Master's Thesis

Product design and development of a movable and removable plate

Department of Design Science

Faculty of Engineering LTH • Lund University • 2014

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LUND UNIVERSITY

ARJOHUNTLEIGH
GETINGE GROUP

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Preface

This is a Master's Thesis in Mechanical Engineering and Mechanical Engineering with Industrial Design, carried out in collaboration with ArjoHuntleigh in Malmö.

We would like to thank ArjoHuntleigh for giving us the opportunity to perform our project at the company, which has given us valuable experience for the future and also for making the project interesting. A special thanks to the R&D department for relevant input to the project.

We especially want to thank our mentor Mimmi Anderberg for the continuous support during the whole project, without her the project would not have happened. Many thanks to our supervisor Håkan Neveryd at Lund University for all the support. A special thanks to our examiner Håkan Eftring for all the help in the early phase of the project.

At last we would like to thank the employees at Mårtenslund retirement home, for the opportunity to observe your daily work.

Lund, June 2014

Charlotte Gunsjö and Niklas Johansson

Abstract

This project was performed in collaboration with ArjoHuntleigh's Innovation Centre in Malmö, Sweden, from January 2014 to June 2014. The objective of the thesis was to design and develop a movable or removable plate/shelf.

The Project has been carried out by using the methodology described in the book "Product development and Design" by Ulrich and Eppinger. The methodology has been modified to fit the project and the time frame. The boundaries and objectives have been set together with ArjoHuntleigh. Throughout the whole project Donald A. Norman's book "The design of everyday things" was used as a source of inspiration.

Research about similar products, products with useful functions and inspirational search and visits was carried out and was very helpful during the project. The result from the research showed that there are many different ways of developing good solutions. With all the information gathered, brainstorming was used to produce concepts. The concepts were evaluated and ranked based both on ArjoHuntleigh's needs and the authors' opinions. A final concept was chosen and further developed. During the further development tests were executed and results adapted to the solution.

During the course of the project the objectives had to be narrowed to ease the development process. Therefore a new assignment directive was produced together with ArjoHuntleigh.

The final solution consists of a footplate, for ArjoHuntleigh's standing and raising aids, that is both movable and removable. A work flow of the footplate's movements was developed. Because of the uniqueness of the solution a patent application was developed in the later stages of the project.

The final solution shows that it is possible to develop a solution that fulfils both possibilities of the objectives; movable and removable. The solution also fulfils all the important demands set from the beginning of the project.

Keywords:

Product development, Design, Footplate, Movable, Removable

Sammanfattning

Det här examensarbetet har utförts av Charlotte Gunsjö och Niklas Johansson under vårterminen 2014 tillsammans med företaget ArjoHuntleigh i Malmö. Charlotte har utfört sitt examensarbete i Maskinteknik med teknisk design och Niklas har utfört sitt i Maskinteknik med inriktning produktutveckling.

ArjoHuntleigh är ett företag som levererar lösningar för vård av personer med nedsatt mobilitet. Lösningar som företaget erbjuder är bland annat transport och hygienlösningar för vårdtagare. ArjoHuntleigh jobbar även aktivt med att förbättra arbetssituationen för vårdgivare genom att göra sina produkter så ergonomiska som möjligt. Företaget ligger i Malmö och där har detta examensarbete utförts.

Uppdraget från ArjoHuntleigh innefattade att ta fram och designa en flyttbar eller borttagbar platta/hylla. Företaget gav projektet en ganska öppen projektplan så att projektet kunde gå i den riktning studenterna ville. Under projektets gång valdes det att fokusera på att göra en flyttbar fotplatta till företagets stå- och lyfthjälpmedel. När detta var bestämt uppdaterades projektplanen något så att kraven för projektet stämde överens med kraven ArjoHuntleigh har på sina stå- och lyfthjälpmedel.

Under början av arbetet valdes det att inte hämta någon information från några medicintekniska produkter över huvud taget utan att endast fokusera på en lösning som var flyttbar. Inspirationsrundor och benchmarking utfördes och därefter en första brainstorming. Efter den första brainstormingfasen var klar och koncept hade tagits fram togs ett beslut att börja studera dagens befintliga lösningar. Både de lösningar ArjoHuntleigh har samt konkurrerande företags produkter benchmarkades. När detta var färdigställt utfördes en andra brainstorming och antalet koncept blev fler och mer utvecklade.

Vid konceptvalet användes metoden från Ulrich och Eppingers bok “Product development and design” med först Concept Screening och sedan Concept Scoring. Efter den första utvärderingen fanns det nio koncept kvar, dessa slogs ihop och utvecklades ytterligare till den andra utvärderingen. Efter denna utvärdering valdes det vilket koncept som skulle gå vidare i utvecklingsarbetet.

För den valda lösningen utvecklades en tänkt arbetsgång för vårdgivaren. Då fotplattan sitter lågt ner på produkten, nära golvet, innefattar det en hög ergonomisk risk för vårdgivaren vid förflyttning. Det lades därför mycket tid på att få fram en rörelse så naturlig som möjligt, samt att användaren inte skulle behöva göra fotplattans förflyttning i flera steg. I uppdragsbeskrivningen står det att lösningen ska vara flyttbar eller borttagbar. Under arbetets gång framgick det att en bra lösning hade

varit en fotplatta som både var flyttbar och borttagbar. En sådan lösning hade underlättat den hygieniska aspekten avsevärt och därför lades det till i arbetsflödet.

Under hela arbetets gång har CAD-program varit en stor hjälp. Dels för att kunna se de olika koncepten på en produkt men även för ritningar och prototypframställning. För att utvärdera hur naturlig rörelsen känns samt lösningens intiuivitet byggdes en enkel mockup i ArjoHuntleighs verkstad. Mockupen, bestående av enkla skenor och trä, testades sedan både på ArjoHuntleighs personal men även på studenter vid LTH. Resultatet av testet användes sedan för vidare utveckling av konceptet. En andra trämodell gjordes även fast med skenor tillverkade i IKDCs verkstad. Denna modell uppenbarade brister och gav bra input till hur slutlösningen skulle se ut.

Fotplattans utseende och funktioner arbetades fram under hela projektet, hela tiden med Donald A Normans råd i bakhuvudet om affordence, mapping, återkopplingar och begränsningar. Särskilt vid framtagningen av handtag, knapp och låsfunktion användes Normans råd.

För att skydda den slutgiltiga lösningen valdes det att skicka in en patentansökan. Denna del av projektet var den mest lärorika men även den mest intensiva. Patentansökan skickades in till ArjoHuntleighs patentingenjör som sedan tog beslutet hur vida lösningen skulle skickas till patentverk runt om i världen eller inte.

Den slutliga lösningen består av skenor som ska fästas på produkten samt en fotplatta med handtag och lås. Lösningen är innovativ och uppfyller de krav som sattes i början av projektet. Konceptet har tagits fram till ett av ArjoHuntleighs stå- och lyfthjälpmedel, Sara Plus, men ska även kunna appliceras på kommande produkter.

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1 Introduction

The initial chapter of this thesis presents a background and objective of the project. It also describes the assignment directives and a short introduction to ArjoHuntleigh, the company which this project is carried out in collaboration with.

1.1 Background

ArjoHuntleigh is a medical technology company which produces high quality products to health facilities all over the world. The products vary from patient lifts and baths to medical beds. Many of the products on the market have some kind of plate or shelf which is used for placing objects, resting limbs or to sit or stand on. The plates often interfere with movements of the caregiver and patients or other product functions.

One of ArjoHuntleigh's focus points are "dedication to increase the quality and efficiency of care" which makes the company strive toward an efficient and more ergonomic way of care [1]. This is the main reason for this Master's thesis because it, like ArjoHuntleigh, seeks a more efficient and ergonomic way of care.

1.2. Objective

The Master's thesis' objective is to design and test a movable plate/shelf, a certain distance from its original position. An alternative solution could be to remove the plate, but then find a solution for detaching/attaching and storing the plate. The plate is not limited to be used on a specific product, so the focus is on all ArjoHuntleigh products. The demands in the assignment directive are sorted in relevance order, the ones at the top are more important than the ones in the bottom.

1.3. Assignment Directives

The task will be to find a solution to move a plate/shelf a certain distance from its original position. An alternative solution could be to remove the plate/shelf, but then to find a solution for detaching/attaching, plus storing the plate/shelf.

Demands:

- Ergonomic for user
- Hygiene
    - Minimise dirt traps
    - Advantageous material selection

    - Efficient to clean
- Time efficient for users
- Correct mechanical and material properties
    - Limiting dimensions and shapes
    - Low production volume
    - Weight
    - Possible solutions
        - 1. Pure mechanical
        - 2. Electro-mechanical solution
    - Preferable is a repositioned plate/shelf, but still attached. Last choice would be a de-attachable solution with a storage solution for the plate/shelf
    - Possible to manufacture
- Cost estimation (not limiting)
- Design/shape/expression in line with ArjoHuntleigh

Not included demands:

- Biocompatibility
    - Allergenic/toxic
    - Recyclable
    - Low environmental impact from manufacturing

Output:

- Described task
- Described work process
- Described analyses
- Test reports
- Evaluation reports
- Benefits
- Described and tested work flows
- One or several described solutions, possible with CAD, 3D simulations, photos, films and sketches
- One or several functional models
- One or several prototypes

Time Frame:

The thesis shall be delivered to the Company no later than 1st of September 2014

1.4. About ArjoHuntleigh

ArjoHuntleigh is a global company with over 5000 employees worldwide. The products produced by ArjoHuntleigh are medical equipment and integrated solutions for patient handling and hygiene, medical beds and therapeutical surfaces, wound healing, DVT prevention, disinfection and diagnostics [1]. The thesis was written in

collaboration with the R&D department at the Malmö office. ArjoHuntleigh is today a part of the Getinge Group and was established in 2007 through a merger between the Eslöv based company ARJO and Huntleigh Technology.

ArjoHuntleigh's mission:

"Dedicated to increasing the quality and efficiency of care"

ArjoHuntleigh's vision:

"World leader in integrated solutions for care of people with reduced mobility and related conditions" [1].

1.4.1. The Mobility Gallery

ArjoHuntleigh has a Mobility gallery where the differences of the various patients/residents are described. The gallery is based on the patients'/residents' functional ability of movement. The purpose of the gallery is to describe the difference of the patients/residents in an easy way, so that the product developers know who they are designing for and also for the caregivers to easily describe which type of patients they handle. It is important for the developers to consider both the patient/resident and the risks the caregiver are exposed to while handling the patient. There are five stages in the Mobility gallery, every stage is clearly different from each other and have their own characteristics [2]. The five stages goes from A to E and are called:

(A) Albert: Figure 1.1. Albert is the most mobile of the patients/residents and is able to perform daily activities without assistance. He may be using a walking stick but is besides that stable and can move on his own. He is independent and can dress and clean himself and therefore is not a risk for the caregiver. The staff still needs to be observant of him since he can become tired quickly. It is important to stimulate Alberts movements so that they do not get worse.

Figure 1.1 Albert

(B) Barbara: Figure 1.2. She is partly capable to perform daily activities independently. The assistance she needs is generally not physically demanding for the caregiver. Barbra can support herself to some degree with the help of for example a walking frame. In some situations she depends on the caregiver but she is not a risk for them. It is very important to stimulate the remaining functional movement she has.

Figure 1.2 Barbara

(C) Carl: Figure 1.3. Carl is dependent on the caregiver in the daily activities but he is able to perform a part in the actions. If the caregivers are not careful they have a risk of getting physically overloaded when working with Carl. Therefore it is very important that the equipment designed for this patient/resident prevent such movements. Carl often sits in a wheelchair and has some trunk stability left. He may be able to use one of his legs. The remaining mobility of Carl is very important to stimulate.

Figure 1.3 Carl

(D) Doris: Figure 1.4. Doris is a patient/resident who is completely dependent on the caregivers. She is sitting in a wheelchair and do not support herself at all. She cannot stand up, not even for a while and she is a high risk of dynamic or static overload for the caregivers. It is important to prevent problems associated with immobility when designing for Doris. It is recommended to stimulate the small amount of movement she has left to slow down the deterioration.

Figure 1.4 Doris

(E) Emma: Figure 1.5. With the last patient, Emma, it is no longer considered important to stimulate movement. She is a passive patient incapable of performing at all in the daily routines and therefore is a high risk for the caregivers considering dynamic and static overload. Emma might be completely bedridden and it is very important to take care of her hygiene and make sure she is comfortable.

Figure 1.5 Emma

1.4.2. The Positive Eight

At ArjoHuntleigh they have developed the positive eight, which is shown in Figure 1.6. The positive eight is a way of work that creates a better life for the patient/resident and a better workplace for the caregiver. As the name suggests, the method is an eight step method. The eight steps can be read at ArjoHuntleigh's homepage, [3], and they are:

1. Mobility
2. Improval of vital bodily functions
3. Reduce immobility acquired conditions
4. Greater ability and quality of life
5. Reduced need of assistance
6. Reduced strain related injuries. Better staff productivity
7. Improved retention through less sick leave and turnover
8. Improved quality of care and final outcome

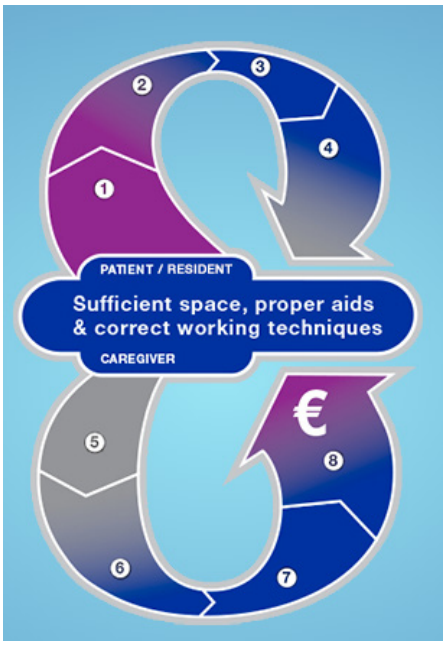

Figure 1.6 Positive eight

2 Method

In this chapter the methodology of the project is presented. First a summary of the development method of Ulrich and Eppinger and later on the advices of Donald A. Norman is described.

2.1 Ulrich and Eppinger

The method used for the product development part was based on the method from "Product design and development" by Ulrich and Eppinger [4, but with some modifications to fit the specific task. The method was chosen because it is well-known for mechanical engineer students at LTH and suitable for the thesis. The development plan is shown in Figure 2.1 below.

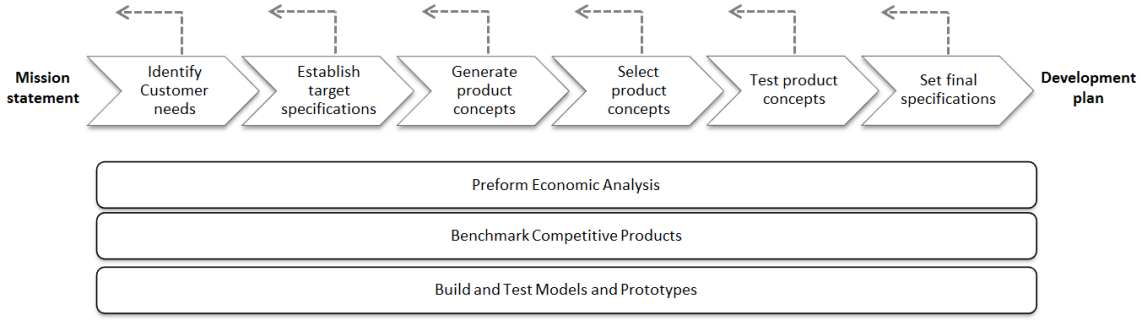

Figure 2.1 Development plan

Mission statement [4, pp. 67-68]

The Mission statement describes the statement of purpose of the project. For example it can be the project planning, a brief or key goals. It is the last phase of the pre project planning and the start of the development phase.

Identifying customer needs [4, pp. 73ff]

The identifications of the needs should be identified without the knowledge of how they are going to be solved. A five step method to gather the needs is:

1. Gather raw data from customers
2. Interpret the raw data in terms of customer needs
3. Organise the needs into hierarchy of primary, secondary and (if necessary) tertiary needs

4. Establish the relative importance of the needs
5. Reflect on the result and the process

Establish target specifications [4, pp. 92ff]

The preliminary specifications of the project. To get a well-developed specification these steps shall be executed:

1. Prepare the list of metrics
2. Collect competitive benchmarking information
3. Set ideal and marginally acceptable target values
4. Reflect on the result and the process

Generate product concepts [4, pp. 117ff]

The concept generation phase is an interactive process which includes:

1. Clarification of the problem
2. Internal search
3. External search
4. Explore systematically
5. Reflection.
6. The concept generation is mainly a brainstorming and benchmarking phase

Select product concepts [4, pp. 143ff]

To select which concept to further develop Ulrich and Eppinger recommend a selection phase. There are two steps in the selection methodology. They are both based on decision matrices which are used to rate, rank and select the best solution for the project. The first step is concept screening, a quick way to eliminate concepts which do not meet the requirements. The second step, the concept scoring, is a more careful analysis of the concepts to be able to choose the solution which is most likely to lead to a success. The steps of concept screening and concept scoring are:

1. Prepare a selection Matrix
2. Rate the concepts
3. Rank the concepts
4. Combine and improve the concepts
5. Select one or more concepts
6. Reflect

Test product concepts [4, pp. 165ff]

Concept testing is closely related to the previous stage, concept selection. However, to confirm the qualities of the chosen solutions some tests are preferred. The concept testing naturally comes after the concept selection, because it is easier and cheaper to do relevant testing with only a few products. The testing is also close to the prototyping, often because a prototype is needed to test the product. The final results can be an indication of how well the product is designed, or how many products the company will sell. A seven step method for testing products is:

1. Define the purpose of the concept test
2. Choose a survey population

3. Choose a survey format
4. Communicate the concept
5. Measure customer response
6. Interpret the results
7. Reflect on the results and the process

The two last phases described by Ulrich and Eppinger, Set final specifications and Development plan are not performed in this project.

