User Centered Design of a Fall Detection System

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Abstract

This master thesis has created a concept of a fall detection system for older people. The system is built around new radar technology that will detect a fall accident and then initiate an alarm sequence that will contact the home care. The system is intended to be installed in the home of the user.

The main focus of the project has been the interaction between user and system and also on the appearance of the main radar unit. A prototype has been made but focus is not on the mechanical engineering but on the design aspects of the product.

A modified version of the Double Diamond process has been used. Since earlier master theses within the same subject can be used as a base of knowledge focus has not been on the two first phases in the method, “Discover” and “Define”. Focus has been on the two later phases “Develop” and “Deliver”, working with models and sketches to design the product.

The project has used a user centered design process to keep the user in focus for the final product. To achieve this, three focus groups has been implemented into the design process. The focus groups have been conducted at meeting point Möllaregården and has been used as an opportunity to test concepts and find a way forward for the project. Concepts have been designed in anticipation of the focus groups and the participants have then been able to come with critique and suggestions for improvements during the meetings. The feedback from the focus groups have then been used for the next phase of the project. Parallel prototyping has been used to develop new concepts and a large number of prototypes has been created during the project

The result of the project is a concept for a fall detection system. The concept includes both a prototype of the finished product as well as a description of the inner workings of the system. A control station is intended to be a part of that system and a concept for that has also been developed. Finally, a physical prototype of both the radar station and the control station has been made using 3D-printing.

The concept and the prototypes are meant to be an asset to the technology company in further development and intended to be modified for testing during spring 2022.

Keywords: User Experience, Universal Design, Interaction Design, Technical Design, Welfare Technologies and Elderly Care

Sammanfattning

Detta projekt har skapat ett koncept för ett trygghetslarm för äldre. Larmet är tänkt att fungera i den äldre personens hemmiljö. Larmet bygger på ny radarteknik och ska märka när den äldre har fallit och då larma hemtjänsten.

Projektet fokuserar främst på interaktionen mellan användaren och systemet samt på systemets utseende. En prototyp kommer tas fram men fokus ligger inte på de inre mekaniska detaljerna.

En modifierad version av Double Diamond-metoden har använts. Då tidigare examensarbeten inom samma ämne har kunnat användas som en grund har vi inte behövt lägga lika mycket tid på de första två faserna ”Discover” och ”Define”. Fokus ligger därför på den andra delen med ”Develop” och ”Deliver”, där vi jobbat med skisser och modeller för att formge produkten.

Det är viktigt att användaren involveras i designprocessen för att den slutgiltiga produkten ska ha användaren i fokus. För att lyckas med det har tre fokusgrupper lagts till i processen. Fokusgrupperna har hållits på mötesplats Möllaregården och använts för att testa de koncept som skapats och hitta en riktning framåt i projektet. I fokusgrupperna har deltagarna fått tycka till och komma med förslag kring förbättringar kring koncept som förberetts inför varje tillfälle. Feedbacken från varje fokusgrupp har sedan använts i nästa fas. Metoden ”Parallel prototyping” har använts för att utveckla nya koncept och en stor mängd prototyper har skapats under projektets gång

Resultatet av projektet är ett koncept för ett falldetektionssystem. I konceptet ingår både en fysisk prototyp av själva enheten samt en beskrivning av hur systemet ska fungera. I konceptet ingår en kontrollstation som även den har formgivits. En fysisk prototyp av radarenheten samt av kontrollstationen har slutligen 3D-printats.

Syftet med konceptet och prototypen är att de ska kunna modifieras för att användas för testning redan våren 2022 samt för att presentera konceptet inom företaget.

Nyckelord: Användarupplevelse, Universell Design, Interaktionsdesign, Teknisk design, Välfärdsteknik och Äldreomsorg

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Lund, January 2022

Ludwig Darle Olsson and Casper Cronberg

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1 Introduction

This chapter aims to introduce the project and its goals. The background, limits of the project as well as problems the work solves is also presented here.

1.1 Background

As the Swedish population ages, the strain upon the elderly care system will increase. The population of persons at 60 or above is projected to increase by 35% by 2050 in developed countries (UN, 2022). The elderly care is not equipped to handle this in its current format and will therefore need to embrace new technologies. This project will attempt to address this as well as giving older persons increased freedom and control.

Some municipalities in Sweden have already started to do remote nightly supervision in the elderly care. This is done by having a camera mounted in the room of the older person. The camera is then turned on three times per night to check that everything is okay. This practice replaces the older system of having someone from the elderly care come out at night to do a physical control.

This has been implemented with unclear results (Wamala Andersson, Richardson, Landerdahl Stridsberg, & Ehn, 2021). Some has appreciated the increased freedom and fact that they are not disturbed during the night. Others feel that having a camera turned on is a violation of their privacy.

This master thesis builds on experiences from those implementations as well as earlier research in the same project from three other master thesis projects, to create a system that mainly uses radar instead of a camera to fill this function and also serves as a fall detection system.

1.2 Goal and Problem

Improvements in tracking and radar technologies will within a short period of time make it possible to use radar to track movements of persons indoors. The goal of this master thesis is to develop a concept that uses those technologies as a fall detection system. The end user of this products is older people that are today using some sort of fall detection system.

This master thesis aims to design this product for the home environment of the user. The product will be a radar that will serve as a safety alarm system in case of emergency, such as a fall or health condition. The product should serve as a fall detection system as well as a system for nightly supervision. The product should also instil a sense of security.

To design a product that feels like an asset to the user, it needs to be investigated what the user wants. The context and the room that the product is supposed to exist in is also relevant here as the product should not feel as an intrusion to the user. To do this it should communicate its purpose in a clear and honest way with colour and form. To fulfil these goals the master thesis will use a design model that involves the end user at different stages in the design process.

The product should be designed to be mass produced and to satisfy the technical needs from the company (appendix 1). A brief summary of these technical needs can be seen below:

- The product should be able to detect fall accidents in the home of older persons. The product should be able to be used for nightly use. It should be permanently mounted and be connected to home care in a Swedish municipality. The product should also radiate safety and fit into the home environment of an older person living in Sweden.
- You should investigate where in the room the product should be placed in order to work as good as possible. Besides being able to detect a person lying on the floor the systems inbuilt camera should be able to provide a detailed picture. You should also investigate where the product is best mounted in other rooms to detect every fall accident in the home.
- You should investigate how the in-built camera can made to be perceived as friendly and if it’s possible to make the picture unfocused/distorted with a physical lever/lid.
- You should consider if the user should be able to control the product in any way. And if the user is doing gymnastics on a mat on the floor. Is it then necessary to be able to turn the system off? Is a portable alarm button necessary? If a portable alarm button or remote is necessary, it should also be designed. during spring 2022. It should be possible to mount a camera and radar in these prototypes. The specifics will be discussed when the project nears completion, and we know what sensors to use.

The final product of the thesis is a 3D-CAD model as well as a non-working prototype constructed by 3D-printing. The prototype should be able to be modified to a working prototype that can be tested by the company in spring 2022.

1.3 User

Our target user is defined as an older person who lives in their own apartment but is in contact with the home care. The target user uses the safety system that is provided by the municipality. That solution is a button on your wrist that you press to alert the home care. This solution works only indoors and won't work unless the user is able to press the button. As the target user is using another safety system today the assumption can be made that the user is willing to make some small changes to their daily routine to get a higher degree of safety.

1.4 Research Contributions

Along with designing this new type of safety alarm, we wanted to find out how a product can be designed to communicate safety to its user. This was examined from the point of view of an older person who is still living in their own apartment but has assistance from elderly or home care. We worked towards this research goal using these questions:

- How can product design be used to create and communicate safety in a home environment?
- What design features and guidelines are important to create a sense of safety and trust for the target audience?
- How can these parameters be validated?

A part of this project was to identify these design features and guidelines. These were then used and exemplified in the final design of the prototype.

1.5 Delimitations

This master thesis was written about adapting a fall detection system using radar to the home to the user, an older person still living at home.

The project will therefore focus on how older persons living at home with assistance of elderly care experience this new kind of technology, as it is supposed to be as adapted for their specific needs and wants

This master thesis will not take into consideration persons living in nursing homes, persons suffering from dementia or with cognitive impairments as that is a different use case and outside the scope of this master thesis.

The fall detection system will need to be present in every room to give a full coverage of fall accidents. But as the other work earlier in the project have focused on the bedroom and as it is the expressed wish of the tech company focus will be put on a use case around the bedroom. This is done since it is believed that any solution that works in the bedroom will also work in other rooms in a home and a use case centring on a bedroom will be more applicable to other similar uses such as nursing homes or hospitals.

Other people who are affected by this product, such as relatives and the home care staff, would also be relevant to investigate but falls outside the scope of this project.

Focus will be the design of the concept and not the mechanics of the finished product.

Issues regarding who will come when the alarm is activated or the user not trusting the home care are part of a larger issue and will not be addressed is this thesis.

2 Literature

The project started with a lot of reading for information, inspiration, and methods. This chapter aims to present what was learnt and used from this reading.

2.1 Previous Work in the Same Project

Reading the earlier theses written about this product space gave a lot of insight into what our work would contribute to the product. They were all more research-focused, with Hay & Westin (2021) being a broad market analysis of what needs of an older person could be possible for the tech company to develop products for. Petterson & Nilsson (2021) dove deeper into two specific functions before narrowing it further down to a scenario about nightly supervision being solved by an IoT solution. Bengtsson (2020) was the first essay on this specific subject and many of the topics discussed there was later expanded on in later theses. It was however the only one with a design aspect with concepts of how a product could be designed. The requirements for the product have evolved and changed quite a bit since then. For example, Bengtsson (2020) operate under the belief that the radar should be placed in the ceiling, something that was thought to be nonoptimal when this project started and later confirmed by the "room study".

Our master thesis uses elements of the previous theses to accelerate the early stages of the development process, most notably:

- The personas made by Hay & Westin (2021) and Petterson & Nilsson (2021) were merged to form new personas we used to develop and evaluate scenarios and prototypes.
- Concepts developed by Bengtsson (2020) were used as inspiration when the first round of sketching began.
- Scenarios and use cases from both Hay & Westin and Petterson & Nilsson were also used as a steppingstone when scenarios for this project were developed.
- Hay & Westins focus on promoting wellness was an inspiration for the goals of this project and eventual product.

2.2 Usability

"The Design of Everyday Things" describes Norman's thoughts and methods regarding product usability. It contains his Seven Principles of Design regarding how to make useful and usable things, as seen under the heading "Seven principles of design", which has been used to improve the interaction with the product in this project.

Usability is an important factor for this project since a lot of the user's trust in a product will be built on it being clear about what is going on and also on it working as expected. Trust can´t be built on looks alone as it would be shattered in an instant if the product doesn't work. This is especially true if the product is a safety product meaning to help the user in very critical situations, such as the product in this project.

2.2.1 **Seven Principles of Design**

Don Normans Seven Principles of Design is a staple for creating usable products. They are presented in his book "The Design of Everyday Things" (Norman, The Design of Everyday Things, 2013) and has since been widely popular as a checklist to make, evaluate and improve the usability of products. In this project it was mainly used when developing the user interface for the product.

- Discoverability: Discoverability evaluates if the functions of the product are available to be discovered by the user just by looking at or interacting with the product.
- Feedback: Feedback is used by the product to tell you what effect your interaction has had. The click of a button, telling you it has been pressed, is feedback. For this project, feedback is one of the more important principles considering that the target audience is often unaccustomed to new technology. Poor feedback makes the process of learning and using a new product confusing and unforgiving since you don't get to know how or even if your actions affect what happens.
- Conceptual model: This represents the model of the product we have in our head. Hopefully the product works decently similar to this model, and with its design aims to give the user the same model as the designer had when deciding how it should work.
- Affordances: The affordances of a product are all the possible things you can do with it. As a designer you must make sure that the proper affordances exist for the user to be able to perform the actions you have intended.
- Signifiers: Signifiers are the things in the product that aim to show the user what affordances are significant and what actions they should do to access them. These are sort of recommendations or clues given from the designer to the user through the product design.

- Mappings: Mapping aims to help clarify the relationship between the controls and the actions they perform. With multiple controls and multiple actions their spatial layout is an important clue to understanding what does what.
- Constraints: Limits on what actions are possible with the product. Adding different types of constraints to the product can help the user take quick and correct decisions when using it.

2.3 How Things Make Us Feel

Donald Norman also describes the effect emotional response has on how we perceive and interact with a product (Norman, 2004). While he earlier has tried to explain the very rational ways of how products should work (Norman, The Design of Everyday Things, 2013), he now explores what it is that makes us love products that might not work very well. It explores the emotional response of seeing and interacting with a product and how one might design to evoke certain emotions.

A lot of the theories are grounded in the "Three levels of perception": the visceral, the behavioural and the reflective level. The visceral level describes the initial feeling you get when looking at an object. The behavioural level describes the feelings that emerge when we use an object. Is it an intuitive joy or a complicated irritation? The reflective deals with the intellectualization of an object. Does it tell a story? Does it help us reach self-realization?

The book also explains that how you feel about an object even affects its usability. If the product puts a person in a good mood, that person gets more creative in looking for ways to make the product work as well as more patient for when the products doesn't work.

2.4 What Makes Us Feel Good?

Lars Tornstam (2011) describes different models of viewing ageing and how it affects our psyche and our experience of the world around us. A model found to be relevant for the project was Aaron Antonovskys Salutogenic Perspective (Tornstam, 2011). This model, commonly used in Medicine and Gerontology, is a pathogenic model focusing on finding out what is wrong with us and what makes us feel bad, trying to treat this. As Tornstam describes it, "What about aging makes us feel sick, and how can we master it?". With the Salutogenic perspective Antonovsky turns this on its head and instead asks "Why do we feel good? How can it be that so many

stay healthy despite physical and psychological strains?". He then proposes it is because they have managed to keep a "Sense of Coherence" or KASAM, "Känsla av Sammanhang", in Swedish in their life. This sense of coherence is said to consist of these three factors:

- Comprehensibility: "I comprehend and make sense of the world around me." Comprehensibility refers to if one feels able to predict life and what's about to happen. When designing a product, it should be comprehensible for the user what happens when and why. If the user can predict what's about to happen the sense of control increases.
- Manageability: "I dispose of available resources to manage the situation around me." Manageability refers to the sense of possessing all the resources to manage any given situation. It refers to a sense of inner control that the user should experience.
- Meaningfulness: "I find meaning in what happens to me." Meaningfulness refers to the emotional and motivational part of life. It refers to the need to see a meaning with things that happen. "What is the purpose of this". In our case the user should see the purpose of the product and the product should remind the user of its purpose.

This model is used for this project since it aims to actively make the user feel better and more secure in their home. If the product can strengthen the user's sense of coherence it should make the experience of having the product good. The three factors also make for great guidelines when designing the interface and interaction.

3 Methodology

This chapter presents and explains the main methods used during this project. This is an overview of the main frameworks of each method, they are presented; in order of use, how they were used and described more in detail when they are used.

3.1 Design Process

3.1.1 **Double Diamond**

Double Diamond is a methodology for the design process developed by the British Design Council. (Design Council, 2021) It divides the process into four parts; *Discover, Define, Develop and Deliver.* The phases vary between broad divergent thinking during *Discover* and *Develop*, and focused action during *Define* and *Deliver*. They are described by the Design Council as:

Discover. The first diamond helps people understand, rather than simply assume, what the problem is. It involves speaking to and spending time with people who are affected by the issues.

Define. The insight gathered from the discovery phase can help you to define the challenge in a different way.

Develop. The second diamond encourages people to give different answers to the clearly defined problem, seeking inspiration from elsewhere and co-designing with a range of different people. This is where the bulk of the work in this project is done.

Deliver. Delivery involves testing out different solutions at small scale, rejecting those that will not work and improving the ones that will.

