CONCEPT FOR A PORTABLE ASSISTIVE LIFTING SEAT
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INDUSTRIAL DESIGN
This exam work has been carried out at the School of Engineering in Jönköping in the subject area Product development – Industrial Design. The work is a part of the Master of Science with a major in Product Development, specialization in Industrial Design.

The author takes full responsibility for opinions, conclusions and findings presented.

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i. Abstract

This project consists on the design of a concept for a portable assistive seat in collaboration with IKEA. The aim of the project is to create a solution that fits within the Omtänksam family of products and shares the company’s values of what is so called Democratic Design:

Form - Quality - Low Price - Function – Sustainability

The Omtänksam Family is focused in products that can help elderly to have a more comfortable life while blending with the home environment. A Portable Assistive Lifting Seat is a real need for many people that require some extra help when standing up or sitting down. The main goal of this project is to design a cheap, safe, simple and light product that can assist people for reducing the effort that is required from them. The product must be comfortable, easy to transport and friendly to interact with. Considering a mass manufacturing perspective is very important to meet the previously formulated requirements. The force that the assistive seat releases must keep performing efficiently during the product service life. A locking system must be provided for avoiding the lifting force to act when the user is sitting, assisting only when it is demanded.

This Thesis describes the process of designing a concept for a Portable Assistive Lifting Seat involving different area such as ergonomics, semantics, manufacturing, mechanical engineering and materials science. The design approach in this case is driven by the Democratic Design Principles combining the human-centered design with a market perspective.

The result takes advantage of form and material for avoiding the need of any extra lifting mechanism. This solution is way simpler than any other one existing in the market and it integrates the solution for many different problems in one single piece. This simplification of the problem allows to reduce the production cost and helps to meet the intended requirements creating an innovative product for the market.

Keywords

Lifting seat
Locking mechanism
Plastic sheet
Democratic design
Product development
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Lars Eriksson: Program Coordinator and Professor at Jönköping University
1. Introduction

A product that can make people’s lives better by assisting them during the sitting down and standing up process, can be carried by the user during the daily routines and fits in the typical Scandinavian home environment.

Background

In most of Western countries we assist to a new phenomenon of a dramatic increase in the elderly population because of the baby-boom generation that was born after the Second World War and the longer life expectancy. There is an increasing need together with a growing market that are starting to demand products that fit with nowadays elderly from a functional and cultural perspective.

Aging involves a series of malfunctioning in the human body that reduce the person capabilities such as vision, hearing and motor capacity. For improving the life quality of elderly people, there are several products out in the market that try to correct the declining human body’s performance such as glasses, headsets, canes or wheelchairs.

The OMTÄNKSAM series is a new product line from IKEA that focus in designing products that can help elderly, but they can also fit in every home. One missing product in this Family is an assistive seat that helps people when sitting down and standing up. The related products out in the market are too expensive and fit within the orthopedic industry. IKEA intends to change this situation with an OMTÄNKSAM simple solution that improves the lives of the increasing elderly population.
Introduction

Purpose
The aim of this project is achieving a Portable Assistive Lifting Seat concept that fits within the OMTÄNKSAM series and the DEMOCRATIC DESIGN principles and can be tested through a functional prototype. The design must be driven through different fields:

- **Engineering:**
  - Materials Science
  - Mechanics
  - Manufacturing
- **Psychological:**
  - Semantics and Semiotics
  - Design Culture
  - Cognitive Ergonomics in Elderly
- **Physical:**
  - Physical Ergonomics in Elderly
  - Anthropometrics
  - Biomechanics

1.1.1 Research problem
Exploring all the possibilities for creating a portable product that assists people when seating down and standing up fulfilling the stakeholders’ requirements and the user needs.

1.1.2 Research questions

- What is the most suitable material and shape for a light, affordable, resistant and easy to transport product?
- How to avoid an institutional-orthopedic perception in favor of a more Scandinavian one?
- How to make the product comfortable and easy to use for elderly?

Organization information
IKEA is a worldwide renowned company based in Älmhult (Sweden) recognized for producing affordable designed furniture, appliances and home accessories. The company’s culture is defined as DEMOCRATIC DESIGN and it is supported in its 5 principles. Ikea was the first company introducing the ready-to-assemble strategy for reducing costs and improving logistics. Ikea’s design philosophy understands the product design and the product development as holistic approach.

![IKEA logo](image)
Introduction

Delimitations

The built prototype aims to be functional and show a behavior as close as possible to the designed product. However, there are some manufacturing limitations that cannot be achieved when delivering the result. These limitations are mostly connected with the use of a Vacuum Forming technology for prototyping instead of injection molding. The result is then a functional prototype as close to reality as the available means permitted.

The finalization of the refinement process would require some testing over the prototype to check the behavior in different case scenarios, so as some fatigue testing for validating the product Service Life within the IKEA parameters. It is understood that this second refinement process is not part of this Thesis goals, but it should be needed as a continuation in the product development.

The force released by the device must be between 200N and 300N. The final product would probably have instead different models and forces for fitting users.

Disposition

The project structure consists on the following sections:

S1. Introduction
   Provides the reader with general background about the thesis explaining the goals and motivation behind it.

S2. Theoretical background
   Includes some relevant information for being able to understand the project, creating a theoretical approach to it.

S3. Method
   Consist in a description of the different methods and techniques used for achieving the final result.

S4. Approach and Implementation.
   It describes how the methods described in S3 are implemented in the project, so as the coordination between the different ones.

S5. Result
   Description and explanation of the final result and the different parts that are involved on it.

S6. Discussion and Conclusions
   Conclusions and reflections about the project given from the authors personal perspective.

S7: References
   Listing of the sources of information that had been used for the project but not personally produced.

S8: Attachments
   Extra information from the project.
2. Theoretical background

2.1 Design Process

2.1.1 What is Design?

The origin of the term Design goes back to the Latin word “designare” and it is used as a verb in the sense “to designate” [1].

The Swedish Industrial Design Foundation, SVID, has the following definition: "Design is a process of developing purposeful and innovative solutions that embody functional and aesthetic demands based on the needs of the intended user. Design is applied in the development of goods, services, processes messages and environments.” [2]

Design has a large variety of fields in which is applied, but all of them share in common a process of Design Thinking that can lead to a plan that defines a solution for the intended issue.

2.1.2 Design Thinking

Design Thinking is a process directly connected with problem-solving. The process of Design Thinking can be developed through different methods as it is explained in 2.1.5 and 2.1.6. Design Thinking involves all the different parts of the process between the proposal of the problem until the proposal of the solution. Design Thinking is a flexible process, which means that it must be able to select and adapt the appropriate Methods depending on the specific problem in order to be effective.

2.1.3 Convergent thinking and Divergent thinking

The process of Design Thinking goes through different stages in which different kind of mindsets have to be applied. The range of mindsets oscillates between Creative thinking and Analytical thinking. This means that both are always applied but certain times the way of thinking leans more towards one end than another.

In the Psychology field, Joy Paul Guildford (1967) made a distinction between ways of thinking when solving problems corresponding with the names of Convergent Thinking and Divergent Thinking instead.

![Figure 3. Convergent and Divergent thinking](image)
2.1.3.1 Divergent thinking

“Divergent thinking is a thought process or method used to generate creative ideas by exploring many possible solutions and typically occurs in a spontaneous, free-flowing manner, such that many ideas are generated in a random, unorganized fashion. Many possible solutions are explored in a short amount of time, and unexpected connections are drawn.” [3]

2.1.3.2 Convergent thinking

“Convergent is oriented towards deriving the single best (or correct) answer to a clearly defined question. It has a strong emphasis on speed, accuracy, logic, and focuses on 11 accumulating information, recognizing the familiar, reapplying set techniques, and preserving the already known. It is based on familiarity with what is already known (i.e., knowledge) and is most effective in situations where a ready-made answer exists and needs simply to be recalled from stored information or worked out from what is already known by applying conventional and logical search, recognition and decision-making strategies. Convergent thinking is a style of thought that attempts to consider all available information and arrive at the single best possible answer.” [3]

2.1.3 Democratic design

(Democratic design is not a Design Thinking methodology, instead it is a system of values.)

“Democratic design comes from the IKEA perspective that everyone has the right to a better everyday life. Products developed from IKEA must meet the five dimensions of Democratic design.” [4]

Democratic design consists on finding the right balance for the five dimensions in order to make the designs feasible for the market.

An advantage of using the Democratic design is that it constantly drives Product design through an innovative pathway. Innovation is somehow enforced by the need of finding a balance between the five Dimensions of Democratic design.
2.1.4 Design Methods

2.1.4.1 Bootcamp Bootleg

The Bootcamp Bootleg is a method developed by the Stanford University that contains tools and techniques to be used during the Design Thinking process. These techniques are used following the process defined in Figure 5.

The Bootcamp Bootleg is the main method used during the current M.Sc. Thesis and is a cyclical process which may require several rounds through the different phases of the process for refining the result (These re-cycles affect the last three phases: Ideate, Prototype and Test).

- **Empathize**

  *Empathy is the foundation of a human-centered design process. To empathize, you:*
  - Observe. View users and their behavior in the context of their lives.
  - Engage. Interact with and interview users through both scheduled and short ‘intercept’ encounters.
  - Immerse. Experience what your user experiences. [5][Page 1]

  Empathizing is the first phase and has a great importance for reaching to an appropriate result. It consists in applying an open attitude to the understanding of the problem and the context.

