordance of "grab" to a still position

In the testing in 4.1.2, it was discovered that "A surface can be utilized to make sure the user stands or sits still while the measurement is done.". This insight will be the guidance for making the affordance of the "grab" a still position of the user. The approach follows the same as for 4.3.1 (See W50 for the full approach).

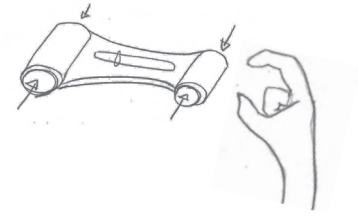


Ill. 125.

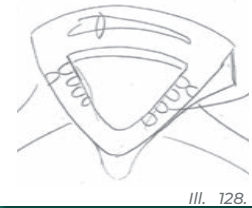


Ill. 126.

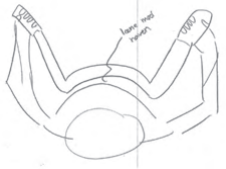
Too big for easy transportation



Ill. 127.



Ill. 128.



Ill. 129.

Too big for easy transportation

After some mock-ups exploring different hand positions, the team ended up with this one: The angle of the hands forces the elbows out, leading to the armpits not touching.

Ill. 130.

"Model 1": A controller-like form with a dent that can be pressed against the table.

Ill. 131.

"Model 2" is just like "idea 1" but smaller and has a different hand position.

A quick test was done to evaluate if people would understand intuitively how to hold the model.

Hands positions differed

Same hand position

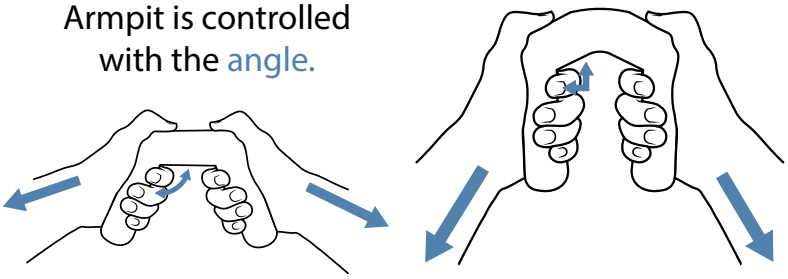
Ill. 132.

The test showed that all test subjects understood how to hold "model 1" but people differed in how they held "model 2". An evaluation of "model 1" made it clear to the team that "model 1" could, with small alterations, accommodate all the necessary principles for a "correct position" (see ill. 67). The team decides to continue with model 1.

The insight: “A surface can be utilized to make sure the user stands or sits still while the measurement is done“ was explored, with the goal of making it clear that the product should be utilized with a table and not be too big for the HCW to easily carry with them.

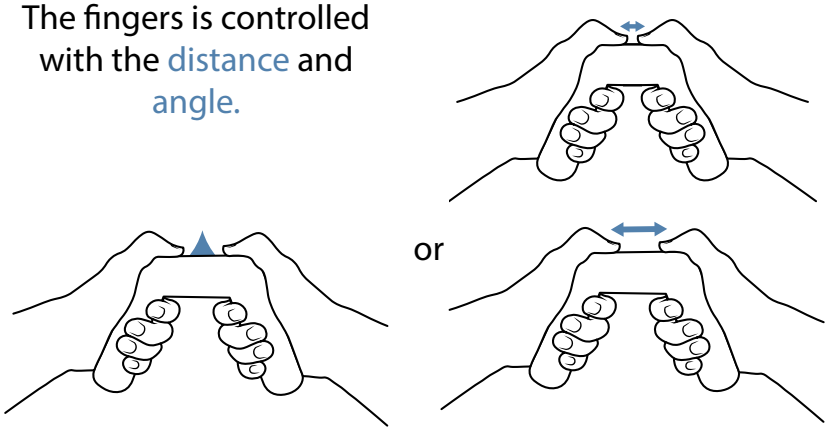
The team went with the smallest volume with the assumption that this “abnormal” shape would remind the HCW and elderly how to use the device, i.e., against the edge of the table. The form was matured in order to be presentable for milestone 4, with inspiration from controllers.

Armpit is controlled with the angle.



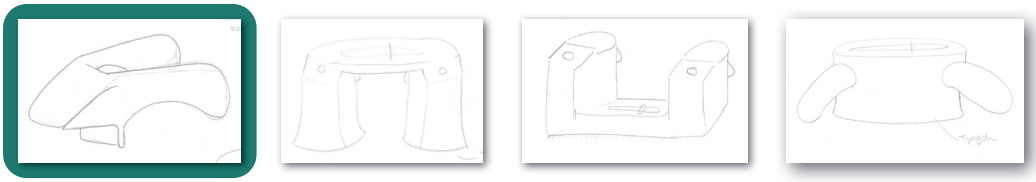
The wrist is controlled with the length.

The fingers is controlled with the distance and angle.



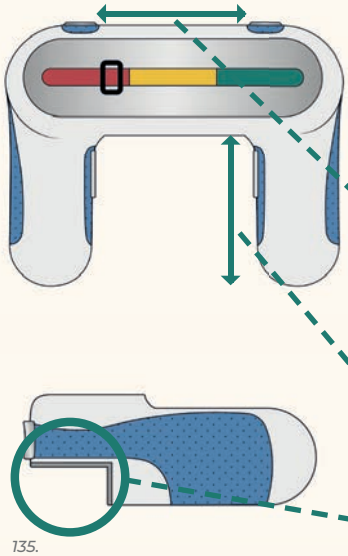
Ill. 133.

Small volume — Big volume



Ill. 134.

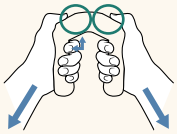
The shape of the product should accommodate the use against the edge of a table



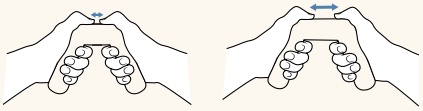
Ill. 135.

The controller

Due to the rotation of the hands, making the wrist facing upwards, the handles could be at a narrow angle.



The top electrodes were spaced with the distance required to have two of the longest thumbs not touch each other based *”The measure of man and woman: human factors in design”* by Tilley 1993.



As the wrist was controlled by the rotation of the hands, the handles were only made to exactly fit the largest hand (Tilley 1993).

The abnormal shape should remind the user to put it against a table.

4.4 Electrical components

Since the critical parts of the proposal are the price and room required to fit the electrical components, an estimate was made to ensure it.

The components were chosen based on back-and-forth with an electronics science engineer. He was given the following requirements for the proposal:

- Display the measurement
- Send measurement data to Cura
- Long battery life

The electrical components found to be necessary for the product to function were: a screen, a CPU, a battery, a charger input, and miscellaneous cords (W52). The two components of interest were the screen and the CPU, as the screen is the communicator to the user and further also a component that can consume most power just like the CPU which is the “brain”.

The electronics engineer proposed both an LCD, OLED, and e-paper. The reason for choosing the e-paper was that there was only a need for two colors, and the refresh time did not need to be high, as it only needed to display one number when the measurement was done, as a thermometer does today. Furthermore, the power consumption was a benefit as the HCW has expressed irritation over the need to recharge their tablets every day. As the screen required 3V to run, the other components were chosen based on the ability to run on the same voltage.

Screen	LCD	OLED	E-paper
Colors	Monochrome	Monochrome or colors	Monochrome or three co-lors
Refresh rate	60-120 Hz	60-120 Hz	0.5 Hz
Power consumption	6 microwatt pr. cm^2	Higher than LCD	$8*10^{-6}$ microw-att pr. cm^2

As for the CPU, two were suggested: the raspberry pi-pico or pico w. These are both embedded (integrated) processors and have higher specs than needed, but as they are widely available, and therefore cheap, they are of interest. The raspberry pi pico w was chosen as it has a wireless connection and thereby the ability to send data to the program Cura on the HCWs’ tablet.

CPU	Raspberry pi pico	Raspberry pi pico w
Wireless connectivity	No	Yes

4.4.1 Calculation of price

As for calculating the price for buying these components, the electronic science engineer suggested we divide the price by 1.25 to deduct the VAT and divide by 3.14 as this would give us the production cost of the component including salary. It could be discussed whether we should divide by 3.14 as we intend to buy the product from the suppliers and not produce them ourselves. But we assume the unit price will be lower as we increase the units (for a full view of links to the different components see W52).

The components required are calculated to cost 126.94 kr. This knowledge will be used when calculating the total cost of developing and producing this product. Furthermore, the size of the components will be used when maturing the product for production, to ensure they can fit inside.

	Reasoning	Price	Divided by 1.25 and 3.14
Charging circuit	N/A	129.00 DKK incl. VAT	32.86 DKK
USB C charger	Every household has a USB C charger as this is standard for all mobile phones.	78.35 DKK incl. VAT	19.96 DKK
LIFEPO4 battery	Fire-resistive, integrated, and rechargeable	102.01 DKK incl. VAT	32.48 DKK
Raspberry pi pico w CPU	Wireless connectivity	59.00 DKK incl. VAT	15.03 DKK
E-paper screen	Low power consumption	102.13 DKK incl. VAT	26.02 DKK
Electrodes x 4	N/A	2.24 DKK incl. VAT	0.57 DKK
TOTAL			126.94 DKK

4.4.2 Estimation of battery capacity

The table below shows the three components that consume power from the battery.

As the screen and electrodes are assessed to consume very little power, they are not included in this rough estimation. The LIFEPO4 battery has a capacity of 1800 mAh, which means that the battery will be able to run the CPU in sleep mode for 1800 hours, and in power with wifi mode for 9 hours.

In our visit to the home care (chapter 2.1), we visited about 10 elders during an 8-hour work shift. We know from Cacta that the measurement will take between 10-30 seconds to conduct. If we take the worst-case scenario of the CPU requiring the most power and sending data for 2 minutes, and this happening five times a day, the device will be able to hold power for 54 days. Actually, the HCW mentioned during the visit that this winter season they can only remember one elderly who had a severe dehydration experience, and that in the summer it was at least one elderly a week.

9 [hours] * 6010 [min]= 54

The team evaluated that the capacity of the LIFEPO4 battery is adequate but would like to revisit the calculations when the user journey is better defined. In this calculation, the wear of the battery will also be taken into account.

Component	Power consumption	How many hours the LIFEPO4 battery can run it *capacity: 1800 mAh*
E-paper screen	0.000008 microwatt So small it does not have an influence.	N/A
Electrodes x 4	Assumed to be very little as bathroom scales with bioimpedance measurements can live on 2xAA batteries for over one year.	N/A
Raspberry pi pico w, CPU	Power: 90 miliA Power with wifi: 200 miliA Sleep: 100 microA	Power: 20 hours Power with wifi: 9 hours Sleep: 1.800 hours

4.5 Business

4.5.1 Business model canvas

As a starting point for defining a business plan for the product, the Business Model Canvas was used. It was used to sum-up the previously gathered knowledge and to define where there were gaps in our knowledge of the business part of the product.

The Business Model Canvas is filled out based on the approach mentioned in Business Model Generation by Osterwalder & Pigneur 2010.

From filling out this model, the team was made aware of some unknowns to which they needed answers. The answers will be described in the following chapters.

Questions we need to explore *(in which chapters are they answered)*

- Subscription or one-time purchase? (4.9 The homecare's evaluation of the concept)
- How much does dehydration cost them now? (4.6.1 Estimated savings for the municipality) i.e., how much can they save with our products
- How much are they willing to pay? (4.6 The business budget)
- How are products marketed in that category? (4.9 The homecare's evaluation of the concept)
- Who will pay for the product? (4.9 The homecare's evaluation of the concept)
- Who knows about all the products in the category? (4.9 The homecare's evaluation of the concept)

The Business model canvas

Key Partners

CURA (Partner).

Software (In-house).

Production (Outsourced):
- Plastic processing
- Electronics
- Assembly
- Packaging

Key Activities

- Sell product for Home care.
- Advertise the product in Home care (explain what the product solves).
- Update according to CURA.
- Maintain cloud services and interfaces.
- Create a trustworthy product.

Key Resources

- Solution to sent data online to CURA
- Measuring device for dehydration
- Small storage
- Sales department
- Building for development and software maintains

Cost Structure

- Integration with Cura
- Maintain software/cloud service
- Advertising
- Cost driven business (we sell to the public sector)

Value Propositions

- Simpler monitoring of elderly dehydration, which is automatically synchronized into CURA.
- It helps for a better relationship between HCW and the elderly, as the hydration level is based on measurement rather than vague methods and observations.
- Safe money by reducing transport and less man hours while improving the health of the elderly.
- Happier employees (HCW helps elderly recover).
- Release time for other tasks.
- Insure their assumption. of dehydration.

Customer Relationship

- N/A

Channels

- Communicates with the municipalities about the savings from the product.
- Center for welfare technology.
- Doctors must be made aware of this.
- Cold canvas.
- Fairs (Is that fairs for this?).
- Inspection center/ Authority department.
- Make HCW and citizens aware of how easy our product is.

Customer Segments

- HCW.
- Citizen affected with diseases where hydration is important.
- The manager of Home care.
- The region.
- The municipality.

Revenue Streams

- N/A

4.5.2 The go-to-market strategy

The go-to-market strategy is to get the product tested in the first mover municipalities and afterward get them into the rest of the municipalities. Then, further in the future, sell the product to other countries in northern Europe and other elderly care systems.

Cacta estimates that it is possible to sell to 44% of the Social and Health Care Assistants in the municipalities in Denmark. As there are 53,301 Social and Health Care Assistants working in home care (Sundhedsdatastyrelsen 2020), there would be 23,452 potential devices to be sold.

Cacta estimates that 10-15% of the municipalities can be classified as first movers. This will create between 2,300-3,450 potential HCWs who need a device. When the first mover municipalities have tested the product and confirmed the use of it, the rest of the market is open meaning we can sell around 20,000 additional products. A second version with an integration to CURA can be developed.

23,452 potential devices to be sold for the municipalities in Denmark.

After selling to the municipalities in Denmark, a veritcal leveraging of the product could be to expand to elderly care in northern Europe or sell the device to people with diseases affected by the hydration level.

The market of northern Europe

Then looking at the northern countries of Europe, there are in total 26,284,145 citizens aged 65 and above in these five countries Germany, Netherlands, Sweden, Finland, and Norway (The world bank 2022). It is assumed that there is the same number of elderlies receiving care and the number of HCWs who will get the device. 44% of the number of Social and Health Care Assistants in the northern countries is:

HCW customer (numbers of sold device) Elders above 65 in DK *100 = amount of HCW pr. elderly [%]

4.61% of 26,284,145 is 1,211,699 HCW in these countries. If we take 44% of these, it means that there are 533,147 potential customers in the northern European countries. This is a very rough estimate and would have to be investigated more to be valid.