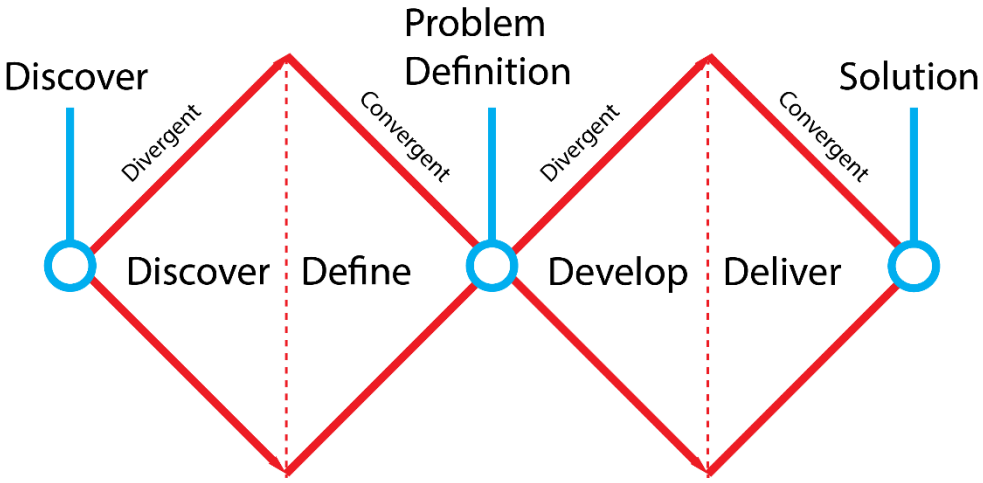

Figure 3.1: Illustration of the Double diamond method.

The previous research done by Bengtsson (2020), Hay & Westin (2021), and Petterson & Nilsson (2021) has prepared greatly for this project. Mapping of users, their needs, their attitude towards the technological solution and even an analysis of fitting aesthetics has been done. The challenge has also been further defined via use cases and personas. This preparatory work fills a lot of the actions needed in the first diamond.

Since this project's mission is to design a finished prototype the second diamond contains most of the relevant actions for completion, and thus most of the work is done here.

3.1.2 **Design Sprint**

Design sprint is a tool commonly used by corporations wanting to take a quick step of progress in a design process. (Google, 2021). The sprint method is designed to in a week brainstorm and develop a solution for a specific problem. The problem is clearly defined at the start of the sprint. We conducted a sprint during the "Define" phase of this project, in which we developed a concept for the entire system and created story boards that describes the system.

Our sprint consists of six methods done in sequence. When conducting a sprint, the users can pick between a large number of methods to make the sprint fit what they want to accomplish. We picked methods that suited the information we had at the start of the sprint and would help us reach the result we sought. These are those six methods:

1. **Voice of User**
   Personas are used to express the wants and needs of the user. These are expressed as HMW's (How might we), for example "How might we give the user the opportunity to stop an alarm"
2. **User Journeys and Pain Points**
   The existing user journeys are used to find areas to improve (pain points). These are expressed as HMW's.
3. **HMW´s and Affinity Mapping**
   Additional HMW's are created if the development group has any additional ideas. All HMW's are then sorted into categories and the most important five are selected.
4. **Review of User Journeys and Success Metrics**
   The old user journeys are revisited and updated to better suit the HMW's.
5. **Boot up and Crazy 8s Sketching**
   The HMW's that were selected as the most interesting are revisited and each group member is tasked with creating 8 ideas from every HMW.
6. **Solution Sketching**
   Each group member creates a solution for the sprint with some of the ideas from the earlier phase. These solutions are then combined into a final concept.

3.2 Interviews

There are four types of interviews: unstructured, semi structured, structured and focus group. The first three types are named according to the level of direction given from interviewer. The fourth type is slightly different and is named after the fact that a group is interviewed instead of a singular person. Focus groups makes it easier to get a nuanced discussion before the group is gives its answer. Both the discussion and the answers to the questions are recorded by the interviewer and this provides a rich database that must later be analysed. (Preece, Rogers, & Sharp, 2015).

Demirbilek & Demikan (2004) describes a design process that involves older persons as users. Even though the subject is quite different and a lot more hands on, as it applies mainly to ergonomics it can well be modified to suit this thesis. The paper proposes the Usability, Safety, Attractiveness and Participatory (USAP) design model as a good model to use when designing for older persons. This article provides a guideline for how to incorporate focus groups into a design process.

3.2.1 **Focus Groups**

This master thesis will use mainly focus groups as qualitative study to review the result of the different design iterations. To use a qualitative method were desirable to the master thesis since the main objective for the survey was to find new insights. The focus groups were implemented in a semi structured way with pre-set questions that were then discussed in the group and answered. Two focus groups were held after each design iteration and the predetermined questions kept them similar. Free discussion was encouraged, and the interviewer used probing questions such as: Can you tell me a bit more about… or can you elaborate on why that makes you feel that way…. That was done to delve deeper into the thought process of the attendants of the focus group and find hidden wants and needs. Notes about the discussion were taken by the interviewer and saved to be processed later.

3.2.2 **Unstructured Interviews**

Unstructured interviews were used as a compliment to the focus groups. The interviews were based on the same questions as the focus group but only as a base for discussion. The interviews were conducted with one interviewer and one secretary that took notes. All the interview subjects are experts in their specific fields. Interviews were user first as a way to gain key insights in and find a direction for the focus groups. And later to complement the focus groups with another perspective.

3.3 Affinity Mapping

Affinity mapping is a method which is used to analyse large amounts of information by sorting it into groups based on emerging themes and relationships. Every piece of information is written on a separate note and one by one they are sorted into different categories. The first note decides the first theme, and the following are looked at to see if they fit in this them or should be a new theme. This continues with the rest of the notes until they are all placed, and all themes have been identified (Friis Dam & Yu Siang, 2020). The old-fashioned analysis strategy described by Kreuger (2002) is very similar to this, but has a focus on analysing focus groups specifically, which is what we mainly used the method for as well. Since you know what question every piece of information correlate to, it is recommended to sort according to the questions and from there trying to find the themes in the answers.

3.4 Prototyping

Prototyping can be used for a variety of functions in the product development process. In early stages it's a compliment for sketching and low-fidelity prototypes gives insight in how the user will approach the product. In the and in the very end a working high-fidelity prototype is a great way to show a finished product concept. (Ulrich & Eppinger, 2012)

In this project prototypes will mainly be used to communicate different concepts to the focus group. The prototypes will change as the project goes on and the focus groups will see how their ideas and inputs on the designs influence the next generation of prototypes.

The questions that any prototype can answer is limited and the designer should therefore have specific questions in mind when creating the prototypes. Different types of prototypes also answer different questions.

Low-fidelity and high-fidelity prototypes serves different functions. A low-fidelity prototype is by design unfinished and therefore invites the beholder to come with suggestions on how to improve it. A low-fidelity prototype is also a good way to try different shapes and a great compliment to sketching in the very early stages of the design project. High-fidelity prototypes can by contrast seem like a finished product and is therefore less inviting to suggestions of improvements. A high-fidelity prototype instead serves a realistic representation of the finished product as a "proof of concept". If the high-fidelity prototype works, the finished product should also work.

3.5 FDM 3D-printing

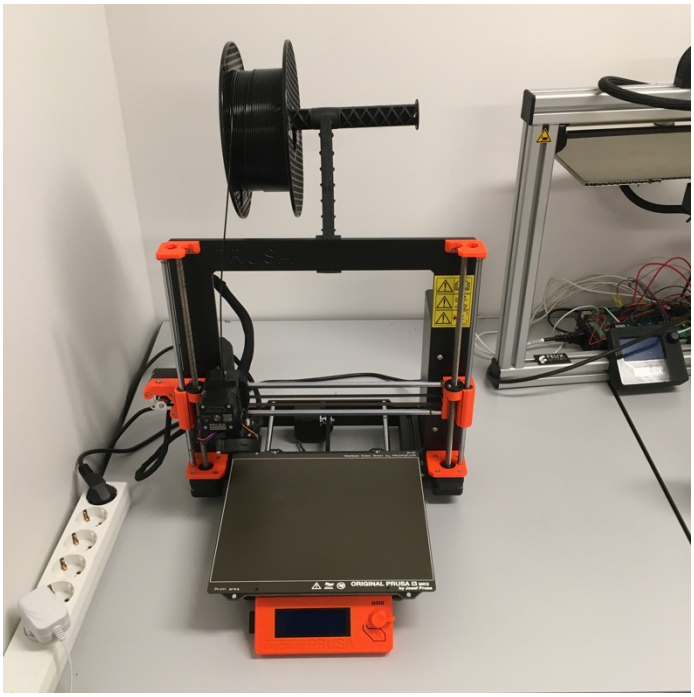

Figure 3.2: The FDM printer used for hi-fidelity prototypes in this master thesis.

Fused deposition modelling or FDM is an additive manufacturing method that builds a solid from the bottom up using heated thermoplastics. The FDM printer uses a nozzle to melt and extrude a thermoplastic filament. The nozzle is connected to a 3-axis system that enables it to place the melted filament in predetermined locations building a cross-section of the entire solid in the XY plane before lifting the nozzle up in Z-direction and printing the next layer in another XY plane. Sometimes support material needs to be added to support overhanging structures.

FDM-3D printing is suitable for prototyping due to low cost compared to other 3D printing methods and short lead times (most parts can be done in 12 hours). The drawbacks for using FDM for prototyping is that the layers between planes are visible. This can partly be mitigated by adjusting the nozzle temperature nut the only way to get a smooth surface is through post processing e.g., sanding and coating. This project will use 3D-printing for high-fidelity prototypes. (Bournias Varotsis, 2022)

4 Discover

The first phase of the Double Diamond, Discover, is a divergent phase of the project where an open mind is needed to find possibilities. It aims to provide the project with the information it needs to work in the right direction. It In this project this was achieved by using work from previous theses, as well as supplementing it with analysis of similar products and of rooms the final product might find itself in. Sketching was used to stay creative.

4.1 Analysis of Adjacent Product Categories

To find what communicates safety in adjacent product categories, a focus group was conducted with co-workers at the technology company. This was done as a to get a frame of reference for the project and to catch potential hazards or desirable attributes early on. It was relevant to do this with co-workers at the technology company as many of them had been involved in earlier work on this project and therefore had knowledge on the subject. The co-workers were asked to sort 10 pictures of baby monitors and 10 pictures of fire alarms as seen in picture 4.1 and 4.2 according to:

- Which one they would like to have at home
- Which one they thought worked the best
- Which one they considered the ugliest
- Which on communicated “safety” the most

Figure 4.1: The pictures of fire alarms used in the from study.

Image 4.2: The pictures of baby monitors used in the form study.

The goal of this exercise was not only the ranking of the products but also the discussion around it. To remember the discussion, notes were taken using pen and paper. This was done since pen and paper are more versatile and less intrusive than typing on keyboard. (Preece, Rogers, & Sharp, 2015)

A few interesting things were found during the exercise, summarized in the list on the next page.

- Fire alarm number six was the one both most desired and least desired splitting the group in two equal camps. The lack of stringency and definition was what stirred both hate and desire.
- Communication of function creates trust. (ex. the big vents in fire alarm number three)
- Precision can be shown with a small well executed detail. This is tricky since if the detail isn´t precise enough the effects are the opposite.
- Anthropomorph or zoomorphic design can be hard to execute well. Baby monitor number nine had a mixed reception with some finding it amusing and others finding the same qualities scary. The clowns (Baby monitor number one) were universally disliked. Possibly due to the playful exterior taking precedence over communicating function. Fire alarm number eight was also universally disliked for similar reasons since the playful exterior didn't align with the serious mission of the product.

4.2 Contextual Analysis

To find the context of the product a deep dive in bedrooms of older people was performed. This was aimed to help discover technical problem areas as well as give a picture of the aesthetic qualities found in the homes of older persons.

Figure 4.3: A example of where the radar could be placed in a typical bedroom. Picture from Hemnet.

Scouring the internet for pictures, a bank of bedrooms was collected. More specifically, the Swedish housing website “Hemnet” was used, limited by the search word “Senior”. A lot of the pictures found here were deemed a bit too styled however and a second search was done on the Swedish second-hand housing “Blocket bostad”. Here a lot more natural interiors were found, such as the the room seen in 4.3. The search was more difficult to limit here, but it was filtered to only show wheelchair accessible residences. This together with our common sense helped us select fitting bedrooms. The analysis for aesthetic qualities did not give a coherent answer, but rather showed that bedrooms can really look different depending on who lives there, and the product will have to be able to fit into any of these styles.

As for discovering what technical problems the radar might have, a focus was put on finding the worst-case scenarios for a room. What is the smallest gap between bed and wall? How big are the biggest rooms? What furniture could be the biggest issue regarding blocking radar signals?

4.3 Design Language of the Technology Company

To get a better understanding of the technology company’s design language a form study was done on a few selected products. We looked at what curves, proportions and other details give them their cohesive look. The technology company’s design philosophy is to make their products for surveillance of common areas subtle and hard to notice if you aren’t actively looking for them. If you see them however, they are made to give a firm impression. Other products made for areas under heavy surveillance are made to look more robust and noticeable as to make sure anyone who enters the area know they are under surveillance. Products in the former category were analysed, see figure 4.4.

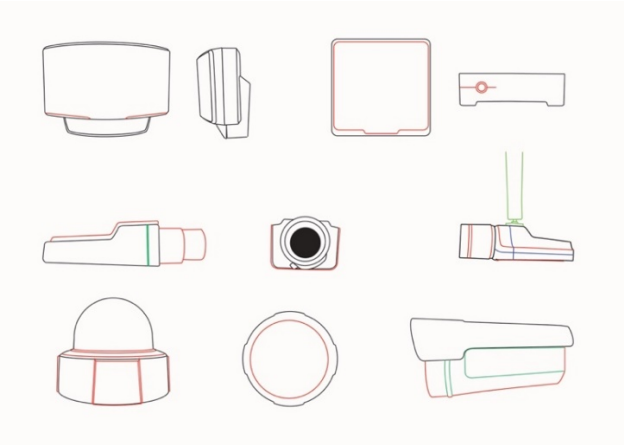

Figure 4.4: Important lines and support lines in different products from the technology company.

Some commonalities were found between the examined products. The major feature binding the products together was a minor curve with a step, see figure 4.5. Curves and colours are consistently used to make the products seem smaller than they are. By making them slope towards the back the products look slimmer, and the colour of different parts of the product are used to make you pay attention to certain parts and hide the rest. The company also tends to use the golden ratio to make their products look harmonious.

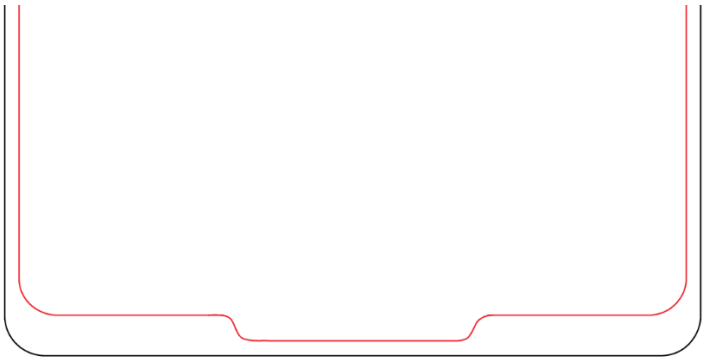

Figure 4.5: Signature support curve with a step.

After the form study was finished a discussion was had with the mentor at the tech company where he clarified that the project shouldn't necessarily result in a product looking like the technology company's current product catalogue. Since this product has a completely new demographic target group and use case compared to their current catalogue it wouldn't be unexpected if it also needed to look different. Instead, he highlighted the importance of matching the product's design to its intended user, environment and function as well as possible. This was reassuring and gave us confidence to continue putting the user first.

4.4 Sketching

To keep the right creative headspace and open up for new solutions, sketching was done throughout the “Discover” phase. Along with the creative mindset it gave a big bank of ideas to keep working from and shapes which could be used later. These ideas and shapes could be chosen from later in the process when deciding what models to build.