- **Define**

  *The define mode is when you unpack and synthesize your empathy findings into compelling needs and insights, and scope a specific and meaningful challenge. It is a mode of “focus” rather than “flaring.” [5][Page 2]*

  Defining consist in materializing the understanding of the problem and the context. It is closely connected with convergent thinking and narrows down the problem as much as possible.
Method

- **Ideate**

  Mentally it represents a process of “going wide” in terms of concepts and outcomes—it is a mode of “flaring” rather than “focus.” The goal of ideation is to explore a wide solution space—both a large quantity of ideas and a diversity among those ideas. [5][Page 3]

  Ideating consist in creating possible solutions to the intended problem. It is closely connected with divergent thinking and expands the range of solutions as much as possible. After going as broad as possible, it requires an evaluation of the ideas for going forward into its implementation.

- **Prototype**

  Prototyping is getting ideas and explorations out of your head and into the physical world. A prototype can be anything that takes a physical form. [5][Page 4]

  Prototyping helps to get an idea to the next step in which more human interaction can take place. It increases the amount of knowledge and information about the design and it is a process of discovering itself.

- **Test**

  Testing is the chance to get feedback on your solutions, refine solutions to make them better, and continue to learn about your users. [5][Page 5]

  Testing is the final evaluation that is done after all the information from the Proposed idea is gathered together. It involves cognitive and physical interaction with the idea and it provides a very valuable feedback from it. After testing, a new cycle of Ideation, prototyping and Testing is started for refining or either completely redesigning. Several cycles must be applied for having a reliable and fulfilling result.

2.2 Human Factors

The international Ergonomics Association gives the following definition of Human Factors:

Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. Ergonomics helps harmonize things that interact with people in terms of people’s needs, abilities and limitations. [6]
Human Factors are organized in three different categories:

- **Physical Ergonomics**
  Physical Ergonomics are the Human Factors around the physical activity. They involve Anatomy, Physiology, Anthropometry and Biomechanics.
  
  - Anthropometry: Area of science that studies the human body measurements and proportions.
  
  - Biomechanics: Area of science that studies the mechanical interaction in biological systems.

- **Cognitive Ergonomics**
  Cognitive Ergonomics are the Human Factors around mental processes: perception, motor response, reasoning and memory. They affect all kind of interactions between the target person and its context. One of the most important fields within Cognitive Ergonomics is Semantics and Semiotics.
  
  - Semantics: Area of science that studies the meaning of things.
  
  - Semiotics: Area of science that studies symbols and signs.

- **Organizational Ergonomics**
  Organizational Ergonomics are the Human Factors around Social Structures. They affect the optimization and harmonization of their internal processes.

2.3 **Assistive technology**

Franklin D. Roosevelt, President of the United States of America from 1933 to 1945, was an iconic user of an assistive device (a wheelchair).

Assistive devices have been an important role through history while helping human beings with different degrees of disabilities to have as much life quality as possible. An assistive product can go from an object as simple and old as a cane to technologically advanced bionic arms.

Figure 6. Frank Delano Roosevelt in his famous wheelchair
There are three main evolving paths for the assistive products nowadays:

- **Highly Technological products**: They are very expensive, and they require to be customized for the user. This makes it impossible for them to be used as mass-consuming products. The target customer is an extreme user.

- **Classic Orthopedic and Prosthetic products**: They are expensive and mostly conceived from a medical and practical point of view. Mostly used by extreme users.

- **Omtänksam**: Omtänksam is the Family of products from Ikea that, as described before, tries to create product for the elderly population that help them in their daily life. They are affordable and treated from a mass-consuming perspective. A big difference with the Classic Orthopedic products is that aspects as semantics and the social interaction with the product are very important. This way, the new Omtänksam products bring the user to the closest stage to a “normal life”. In this case, the target customer is not an extreme user, but the average elderly population.

### 2.4 Assistive seats

![Assistant seat](image)

Figure 7. Assistive seat

Assistive seats belong to the category of Assistive products gathering around mobility. Assistive seats involve all kinds of devices that help people when sitting down, while sitting or/and when standing up by decreasing the necessary effort for doing the intended motion. There are many different types of assistive seats: Transport chairs, chair liners, booster seats, back supports, adaptative seats, lifting seats, lift chairs, etc.
2.5 Portable Assistive Lifting Seats

A Portable Assistive Lifting Seat (PALS) is a lightweight object that can be easily transported and gives some extra lifting force to the user when standing up reducing considerably the effort that the user needs to do. PALS also help users when sitting down by making the movement more progressive and safe. This kind of product can be used in most armchairs and sofas allowing a more autonomous and mobile life for those who need it.

This Thesis aims to develop a Portable Assistive Lifting Seat from an Omtänksam perspective.
3. Method

3.1 Gantt Chart
A Gantt chart one is of the tools used in Traditional Project Management. It breaks down the project into a Task List which is linked with a timeline. This way it is possible see how long it takes for each activity and when it is taking place in a very graphical and explicit way. It is possible to show the interaction between the different task, showing the flow.

3.2 Literature Review
A Literature Review takes place for gathering different information that will help to develop a project. The bibliography must be selected in a way that is connected to the project and brings to it a deeper contextual knowledge than the initial one.

3.3 Personas
“A persona, in user-centered design is a fictional character created to represent a user type that might use a site, brand, or product in a similar way.” [7]
A persona is helpful to make the target customer fit within the different stakeholders’ criteria, helping to drive the product development in a common way.
A persona helps to get deeper into the product understanding from a user perspective, being an optimal tool for empathizing.

3.4 Scenarios
“Scenarios are understood to be a small bespoke set of structured conceptual systems of equally plausible future contexts, often presented as narrative descriptions, manufactured for someone and for a purpose, typically to provide inputs for further work. Because scenarios are about the context or environment rather than the self, they are not about oneself or one’s actions but about what happens to one independent of agency. However, this also entails they are specifically for someone, as an environment entails the context that surrounds an individual. This actor-specificity is one characteristic that differentiates scenarios from forecasts, which are for anyone.” [8]
Basically, a scenario puts together different Personas participating in a common scene and gets the outcome of that interaction.

3.5 Semantic Analysis
As it is explained in 2.2, Semantics studies the meaning of things. The connection with an existing meaning is an event that happens just after perception takes place. Using descriptive tools such as Image Boards and Word Boards can help to tackle a Product Development project.
3.6 Competitor Product Analysis
Consists in analyzing and describing other similar competitor products in the market in order to get to know some of the strengths and weaknesses to overcome. A product data sheet should be made for each of the competitors describing the product parts, the way it is used, some user opinions, price, strengths and weaknesses.

3.7 Anthropometry Research
An Anthropometric Research consists on finding which are the dimensions of the human body that need to be known for developing the project. After identifying which are those dimensions, data must be collected and analyzed for getting the statistical percentiles that are significative for the project.

3.8 Biomechanical Study
A Biomechanical Study consist in the understanding and evaluation of certain kind of motion that involves specific parts of the human body. This study breaks the movement into different stages and simplifies the problem into a mechanic idealization that helps to have a better understanding. Even though the study is focus in the human body and the motion, it is possible to focus also in how the interaction is affected by different external element or objects.

3.9 Field Observation
“The purpose of a field report in the social sciences is to describe the observation of people, places, and/or events and to analyze that observation data in order to identify and categorize common themes in relation to the research problem underpinning the study. The content represents the researcher's interpretation of meaning found in data that has been gathered during one or more observational events.” [9]

3.10 User Observation
Consist in observing, taking notes and analyzing certain kind of User interaction helping to understand the whole process from a causal perspective.

3.11 Imageboard
An imageboard is a collage of different pictures that are selected around a topic. Depending on the goal, they can be done around specific aspects like mood, style, places, etc. Putting all the images together reduces to have a defined direction for a later analysis.

3.12 Product Benefits Specification
Product Benefits Specification is a Product Development technique developed by Patrick W. Jordan in his book “Designing Pleasurable Products” [10] that consists of listing in different categories the desired benefits for the outcome. The categories of benefits are Physio-pleasure, Socio-pleasure, Psycho-pleasure and Ideo-pleasure.
3.13 Interviews

Interviews are qualitative research techniques consisting on: “Conducting intensive individual interviews with a small number of respondents to explore their perspectives on a particular idea, program or situation”. [10]

There are three different formats of interviews: structured, semi-structured and unstructured [11]. However, only Structured ones were used for this project.

“Structured interviews consist of a series of pre-determined questions that all interviewees answer in the same order. Data analysis usually tends to be more straightforward because the researcher can compare and contrast different answers given to the same questions.” [11]

3.14 Specific Technical Research

A Specific Technical Research (STR) is the procedure of getting more knowledge about a specific issue. For doing that, different techniques of compelling data might be used. STR has been used during this project in different fields:

- Elderly Sitting Ergonomics
- Mechanical Locking Systems
- Upholstery
- Thermoplastic Materials: Using material Boards that compare the different characteristics among a group of possible materials aiming to choose the most adequate ones. (Software for retrieving data: CES Edupack)

3.15 Sketching

There are similar definitions of “Sketch” according to the Oxford dictionary:

- A rough or unfinished drawing or painting often made to assist in making a more finished picture. [1]
- A brief written or spoken account or description, giving only basic details. [1]
- A rough or unfinished version of any creative work. [1]

All the definitions empathize in the “degree of definition”. Sketches might be more or less defined, and their main intention is fast representation of certain information.