Around 533,000 potential customers in the northern European countries.

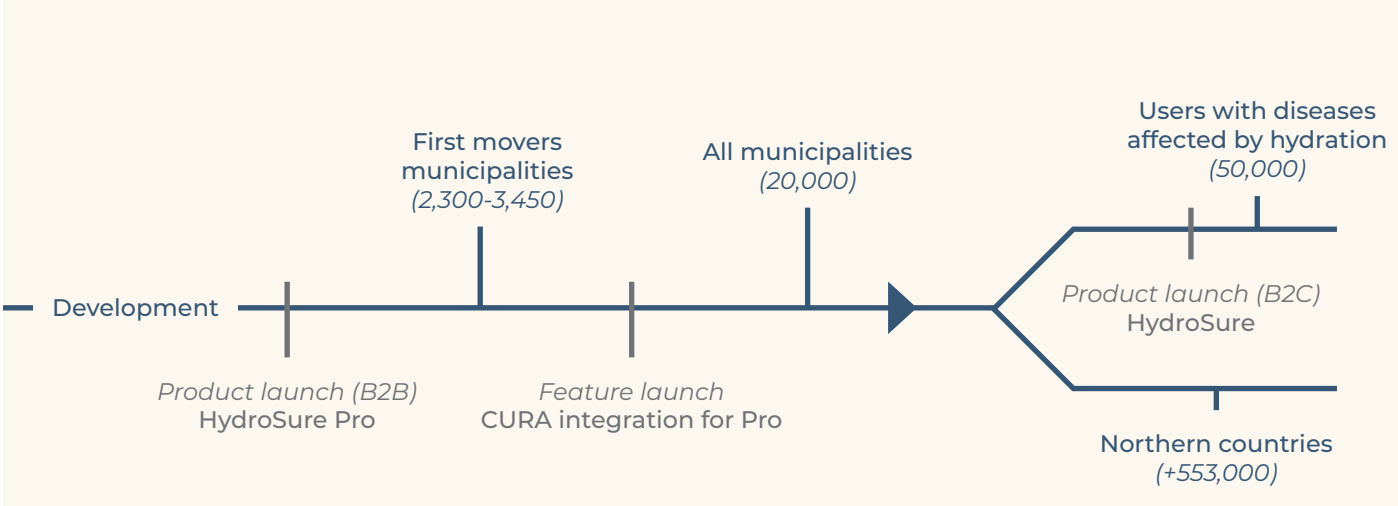
The market for people with diseases affected by the hydration level of the body

In our visits through the project, it has been brought to our attention that many diseases are affected by the hydration level of the body, meaning there are many potential customers. In order to investigate the market potential, a general practitioner was contacted. Th doctor mentioned that heart diseases, where the heart does not pump properly, stomach and intestinal infections, and kidney diseases are affected by the hydration level of the body.

Some general numbers on how many people are affected by these diseases were found on the webpages of the given interest organizations: coronary heart disease: 450,000 people (Danske Regioner 2020), crohns disease: 55,000 people (Apotekerforeningen 2019), and kidney disease, which 10% of the adult population suffers from: 24,000 (Elung-Jensen 2021). Furthermore, it should be mentioned that if you are on diuretic medication, it is also important to drink plenty and that diuretic medication belongs to the most widely used medicines, since approx. 10% of all Danes consume a daily dose (Apotekerforeningen 2019).

It is important to emphasize that these numbers are very rough as the disease numbers are found for the general area of the disease and not specific diseases that are affected by the hydration level of the body. If we aim for 5% of this market, there is a potential to have 50,000+ customers.

More than 50,000 potential customers with diseases affected by the hydration level of the body.



4.6 The business budget

The market strategy indicates that we can sell 23.452 devices within the first five years after launch and there is a potential of selling an additional 1.211.699 devices if the business is expanded into the northern countries. The budget will be based on selling 23.452 devices or 50.000 devices in the first five years (W52) (table 4.6,1).

In order to know when break-even is reached and the product can start making a profit, the selling price is estimated. Looking at products in the same category the selling price has been evaluated to be between 500-2,000 DDK (ill. 136).

Based on the products in the same category and a willingness-to-pay fake door test done by Cacta, the price level is indicated to be between 1,000-1,500 DDK. The selling price is placed between these two numbers i.e. at 1,350 DKK. Each product sold will have a profit of 1,203.06 DKK meaning the Development cost and Others will be paid back when the project has sold 11,670 units i.e. reached break even point. This can be achieved after the first-mover municipalities have tested and approved the product.

	Total	per. 23.452-units	per. 50.000-units
Development cost, *based on Cacta*	10.189.804,00 DDK	434 DDK	204 DKK
Production			
Three injection molded compo-nents in ABS plastic	3x mold (30.000 DKK) *(only price pr. unit (production + materiales))*	0,83 DKK ~ 20,00 DKK	0,83 DKK ~ 20,00 DKK
Electrical components	*(only price pr. unit)*	127 DDK	127 DDK
Others, *based on Cacta*	4.082.890,00 DDK	174 DDK	82 DDK
Total cost price pr. unit		**765 DDK**	**442 DDK**
Revenue		**585 DKK**	**908 DKK**

Table 4.6,1

Competitor in the market of products for dehydration.

A device utilizing the same technology.

The products family we want to be a part of: blood pressure meter and thermostats.

A device utilizing the same technolo-gy

Ill. 136.

4.6.1 Estimated savings for the municipality

In order to validate the benefit of developing this product and investing in it, the yearly savings for the municipality are calculated. This will also be a big selling argument for the municipalities to invest in the product.

Cacta estimates the following savings for a municipality by reducing hospitalizations. Right now, a municipality uses 50 mill. DKK on hospitalizations due to dehydration, Cacta assumes that the device cannot eliminate 15% of the hospitalizations, making the saving over 43 mill. DKK pr. year. In our case, we will subtract the purchase price of the products. We estimate that the selling price will be 1,350 DKK and that all municipalities will buy the product so that 44% (Cacta 2023) of the social and healthcare assistant will have the device. Furthermore, the salary of the HCW will not be added, as we assume they will use the same amount of time as now. In this calculation, it is also assumed that the device can be used for five years before it needs to be replaced, giving them a write-off period of five years.

In total the municipality will be able to save 78% of their current spendings on hospitalizations due to dehydration pr. year. In addition, it is worth mentioning that the municipality only pays ⅓ of the price for hospitalization of elderly people with dehydration. The regions pay ⅔ of this price meaning the regions have even more to save.

$$\frac{\textit{yearly saving - (pushcase prices / write-off period)}}{\textit{yearly cost of dehydration}} * 100 = \textit{procent of saving per. year}$$

$$\frac{45{,}885{,}333 - (1350 * 23{,}452 / 5)}{50{,}453{,}333} * 100 = 78\ \%\ \textit{per. year}$$

78 % yearly saving of dehydration

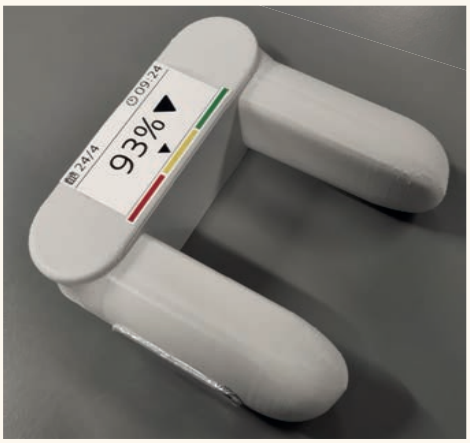
- The 15% of the hospitalizations that cannot by eliminate.
- Salary for the HCW to do service.
- Pruchase price of the device.

4.7 The evaluation of the concept from homecare

The team wanted to get feedback on the user scenario from the HCW in Home Care Nord Land Øst in Aalborg (whom we visited in chapter 2.1). In order for the HCW to understand the use of the product, the user scenario was sketched out, and a rendering and a 3D- printed model of the product were brought along (W54). Furthermore, the Business Model Canvas (chapter 4.5.1) prompted some questions the team wanted the manager's perspectives on. The setting for the feedback with the HCW was a lunch break, so it was a discussion around the table. The manager's feedback was given over a call.

Ill. 137. Rendering of the concpet

Ill. 138. Rendering of the concpet



Ill. 139. 3D-printed mock-up for the concept

Problem: It has not been tested if the enderly have enough flexability in their wrist to use the product propperly.

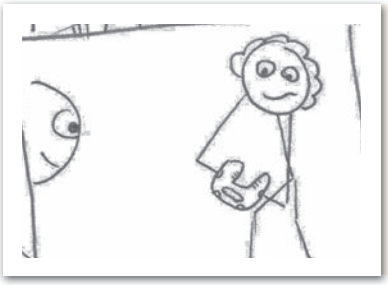
Before the visit, the team considered a scenario where the HCW gave the product to the elderly who kept it overnight, which would give data, or one where the HCW just had the device with them like a thermometer. The team decided on presenting the last scenario. This is due to the team seeing a problem if HCW encountered multiple elderly with symptoms of dehydration during the day, as they then would not have a second device to give the next elderly. This problem was confirmed as the HCW mentioned that, during this winter season, they only remembered one elderly who had a severe dehydration experience and that in the summer it was at least one elderly a week for each team i.e. two elderly a week.

In the summer period, each team experiences at least one elderly a week getting dehydrated.

The HCW further confirmed the team's assumption that it is difficult to hand over subjective observations about the dehydration of the elderlies to colleagues by a written statement in CURA. They cannot do it verbally as they do not meet the HCW working the night shift. Likewise, they add that to observe dehydration in an elderly person, you have to know the elderly to know what normal is. In conclusion, the HCWs see the product as a helpful aid in monitoring the course of dehydration, so they can modify their treatment accordingly.

They are very fond of the idea and say it could replace the fluid chart, if the measurement is ensured to be valid.

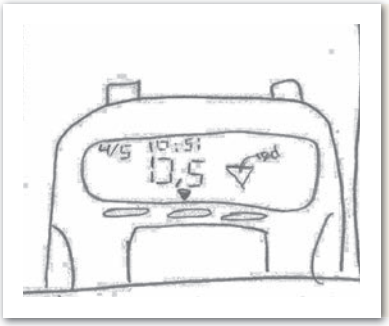
The product can help quantify the monitoring of the dehydration



Ill. 140.

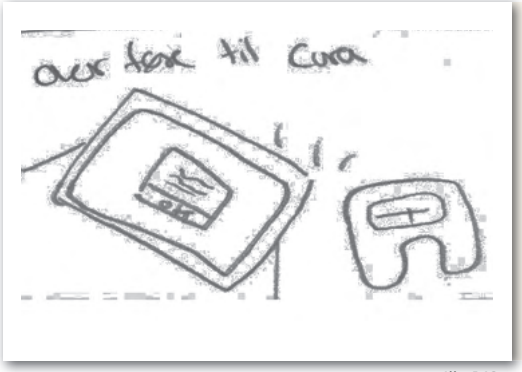
The HCWs display a strong objection to the elderly pressing a button in order for the measurement to take place. They say that not all eldelys can use or push with their fingers and that they would prefer if they could have the control e.g. hold the product on the elderly or like an oximeter.

i This contradicts the independent part which the team has identified as important for the elderly to not compromise thier dignity.



Ill. 141.

The scenario was based on the possibility of a 0-measurement i.e. a measurement that is done when the elderly is well in order to compare when dehydration is suspected. The team assumed the elderly had a doctor visit once a month where such a measurement could be conducted. This assumption is denied by the HCWs. Likewise, they are skeptical about it being realistic to do since it would cost money and time.



Ill. 142.

The HCWs are skeptical of the product being integrated with CURA so it can automatically synchronize the data to the elderly.

Their worries lie in that they seldom follow their visitation schedule, so the device does not know where they are, hence, which elderly the data should automatically synchronize to.

Also the constant connection to the iPad will consume power from the iPad which is not always fully charged. They say it is already a problem to keep them charged. They would rather do it manually.

4.7.1 Call to the manager

During our visit the manager did not have time to speak, so we called later. At the phone call, it was clarified that it would not make sense to subscribe for the product it should one-time purchase. Since it was in a reachable price range. If the product would be a part of the bag of the Social and health care assistant it would be part of the budget of the home care. When they have new equipment like a thermometer or blood pressure monitors they have catalogs from the companies the which the municipalities have procurement contracts like Aberna or at Hjælpemiddeldepotet.

The team will explore if the HCWs' strong objection against the elderly pushing a button is well-founded. Further, the scenario of a 0-measurement was reevaluated. Instead, the device will be the HCW tool to monitor the course of dehydration to quantify the subjective observations. Finally, the data will not be automatically synchronized. Instead, the HCW will manually write the measurement in CURA.

4.8 Cacta's evaluation of the concept

The main concern is form. Is it the best to empower the elderly to do the measurement themselves, as there is uncertainty about the mobility required to perform the measurement (see illu. 138 in chapter 4.7.)? This refers back to the ongoing dilemma between ensuring the 'correct position' and giving the elderly the possibility to do the measurement themselves i.e. designing for their mobility (chapter 2.10). The goal will be to clarify this dilemma during this visit to Cacta, as they have knowledge about the technological requirements. For the visit, we bring all the latest mock-ups and the presentation from Milestone 4 (see the documentation in W55).

The dilemma between 'correct position' and mobility, including comfort, of the elderly

Cacta questioned if the form is comfortable enough and if the elderly can even do the measurement, referring to old hands and disability, ill. 138. They recommended that we ensure that the handle is ergonomic. Regarding the dilemma, Mads said the technology was not dependent on the placement being accurate down to millimeters and we should slightly ease the requirement of "correct position". E.g. for the curve it was okay that the hand moved a bit. Mads said the accuracy of the placement is still unknown and that it needs to be tested later. It is beyond what we can do now. Mads elaborated on the most critical aspect in order for a valid measurement, and concluded that the most critical parts of the technology are the contact surface and that the electrodes are spaced 5 cm.

Ill. 143.

Mads suggested that we take 80% of the Controller's form and 10% from the Curve and combine them into one. This means that we should avoid using the table edge but use the knowledge of the table stabilizing the hand.

Technical requirements for the contact surface

We were concerned about the influence of moisture on the connections from product to hand, as this can influence the conductivity. Cacta says moisture could be a potential problem for the measurement. But they assume that the software can get around it as the product will send different frequencies through the body.