Different ways to communicate the functions of the product were explored as well. Since radar is a technology not commonly used in indoors consumer products, some time was invested into how it could be communicated to the consumer. Some themes which would reoccur during the project were also established, for example the balance between a figurative or discreet design. A collection of some of these sketches can be seen in 4.6.

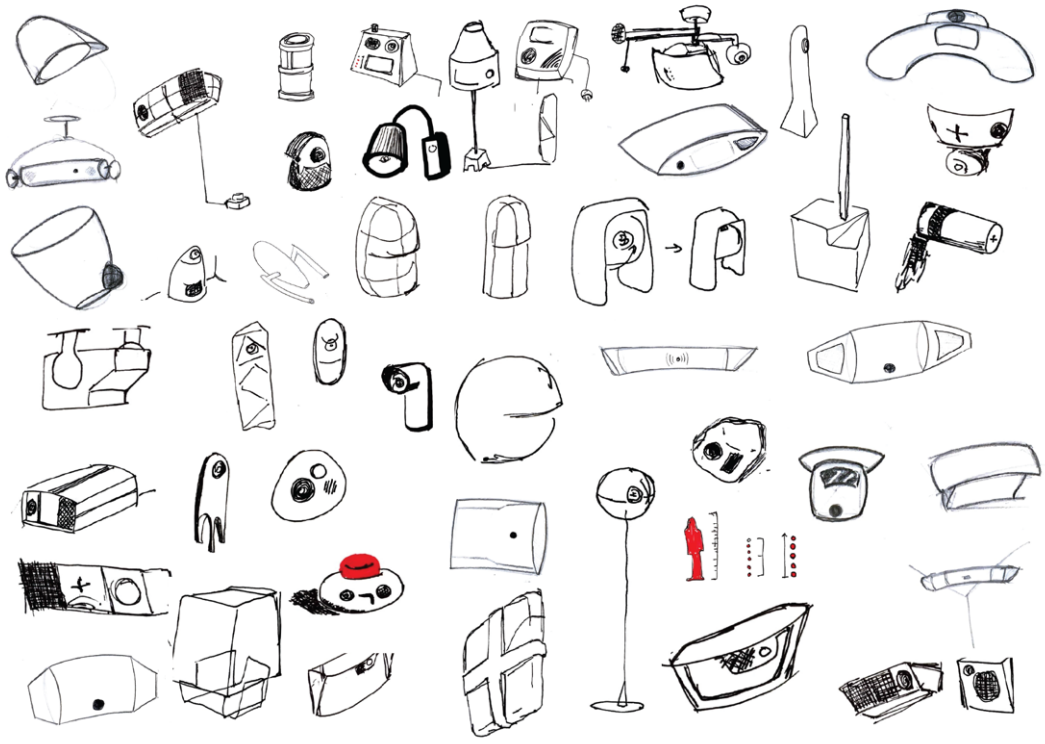

Figure 4.6: Some of the sketches from the first sketching phase.

5 Define

The second phase of the double diamond, Define, is a convergent phase of the project, limiting the scope. It aims to find the goals of the project and focus the efforts of the work based on the discoveries of the previous phase. This project finds these goals by defining the environment the product will work in as well as how the interaction with the product might work.

5.1 Room & Radar

Five rooms in different sizes were designed to summarize the library of pictures. Each room was made with three different interiors to better represent the possible environments our product should work in. The radar specification given to by the technology company to use for this testing are as follows:

- The radar can see 150 degrees (+/-75 degrees) horizontally
- The radar can see 150 degrees (+/-75 degrees) vertically
- The radar can see 10 meters straight ahead
- The radar can see 8 meters at the extreme ends of the cone, at +/-75 degrees
- At least half the body of the user should be seen by the radar to ensure it registers.

Using these model rooms and the radar specifications given to us by the technology company tests of how much of the room the radar could “see” was made in the CAD software. First and foremost, it was found that the range of the radar was enough to cover every room. An issue the radar coverage faces is blockage from furniture. Radar waves can go through soft material as textiles or wood, giving it vision behind furniture made from these materials. It does however bounce off metallic materials, which would leave a blind spot. All metallic furniture could provide this issue, but one big thing present in every bedroom is the bed. We studied where in the rooms we should put the radar to minimize these blind spots.

We found that the height at which the radar is installed makes big difference. This can be seen in picture 5.1, where the left picture shows a radar mounted by the ceiling and the right shows it mounted at the middle of the wall. The light green area in the room shows where the radar has vision and the dark green shows the projected blind spot on the floor the bed would leave. The red blocks represent the bed and the blue are other furniture.

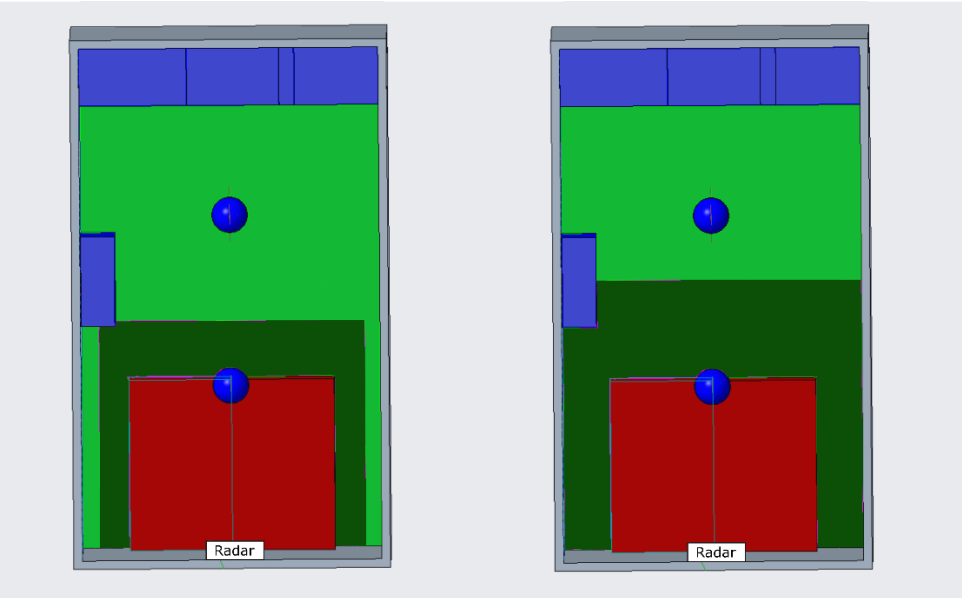

Figure 5.1: Simulations of the radar blind spot. Radar installed directly above the middle of the bed but at different heights. The left picture shows the radar at ceiling height and the picture to the left shows it installed halfway down the wall.

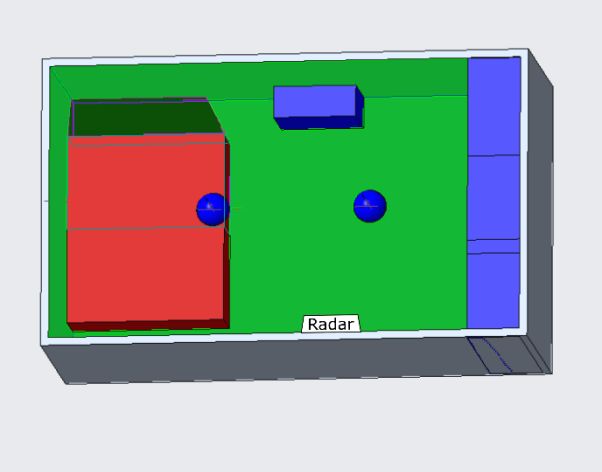

Figure 5.2 Radar installed on a side wall. Notice the blind spot between the bed and opposite wall.

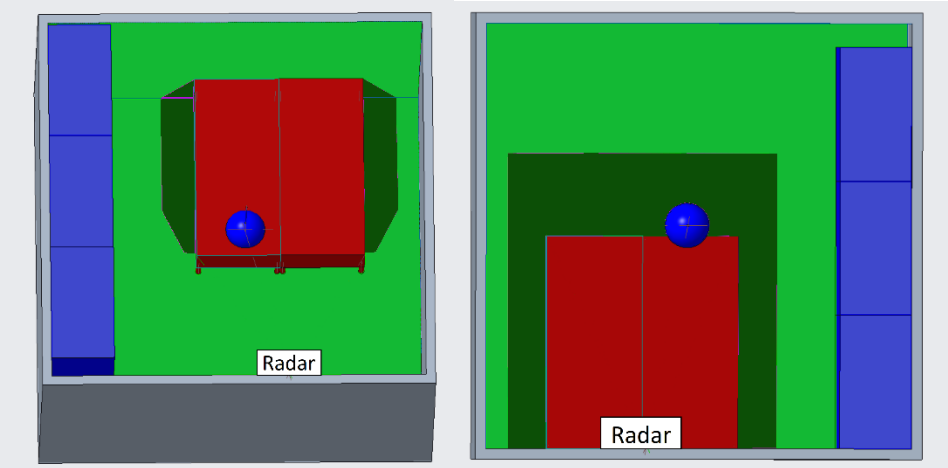

Figure 5.3 The different blind spots: On the left with the radar installed on wall facing the bed and on the right with the radar installed above the head end of the bed.

Different positions for the radar in the room were also investigated. Above the bed, on the wall to the side of the bed, picture 5.2, and the wall facing the bed, picture 5.3, were tested. Installing the radar on the wall to side of the bed was found to leave a dangerous blind spot on the opposite side of the bed. Putting the radar on the wall facing the bed was found to give blind spots a bit smaller than putting the radar directly above the bed. You do however have to consider that the definition of the radar gets exponentially worse the farther away it is installed.

All these tests were done assuming the worst-case scenario; a high bed, the lowest permitted ceiling for dwelling according to Swedish building standard as well as the assumption that it will be impossible for the radar to see anything through the bed.

5.2 Sprint in Action: Defining Interaction

The design team felt a need to define what each module of the safety system should contain, both regarding to components and functions. To accomplish this a design sprint was carried out in accordance witch the design sprint guidelines as presented in the “Design Sprint Kit” by Google. (Google, 2021). The sprint was carried out over a period of one week with two of the days for planning the sprint in advance and later discussing and documenting the results of the sprint. The result of the sprint was storyboards of how the interaction should work and a definition of what functions and components the system would include.

5.2.1 **Voice of the User Through Personas**

Extensive market research was done in an earlier master thesis on the same subject (Hay & Westin, 2021). That research resulted in five personas to be used in development of products for users that are older persons. In additions to this tree additional personas were created in Petterson & Nilsson (2021). These personas also held value since that master thesis and this one has large similarities. There were a few similar personas, and a few were deemed not to be relevant for our specific product concept, we did not use all the personas. Some were merged into one, keeping the important characteristics.

This resulted in five personas, three older adults, one care worker and one municipality procurer (see appendix)

We used these personas to get to know our users. First and foremost, the older persons but also the care worker and municipality buyer. This resulted in ideas for opportunities expressed as HMWs. HMWs (short for How Might We) is questions, insights or pain points reframed as opportunities. These HMWs are written down on post it-notes to be remembered and used for affinity mapping.

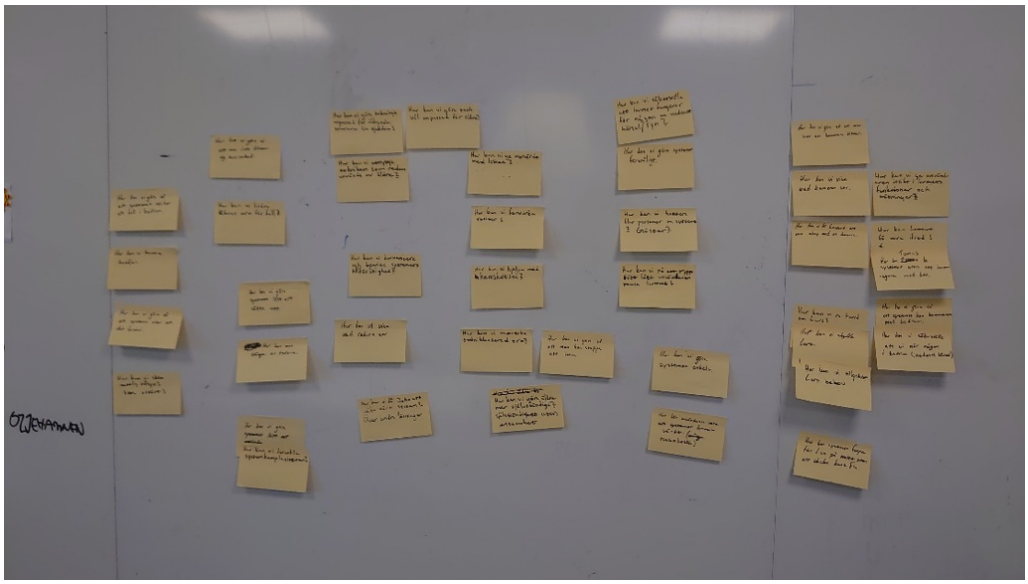

Figure 5.4: HMWs from the design sprint

5.2.2 **User journey & Pain points**

The user scenarios used by Petterson & Nilsson's (2021) master thesis were also used in the sprint. This was done as the later parts of that master thesis directly lead into this master thesis. Specific pain-points were also identified and used.

These user scenarios and pain points were then used to brainstorm and create even more HMWs.

5.2.3 **HMWs and Affinity Mapping**

All HMWs created in earlier steps were reviewed and sorted into categories. They were then all discussed and rewritten, combined or removed depending on relevancy. Each member of the design team then highlighted their five favourite ideas with a marker. This highlighted the most important HMWs which could be kept in mint at later stages.

5.2.4 **Review of User journey & Success Metrics**

The user scenarios from earlier thesis were revisited and reworked. Large parts were kept intact but the scenario around supervision customizations was removed since that is not the focus of this mater thesis. Parts where the scenarios refer to specific technical solutions were also removed since the purpose of the sprint is to define what technical components to use in the product.

5.2.5 **Boot up & Crazy 8s Sketching**

The HMW's were revisited, and each member of the team took some time to write down their most compelling ideas. These ideas were then explored with crazy 8s.

After deciding which ´six HMWs deemed most interesting a session of Crazy 8s sketching to discover more was held. This resulted in a large number of sketches. These sketches were then reviewed as even seemingly crazy ideas could hold some merit. When the merits and disadvantages the results from this stem had been discussed at length the next step was initiated.

5.2.6 **Solutions Sketching**

After reviewing and discussing the results of the crazy 8s each team member created a solution for the entire system. This resulted in two different solutions.

The two prototypes were discussed and combined into a final concept. The final concept was also created in three different versions corresponding to three different control systems:

- Controlled by voice command
- Controlled by physical controller

- Controlled by mobile app on phone or tablet

The openness of these different versions was kept since the group felt that testing was necessary to decide which one to move forward with. It was also considered that the differing needs of the target consumer called for more than one control option.

The final concept consisted of a radar unit equipped with:

- Radar
- Speaker
- Microphone
- Lamp (Able to change direction and intensity)
- CPU

Control station with controls for: (if physical otherwise replaced by app or voice command)

- Timer
- Night lamp
- Radio/ music
- Alarm bell
- Alarm button

The technology company had earlier expressed concern that the radar unit would be too expensive to place in every room. In that case a lesser unit was created that could serve as a complement to the radar unit with some of the same functions. In that way the team reasoned that a large part of the function could be kept at a lesser price even thought a radar unit in every room was deemed to be preferable.

Lesser unit:

- Speaker
- Microphone
- Lamp (Able to change direction and intensity)
- CPU

However, after discussions with our supervisor the cost of the radar unit was deemed to be outweighed by the cost of producing another additional product. If not now right away, it would surely be outweighed in three to five years when producing this product would be in question since the cost of the still relatively new radar technology should be lower by then. The coverage and precision of the alarm are also benefitting from a radar in every unit.