Two different kinds of sketching techniques have been used during this project:

- Hand sketching: With ballpoints, pens, pencils, rollers, markers, etc. Done over a paper surface.
- Digital sketching: Done in a Digital Sketching Pad (Wacom Cintiq) with the aid of the software Autodesk Sketchbook Pro 2018 and Adobe Photoshop CC 2017.
3.16 Prototyping

As it was explained in the Bootcamp Bootleg process (2.1.4.1): Prototyping is getting ideas and explorations out of your head and into the physical world. A prototype can be anything that takes a physical form. [5][Page 4]

There are many possible ways of “turning your head into the physical world” and the ones used during this M.Sc. Thesis are described below:

3.16.1 Mock-ups

“Mock-ups are used by designers mainly to acquire feedback from users about designs and design ideas early in the design process. Mock-ups are 'very early prototypes' made of cardboard or otherwise low-fidelity materials. The user, aided by the designer, may test the mock-up (imagining that it works) and thus provide valuable feedback about functionality/usability/understanding of the basic design idea/etc.” [13]

3.16.2 Computer Aided Design (CAD) modelling

“Computer-aided design (CAD) is the use of computer programs to create, modify, analyze and document two- or three-dimensional graphical representations of physical objects as an alternative to manual drafts and product prototypes. CAD is widely used in product and industrial design.” [14]

There are different kind of CAD software:

- Surface modelling CAD: Used for more complex geometries. It gives more freedom for definition but less flexibility for testing and redoing. It was used for few parts of the proposal. The software used was “Autodesk Alias AutoStudio 2016”.
- Solid modelling CAD: Used for most of the manufacturing goods in the market. It allows trying and testing reducing the amount of time that is needed to be spent on it. Even it is called Solid Modelling, it also allows to create Surface-based models but with a different kind of construction and definition. It was used in most of the parts of the projects. The software used was “Solidworks 2015”

3.16.3 Finite Elements Analysis (FEA)

“The Finite Element Analysis (FEA) is the simulation of any given physical phenomenon using the numerical technique called Finite Element Method (FEM). Engineers use it to reduce the number of physical prototypes and experiments and optimize components in their design phase to develop better products, faster.” [15]

FEA was a necessary tool during this project and assisted the development during different stages. The Simulation and Analysis Module of Solidworks was used for the Finite Element Analysis.
3.16.4 Rendering

“Rendering or image synthesis is the automatic process of generating a photorealistic or non-photorealistic image from a 2D or 3D model (or models in what collectively could be called a scene file) by means of computer programs. Also, the results of displaying such a model can be called a render. A scene file contains objects in a strictly defined language or data structure; it would contain geometry, viewpoint, texture, lighting, and shading information as a description of the virtual scene. The data contained in the scene file is then passed to a rendering program to be processed and output to a digital image or raster graphics image file.” [16]

The rendering Software used for this project was Keyshot 7, which is a very intuitive and easy to use. The program allows multiple operation for setting the desired scene and then getting an image as an outcome.

3.16.5 3-D Printing

“3D printing or additive manufacturing is a process of making three dimensional solid objects from a digital file.” [17]

“The creation of a 3D printed object is achieved using additive processes. In an additive process an object is created by laying down successive layers of material until the object is created. Each of these layers can be seen as a thinly sliced horizontal cross-section of the eventual object.” [17]

“3D printing is the opposite of subtractive manufacturing which is cutting out / hollowing out a piece of metal or plastic with for instance a milling machine.” [17]

“3D printing enables you to produce complex (functional) shapes using less material than traditional manufacturing methods.” [17]

The 3D printer used for this project was a Makerbot Replicator 2X and uses ABS filament. The Computer Aided Manufacturing (CAM) software used for preparing the files was Makerbot Print.

3.16.6 Computer Numerical Control (CNC) Milling

“CNC is a subtractive manufacturing process base on a computer numerical controlled (CNC) machining. Milling itself is a machining process similar to both drilling and cutting, and able to achieve many of the operations performed by cutting and drilling machines. Like drilling, milling uses a rotating cylindrical cutting tool. However, the cutter in a milling machine is able to move along multiple axes, and can create a variety of shapes, slots and holes. In addition, the work-piece is often moved across the milling tool in different directions, unlike the single axis motion of a drill.” [18]

For being able to CNC milling a piece, it is necessary to use a CAM program but, in this case, this process was carried out at Ikea HQ prototyping Lab.
3.16.7 Vacuum Forming

![Diagram of Vacuum Forming](image)

“Vacuum forming, the most basic process of thermoforming, is the process of heating a thermoplastic sheet to a forming temperature, positioning the plastic over a mold and allowing a vacuum of air between the plastic and the mold to suck the plastic over the mold to take its shape.” [19]

The Vacuum forming for this project has been done in collaboration with Prioplast, a Vacuum forming company based in Jönköping (Sweden).

3.16.8 Upholstering

Upholstering consists on applying over furniture all those parts that require some padding because of the direct contact with the user such as backrests, seats or armrests. The upholstery involves the use of diverse materials like padding or foam, spring coils, webbing, fabric, leather, fur, etcetera. The upholstery part plays an important role in the ergonomics of a furniture product.

3.16.9 Surface Finishing and Painting.

Surface finishing is the last Step on prototyping before assembling the pieces together. The goal of surface finishing is to achieve a surface quality as close as possible to the intended product. There are different steps in the Surface finishing and Painting:

- Rough sanding of possible imperfections.
- Applying spackle over possible gaps/holes.
- Applying a filler spray layer for covering pores
- Gradient sanding (120, 240, 400, 600, 800)
- Water gradient sanding (1000, 2000)
- Making paint tests apart
- Masking with tape if necessary
- 1st layer of Spray color painting
- 2nd layer of Spray color painting
- Applying a clearcoat spray layer if necessary.
4. Approach and Implementation

4.1 Project Planning

The initial step for facing the project was to create a planning using one of the most common Project Management (PM) tools: The Gantt Chart. Making a perfect estimation of how long every task would take by this time in the project was almost impossible but, nevertheless, it helped to establish time limits and to break the project down into a working structure.

This traditional PM strategy was completed by diverse techniques of Agile Project Management for a daily work basis.
4.2 Project Brief

After making the Project Planification, it was necessary to define the context, constrains, goals and purpose of the project. For doing so, a Project Brief was written as it is shown in Chapter 1. Introduction.

4.3 Empathize

The first phase of the project consisted on getting engaged with the project through a process of documentation and observation in order for getting a knowledge foundation that made possible to face the project in the most adequate way.

4.3.1 Literature Review

A critical reading of several books and articles helped to get more knowledge around different disciplines: semantics, ergonomics, UX, biomechanics, etc. The following list contains the Bibliography that was read at this initial phase of the project. References to these sources are given in other specific sections of this document.

- **Design Pleasurable Products. An introduction to the new human factors**  
  *Patrick W. Jordan 2000*

- **The Semantic Turn. A new foundation for design**  
  *Klaus Krippendorff 2006*

- **Design for Product Understanding. The Aesthetics of Design from a Semiotic Approach**  
  *Rune Monö 1997*

- **Sittmöblers Mätt**  
  *Erik Berglund. Möbelinstitutets rapport nr 50*

- **Ergonomics and Design. A reference Guide**  
  *Scott Openshaw & Erin Taylor 2006*

- **Sitting Biomechanics Part I**  
  *Donald D. Harrison 1999*

- **Ergonomics data and guidelines for the application of ISO/IEC Guide 71 to products and services to address the needs of older persons and persons with disabilities (ISO/TR 22411:2008)**  
  *SIS (Swedish Standard Institute) 2012*

- **Handbook of Human Factors and Ergonomics Methods**  
  *Neville Stanton, Alan Hedge, Karel Brookhuis, Eduardo Salas & Hal Hendrick 2005*

- **Advances in Occupational, Social, and Organizational Ergonomics**  
  *Peter Vink & Jussi Kantola, 2017 (pp.393-402)*
Findings and Analysis

• **Manufacturing processes for design professionals**  
  *Rob Thompson, 2007*

• **Shaping things**  
  *Bruce Sterling (MIT), 2005*

### 4.3.2 Personas

Personas are unique approaches to the target customers for the product is being designed. In this case, the ones used had already been deeply constructed by IKEA, while analyzing the OMTÅNKSAM family of products. However, since it is an internal document from IKEA, it cannot be shared in this Thesis.

### 4.3.3 Scenarios

Defining the Scenarios consisted in visualizing different hypothesis for the User Experience allowing to get a deeper knowledge of the interaction with the product and within the users. It was combined with some role playing to get familiar with the hypothesis. This method helped finding risks and opportunities that otherwise wouldn’t be considered. It also helped to wider approach to the product.

1. One day, an **old couple** receives Upplyft from their daughter because her dad already has problems for standing up by himself. They have been thinking for very long time about **buying a lifting chair**, but they wanted to **keep their beloved armchair** that has been together with them since they had their first child. They are afraid of using it because their armchair has **low armrests** and they are aware of **loosing balance** if the pushing effect is too strong because of not being able to keep in contact with the armrests during the whole process of standing up. Their daughter is also afraid of this risk and **considers returning** it to the shop.
2. A son decides to buy it for those occasions when his old mother is visiting him. The son’s apartment is very small, so he can’t fit a lift chair there. His intention is also to make his mother give it a try. She is quite reluctant to get new stuff, but she is starting to need some assistance during some periods because even though she is still independent, she has some severe arthritis problems and she can’t use her arms for helping when standing up because of an old shoulder injury. She finds it quite uncomfortable because, since she is sitting further up, she is not reaching the floor with her feet anymore and that also makes her feel having more pressure in the back part of her thighs. The son is living alone but he has a cat and he is afraid about possible accidents with the cat being smashed. Ironically, the cat loves the product as his shelter, feeling warm and protected there, it is his new favorite spot in the apartment.