Ulrich and Eppinger's method is used through the whole thesis but with a few changes. For example, the first step Mission statement has already been done by ArjoHuntleigh.

2.2 Donald A. Norman

Donald A. Norman is a well-known name in the product development world. His book "The design of everyday things" [5] revolutionised the design world in the 90's. The overall message of the book is that it is not the users fault if the product does not work, but the design of the product. Norman also puts a lot of weight on the power of observations. The designer will never know how to design if he/she has not seen similar things been used. People will do as they always have done. Therefore the design should play on already known patterns in people's lives. It is a communication between the designer and the user, standards can be used but mainly it is best to play on people's habits. Norman gives a checklist of things to consider when designing with people in mind:

Visibility, [5, pp. 99ff]

"A good designer makes sure that appropriate actions are perceptible and inappropriate ones invisible." The user must see the relevant parts to be able to understand the products functions. When the user find the relevant parts he or she knows what mode the parts are in and what to do to change the mode.

Affordances [5, pp. 9ff]

Basically Affordance means that the user will know that a button should be pushed and a lever should be pulled. Door handles for example, if the user should push the door open the handle is often shaped so the user have something to push on, and if the door shall be pulled open the handle is often shaped so the user have something to pull on.

Mapping [5, pp. 23ff]

Basically it means that the user will know what will happen when he or she for example pushes the button. Norman gives an example with a car. To turn the car to the right the user has to turn the steering wheel clockwise. This makes the car turn and the user gets feedback. Mapping is easily learned and remembered.

Constraints [5]

To be sure that the product will be used right, make it impossible to do something wrong. Design things so the user cannot do the action wrong or design so the action can be done in many ways without confusing the user. But be smart and make sure that it is easy to understand the way of work.

Feedback [5, pp. 27ff]

It is important to show the effect of an action, and give the user feedback. Without feedback the user does not know what or why something happened. Feedback is a critical part of the design work. Feedback means that the user gets information about why something happened. For example if there is a lock mechanism, a clicking sound tells the user that the mechanism is locked.

Conceptual model [5, pp. 12ff]

A good conceptual model is a combination of the expressions mentioned above. With a good conceptual model the users will be able to predict the effect of their actions and without the model they will operate blindly.

Donald A. Normans methodology has been used in this thesis as an overall knowledge. All the design choices and concept decisions have been taken with Normand's advises in mind. Since it is important that the product shall be intuitive, the four steps Norman recommends have been used frequently.

3 Information and Brainstorming

This chapter describes the first phase of the project which is information gathering and a first brainstorming session. The information gathering was carried out through inspirational visits, external search, benchmarking and visit to a retirement home.

3.1 Inspirational Visits

In the early stages of the thesis, inspirational visits to Malmö, Svågertorp was done. The reason for the visits was to get inspired by solutions from the non-medical business and thereby get a more open mind. At Svågertop, a number of companies were visited, for example Biltema, IKEA, Bauhaus and Media Markt. There were a total of three visits to Svågertorp and every time was more successful than the last one.

3.2 The Web

A huge source of inspiration can be found on the internet. In the beginning of the project YouTube was successfully used as a source of inspiration. For instance, a lot of inspiration was found in smart furniture which can be folded and transformed into various shapes [6]. Another great way to find inspiration was to use Google's image search. This led to a lot of new ways of thinking.

3.3 Technical Benchmark

Benchmarking is a study of existing products with similar functions to the product under development or the sub problems that emerges during the course of development. Benchmarking can indicate which solutions are the most common and if they are helpful to the project. Information can be revealed for which of the existing solutions can be implemented on the product being developed. Benchmarking can also be used to find products with similar solutions but in different markets.

This first benchmark focuses on technical solutions that are not in the medical care business. When looking at products from outside the medical care business, interesting solutions can be found that can be implemented or adapted to fit medical aids. If the products functions are not directly transferable to a medical aid, inspiration for other solutions can be gathered.

Toyota BT Levio P

The Toyota BT Levio P, shown in Figure 3.1, is equipped with a flip-down operator platform that allows the user to travel long distances without having to walk. Various types of driver platforms are available. For example, the platform can be flip-down if the truck is mostly pedestrian operated and stay-down if the user has no intention of walking while operating it [7].

Figure 3.1 Toyota Levio P

The flip-down platform looks like a fairly easy and good solution when a plate needs to be movable. In a single movement the platform goes from a usable position to an idle non-use position. The platform is made for a person standing on it which shows that it can handle a significant load. The negative part is that the platform takes up some usable space when folded up.

Sectional garage doors

Sectional doors are usually constructed of three to eight panels which can slide up and overhead. Because they slide up and not out, sectional doors do not require any space outside the garage when being opened, unlike regular garage doors. On a sectional garage door, see Figure 3.2, each panel has its own connection to the track which makes it reliable and robust compared to solutions where there are only one or a couple connections.

Figure 3.2 Garage door

Sectional garage doors are good when it is wanted to transfer a movement in one direction into a perpendicular direction. They can normally handle a quite heavy load in the movement directions but when the force is applied perpendicular to the movement directions the doors become much weaker.

Workshop cabinet drawer

The drawer in a workshop cabinet is made for sliding in and out. There are different solutions for these kinds of drawers; one of them is shown in Figure 3.3. Most common for heavy duty are telescopic rails, but rails with wheels are also used. The telescopic rails can have an extension length of 150% and extend in two directions while wheel rails often have a maximum extension length of 100% and can only extend in one direction. Drawers with wheel rails can normally be removed from its rail in an easy way.

Figure 3.3 Workshop drawer

Sack truck (foldable)

Regular sack trucks have been used for many years and nowadays they are foldable, see Figure 3.4, to be able to store them in confined places. The most advanced ones even have foldable wheels that, with only a pull to a lever, folds out at the same time as the loading platform.

Figure 3.4 Foldable sack truck

Wall mounted folding seat

The wall mounted foldable seats, shown in Figure 3.5, are today used in for example elevators, grocery stores and malls. The seat can bear heavy loads and does not take up lots of space. The negative thing is that the seat needs a wall to be attached to.

Figure 3.5 Wall mounted folding seat

Foldable arm support

The arm support, shown in Figure 3.6, is designed to carry the load of the users arm while sitting by the computer. The support can be folded under the desktop so that it is not in the way when not used. The product can take a small load, and the movement of the support is simple.

Figure 3.6 Foldable arm support

Children's seat in trolleys

The seat for children in shopping trolleys, see Figure 3.7, has a great way of solving the disappearance when in passive position and it can also be used as a tray, shown in Figure 3.8. The solution can take a high load.

Figure 3.7 Food trolley

Figure 3.8 The seat used as a tray

Night stand

A smart and practical shelf, see Figure 3.9, for the things you want close when in bed or in the sofa. The solution is capable of carrying a small amount of weight but it is practical and has good usability. The shelf can be folded away when not used and can be put on different furniture.

Figure 3.9 Night stand

3.3.1 Reflection

The benchmark showed that there are a lot of products with movable/removable shelves/plates with different movable solutions. The shelves/plates can for example be folded, slid and removed. The benchmark resulted in valuable information for the projects next phase, the brainstorming.

3.4 Brainstorming 1

The first brainstorming was carried out without having any knowledge of ArjoHuntleigh's products or which type of product the plate would be used on. The thought behind this way of addressing the problem was that a wider range of solutions can be found when the box you are constrained to is bigger and the limits fewer. The sessions were executed the same way, initially brainstorming was done individually and after approximately ten minutes the ideas were evaluated, improved and combined in group.

The focus for the first session was the "movable/removable" part of the problem. Therefore, weight, limiting dimensions etcetera were discarded for later on in the development process. The knowledge gathered from the benchmark and knowledge from before the project started were used to produce as many solutions as possible

The concept ideas generated during brainstorming are presented in Chapter 6.

During the brainstorm only positive feedback were given to keep the ideas flowing and not be limiting. A lot of different concept ideas were generated thanks to the mentioned approach. Some of the solutions turned out to be more or less relevant to the project, but it was believed that the irrelevant solutions would be sorted out during the concept selection. During the brainstorming the information from the technical

benchmarking was very helpful. Some of the concepts generated were very similar to the products which were benchmarked.

3.5 Mårtenslund

A visit to Mårtenslund retirement home in Lund was made. During the mornings first hours when the elderly are getting out of bed and doing their morning routines the most of the home's medical aids are used. The visit was therefore planned to be within those hours. At Mårtenslund the residents are in Barbra, Carl and Doris' condition, see Chapter 1.4. The home has a range of equipment, for example Liko's Sabina II, Ross ReTurn and Invacare beds, see chapter 5.1. Because of the varying conditions of the patients/residents, the different aids where only used on some of the patients.

The assistive devices at Mårtenslund were mainly used for bathroom visits or transfers to the shower or a wheelchair. The bathrooms were tight and became very crowded when the caregivers were helping the residents with toilet visits. Because of the size of the bathrooms and hallways it is important that the assistive devices and its functions do not take up too much space. When the caregivers were helping the more immobile and heavier residents they were working in pairs which made the facilities even more crowded.

The caregivers were very positive when talking about medical aids in general and they were extra positive about the sit-to-stand lift Sabina II. Nowadays, when the caregivers are used to using the lift, they would have a hard time managing without it. The one thing negative they had to say about Sabina II was that it was difficult getting over thresholds and they thought it had to do with the small wheels [8].

The residents of Mårtenslund were mostly positive when talking about the aids. The ones who were not positive were mainly complaining about the ergonomic difficulties, but they all said that the aids were better than nothing.

The visit to Mårtenlund was very instructive and interesting because it showed which tasks and challenges the caregivers at a retirement home deals with on a regularly basis. To see and try the actual work onsite gave a lot more than reading about it or watching it on different websites.

3.6 ArjoHuntleigh Benchmark

The goal of the benchmark was to get better knowledge of the ArjoHuntleigh products and which of them that could be relevant to the project. The large product range of ArjoHuntleigh includes therapeutic support systems, vascular therapy and diagnostics aids. This benchmark focuses on the aids that have or could have a plate/shelf of some sort.

3.6.1 Patient Transfer Solutions

Ceiling lifts

ArjoHuntleigh's ceiling lifts are called Maxi Sky and comes in four different versions, one of them shown in Figure 3.10. They can all be handled by a single

caregiver and there are both portable and fixed lifts. The Maxi sky lift could use a plate for example to the remote control [9].

Figure 3.10 Maxi Sky

Standing and raising aids

There are five different standing and raising aids at ArjoHuntleigh. Four of them are in the Sara line, Sara Plus is shown in Figure 3.11, and one is called Walker, shown in Figure 3.12. The standing and raising aids enables patients/residents to be raised up from beds, chairs, toilets and for transportation to the mentioned. The aids in the Sara line are designed to help the patient/resident to stand up. A plate is used in these aids as a footplate but another scenario could be to use a plate/shelf to transport things along with the patient/resident [10].

Figure 3.11 Sara Plus

Figure 3.12 Walker

Passive floor lifts

The passive lifts at ArjoHuntleigh are called Tenor, Minstrel and the Maxi-series. Maxi Twin is shown in Figure 3.13. The lifts are all mobile and are used to transport the patient between furniture and for example a wheelchair. As the name implies the patients are passive when lifted. A plate/shelf can be used in these products for example a storage place for the remote control [11].

Figure 3.13 Maxi Twin

3.6.2 Medical Beds

Hospital beds

There are a large number of ArjoHuntleigh hospital beds, the Enterprise series, one shown in Figure 3.14, and the Bariatric series both have four different beds. The critical Care beds come in three different ways and there is also an air fluidized therapy bed. All the beds could have a plate/shelf at the side so the patient/resident can put things aside or a larger plate/shelf to put food on [12].

Figure 3.14 Enterprise 800

Bedside locker

ArjoHuntleigh has three different bedside lockers and they are all compatible with the Enterprise bed series. There is a bedside locker, an over bed table, shown in Figure 3.15 and a combination of the two. The solutions already have a plate/shelf in them but they are not movable. The whole product is movable but it would be a great feature if the plates/shelves themselves could be movable [13].

Figure 3.15 Overbed table

Patient trolleys/ Stretchers

The trolleys in ArjoHuntleigh's product range are called Lifeguard, one of them is shown in Figure 3.16 and comes in three different versions. They all have a shelf as an optional feature which is removable but not movable. A movable shelf for the Lifeguard could be a good feature so the plate is not lost while removed [14].

Figure 3.16 Lifeguard

Community beds

Minuet 2, shown in Figure 3.17, is ArjoHuntleigh's community bed. The bed has all the features a community bed should have except for a movable plate/shelf to place things on for the patient/resident. A movable plate as such for the Minuet 2 could be a good feature [15].

Figure 3.17 Minuet 2

Birthing beds

The birthing bed ArjoHuntleigh has is a single bed solution for labour, delivery and recovery, shown in Figure 3.18. The bed has removable accessories that could be movable instead [16].

Figure 3.18 Birthing Bed

Cots and Cribs

ArjoHuntleigh has five cots and cribs, to care for the new-borns, one is shown in Figure 3.19. In the line there are three solutions which have removable plates/shelves. These plates/shelves could be movable instead so the risk of losing them decreases [17].

Figure 3.19 Crib

3.6.3 Hygiene Systems

Showering

In ArjoHuntleigh's product range there are both shower chairs and trolleys. The chairs, Carendo shown in Figure 3.20, Carino and Carima could all have use for a movable plate/shelf. For example the caregivers could use a shelf to put things on while showering the patient/resident. The shower trolleys Carevo, Concerto (shown in Figure 3.21) and Basic could also use the same type of shelf [18].

Figure 3.20 Carendo

Figure 3.21 Concerto

Bathing

ArjoHuntleigh provides a wide range of bath solutions for independent and totally dependent users. One of them, the Rhapsody, is shown in Figure 3.22. They have four different central bathing areas and they all could use a shelf for the

patient/resident or the caregiver to put things on. ArjoHuntleigh also have four private bathing area solutions and they could also use a shelf [19].

Figure 3.22 Rhapsody

Burns treatment

Primo Ferro, shown in Figure 3.23, the burn treatment solution is a bathing system design for gentle handling of the patient/resident. The bathtub has a fixed shelf in one end but could use a movable one in the other end for example put hygiene products on [20].

Figure 3.23 Primo Ferro

3.6.4 Reflection

The benchmark resulted in a better knowledge of ArjoHunleigh's products. Movable or removable plates/shelves were mainly found in three product categories; lifts, shower-trolleys and beds. The problem is often where to move the plate so it does not interfere with the product's other functions. It is relatively easy to hide a plate under a bed or a bathtub when it is not in use but it is harder to move the plate to a good position on a lift.

4 Delimitations

This chapter describes a narrowing process of the project which gives it a more described target. The delimitations are done with information about ergonomics and a discussion which leads to new assignment directives.

4.1 Ergonomics

To work in a kneeling or crouching position can sometimes be necessary but it also increases the risk of overloading specific body parts. It is of most importance to limit the amount of time in those kinds of working positions. Technical solutions can sometimes take away the bad working positions or at least help with improving the conditions.

To work bent over, twisted or in an outstretched position can result in strain that is undesirable because the joints are working in their extremes. Working positions and movements where the hands are below the knees and far from the torso is not unusual. If these kinds of movements are very long lasting or repetitive it is necessary to change the working conditions.

If the working position is both bent over and twisted or both outstretched and twisted the risk of injury becomes even higher [21, pp. 22-25].

4.2 Discussion

The assignment directives presented in the thesis are very general and not focused on any product, or even any type of products. To be able to produce a more defined and useful solution, delimitations had to be made. Because plates/shelves for ArjoHuntleigh products are mainly found in lifts, shower-trolleys and beds, the focus needed to be on those products. As movements close to the floor are a risk for the user and the most difficult to develop the team chose to develop a plate/shelf for standing and raising aids, especially Sara Plus, see Figure 3.11 The plates/shelves normally used on standing and raising aids are footplates and they need to be able to carry a patient's weight. The Sara 3000, Figure 5.1, is designed to carry a patient who weighs up to 200 kg which is more than Sara Plus. To be able to accommodate for future products the 200 kg safe working load of Sara 3000 seemed reasonable for this project.

With the help from ArjoHuntleigh, new assignment directives were developed. The new assignment directives have a couple of additions. A load resistance of 400 kg was added as demand because two times the safe working load was a reasonable

number. The assignment directive about a low production volume does not consider the standing and raising aids, so it was also removed. The new assignment directives are shown in Appendix A.

4.3 Sara Plus

Sara Plus, Figure 3.11, is an ergonomic standing and raising aid that mobilises patients/residents during everyday activities such as transfers and toileting. When used for transfers, the patient/resident places their feet on the footplate and, with the help from a sling that goes around the back, lifts them up to a standing position. (see Figure 4.1 and 4.2)

Sara Plus can also be used for gait training where the caregiver removes the footplate and has to, for example, place it on the floor or on a table. When the footplate is removed the patient/resident is raised to a standing position on the floor and can use the product for balance, stepping and walking training. Sara Plus is made for users in Carl's condition. See Figure 4.3.

Figure 4.1 Sara Plus as transport

Figure 4.2 Sara Plus as a raising aid

Figure 4.3 Sara Plus as a gait training aid

5 Medical Benchmarking and Brainstorming

The chapter contains a benchmark of medical equipment, mostly standing and raising aids. A second brainstorm ends the chapter.

5.1 Benchmark Standing and Raising Aids

Standing and raising aids are well used at hospitals and in the elderly care. The main function is to enable the patients/residents to be transported between furniture. There are different aids for every mobility level. The aids can also be used to train the patients/residents ability to stand up [1].

5.1.1 ArjoHuntleigh

As described earlier in this thesis ArjoHuntleigh has a number of standing and raising aids [1]. They are all described below.