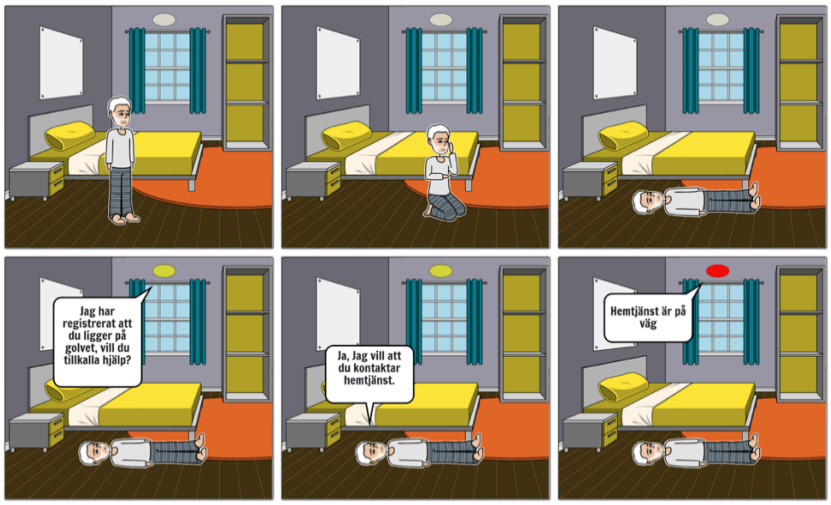

Figure 5.5: Storyboard showing an old man falling. The system discovers that he is on the floor and asks if he wants to contact home care, to which he replies approvingly. The system then notifies him that home care is on their way.

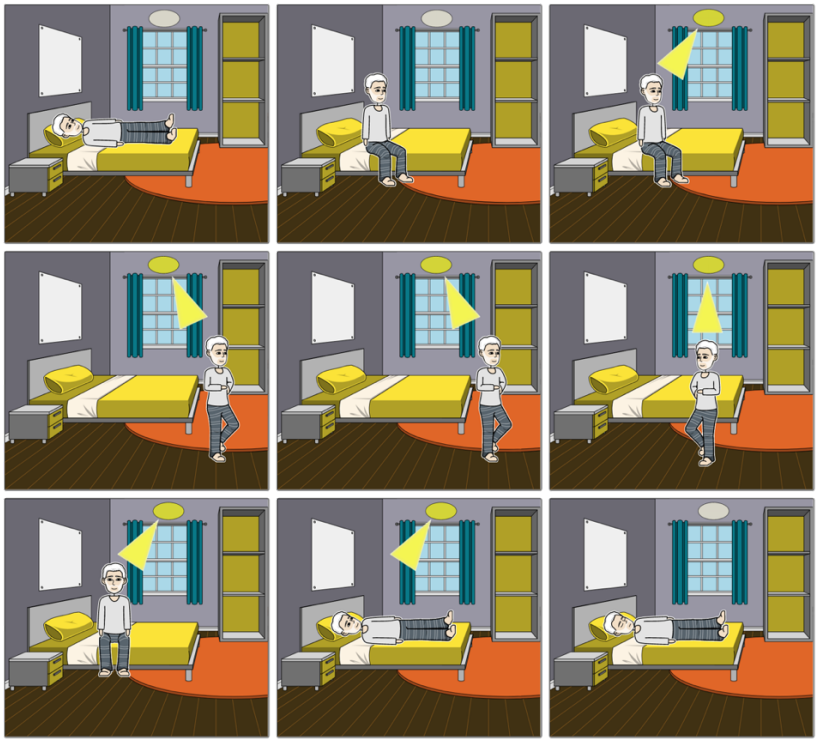

Figure 5.6: Storyboard showing an old man getting up from bed at night and going out of the room. The system notices when the man sits up in bed and turns on the night lamp. The light illuminates the floor in front of the man to prevent a falling accident. The light turns off when the man lies down in bed again.

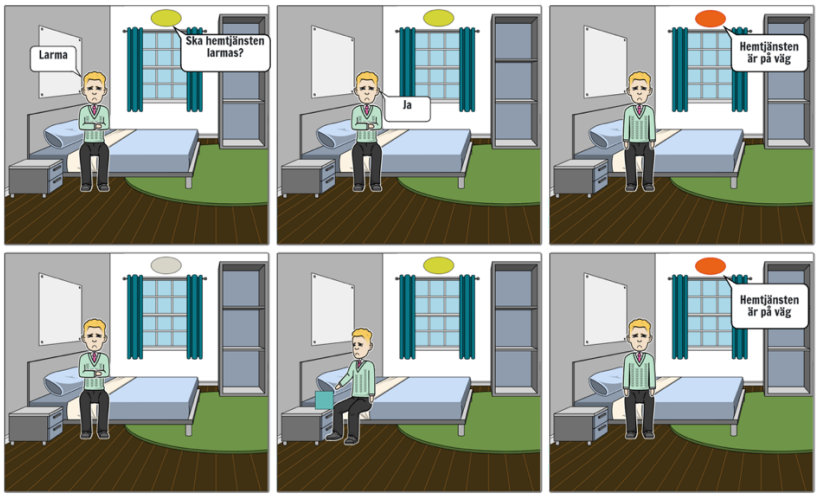

Figure 5.7: Two short Storyboards showing an old man sitting on the side of his bed. In the first the man tells the system to go into alarm mode using vocal command. The system then goes into alarm mode and notifies the man that home care is on their way. In the second scenario the man presses the alarm button on his control station to the same effect.

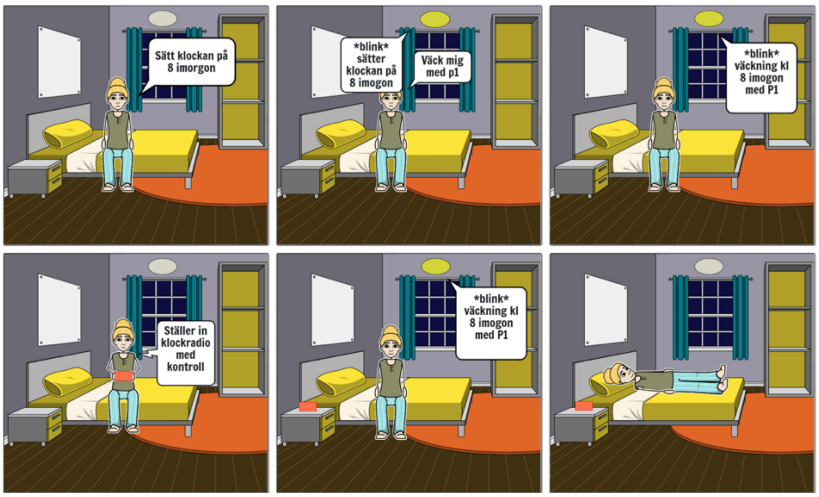

Figure 5.8: Two short storyboards showing an old woman sitting on the side of her bed. In the first storyboard she uses voice command to set a clock radio for the next morning. In the next short storyboard, she uses the control station to the same effect.

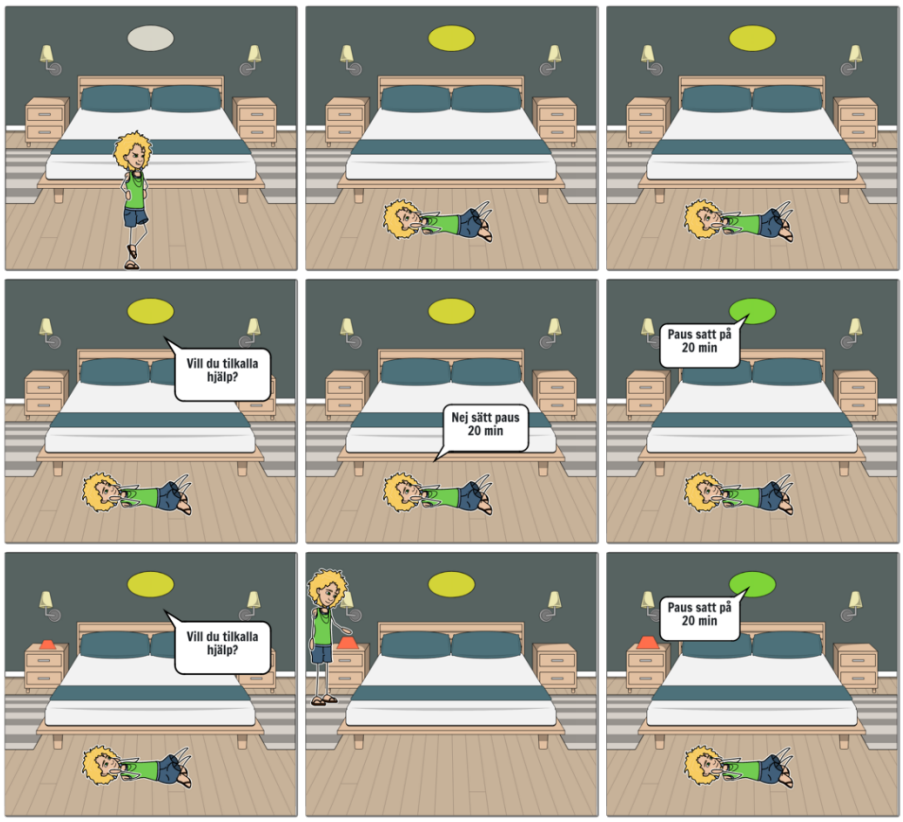

Figure 5.9: Two storyboards showing an older woman doing gymnastic exercises on the floor. The system discovers that she is on the floor and asks if she wants to contact home care. She answers disapprovingly and puts the system in pause mode using voice control. The second storyboard shows how she can use the control station to the same effect.

6 Develop

The third phase of the double diamond, Develop, is where most of the generative work of the project was done. Based on the goals and requirements from the previous phase, multiple solutions were developed.

It started with a new session of sketching. This led to two rounds of prototyping, each ending with a focus group, which was analysed and used for the next iteration. More work was done defining the interactions and a control station was developed.

6.1 Sketching

A new round of sketching was held to facilitate further prototyping in anticipation of the first focus groups. This was necessary since the technical concept had solidified since the last sketching session. The new set of sketches were made with a focus on prototyping in the way that they should be possible to manufacture. The new set of sketches were based on the sketches in the Discover phase but updated to only include the more feasible concepts. All sketches were also made with the base requirements in mind. Such as camera, microphone and speakers.

6.2 Parallel Prototyping

To make sure a solution wasn't selected too hastily, our first phase of prototyping focused on developing multiple alternative design directions. To keep us on this track, parallel prototyping was used (Martin & Hanington, 2012). This helped us quickly examine many different directions of design. In the middle and the end of this prototyping period the prototypes were evaluated and sorted with a method similar to affinity mapping. While sorting and discussing, these themes emerged:

- Simple
- Stable, Secure
- Kind
- Playful
- Communication of function
- Discrete
- Night Light
- Wild Card

These represent the directions we have identified as possible ways forward with the design. The wild card is used as a chance to bring along an idea that we believe in but doesn't necessarily fit any of the reasonable categories.

Figure 6.1: Some of the models we made during the phase of parallel prototyping.

The categories were later revisited after a meeting with our university supervisor and Susanne Frennert. The reason for this was that the old categories were deemed to be too similar. The "simple" category was split into the categories "safe/stable" and "discrete". New categories were also created relating to camouflaging, Creating the categories "camouflage" and "furnishing". There is a perceived stigma relating to care products in a home environment and these categories were created to address that. At the same time clear communication of the function of the product can also lead to increased trust in the product and the category "communication of function" was created to fill that niche. Yet another avenue of approach is the "fire alarm" approach, which was tested in the early form study of fire alarms and baby monitors.

This thought process was incorporated in the “safe/stable” and “discrete” categories. Nostalgia could also be a powerful emotion that could help a user to connect to the product. The important part here is to find the right reference and to be able to translate that to the product. This reasoning led to the creation of the “nostalgia” category.

All avenues were explored using parallel prototyping, to be evaluated later in focus group one. This gave a large number of prototypes that were then sorted into the eight categories, that had been identified:

1. Safe/stable
2. Playful
3. Communication of function
4. Discreet
5. Furniture (lamp/speaker)
6. Nostalgia
7. Camouflage (Vent)
8. Customization

Finally, the eight prototypes that represented each category the best was selected. This was done through discussions with our mentors from the company, and discussions between ourselves.

The category customization was decided to be removed. Instead, the focus group would be asked whether they would be interested in having a say in the appearance of the safety alarm. The seven prototypes selected to represent the seven categories were then remade so that the level of detail and size were similar. A drawing of each concept was also created in illustrator to better illustrate parts of the concepts that were not expressed by the foam prototypes. Pictures 6.2 and 6.3 show the models brought along while 6.4 and 6.5 shows the illustrations.