Software should be able to take problems of moisture into account

The type of bioimpedance which should be used for this project is at 50 Hz. This frequency is better when you want to sort out elements compared to the bioimpedance normally used in handheld devices which is 5 Hz, but it needs to be tested. Solution B would be to use the gel that is applied to the electrodes, ensuring a connection. Mads and Ida also assume that the software will be able to tell if the hands are too sweaty and need to be dried before the measurement can be done. On the other hand, the chance of the elderlies' hands being too sweaty is low, as they probably are dehydrated and as elderlies swear less.

The output of the measurement

Mads assumed the measurement would output a number rather than a percentage. He continued that it will be difficult to communicate with the HCW and get them to understand that they cannot compare the different elderlies' numbers. E.g., Preben's number can be 65 and Oda's 65. Yet, Preben is not dehydrated but Oda is to a severe degree as she normally measures 75.

The importance of differentiating

Ill. 144.

The discussion returned to the form. Mads emphasized the importance of differentiating from competitors as they quickly could take over our customers if customers cannot see the differences between the two products. If the form is different from the competitors in the eyes of the customer, the customer thinks they are different. This will also force the competitor to develop a lookalike product in order to compete with us, giving us an advantage of more time on the market.

In conclusion, we were recommended to change the form so it is more comfortable to use. The most critical part is the contact surface between hands and product and that the electrodes are spaced 5 cm. The team accepts that they would not need the user to be in a specific position, but ensure they sit in the same position every time. Finally, the team should focus on differentiating the form from the competitors, requiring we take a step back and see how we "design the product for the table".

4.9 Form development

In light of the feedback the team received during their visits to the homecare (chapter 4.7) and Cacta (chapter 4.8) they revisited the form (W56) with the following in mind:

- **Explore the elderly's ability to push a button.**
- **Ensure ergonomic comfort for the elderly.**
- **Design the form so it ensures the users use a table.**
- **Ensure the elderly sits in the same position every measurement.**

4.9.1 Exploring the push force of the elderly

To explore the elderly´s ability to push a button, the team needs to know how much force needs to be applied for the electrodes to work. In the academic paper: "Dry electrodes for bioimpedance measurements—design, characterization and comparison", it is concluded that the higher the frequency the less the contact force impacts the bioimpedance measurement. The test shows that the contact force at 5N can decrease the electrode-skin impedance significantly, i.e. we should make sure the contact force is more than 5N. A solution to ensure this could be to utilize a comparison spring that will apply the force at 5N to the electrode.

This solution would require the elderly to have a certain grip strength leading the team to wonder if the elderly is able to push with 5N? According to an article by the Professor and Director of the Clinical Anatomy Learning Centre, Lancaster University (Taylor 2020), the muscle mass starts to decay by 1% a year from when you reach middle age. A test showed that people between the ages of 20-30 had an average grip strength of 46kg for men and 29kg for women. This had decreased to 39kg and 23.5kg, respectively, for people between the ages of 60-69.

5N = 0,5kg < 23.5kg

The team concludes that it should be possible for an elderly to push down a button that requires 5N to be pressed.

The product should enhance the contact force to the electrodes to be more than 5N.

4.9.2 Ensuring a comfortable 'correct position'

The following section redevelops the form of the product (full documentation of the process can be found in W56). The leading requirement for this process was: How to assure the product is ergonomically comfortable for the elderly while utilizing a table to ensure the elderly sits in the same position for every measurement?

In the visit at Cacta, there was a discussion of just turning the concept 180 degrees as the device then would have a stronger feedforward of 'needs a surface to stand on'. The team explored this idea using elements of "Funktionsflade-variationsmetoden" (Tjalve 1989). They sliced the concept up into a handle, a screen, electrodes, and a foot.

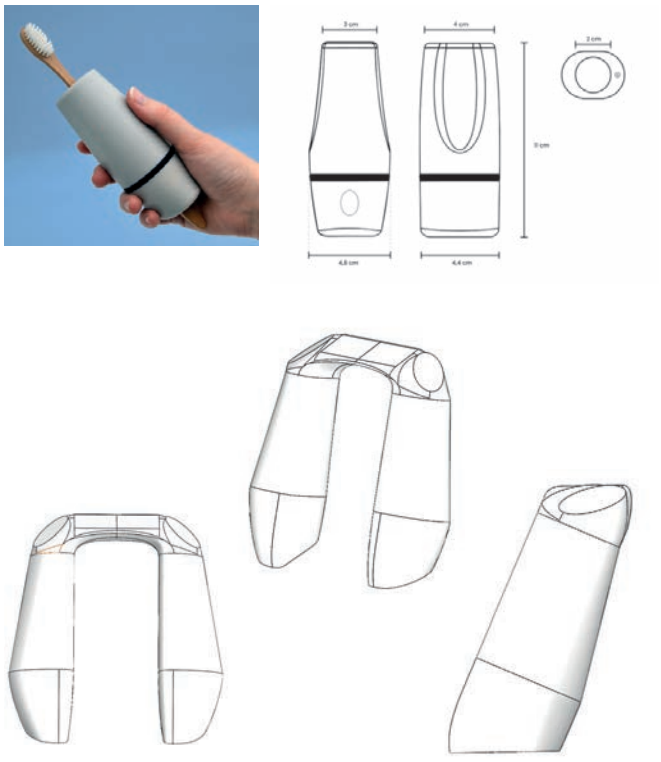
Ill. 146.

Every variation of the screen being at the bottom had the problem of the user not being able to see the screen as they used the product.

Ill. 147.

Placing the screen on top made it possible to view while using the product. But the team had a difficult time making the product afford *'needs a surface to stand on'*.

The team let the foot be for now and focused on exploring a more comfortable grip. On the visit to Cacta, they commented that the grip was maybe a bit too small for the elderly. They added that we maybe could get inspired by a startup called Manigrip. They have made a device that makes people with bad grip able to grip around different objects. The team decided on using the dimension from Manigrip's product (Manigrip n.d.) as inspiration.



Ill. 145. Manigrips product and to the right the end product it inspired.

A test of the ergonomics of the form was made.

The dimensions of the form were based on a combination of numbers from "*The measure of man and woman: human factors in design*" by Tilley 1993 and the Manigrib product. The team wanted to test if this widening, (see ill. 157), at the bottom and thickness of the handle were comfortable. The test was made on a big and small hand, according to the measurements of man.

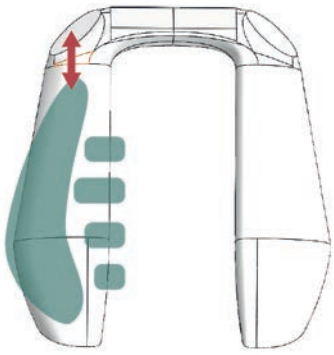
The widening did so the test subjects wanted to hold their palms there, but the handle was too long for the large hand to reach the buttons. The small hand could use the wider part to rest her hand on. If the wider part was lifted the small hand would no longer have a comfortable grip.

Hand size S *Ill. 149.*



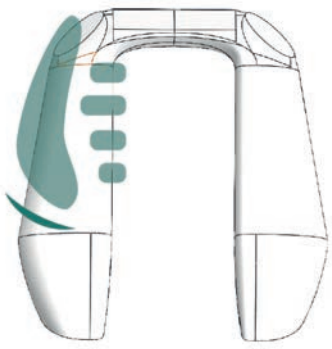
Hand size L *Ill. 148.*





Large hand has comfort grib around widening but can not reach button.

If the widening is moved up on the handle so the large hand has comfortable grib, the small hand is "pushed away" by the widening.



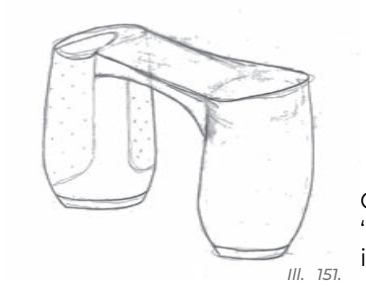
Small hand can rest on the widening and reach the button

In conclusion, Manigrib is designed for use scenarios where you can decide where you want to hold your hand on the product. This is the reason why the form does not work for us, as we need to fit both small and large hands while the thumb is reaching the same position making it two different forms that would be comfortable for them. However, the team will keep in mind that the handle might need to be bigger as it then would not require the elderlies to be able to close their hands as much. Further, the test showed that the form does not indicate that it should stand on the table and maybe it could be beneficial if the elderly could relax in the position.

Ill. 150.

Continuing exploring the foot

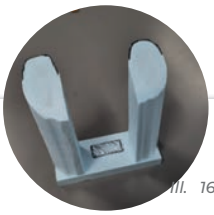
The team took inspiration from how other products signal 'should stand on a surface'. Next to the sketches are the noted comments.



Ill. 151.

Ill. 152.

Can we just add a 'bridge' for display? No, it seems to be very big.



Ill. 160.

Ill. 159.

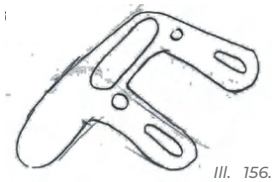
Can we tilt the handles back- and inwards so the user can see the display? Now it looks like demon horns.

Ill. 154.

Ill. 155.

Ill. 153.

What if you can flip out some legs. This principle adds complexity to the product. Moving elements can break. Expensive to make.



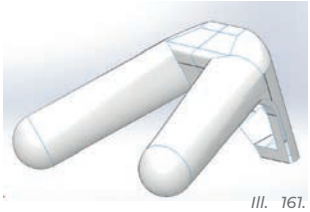
Ill. 156.

Ill. 157.

One form, easy to clean. Three legs afford "place me" but not too big to carry with you. The foot can be made into a handle to hold when carrying. Space enough for the electrodes and you can see the display. We assume the angle can be tilted so it is comfortable to grab when sitting at a table.

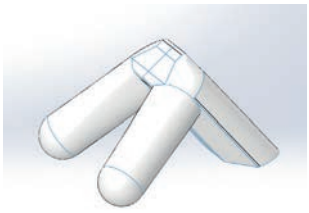
We need to ensure it does not look too much like a con-troller for gaming but more like a medical device.

Went into 3D to get a better understanding of the form and the market dimensions.



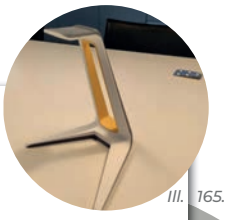
Ill. 161.

The team assumes the wide leg will require a complicated mould in order to be injection molded, which will increase the cost.

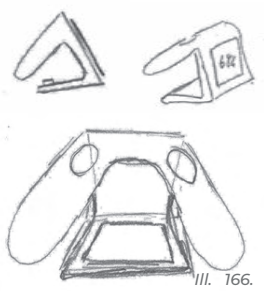


Ill. 158.

The wide leg has too much volume compared to the other elements.



Ill. 165.



Ill. 166.

Can we use this type of foot? Looks weird and affords a rocking motion, which is not optimal as you should sit still.

Ill. 168.

Ill. 167.

Can the form be like a strip of paper you fold? Also affords a rocking motion, which is not optimal as you should sit still.

Ill. 162.

Ill. 163.

Ill. 164.

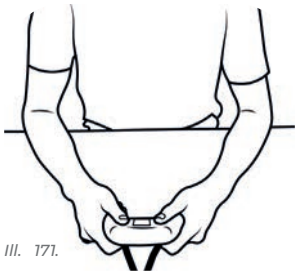
What if we make more volume at the bottom? It does not look like a device you take with you.

Ill. 169.

Large hand fit on the product

Ill. 170.

Small hand fit on the product



Ill. 171.

The position of the body when using the product

What	Why
A surface that indicates it should stand on a table.	It makes sure the user is sitting still and in the same position.
A display with a number.	Then HCW can write the number into CURA.
USB-C connector.	They are already charging devices and USB-c is the standard.
The dimensions of the product are based on the book The Measurement of Man.	It will fit 99 percent of all humans.
The electrodes, spaced with 5 cm, should be push-in buttons.	This will ensure the best connection and the touching area is 4 cm2.
The product is angled against the table.	This will ensure a comfortable position for the wrist.
It should be transportable.	HCW needs to bring it in their bag.

The next step is to mature the form for production and find out how to fulfill the requirements set by the standard for medical devices in home care.

05 Concept detailing

In this chapter, the team is going to revisit the go-to-market strategy and vision. Further, they will go in-depth with the production, budget, and mature the form for production.

5.1 Revisit the business plan

Since chapter 4.5, the team has visited both the homecare in Nord Land Øst and Cacta to get feedback on the product and business case. This chapter will describe the changes that were made to the business plan and why.

5.1.1 Go-to-market strategy

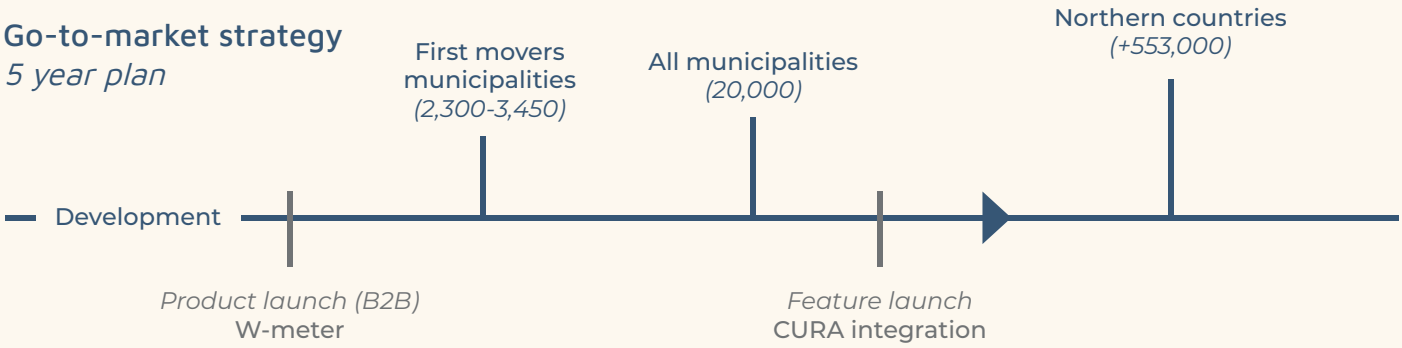
The go-to-market strategy is changed from Chapter 4.5. The plan still entails getting the product tested in the first mover municipalities and afterward getting them into the rest of the municipalities. But the future selling will no longer involve people with diseases affected by the hydration level of the body, but only the market of the other countries in northern Europe. This is due to the varying use cases this market might have, which is something the team is unsure of whether the product is designed for.

As identified in Chapter 4.5.2, there are 23,452 potential devices to be sold in total in the Danish market. The first stage of the to-go-market strategy is testing in the first-mover municipalities. As identified in Chapter 4.5.2, there are 2,300 to 3,450 potential devices to be sold in the first mover municipalities. Additionally, 20,000 products are to be sold in stage two. Stage three is the launch of automatic data synchronization to CURA and is intended to be developed in stage 2. This service will be by subscription and entails the device getting an upgrade so it can synchronize the data to CURA automatically.