Sara Plus

Removing the footplate on Sara Plus is quite heavy but it helps that it is possible to remove it with one hand and use the other hand for leverage and stability from the body of Sara Plus. When placing the plate back in position it is more difficult and it could be troublesome for weaker caregivers.

Sara 3000

Sara 3000, Figure 5.1, is a standing and raising aid smaller than Sara Plus. The main function is transportation, especially between furniture and to and from the toilet, and it cannot be used for gait training. Sara 3000 activates the mobility of the patients/residents and is supposed to make it easier to uphold their strength. Sara 3000 is made for users in Barbara and Carl's condition [23].

Figure 5.1 Sara 3000

The footplate on Sara 3000 could be movable to be able to help patients/residents standing up on the floor. Except the mentioned, there are few advantages of having a movable footplate on Sara 3000.

Sara Lite

Sara Lite, Figure 5.2, is designed to fulfil the basic needs of a standing and raising aid. Like Sara 3000, Sara Lite is used for transportation of the patients/residents to and from the toilet and for example to a wheelchair but not as a standing exercise aid. Sara Lite is made for users in Carl's condition. There is a fixed footplate on Sara Lite [24].

Figure 5.2 Sara Lite

Because of Sara Lite's simplicity there are no real advantages of having a movable footplate.

Sara Stedy

Sara Stedy, Figure 5.3, is a mobile support aid for the more mobile patients/residents. The main function is to transport the patient/resident while at the same time train their ability to stand up. Sara Stedy is made for users in Albert, Barbara and Carl's condition [25].

Figure 5.3 Sara Stedy

Sara Stedy shows no advantages of having a movable footplate because it can only function as a transportation aid.

5.1.2 Hill-Rom (Liko)

Hill-rom is a strong competitor to ArjoHuntleigh when it comes to medical and care equipment with more than 6000 employees all over the world. In October 2008 Hill-rom acquired the Swedish company Liko which focuses on developing patient lift systems. Hill-rom's products vary from medical beds and patient lifts to stretchers and airway clearance systems [26].

RollOn

RollOn, Figure 5.4, is a raising aid for transfer to and from the toilet and between the bed and a chair. With RollOn, the patients/residents use their own strength, with the help of the caregiver to get into a standing position. The ArjoHuntleigh product similar to RollOn is Sara Lite. RollOn has a fixed footplate and as with Sara Lite there are no advantages to change it to a movable [27].

Figure 5.4 RollOn

Sabina II

Sabina II, Figure 5.5, is Liko's most advanced raising aid. The aid can be used as transfer between furniture and the bed and has a fixed footplate. Sabina II can in some extent be used as a conventional lift for lifting in a sitting position [28]. The ArjoHuntleigh product similar to Sabina II is Sara 3000.

Figure 5.5 Sabina II

5.1.3 Ato Form

Ato form is a Germany based company which specialises in rehabilitation and orthopaedic aids, especially in the field of children rehabilitation [29].

Vita Lift

One of Ato form's products, the Vita-Lift, Figure 5.6, has a foldable foot plate that can be folded towards the "body" of the lift to enable gait training for users. Vita-Lift is similar to ArjoHuntleigh's Sara Plus but with a slightly different way of raising the patient to a standing position.

Figure 5.6 Vita Lift

Because Vita-Lift is large and bulky the footrest “hides” easily when folded up. The footrest is quite small and has two supports on each side which makes it robust and stable [30].

MoweGo

MoweGo, Figure 5.7, is a gait training aid which has a footrest as an accessory. The aid comes in five different sizes and is a support for the patient while gait training. The ArjoHuntleigh product similar to MoweGo is Walker.

Figure 5.7 MoweGo

5.1.4 Etac

Etac is a Europe based company with around 800 employees and a turnover of over 100 million Euro. Etac develops a wide range of home health care products in the

categories hygiene, walkers, manual wheelchairs, patient lifts and small aids for daily living [32].

Molift Quick Raiser 1 and 2

The Molift Raiser, Figure 5.8, is a transport aid very similar to Sara Lite. Both the Quick raiser and Sara Lite are basic and low weight lifts. There is a fixed footplate on the Molift Raiser [33].

Figure 5.8 Molift Quick Raiser 1

Nova 500

Nova 500, Figure 5.9, is one of Etac's sit-to-stand lifts which is intended for users with limited strength or mobility but can stay in a supported standing position. The footrest on the Nova 500 is not movable but nevertheless is it removable. The footrest is placed close to the floor and when it is not in use the plate is supposed to be placed somewhere away from the lift [34].

Figure 5.9 Nova 500

The footrest is placed close to the floor but because the leg support is connected to it the motion when removing it should not be troublesome, especially if it is possible to grab the frame at the same time. Overall the Nova 500 looks very similar to ArjoHuntleigh's Sara 3000.

5.2 Benchmark Other Medical Aids

There are a large number of different producers of medical aids. Most of the sit to stand aids are similar to each other and to get more inspiration other medical aids were benchmarked.

5.2.1 Invacare

Invacare Corporation has its headquarters in Ohio, USA and has a branch in Sweden where they mainly develops and produces wheelchairs and walkers. Invacare is a global leader in manufacture and distribution of innovative home and long-term care medical products [35].

Rea Azalea, Figure 5.10, is a wheelchair for the moderately active patient/resident as well as for the more passive ones. The seating system allows the user to adjust the seat position to where the user has maximum comfort. Both the seat and the backrest can be tilted electronically or manually. The leg rests are extendible and rotatable to accommodate for users with different leg lengths and injuries where the leg needs to be elevated [36].

Figure 5.10 Rea Azalea

The leg rests on Azalea are made for carrying the weight of a leg and not the weight of an entire user. The rotate function for the leg rest is a good way to get it in and out of position.

5.2.2 Handicare

Handicare is one of Europe's leading medical aid companies with products distributed by partners and retailers in more than 40 countries all over the world. Handicare has a

wide assortment of quality products from wheelchairs, scooters and sitting systems to stair lifts, car adaptations systems and stand up lifts [37].

The ReTurn7500, Figure 5.11, enables easy transfers without any heavy lifting. It is mainly usable for patients/residents with some degree of strength and who can stand up with the help of the handlebars of the ReTurn. Thanks to its lightness and small size it can easily be used in cramped places like a bathroom or a small bedroom. The ReTurn is easy to assemble and disassemble for transport or storage [38].

Figure 5.11 ReTurn7500

ReTurn7500 was very popular with the staff at Mårtenslund. They felt that using the ReTurn is an easy and simple way of patient transfer. When the patient/resident still can stand up by themselves ReTurn stands out from the bigger and heavier patient transfer aids because of its lightness and simplicity [8].

5.2.3 Hill-Rom

One of the most interesting products except for the standing and raising aids is the birthing bed Affinity IV Figure 5.12. The birthing bed has two calf supports which swings into position and locks with a single lever. When the calf support is not needed it swings back under the bed [26].

Figure 5.12 Affinity IV

This solution seems very user friendly and can still carry a significant amount of weight. The calf support rotates instead of sliding or folding which gives it a smooth motion. When the calf support is under the bed it is not a disturbance for the caregiver or the patient.

5.3 Reflection of the Benchmark

Overall the different standing and raising aids are very similar to each other. Most of them have fixated footplates but some have removable and a few of them even have movable. On the existing lifts with movable footplates there is a risk of interference between the user and the lift because the footplate is not movable enough. The benchmark shows that there is a product space to be filled with a movable footplate so that the standing and raising aids could be used for gait training. The three benchmarked products which are not standing and raising aids show different types of movable solutions. These were good inspiration for the last brainstorming session.

5.4 General Work Flow

A work flow, in this context, describes the sequence of operations needed to be performed in order to carry out the task, in this case, remove or move the footplate. The work flow can be used to easier describe functions or produce evaluation criteria.

To better illustrate the goal of the plates function a general work flow were developed. Figure 5.13 shows Sara Plus with the footplate in the sit to stand mode. In Figure 5.14 Sara Plus is in the gait training mode. In gait training mode the footplate is moved or removed to a place where it does not interfere with the patient/resident's walk, the caregiver's ability to instruct and help or Sara Plus' functions.

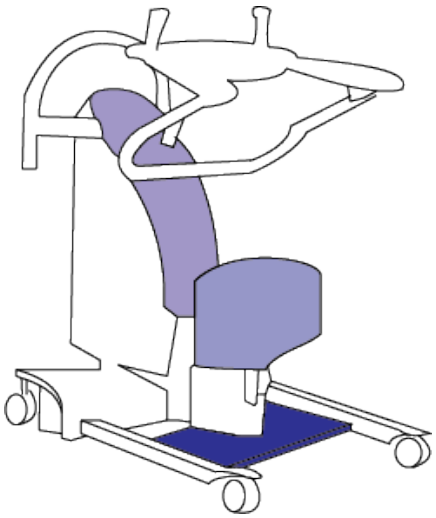

Figure 5.13 Sara Plus with footplate

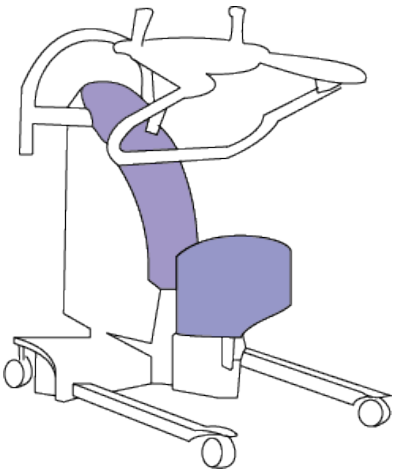

Figure 5.14 Sara Plus without footplate

5.5 Brainstorming 2

When it was decided that the plate/shelf should be a footplate to one of the Sara lifts a second brainstorming was carried out. With knowledge gathered from the different benchmarks a few more concepts were developed. The further development of the solutions from the first brainstorm was helpful during the second brainstorming phase. The second brainstorming session was carried out the same way as the first one. At first, the brainstorming was done individually and after approximately ten minutes discussed and improved in group.

The concept ideas generated during brainstorming are presented in chapter 6.

5.6 Reflection

The work with the concept generation was both exciting and challenging. It was mainly because the choice not to look at ArjoHuntleigh products before the first session of brainstorming. It was noticed that the second brainstorm were harder to perform than the first one. This was mainly because the first session did not have any constraints and therefore the creativity could not be blocked. The second session was focused on lifts and therefore it was harder to produce new ideas because of the limiting constraints. Because of the first brainstorming it was harder to think of new solutions because the most obvious solutions already had been discussed.

6 Concepts

Both of the brainstorming sessions' concepts are presented in this chapter. The concepts are presented with a small description and a figure.

6.1 Concepts from Brainstorm 1

Presented below are the concepts generated from the first brainstorming session.

1 Simple

A simple plate that fold up and down. This solution is set as reference in the concept screening.

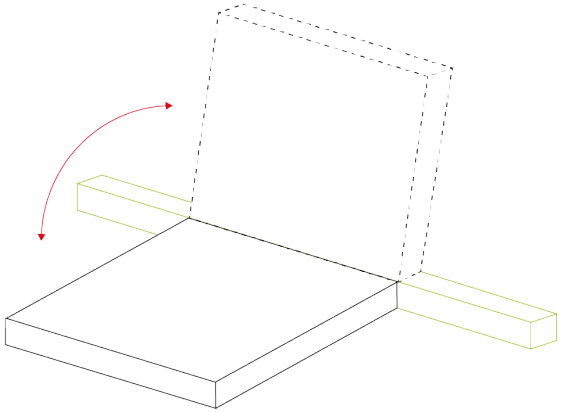

Figure 6.1 Simple

2. Double

Two separate plates that folds down towards each other.

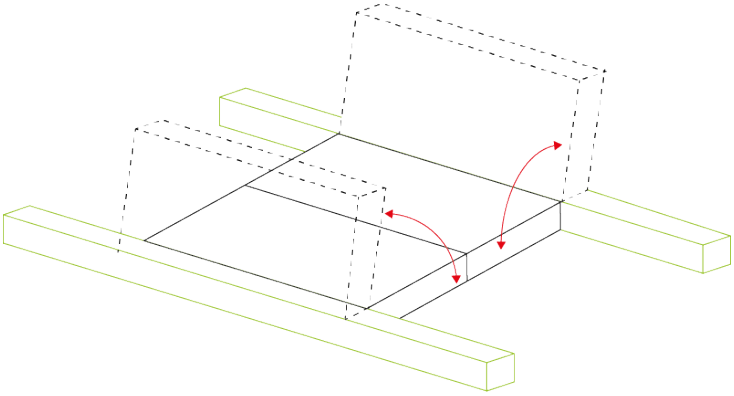

Figure 6.2 Double

3. Door

This solution is similar to “Simple” but has two supports that make the plate more resistant to weight.

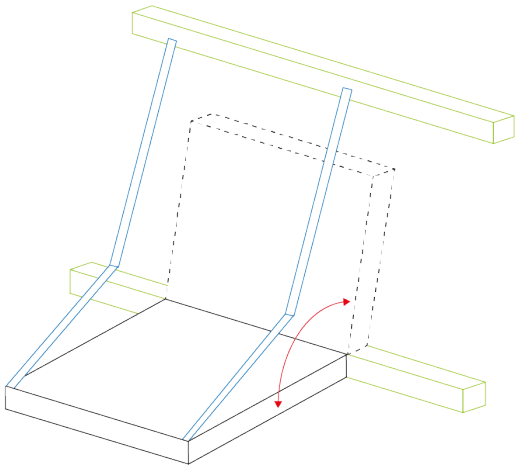

Figure 6.3 Door

4. Wire

The same solution as “Door” but the supports is now wires instead. With this solution it is important to be aware of the possibility of dirt traps.

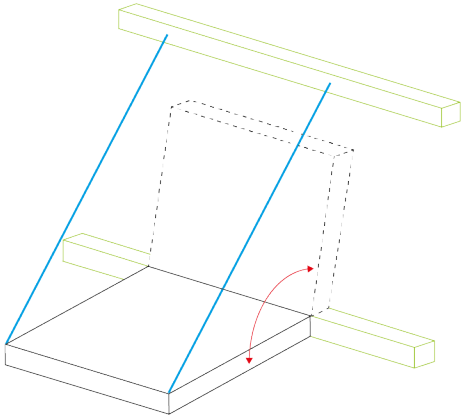

Figure 6.4 Wire

5. Click

Similar to “Double” but in this case it has wheels attached. The wheels are attaches with hinges and they strength the plate when it is lowered. It is important that the wheels do not make it harder for the user to get over thresholds.

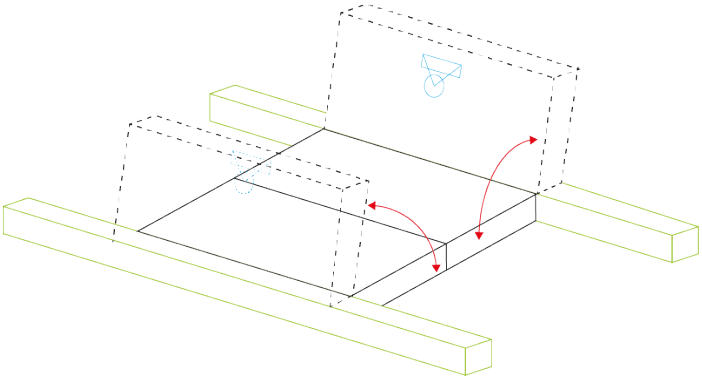

Figure 6.5 Click

6. Suspension

This solution is similar as Simple but in this case the plate has support from the sides as well.

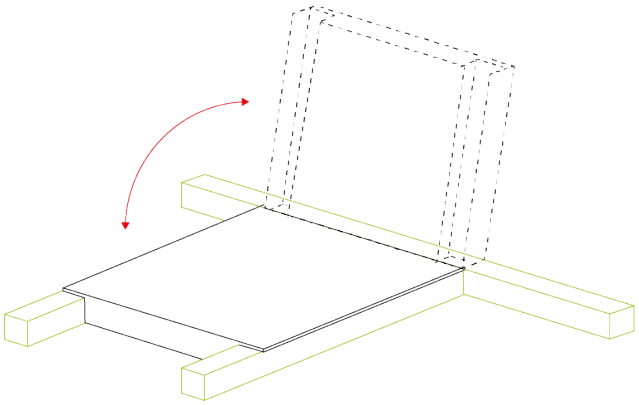

Figure 6.6 Suspension

7. Side

A similar solution to Simple but the plate is attached to the side, not the front.

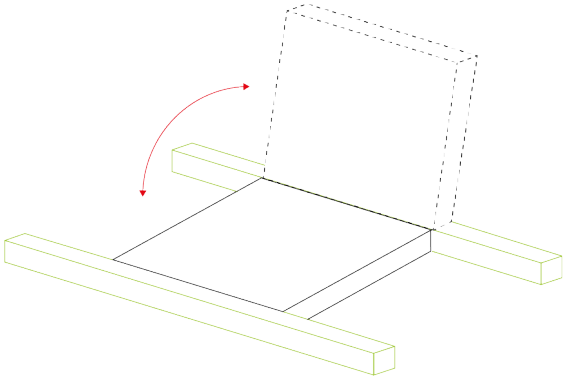

Figure 6.7 Side

8. Accordion

Works as a jalousie, are fasten in one end and then rolled up like a garage door.

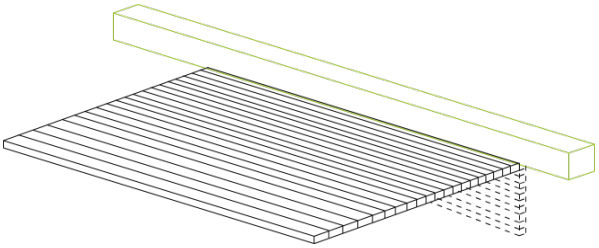

Figure 6.8 Accordion

9. Black Box

This solution was inspired by a foldable table which can be seen 25 seconds into a Smart Furniture video on Youtube. [6]. The idea is that when you unpack the box there is a plate and the supports for it.