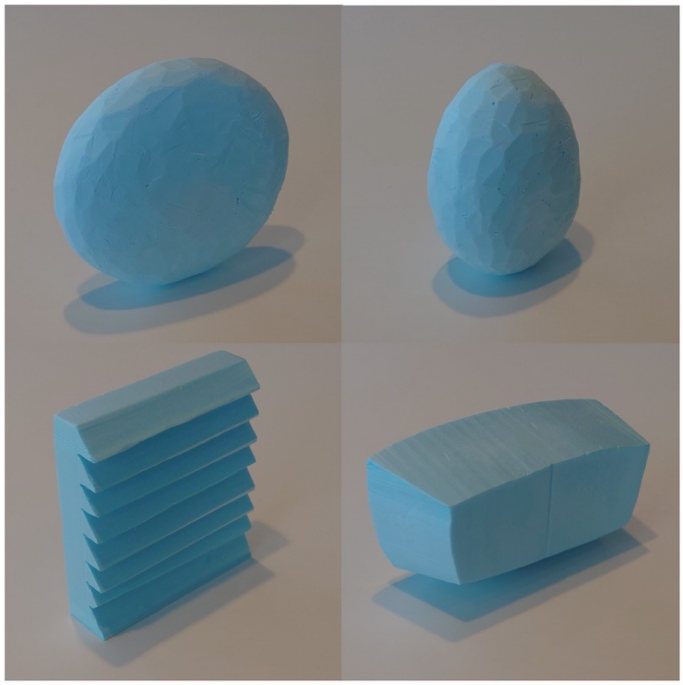

Figure 6.2: Model 1,2,3 and 4

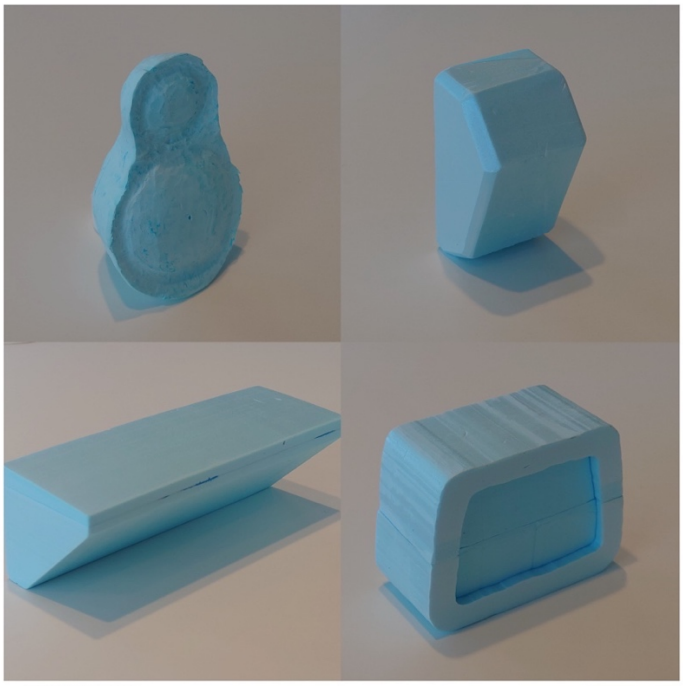

Figure 6.3: model 5,6,7 and 8

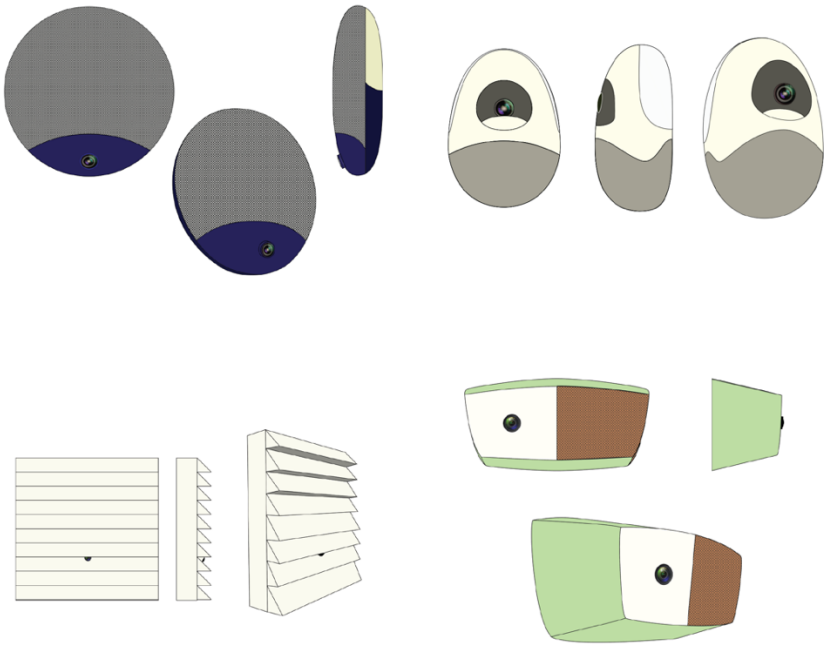

Figure 6.4: Illustrations of model 1,2,3 and 4

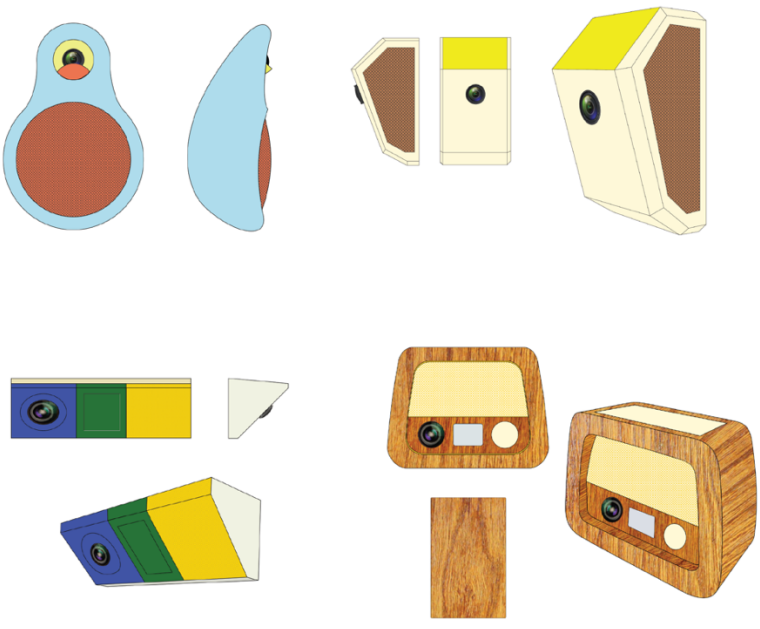

Figure 6.5: Illustrations of model 5,6,7 and 8

6.3 Focus Group One

In accordance with the principles of universal design (Demirbilek & Demikan, 2004) two focus groups were held after the first iteration of parallel prototyping. These focus groups with six participants in each group were held at meeting point Möllaregården. Möllaregården is an activity center for older persons in Lund with activities such as dance lessons, lectures, crafts and physical activities. The participants of the focus group were between 80 to 90 years old. Eight of the participants had smartphones and used them daily but only a few used them for more than making or receiving calls. About half of the participants were using existing fall detection systems and the other half expected to be using them within 3 years. The group came from different backgrounds, participants had worked in everything from industry to health care, service or farming. None had worked with IT-related questions. The purpose of this focus group was to involve the end user early in the design process and in that way accommodate the needs of that group in the finished product. This is in concordance with what Demibilek & Demikian (2004) found when improving the design of a door handle by involving older persons as users: "*The sketches proved that involving elderly in the design making process enhances the design solutions"*

The first objective of the first focus group was the interactions as defined by the sprint and presented on the storyboards. The second objective was to evaluate the final eight prototypes that was the result of the parallel prototyping stage and the different directions these prototypes represented. This way the project group wanted to find out what control mechanism to continue to develop: voice control, a physical controller or an app and what functions should be included. After the focus groups were conducted the results and the notes were discussed and reviewed using affinity mapping. The affinity mapping focused on the form and design of the radar and the interaction design was later reviewed using KASAM. Using the affinity mapping system, it was concluded that:

- (1) The size of this model was both something that attracted some and something others disliked. The size itself could be perceived as both clumsy and reassuring. The dark colour was possibly also a factor as it made it seem less discreet compared to other models.
- (2) Had a few enthusiastic fans in both groups. By those who liked it was mainly perceived as cute. No one disliked it.
- (3) There was a general support for a discreet solution. Something similar to the ventilation inspired prototype. Many said that they appreciated that it was very discreet.
- (4) Did not generate any interest. Some said that the corners were too sharp.
- (5) Some kind of shape that could be related to had many supporters. Some said that it looked a bit like a chicken or a pregnant woman. Many

appreciated that it had an ambiguous shape that could be perceived differently. “It feels like an installation”

- (6) Did not generate any strong feelings whatsoever
- (7) Was disliked by many. The colours were possibly the reason for this.
- (8) Was liked by many and a nostalgic direction for the design could therefore be a valid option.

The results of the analysis of focus group 1 showed that three main themes showed promise. There were many supporters of the very discreet concepts and discreet aspects in other concepts was also approved of. The more playful variants also had strong support and while not as universally liked by the participants as the discreet version they did gain the strongest support from those that liked them. The nostalgic version also had strong support. It was also clear that it was important for the next test that all the different models had the same colour as that was part of the reason that some models received negative critique.

6.4 Interview with Expert

An interview was held with an expert in the area. The interview subject was an expert in the field, both professionally as an associate professor of Health Sciences at Lund University, and through personal experience of the issues facing the target group as she is now retired and has regular contact with persons using different fall detection systems. The same storyboards and prototypes were used in this interview as in the focus group and the scenarios and prototypes were discussed at length. Further questions arose around the pause function and the importance of the response time was stressed again. The reception to the night lamp scenario was also very positive. The interview did in large parts give the same results as the focus group regarding the shape and size of the radar.

6.5 Analysis Using SoC

In order to find areas to improve in the interaction design, the results of the affinity mapping of the notes from the focus group and the interview were analysed and sorted using the Sense of Coherence parameters (Tornstam, 2011). We aimed to find how we could help fulfil the criteria for SoC using the product. The points include thoughts expressed by the participants during the focus group and interview along with our own analysis of the notes from the focus group. The results are described below.

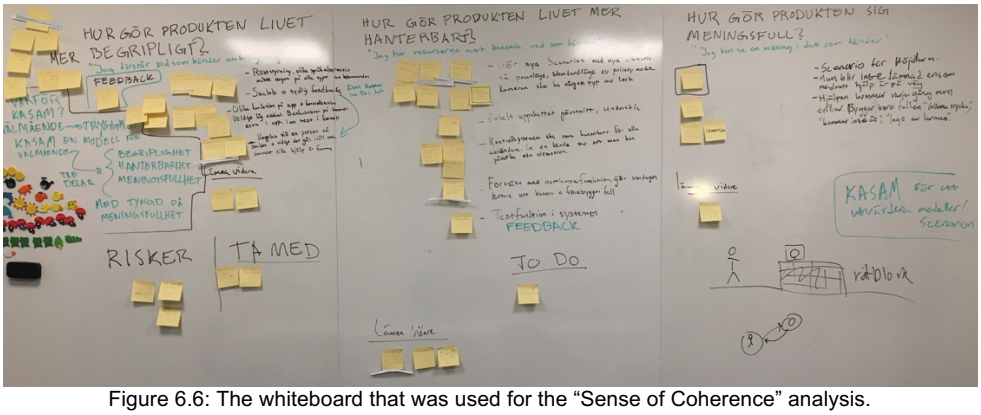

Figure 6.6: The whiteboard that was used for the “Sense of Coherence” analysis.

6.5.1.1 Comprehensibility: How can the product make life more comprehensible?

- Voice control should be able to include different languages
- Feedback should always be direct and clear
- The controller and the app should have different functions. The controller should only control necessary functions and the threshold for using it should be very low. More complicated functions (such as extra health information, alarm clock and the ability to play radio) should be reserved for the app.
- There should be no text on the controller. In that way there can be no language requirement for using it.
- When the alarm is triggered, the user should be connected to an operator in a similar way as when calling 911. The operator should then stay in contact with the user until help arrives. This way the user isn’t left alone when fallen. Having contact with the operator will also be comforting for the user when waiting for help.

6.5.1.2 Manageability: How can the product make life more manageable?

- Revisit the function of the pause mode. Create new alternatives of pause mode rating to normal mode and eventual privacy mode.
- The camera should have some kind of indication that shoves the user if it is active or not.
- Investigate the 112 app since its very appreciated by the target users and could be a guide in the design of the app
- The controller should be easy to navigate for all users, this gives a sense of control over the situation
- Keep the night lamp since the function is very appreciated and it prevents accidents.
- The system should include a test function since this is an appreciated function in today’s wrist-worn safety buttons

6.5.1.3 Meaningfulness: How does the product make itself meaningful?

- With the safety system the user can live at home longer
- The radar should give a warning when the user steps up on a chair. A warning will act as a confirmation that the alarm is indeed working and will prevent an accident.
- The user has company when waiting for help. In that way the user is not left alone as is the case with existing alarms.
- Help arrives with every falling accident since there is no action necessary on the user's part to call for help when an accident has occurred. In today's button-solutions home care won't show up if the care recipient forgets to press the button, something that often happens since a fall can leave the care recipient dizzy and confused. A radar solution will circumvent this issue.
- The product can collect additional heath data. This can then be presented in the app and give the consumer better health awareness if so desired.

6.5.1.4 Thing to keep in mind for further development

- Power outage is an issue for elderly care since all the equipment go offline. A battery might be desirable to prevent this.
- The professional secrecy and responsibility of the care system is generally trusted by the target consumer

6.5.1.5 Risks

- The consumer could be "trapped" inside their apartment since that is the only area covered by the fall detection system
- What are the boundaries of "the home"? Should the fall detection system cover common areas such as the shared laundry room or the stair outside the apartment?
- Some users worry about who has access to their information.

6.5.1.6 Thing for further development outside the bounds of this thesis project

- A more robust version of the radar that can be mounted outside to cover a garden or balcony
- The possibility to control the alarm by body movement
- The development of the app

6.6 New Interactions

After focus group 1 it was decided that it was time to elaborate further on the interactions as they are described in the storyboards. The storyboards were never intended to specify the functions of the radar but created to showcase different functions and interactions to the focus group. Therefore, certain specifics were

intentionally left vague in the storyboards to encourage the focus group to inquire and start a discussion. In this stage however it was desirable to create a more precise diagram over the tree main scenarios: The scenario where the radar is triggered, the scenario where the user wants to sound the alarm but has not fallen and the night scenario. Three flow charts describing these different scenarios were created to explore them and to ensure that no eventuality was missed.

Seven short videos were also created to recreate the scenarios as they were presented in the storyboards. These videos were created with the intention to be shown in focus group 2 to give an even better understanding of the product than the storyboards. Certain aspects such as voice control and waiting times are also more suited to being illustrated in video. It was also a way to further emphasize with the user and to understand the scenarios from the user's perspective.

6.6.1 **Flow Charts**

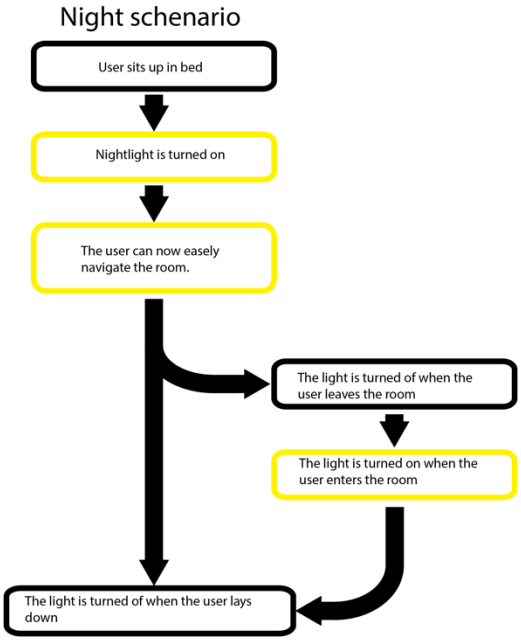

Figure 6.7: Flow chart illustration the night lamp scenario.

Flow chart 1 describes how the night lamp works. Many functions such as the radio function and the ability to provide the user with health statistics were intended to add value to the product. But since it was discovered in focus group 1 that they could instead make the concept unnecessary complicated it was decided that all these

functions should be reserved for the app. (more about this in 5.8) The only exception was the night lamp function.

The need for this function was great since many of the attendees described sleeping with an open door and light in the hallway or similar even though it bothered them. They did this in order to have some light on when they needed to go to the bathroom, something that usually happened several times per night. The night lamp solves this by being off when the user lays down in the bed and turning on when the user sits up on the bedframe.

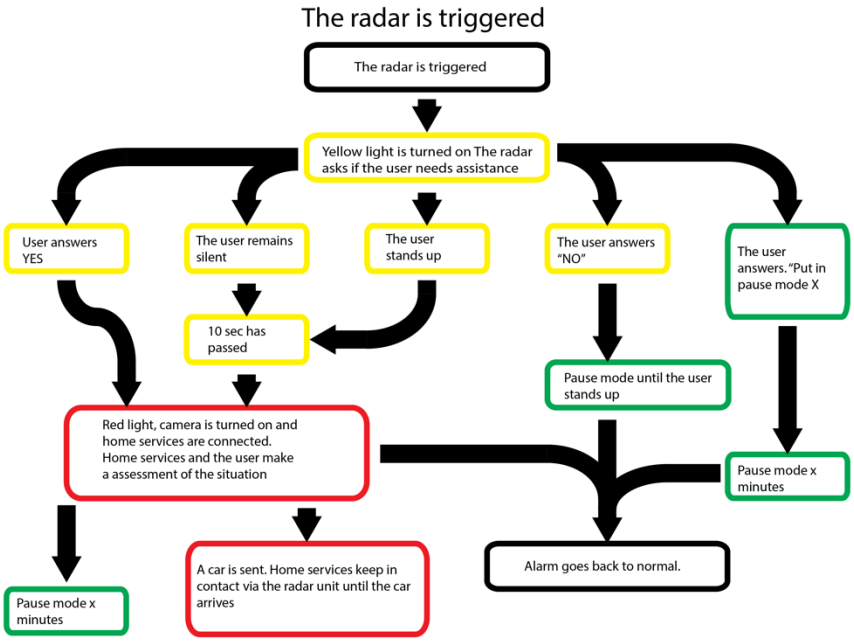

Figure 6.8: Flow chart illustrating the different options when the radar is triggered

Flow chart 2 describes the scenario when the radar is triggered for any reason. It's important to note in this scenario that the flow charts describe the interactions from the point of view of the radar and that any triggering of the radar could therefore be a false alarm. When the radar detects a fall, the yellow light will turn on, indicating that the radar is triggered. The speaker in the radar module will also play a pre-recorded line "I have noticed that you are in the floor. Do you want me to contact the home care?" The radar will the wait 10 seconds for an answer and will depending on the answer either go into alarm mode or pause mode.

The radar will go into pause mode until the user is standing up again if the user answers the pre-recorded line with no or equivalent. The radar will also go into pause mode for up till 30 minutes if the user answers the pre-recorded line with a request for pause mode. Pause mode will be indicated by the lights of the radar switching to green and another voice line.