3. A man gets his ankle broken and he returns home from the hospital with serious mobility problems. His wife, feeling helpless in the face of the situation, told her co-workers about her husband’s problem. One of them told her about a product her mother was using when visiting him which could help her husband. She brings one home and her husband is very happy about the extra help. However, after some time using it, he thinks he might be too heavy for the product since it feels too hard and uncomfortable during his long periods of sitting while recovering. In this way, he also thinks that he could need some more pushing effect than the one he is given.
4. An outgoing elderly couple who likes traveling around, buys it for visiting their daughter who does not have a lift chair as they do have at home for helping her father standing up (they normally spend a week there). They think that the product might be too heavy for carrying it around. One other reason why they bought it is because they also needed something specific for using in the kitchen chairs. A problem they see is that it does not adapt as good to the armchairs as to the kitchen chairs; tending to be more slippery. Also, some of their chairs have a small curvature and the product bounces there. They are an active couple, so they would like to take it to restaurants and public spaces without being embarrassed in front of their friends and other people.

5. A couple brings one of their mothers to live together with them because she feels very alone since his husband passed away. She needs some aid and it is getting worse as time goes by, but they don't want to change their home style keeping it as fresh as they always wanted it to be for their family. They care a lot about safety regarding their children and that is one of their main concern as customers. The wife also thinks it can be useful for her, since she is pregnant, and she knows that the last months before giving birth it is very difficult to stand up without help. The mother uses a cane and they are afraid of her losing balance after standing when aiming for getting it.
4.3.4 Semantic Analysis

The semantic analysis is based in the book: *The Semantic Turn. A new foundation for design*, Klaus Krippendorff 2006

Product semantics, through human centered design shows that meaning matters more than function:

“Humans do not see and act on the physical qualities of things, but on what they mean to them”

[20]

**Meaning-centered design:** sense, meaning and context.

- **Sense:**
  “Sense is the feeling of being in contact with the world without reflection, interpretation or explanation” [20].

  It involves all the senses: Seeing, meaning, touching, tasting, smelling, etc.

- **Meaning:**
  “Meaning restores perceived differences between what is sensed and what seems to be happening” [20].

  It is a way to remain in touch with a world that had become uncertain or in doubt. Artifacts mean their affordances, the set of their imaginable uses.

  Meaning is a structured space, a network of expected senses, a set of possibilities.

- **Context:**
  Context limits the number of meanings. What the designer aims for is a second order understanding: Understanding others understanding [20].

The following pages contain:

- An analysis of the traditional Orthopedic products' Semantics.
- An analysis of the Good Ikea products' Semantics
- A word-board confronting the previous two.
Findings and Analysis

What is perceived?

- **Colors:** Mainly black, grey, metallic and white. Some other core colors, generally cold.
- **Textures:** Plastic, aluminum, steel, leather and fabric.
- **Formal structure:** Fragmented, based in addiction, open volumes, discontinuity, symmetric, lack of formal hierarchy.
- **Usual parts:** Levers, wheels, handles, straps, pipes, holes, wires and adjusting mechanisms.

What are the meanings behind?

Uncontrolled complexity / Boring / Confusion / Insect / Hygienic / Safety / Medical / Objects to be hidden / Aid need / Institutional

Figure 16. Orthopedic Semantics
Findings and Analysis

What is perceived?

- **Colors:** White, black and pale colors. Materials shown in their natural colors.
- **Textures:** Plastic, aluminum, steel, leather, wood and fabric.
- **Formal structure:** Holistic intention, Merged forms, Soft form transitions, Minimal, Simple, Formal volumetric definition, Well defined hierarchy, Continuity.
- **Usual parts:** Merged transitions, Handles, Well defined borders and Dominant core forms.

What are the meanings behind?

Simplicity / Merged / Holistic design / Clean / Warm / Home / Clear / Light
Figure 18. Semantic word board
4.3.5 Competitor Products Analysis

Analyzing and describing other competitor products in the market allows to get to know some of the strengths and weaknesses to overcome. A product sheet has been made for each of the competitors describing the product parts, the way it is used, some user opinions, price, strengths and weaknesses.

- **Electrical lifters.**

**Description**

The lifting mechanism consists on an electric motor that allows to adjust and regulate the lifting process as it is wanted. The movement is progressive. The movement is activated manually by the user either with a lever or a remote controller.

<table>
<thead>
<tr>
<th>Parts</th>
<th>Lifting capacity</th>
<th>100% lift for up to 135 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lifting capacity</strong></td>
<td>100% lift for up to 135 kg</td>
<td></td>
</tr>
<tr>
<td><strong>Dimensions</strong></td>
<td>500/480 x 500/430 x 105 mm</td>
<td></td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>7700 g</td>
<td></td>
</tr>
<tr>
<td><strong>Price</strong></td>
<td>100-130€-150 (online, not retail)</td>
<td></td>
</tr>
<tr>
<td><strong>Rating</strong></td>
<td>3/5 (U-Shaped distribution)</td>
<td></td>
</tr>
<tr>
<td><strong>Defective Units</strong></td>
<td>18% (Initially defective + After some use)</td>
<td></td>
</tr>
</tbody>
</table>
Findings and Analysis

Appearance

Customer Profiles

- Daughter that buys it for her parents or grandparents.
- Son buys for those occasions when his mother is visiting.
- An elderly couple buys it for visiting their daughter who does not have a lift chair as their one.
- Person buys it after a surgery in order to have more independence while recovering himself.
- Person with knee problems.
- Person with an occasional injury as a sprain or broken ankle.
- Old person that doesn’t want to change his old chair for a medical lift chair (strong emotional connection).
- People suffering from neurodegenerative diseases like Multiple Sclerosis, Parkinson and Amyotrophic Lateral Sclerosis.
- Customers owning a lifting chair but still need some help at other places such as the kitchen.

Positive reviews

- Allows more independence for users.
- The user likes the fixed remote control.
- Easy and slow.
- Progressive.
- Solves problem with kitchen chairs (no lift chairs)

The current extracts from reviews belong to analysis from the U.S.A market. Cultural factors might be taken into consideration.
The current extracts from reviews belong to analysis from the U.S.A market. Cultural factors might be taken into consideration.

- Works better with Low chairs. Especially for small people.
- Too noisy.
- The seat is too high > feet not touching the floor.
- The seat is level with the armrests in a way that it is not possible to use the armrests to balance yourself out of the chair.
- There is an angle compatibility problem when used with recliner chairs.
- Easy to roll off to one side for elderly people.
- Watch where you place your hands. They can be pinched if holding onto the sides of the seat.
- The discomfort is caused by the irregular bumps in the base seat plate under the foam padding (user with severe arthritis in the hips).
- Uncomfortable. It made her tip over.
- Uncomfortable cushion.
- Some user putting a small pad over it.
- Low quality handles.
- Hard as a rock.
- It can’t be used outside (garden, car…) because of being electric.
- Heavy for elderly.
- Power handles seem fragile. Weak and dysfunctional switchers.
- It doesn’t work well in upholstered furniture: It works better on a hard surface like a wooden chair.
- Hard, needs a cushion. Not possible to sit there the whole day.
- Even adding 10cm extra or cushioning seemed too hard (shape related issue).
- The 20” model fills the whole seat and gives more stability than the 17”.
- Arms of the chair too low for standing up.
- 90kg user: The mechanism loses strength over time.
- Very hard: Back pain and Sacrum pain.
- Too high in the chair and easy to slide forward.
- Too bulky, make it more compact.
- Problem with height for those over 180cm.
- Too heavy to carry it around.
- Need of a stable surface to be placed on.
- Requires a hard surface to be placed on.

Table 1. Competitors 1
• **Gas Spring lifters.**

**Des.** The lifting mechanism is based in a gas spring that can be adjustable by changing the angle. The user activates it with his natural movement while sitting down and standing up.

**Parts**

- **Polyester cover + Polyurethane foam**
- **Adjustable Strength**
- **Gas spring**
- **Handle**

**Figure 21. Lifting Seat 03**

<table>
<thead>
<tr>
<th>Lift.</th>
<th>70% lift for up to 150 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dim.</td>
<td>480x430x105mm</td>
</tr>
<tr>
<td>Weight</td>
<td>4100g</td>
</tr>
</tbody>
</table>

**UK market:** This kind of product is Tax Relief. No VAT is paid. (online, not retail)

**Price**
- Low quality lifting mechanism: 45-65€
- High quality lifting mechanism: 160-170€

**USA market:** 70-110€ (Low quality not found) (online, not retail)

**Rating** 3/5 (Triangle distribution)

**Defective Units** Not significant amount: Problems are generally related to User Interaction and to the adjustment of the strength.