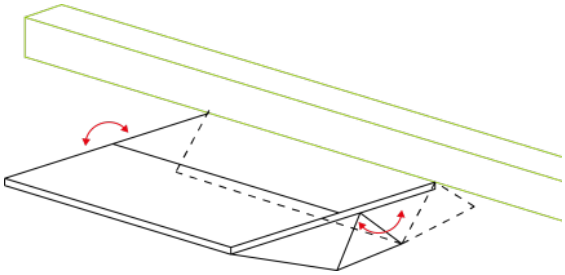

Figure 6.9 Black Box

10. Shoot

This is a relatively easy solution that works similar to an IKEA drawer. It slides back and forth in a one dimensional way.

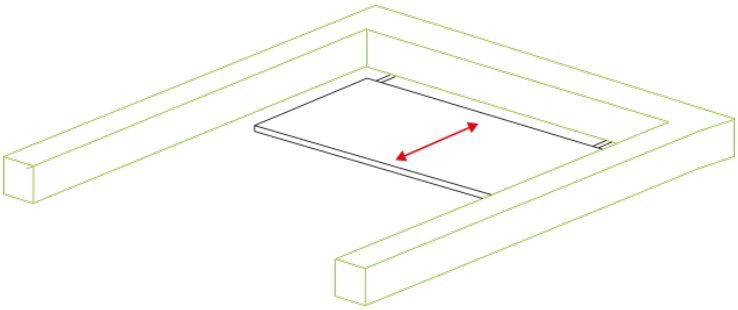

Figure 6.10 Shoot

11. Roll-Up

It will function like a jalousie and be fastened to a beam across from its starting point.

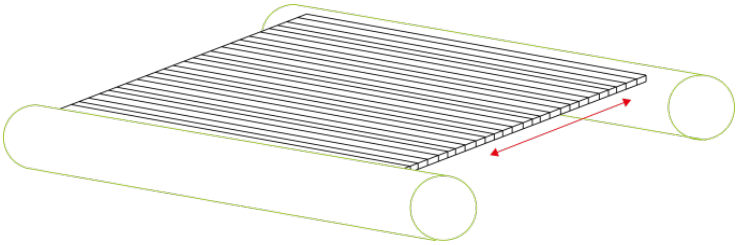

Figure 6.11 Roll-Up

12 Super Duper

A complicated solution which involves both rails and wheels. The way of work is to turn the plate, this makes the wheels move towards the middle, then the plate folds down and the wheels moves to the centre of the plate. As with “Click” it is important that the wheels do not make it harder to get over thresholds.

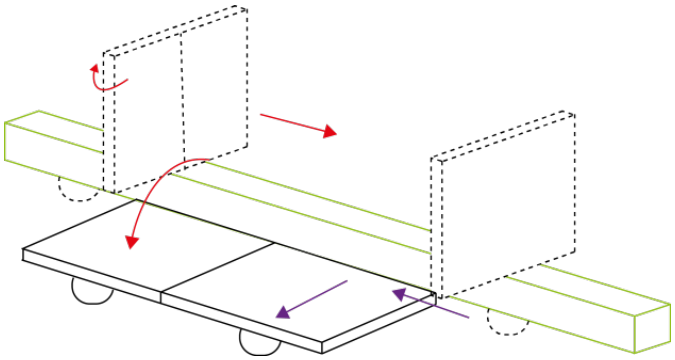

Figure 6.12 Super Duper

13. Re-Flex

Works similar to a “Reflector Wrist Band” but has to be much stronger. When not in use, Re-flex will roll/fold back into the product. This solution will handle the movable part of the task but will probably not be able to carry a lot of weight

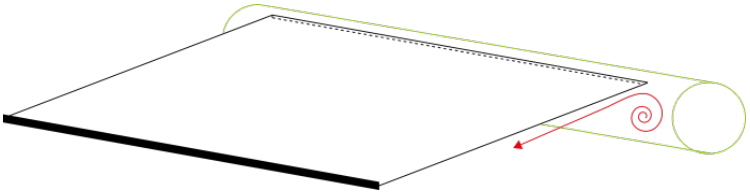

Figure 6.13 Re-Flex

14. Front to Back

The two plates rotate around their mounting places and then slides in or out.

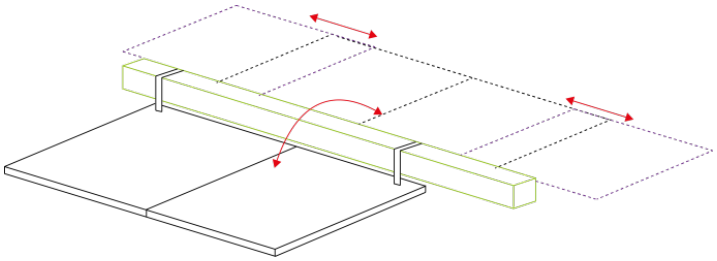

Figure 6.14 Front to Back

15. Re- Flex 2.0

Re-flex 2.0 has almost the same function as Re-flex but is strengthened by a scissors construction.

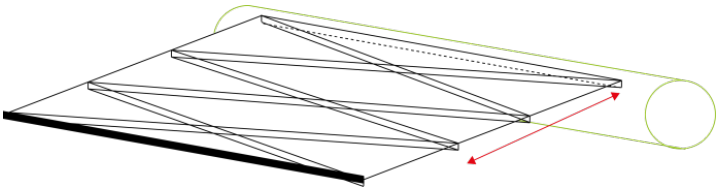

Figure 6.15 Re-Flex 2.0

16. Magnet

A removable plate, with a built in magnet, which can be placed on the outside of the product. Some part of the product will have a steel/iron part where the plate will be fastened magnetically.

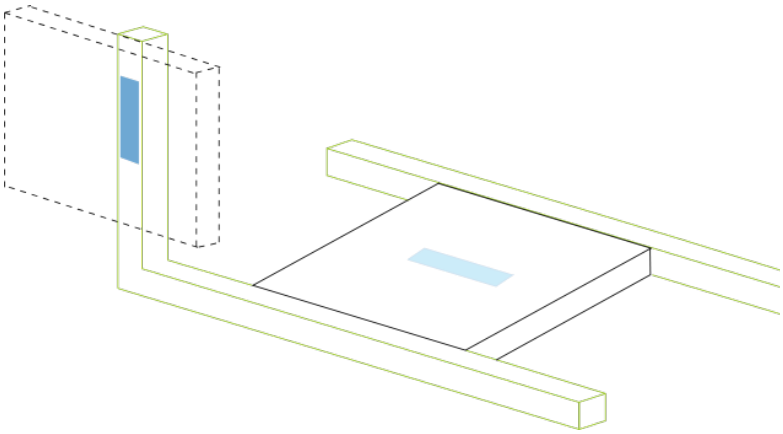

Figure 6.16 Magnet

17. Fan

The plate will fold out similar to a Japanese fan. Each section of the fan will be a separate piece.

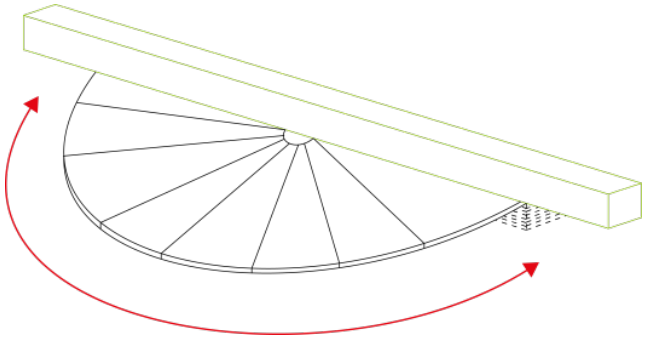

Figure 6.17 Fan

6.2 Concepts from Brainstorm 2

Presented below are the concepts generated from the second brainstorming session.

18. Two- Time

A combination of two movements. The first movement is a sliding motion and the second is a folding motion.

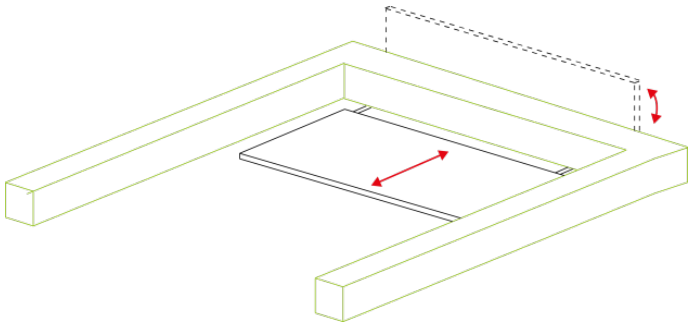

Figure 6.18 Two- Time

19. BAM

A two-part solution where the plates first angles upward, then rotates back and finally folds upwards.

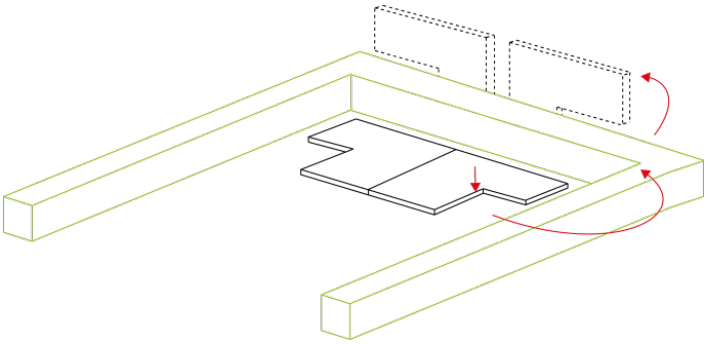

Figure 6.19 BAM

20. Down Under

A solution which includes a lot of steps. Two plates moves downward and then slides away from the centre. In the “out” position the plates either slides or rotates to a “hidden” place of the product.

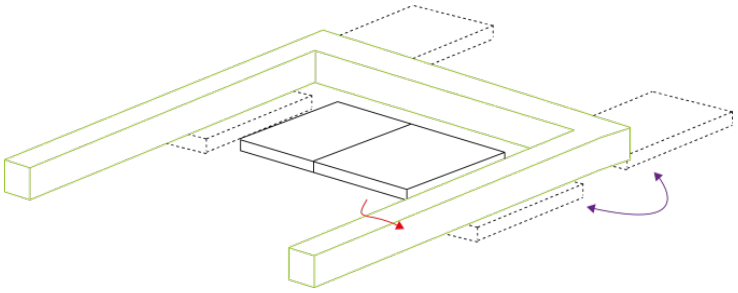

Figure 6.20 Down Under

21. The Arm

The mechanics of this idea is similar to a classical desk lamp but without the springs

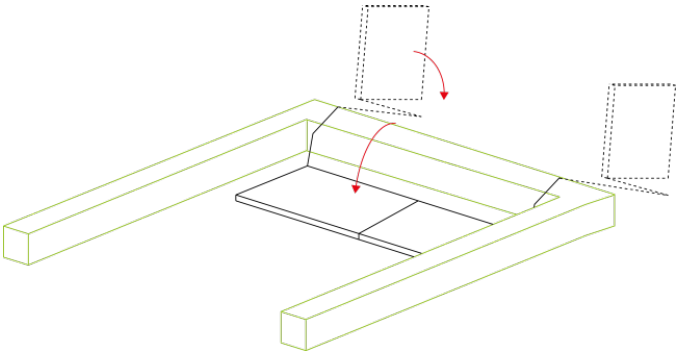

Figure 6.21 The Arm

22 Angle Turn

This is a further development of the Sara solution. Instead of turning the plate once, it is turned twice. First the arm is turned and then the plate.

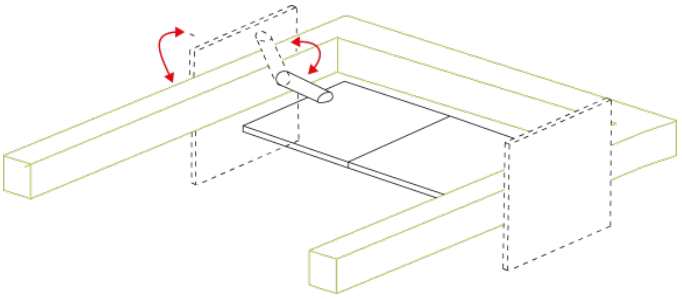

Figure 6.22 Angle Turn

23. Sara

The solution is inspired by ArjoHuntleigh's product Sara Stedy. The plates are turned down to active position and turned up when not used.

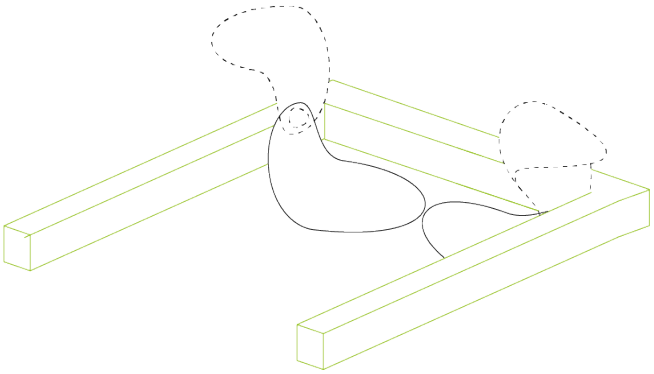

Figure 6.23 Sara

7 Concept Selection

The concepts are evaluated with Ulrich and Eppinger's concept screening and concept scoring. Between the two selection phases a further development phase is presented.

7.1 User Needs and Specifications

The user needs have mainly been gathered from the *Assignment directives* and discussions with design engineers at ArjoHuntleigh but also interviews with employees and residents at Mårtenslund and the authors own opinions and reflections. When the thesis was focused on standing and raising aids some needs and specifications were added.

Ergonomics, especially in medical care, has a lot of rules and standards that has to be followed. Though the rules and standards were not used as needs and specification, ergonomics were given extra attention throughout the project.

The specifications have been derived from the user needs and are shown in Table 7-1.

Table 7-1

User needs	*Specification*
Ergonomic for user (Caregiver)	Advantageous working position
	Low force required
	Number of movement steps
	Intuitive
	Enables one hand movement
	Low weight plate
Hygienically	Minimise the amount of dirt traps
	Advantageous material selection
	Easy to clean
Time efficient for user	Number of movement steps
	Intuitive
Correct mechanical properties	400kg Load resistance
	Minimise weight
	Possible to manufacture
Works with standing and raising aids	Does not interfere with stand up
	Does not interfere with walk
	Does not interfere with sight
Secure for the patient/resident	Stability
	Feels reliable
	Low risk of pinching
Secure for caregiver	Low risk of pinching

7.2 Concept Screening

Concept screening is a quick, approximate evaluation aimed at narrowing the number of concept and then improving them. At first, criteria are developed and one of the concepts is chosen as a reference. The remaining concepts are then compared to the reference for every criterion. The concepts with the highest score proceeds to the next phase of the concept selection.

For the concept screening five criteria were selected and set the constraints for the first selection. The criteria were chosen from the user needs. The demands were rewritten so that it was easy to grade the different concepts. The demands that were chosen as criteria were the ones that in the early stage of the design work could be graded. For example, in this stage it was not decided which material that would be used for the design, therefore the criterion involving material were not in the concept screening. The criteria were:

The solution is intuitive

Intuitive in the Oxford dictionary [40]: "using or based on what one feels to be true even without conscious reasoning; instinctive". In the context of this concept screening intuitive means that it should be easy to understand how the product is supposed to be used and it should be next to impossible to do it wrong.

The solution minimises dirt traps

Dirt traps is places where dirt can accumulate and is hard to remove. Dirt is prone to accumulate when there are a lot of moving parts and complex structures.

Interference

This criterion describes how little the plate interferes with the product's other functions or the caregiver and patients movements when not in usable position.

The solution is possible to develop

Due to the time frame of the project, a too advanced solution is not preferable.

Load resistance

The plate should be able to carry a 400kg load. If the design shows promise of carrying a heavy load without any changes to the design it generates a high score.

The solution minimises the risk of pinching

The risk of pinching is high when there are a lot of moving parts that especially fold towards or into each other.

Simple was set as the reference for the concept screening and the other concepts were given values seen in Table 7-2.

Table 7-2, grades

+	if they were better than Simple
0	if they were just as good as Simple
-	if they were worse than Simple

The result of the concept screening is shown in Table 7-3.

Table 7-3 Concept Screening

Concepts	Selection criteria	The solution is intuitive	The solution minimise dirt traps	Interference	The solution is possible to develop	Load resistance	The solution minimise the risk of pinching	Sum +	Sum 0	Sum -	Net score	Rank	Continue?
1	Simple (R)	0	0	0	0	0	0	0	6	0	0	3	YES
2	Double	0	0	+	0	0	-	1	4	1	0	3	YES
3	Door	0	-	0	0	+	-	1	3	2	-1	4	NO
4	Wire	0	-	0	0	+	0	1	4	1	0	3	YES
5	Click	0	0	0	0	+	-	1	4	1	0	3	YES
6	Suspension	0	-	0	-	+	-	1	2	3	-2	5	NO
7	Side	0	0	0	0	0	0	0	6	0	0	3	YES
8	Accordion	0	0	+	-	-	-	1	2	3	-2	5	NO
9	Black Box	-	-	+	-	0	-	1	1	4	-3	6	NO
10	Shoot	0	0	0	0	+	0	1	5	0	1	2	YES
11	Roll-up	0	-	+	-	-	+	2	1	3	-1	4	NO
12	Super-Duper	-	-	+	-	+	-	2	0	4	-2	5	NO
13	Re-flex	0	-	+	-	-	+	2	1	3	-1	4	NO
14	Front-to-Back	-	-	+	-	0	-	1	1	4	-3	6	NO
15	Re-flex 2.0	0	-	+	-	-	0	1	2	4	-2	5	NO
16	Magnet	0	+	+	0	0	0	2	4	0	2	1	YES
17	Fan	0	0	+	0	-	-	1	3	2	-1	4	NO
18	Two-Time	0	-	0	0	0	0	0	5	1	-1	4	Wildcard
19	BAM	-	-	+	-	-	-	1	0	5	-4	7	NO
20	Down Under	-	-	+	-	0	-	1	1	4	-3	6	NO
21	The Arm	-	-	+	-	-	-	1	0	5	-4	7	NO
22	Angle Turn	0	0	+	0	0	-	1	4	1	0	3	YES
23	Sara	0	+	-	0	0	-	1	3	2	-1	4	NO

After the concept screening there were nine concepts remaining. Eight of the concepts got through to the next round because they got rated zero or higher and one of the concepts were chosen as wildcard. The wildcard, Two-Time, showed good qualities and was the authors' favourite concept. Therefore it got through to the next round even though it got net score below zero.