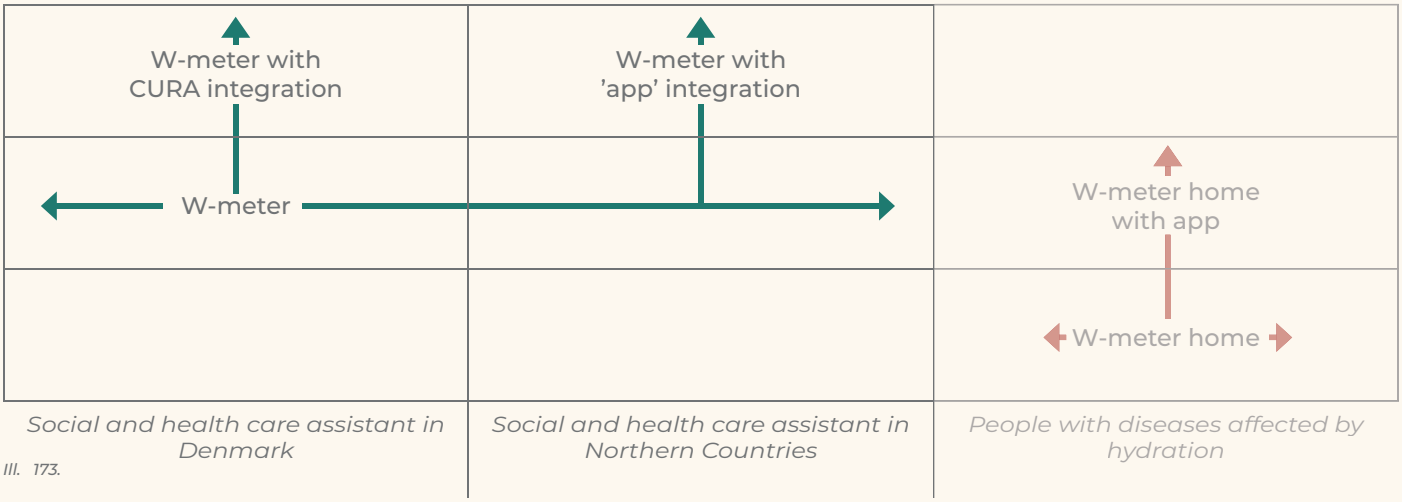
A second subscription service had also been considered. This revolved around the change of needed devices for the winter and summer periods. The municipality would pay a fixed amount, depending on the number of devices, to have a lower number of devices in the winter and more in the summer period. This subscription idea was dismissed as it required the company to store all the devices during the winter and ensure they all were functioning again in the summer. Repair and storage are big costs.

The team has also considered making a repair service where the user could send in a dysfunctional device and then receive a new one within 24 hours of registering the dysfunctional device in the system. The dysfunctional device might be repaired, or the parts recycled. But, as mentioned above, repair is a big cost and as the product is fairly cheap it does not make sense business-wise as there is little to no profit, and it does not add value for the customer.

After selling to the municipalities in Denmark, the product could be expanded to elder care in northern Europe representing an additional 533,147 potential customers (chapter 4.5.2). Here there probably needs to be some adjustment to the business plan since the elder care systems vary compared to the Danish one.



Product and process architectures



Ill. 173.

5.1.2 Business model canvas

The business model canvas is updated according to newly gathered knowledge.

Key Partners

Key partners *(Motivation for partnership)*

- The municipality *(insight into user needs)*
- CURA *(implementation in main user platform)*
- Production *(knowledge sharing and production)*
- Packaging e.g Postnord *(sending product to customers)*

Key Activities

- Product maturing.
- Developing and updating software.
- Testing the product.
- Marketing *'a trustworthy product'*.

Key Resources

- Funding for medical devices
- Software development
- Medical test advice and approval
- Good network with municipalities.

Cost Structure

Sales price: 1350 DKK
Operation cost for 50,000-units: 220 DKK (chapter 5.4)

Salary and software development are evaluated to be the most expensive costs. The business aims to be sustainable meaning long lasting, quality products that can be disassembled and recycled with a lean cost.

Value Propositions

The product prevents the risk of dehydration by estimating the hydration level of the body.
The value for:

- the **elderlies** feel safer and included as they are taking part in the measurement.
- the user **(HCW)** is that they now have a tool that enables them to communicate the state of the elderly's dehydration to their colleagues, making it possible to monitor the course of dehydration for the elderly and alter the treatment as needed.
- the **customer** is cost savings. The health care sector in the municipalities can save 75% i.e. 51 mill DKK, while the regions can save twice as much i.e. 102 mill. DKK.

Customer Relationship

Self-service on our website to buy the product.

Membership creation as we want feedback from the users. This can be acquired by attending the welfare technology courses, by visiting the first mover municipalities with which we must have a good relation.

Channels

The customers can buy the product via our web shop or the municipalities' own platforms e.g. Center for Assistive Devices (Hjælpemiddelcentralen) and procurement contracts in the municipalities.

Further, we should ensure the product is represented when welfare technology courses are held.

Customer Segments

Niche market i.e., specialized customer segment (Osterwalder & Pigneur 2010). The customers are the purchasers and the managers in the health care section in the municipalities.

The users are the Social and health care assistant and nurses in the health care section in the municipalities. (23,452 in Denmark and +530,000 in northern European countries)

Revenue Streams

We sell the product on the web shop or through the municipalities' own platforms i.e. sales of activities. The customers have an additional opportunity to make a subscription agreement in order to get the feature that allows the product to automatically transmit the data to CURA.

The sales price of the product is 1350 DKK (see chapter 4.6 for a further explanation)

5.2 Requirements set by the standards

In the maturation of a product, a key activity is altering the product, so it fulfills the requirements set by the standards for the given device classification. This chapter will give an overview of the different standards that the product must fulfill.

5.2.1 Medical device classification

In order to see which standards the product should fulfill, a questionnaire was taken. The questionnaire (Accelerace n.d..), which was made by Accelerace can give an indication of medical device classification of the product. The questionnaire indicated the product is a 2A classification (see Table 5.1.1.1).

Classification 2A
Active device for diagnosis. If intended to supply energy, to image in vivo distribution of radiopharmaceuticals, or for direct diagnosis or monitoring of vital physiological processes.

Table 5.1.1.1 Description by Cacta.

This 2A classification gives direction in terms of the technology, but not durability, cleaning, etc. As the technology was black-boxed in the beginning, because Cacta is still developing it, this classification does not give requirements to this project. Thus, the classification gives an indication of the risk category which the team will use to clarify the classification in the standards to come. The team progressed to find a standard that could give some requirements for the product. The team identified the following as relevant to the product.

The general standard for medical electrical equipment: *DS/EN 60601-1:2006 - General requirements for basic safety and essential performance*. This standard gives some requirements for the strength and cleaning of the product.

The sub-standard for medical electrical equipment used in home care: DS/EN 60601-1-11:2015 - *Requirements for medical electrical equipment and medical electrical systems used in the home healthcare environment*. Besides the given requirements for the power indication and strength test, listed below, this standard revolves around extra instruction to ensure it is done correctly.

8.3.1 *Ingress of water or particulate matter into ME EQUIPMENT (DS/EN 60601-1-11:2015, page 23)

- Requirement of being categorized as an IP 22 rating. The product should undergo three tests, and afterward still maintain basic safety and essential performance.

The product must fulfill the requirements for the IP22 -rating.

8.5.1 * Indication of state (DS/EN 60601-1-11:2015, page 24)

- As the electrical power source is necessary in order for the product to work, it is required to indicate the state of the power source. This indication must be visible either continuously or by operator action. Further, how the state of the power source is determined will be described in the instructions. Checked by inspection.

The product must indicate the state of the power available in the product during a use scenario.

Further the sub-standard lists some 'Mechanical strength test applicability' the product must fulfill. (DS/EN 60601-1-11:2015, page 27, table 2, transit-operable and hand-held):

Push (DS/EN 60601-1:2006, 15.3.2)

- External parts must withstand a steady force of 250 N ± 10 N for 5 seconds. This test is not made to the bottom of the external parts if it has a mass greater than 18kg. The test must not result in any damages that can result in an unacceptable risk. Checked by inspection.

Drop (DS/EN 60601-1:2006, 15.3.4.1)

- The product must be able to withstand a fall from three different starting orientations relevant for normal use. The falls must be made from a normal use height or from 1 meter, whichever is greater. It should fall onto a 50 mm ± 5 mm thick board, made from hardwood, placed horizontally on concrete. The test must not result in any damages that can result in an unacceptable risk. Checked by inspection.

Additionally, the product must withstand a molding stress relief test (DS/EN 60601-1:2006, 15.3.6), a shock test (DS/EN 60601-1-11:2015, 10.1.3 b), and a vibration test (DS/EN 60601-1-11:2015, 10.1.3 c). But as these tests do not have a direct influence on the product form in its current development state, these will be noted for future testing.

5.2.2 Cleaning classification

A crucial part of the product design is how much the product needs to be cleaned. Both Statens Serum Institut 2017 and the ISO 17664-2:2021 - *Processing of health care products? Information to be provided by the medical device manufacturer for the processing of medical devices?* (Annex E) classified the product as a non-critical device in the Spaulding classification (classification for cleaning in the medical sector) as it has direct contact with the patient by the skin. The ISO standard is for non-critical medical devices. The standard states that:

- The manufacturer is responsible for ensuring that the cleaning of the device can be done effectively.
- There should be a guideline of how to clean and disinfect the devices.
- The manufacturer should make a risk analysis of where the risks are.

The standard also provided a list of elements you could use as a starting point for the risk evaluation (ISO 17664-2:2021, page 4). Further, the standard also includes a list

of descriptions of what features should receive extra attention (ISO 17664-2:2021, Annex C)

It should be mentioned that the team is not professionally skilled to make a proper risk analysis. However, we believe the buttons have the highest risk of transferring contamination. The reasoning behind this is that the electrodes, which all elderly need to touch, are traveling buttons and thereby filth can accumulate in the joints. Even though the risk is highest here, the device is non-invasive and thereby categorized as a non-critical medical device, i.e., the lowest level of cleaning needs to be performed.

The requirements listed will be implemented into the product, to the degree possible, in the maturing phase.

5.3 Production of the product

5.3.1 The production methods and materials

According to the market analysis and go-to-market strategy, the product can be sold to 23,452 users within the first two years after launch and there is a potential of selling an additional 1,211,699 devices if the business is expanded into the northern countries. Further, the product is estimated to have a lifetime of 5 years (chapter 5.4), before it needs reparation, meaning that we can sell 23,452+ devices every 5 years. These numbers influence the production and material requirements.

Choice of material

The product is evaluated to be in plastic due to its form properties. Further, the electrodes need to be chosen, and as the product will be manually assembled and rated IP22, rubber is also required.

Choice of production method

Blow molding

- Not possible due to the degree of details
+ Cheaper

Rotational molding

- Not possible due to the degree of details
+ Cheaper

Injection molding

+ Possible to do with the degree of details
+ Higher quality of appearance
+ Add construction to components inside
- More expensive

Regular injection molding

+ Cheaper i.e. simpler machinery and molds

2K/over-molding

+ Nice appearance
+ Better forward affordance to be griped
- More expensive

The form is evaluated to be produced in plastic. Below, ill. 174, is the thought process with pros and cons of the relevant different production methods for plastic parts:

It could be enough just to change the texture of the surface which can be done by regular injection molding. It will be evaluated if 2K molding is necessary by making renderings of the two different versions. The requirement is an easy feedforward to the user of where to place their hand i.e. use the product.

Ill. 175. Rendering of grip with color

Ill. 176. Rendering of grip withot color

Ill. 174. Choice of production method for shells

Choice of assembly method

The two injection molded forms must in some way be assembled with the rest of the product. To assemble the product, two assembly methode are evaluated to be relevant.

Known unknowns
- What are the tolerance requirements for each assembly process?
- How expensive is ultrasonic welding?

Manuel assembly i.e. self-cutting screws was chosen because it will make the product more sustainable. The product can be designed for disassembly. On the other hand, it will make it more difficult to get the product IP22 rated. Cleaning will also be influenced, as filth can accumulate in the gaps. The cleaning part is most critical around the electrodes since all the elderlies are touching them in doing the measurement. But as the product is categorized as a non-critical medical device, the requirement for cleaning is modest.

Ultrasonic welding

- Not possible to repair
- Not possible to disassemble
+ No gaps for filth to accumulate
+ IP22 rating is easier to get

Self-cutting screws and a gasket

+ More sustainable (able to disassemble and reparable)
+ Marketing more sustainable
- Possible for filth to get in gaps
- More difficult to get IP22 rated
- More manual assembly

Choice of plastic type

To determine the best-qualified plastic, the method explained in "How to select the right plastics material" Kjær 2006) was used (See full documentation of the method in W58). The first step in this method was to establish general demands for the parts according to planned use. After the general demands needed to be translated to demands for the material (see table 5.3.1.1).

The next step is to select the plastic types based on them fulfilling the material demands according to the tables in "How to select the right plastics materials". The selection ended with the two plastics: ABS and SAN. ABS was chosen because in table 6 (Kjær 2006) it performed better than SAN in terms of relative impact strength. This property was evaluated as a better fit for the environment it must perform in i.e., the daily work of the HCW. It should be mentioned that ABS is more expensive than the other plastics of interest i.e., in order SAN, POM, and PBTP but has better impact strength.

The product should be made in ABS plastic.

Demands for the use of the product (What it is based on)	Translated demands for the material [cate-gory]
The product should be injection molded (Cho-sen method based on the quantity)	forming process Injection molding [1]
Screw (Design for disassembly) or seal (clean-ness)	Assembly process: Self-cutting screws or ul-trasonic welding [1]
Grey color (The appearance of the device in the same product category)	Optic and surface - Bright colors [1]
Should be cleaned according to standards	Resistant to alcohols [1]
In contact with skin	Resistant to fat from the skin [1]
Should be able to tolerate a fall from working height without it being hazardous (Standard 60601--1:20006)	Should not be brittle [2]
Can not have shrinkage or internal stress which can lead to risk (Standard 60601--1:20006)	Not a requirement for the material but rather for the design [-]
Being used at normal room and outside temper-ature in DK (Use context)	10 to 40 □ [1]
In use for 5 years	Related to creep (but the product is not under stress) [-]
Recyclable	Plastics should be recyclable [-]

Choice of electrodes

We have black boxed the technology, so the team asked Cacta what material the electrodes should be made in. This led us to the academic paper: “Dry electrodes for bioimpedance measurements —design, characterization and comparison” by Kusche et al. 2019 for the choice of material for the electrodes. The article compared different electrodes and concluded that the best materials for the electrode are metal materials, specifically the gold coated was the best of all. Further, the gold electrodes are the easiest to produce and connect to a circuit.