If, however, the user answers that help is required or something similar or remains silent the radar will go into alarm mode. This will be indicated by the lights of the radar switching to red and another voice line saying that home care is being contacted. The camera will then be turned on and the user will be connected to the home service. The system will go into alarm mode even if the user manages to stand up again but does not answer the radar. This is because it was discovered in the interview that it can be difficult for the older person to know initially how bad a fall has been, and that the person can be hurt even if they manage to get up again. When the user gets contact with home service, they will together discuss what has happened and the need for aid. They will then stay in contact until help arrives so that the user is not left alone during the time of distress.

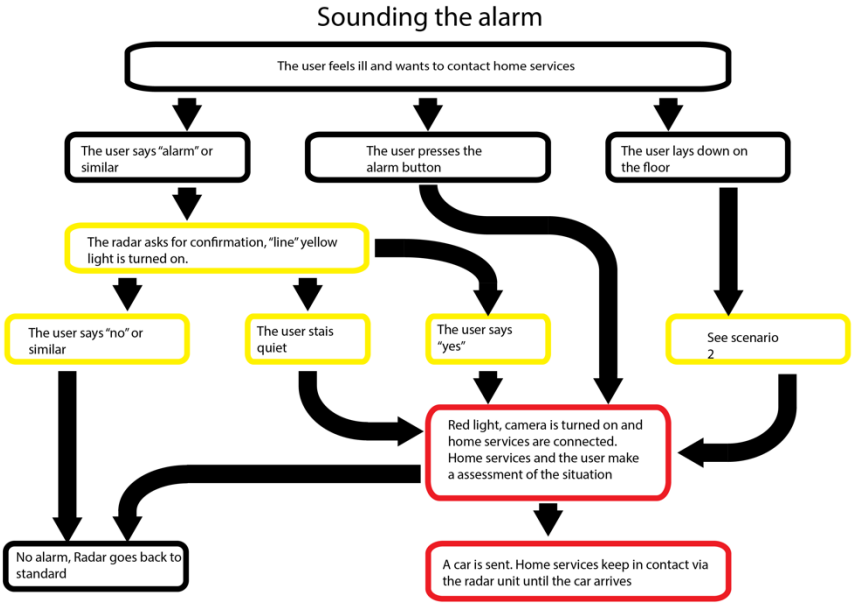

Figure 6.9: Flow chart illustration the different options when the user wants to trigger the alarm function.

Flow chart 3 describes the scenario when the user for any reason wants to trigger the alarm but has not fallen. There are three possible ways for the user to achieve this. Pressing the alarm button on the control, using voice command to tell the radar unit to alarm or simply laying down on the floor. If the user lays down on the floor the radar will operate as illustrated in flow chart 2. If the user presses the alarm button the alarm mode will be triggered directly. If the user says “alarm” the radar will ask for a confirmation. If the answer to that is “yes” or simply a lack of answer alarm mode will be triggered. The alarm mode is the same as in scenario 2.

6.6.2 **Videos**

To illustrate the functions described in the flow charts to the focus group a few videos were made. The scenarios illustrated in the storyboards for focus group 1 was all recreated in video form except the scenario referring to setting an alarm for the morning. This decision was made since the alarm function was no longer deemed to be a core function and therefore now fell outside the scope of the project. There were seven videos made in total illustrating seven different cases:

- **Fall detection when the user is responding**
  This video shows a scenario where the user falls, the alarm is triggered and the user the responds "yes" to the line: "I have noticed that you are in the floor. Do you want me to contact the home care?". The radar is put in alarm mode and the user is connected to home care. They discuss the situation and help is sent out. They then keep contact until help arrives.
- **Fall detection when the user is not responding**
  This video shows a scenario where the user falls, the alarm is triggered but the user does not respond to the line: "I have noticed that you are in the floor. Do you want me to contact the home care?". The radar is put in alarm mode and the user is connected to home care. Home care is not able to contact the user who is unconscious, and help is sent out. Home care keep trying to contact the user in case the user wakes up before help arrives.
- **False alarm with response from the user**
  This video shows a scenario where the user drops something under the bed and gets down on the floor to pick it up. The alarm is triggered but the user responds "no" to the line; "I have noticed that you are in the floor. Do you want me to contact the home care?", thereby putting the alarm in pause mode until the user stands up again. The user then stands up and the alarm goes back to normal.
- **False alarm but the user does not respond**
  This video shows a scenario where the user drops something under the bed and gets down on the floor to pick it up. The alarm is triggered, and since the user does not respond to the line; "I have noticed that you are in the floor. Do you want me to contact the home care?", The alarm goes into alarm mode and home care is contacted. They discuss the situation and as the user does not need any help nobody is sent out.
- **Triggering of alarm with control panel**
  This video shows a scenario where the user does not feel well and decides to trigger the alarm by pressing the alarm button on the control station. The user is connected to the home care and they discuss the situation. Help is then sent out.
- **Night lamp**
  This video illustrates the function of the night lamp. The first scene shows the user turning on the night lamp function by pressing the button for the night lamp. The alarm shows that the night lamp function has been turned

on by blinking twice and saying: “The night lamp is now turned on.”. The next scene shows the user at night sitting up in bed. The night lamp is turned on. The user gets up and leaves the room. The user comes back and lays down in bed. The night lamp is then turned off.

- **Setting the pause mode**
  This video shows the user dropping something under the bed. The user sets the pause button on the control station by turning the handle. The alarm confirms this by turning on a green light and saying: “The alarm has been paused for X minutes.”. The user is now free to lay down on the floor to pick up what’s been dropped without triggering the alarm.

6.7 New Pause Mode

As there were concerns raised around the pause function in focus group 1 that function was revisited. The concerns related to what would happen in the case the alarm was turned completely off during the pause mode and the user got a heart attack while doing gymnastic exercises in the floor. The alarm would then not trigger until the timer for the pause button ran out. The team had a brainstorm session based on the SoC principles and came up with five different solutions to the problem, see appendix 10.3. In the end the concept presented below was chosen:

Standard mode:

- Camera off, turn on at alarm mode
- Radar on with full function and logging of heath data for the app. Gives a warning when in a high-risk situation, for example standing on a chair.

Pause mode:

- Camera off, turned on at alarm mode
- Alarm at low movement
- Timer

As seen above the main change from earlier with this concept is that the radar is not completely turned off when in pause mode but will still go into alarm mode at a lack of movement. As the radar can measure both breathing and even possibly pulse, a lack in any of those values should trigger the alarm.

6.8 Usability of the System

The decision was made to only include the most basic functions in the control station since some of the participants of the first focus group felt that the concept was too complicated. The design team also had concern that to many functions could dilute

the sense of security that the alarm is supposed to instil in the user. The decision was therefore made that the control station should only have three functions. The two most basic functions being alarm and timer in addition to a switch for the night lamp function since that function was greatly appreciated by most users and should therefore be considered a core function. All other functions such as health and habit statics, alarm clock and radio should be reserved for the app to make the core use case as uncomplicated as possible. The assumption was then made that the users that are most interested in learning the extra functions are also more capable of handling an app. The control station was made in accordance with the seven principles of design (Norman, The Design of Everyday Things, 2013).

Figure 6.10: The first prototype of the control station.

6.8.1 **Discoverability**

The control station should be noticeable, and it should be easy to discover what function is controlled by what button. The alarm button should be easy to discover and use even for other people than the resident.

6.8.2 **Feedback**

There should be a notable “click” in the buttons. Tactile feedback assures the user that the control has registered commands. The radar on the wall should also respond to commands on the control station with sound and light.

- Red light, audio reply and contact with home service when the alarm is triggered at the control station.
- Green light, audio reply when the timer function is set by at the control station.
- Light pulse and voice command when the night lamp function is set at the control station.

In short, the tactile buttons let the user know that the request has been heard. The reply from the wall mounted radar lets the user know that the request has been received and is being processed.

6.8.3 **Conceptual Model**

The control station should help the user create a conceptual model of how the system works. This is achieved by choosing buttons that visually represent the function they control. The alarm button was therefore designed to be a big red button, noticeably larger than the other two to signify that this is the main function of the control station. The pause button was chosen to be a turning handle similar to an egg clock as this is a form that’s commonly used in timers. The button for the night lamp was a simple on/off switch as this is what is commonly used in lamps. In this way all controls are easily differentiable and closely corresponded to the given function.

6.8.4 **Affordances**

The user should be capable of determining just how each part of the control station can be used. The tuning handle affords turning but not pushing. The on/off switch affords pushing and not turning. It also affords being out into two different modes where it stays until pushed again. The big red button affords pushing but not being put into two different modes. It does not either afford turning. These affordances hopefully make it clear what function is connected to what control, since only one control corresponds to each desired action. The only control that affords setting a timer to different times is the turning handle, the only control that affords putting something in an active or passive mode is the on/off button and the only control that affords to be quickly pushed is the big red alarm button.

6.8.5 **Signifiers**

The user should be able to tell the function of the control station and the function of each button just from observing it. For the user to be able to easily see that the control station is connected to the radar it would therefore be advantageous if they had a similar shape or identifiable curves. This detail was left for later in the process as the shape of the radar was not yet decided and would be after focus group 2. It was also discussed that if the radar and control station were connected by a cord this would serve the same function.

It was decided to avoid any descriptive text on the control station since the analysis of focus group 1 had shown that it was important that language was not a factor in if ease of use.

To make sure that the difference in function the different controls represent the are also made to look distinctly different.

The big red button in itself is some sort of signifier for an alarm but this was enhanced by a symbol of an alarm bell. Labels were also added to the two other controls clarify the use further in accordance with Don Normans thoughts about knowledge in the world. *"Knowledge in the world is accessible. It's self-reminding. It's always there, waiting to be seen, waiting to be used."* (Norman, 2013, p110). This was implemented by adding on/off labels at the sides of the on/off switch and signifiers with different times at the sides of the turning handle.

6.8.6 **Mappings**

Mapping is used in the control to show the ranked importance of the controls by spacing the alarm button away from the other two controls. The alarm button was also made noticeable bigger. These two design decisions were made to mark the alarm button as more important than the other two controls.

6.8.7 **Constraints**

Two constraints were implemented in the control from the start. First the night lamp was chosen to have only a on/off control even though it would have been possible to have controls to adjust light intensity as well as colour. This was done to keep the control as simple as possible as it was reasoned that those functions would be better served in the app. The other main constraint implemented was to give the timer a max time of 30 minutes. This was since having a too long of a timer would defeat the purpose of the timer since the alarm would then essentially be put in pause mode permanently. This was never the intention with the pause mode and while it's possible that it should allow for more than 30 minutes of pause it should only ever be used as a temporary measure.

6.9 New Concepts

Using the results from the analysis of focus group 1 parallel prototyping was once again used to create a new set of prototypes for the next phase. The nostalgia direction was deemed to be too complicated and time consuming to pursue since finding a common nostalgic reference for the entire target group which had only positive connotations and was possible to adapt to the radar was deemed to not fit in the frame of this master thesis. It was therefore decided that this period of parallel prototyping should produce models that were either discreet, playful or a combination of the two. Since the discreet factor was important for so many of the focus group and it was deemed to be more important that the product was acceptable by all instead of liked by a few, it was decided that all prototypes should be discreet on some level. It was also decided that all prototypes should be realistic in that they should be closer to the finished product than the previous phase.

Figure 6.11: Three models from this prototyping phase. All of these are large enough to fit all components

Four concepts were selected as the ones that best represented the desired direction. Two concepts were selected on the merits of being very discrete, a square version and a round version. The third concept was selected on the merits of being relatable and playful as this had shown to be desirable in the previous focus group. The last concept was as a concept that tried to incorporate all factors in being both relatable and playful and almost as discreet at the discreet concepts.

Figure 6.12: The four models brought to focus group 2. The very discreet options are in the top row and the most playful one in the bottom left corner. The one in the bottom right corner is the one that seeks to be a mix between relatable and discreet.

6.10 Focus Group Two

The second iteration of the focus group at Möllaregården, a meeting point for seniors in Lund, took place on the 29th of November. This time we had brought new 3D-printed models of the alarm, a sketch of the control station for the alarm as well as

videos depicting scenarios where you would interact with the alarm. The aim was to get guidance regarding what shape to develop into a final prototype, get feedback for the control station and the scenarios. The agenda was set, there would be a presentation with a recap first, then we would watch the videos and discuss them, followed by a short break and coffee being served, after which we would do interviews regarding models and control stations in smaller groups.

When we arrived at Möllaregården we immediately saw that there were even more people here now than the last time. 17 people were there for the presentation and discussion about the movies but five had to leave before we could get to interview them, leaving us with three groups of four people for the interviews. This time we decided to do all interviews together, with one of us moderating and the other taking notes. The interviews were held short to make sure every group was heard. To evaluate the models, we asked each group to rank the four models from the one they would like to have at home the most to least. Probing questions were asked to get an understanding of why they were ranked as they were. The control station was examined with questions regarding usability and clarity.

Videos were a great tool to clearly and easily communicate how we thought the product should be working in different scenarios. It was also great for research purposes, to empathize with the users in the difficult situations that they are supposed to use the alarm in. One thing that came up during the discussions regarding the videos was that the alarm would have to turn on if the user was to suffer a heart attack or similar during sleep. This could be achieved since the radar can be used to measure stillness as well as pulse and blood pressure. Otherwise, a lot of the worries expressed by the participants during the visit were related to things outside the scope of our work. Like how long it will take for the home care to arrive, whether the people who arrive from the home care are trustworthy and other general concerns about the human factor of the product. There were also a lot of questions regarding the cost of the system and who would be paying for it.

To our surprise the square model was by far the most popular, getting ranked the highest in every group. It was a surprise since we thought it would be too angular and sharp in its expression to look nice in a home environment. Robin's Kaizen study also seemed to point in the opposite direction, that older persons would like rounded shapes more, but it could just be a case of two small sample sizes thinking differently.

When asked why they ranked the square so highly, the discreteness and conventional look of the model was valued a lot. Some appreciated certain design elements of the model such as the speaker cover. In addition, in all groups the discussion about which model was the best quickly turned into conversations about which model was most discrete, signaling that this is the most important factor for this product's success is discreteness. The following are all quotes said about the square model in a positive regard:

“It’s like a vent”

“You can’t really see it that much”

“It’s the most discreet”

Even after using Don Norman's 7 principles to make the sketch for the control station, more work needed to be done. It needs to be made clearer what the functions are and what the buttons do. The night light was particularly confusing since a lot of participants thought they would need to turn it on by themselves every time they wanted it to shine. This is not the case, and something needs to be done for that to be clear. Perhaps the presence of a button for the night light, something you won’t use very often and never is a critical function to use, is confusing in itself.

Another thing brought up during the discussions of the control station was size. The alarm buttons that are being used today are small and portable which was brought up as a good thing. Questions were raised about how you would be able to alarm if you weren’t near the stationary control we brought along. The question is whether this is necessary with this new system. When you have a radar in every room, combined with a broader set of alarm parameters for the automatic alarm, such as pulse, blood pressure and stillness, and alarm via voice control you can achieve the comprehensive protection a portable button gives today.

“What’s safe with the alarm today is that you always have it with you”

This was said about the alarm system used today. Our new system would however always be *with* you, just not always *on* you.

Something that needs to be remembered when discussing the control station is the targeted user group. It is a very large group with a lot of different prerequisites for their daily life. Problems with hand strength and precision is one very regular problem in this group. Since the control station is the way of interaction intended to work for everyone in the group, extra consideration needs to be taken for those who have the hardest time with the buttons. This means that the buttons, and the station, can’t be too small. It was brought up by one participant in the focus group.

“It could not be much smaller. If you shrink it the buttons gets smaller to”

This might come with the cost of a control station that feels big and clumsy by others, but that might also be a cost worth to pay. It might also leave space open for further development of a smaller, remote control at a later point in time. An app has also been discussed, which could also be an alternative.