The concept called Re-flex is a favourite, but today there is no material or technology that can function like Re-flex while still being able to carry a heavy load. If such a

material or technology is developed in the future Re-Flex would be a great way to solve this task.

7.3 Further Development

The remaining nine concepts were sorted into groups depending on the similarities of the solutions. The sorting of concepts resulted in six concepts/groups instead of the original nine. Wire is the same type of solution as Simple and therefore they were grouped and named Simple. The same thing happened with Double and Click which were grouped into Double, and Shoot and Two-time became Shoot. Angle-turn is similar to Double but since Angle-turn is a lot more complex it was decided not to group them.

In a concept scoring phase the concept ideas needs to be more defined and specified than in the concept screening phase. To get more defined and specified concepts they were broken down into three sub problems:

1. **How to fasten the plate to the product?**

   Will the plate be mounted directly to the frame or is some kind of extra component needed.

2. **How to make the plate disappear?**

   If there are any changes for the plate or product, that needs to be made for the solution to work.

3. **How to strengthen the plate?**

   Additional components or modifications making the plate more stable and strengthens it.

With the sub problems as the main focus, solutions to the problems were generated through brainstorming and discussions while observing ArjoHuntleigh's standing and raising aids. The different ways of concept generation produced good solutions for every problem. Some of the concept ideas already had specified movements and limited mounting positions which led to sparse amounts of new ideas. The different concepts solutions of the sub problems are described together with a CAD model of the solution.

Simple, Figure 7.1

1. Simple needs to be fasten with some kind of shafts which it can rotate around
2. Because Simple only folds in one direction an eventual leg or knee support will be in the way of the folding motion. If Simple only folds up to the leg support, it will be in the way of the patient/resident. To ensure that simple is not interfering with the patient/resident the leg support needs to be removable or in some way retractable.
3. Simple is only fastened with some kind of shaft which does not make it that strong. To make it stronger supporting brackets are placed on the lift which can hold some of the load.

Figure 7.1 Simple

Double, Figure 7.2

1. There are no natural fastening points on the standing and raising aids which leads to using brackets that is fastened to the side of the product.
2. On Sara plus, the leg support is placed high enough for Double to go underneath it when moving Double. On other lifts the leg support is too close which forces Double to incorporate some kind of slots to avoid it colliding with the leg support.
3. To make Double stronger a support was added to the product, where the back of the plates will attach.

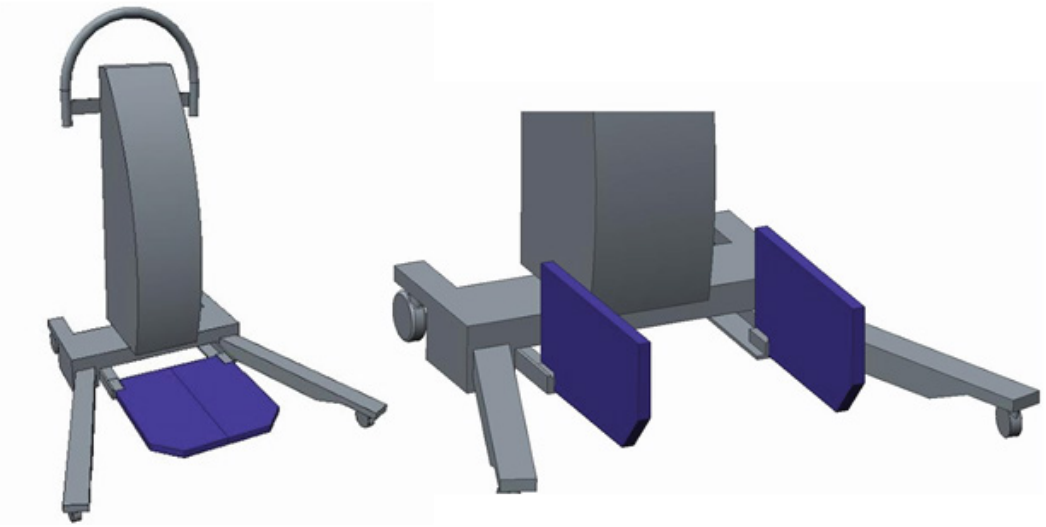

Figure 7.2 Double

Side, Figure 7.3

1. Side will use the same kind of solution as Double.
2. Side has the same problem as double but more difficult. The leg support needs to be removed when the plate is folded/rotated.
3. Side will use the same solution as Double

Figure 7.3 Side

Magnet, Figure 7.4

1. Magnet shall be fastened will rails. It can either be an rail with or without wheels.
2. When the footrest is not being used it will be attached to the product with help of a hook of some sort.
3. The rails will carry the entire load by themselves.

Figure 7.4 Magnet

Shoot, Figure 7.5

1. Shoot shall be fastened with rails. The rails will include wheels or spheres of some sort to make them slide back and forth.
2. It was decided that the concept should work like Two-Time, first pulled back and then rotated upwards.
3. The rails will carry the entire load by themselves.

Figure 7.5 Shoot

Angle Turn

When Angle Turn was constructed in CAD a lot of problems occurred. The advanced construction involving movement and rotations did not work as hoped. It was decided not to proceed with the concept since it did not work as well as hoped.

7.4 Concept Scoring

The concepts, now more developed, were used in the last step in the concept selection phase, the concept scoring. In this phase the criteria are weighted against each other so that the most important one gives a higher score. The concepts score are determined by the weighted sum of the score.

The criteria in the concept scoring matrix were produced with the help of the customer needs. To make the criteria more understandable they were given a clarification. Some of the demands from the assignment directives were not used as criteria because the concepts were not fully defined in all aspects. For example, cost estimations were hard to make because the materials of the plates were not set and the manufacturing methods would be similar, if not the same, for all the concepts. All the criteria, with their clarification, can be seen in the Table 7-4.

Table 7-4, Criteria

Category	Criterion	Clarification
Ergonomic	**Intuitive**	How easy it is for the caregiver to understand how the product is supposed to be used, even the first time the caregiver gets in contact with the product.
	Enables one hand movement	How easy it is for the caregiver to move the plate between sit to stand position and gait training position with one hand. If it is possible for the caregiver to move the plate with one hand the caregiver can use the other hand for leverage or to hold something.
	Number of movement steps	How easy it is for the caregiver to move the plate into "sit to stand" or gait training position. If the movement includes a lot of different steps it is considered difficult to move.
	Force required	How much force the caregiver must use to move the plate between standing and gait training position. Low force is desired.
	Working position	The position the caregiver needs to be in to be able to move the plate between sit to stand position and gait training position. This criterion concerns both the ergonomics part and the infectious part
	Time efficient	The time it takes for the caregiver to move the plate between the positions.
Works with Sara Plus	**Interference with walk**	The patient/resident should not be disturbed by the plate while gait training. Both the perceived and the actual physical disturbance are regarded.

	Interference with stand up	The footplate should not interfere with the lifts ability to get close to the patient/resident when they are sitting on a chair or a toilet. It should not either interfere with when the patient/resident is standing up.
	Interference with sight	The caregiver should be able to watch the patients/residents movements while gait training. The caregiver shall also be able to help the patient/resident with the gait training without interference of the plate.
Mechanical	**Stability**	The plate should not be able to wobble or bend when the patient/resident is standing on it.
	Mass	The plate's mass should be low because the weight of the product which the plate will be mounted on should not increase too much.
Security	**Risk of pinching**	The risk of pinching should be low. A lot of moving, especially heavy, parts enhances the pinching risk.
	Reliable	The plate should feel reliable and secure for the patient/resident to stand on.
Hygiene	**Dirt traps**	There should not be lot of places where dirt can accumulate.
	Easy to clean	The plate should be easy to clean. The plate is hard to clean if it has obscured places where it is hard to reach.

When the criteria were defined, weights were distributed. The weights are based on the criteria's importance to the product according to the assignment directives and the customer needs. The solutions were ranked against each other in every criterion but the same score could be given to more than one solution. They were given a rate between one and five and the result can be seen in Table 7-6. The different rates can be seen in Table 7-5:

Table 7-5, grades

1	The solution fulfils the criterion very poorly
2	The solution fulfils the criterion poorly
3	The solution fulfils the criterion
4	The solution fulfils the criterion good
5	The solution fulfils the criterion very good

Table 7-6 Concept Scoring

			CONCEPT									
			SIMPLE		DOUBLE		SIDE		SHOOT		MAGNET	
Selection criteria	Weight		Rating	Weighted score	Rating	Weighted score	Rating	Weighted score	Rating	Weighted score	Rating	Weighted score
Ergonomic												
Intuitive	10		3	30	4	40	3	30	3	30	3	30
Enables one hand movement	4		4	16	4	16	4	16	4	16	1	4
Number of movement steps	6		3	18	3	18	3	18	3	18	2	12
Low force required	6		3	18	3	18	3	18	3	18	2	12
Working position	9		4	36	3	27	4	36	3	27	2	18
Time efficient	2		3	6	4	8	3	6	4	8	2	4
Works with Sara												
Interference with walk	9		1	9	3	27	2	18	5	45	5	45
Interference with stand up	12		5	60	3	36	1	12	5	60	5	60
Interference with sight	5		4	20	3	15	2	10	4	20	5	25
Mechanical												
Stability	6		4	24	2	12	3	18	4	24	5	30
Mass	4		3	12	2	8	3	12	3	12	3	12
Security												
Risk of pinching	8		5	40	2	16	5	40	4	32	4	32
Reliable	5		3	15	1	5	2	10	4	20	4	20
Hygine												
Dirt traps	6		3	18	2	12	3	18	2	12	3	18
Easy to clean	8		3	24	2	16	3	24	3	24	5	40
TOTAL SCORE	100		51	346	41	274	44	286	54	366	51	362
Rank				3		5		4		1		2
Continue?			NO		NO		NO		YES		MAYBE	

The solutions were given their rates in every criterion and the rate multiplied with the criteria weight became the weighted score. The solution with the highest total weighted score is the solution chosen to further develop.

As shown in Table 7-6 the solution with the highest score is Shoot and therefore it is chosen as the solution to further develop. In the assignment directives given from ArjoHuntleigh it was specified that the footplate should be movable and if no other solution worked, the footplate should be removable. Magnet got nearly as good grades as Shoot but it is a removable solution and not movable. Magnet is therefore chosen to develop if Shoot does not work as hoped. The three solutions with the lowest rank; Simple, Side and Double, were not chosen for further development.

Note that the concept with the highest rank is the more developed concept that in the concept screening was chosen as wildcard. Since the concept proves that it has the right qualities for further development it was shown to be the right decision to continue with the wildcard in the beginning of the project.

According to Ulrich and Eppinger it is important to reflect over the selected concept, this was made together with ArjoHuntleigh's product developers and it was agreed to continue the project with building mockups of Shoot.

8 Concept Development

For the chosen concept a work flow was developed and a mockup of the concept was built. One of the mockups was tested on both ArjoHuntleigh's employees and students at Lund University.

8.1 Work Flow

With the selected solution a work flow was developed. The point of having a work flow was to better communicate the different stages and movements of the solution. The work flow has three stages which are shown in Figure 8.1 and described below.

Position A: When the footplate is in its original position and a person can use the lift as a sit-to-stand aid.

The caregiver grabs the handle on the plate and moves it forward.

Position B: The caregiver moves the footplate to this position.

The caregiver now starts to rotate the plate upwards.

Position C: The caregiver has rotated the footplate to the position when the lift can be used for gait training or help the patients/residents to stand up on the floor.

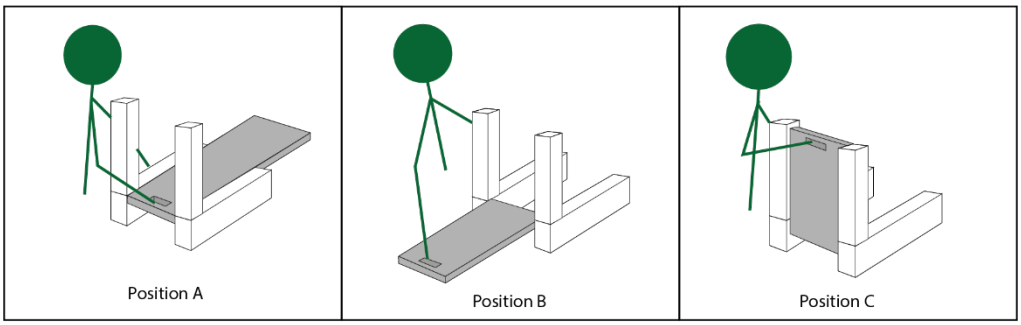

Figure 8.1 Work flow

The assignment directives say that the plate should be movable, or if that does not work, removable. During the second mockup development (se chapter 8.2) the feature of a movable and removable footplate was developed. The main reason for the new feature is the hygiene aspect. The caregivers will, with the new position, have the opportunity to remove the footplate to, for example, clean it. The new position, **Position D;** when the footplate is removed from the lift, was added to the work flow, see Figure 8.2.

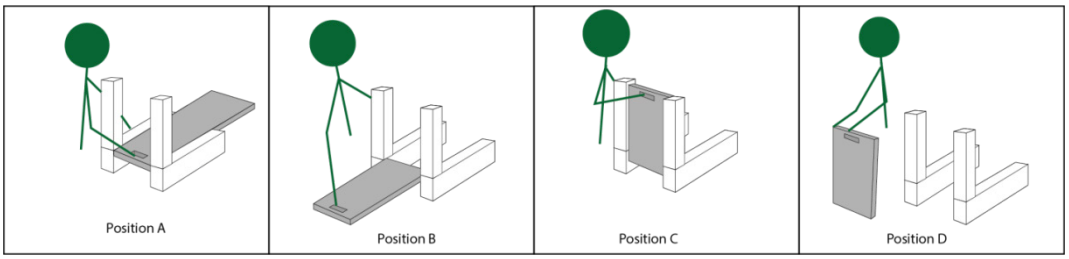

Figure 8.2 New Work flow

8.2 Mockups

The goals of the Mockups are to better understand the concepts and what the difference is between theory and practice. With the mockups it will be easier to get a better knowledge of how the concepts interact with the ArjoHuntleigh products, if anything on the product or the plate has to be changed. Another great outcome of creating mockups is the instant knowledge of the geometries and to try out the movement of the concepts. With the mockups it will also be possible to perform simple tests of the design and see what parts that are going to be the most difficult to develop. The construction of the mockups was made at ArjoHuntleigh's workshop in Malmö.

8.2.1 First Mockup M1

The first mockup, called M1, was a simple wooden frame made to illustrate the movement of the plate. A pair of rails was attached to the frame so the plate could be moved correctly. The pictures in Appendix B show the work flow sequence.

The tests of M1 led to a few valuable observations for the further development of the product. The first observation was that the existing rails are too long for the design. They would be in the way of the patients/residents and a possible safety risk. The second observation also regarded the rails, which have to be able to take a large amount of weight. After some research it was discovered that rails with the correct dimensions that can take a heavy load do not exist on the market therefore rails need to be developed. Another reflection when working with the first mockup was that the plate would need some type of handle to make it easier to use for the caregiver. The last remark led to a discussion about however the plate should be possible to remove from the product. This would help for example in the cleaning process but it would also be a risk of losing the plate in that process.

8.2.2 Second Mockup M2

The second step in the mockup process was to create a more developed mockup called M2.

Because the first observations of M1 considered the rails, the next step in the mockup phase was to develop a pair of rails that would work with the plate and the products. With the help of a brainstorming session a solution for the problem was developed. During this phase position D was added to the work flow. The solution's rails can be

seen in Figure 8.3 and the footplate can be seen in Figure 8.4. With the help from employees of the IKDC workshop the rails were CNC milled in aluminium. The aluminium rails were then fastened on M2 and ready for evaluation.

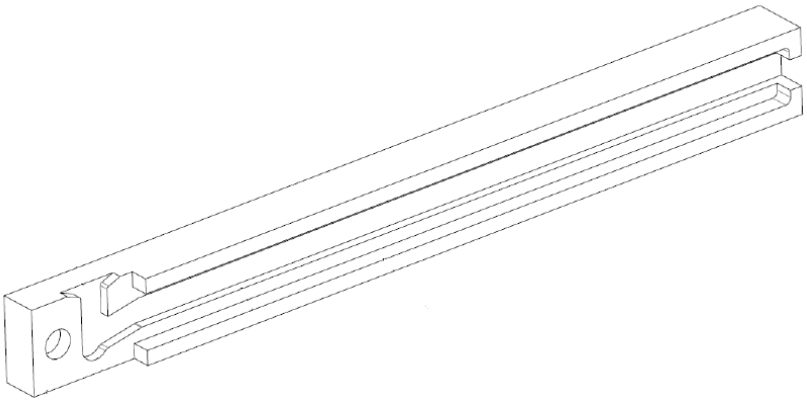

Figure 8.3 Rail M2

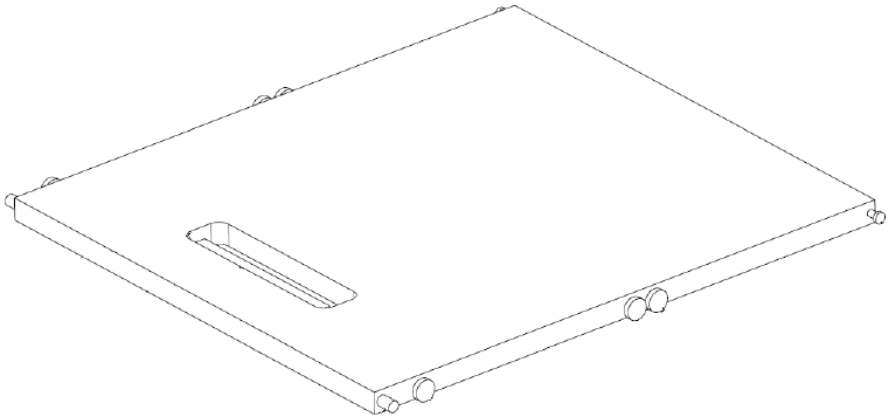

Figure 8.4 Footplate M2

When evaluated, M2 showed some good qualities but had one major problem. When at position B there is a large risk for the caregiver to drop the plate on the floor because there is nothing holding the plate in a horizontal position. This would not only be bad ergonomically for the caregiver but also a huge hygiene risk because the caregiver would touch the dirty floor.