Choice of rubber

We chose a 40A shore rubber since it has the same softness as a rubber inner tube (Hapco n.d).

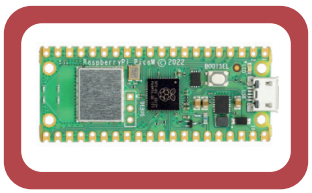
It was chosen to use injection molding, either regular or K2, due to the possible degree of detail. The plastic should be ABS as this has a higher relative impact strength, compared to the other candidate, a property that could be useful in the use environment.

The two external shells are manually assembled with self-screwing screws and sealed with a rubber gasket, shore 40A, as a solution to getting the product a IP22 rating and being cleanable. The electrodes are gold coated to ensure good connection to the skin.

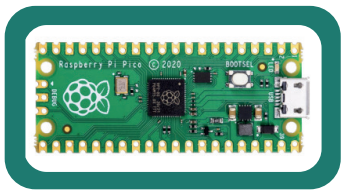
5.3.2 Revisiting the electrical components

The components were revisited as new insight had been acquired (see full overview in W60).

The CPU was changed to the Raspberry Pi pico which cannot send data wirelessly. This change was because the product does not need to send data (chapter 4.7). The battery did not fit into the form of the product, so it was changed from rectangular to cylinder form. Further, the electrodes needed to be specialized components due to form, and finally a reed switch was added to the component list.

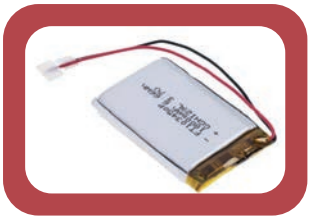


Raspberry pi pico w



Raspberry pi pico

Ill. 177.

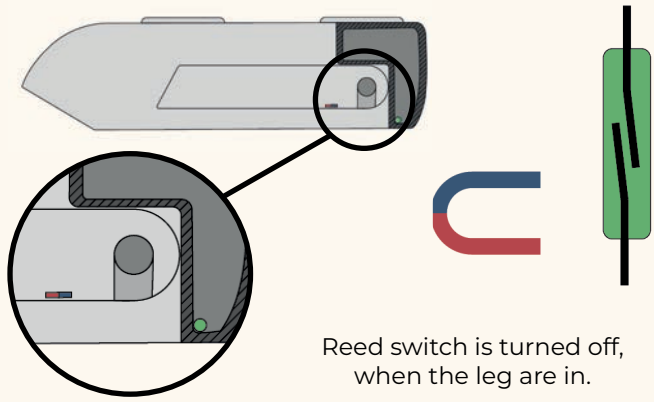


Flat, LIFEPO4

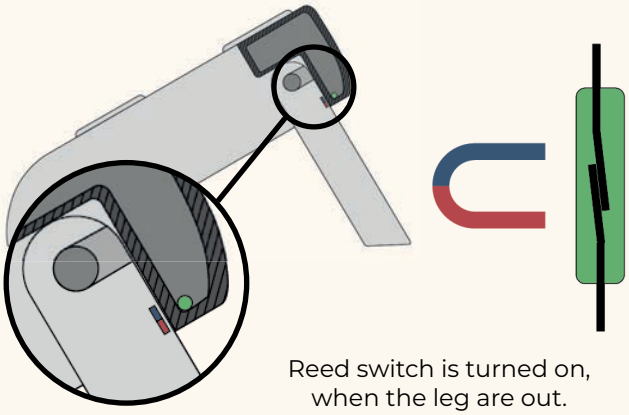
Cylinder, LIFEPO4

Ill. 178.

The reed switch [SPST-NO] was added as the team wanted to make the on/off switch a part of the use of the product. The device is turned on by flicking out the leg. In the leg there are magnets, which when they come close to the reed switch will activate it, turning on the product. By adding this feature, the product cannot be used without turning it on, as the leg will be in the way of your hand grabbing the handles. Further, the device is easier to transport in a bag.



Reed switch is turned off, when the leg are in.



Reed switch is turned on, when the leg are out.

Ill. 179.

5.3.2.1 Estimating the power consumption

The power consumption will be based on the yearly use scenario of the product. Further, the influence of the use scenario on the long-term use of the battery will be calculated.

During the visit to Hjemmeplejen Land Øst Nord (view W54), the team asked the HCW how often they experience the elderly being dehydrated. They mentioned that they recently had a case, but otherwise, most cases are in the summer when each team experiences a case each week.

One elderly during the winter period.
Two elderly a week during the summer.

With safety factor:
One elderly a month during winter, spring, and fall = 9 elderlies.
Four elderly a week during summer = 48 elderlies.
In total with a safety factor, it is 57 elderlies in a year that experience dehydration but, of course, it varies from home care to home care.

Once dehydration is identified, the elderly often get two more visits during the day, prescribed by the HCW. It is estimated that in total an elderly with dehydration has 3 visits a day. The HCW explains that if the elderly is not better after 24 hours, visits have to be prescribed to the elderly. In the worst case, the treatment continues on average for 5 days. For one elderly experiencing dehydration, this becomes 15 visits in the course of dehydration.

15 visits * 57 elderly = 855 uses in a year

To determine the power consumption, an estimate of the use scenario of one measurement and the power consumption was made. The use of the product is mapped with a timeline. The technology needs a maximum of 30 seconds to take a measurement. But then there is everything else e.g. turning on the product, reading the output, cleaning it, etc. Approx. 5 min per measurement, (see ill. 186)

Due to the small power consumption of the screen, it will not be taken into account in this estimation, as other components who also uses a small amount of power e.g. amplifiers, readers, isn't either. They will be taken into account by double the total power consumption of the product.

We assume max. power is used while we measure and otherwise we are in sleep mode. The screen only uses power when it needs to refresh the screen, otherwise it can stay the same. In the worst case, that is 6 times a use (ill. 186).

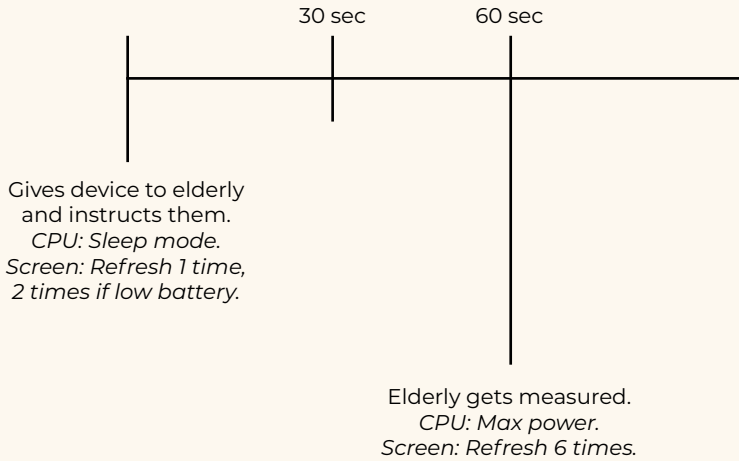
In total the product consumes 0.8558 mAh during one use.

As it was not possible to find the power consumption for the other component and the product will need amplifiers, readers, and other components that consume litt-

Component	Power consumption noted in datasheet
Charging circuit	-
Charger	-
Battery	-
CPU	Maximum power: 91 mA Sleep mode: 1.3 mA
Screen (6,44 cm2)	0.000008 microwatt pr. cm2 (4.4.2) => 0,000052 microwatt. Ultra-low power consumption.
Electrodes	N/A
Reed Relay	-

Ill. 180.

User. *Active components*



Ill. 181. Fig 5.3.2.1,1.

le power, the power is multiplied by 2 as the CPU is the component consuming the most power and is currently in total. This number will be 1.71mAh.

The device has two batteries with 1550 mAh, each in one handle, giving a total of 3100 mAh.

3100 mAh / 1.71 mAh = 1810 times the use scenario can be run in one charge.

855 /1810 = 0.47 ≈ Needs charging every 2 years.

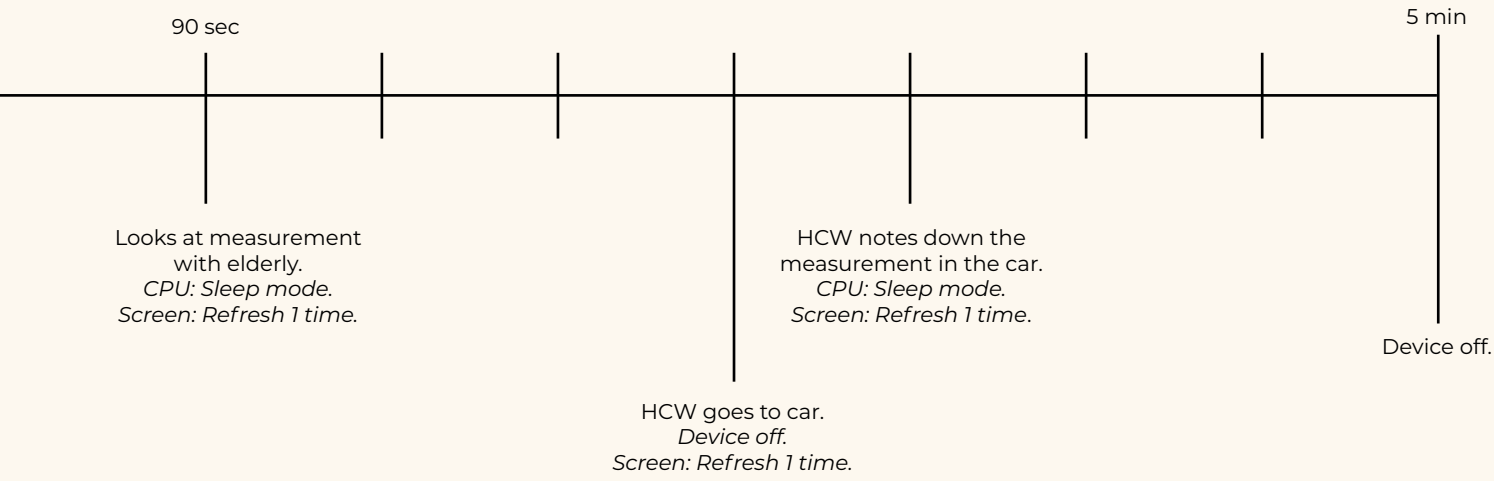
Self-discharge rate

The battery chosen is a LIFEPO4 battery, which has a self-discharge rate of 5% per month. Meaning it will be by itself discharges in 20monthsh (Jay 2020.). As the use case scenario takes 24 months to discharge the battery, the charging need of the product is revaluated to by 1 time a year.

Charging needs after 5 years of use

The life span of the product is estimated to be 5 years, the reason being a comparison of the lifetimes of similar products e.g. a thermometer as it has similar components. The battery is 3.2 V and has a standard capacity of 1550 mAh. It has a cycle characteristic of 2000 times. In two years, only one cycle are used. This makes the battery life decrease minimally a year. This means the use of the product in 5 years will not decrease the battery life significantly (see W60).

It can be concluded that the product will need charging every second year and not have any significant decrease in battery life over 5 years. In the future development of this product, one could argue that this battery is overpowered for this product and could be switched to one with less capacity and cycles. The battery sould still be a standard component, as this is cheaper.



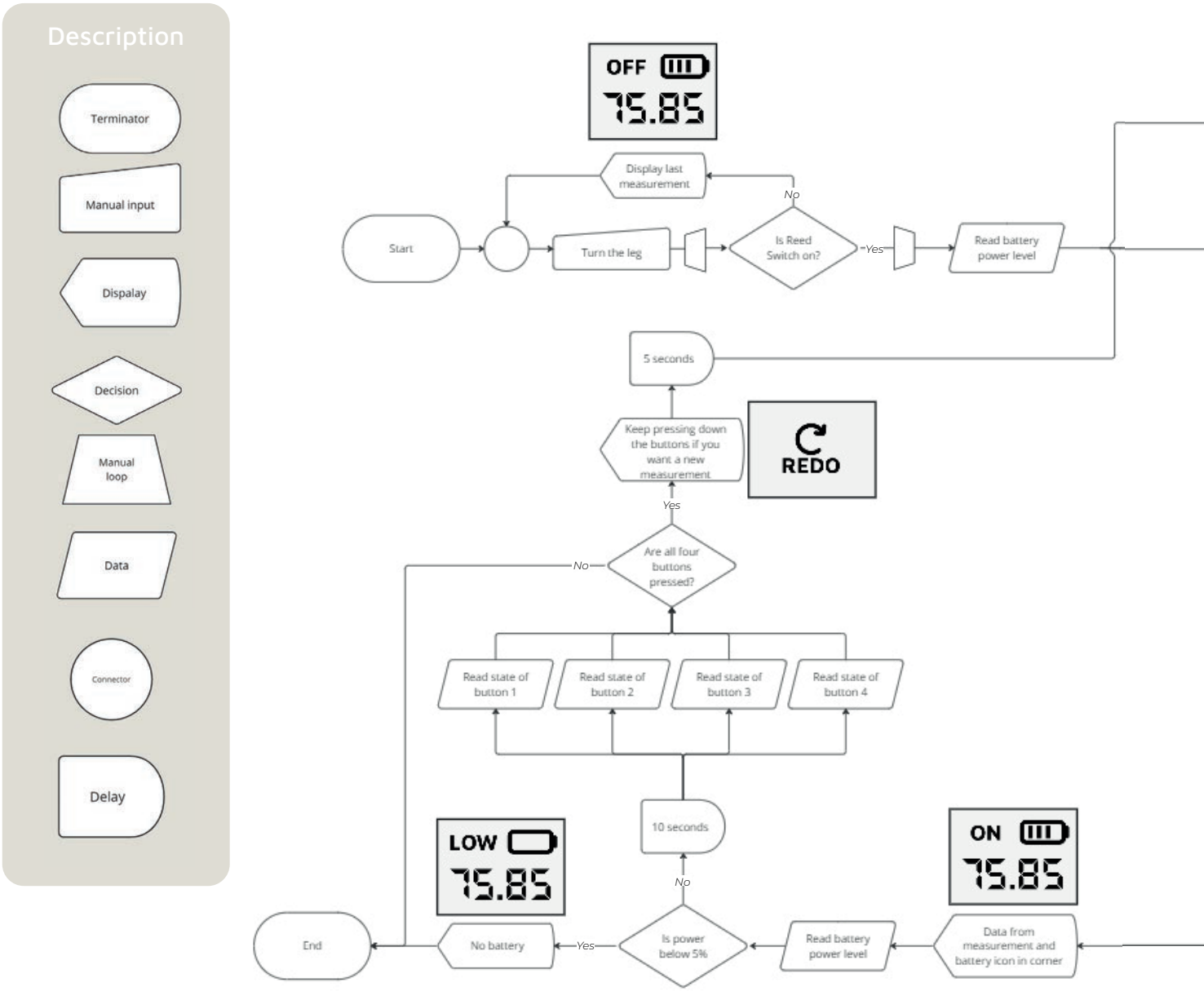
Sleep mode: 1.3 mA, used for 4 min 30 sec => 1.3 mA * 270 sec / 3600 sec = 0.0975 mAh