**Figure 23. Lifting Seats**

- **High Quality**
- **Low Quality**
Findings and Analysis

Customer Profiles

- User doesn’t have room for a special chair unless getting rid of an expensive sofa.
- User buys it because it allows going on holiday with her husband.
- Bought for being used in the user’s wheelchair.
- Several users with shoulders and hand injuries that can’t use their arms for supporting while standing up.
- Person with arthritis.
- Bought for father with MS.
- Bought of person that suffered a stroke.
- A user gets 4 of them for using at different spots around the house.

Positive reviews

- Great aid for user with arthritis.
- Helps a lot for sitting down softly.
- It makes her feel more independent.
- The higher sitting position helps a lot for standing.
- It seems that the armrest is less important in this lifter than in the electric one because the movement is faster (more natural) and easier to balance.

Negative reviews

- Too heavy to move.
- It doesn’t work for recliners.
- Problems for weight adjustment.
- Instructions are difficult to understand for elderly.
- Uncomfortable.
- Not as flexible as expected.
- Difficult to understand how to start using it.
- Tricky to adjust it.
- Needs to be close to the seat edge.
- Better if larger and softer.
- Too strong even in the lowest strength.
- Felt like perching on the chair.
- Accident! When she dropped something off the floor and bent over to pick it up, she activated the mechanism.
- The adjusting area has everything painted in black color, making it difficult to see how to switch the strength.
- It looks a little bit embarrassing when used out.
- Not comfortable for long time use.
- Feels like a catapult without armrests.

Table 2. Competitors 2
Findings and Analysis

The following products are not real competitors, but instead, useful products to analyze for related functions.

- **Ergonomic Seat Cushions.**

  **Description**
  Gripping rubber bottom, breathable mesh fabric, removable cover with zipper, memory foam, ergonomic shape and antibacterial.

  **Parts**
  - Curved Shape Fits Contours Of Legs
  - High-Density Memory Foam
  - Scooped Out Seat Provides Hip Support & Increased Blood Flow
  - Raised Back Promotes Proper Spine Alignment
  - Ventilation gap for genitals
  - High density memory foam
  - Curvature for a firm hold on the buttock
  - Heightened rear end improves caudal pressure
  - Material that allows for cool air flow
  - Shape to fit the contour of your legs

  **Dimensions**
  400/450-355-75/100mm

  **Weight**
  800-1000 g

  **Price**
  20-25 €

  **Rating**
  4.5/5

  **Appearance**

  Figure 24. Ergo-cushion 1

  Figure 25. Ergo-cushion 2

  **Positive reviews**
  - Very supportive.
  - Very comfortable.
  - Makes a different for the lower back.
  - Takes the pressure off your back.
  - Cuts off circulation mid-thigh.
Findings and Analysis

Negative reviews

- It needs something to keep it in place.
- Memory foam tends to get flat.
- Difficult to know what is the front side and the back one.
- Feels like you are sliding forward out of your chair.
- The foam was too thick and being memory foam it gets uncomfortably stiff when it is cold (because of A.C.)

Table 3. Competitors 3

- Swivel cushions.

<table>
<thead>
<tr>
<th>Description</th>
<th>The cushion is separated from the base, so it can spin around the main axis. This way it helps people with mobility problems to be able to rotate easily. It has an anti-slip rubber base, memory foam cushion and removable cover.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions</td>
<td>Ø380x60 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>1040 g</td>
</tr>
<tr>
<td>Price</td>
<td>28 €</td>
</tr>
</tbody>
</table>

Appearance

Figures 26 & 27. Swivel 1&2

Table 4. Competitors 4

Analyzing the products and, especially the customer’s reviews, introduced in the Design Thinking process new aspects that were not considered until then.
4.3.6 Anthropometric Research

Designing a product for our target group requires to check the Human Body Measurements connected with our focus area. The data has been collected from the program “People Size, 2008” and the sample is taken from British Males and Females 40 to 65 years old. The reason for not taking +65 is that it wasn’t available for all the required body measurements. However, the difference from some parts was checked afterwards resulting always inferior to +/- 10mm for our case study. The selected percentiles have been the 5th and 95th.

<table>
<thead>
<tr>
<th>BODY PART</th>
<th>MALE (5th -95th)</th>
<th>FEMALE (5th -95th)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-A’ Hip breadth (Max.), sitting</td>
<td>341-433</td>
<td>346-466</td>
</tr>
<tr>
<td>B-B’ Buttock to back of knee, sitting</td>
<td>455-554</td>
<td>437-532</td>
</tr>
<tr>
<td>C-C’ Knee to knee breadth, sitting</td>
<td>180-225</td>
<td>177-226</td>
</tr>
<tr>
<td>D-D’ Seat height (lower legs vertical &amp; thigh horizontal)</td>
<td>381-468</td>
<td>353-440</td>
</tr>
<tr>
<td>E-E’ Rear of buttock to rear of Ischia, sitting</td>
<td>62-91</td>
<td>65-103</td>
</tr>
<tr>
<td>F-F’ Edge of Ischia to lateral surface of thigh, sitting</td>
<td>111-160</td>
<td>98-157</td>
</tr>
<tr>
<td>G-G’ Ischia Breadth, sitting</td>
<td>26-35</td>
<td>23-32</td>
</tr>
<tr>
<td>H-H’ Ischia Length, sitting</td>
<td>39-51</td>
<td>38-50</td>
</tr>
</tbody>
</table>

Table 5. Body measurements

Figure 28. Body Measurements
4.3.7 Biomechanical Study

When aiming for designing an assistive seat; it is necessary to understand the motion that is involved. For getting the necessary information, some subjects were asked to stand up both from an armchair and a dining chair. The subjects considered are a man (26) and a woman (22) and they were not conditionate to move in any specific manner. Since the spectrum of age, sizes and types of users is not as wide as possible, the results of the study will be just considered for a further analysis. Another relevant consideration is the lack of tests in a dining chair without armrests.

Figure 29. Biomechanical studies
Findings and Analysis

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>The user has a low counter-balance, keeping close to the vertical axis during the process. The body proportions are average, and the armrest don’t affect too much the movement. Smooth transition. <strong>A5</strong> shows the user already moving before completely standing up.</td>
<td>The user has a long torso, so as long extremities that enable a big counter-balance while standing up. The armrests allow a more tilted and extreme motion when standing up. <strong>B1</strong> seems quite extreme <strong>B5</strong> shows the legs keep inclination inwards.</td>
<td>The counter-balance effect is smaller because of the bigger angle for the sitting position. Armrests are very important for the motion even though the initial handling is quite far from the user. <strong>C1-C2</strong> is a position adjustment before standing up. In <strong>C3 and C4</strong> the armrest is used.</td>
</tr>
</tbody>
</table>

The detail study intends to know what the most suitable angle for the sheet would be for bending considering the support that is given back to the user while standing up.

Table 6. Biomechanical Study

### 4.3.8 Field Observation

The process consisted in a critical visit to Ikea where I focus in important aspects for the on-going project like similar products, different ergonomic strategies, and interesting materials/shapes. The obtained information is objective and qualitative, but it is important for empathizing with the brand and the aimed product.

- Images **01,02,03** and **04** represent **BYLLAN**, a product with many functional similarities to the one we are aiming for. I tested the product, and the ergonomics where not completely bad, even the position was not the best. It was difficult to move on it and to choose the appropriate position for having it (01). A good characteristic of the product is the weight (seems very light). Construction wise, in general I would say the quality is very low, specially in the integration of the cushion with the solid case, where it feels weak and even unsafe. However, there are some interesting features:

1. How the gripping surface is achieved through the molding methodology (03).
2. How the button socket is also solved with the same strategy (04).
3. The easy solution for the handle.
4. The good way of hiding the zipper for the removable cover.
Figure 30. Field observation
Images 05, 06, 07 and 08 represent different chairs with a solid finishing (no cushioning included) where ergonomics were checked.

In image 05 we can see two similar chairs with small visual differences in the form but huge differences in the ergonomics. The white chair (SNILLE) has a more extreme curvature for side support which in my case (not a 5th percentile user) makes it very uncomfortable to sit in, since my legs felt pressed from the sides. On the other hand, the black chair (SKÅLBERG) has excellent ergonomics without being so constrictive to the side. The user can notice a big increase in the comfort because of the smooth curvature and it is adapted to most of the users. The finishing in the black one tends to be matt and rough while in the white one is glossy and very smooth. The user can notice this because it makes the white one more slippery.

The image 08 shows the model FANBYN and it is probably one of the most slippery chairs I ever tried. It was very uncomfortable to use from the very beginning, slipping down just after replacing myself in the proper spot. Again, this is caused because of the lumbar curvature and the glossy finishing.

The images 09 and 10 show the process of testing the JUSTINA pad (t: 40mm) over a rigid chair. This experiment was very interesting because volumetrically wise, I didn’t want to use more than 40-50mm cushioning. I didn’t use it for very long time and that should be considered. But with that said, I must say that the experience was quite comfortable showing that it is possible to achieve a comfortable cushioning over a hard surface for short time with less than 50 mm.

The image 11 shows a VARIERA tray which has a wavy shape. When trying to bend it in both directions I could appreciate the huge stiffness it gets in the long side. A similar strategy could be applied for the UPPSVING design.