8.3 Further Development

Since the second mockup did not work as supposed a brainstorming session was held together with design engineers from ArjoHuntleigh. The brainstorm mainly focused on finding a solution to the problem M2 had with position B and if there were any changes that could be made to the design. The brainstorming session was a great success and a new concept were taking form for further development.

The new solution has the wheels fastened on the rails instead of the footplate. The rails also have a plateau in the front to prevent the footplate from falling down when rotated. The work flow for the new solution, M3, is the same as for M2. The new solution, M3, is presented in chapter 9.

8.3.1 Removal

With M2 the removal of the plate came natural. With M3 there had to be more design work. Since the wheels are on the rails and not on the plate the tracks on the plate had to be designed so the movement between positions A-C is not compromised even if the footplate is able to be removed. To solve the problem the rail got an opening that only can be used when the plate is in the right position. In Position C the caregiver must keep on rotating the plate to the removal position and then the plate can be pulled away from the lift.

8.4 Concept Testing

To be able to know how ergonomic and intuitive the solution is a test was conducted. In the test M1 was used as the test product. The test included five ArjoHuntleigh employees and five students at LTH. The main focus of the test was to analyse if the movements of the plate were intuitive enough.

8.4.1 Concept User Evaluation

The brief of the test, photographs of one test and the questions can be seen in Appendix C.

The setup of the test:

1. A short summary of the project and the test.
2. The test person performs the movement from position A to position C.
3. Questions.
4. Information of how the solution is supposed to be used.
5. The test person performs the movement from position A to position C.
6. Questions.

The test persons graded the solution between one (1) and four (4), where one is really bad, two is bad, three is good and four is really good. The test persons were also asked questions of how the movement of the plate could be more intuitive and why something was difficult. Their answers can be seen below.

How can the solution be more intuitive?

- Better clarification, the user needs to know what to do right away.
- Arrows, the plate could have an arrow showing the direction of the movement.
- Different colours of the plate and the handle, so the user sees the handle better.

How can the rotation be more intuitive?

- The plate could start the rotation by itself.
- The mass of the plate must be optimised.
- A rotation arrow on the rails.
- Much better clarification, the user needs better feedback.

8.4.2 Reflection

During the test other relevant inputs were given. The most important input was that there is always a risk when the user sits down. Another great remark was that the user needs a lot of space when moving the plate.

The test group was master students at LTH and ArjoHuntleigh employees. At first, this was considered bad because most of the test persons would have too much knowledge of the products and/or the design work. The tests, especially with the students, showed that they did not have too much knowledge and made valuable mistakes. The test gave an overall good result of how the design could be improved and what the difficulties of the task were.

During the tests in the school it became obvious that the information they got before they were asked to try the movement was lacking in clearness. Because lack of clearness the students had to get an extra explanation on what the constraints were and what they could do with the footplate. This had no influence on the actual tests because they were able to execute the task as expected.

The test was divided in to two parts. First the test person got to perform the movement without any instruction of how it was supposed to work. Afterwards the test person got directions and then performed the movement again. Mostly the second time did not have to be executed because the test person did not have any problem even without instructions. The times the test person had problems with the movement the first time they all improved a lot when they were instructed.

9 Final Result

The projects final result is presented in this chapter. The different parts of the solution are described and the concepts work flow shown.

To better understand the information it is recommended to look at the technical drawings and position drawings, found in Appendix D, alongside this chapter.

9.1 Overview

The final solution is mounted on a simple chassis, see Figure 9.1. This is because the solution should work on different existing ArjoHuntleigh products and future products. The solution contains two assembly parts, the rail and the footplate, both described later on in this chapter.

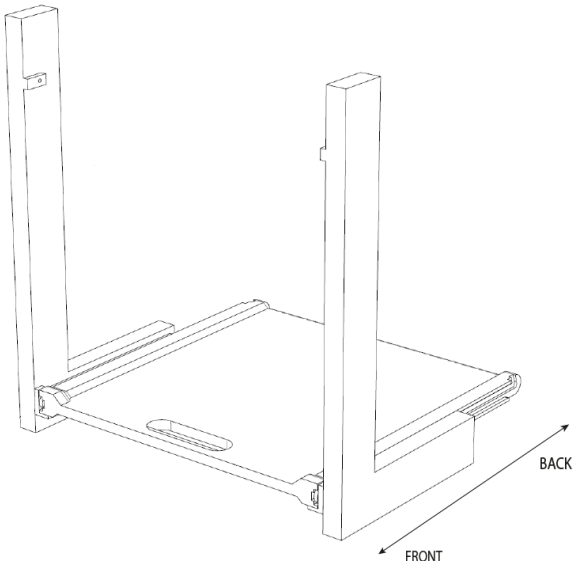

Figure 9.1 Solution overview

In Chapter 8, a work flow for the footplate is described. The final solution works as intended in Chapter 8, and the work flow, with the final solution, can be seen in Figure 9.2.

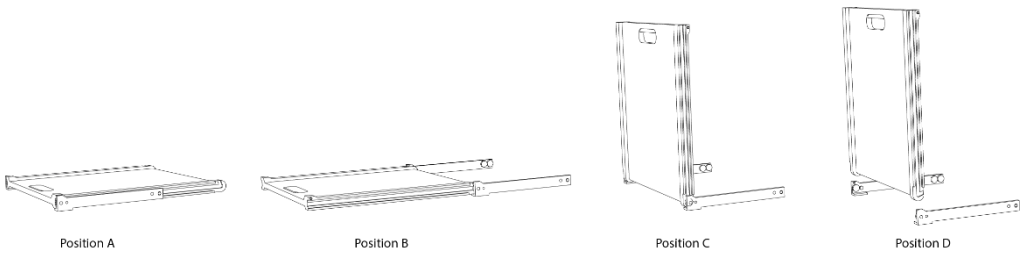

Figure 9.2 Solution work flow

9.2 The Rail

The solution has two rails, see Figure 9.3, mirrored to each other and they are attached to the chassis.

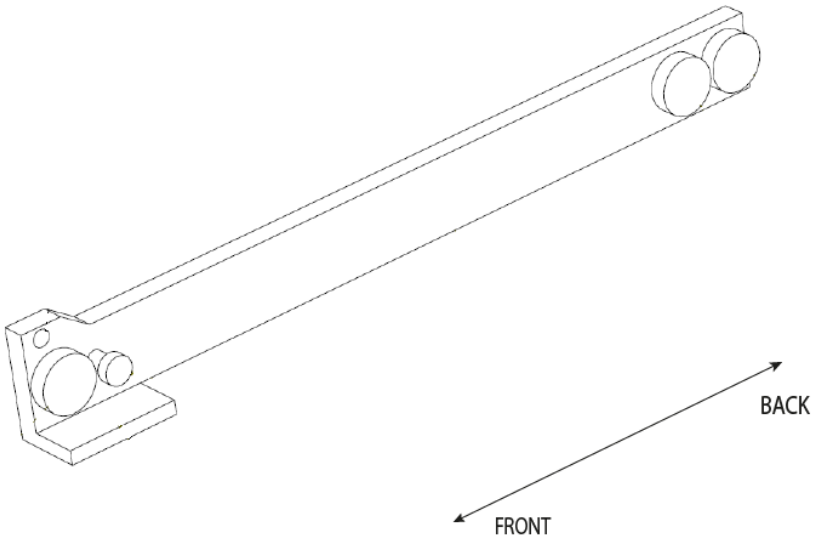

Figure 9.3 Rail

The rails have two different sizes of wheels. The large wheels are holding the footplate in place and take the entire load. The number of large wheels can vary depending on the products working load. The small wheel sit further from the rail body and its function is to be the rotation axis when the footplate rotates between position B and position C.

In the front part of the rail there is a plateau at the bottom. The plateaus function is to keep the footplate from falling down when rotating or when it is in position C. In the upper front of the rails there are holes. The holes function is to keep the locking pins in the locking position. From the hole to the front end there is an inclining track. The inclining track's function is guiding the locking pins to the right position if the locking mechanism is released before the footplate is in position A. When the locking mechanism is released the user shall be able to push the plate in place instead of having to push the button again.

9.3 The Footplate

The footplate includes one body, one handgrip and two tracks on each side, see Figure 9.4. Inside the handgrip there is a button. When the button is pressed the plate is unlocked, more about this later on in this chapter.

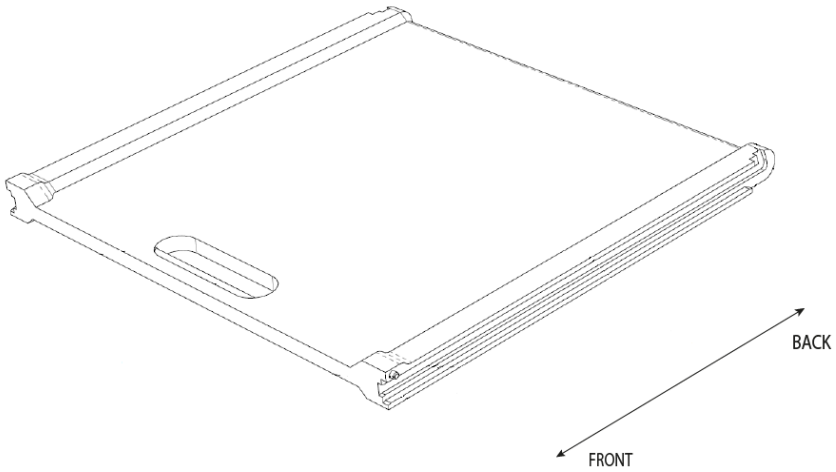

Figure 9.4 Footplate

The footplate's tracks connect the footplate to the rails. There is a large track for the large wheels and inside the large track there is a smaller one for the small wheel. The large tack runs along the whole side of the footplate. The small track ends just before the large track so that the small wheel can stop the footplate and the footplate can rotate around it.

In the back of the footplate the small track changes its direction, so the user can remove the footplate from the product (to position D). The final design can be seen in Figure 9.5.

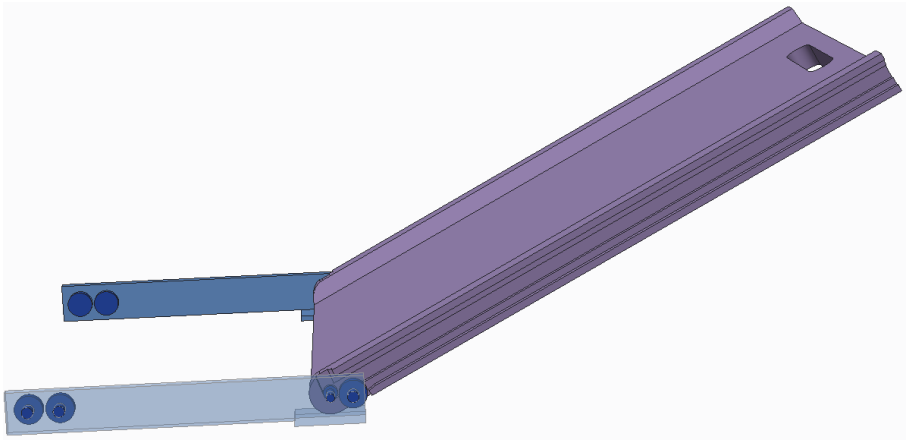

Figure 9.5 Final design

9.4 The Locks

For the lock in position A a mechanism, Figure 9.6, were developed with the help of ArjoHuntleigh's design engineers. The thought behind the lock is to simplify the handling of the footplate for the user. Therefore the lock button is placed inside the handgrip. When the handgrip is grabbed the button inside of it is pushed and the user is able to move the plate. When the button is released the plate can be locked. If the caregiver should release the plate to early the plate will be able to be pushed into the locked position without the button being pushed.

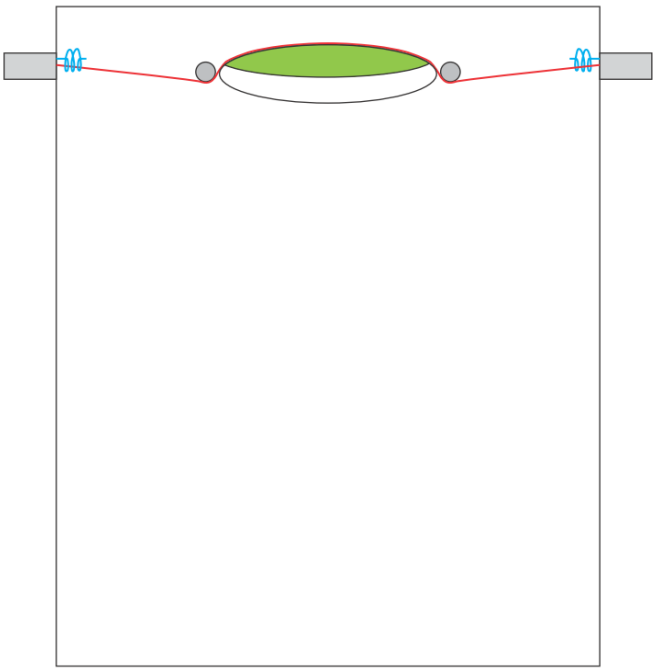

Figure 9.6 The lock mechanism

The mechanical work flow of the lock:

1. The user grabs the handle and pushes the button inside of it.

2. When the button is pushed, the wire pulls the pins to the inside of the plate.

3. When the handle is released and the button no longer is pushed in, the springs ensure that the pins get back to their normal state.

To lock the plate in position C there will be a lock using a magnet. On the plate a small steel block is placed and on the product's body there is a hole with a magnet inside. When the caregiver rotates the plate to position C the block will fit to the hole and the magnet will lock the footplate. The magnet will be strong enough for the plate to not move, but not too strong for the caregiver to unlock the plate. This can be seen in Figure 9.7.

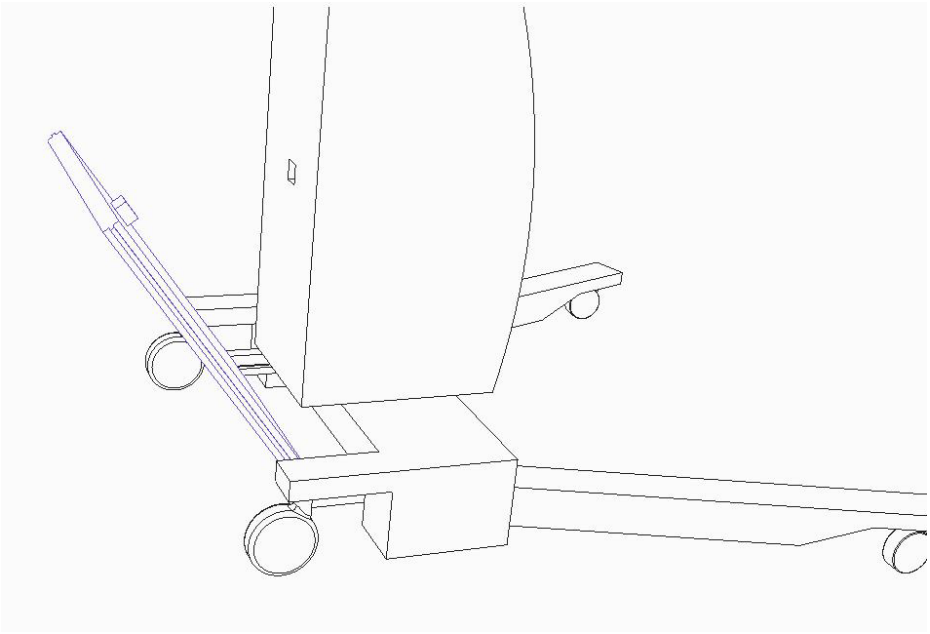

Figure 9.7 Magnet Lock

9.4.1 Button

Since the mechanism contains a button inside the handgrip, different types of buttons were evaluated, and they can all be seen in Figure 9.8.

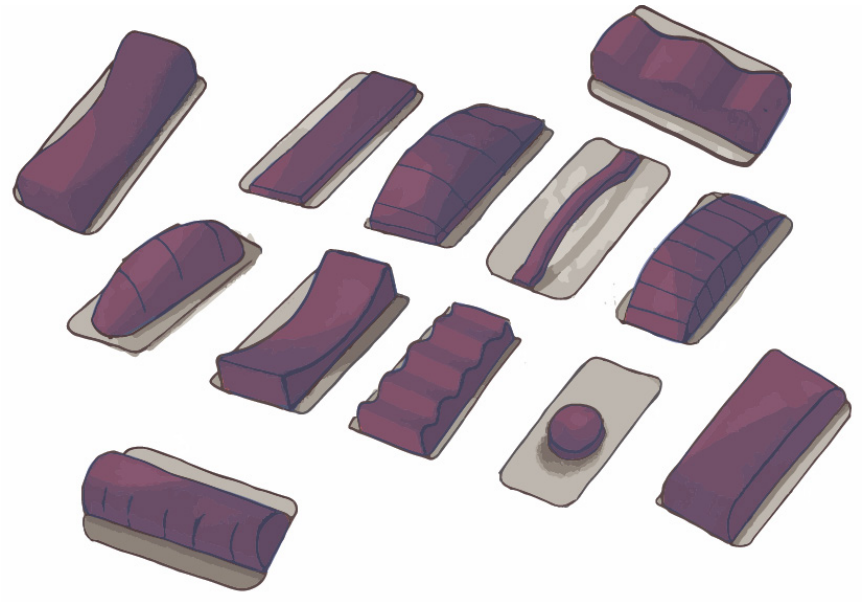

Figure 9.8 Buttons

10 Patent Application

To protect the solution it was decided to send in a patent application to ArjoHuntleigh's patent engineers. The application work and the result are described in this chapter

Patents in Europe are designed to protect technical inventions in all fields of technology. Code for computer programs, mathematical methods and business models as such cannot be patented. The patent is valid in the specific country where the application is made, for a specified period of time [41]. The right granted to the owner of the patent is the right to prevent others from making, using, selling, importing or distributing a patented invention without permission. The owner of the patent may give permission to, or license, other parties to use the patent. The owner can also sell the right to the invention [42].