max power: 91 mA, used for 30 sec => 91 mA * 30 sec / 3600 sec = 0.7583 mAh

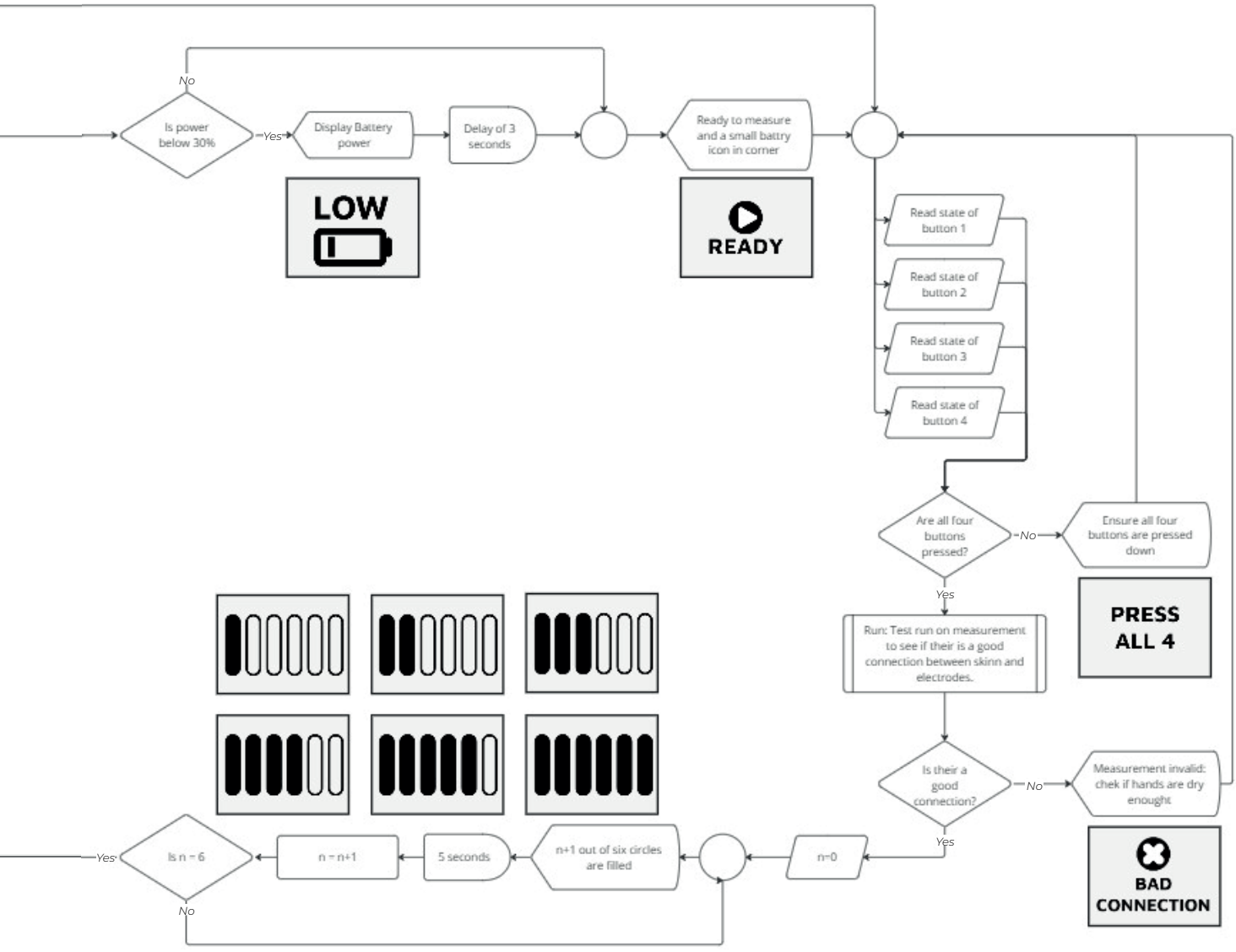
The screen is 0.0000161 mA x 11 refreshes = 0,0001771mAs

5.3.3 Flowchart of software

A flowchart is made to define how the device is working. The flowchart elaborated on how the device is indicating battery and how the feedback from the device is in the case of an error in the measurement (AD 5, Mekatroniske produkter og systemer, lektion 6, slide 13-16). The flowchart below should be seen as the initial thoughts on how the device should work, but needs testing with the user in order to find errors and insufficient feed-forward and -back of the use.

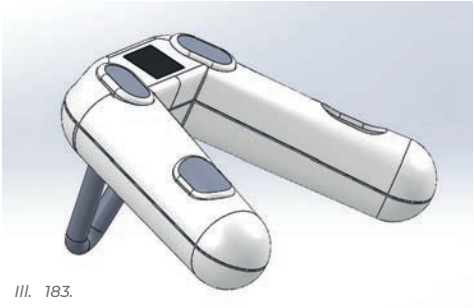


Ill. 182. Flowchart


No
Is power below 30%
Yes
Display Battery power
Delay of 3 seconds
Ready to measure and a small battry icon in corner
LOW
READY
Read state of button 1
Read state of button 2
Read state of button 3
Read state of button 4
Are all four buttons pressed?
No
Ensure all four buttons are pressed down
PRESS ALL 4
Yes
Run: Test run on measurement to see if their is a good connection between skinn and electrodes.
Is their a good connection?
No
Measurement invalid: chek if hands are dry enought
BAD CONNECTION
Yes
n=0
n+1 out of six circles are filled
5 seconds
n = n+1
Is n = 6
Yes
No

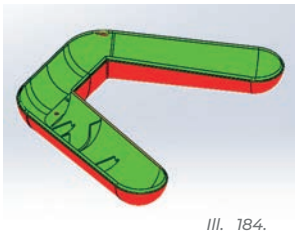
5.3.4 The productions influence on the form

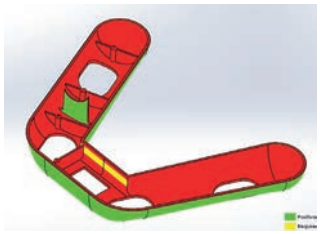
In this chapter the maturing process of the product is described using screenshots from a 3D program with additional comments.



Ill. 183.

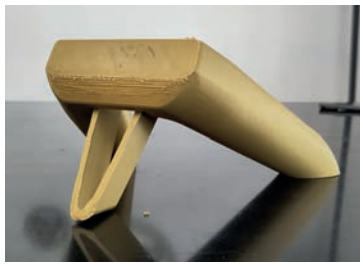
Cheaper if the leg is made of metal, but it does not indicate that the product should stand on the table.

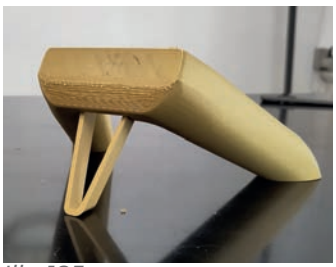




Ill. 184.

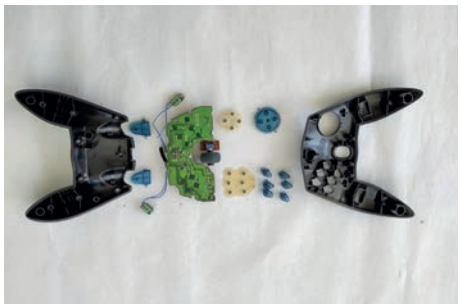
A draft analysis was made to test if the form is possible to make with injection molding. The analysis showed some areas (yellow marked) that need to be adjusted so the form had a draft of 1 degree.





Ill. 185.

Test of different leg shapes. The marked leg is chosen as it make the product cohesive in its form language and weight balance.



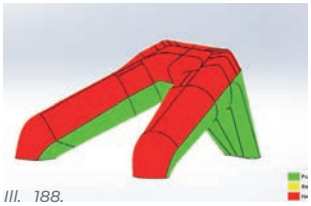
Ill. 186.

A games controller was disassembled to use as reference for thickness of the shells, assembly and ribs.

Ill. 187.

The screen, electrodes, sealing gaskets, and feedforward of where to grip, is now made. The shell is still missing the final adjustment of the draft angle along with the ribs and screw holes on the inside, for the electrical components to be installed and outside for the assembly of the two shells.

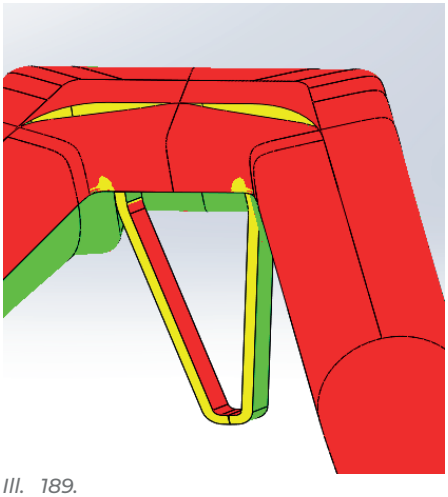
There are two versions as the team are unsure of how much it would cost to make the grip surface in silicone. The alternative is making a more textured surface.



Ill. 188.

A leg that is a part of the form, gives better indication that it should be standing on a table. But the leg has a lot of unused volume in the front, which just takes up space in the HCWer's backpack. Maybe we could make the leg flip in? Then it would also be obvious when it is ready to be used as the leg otherwise would be in the way of the user's hands.

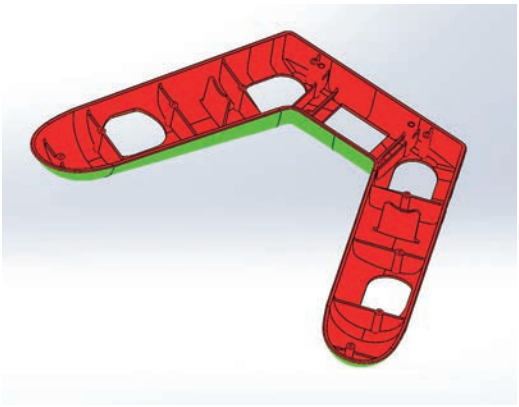
Additionally the product has some strange shoulders.

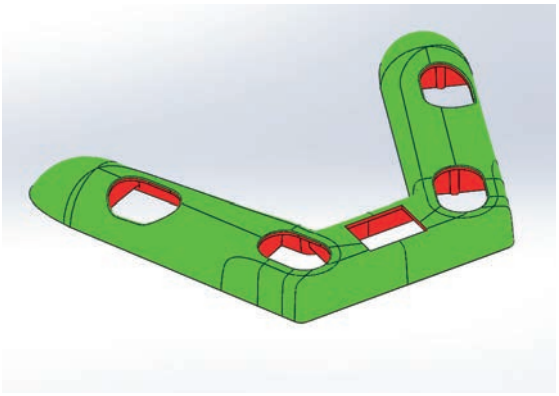


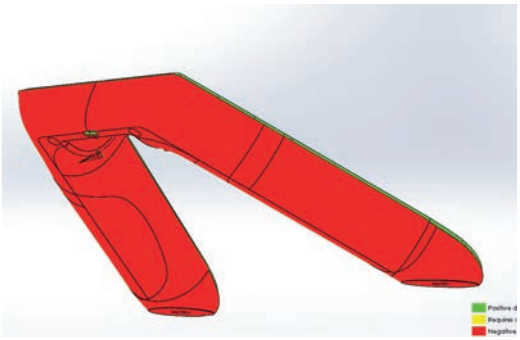
Ill. 189.

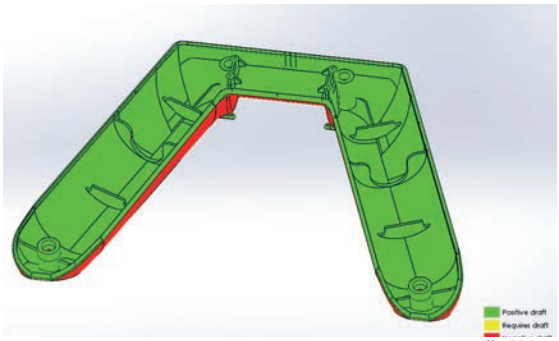
The leg can now be flipped in, and excessive material is removed. The leg can also easily be removed allowing for a deep clean.

Some adjustment of the shell still needs to be made in order for the product to fill the requirements of draft angles related to injection molding. Further, the screen, electrodes, sealing gaskets for IP22-rating, and feedforward of where to grip needs to be made.