7 Deliver

This phase concludes the double diamond process and therefore also the deliverables of the master thesis. This chapter presents the final model and the results of the last focus group. The continued development of the control station is discussed, and the final focus group ends the chapter.

7.1 Changes to the Final Model

The results could not have been clearer after the second focus group. The square model was by far the most appreciated. Therefore, it was decided that this concept should be the final one. A few small changes were made:

Figure 7.1: The final concept

A black box was incorporated around the camera lens to connect the camera lens to the rest of the radar, as well as softening the impression of the lens. This is also more in line with the design language of the tech company. A collar was also created around the lens mount to further blur the line between lens and the black square.

Figure 7.2: Side view of the radar

A new under part was created and the shell was raised 5 millimetres in total to make room for all electronic components. A new mounting system was created to make the installation of the radar system as simple as possible. The new system consisted of a metal plate that is screwed on to the wall. The radar is then snapped on to the plate.

Figure 7.3: A view of the black square around the camera

The lower lip of the box was made to be less sharp since there were some concerns within the group that the old version was too sharp and gave the radar an aggressive look. The speaker cover was also redesigned to be more in line with the design language of the technology company, but it was kept in a different material and colour since the distinguished look of the speaker cover was a part of what made the concept popular.

Figure 7.4: Front view of the radar

The rounding's in the corners of the cover was enlarged to give the shell a softer look.

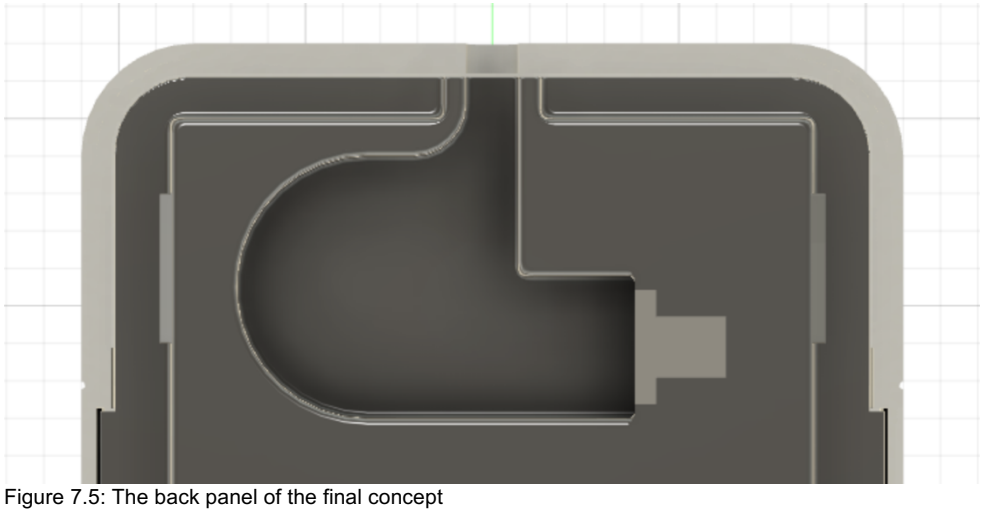

Figure 7.5: The back panel of the final concept

A channel for the cable was added to the under part of the shell. This was done to give a bit of leeway for the cable connection., but it was also part of the reason that the shell had to be raised 5 mm.

7.2 Developed Control Station

Figure 7.6: The developed control station

The control station in figure 7.6 is very similar to the rough prototype that was presented to focus group 2. Based on the response from that focus group only a few changes were made. These changes were as following:

- The switch for the night lamp function was moved to the side of the control station. This was done to further differentiate this function from the other two. The move to the side of the control also changes the perceived hierarchical importance of the controls making the switch seem less important than the other two controls.
- The two remaining controls (alarm button and pause timer) were moved further apart. They were also moved to different heights, the timer slightly lowered, and the button slightly raised. This was done to further differentiate between the controls on top of the control station.
- The shell of the control station was given a similar shape to the radar so that they would be perceived as connected.

7.3 Focus Group Three

The third and final focus group at Möllaregården took place on December 13th. This time the new, updated model of the radar and the updated control station were the points of discussion. This time 20 people showed up to discuss.

There was no presentation this time as the material brought to the focus group was more suited to a discussion in smaller groups. Therefore, interviews were started right away. The participants were divided into four groups to make sure everyone got room to speak their mind.

When speaking about the final design everyone had a reaction ranging from positive to neutral to the final design. As this product is aimed to be able to fit into as many people's lives and dwellings as possible, this is the sort of reaction we were looking for and a great result. The changes from last time were seen as improvements by most. The bigger radius around the corners were well received and the “smart surface” surrounding the camera was also appreciated as it softened the impression of the lens.

The control station was discussed and while it was not immediately clear what every button did, almost everyone could figure out what the alarm button does. This is of course the most critical button to understand, so it was good that its function communicated so clearly. The other functions seem a bit harder to understand as their nature is a bit more complicated than the alarm, while also not being nearly as important for the functionality as the alarm. One participant said that it would be no problem to learn the functions and their control as long as you were given a user manual. The rest of the group agreed with this.

Moving the button for the night light to the side of the control station was also a good move. Participants found it less confusing as there were one button less to analyse and the risk of mixing it up with something else was removed. It was however brought up that the button might be a bit hard to press if you have to hold the control station still with your other hand while pressing this button. A few solutions were discussed, such as double-sided tape or some sort of rubber underneath the station, adding friction. Some concerns were also expressed about where you would put the control station, since it might not fit on everyone’s bedside table. This could open up for a smaller, portable control to be developed further down the line.

One risk of the system was brought up by a participant: What would happen during a power outage, since the alarm works on power from the mains? This is obviously a big risk and some system change should be put in place to accommodate for this. Perhaps the alarm should include a reserve battery to use if the power goes out which then would be recharged when the power is back.

As this was the last time we visited the meeting point for a focus group, we took the opportunity to ask how the participants there had experienced the series of interviews. The answers were positive as they appreciated the chance to affect the technology of the future. They also found that they felt their feedback had made a difference in how the alarm was eventually decided to look and function.

All in all, the changes from last time were appreciated by the groups.

7.4 The Final Concept

The final concept consists of the radar unit with camera, speaker, microphone, and lamp as well as multiple ways to control the alarm system, this project has however only developed one way fully which is the control station. The radar is used to measure the position of the user and detect falls. It can also be used for nightly supervision and keeping statistics for sleep. The camera will only be used during contact with the home care to simplify the contact and to quickly get an overview of the situation. Finally, the microphone and speaker are used to communicate with home care as well as for voice control of the system.

After our collaboration with Möllaregården, a meeting point for older persons, the design language of the radar unit has become discreet as this was the most appreciated throughout all visits. The product was in the end designed more as an architectural element akin to power outlets or ventilation grilles. This is also a line of design which the technology company works a lot with, things that don't attract attention unless you know to look for them. This is however not why this direction of design was chosen, it was chosen because it was so popular with our focus group and made them feel the most comfortable with the product.

Figure 7.7: The final model of the radar unit

The radar unit signals the state of the alarm system with both light and sound. When the radar has noticed the user being on the floor it will shine a yellow light and when an alarm is sent, and home care is contacted it will shine a red light. When the alarm is in the pause mode it will shine green. To help our users with reduced colour vision, the red light signalling that home care is being contacted will blink as well. Along with the lightning, the radar unit will also use pre-recorded voice lines to update the user on the state of the system.

Interacting with the system is something a lot of thought was put into during the project, although not quite as much time was put into it as the physical design of the radar unit which is the primary goal of this project. With a target audience as big and diverse as the one this system aims to meet, it is virtually impossible to find a single solution that perfectly fits everyone. Instead, multiple modes of interaction can be used and combined for a solution that fits every user. During the project we have mainly focused on the most basic mode of interaction, the control station. This provides the user with a button that directly sends an alarm and connects them to the home care as well as a handle that controls the pause function.

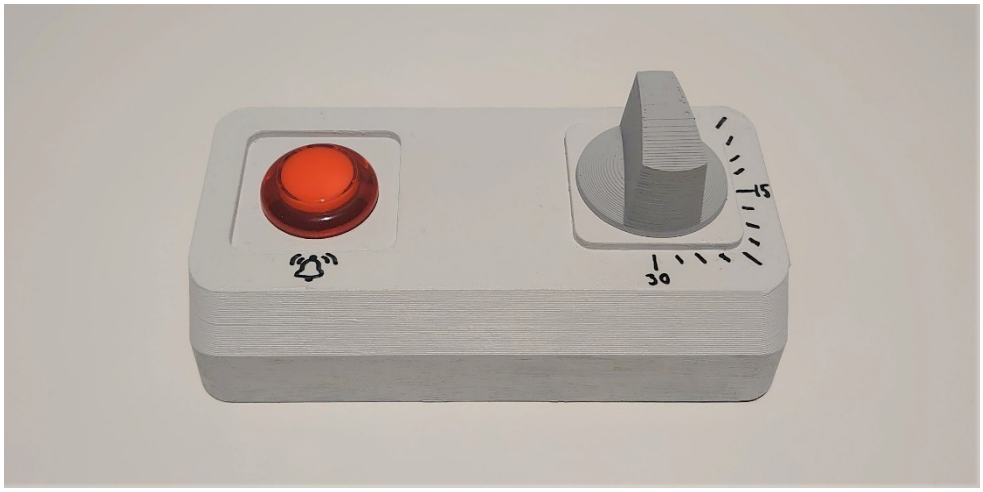

Figure 7.8: The control station

However, we have also thought about using an app, voice control or even the alarm buttons which are used today in conjunction with the control station to control the alarm system. The app could be used to control more advanced function, such as an alarm clock or calendar, while also giving the user access to statistics regarding their sleep. Voice control could be an intuitive and good mode of interaction for a user that doesn't want to spend time learning technology to be able to use their alarm system. Integrating the alarm button which is commonly used today could make the transfer of system easier and more comfortable. It would also give the user access to a portable alarm button. On top of these options, the most important functions of the alarm, such as fall detection and nighty supervision are basically fully automated. If a user only wants to use the system for this, they basically don't need to actively interact with the system at all.

8 Discussion

This chapter contains discussion regarding the project. The discussion covers both parts of the project that were a success and some parts that could have been done differently. We also discuss what could be interesting areas to investigate in the future and work that needs to be done but did not fit into the timeframe for this project.

8.1 Design Process

This master thesis used the Double Diamond process as a design process. The technology company had already had three different master theses on this project and the information from those projects could be used to shorten the discover and define phases of this project. This enabled our master thesis to start quickly but created a very large develop phase in the middle of the project.

The double diamond process was combined with the methods presented by Demirbilek & Demikan (2004). This was done to create a method that followed the iterative process of Double Diamond but with a greater focus on the end user. This mainly affected the Double Diamond process by the addition of three sessions of focus groups. Two focus groups were added in the Develop phase and one in the Deliver phase.

The focus groups came to serve as checkpoints in the design process. Furthermore, the fact that there were two checkpoints in the develop phase essentially split that part of the process in two. The first focus group came to serve as the ending and evaluation of the Discover, Define and early part of Deliver phases. This worked well as that meant that the design team could then more easily move on. In a similar way the second focus group came to serve as the ending of the develop phase of the project. After that focus group the focus was no longer on developing different parallel concepts and prototypes but only on improving on the selected concept. The third and final focus group then became the ending of the deliver phase and an evaluation of the entire project. After that focus group only minor changes were made. The merging of the two design processes was a success since it split the otherwise very long develop phase into two parts that were easier to manage.

It also created a sense of progression in the project as the number of models decreased in every focus group at the same time as the quality increased.

The sprint method as developed by Google (2001) was also used once in the end of the Define phase as a lead up to the Develop phase. It proved to be a useful tool to quickly create a concept of the interaction between user and product. It was initially intended to be a sprint session after each focus group, but those plans were abandoned since it was not compatible with the parallel prototyping approach that was used. The sprint method was found to excel in creating a rough concept quickly but not adapted to reefing a concept over the period of two weeks or more.

8.2 Focus Group

Along the course of this project, we have used reoccurring focus groups to evaluate our ideas and discover what our potential users value. Focus groups are a form of qualitative study (Preece, Rogers, & Sharp, 2015). It is therefore important to keep in mind that the sample size is relatively small and might not represent the target audience. This is especially important to keep in mind when the target user group as diverse as the one in this project. Older people that live at home with some assistance of elderly care is a very broad group even if only referring to those that live in Lund.

When conducting the focus groups new insights, and not confirmation, was what primarily was searched for. It was decided that this should be the focus since the design team does not have the same experiences and frame of reference as the target user and because gaining new insight might be crucial to not overlook an important aspect of the product. Some confirmation on specific detail can be gained even from a qualitative focus group. It is however important that its only on aspects that can be considered universal for the entire group, otherwise the assumption needs to be made that the group is representative of the target user group, something that might not be true. This is case with the night lamp. It was received well by a large part focus group but since there is no way to know if that is representative of the user group an on/off switch was added so that users that do not desire that function can turn it off.

The designers also must bear in mind that while the focus group might have more experience in the specific use case, they do not have experience of product development (Martin & Hanington, 2012). The designer therefore must filter all ideas that come up in the focus groups trough their own knowledge before implementing them in the product.

At our first session of focus groups, we had 12 participants. This number then grew every session from 12 to 17 to 20, as everyone who had previously participated returned and more people joined in. While we were happy so many showed up, this

is too many people for one focus group. Kreuger (2002) recommends having six to eight participants in a focus group. We solved this by splitting the participants into smaller groups, discussing with one group at a time. The original 12 participants got a good insight in the entire process and were able to ask questions about changes that had been made since the last session. On the other hand, they sometimes got attached to the project and had a harder time giving critique. Some of the hardest critique often came from participants that participated for the first time in the project.

This project focused on designing a product solely for the older person who is supposed to have the system in their home and therefore, the focus groups consisted of this type of potential future user. There are however many more stakeholders in a system such as this. Other stakeholders are the personal and IT-specialist of the home care. Because of the time constraints of the project, focus groups with these stakeholders were never held but in a larger project they should have been consulted. We do recommend that this is done in the future development of the product.

8.3 Functions in the Control Station and the App

When we started working on how to interact with the alarm system, we quickly realised that different modes of interaction would be needed to ensure the systems usability for everyone in our wide target audience. We discussed a control station, voice control as well as an app. In this early state of the project, we wanted all the modes of interaction to be complete in themselves and equal in what functions they provide.

During the first focus group we investigated if our users would be interested in having bonus functions such as an alarm clock or radio. Most of the participants just wanted to know the system works and were not interested in interacting with it more than necessarily. They also didn't express concern about integrity or what information the system sent to the home care. There was however one participant who was very concerned with what information would be available through the system and who would have access to it. There was a larger need for control of the system and the information.

This result from the first round of group interviews and discussing it with our supervisor at the company, we decided to split the functions and make the ways of interaction aim to meet different needs from different types of users. We decided to make the control station act as a base, providing basic functions as easily as possible and use the app to let the user get access to statistics and more advanced functions. The app becomes a bit more complex, with a higher threshold for the user to start, but we reasoned that if you were interested in these extra functions and statistics, this would be an effort worth making. If a user is uninterested in learning any new technology and already used to the available alarm button, this could also be used

in conjunction with the radar unit, further simplifying the interaction and lowering the threshold to the system.

Locking certain features behind technology our user might not master can of course be interpreted as problematic, but we see it as a way of letting every individual user get the level of complexity for the system they want. Everyone still gets the possibility to control the system more, use the extra functions and check their data, while this complexity is not forced onto anyone. Also, both Hay & Westin (2021) and Fristedt et al. (2021) have found that older adults attitude towards new technology is quite positive, while they might feel that the technology is not developed with them in mind. Another study, (Readly, 2021), shows that older adults have become increasingly digital in their daily life during the Covid-19 pandemic.