Finally, Images 12 and 13 show the bending process over a laminated veneer product. Even it can stand the bending very well, I would say it feels fragile at certain point. Of course, the product was not designed for bending, which means that the glue used between layers is probably a stiff epoxy resin that doesn’t allow the deformation instead of a silicon-based glue.
4.3.9 User Observation

To get a better understanding of the needs of the elderly and their opinions regarding a moving armrest a discussion is held together with an 85-year old woman. Physically she is in good shape, but with a worn-out hip joint, which forces her to move slowly and stiff. Personally, she does not reflect over her way of sitting down and rising, since she says that “it all hurts no matter how she does it”. When seeing her sit down in her own arm chair the first thing to notice is that even though the seat is quite deep, she only sits on the tip of the seat, leaning in a large angle back against the backrest. Three pillows are put behind her in order to provide support. When asked to stand up she leans forward with a firm grip of the armrests, putting a major part of the force on the armrests to relieve the hurting hip. The lack of space underneath the seat and short armrests of the chair prevents her from moving forward and sliding her feet below the chair, making the rising vertical. This puts even more force on the armrest and requires them to be very stable and have good gripping surfaces. These might be reasons why she does not prefer a solution using movable armrests. The idea of an assisting seat is though something she is very positive to.

Figure 31. User Observation

| Need of armrest | Legs as close as possible to the armchair | Difficulties to bend forward because of the position of the Centre of Gravity | Forced into a straight up movement |
4.3.10 User Observation

The following analysis is based in the theory contained in the book: Designing Pleasurable Products (Patrick W. Jordan, 2002)

- **Color**: The main color scale varies in a scale between cold grays and navy blues keeping a neutral and mature image of the products.

- **Form**: The soft curvature with big radius predominates with some connections with almost straight lines. Textures are quite relevant both in fabrics (grained) and in rubber (extra gripping elements). Seaming (*double welt seam*) strategy is normally mirrored and placed in edges.

- **Sound**: The kind of product materials and connection with mature users aims for SILENCE as a core value of the product.

- **Product Graphics**: NONE or HIDDEN

- **Materials**: Filling foams (Polyester 35kg/m³, Memory foam 50kg/m³, High-resilient polyether cold foam 38kg/m³), Solid Wood, ABS Plastic, Silicon Rubber and Fabric (65% Polyester 35% cotton).
• **Interaction Design**: This product series intends to have the easiest possible interaction with the product, having a clear reference (avoiding contradictions) about how they should be used.

Figure 35. Omtänksam Image Board
Figure 36. Omtänksam Image Board 2
4.3.11 Interviews

Conducting a structured interview with a target person helped to get selected information we would like to know (generally qualitative). Interviews were conducted with experts in Ergonomics/biomechanics, Elderly interaction and Materials engineering. The questions for these interviews are contained as an Attachment in Section 8.1 Questions for Interviews.

<table>
<thead>
<tr>
<th>Name</th>
<th>Occupation</th>
<th>Materials and Manufacturing Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juan Carlos Hernando</td>
<td>Ph.D. Student. Materials + Manufacturing</td>
<td></td>
</tr>
<tr>
<td>Mirza Cenanovic</td>
<td>Researcher. Simulation + Optimization</td>
<td>Martin Riestra</td>
</tr>
<tr>
<td>Martin Riestra</td>
<td>Product Development Engineer at IKEA</td>
<td></td>
</tr>
</tbody>
</table>

**Q1**
- **B**
  - But maybe minimize flat areas. Avoid A because of stress concentration close to the folding edge.
- **B**
  - Because it is easier to adjust during the optimization process and seems easier to manufacture. A is too constricted by the design.
- **A**
  - No justification given.

**Q2**
- **A combination of A and B**
  - Adding a small curvature upwards in the perimeter of B.
- **B**
  - There are only 2 possible solutions: Either increase the Young modulus or the thickness around the radius.
- No justification given.

**Q3**
- I would consider the possibilities for the material finishing before selecting it. It conditionate the further design.
- No
- Availability

**Q4**
- **Laminated Veneer** for aesthetical reasons or **Polyamide** because of the weight.
- **Steel Alloy** because of having the biggest Young Modulus. Otherwise, a possible laminated construction using elastic glue.
- Laminated Veneer. Ikea has very nice designs in plywood matching the rest of the range.

**Q5**
- **No**
  - Because of the stress concentration.
- **No**
  - Because of the stress concentration.
- The main concern here would be Flat packaging. Not necessarily different material, there can be different parts of the same material.
Conclusions: Avoid stress concentration, E as main property for fatigue, finishing possibilities for matching the rest of the range (IKEA family), Flat packaging. Adjustability for optimization is very important, possibility of stacking and mass transporting, ease of manufacturing and availability.

ERGONOMICS & BIOMECHANICS

<table>
<thead>
<tr>
<th>Name</th>
<th>Sara Kallin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupation</td>
<td>M.Sc. Prosthetics &amp; Orthotics</td>
</tr>
<tr>
<td></td>
<td>Ph.D. Student. Prosthetics &amp; Orthotics</td>
</tr>
<tr>
<td>Q1</td>
<td>2 Kg. It depends on the generated momentum (shape factor), the handling and the comfort.</td>
</tr>
<tr>
<td>Q2</td>
<td><strong>A or B. Not C.</strong> B is more universal (focus in the handle ergonomics). A is helpful for users with clutches.</td>
</tr>
<tr>
<td>Q3</td>
<td><strong>B.</strong> Flat sheet + Saddle cushion because it doesn’t constrict the user, but it helps to adapt to the human anatomy. It is also important to have the front saddle curvature to avoid sliding forward.</td>
</tr>
</tbody>
</table>
| Q4         | • Avoid sharp edges, sharp spots and big discontinuities in the surface.  
           | • Surface finishing: The Friction shouldn’t be too little nor too much (multilayered friction).  
           | • Temperature. |
| Q5         | **Not sure.** It depends on several parameters like weight, kind of foam, time of use. |
| Q6         | **B.** Curved corner to dissipate stress better but avoid putting too much material on the corner, so it doesn’t press the back of the knee. |
| Q7         | **Pressing.** Specially from a cognitive point of view: when we stand up we use armrests for pressing down when standing up. |
| Q8         | **Corner.** It is the easiest for reaching, also from a safety perspective. |
| Q9         | The main problem is that it only fits for very specific body dimension, being uncomfortable for all the rest. It is also problematic because it does not allow users to move around the seat, making it uncomfortable after a while. |
| Q10        | Excessive lateral support is mostly problematic unless for extreme users. |
| Q11 | For users with a hip replacement it is important to keep an angle over 90° between the torso and the legs. Abductor movements should be controlled. |
| Q12 | The back curvature can limit the movement of some users and feel uncomfortable. |
| Q13 | Both the elevated curvature and the gap in the back are not suitable for all the users. If a more universal target group is aimed, a light curvature might be more adequate. |
| Q14 | Good Luck! |

Table 8. Answers ergonomics

**Conclusions:** *Light, avoid sharp edges and spots, cognitive ergonomics for the unlocking system, put special attention to the Ischial tuberosities’ area for increasing comfort. Ensure support in the whole area and make sure that the design is as universal as possible.*
4.3.12 Specific Technical Research
This chapter contains further research in those areas where more knowledge was required. Some of the present information contains whole fragments from the origin source in this format “Text in Italic”

4.3.12.1 Elderly Sitting Ergonomics

- Advances in Occupational, Social, and Organizational Ergonomics
  1. Peter Vink & Jussi Kantola, 2017 (pp.393-402) [21]

“The Evaluation of an assistive chair design for the elderly” is a similar experiment to the one concerning the current project and was conducted by Chiwu Huang to analyze the difficulties in sit-to-stand and stand-to-sit maneuvers for elderly. That experiment proposed the use of an assistive device underneath the seat as a hypothetical solution for that problem. For conducting a scientific study two identical prototypes were built with a difference:

![Chair A](image1) ![Chair B](image2)

*Chair A. It has an assistive device.  Chair B. No assistive device.*

In order to measure the effectiveness of the assistive device two groups of elderly subjects were asked to test the chairs. The result showed that 80% felt a better mobility. The ones using chair A also took shorter time for getting up and sitting down. The average leaning angle was found to be much smaller in Chair A than in Chair B.

![Figure 39: Leaning Angle](image3)
Findings and Analysis

- **Ergonomics and Design. A reference Guide**  
  *Scott Openshaw & Erin Taylor, 2006 [22]*

  o “Natural Range of Motion” (ROM), p. 18: Zone 0 allows for a better comfort in motion because of the increase in flexibility and blood flow. The body minimizes stress over the locomotor system.

  ![Figure 40. Natural range of motion](image)

  o *Chair Controls*, p. 26: They should be few and intuitive.