For the moment no worldwide patents or international patents exist. An application must be filed for every country for which the patentee seeks to protect his/her invention. In Europe and Africa there are regional patent offices but the fees have to be paid for every country in that region.

10.1 The Application Work

To ensure that the invention was unique and not already invented by somebody else previous patent applications and patents were sorted through. The information was gathered at various patent organisations and already acquired documents at ArjoHuntleigh. The documents showed that the invention could be unique. A lot of valuable information about the structure of an application and the information it should contain were gathered.

The application is required to be as comprehensive as possible which led to that all alternatives of the invention needed to be explored. To be able to produce the best version of the invention and add alternatives product developers from ArjoHuntleigh were included in brainstorming sessions. During the brainstorming sessions upgrades to the preferred solution and alternative solutions were added.

10.2 Reflections

To do something for the first time is never easy, especially not a patent application. Because of the short time frame of a Master's thesis the patent application had to be done in a very short amount of time. The writing of the application was challenging

but very worthwhile and interesting. The knowledge gathered about a patent application will be useful in many other projects, especially the understanding of how many patents there are and how important it is to be accurate in every decision. Another knowledge from this phase was that in many cases applications are sent in to the patent office's not only to get a patent but because they become official and prevents other companies from patenting similar solutions.

11 Discussion

The purpose of this master's thesis was to design a movable or removable plate of some sort for ArjoHuntleigh in Malmö. Over time the project moved towards standing and raising aids and the development of a movable footplate for the aids.

The development methodology used was the one presented by Ulrich and Eppinger. This was because we are used to the methodology and believed it to be useful in this project. Of course we made alterations to the method when we believed it necessary but the frame came from Ulrich and Eppinger. The reason that we made changes to the methodology was because the project given to us by ArjoHuntleigh was very broad and we were able to set our own constraints. If we would have been given a more technical task the methodology would work without our alteration. We feel that we have been using a good structure during the thesis and would recommend the method to other students.

For the design decisions we have been using Donald A Normans' advices to think about affordance, mapping, feedback and constraints. Especially in the development of the lock and the design of the handgrip and button the knowledge Norman provides became useful. The advices followed through the whole project and were always kept in mind.

The solution for the movable and removable footplate that was produced is a great way of solving the task given to us. When the footplate is only removable the risk of the users misplacing it, losing it or dropping it and injuring themselves is quite high. If the footplate is only movable it is more difficult to clean and if the extra space or sight is needed there is no option. Though the solution is usable for existing standing and raising aids we think it would be even more useful for future products. The solution could be even better if the products can be designed so the same lock can be used both in position A and position B.

The tests which were executed did not include any medical personnel, only students and ArjoHuntleigh personnel. There might have been better test results with medical personnel but we felt that the tests with the students gave us valuable information because they had no previous knowledge of the product.

Towards the end of the design phase, we and ArjoHuntleigh felt that the solution needed to get patented. During the patent work we got a lot of help from ArjoHuntleigh, especially from our mentor. The patent work was very interesting and it spawned new ideas for the solution. We believe that the patent work gave us a lot of valuable experience and was necessary to make the thesis as good as possible.

It has been an interesting development and exciting to be a part of a larger project than the previous ones in our education. To be stationed at ArjoHuntleigh's innovation center in Malmö has been really good because the product developers and design engineers have always helped us in any way they could. The workshop at ArjoHuntleigh in Malmö have also been a great access to us, the ability to create quick models of our concepts to describe them and test them have meant a lot to the project.

Overall we are satisfied with the project and the solution. We have designed a product which we believe stands up to the assignment directives and we are proud of the result.

Ergonomic for user

The movement is easy and natural

The footplate is both movable and removable

Hygiene

The plate is removable and therefore easy to wash

Dirt traps minimised relative to the selected solution

Time efficient for users

Simple and few movement steps

Correct mechanical and material properties

No advanced materials or manufacturing techniques is needed due to a relatively simple solution

If Plastic or aluminium is chosen the weight will be low (se recommendations)

Strong footplate and rails

Cost estimation

No advanced materials or manufacturing techniques is needed due to a relatively simple solution

Design/shape/expression in line with ArjoHuntleigh

Colours in line with ArjoHuntleigh

We hope that we will see our solution, or a part of our solution, in future ArjoHuntleigh products.

12 Recommendations

The master's thesis was carried out during a limited amount of time, if ArjoHuntleigh wants to proceed with the development of the concepts there are a few recommendations.

ArjoHuntleigh's next step should be making full scale prototypes of M3 for testing the movement, especially from position C to position D. The prototype can also be used to further test the intuitiveness.

Table 7-6 can be used to evaluate the prototype and its different functions. The design is deliberately simplified which makes it easier to add functions and change the design. The simplified design makes it also easier to adapt the solution to different products.

The product is meant for both existing and future standing and raising aids and therefore it is important to decide if the solution is worth implementing on existing products or saved for use in future ones. If implemented on existing products there are a few modifications that have to be made to be able to fit the solution to the products.

There have been small scale strength analysis of the wheels and the wheel shafts but not extensive enough. To ensure the strength of the solution extensive strength analysis of the whole solution need to be executed. Will the footplate be able to carry the load completely and what happens when it breaks? From the strength analysis derives important information that can help out with the selection of material and dimensions.

The lock, both in position A and position C, is an important element that has to be further developed.

It will be advantageous to use a light material for the footplate because otherwise it will be very hard to perform the rotation motion from position B to position C, and back. The material will also have to be able to carry the heavy load put on the footplate which suggests using some kind of plastic or aluminium. If plastic is chosen, the preferable manufacturing method is injection moulding with some sort of thermoplastic.

The wheels on the rails and the tracks on the footplate will have to carry a lot of weight. Because they are in an exposed position they will have to be in a stronger and more robust material. Preferable some kind of constructional steel will be used, especially for the wheel shafts.

Problems with hygiene could occur because of the moving wheels on the rails. To avoid some of the dirt getting to the wheels some kind of protection from above can be developed. A protector placed on the footplate that protects the wheels and tracks would be favourable.

The area around the handle on the footplate needs to be in one colour and the button itself needs to be in another. The reason for the different colours is that it will be easier to spot the handle and therefor it will be more intuitive. The colour scheme should, of course, follow ArjoHuntleigh's colours.

13 References

[1] ArjoHuntleigh (Electronic)
http://www.arjohuntleigh.com, 2014-06-18

[2] ArjoHuntleigh Mobility gallery (Electronic)
http://www.arjohuntleigh.com/knowledge/mobility-gallery/, 2014-06-18

[3] ArjoHuntleigh Positive Eight (Electronic)
http://www.arjohuntleigh.com/knowledge/positive-8/, 2014-06-18

[4] Ulrich, Karl, Eppinger, Steven (2008). Product Design and Development. McGraw-Hill, New York NY, USA

[5] Norman, D. (1988). The design of everyday things. New York: Basic Books,New York, USA

[6] Youtube, Smart Furniture (Electronic)
http://www.youtube.com/watch?v=Lznm9MlCH_s 2014-06-18

[7] Toyota BT Levio Brochure (Electronic)
http://www.toyota-forklifts.eu/SiteCollectionDocuments/PDF%20files/BT%20Levio%20brochure.pdf, 2014-06-18

[8]Holmqvist, Marie, site manager, Mårtenslund, 2014-03-19
mari.holmqvist@lund.se

[9] ArjoHuntleigh, Cealing lifts (Electronic)
http://www.arjohuntleigh.com/products/patient-transfer-solutions/ceiling-lifts/, 2014-06-18

[10] ArjoHuntleigh, Standing and raising aids (Electronic)
http://www.arjohuntleigh.com/products/patient-transfer-solutions/standing-raising-aids/, 2014-06-18

[11] ArjoHuntleigh, Passive floor lifts (Electronic)
http://www.arjohuntleigh.com/products/patient-transfer-solutions/passive-floor-lifters/, 2014-06-18

[12] ArjoHuntleigh, Medical beds (Electronic)
http://www.arjohuntleigh.com/products/medical-beds/hospital-beds/, 2014-06-18

[13] ArjoHuntleigh, Bedside locker (Electronic)
http://www.arjohuntleigh.com/products/medical-beds/bedside-locker/. 2014-06-18

[14] ArjoHuntleigh, patient-trolleys-stretchers (Electronic) http://www.arjohuntleigh.com/products/medical-beds/patient-trolleys-stretchers/, 2014-06-18

[15] ArjoHuntleigh, Community beds (Electronic) http://www.arjohuntleigh.com/products/medical-beds/community-beds/, 2014-06-18

[16] ArjoHuntleigh, Birthing beds (Electronic) http://www.arjohuntleigh.com/products/medical-beds/birthing-beds/, 2014-06-18

[17] ArjoHuntleigh, Cots and cribs (Electronic) http://www.arjohuntleigh.com/products/medical-beds/cots-cribs/, 2014-06-18

[18] ArjoHuntleigh, Showering (Electronic) http://www.arjohuntleigh.com/products/hygiene-systems/showering/shower-chairs/, 2014-06-18

[19] ArjoHuntleigh, Bathing (Electronic) http://www.arjohuntleigh.com/products/hygiene-systems/bathing/, 2014-06-18

[20] ArjoHuntleigh, Burns treatment (Electronic) http://www.arjohuntleigh.com/products/hygiene-systems/burns-treatment/, 2014-06-18

[21] Belastningsergonomi (2012). Stockholm, Arbetsmiljöverkets författningssamling (The Swedish Work Environment Authority), AFS 2012:2

[22] ArjoHuntleigh, Sara Plus (Electronic) http://www.arjohuntleigh.se/sv/Product.asp?pagenumber=744&Product_Id=19&ProductCategory_Id=13, 2014-06-18

[23] ArjoHuntleigh, Sara 3000 (Electronic) http://www.arjohuntleigh.se/sv/Product.asp?PageNumber=744&ProductCategory_Id=13&Product_Id=20, 2014-06-18

[24] ArjoHuntleigh, Sara Lite (Electronic) http://www.arjohuntleigh.se/sv/Product.asp?PageNumber=744&ProductCategory_Id=13&Product_Id=332, 2014-06-18

[25] ArjoHuntleigh, Sara Stedy (Electronic) http://www.arjohuntleigh.se/sv/Product.asp?PageNumber=744&ProductCategory_Id=13&Product_Id=544, 2014-06-18

[26] Hill-rom (Electronic) http://www.hill-rom.co.uk/ 2014-06-14

[27] Hill-rom, RollOn (Electronic) http://www.liko.se/se/Sverige/Produkter/Uppresning/RollOn/ 2014-06-18

[28] Hill-rom, Sabina II (Electronic) http://www.liko.se/se/Sverige/Produkter/Uppresning/Sabina-II/, 2014-06-18

[29] Ato-form (Electronic)
http://www.ato-form.com/, 2014-06-18

[30] Ato-form, Vita lift (Electronic)
http://www.ato-form.com/en/lifter/vita-lift.php, 2014-06-18

[31] Ato-form, MoweGo (Electronic)
http://www.ato-form.com/en/walking/mowego.php, 2014-06-18

[32] Etac (Electronic)
http://www.etac.se/, 2014-06-18

[33] Etac, Quick raiser (Electronic)
http://www.etac.se/se/Produkter/Vuxen/Lyftar-och-selar/Mobila-Lyftar/Uppresningslyft-Quick-Raiser-II/, 2014-06-18

[34] Etac, Nova 500 (Electronic)
http://www.etac.se/se/Produkter/Vuxen/Lyftar-och-selar/Mobila-Lyftar/Nova-500-Uppresningslyft/ 2014-06-18

[35] Invacare (Electronic)
http://www.invacare.com/cgi-bin/imhqprd/default.jsp, 2014-06-18

[36] Invacare, Rea Azalea (Electronic)
http://doclibrary.invacare.fr/Office/Europe/Marketing/MktDocSE.nsf/MListeDocument?openform&bu=2000&subgroup=2200&family=2202&product=65_AZA, 2014-06-18

[37] Handicare (Electronic)
http://www.handicare.com/en/home.aspx, 2014-06-18

[38] Handicare, ReTurn 7500 (Electronic)
http://www.handicare.com/en/products/systemromedic-%E2%80%93-transfer-and-lifting-aids/systemromedic-%E2%80%93-transfer-and-lifting-aids/systemromedic-%E2%80%93-manual-transfer-aids/systemromedic-%E2%80%93-assistive-devices-for-mobility-support-during-sit-to-stand/systemromedic-%E2%80%93-return7500/c-39/c-204/p-293, 2014-06-18

[39] Hill-rom, Affinity IV (Electronic)
http://www.hill-rom.com/usa/Products/Category/Hospital-Beds/Affinity-4-Birthing-Bed/, 2014-06-18

[40] Oxford dictionaries, Intuitive (Electronic)
http://www.oxforddictionaries.com/definition/english/intuitive?q=intuitive, 2014-06-18

[41] European patent office (Electronic)
http://www.epo.org/service-support/faq/basics.html, 2014-06-18

[42] World intellectual property organization (Electronic)
http://www.wipo.int/patents/en/faq_patents.html, 2014-06-18

13.1 Reference of Figures

Figure 1.1 Albert:
http://www.arjohuntleigh.com/knowledge/mobility-gallery/albert/

Figure 1.2 Barbara:
http://www.arjohuntleigh.com/knowledge/mobility-gallery/barbara/

Figure 1.3 Carl:
http://www.arjohuntleigh.com/knowledge/mobility-gallery/carl/

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http://www.arjohuntleigh.com/knowledge/mobility-gallery/doris/

Figure 1.5 Emma:
http://www.arjohuntleigh.com/knowledge/mobility-gallery/emma/

Figure 1.6 Positive eight:
http://www.arjohuntleigh.com/static_html/p8/#

Figure 3.1Toyota Levio P:
http://www.baltic.toyota-forklifts.eu/En/Products/powered-pallet-trucks/bt-levio-p-series/Pages/Default.aspx

Figure 3.2 Garage door:
http://upload.wikimedia.org/wikipedia/commons/8/8d/Garage_door_sliding_up.jpg

Figure 3.3 Workshop drawer:
http://img.directindustry.com/images_di/photo-g/drawer-cabinets-9332-4190063.jpg

Figure 3.4 Foldable sack truck:
http://pictures.ese.co.uk/images/Product/largeSquare/2186.jpg

Figure 3.5 Wall mounted folding seat:
http://www.emdon.se/bilder/artikelbild.jpg

Figure 3.6 Foldable arm support:
https://encrypted-tbn2.gstatic.com/images?q=tbn:ANd9GcTwxE1CoLNd0X3f3TFXaA3BcSCh7kNHxzr5x7v8SrD8DIvUap6o

Figure 3.7 Food trolley:
https://encrypted-tbn3.gstatic.com/images?q=tbn:ANd9GcSzBF8a98xk8VX2NMzbtq6nz2lNeRqOXGU7a4v1YM8c0I9ELlu55w

Figure 3.8 The seat used as a tray:
http://www.exactibutik.se/wp/wp-content/uploads/2014/01/prod_bxm_security_barnsits-500x568.jpg

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https://encrypted-tbn3.gstatic.com/images?q=tbn:ANd9GcSuAwlXGFQifbpm4IctaZ1C26V7kbiwMXe4tG01FE7tbShjfce0pg

Figure 3.10 Maxi Sky:
http://www.arjohuntleigh.com/products/patient-transfer-solutions/ceiling-lifts/

Figure 3.11 Sara Plus:
http://www.arjohuntleigh.com/products/patient-transfer-solutions/standing-raising-aids/sara-plus/

Figure 3.12 Walker:
http://www.arjohuntleigh.com/products/patient-transfer-solutions/standing-raising-aids/walker/

Figure 3.13 Maxi Twin:
http://www.arjohuntleigh.com/products/patient-transfer-solutions/passive-floor-lifters/

Figure 3.14 Enterprise 800:
http://www.arjohuntleigh.com/products/medical-beds/hospital-beds/

Figure 3.15 Overbed table:
http://www.arjohuntleigh.com/products/medical-beds/bedside-locker/

Figure 3.16 Lifeguard:
http://www.arjohuntleigh.com/products/medical-beds/patient-trolleys-stretchers/

Figure 3.17 Minuet 2:
http://www.arjohuntleigh.com/products/medical-beds/community-beds/

Figure 3.18 Birthing Bed:
http://www.arjohuntleigh.com/products/medical-beds/birthing-beds/birthright-delivery-bed/

Figure 3.19 Crib:
http://www.arjohuntleigh.com/products/medical-beds/cots-cribs/

Figure 3.20 Carendo:
http://www.arjohuntleigh.com/products/hygiene-systems/showering/shower-chairs/carendo/

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http://www.arjohuntleigh.com/products/hygiene-systems/showering/shower-trolleys/concerto/

Figure 3.22 Rhapsody:
http://www.arjohuntleigh.com/products/hygiene-systems/bathing/

Figure 3.23 Primo Ferro:
http://www.arjohuntleigh.com/products/hygiene-systems/burns-treatment/primo-ferro/

Figure 4.1 Sara Plus Transport
http://www.aphmed.com/wp-content/uploads/2012/11/SARA-Plus-017sm2.jpg

Figure 4.2 Sara Plus Raising
http://cdn.medicaleshop.com/content-images/arjohuntleigh/sara-plus-patient-lift/sara-plus-3.jpg

Figure 4.3 Sara Plus Gait train
http://www.aphmed.com/wp-content/uploads/2012/11/SARA-Plus-0613.jpg

Figure 5.1 Sara 3000:
http://www.arjohuntleigh.com/products/patient-transfer-solutions/standing-raising-aids/sara-3000/

Figure 5.2 Sara Lite:
http://www.arjohuntleigh.com/products/patient-transfer-solutions/standing-raising-aids/sara-lite/

Figure 5.3 Sara Stedy:
http://www.arjohuntleigh.com/products/patient-transfer-solutions/standing-raising-aids/sara-stedy/

Figure 5.4 RollOn:
http://www.hill-rom.co.uk/uk/United-Kingdom/Products/Liko-Raising-Aids/RollOn/

Figure 5.5 Sabina II:
http://www.hill-rom.co.uk/uk/United-Kingdom/Products/Liko-Raising-Aids/Sabina-II//

Figure 5.6 Vita-Lift:
http://www.ato-form.com/en/lifter/vita-lift.php

Figure 5.7 MoweGo:
http://www.ato-form.com/en/walking/mowego.php

Figure 5.8 Molift Quick Raiser 1:
http://www.etac.com/en/etaccomexp/Start-Page/Products/Lifts-mobile-lifts/Etac-Molift-Quick-Raiser/

Figure 5.9 Nova 500:
http://www.etac.com/en/etaccomexp/Start-Page/Products/Lifts-mobile-lifts/Nova-Sit-to-stand-Lift/

Figure 5.10 Rea Azalea:
http://www.invacare-rea.com/articles/invc-rea-azalea--44-66.php

Figure 5.11 ReTurn7500:
http://www.handicare.se/Produkter/SystemRoMedic/Stod/Uppresningshjalpmedel/ReTurn75001/

Figure 5.12 Affinity IV:
http://www.hill-rom.com/usa/Products/Category/Hospital-Beds/Affinity-4-Birthing-Bed/

13.2 Table of Figures

Appendix A: Assignment directives

A.1 New Assignment Directives

The task will be to find a solution to move a plate/shelf a certain distance from its original position **for a standing and raising aid**. An alternative solution could be to remove the plate/shelf, but then to find a solution for detaching/attaching, plus storing the plate/shelf.