Voice control is something we think could be a great way of interacting with the alarm system due to how intuitive it is. This intuitiveness could also help bridge the gap between the control station and the app as it makes it less complex. You suddenly don't need to memorize any buttons but can instead just tell the system what you want. There are however issues, both with the technology itself and with how it would work for our users. The technology is not quite as stable and precise as it needs to be for this application today. Since it is a security system, trusting that the technology to work is very important. A bad experience with voice control could damage this trust. The technology could possibly be good enough in three to five years though, when this product is aimed to be realized, as it is an area with a lot of development from big companies such as Amazon, Google, and Apple. A bigger issue is the increased prevalence of impaired speech and hearing corelated with aging. This further complicates the use of voice control. We do however like it as an option, provided it works as good as it needs to.

8.4 Important Factors Outside the Scope of the Project

8.4.1 **Response Time**

One big, reoccurring worry of the participants of our focus groups were the response time of the system. How long will it take for help to arrive after an alarm has been sent? This is a big problem already with the systems in place today and highly dependent on who is your care provider. Some of the participants said they sometimes must wait 30-50 minutes for help to arrive after they have fallen, which is a very long time to be in such a state of distress. This is a factor which will negatively impact the experience of our product but is also something outside our control since it mainly depends on the organisation of the home care system.

The final concept seeks to facilitate a quicker response time by providing a better contact between the user and the home care. This is done by connecting the user to a handler as quickly as possible when the fall detection system enters alarm mode. This decreases the risk of false alarms when the user accidentally presses the alarm button, something that is very common in the systems today. This system also provides the user with a contact while waiting for the home care to arrive, eliminating the need for the older person to wait alone.

8.4.2 **Does the Technology Work?**

The radar technology that is used in this project does not exist yet but is under development and is theorised to be on the market within the next two to four years. As the system is largely dependent on radar it won't be finished until the radar technology is ready even though testing may be able to start as soon as next semester.

As the technology company that this master thesis is done in corporation with is both testing and developing said radar technology, we have been able to work closely with experts in the field and gain good knowledge in the limitations and possibilities with the technologies. This has been a must to be able to complete the project.

Some question marks do still exist, mainly the discussion around blind spots in different rooms. This was shown to be a potential problem in chapter 4.6. The radar shadow in the cases that were studied was relatively small and a person could only potentially disappear behind e.g. the bed in image 4.3 if they were lying on the floor. This could be solved in the programming of the product. A solution would be to have the fall detection remember that there is a person in the room and that the must therefore be in the floor if they can't be seen.

Another potential problem for the radar could be reflective surfaces. Surfaces with metal such as a mirror, or possibly a TV-set could serve as mirrors to the radar, showing to images of a person in a room. This might trick the fall detection system into thinking that there are two persons in the room. This could potentially be a problem but must be further investigated in testing. In most cases this problem could be solved by defining borders for the room. Since the false "shadow" of the person would then fall outside the borders of the room it could then safely be classified as a false shadow and therefore be discarded. This has not been tested in practise and is therefore still unclear.

8.5 Future Work

This section discusses how close our final model is to be a usable product and gives some suggestions for further improvement. What we have accomplished with this project is a proposition for how the outside of the radar could look as well as how the interaction could work. This concept is now ready to be presented to other stakeholders in the company and potential customers. If this goes well it might become a real product. To take this concept all the way there, a bit more work needs to be done.

First and foremost, the electronics and programming of the system needs to be developed. We have made sure via discussions with our supervisors at the company that all the electronical components will fit inside our model, but since it has not been in the scope of this project, we have not constructed the inside. As for the code driving the system, it is being developed and tested concurrently with our project.

Another vital part outside the scope of this project is how the system will interact with the home care. Where does the call from the radar go when an alarm is sent? What happens next? We have theorized about the call reaching some sort of alarm centre, which then forwards the information and decides whether to send staff to the home of the older adult, but since our main focus of this project is the experience of the older adult, we haven't looked into it further. The home care staff will probably interact with this system even more than the older adults which have them at home, making their perspective on the system very important.

After these parts are finished, user testing can commence. Technical testing could be done by using a few of the company's available products, and further down the line product testing could put our work to use.

Given the time constraints of this project there are a lot of thoughts and ideas that we were not able to fully investigate and develop. The section below aims to present some of these ideas as opportunities for further improvement.

8.5.1 **A Version of the Radar for Bathrooms**

Given that 80% of fall incidents for older adults happen in the bathroom (Belvedere, 2020), a version suited for this environment will be necessary in the future. It would of course need to be water and moisture resistant. This version would also have to face the ethical questions of having a camera on the product again, as the bathroom is a place where you expect privacy.

8.5.2 **Outdoor Coverage**

One thing that was wished for during a focus group was coverage of a balcony or terrace. This could open for a version of the radar suited for being mounted outdoors, or a whole other solution to work in tandem with the indoor system. A risk with the system only working indoors is that the user might feel trapped indoors or unsafe going out. Making the system have coverage for being outdoors will also help promote the health of the users as fresh air and movement are important factors for a healthy living.

8.5.3 **The Extra Functions**

We left the extra functions to focus on the main functionality and the physical design of the system. This was done due to a constraint of time as well as a low interest from the focus group. The main functionality and physical design of the product was deemed to most important factors for the success of this project. There is however value to obtain for the user by developing and including additional features such as a built-in radio, calendar, or alarm clock. It could be an interesting piece of future development for the product, possibly giving the user a closer relation to the product.

8.5.4 **The App**

Given that our decisions to let the app handle the more advanced functions of the system and to make sure the base functions would feel as good as possible for the user, the app was not a focus of this project. It is however important for the future of the product since a lot of the functionality we have considered for future development depends on the app to be interacted with.

8.5.5 **Other Directions for Design**

During the start of the project, we investigated multiple directions for the design. After the first and second focus group we felt we had enough arguments to move on with the discreet direction. One of the directions which did well and could be interesting to investigate for another type of impression would be the nostalgic direction. The nostalgic model immediately made the participants of our focus group reminisce about the old radio it borrowed its shape from. Nostalgia is however a fine balance to design around, as you need to make sure to really get it right or it might not be received well. It’s also not universal what references trigger the feeling, and what wakes happy memories for one, might wake bad memories from another.

This volatility as well as the discreet direction was more popular made us drop this idea quite early, but it would be interesting to see where it might lead.

8.5.6 **Usability Testing of the Control Station**

During the focus groups we did some light testing of how the control station was experienced and read by the participants A more in-depth study of this and the other ways of interaction would however be a great thing to do in the future. This could lead to a new or improved control station and a better experience for the users of the product.

9 Conclusion

9.1 Fulfillment of the Design Brief

The concept will here be compared to the brief in appendix 11.1 written out and translated for reference:

The product should be able to detect fall accidents in the home of older persons. The product should be able to be used for nightly use. It should be permanently mounted and be connected to home care in a Swedish municipality. The product should also radiate safety and fit into the home environment of an older person living in Sweden.

The final concept fulfils these requirements. The concept is made to be mounted on the wall approximately one decimetre under the celling. It has a connection for an internet cable that can either be completely hidden or led upwards towards the roof. The square shape of the final concept was well liked by the focus groups and a big part of that was that it felt familiar. That coupled with the architectural elements of the design makes it fit in well into most homes.

You should investigate where in the room the product should be placed in order to work as good as possible. Besides being able to detect a person lying on the floor the systems inbuilt camera should be able to provide a detailed picture. You should also investigate where the product is best mounted in other rooms to detect every fall accident in the home.

This was done early on in development, and it was discovered that the product should be placed high on the wall for optimal coverage with the radar. That knowledge then guided later development. The room-study focused on bedroom but what was discovered could also be applied to other rooms in a home.

You should investigate how the in-built camera can made to be perceived as friendly and if it's possible to make the picture unfocused/distorted with a physical lever/lid.

The smart surface of the final concept hides the camera without obstructing it. The small collar around the lens also makes it blend into the surface. We decided not to hide the lens completely since that was not deemed to be desirable from the results of the focus groups. There are however digital solutions to make the picture unfocused or distorted to give greater privacy. A digital solution would be preferable since many users don't trust that the camera is working properly if the lens is in any way covered.

You should consider if the user should be able to control the product in any way. And if the user is doing gymnastics on a mat on the floor. Is it then necessary to be able to turn the system off? Is a portable alarm button necessary? If a portable alarm button or remote is necessary, it should

also be designed. during spring 2022. It should be possible to mount a camera and radar in these prototypes. The specifics will be discussed when the project nears completion, and we know what sensors to use.

The final concept includes a pause mode that can be activated if the user wants to get down on the floor. There is also the option for the user to stop an unwanted alarm by vocal command if the user forgets to pause the alarm function. The concept is designed to be as small as possible and be able to fit all the necessary components. During testing it might however be necessary to scale it up by a fraction depending on what radar is used. While focus was always on the radar unit a control station was also created. It was decided to keep the control station as simple as possible to be accessible to all. The concept is also designed to fit all necessary components listed in the brief except for a lid in front of the camera since that was not deemed to be desirable.

9.2 Research Contribution Fulfilment

This section aims to provide an answer to the questions asked in section 1.4, Research Contributions.

How can product design be used to create and communicate safety in a home environment?

To create something that gives the user a sense of safety it needs to be done on the user's conditions. User centred design provides tools to empathize the user and understand their conditions. Our potential users have told us how the looks of the product are unimportant, it just needs to work. This can influence the looks by making a stable impression and communicate its function clearly and confidently. To apply this on a home environment, it also needs to look familiar and like something that should be there, even though it is a new product.

What design features and guidelines are extra important to create a sense of safety and trust for the target audience?

We have found that for our type of product, a safety alarm aimed at helping you when you need it the most, a product which can often be stigmatizing as a thing you only need when you get old and frail, the design needs to strike a balance between stability and discreetness. The stability helps build trust in that the system works when it needs to. This also needs to be reflected in the interaction with the system, making sure it's easy to understand and control. The discreetness can help reduce the stigma of the product. The discreet concepts were by far the most popular and accepted concepts during the focus groups. The final product aims to present itself more as an architectural element along the lines of ventilation, fire alarms, or a junction box than a singular product. This helps it blend into any home, and makes it look like something you have seen before.

How can these parameters be validated?

There are plenty of methods to validate design. We decided to use focus groups throughout the project, and it worked great for us. Being able to talk to people in the situation we were designing for and taking part of their experiences and thoughts has been invaluable for this project. It gave us insights as well as feedback on how the radar was being perceived. Starting the focus groups early in the project and coming back multiple times was also a strength, giving both us and the participants continuity and a receipt of improvement all along the project.

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11 Appendix

11.1 Product needs from Technology company

Förslag på exjobbsdefinition - Industrial design of product for elderly care

Ni ska undersöka hur man bäst designar en produkt för att öka tryggheten hos äldre.

Produkten ska upptäcka fallolyckor i hemmet hos äldre personer. Produkten ska också kunna användas för så kallad ”Nattlig tillsyn”. Den skall vara fast monterad och vara uppkopplad till hemtjänsten i någon svensk kommun. Produkten ska utstråla trygghet och förtroende och passa in hemma hos äldre personer i Sverige. (Produkten kopplas in till en router. Designen av denna router ingår inte i exjobbet.)

Ni ska undersöka var, i rummet, produkten bäst monteras så att dess sensorer fungerar så bra som möjligt. Förutom att kunna upptäcka en person som ligger på golvet så ska dess kamera kunna ge en detaljrik bild av en person som ligger i sängen. Ni ska också undersöka var produkten bäst monteras i andra rum i en lägenhet så att alla fallolyckor i ett hem kan registreras.

Ni ska undersöka hur den inbyggda kameran kan fås att uppfattas som vänlig och hur det går att göra kameran ofokuserad/distorderad med hjälp av en fysisk spak/lucka.

Ni ska fundera på om användaren ska kunna kontrollera produkten på något sätt. Om användaren gör morgongymnastik på en matta på golvet, behöver då larmfunktionen behöva stängas av? Behövs det en bärbar larmknapp? Om ni kommer fram till att det behövs någon sorts larmknapp/armband/fjärrkontroll så ska denna också designas.

Designen ska kunna modifieras så att det går att tillverka ett antal prototyper som kan testas hos äldre personer under våren 2022. I dessa prototyper ska det gå att

montera en befintlig kamera och en radar. Exakt hur detta ska göra får vi diskutera när er design börjar bli klar och vi vet exakt vilka sensorer som vi ska använda.

Produkten ska:

- vara snygg och diskret
- utstråla trygghet och förtroende
- vara lätt att montera på olika typer av tak och väggar
- passa in i olika hem och äldreboenden
- vara möjlig att damma och torka av
- vara möjlig att producera ha rimligt låg produktionskostnad
    - räkna med att det tillverkas 25.000st/år

- ha plats för ett kretskort om 50cm2
- ha bra hantering av en nätverkssladd
- ha plats för en radar
- ha plats för en högtalare
- ha plats för en mikrofon
- ha plats för en vidvinkelkamera
- ha belysning till kameran (vitt ljus eller IR-ljus)
- ha en lucka, eller liknande, framför kameraobjektivet.
    - Luckan ska ha tre lägen. Öppen, ”suddig” och stängd.

- eventuellt ha en larmknapp/armband/fjärrkontroll som tillbehör

11.2 Questions used in focus group 1 and interview 1

För att detta ska funka så bra som möjligt vill jag att vi försöker tänka på några grejer i diskussionen.

Det finns inget som är rätt eller fel här utan bara olika sätt att se på saker. Jag vill uppmuntra er att dela med er av ert sätt att se på det även om ni inte håller med om vad som sagts innan. Vi är här både för positiva och kritiska åsikter och tankar och det är ofta det kritiska som är mest hjälpsamt.

Vi försöker prata en i taget, det underlättar för den som antecknar. Alla anteckningar är helt anonyma och resultatet kommer vara likaså.

Börja med presentation av sig själva.

Diskussion om Storyboards

Vad tycker ni om scenarierna? Hur realistiska tycker ni de känns? Varför/Varför inte?

Vad har vi missat för scenarion vi borde tänka på framöver?

Vad tycker ni om de föreslagna extrafunktionerna? (Nattlampa, väckarklocka, Larmpaus,

Godnattsignal, högtalare (radio och musik)) Hur hade ni velat styra dem?

Vilken teknik använder ni hemma idag?

Diskussion om Modeller

Vilken form kommunicerar trygghet mest för er? Vilken hade ni helst haft hemma hos er? Varför?

Vilken gillar ni minst? Varför?

Hur känner ni kring att ha en kamera i hemmet? Hade det varit viktigt att kunna täcka över den?

Har ni trygghetslarm idag? Hur tycker ni det funkar? Vad funkar bra/dåligt?

Hade ni velat kunna påverka utseendet? Är det viktigt att den passar i

11.3 New Pause modes

11.3.1 **Concept 1**

Standard mode:

- Camera on, records the latest 20 sec, can be saved in case of a fall
- Radar on with full function and logging of heath data for the app.

Pause mode:

- Camera off, turned on at alarm mode
- Radar off
- Timer

11.3.2 **Concept 2**

Standard mode:

- Camera off, turn on at alarm mode
- Radar on with full function and logging of heath data for the app. Warning when on high chairs

Pause mode:

- Camera off, turned on at alarm mode
- Alarm at low movement
- Timer

11.3.3 **Concept 3**

- Camera on, records the latest 20 sec, can be saved in case of a fall
- Radar on with full function and logging of heath data for the app. Warning when on high chairs

Pause mode:

- Camera off, turned on at alarm mode
- Alarm at low movement
- Timer

11.3.4 **Concept 4**

- Camera on, records the latest 20 sec, can be saved in case of a fall
- Radar on with full function and logging of heath data for the app.

Pause mode:

- Camera off, turned on at alarm mode
- Alarm at low movement
- Timer

Integrity mode:

- Camera off, turned on at alarm mode
- Radar on with full function but no logging of heath data for the app.
- Timer

11.3.5 **Concept 5 as envisioned before focus group 1**

- Camera off, turn on at alarm mode
- Radar on with full function and logging of heath data for the app. Warning when on high chairs

Pause mode:

- Camera off, turned on at alarm mode
- Radar off
- Timer