<table>
<thead>
<tr>
<th>Type of knob</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round knob</td>
<td>Should be turned</td>
</tr>
<tr>
<td>Flat lever</td>
<td>Should be pulled-pushed</td>
</tr>
</tbody>
</table>

55
Controls must be easy to manipulate, without forcing into a difficult grip and having enough clearance space.

- Ergonomics data and guidelines for the application of ISO/IEC Guide 71 to products and services to address the needs of older persons and persons with disabilities (ISO/TR 22411:2008)
  SIS (Swedish Standard Institute) 2012 [23]
  
  o Factors to consider with Design Guidelines, p.7: It is very important to present the information via different senses, but also via different aspects of the same sense.
  o Distinctive form, p.35: A distinctive form helps to identify through touching, so as visually. Distinctive forms also help to differentiate between parts of the same product.
  o Easy of handling, p.36: The size, form and mass of a product affect how easy it is to lift, hold and carry. Special focus on table 8 of the referenced book — Aspects of handling for ease of use
  o Controls handling, p.38: Twisting, turning, pushing or pulling can be a problem for users with impairments. Aspect to consider when designing the controls:
    - Comfortable grip.
    - Avoid twisting of the wrist.
    - Minimize number of actions.
    - Offer minimal resistance.
    - Textured surface increase friction when applicating the force and increase tactile feedback.
    - Easy to reach.
    - Avoid combined movements (e.g. pressing and turning).
  o Surface finish, p.61: The use of textures is very important for achieving non-slippery surfaces that aid gripping and manipulating. Sharp points and edges should be avoided.
  o Principles of Accessible Design, p.134:
    - Principle 1: Equitable use
    - Principle 2: Flexibility in use
    - Principle 3: Simple and intuitive use
    - Principle 4: Perceptible information
    - Principle 5: Tolerance for error
    - Principle 6: Low physical effort
    - Principle 7: Size and space for approach and use
Schoberth classified postures depending on the location of the Gravity Center in 1962. The average pelvis rotation for standing up is 40 degrees.

A, B > 25% (of the weight is transmitted to the floor)  C 25%  D <25%

It is preferred to provide a backward movement of the legs of c. 60 degrees to the floor when standing up.
4.3.12.2 Mechanical Locking Systems

An analysis of existing locking mechanisms has been made for reaching an overall understanding of the different locking strategies. The selection of mechanisms was based in different factors: For example, *folding knives* and *snap hooks* are very good reference products because they lock automatically, and they are exposed to big loads. Both examples are also easy and intuitive to unlock. Other locks have been chosen because of having a distinct motion, a specific geometric strategy or because of their simplicity.

- **Frame lock - Liner lock:** Very simple mechanism with just 2 main parts. Geometry is very important. Very strong system. Unlock is based in as side force that releases the blade.

- **Snap hook lock:** A system that allows a smooth lock and resistant enough for human body loads. Based in a spring and a closed geometry.

- **Back lock & button lock:** Consists mainly in a spring lever, a pivot point and well-defined geometry. Easy to activate but more components. Button lock is one of the simplest solutions which consist in a button that contains a spring and is able to lock automatically when it is not pressed.
• **Pinion-Rack lock:** It can be very smooth and progressive. With a proper strategy, the rack can be used as a pulling lock without needing necessary a pinion.

![Figure 46. Pinion-Rack lock](image)

• **Sliding lock:** Sliding motions are simple strategies for lock requiring low technology, normally based in a geometric factor.

![Figure 47. Sliding locks](image)

• **Twist lock:** It is not a common strategy for locking, but it seemed interesting enough for considering it as possibility. The main advantages are simplicity and stress dissipation.

![Figure 48. Twist lock](image)
## 4.3.13.3 Upholstery

<table>
<thead>
<tr>
<th>UPHOLSTERY FOAMS</th>
<th>DENSITY:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LDF</strong> LOW DENSITY FOAMS</td>
<td>There is a strong connection between density and &quot;temperature sensitivity&quot;.</td>
</tr>
<tr>
<td></td>
<td>- Soft and instantly react to the user's body.</td>
</tr>
<tr>
<td></td>
<td>- They tend to deteriorate faster (cheaper).</td>
</tr>
<tr>
<td></td>
<td>- Temperature changes don't significantly affect their conforming abilities.</td>
</tr>
<tr>
<td></td>
<td>- <strong>Convectional Polyfoam:</strong> Less than 1.5 PCF</td>
</tr>
<tr>
<td><strong>MDF</strong> MEDIUM DENSITY FOAMS</td>
<td>Performs within in between a range of values in:</td>
</tr>
<tr>
<td></td>
<td>- Firmness.</td>
</tr>
<tr>
<td></td>
<td>- Durability.</td>
</tr>
<tr>
<td></td>
<td>- Costs.</td>
</tr>
<tr>
<td></td>
<td>- Performance.</td>
</tr>
<tr>
<td></td>
<td>- <strong>Convectional Polyfoam:</strong> 1.5 to 1.8 PCF</td>
</tr>
<tr>
<td><strong>HDF</strong> HIGH DENSITY FOAMS</td>
<td>- Firmer and adapt slower to the user's body.</td>
</tr>
<tr>
<td></td>
<td>- Longevity.</td>
</tr>
<tr>
<td></td>
<td>- More expensive.</td>
</tr>
<tr>
<td></td>
<td>- It is the most temperature sensitive because it conforms very closely when it is warm and offers little to no conforming when it is cold.</td>
</tr>
<tr>
<td></td>
<td>-<strong>Convectional Polyfoam:</strong> More than 1.8 PCF</td>
</tr>
</tbody>
</table>

### COMPRESSION:

**OPEN CELL**
- Open pores allow water and air to flow through easily.
- Comfortable.
- Cool for seating.
- Low maintenance.

**CLOSED CELL**
- Not absorbent.
- Made from PVN. Firmer than Polyurethane.
- More expensive.
- Floats.
- Normally used as a sheet underneath the other foam for increasing the support in the cushion.

### TYPES

**POLYURETHANE (PUR, PU)**
- Most common.
  - Less heat accumulation.
  - Less affected by cold temperatures.
  - Soft and flexible.
  - Better performance in wet environments.

**POLYETHER**
- Higher tensile strength.
- Harder.
- Good for textile applications.

**POLYESTER**
- Higher tensile strength.
- Harder.
- Good for textile applications.

**VISCOELASTIC (Memory Foam / Slow Recovery Foam)**
Findings and Analysis

- HDMF Softens in reaction to body heat. It is the standard for orthopedic uses. (Problem with weight)
- Denser.
- Open cell structure.
- Helps to relieve pressure points.

**NATURAL FOAM**
(Latex)
- Natural from rubber tree.
- Resistant to bacteria, mildew and mold.
- High density (c. 6PCF).
- Long lasting.
- Biodegradable

PCF = Pound per Cubic Foot (American Foam Industry Standards) 1PCF = 16.02 Kg/m³
Recommended Foam Firmness for a Dining Chair Slip Seat: 1”>>45-50 ILD 2”>>30-35 ILD

### 4.3.13.4 Thermoplastic materials

It consists on comparing different characteristic that are important for the project among a group of possible materials aiming to choose the most adequate ones. The material selection involves both sheets, cushioning system, locking system, gripping surface, fabric... This research method has 3 different stages:

- Material chart using CES software and all the subsequent analysis.
- Research on similar object with similar mechanical requirements to check their material selection.
- Simulation of a same hypotheses and scenario with different materials to check the different behaviors (it is acceptable to play around with thickness).

<table>
<thead>
<tr>
<th>Typical uses</th>
<th>Age-Hardening Wrought Al-Alloys</th>
<th>Low Alloy Steels</th>
<th>Polyamides</th>
<th>Oak Along Grain (Hardwood)</th>
<th>Pine Along Grain (Softwood)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Density (Kg/m³)</strong></td>
<td>2500-2900</td>
<td>7800-7900</td>
<td>1120-1140</td>
<td>850-1030</td>
<td>440-600</td>
</tr>
<tr>
<td><strong>Price (USD/Kg)</strong></td>
<td>1,9-2</td>
<td>0,69-0,82</td>
<td>2,58-2,8</td>
<td>0,66-0,73</td>
<td>0,67-1,34</td>
</tr>
<tr>
<td><strong>Young Modulus (GPa)</strong></td>
<td>68-80</td>
<td>205-217</td>
<td>2,62-3,2</td>
<td>20,6-25,2</td>
<td>8,4-10,3</td>
</tr>
<tr>
<td><strong>Yield Strength (MPa)</strong></td>
<td>95-610</td>
<td>400-1500</td>
<td>50-94.8</td>
<td>43-52</td>
<td>60-100</td>
</tr>
<tr>
<td><strong>Fatigue Strength at 10⁷ cycles (MPa)</strong></td>
<td>57-210</td>
<td>248-700</td>
<td>36-66</td>
<td>42-52</td>
<td>19-23</td>
</tr>
<tr>
<td><strong>Recyclability</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>CO₂ Rec. Footprint (Kg/Kg)</strong></td>
<td>2,63-2,91</td>
<td>0,606-0,669</td>
<td>3,17-3,5</td>
<td>Usable as combustion</td>
<td>Usable as combustion</td>
</tr>
</tbody>
</table>

Table 9. Upholstery

Table 10. Mechanical properties of materials
Thoughts from the comparison:

- Veneer: Possible problem with wood properties Across Grain.
- Mechanical, ecological and price wise, Low Alloy Steels are by far the best. The real challenge using them is to reduce the weight as much as possible. The weight ratio is 1/7 with polyamide and 1/3 with aluminum. However, the thickness of the sheet is probably not going to reduce in the same proportion which means that some lightening strategies will be required in the design. The fact that the low alloy steels are used for springs, bearing, gears and knives is a good indicator of how great the fatigue behavior is in this material.
4.4 Define

The current project consists on a Real Product Development process and because of this, the “Define” stage might be retaken in separate parts of the process without having finished yet the Bootcamp Bootleg Cycle. This way of proceeding is done in order to maximize productivity and for not blocking the development.

4.4.1 Product Benefits Specification

It was found more appropriate to do a Product Benefits Specification instead of the traditional Product Requirement Specification. The main reason for it, is to make sure that the result is different from an orthopedic solution. When it comes to requirements, the orthopedic solution would satisfy many requirements, but it is more difficult for it to fit it when the requirements are Benefit-Based.