Demands:

- Ergonomic for user
- Hygiene
    - Minimise dirt traps
    - Advantageous material selection
    - Efficient to clean
- Time efficient for users
- Correct mechanical and material properties
    - Limiting dimensions and shapes
    - **Load resistance 400kg**
    - ~~**Low production volume**~~
      (The standing and raising aids do not have a low production volume)
    - Weight
    - Possible solutions
        - 1. Pure mechanical
        - 2. Electro-mechanical solution
    - Preferable is a repositioned plate/shelf, but still attached. Last choice would be a de-attachable solution with a storage solution for the plate/shelf
    - Possible to manufacture
- Cost estimation (not limiting)
- Design/shape/expression in line with ArjoHuntleigh

Not included demands:

- Biocompatibility
    - Allergenic/toxic
    - Recyclable

- Low environmental impact from manufacturing

Output:

- Described task
- Described work process
- Described analyses
- Test reports
- Evaluation reports
- Benefits
- Described and tested work flows
- One or several described solutions, possible with CAD, 3D simulations, photos, films and sketches
- One or several functional models
- One or several prototypes

Time Frame:

The thesis shall be delivered to the Company no later than 1st of September 2014

A.2 Old Assignment Directives

The task will be to find a solution to move a plate/shelf a certain distance from its original position. An alternative solution could be to remove the plate/shelf, but then to find a solution for detaching/attaching, plus storing the plate/shelf.

Demands:

- Ergonomic for user
- Hygiene
    - Minimise dirt traps
    - Advantageous material selection
    - Efficient to clean
- Time efficient for users
- Correct mechanical and material properties
    - Limiting dimensions and shapes
    - Low production volume
    - Weight
    - Possible solutions
        - 1. Pure mechanical
        - 2. Electro-mechanical solution
    - Preferable is a repositioned plate/shelf, but still attached. Last choice would be a de-attachable solution with a storage solution for the plate/shelf
    - Possible to manufacture
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Appendix B: Photographs of the First Mockup

B.1 Position A

B.2 Position B

B.3 Position C

Appendix C: Concept User Evaluation

C.1 Swedish Directives

Hej!

Vi läser Maskinteknik och gör just nu vårat examensarbete på ett företag som heter ArjoHuntleigh, de utvecklar och tillverkar t.ex. personlyftar, vårdsängar och duschvagnar. Vi utvecklar just nu en platta för Arjohuntleigh och vill testa hur intuitiv den är.

Vi skulle vilja be dig flytta plattan från läge A till läge B. Där läge A är det läget som plattan är i just nu, det vill säga då en man kan ställa något på den. Läge B är då plattan är flyttad till en position där den inte är i vägen för någon. En person ska kunna stå på denna sidan (ställer mig på plats) och en person ska kunna stå på golvytan som just nu är under fotplattan.

Plattan får inte plockas bort från modellen utan måste sitta kvar.

Var så god a börja.

Du får gärna tänka högt om du vill.

-Testperson utför del ett av testet-

-Frågor del ett-

Nu ska vi visa hur vi har tänkt att man ska göra. Testa nu att göra som vi gjorde.

-Testperson utför del två av testet-

-Frågor del 2-

Tack för att du deltagit i vårt test

C.2 English Directives

Hi!

We are mechanical engineering students currently doing our master's thesis at ArjoHuntleigh, a company that develops and produces for example patient transfer solutions, medical beds and shower chairs. We are currently developing a plate for ArjoHuntleigh and would like to test how intuitive it s.

We would like to ask you to move the plate from position A to position B. Position A is the position which the plate is in right now, when something can be placed on it. Position B is when the plate is moved where it is not in the way of someone. A person should able to stand on the side (walking to the spot and standing there) and another person should be able to stand on the floor underneath where the plate is right nor.

The plate cannot be removed from the model.

Please begin.

Don't hesitate to say what you are thinking.

-The test person performs part one of the test-

-Questions part 1-

Now we will you show the movements should look like.

-Shows how we would like it to work-

Now try it.

-The test person does part two of the test-

-Questions-

Thank you for participating in our test

C.3 Photographs from the Test

C.4 Test Result


Hur lätt var det att utföra uppgiften efter att vi hade visat?
1
2
3
4


Hur lätt var det att förstå att plattan skulle roteras uppåt efter att vi hade visat?
1
2
3
4

C.5 Test Form

Namn:

Avdelning:

Före vi visat hur det fungerar:

Fråga:	Betyg/Motivation			
Hur lätt var det, baserat på den information som gavs och hur modellen ser ut, att utföra uppgiften?	1	2	3	4
Varför?				
Vad kan förbättras?				
Hur lätt var det att förstå att plattan skulle roteras upp för att komma till sitt passiva läge?	1	2	3	4
Varför?				
Vad kan förbättras?				

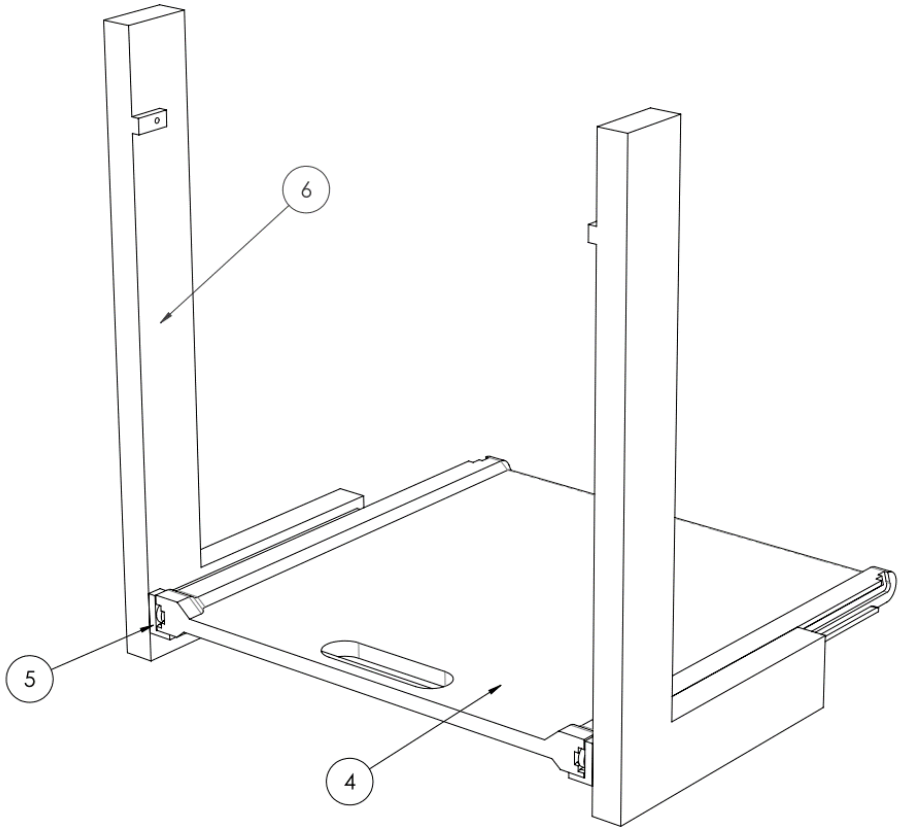
Efter vi visat hur det fungerar:

Fråga:	Betyg/Motivation			
Hur lätt var det, baserat på den information som gavs och hur modellen ser ut, att utföra uppgiften?	1	2	3	4
Varför?				
Vad kan förbättras?				
Hur lätt var det att förstå att plattan skulle roteras upp för att komma till sitt passiva läge?	1	2	3	4
Varför?				
Vad kan förbättras?				

Övriga kommentarer:

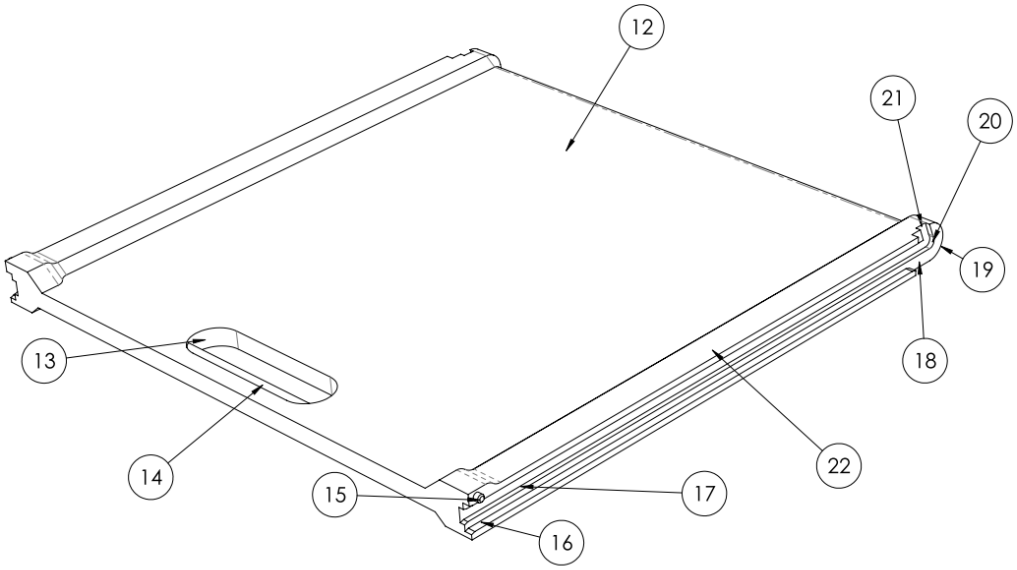
Appendix D: Drawings of Final Solution

The assembly:



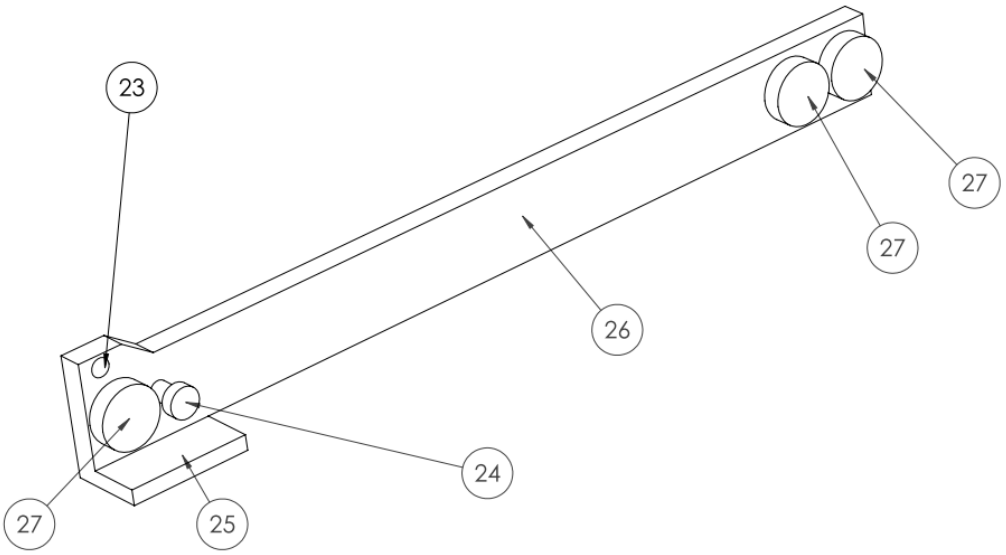
4. The Footplate
5. The Rail
6. The Chassis

The footplate:



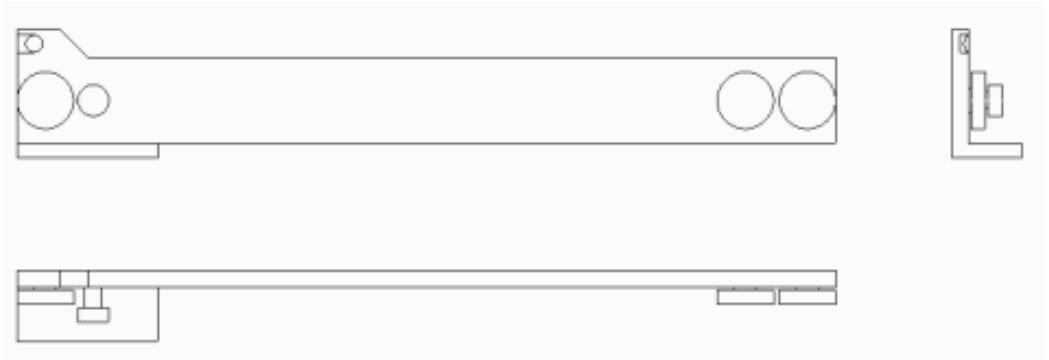
12. Footplate body
13. Handgrip
14. Button
15. Locking pin
16. Large track
17. Small track
18. Gap
19. Outer radius
20. Inner radius
21. Exit track
22. Rail body

The rail:



23. Locking hole
24. Small wheel
25. Plateau
26. Rail Body
27. Large wheel

Rail views:

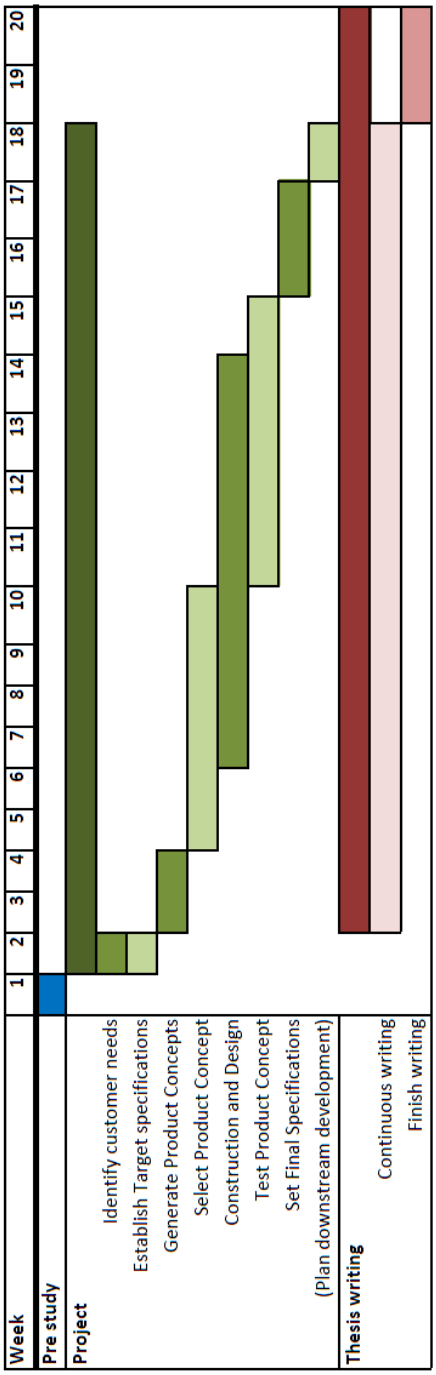


Appendix E: Time Evaluation

E.1 Distribution of Work

Since the beginning of the project both students have been open with that all the work should be done together. The students have been sitting next to each other during the whole project and therefore the workload has been divided equally. The concept generation and concept selection were executed together so that both students have equal knowledge of all the parts of the project. Sometimes work has been divided because of time efficiency, for example when one of the students has constructed a concept in CAD the other one has been working on the mockup. The whole report has been written by both students, when one student has been writing a part the other one then went through it so both student can stand for everything that is included in the report.

Timetable developed in the beginning of the project



Timetable actual outcome