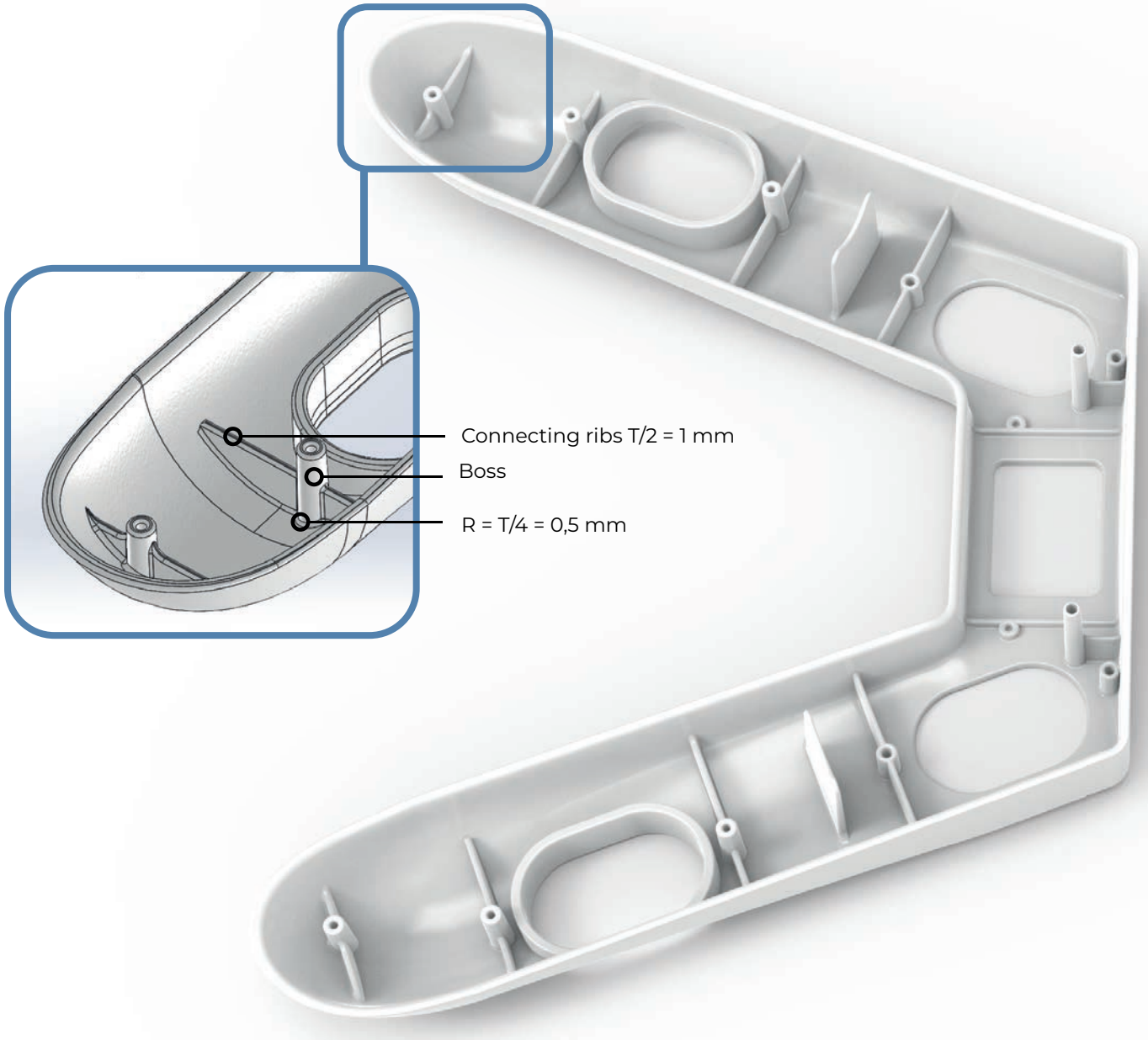


Ill. 190.

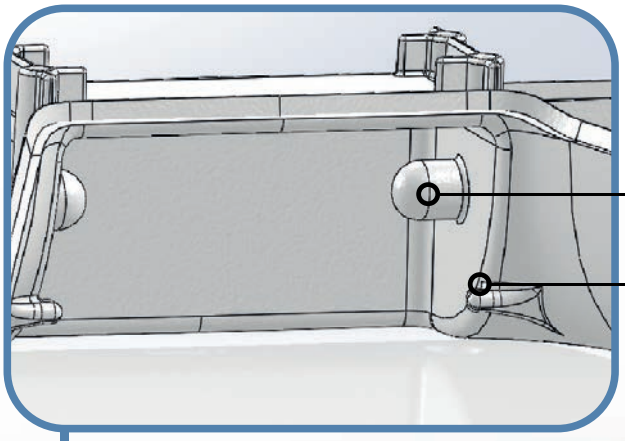
The shell's final adjustment of the 1 degree draft angle of. Adding ribs and screw holes inside for assembly of the electrical components and the two shells.

Design rules for injection molding

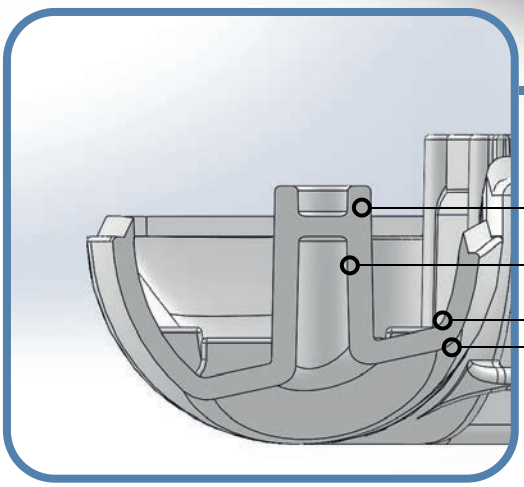
The guidelines for injection molding was followed during the construction of the shells using guidelinesfrom RTP "Part Design Guidelines for Injection Molded Thermoplatics" (RTP n.d.). As the shell will be made in ABS, the draft angle should be 1 degree (Melito 2023). The 3D model is currently matured to the degree where only some filets are missing. These filets are important as they decrease the risk of cracks in the material, when the product is in use.



III. 191.



The bottom shell will be more complicated to injection mold due to these two elements. They make it necessary to introduce a core feature, as this form cannot be made using only a two-way mould, making the mold more complex and thereby expensive. An alternative the team considered was to make the leg in a different mould but this required more manual assembling and more cracks where filth could collect. Further the leg would have a greater volume in the HCW backpage, which isn't wanted.



Same thinkness (T) of 2 mm

Draft 1°

Inside Radius > T/2 = 1,5 mm

Outside Radius = Inside Radius + T = 3,5 mm

5.4 The project finances

A qualified guess is made of the cost price for the current concept proposal. The aim is to estimate the cost price but also to identify which parts of the concept proposal have the most influence on the price. In Chapter 5.1 it was estimated that there can be 23,452 units sold in Denmark and 533,147 units in northern Europe, if we aim for 44% of all HCW to have this product.

Calculation of the production cost

The estimation of the cost of each component can be found in ill. 189. The tables contain the material, process, fastening methods, etc. of the component, which effects the production cost. The cost price for the injection molded components is based on an individual calculation price of the production based on a method introduced in the course Production and Economy (Hansen 2021) (The full calculation can be found in W61) (ill. 192).

Many assumptions had to be made. The most important assumptions we made in the process of calculating the production cost is:

Black boxing electrodes: We and Cacta do not at the current stage in the process have an idea of the cost price of the electrodes. We set it to a price of 5 DKK even though they must be custom-made. But because they have a simple construction, a metal sheet with a PCB under and wires, the price is evaluated to be low.

Electrode holders and gaskets for the electrodes are the same: We assume a small adjustment in the design of the shell will make it possible to use the same parts for all four electrode buttons.

Wages are set to 4$ as this is the average hourly wage in China (Zhang & Zhou 2023). The price calculation of the shell includes the operation cost of the machine. In this, the hourly wage is included.

The calculations on the 'development cost' and 'others' are based on Cacta's calculations (ill. 193).

In the case of the product being sold to 44% of the HCW in Denmark, we estimate that the project can reach breakeven at <= 12,690 units.

By looking at what differs from 2,500 - 50,000 units, we can see that the electrical components make up 60% of the production cost for 2,500 units and increases to 79% for 50,000 due to the increased number of products, that can split the cost for the injection molds. If the units are increased to 50,000, it could be beneficial to evaluate if some of the electrical components could be switched for cheaper versions. The team evaluated that such a component could be the batteries as they are among the most expensive components, and the battery calculation (chapter 5.3.2.1) concluded that the batteries are overpowered in terms of capacity and cycles.

One erer Further, the push button electrodes only account for 4% (50,000 units) and 8% (2,500 units). The team had discussed if the mechanical solution for the push button should be switched for a software solution. The software indicates if the user does not push hard enough, and the electrodes vibrate to indicate whether the user pressed hard enough. Mechanical solution: the spring requires 5N to be pressed down to ensure the appropriate connection between the skin and the electrode. After calculating the cost of the mechanical solution, it makes sense to solve it mechanically instead of by software, since the development of such software is assumed to be more expensive, even though the software would be a fixed cost and the push button electrodes a variable cost. Further, the buttons give the user haptic feedback when doing the measurement correctly.

The operation cost for producing 2,500 units (first mover municipalities) is estimated to be 287 DKK. For both the market in Denmark of 23,262 units and the 50,000 units, the breakeven is around 12,500 units.

BOM

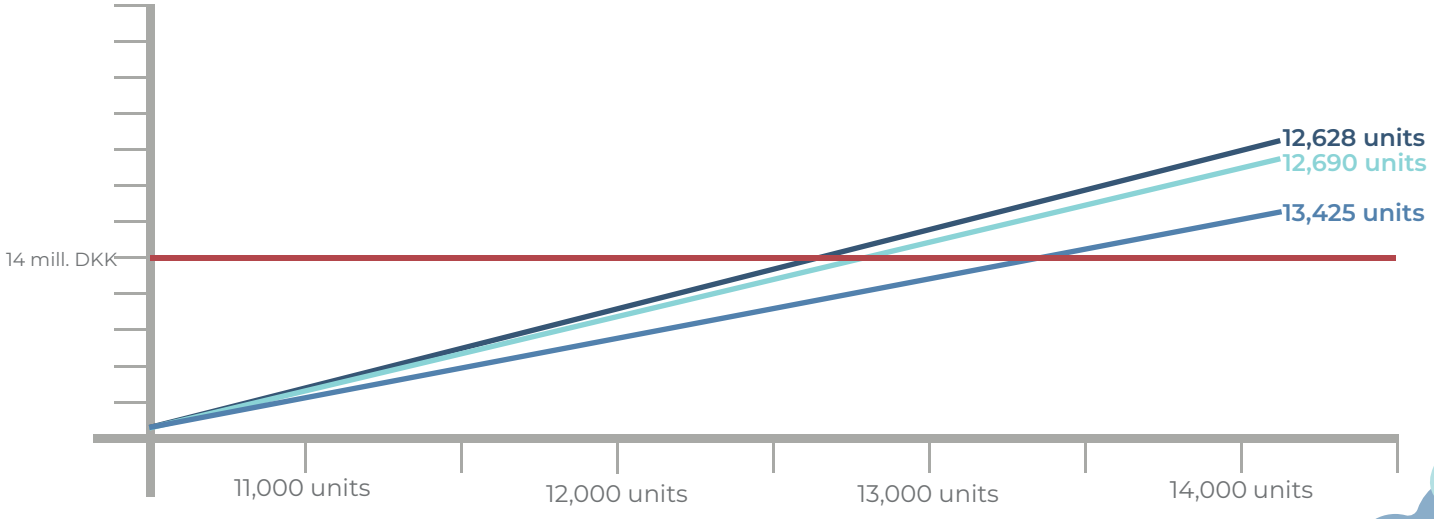
ırt no.	Part name	Qty.	Std. compor	Material	Color	Process	Surface finish	Fixture	Unit price	Unit price DDK	Price at 2500 units	Price at 50000 units
1	Screen protector	1		ASB - sheet	Transparent	CNC	SPI - A2	Ultrasonic welding to part 2		- kr.	0,46 kr.	0,46 kr.
2	Top shell	1		ASB	292 C and Cool Gray 1 C	Injection molding - re	SPI - B1 / SPI - D3	Screwed to part 19		- kr.	0,91 kr.	0,68 kr.
3	Screen - Electronic Paper Display	1	x	-	-	-	-	Screwed to part 2		17,06 kr.	17,06 kr.	17,06 kr.
4	Front electrode	2		Gold coated	-	-	-	Fixed to part 6		5,00 kr.	10,00 kr.	10,00 kr.
5	Back electrode right	1		Gold coated	-	-	-	Fixed to gasket for the		5,00 kr.	5,00 kr.	5,00 kr.
6	Gasket for front electrodes	2		Rubber Shore 40A	292 C	Molded	-	Fixed to part 4 and 11	$ 0,10	0,75 kr.	1,50 kr.	1,50 kr.
7	Gasket for back electrodes right	1		Rubber Shore 40A	292 C	Molded	-	Fixed to part 5 and 12	$ 0,10	0,75 kr.	0,75 kr.	0,75 kr.
8	Compression spring - 5 newton	4	x	AISI 302 Stainless steel	-	-	-	-		4,03 kr.	16,12 kr.	16,12 kr.
9	Momentary Pushbutton Switch (KFC347)	4	x	-	-	-	-	Press fit to part 11 or 12	$ 0,03	0,23 kr.	0,90 kr.	0,90 kr.
10	Back electrode left	1		Gold coated	-	-	-	Fixed to part 13		5,00 kr.	5,00 kr.	5,00 kr.
11	Electrode-button holder front	2		ABS	Cool Gray 1 C	Injection molding - re	As machined	Screwed to part 2		- kr.	0,72 kr.	0,25 kr.
12	Electrode-button holder back	2		ABS	Cool Gray 1 C	Injection molding - re	As machined	Screwed to part 2		- kr.	0,72 kr.	0,25 kr.
13	Gasket for back electrodes left	1		Rubber Shore 40A	292 C	Molded	-	Fixed to part 10 and 12	$ 0,10	0,75 kr.	0,75 kr.	0,75 kr.
14	Battery	2	x	-	-	-	-	Fixed by ribs		29,11 kr.	58,22 kr.	58,22 kr.
15	CPU - Raspberry Pi Pico	1	x	-	-	-	-	Screwed to part 19		10,35 kr.	10,35 kr.	10,35 kr.
16	Reed switch	1	x	-	-	-	-	Press fit		1,00 kr.	1,00 kr.	1,00 kr.
17	USB - C port	1	x	-	-	-	-	Press fit	$ 3,11	23,36 kr.	23,36 kr.	23,36 kr.
18	Gasket between top and bottom shell - Ø3	1		Rubber Shore 40A	Cool Gray 1 C	Molded	-	-	$ 0,50	3,75 kr.	3,75 kr.	3,75 kr.
19	Bottom shell	1		ASB	292 C and Cool Gray 1 C	Injection molding - co	SPI - B1 / SPI - D3	Screwed to part 2		- kr.	4,85 kr.	2,55 kr.
20	Rubber plugs front Ø7 x 13 mm	2		Rubber Shore 40A	Cool Gray 1 C	Molded	-	-	$ 0,05	0,38 kr.	0,75 kr.	0,75 kr.
21	Rubber plugs back Ø7 x 9 mm	2		Rubber Shore 40A	Cool Gray 1 C	Molded	-	-	$ 0,05	0,38 kr.	0,75 kr.	0,75 kr.
22	Leg	1		ASB	292 C	Injection molding - re	SPI - B1	-		- kr.	0,70 kr.	0,47 kr.
23	Magnet Ø2 mm x -4 mm	1	x	-	-	-	-	-		3,13 kr.	3,13 kr.	3,13 kr.
24	Assembly screws - self cutting M2 x 10 mm	12	x	-	-	-	-	-	$ 0,02	0,15 kr.	1,80 kr.	1,80 kr.
25	Screws for screen (extra big head) – self cutting M2 x 3 m	6	x	-	-	-	-	-	$ 0,02	0,15 kr.	0,90 kr.	0,90 kr.
26	Wires	-	x	-	-	-	-	-			2,00 kr.	2,00 kr.
										Total cost for compontents	171,45 kr.	167,74 kr.
							Assembly time 20 min	Assembly of the product	Hourly	Cost pr. unit		
						25 % of the cost (Prodcution and Economi)		Overhead	$ 4,00	$ 1,33	10,00 kr.	10,00 kr.
											42,86 kr.	41,94 kr.
										Total cost	224,32 kr.	219,68 kr.

Item no.	Soruce for price estimate
1	See calculation W61
2	See calculation below
3	Price dived by 3,14 https://www.digikey.dk/da/products/detail/pervasive-displays/E2144CS021/6821161
4	Guess
5	Guess
6	https://www.alibaba.com/product-detail/IATF16949-Factory-Custom-Sealing-Rubber-End_1600768571310.html?spm=a2700.galleryofferlist.0.0.282f5bfa9I909r
7	https://www.alibaba.com/product-detail/IATF16949-Factory-Custom-Sealing-Rubber-End_1600768571310.html?spm=a2700.galleryofferlist.0.0.282f5bfa9I909r
8	https://www.fjedre.dk/c04800350500s
9	https://www.alibaba.com/product-detail/Miniature-Micro-Momentary-Tactile-Tact-Touch_1600767720881.html?spm=a2700.galleryofferlist.normal_offer.d_title.1e335522SvJPP7
10	Guess
11	See calculation W61
12	See calculation W61
7	https://www.alibaba.com/product-detail/IATF16949-Factory-Custom-Sealing-Rubber-End_1600768571310.html?spm=a2700.galleryofferlist.0.0.282f5bfa9I909r
14	Price dived by 3,14 https://dk.rs-online.com/web/p/genopladelige-batterier-i-specialstoerrelser/8183005
15	Price dived by 3,14 (cheaper) + 1,2 (tax): https://raspberrypi.dk/produkt/raspberry-pi-pico/
16	Price dived by 3,14 (cheaper) + 1,2 (tax): https://arduinotech.dk/shop/reed-switch-2x14mm-glass-no/?gclid=Cj0KCQjwmZejBhC_ARIsAGhCqnfyhiXpgdsOQn3-H4yPwBNnx_h8FBQTU7BX-RspmXZGbVQhTUFCsocaAiG0EALw_wcB
17	Price at 100 pieces + Price dived by 3,14 https://www.sparkfun.com/products/15217
18	https://www.alibaba.com/product-detail/custom-rubber-seal-gasket-white-square_1600221332019.html?spm=a2700.galleryofferlist.normal_offer.d_title.6e9953ca0SG4qR
19	See calculation W61
20	https://www.alibaba.com/product-detail/IATF16949-Factory-Custom-Sealing-Rubber-End_1600768571310.html?spm=a2700.galleryofferlist.0.0.282f5bfa9I909r
21	https://www.alibaba.com/product-detail/IATF16949-Factory-Custom-Sealing-Rubber-End_1600768571310.html?spm=a2700.galleryofferlist.0.0.282f5bfa9I909r
22	See calculation W61
23	https://www.magnetz.dk/power-magnet-stav-3x10-mm
24	https://www.alibaba.com/product-detail/PT-Self-Tapping-Screw-for-ABS_759870934.html?spm=a2700.galleryofferlist.0.0.10bfe482rqsbYr
25	https://www.alibaba.com/product-detail/PT-Self-Tapping-Screw-for-ABS_759870934.html?spm=a2700.galleryofferlist.0.0.10bfe482rqsbYr
26	Guess

Total quantity		First-mover municipality *2,500 devices*		The Danish municipalities *23,262 devices*		50.000 unit production *50,000 devices*	
	Total cost	Cost per. device		Cost per. device		Cost per. device	
Investment (fixed)	10,189,804 DKK	4,076 Dkk	68%	438 DKK	53%	204 DKK	40%
Overhead cost sales and marketing (fixed)	4,082,890 DKK	1,633 DKK	27%	176 DKK	21%	82 DKK	16%
Operating cost							
Material and production cost (variabel)		221.44 DKK		171.45 DKK		167.74 DKK	
Production salary (variabel)		10.00 DKK		10.00 DKK		10.00 DKK	
Overhead costs (variabel)		55.36 DKK		42.86 DKK		41.94 DKK	
Total cost (per. device)		5,996 DKK		839 DKK		505 DKK	
Sales revenue (per. device)		1350 DKK		1350 DKK		1350 DKK	
Operating profit (per. device)		-4,646 DKK				845 DKK	
Breakeven [units]				12,690 units		12,628 units	

Indicated the production cost of 2,500 devices in a case where the product is altered after stage 1. Which could make sence.

Ill. 193. The cost of both production, development, and other held against different quantities



Conclusion

Achieving the best compromise between comfort vs a valid measurement

One of the big dilemmas of the project has been to find a compromise between a comfortable position for the elderly during the measurement and ensuring the measurement is valid. These aspects both influence the overall form of the product proposal. In exploring the right balance, the project has been on the scale from “handcuffs” to ”no control”. The current product proposal utilizes nudging to have the user sit in the same position every time. The nudging lies in the angled handles, marked grip area and finger-formed electrodes, so the user only needs to focus on griping the device and having the elbows at the edge, as this ensures the correct position. Furthermore, the tabletop ensures the elderly sits still while the measurement is done. Our struggle with finding the balance between the two elements stopped the product proposal from developing a more detailed feedforward of how the elderly should use the product and testing it with the elderly.

The aim has been to solve the two most critical aspects of the measurement identified by Cacta: electrodes spaced 5 cm, and a good contact surface between skin and electrodes. The team has achieved the 5 cm of spacing but are unsure of the contact area. For ensuring a good contact, some development has to be done to test if the connection is good enough. For maturing the product proposal more, the next step would be to test it with the technology, i.e. the further matured electrodes. To qualify if it is the right compromise between comfort and valid measurement, the product should be tested on elderly people.

The engineering aspect of the design problem

In creating this product proposal, we have been focusing on tackling what we evaluated are the most critical aspects of the engineering parts. The most critical aspect is the technology of the measurement, but as this is being developed by Cacta, it has been black-boxed in this project. The project has instead been focusing on determining the electrical components needed and maturing the shells to accommodate for injection molding. Apart from the battery and the specific electrodes, the components found are well fitted for the product. As for the maturing of the shells, only the principle of the 5 N push buttons is questionable as some conditions are not fully solved yet. The next step should be to develop that more in-depth. The same goes for incorporating the cleaning facets to them as they travel up and down.

The goal was to design the product for disassembly. We have managed to address it to some extent by assembling the product with screws and gaskets. It is not yet clarified if the product has enough screws or if the assembly could be designed with fewer screws, e.g. with a snap-fit. The chosen assembly method also affected the ease of the cleaning of the product, as filth often accumulates in the cracks. But as the device is classified as ‘non-critical’, the product was made cleanable by adding gaskets. But there are some areas to be solved like the crack by the traveling-button-electrodes, which is a known unknown technology. Are the buttons even necessary, or could the unsurety of contact surface be solved by software? If the problem can be solved by software, it would make cleaning the product easier. The next step would be to test the principle of the traveling-button-electrodes to see if it is the right solution or if the measurement will be more valid when using gel. If gel is better, it would simplify the shells by placing the electrodes on the outside, but it will make it more troublesome to do the measurement.

More than a measuring tool

A vision in the project has been to develop a tool that the user not only needs, but wants, making it a design problem. The goal was to focus on adding more value for each user so the product would be desirable. If the value proposition for the product is compared with the customer profiles of the three stakeholders, i.e. the manager/municipality, the HCW, and the elderly, it seems likely the product will create extra value to a certain degree for all three stakeholders.

For the manager/municipality the product will save money. But the product is not evaluated to be able to reduce man hours, which in the future is one of the resources the elder care sector has the least of.

The product will make the HCW able to do better care by preventing hospitalization and quantifying the communication concerning the elderly’s state of dehydration between coworkers. The product can help the HCW keep a good relationship with elderly by removing mistrust between the two, as the device provides the facts. On the other hand, we have designed an extra tool which needs to become a part of the HCWs’ routines, which could create new pains for the HCW. This use case needs to be tested to see if the improvement is worth the new pains it creates. However, our visits during the project confirmed that the HCW would like a device like this.

For the elderly, it is limited to which degree the product proposal creates extra value for them. The biggest job that the product solves for the elderly is better health by avoiding hospitalization. But the aspects of being independent and keeping relations with relatives are more limited since the product is more addressed towards the HCW. On the other hand, the product does not do surveillance of the elderly like a watch on the arm would do. By ensuring the elderly do not feel under surveillance, the product helps to not compromise the dignity of the elderly. The elderly are becoming a part of doing the measuring, which hopefully will make them feeling included and informed. It could be interesting to explore this even more e.g. by involving the elderly more in development.

Reflection

Finding the best user fit

One of the challenges of the process has been to find the best fit between user, product, and business case. In the search for that, we tried to make the solution tangible (i.e. Tangible synthesis), (visit to Høje Tranders Friplejehjem, chapter 2.4), which is a common approach in design thinking (Laursen & Tollestrup 2017). The tangible concepts made it necessary to make the concepts less abstract, i.e. move down the ladders in Lerdal's pyramid (Tollestrup 2004). This was done before our vision was fully set, as the user needed the concepts to appear real in order to understand them. This need for the user made the team focus on "tangible" concepts instead of exploring the ambiguity of the problem and vision. A better solution for the self-supporting elderly might have been possible to identify, if we had explored or revisited the vision more. On the other hand, we could have tested Leap of Faith Assumptions (LOAF) earlier as we found this was not a business case for the self-supporting elderly as they did not see it as a problem for them.

The grumpy old man

We wanted to seek the wicked problem 'how do we design an aid product for a user that does not want and does not think they need help', as the theory claims the most radical innovation is made when there is a wicked problem to be solved (Buchanan 1992). But when exploring a wicked problem, it comes with a risk, since you are not always sure you will find any good innovation. In this project we spent a lot of time exploring the direction of designing for the grumpy old man, even though we earlier in the process had identified that the HCW wanted a product that helps in the course of dehydration. If the project was directed by the business perspective of Lean Startup (Ries 2011), we should have tested the LOAF "design a product for the grumpy old man which he would use even though he did want help". If we had done that, the team would have been able to Pivot earlier on in the process, thereby giving the direction of the HCW more time, so we could have been able to mature the product more in-depth. The reason why we did not Pivot earlier was a big business opportunity we saw in creating a product that made the elderly self-supporting. This feeling came from the interview with Rikke, the manager for home care Nord Land Øst, who said that self-supporting devices for the elderly were the future because the number of HCWs is decreasing, and the number of elderly is increasing. This was backed up by statistics. Also, in our visit to Cacta, we were informed that if a product could save man-hours in public care, the public sector would be willing to pay a lot, as the recourse in man-hours is low. Due to these insights, we chased a business opportunity for a business case where the product was not interesting for the core user.

Instead of trying to fit the product to the user, we should have been focusing on doing more co-creation with the elderly i.e. creating a design the elderly wanted. However, a grumpy old man is probably not a person who would join a co-creation session; that is, if we had been able to find one. Even though we did Pivot and ended up designing a product for the HCW, the course of the grumpy old man gave insights into how we could design an aid product that the HCW could use with the elderly without being intrusive, as mentioned in the conclusion.

Requirements from the technology

Our approach at the beginning of the process was not related to the technology Cacta is developing. With the risk of appearing naive, we tried not to lock the design process with too many requirements from the technology. This followed the theory of Fixation described by Cross (2006), that if you get too much expert knowledge in a certain topic it can restrict you to create radical innovation. Later in the process, the requirements from the technology restricted us so much that we ended up designing "handcuffs" for a grumpy old man. This might indicate that we got fixated on the requirements and forgot to find the balance as to who we were designing to. Maybe it would have been beneficial to wait until there was a clear vision and a working concept before the hard requirements were introduced. This might have made the team focus on fitting the technology to the concept and not the concept to the technology.

This ties into one of the big dilemmas of the project: comfortable- versus precise measurement. This is an ambiguity to which we tried to find the right compromise: the perfect measurement where the person is locked in one position and the most comfortable position where you are sitting. The product would not work if one of them were left out as the elderly would not use it if it were too uncomfortable. The same goes for the technology: if it is inaccurate, the product is useless, especially in the health sector. This dilemma could also have been a contributing factor to us wanting to design for the elderly, as precision matters a lot in the health sector. Additionally, there was also uncertainty from Cacta about the requirements from the technology, as the technology was under development. This meant that the requirements for the technology were very fuzzy in how much the users position must be controlled.

Cooperation with the startup Cacta

A big part of this project has also been our cooperation with the startup Cacta which has affected our actions. Cacta had already identified the problem of dehydrating elderly in elder care and defined that it should be a monitoring device for HCW to monitor the course of dehydration. This we tried to challenge as one of the approaches to design thinking is to reframe the problem (Laursen & Tollestrup 2017). Maybe we were too keen on reframing the solution and problem and ended up overlooking the good opportunity Cacta already had identified e.g. we wanted to reframe the problem and focus on the grumpy old man while the business case was not there. However, in trying to reframe the problem we ended up discovering some important nuance to the problem, e.g. the need for including the elderly to ensure their dignity, as a lot of it lies in their independence.

Another influence our cooperation with Cacta had on the project was the business minded focus. As Cacta is a start up, they focus a lot on making the best business case. In our case, we need to focus on making the best fit between user, product and business case. An example of the influence their different focuses had on the project is in chapter 3. Here we suddenly focused on deciding if the product should be a sport device or a medical device, as this would influence the testing later on for product approval, instead of finding the best product group for the user. In all of chapter 3, we spent the time

on researching the elderly to find the business match with the user instead of finding the match between the user and the product. This focus could potentially have been influenced by Cactas focus on business. Instead, the team should have used their design thinking approach and got out of the building.

Project planning

Our initial project plan was inspired by the approach from Ulrich-Eppinger (2012): doing the product development process in the six-phase. We wanted to identify user needs, develop the product architecture, detail the design, and test it. In reality, our process looked more like the New Concept development model proposed by Koen et al (2002). We kept spinning around in the engine, i.e., we were designing for the HCW, elderly, and then the HCW again. This led to us not getting out of the fuzzy front as early as hoped, meaning there was less time to deal with testing the interactions and maturing the details of the product. On the other hand, it created a more nuanced product for both the HCW and the elderly.

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Ilustration list

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