**Target Group**  
Western citizen over 65 years old, retired, living alone or with their children.

**Product Benefits**

- It should be carried without harming the user, whatever part is in contact with the user should spread the pressure as much as it is possible.
- The product should be easy to be carried around, so the weight, dimensions and carrying way should be as good as possible.
- Users will be sitting on the product for long time, so it must be comfortable and allow natural movements in the chair.
- The pushing effect when standing must not be too strong (sort of a catapult). Instead, it should be progressive.
- The product must stay in the expected place during the whole process, without sliding.
- The movement up and down must not bounce or have any side displacement, instead it must be soft and well controlled.
- The foam of the product must stand for very long periods of time giving the support that is needed for the target user and adapting in the best possible way to the user’s body.
- The fabric from the cover must allow a proper ventilation. It also must be clean always, so this involves the possibility of an easy way to remove the cover and put it back.
- The lock should work in a very natural way. Locking automatically during the sitting down and releasing the movement softly when it is unlocked.
- The unlocking mechanism must be easy to activate and easy to access for the user.
Findings and Analysis

**Product Benefits**

- The product should blend in the environment (own home, at relatives’ homes, in the park, at a restaurant...) without standing out from it. The intention is that the user is not embarrassed from carrying it around or using it actively.
- The materials and finishing (even they must not stand out) must feel high quality.
- The product should be easy to use at the first attempt. Both sitting down, standing up and especially unlocking it.

**Socio-pleasure**

- **Product Benefits**
  - The product should look friendly and inviting to interact with.
  - The product must look safe and not risky at all.
  - The product must be intuitive for using, applying recognition strategies for activities like carrying it or unlocking it.

**Psycho-pleasure**

- **Product Benefits**
  - The product should give aesthetic pleasure.
  - The product should reflect the users' maturity.

Table 11. Product Benefits Specification

**4.4.2 Lock Requirements Specification**

Without a locking system, it can occur that the user feels the pushback effect while sitting down creating an uncomfortable and unbalance feeling. Because of this reason, it was decided to include a lock. However, a lock for this kind of product has several requirements:

- It must be able to stand pulling forces of at least 300N for long time (x100,000 cycles) without lowering the performance.
- It must be a soft motion that is not felt by the user.
- It must not require big effort for releasing.
- The locking system must be as light as possible, expecting it to be 250-500g. Any weight over 500g could be considered excessive for the overall product definition.
- It must be cheap, easy to integrate and it might have few components.
- The manufacturing complexity and the assembling process should be simple.
- The lock shouldn’t affect the overall design unless in the knob part, which is considered a design element of the product.
- No feeling of loose elements, vibrations, noise is acceptable.
Findings and Analysis

- The lock must be adapted to small variations in the sheet behavior over time.
- It must lock automatically while sitting down, without needing any extra user action.
- The lock must be centered, and it must not create any asymmetric stress concentration because of the position.
- After developing the ergonomic study concerning the product, it was decided that the knob position for interacting with the user should be easy to access, safe and if possible not sticking out of the main volume. The desired motion would be pressing a button as indicated in the image (this includes physical, safety and cognitive considerations).

![Figure 49. Activation system](image)

• For safety, practical and mechanical reasons, the lock should be placed in the colored area without compromising the structural integrity (avoid stress concentrations in the meeting).

![Figure 50. Safe area](image)

Pressing a button in the corner is safe because it is not affected by the bending down process. It is also safe because of not sticking out of the general volume. It is easy for the user to understand how it works.
4.3 Ideate

4.3.1 Early Ideation

The type of functional constrictions requires from some simultaneous technical research and testing in order to reach to something feasible (it is not enough with proposing something, it has to work. It is not a concept work. Instead, a true product development one). These factors enhance a symbiosis within Sketching, Mock Ups, C.A.D. and F.E.A. The timeline of the concept development is not constant and consisted in several ways back and forward along the mentioned symbiosis.

Sketching has been the main thinking supporting methodology, both for ideating and for clarifying. The first 2 concepts where summarized using Autodesk Sketchbook Pro and the result corresponded with the following images:

Concept 1. *A Plastic Sheet based solution*

![Figure 51. Concept 1. Plastic Sheet](image-url)
The **Concept 1** intends to reduce to the minimum the necessary pieces for the function of the product. A sheet that solves the problems just with the adequate form, a cushion for increasing the comfort and a locking system located in the researched safe area. The plastic sheet has holes in the bottom for having an easier adaptation to the surface of the armchairs (changed later for smaller ribs). The ribs help to increase the stiffness of the sheet for concentrating the elastic energy in the corner and they also serve as supporting elements when in a rest position.

**Concept 2. A Double Torsion Springs based solution**

The **Concept 2** is the spring based solution that requires less components in an easier integration. Focusing the lifting function in the springs allows to have a cheap and human alike material as veneer that could match with several other Ikea Families and is a well-developed manufacturing process by Ikea.

*After having several meetings with Ikea, it was decided to go for the Concept 1 because of considerable advantages that will be commented next. By this time, the price was also decided, with an aim for a retail price of 25 Euros (Big and useful constriction).*
Findings and Analysis

Figure 53. Concept 1 optimization 01

Figure 54. Concept 1 optimization 02
4.3.2 Mock Ups

Building Mock Ups has helped along the process in many ways, but mostly in a spatial one: Bringing a sense of scale to the ideating process, enhancing this way well-proportioned proposals.
Most of the size adjustments relate to the handling cleansing for gripping and triggering the unlocking mechanism. Another size problem depends on the overall dimensions for sitting over it and for transporting the product: What is the optimal minimum area for sitting and placing over existing armchairs? What is the best place for placing a handle? What is the minimum functional dimension that allows a comfortable transportation? After doing and testing over the current mock-ups, it was decided that a 400x400 square is comfortable for all the mentioned requirements. In the same way, it was noticed that the most balance place for the handle is either the front or the back of the product. The front is discarded for needing an extra piece and increasing the stress over the most delicate area when it comes to possible deformations.
4.3.3 Finite Elements Analysis (F.E.A.)

**Preliminary Study:** It is based on simulating several basic hypotheses (shape, material and load) through a Finite Elements Method software. Getting and comparing useful information like stress, buckling, displacement and Factor of safety. The information from the basic models might help to choose a way to go forward in the project. This method continues the previous work done with the Materials Research, the Interviews to experts and the Ergonomics and Biomechanics Research working with the selected material and modifying other form parameters.

- **Manufacturing:** Even though the manufacturing method has not been chosen yet, it makes sense for the specific purpose to go for designs that can be mechanized from a sheet basis (avoiding ribs) which will be cheaper and easier.

- **Material:** The chosen one for starting the simulations is **Low Alloy Steel** since it is the one that fits best the requirements for the desired function having the biggest Elastic Module, Elastic limit and Fatigue resistance that will allow us to get the smallest possible thickness. Polyamide was already prototyped with a required 8mm thickness in the corner which is too much. In case a Steel solution is too heavy (even after applying some strategies for making it lighter) Aluminum will be the next one that will be tried.

- **Radius:** Since the thickness is smaller, the radius in the corner also needs to be smaller; allowing to have a minimum total height when folded. Fist trials are going to be made for a 15mm radius in the corner giving a total height of 30mm. The main idea is to minimize it as much as possible and that would be the requirement for further refining simulations.

- **Angle:** 35º. The angle decision is strictly dependent on the Ergonomics and Biomechanics Research and intends to be as comfort as it is possible.

- **Shape:** Some decisions have been taking based on the different research previously conducted:
  - The first simulation will be focused strictly in checking the **minimum possible thickness** allowed in steel. Once that thickness is found, the **total weight** (maximum weight reduction by design to be considered is 30%) must be checked to see the feasibility.
  - The **top surface should be flat** because since the product needs to be transportable and the considered measurements are around 400x450mm, the movement should not be restricted on the surface with side curvature; which could be problematic for bigger users.
Findings and Analysis

- There are different parameters that can be changed during the optimization process: **a**-distance between nerves, **b**-nerve’s width, **c**-nerve’s height, **d**-nerve’s distance to the border, **r**-radius of fillets, **n**-number of nerves.

![Figure 58. Nerves Options](image)

- Other important parameter is the **continuity of the curvature** and the shape of the nerves, which can be adjusted to minimize stress concentrations.

- The advice given by Sara Kallin about avoiding any sharp edge in the area close to the Ischial tuberosities has been taken into account and the nerves will be wider and so they fit in the area. This would be the starting hypothesis.

**Loads:** The way in which the load is going to be transmitted to the seat is directly connected with the **Human Body Weight** distribution and with the **Seat’s Area**. This way, we have two main areas:

- **Z1** is the one underneath the torso of the user, getting most of the weight.
- **Z2** is the area underneath the thighs.

**Z1** is the most critical area because, since it is further from the fulcrum, it generates the biggest momentum.

Three different weight hypotheses have been considered: 60, 75 and 90 Kg for initial simulations.
The weight from the top cushion (ca. 500g) so as the one from the lock mechanism has not been considered for the simulations.

**Figure 59. Loads distribution**

<table>
<thead>
<tr>
<th>Z1 = 0.1 m²</th>
<th>Z2 = 0.05 m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.6</td>
<td>13.4</td>
</tr>
<tr>
<td>50.2</td>
<td>3.2</td>
</tr>
<tr>
<td>5.4</td>
<td>4.4</td>
</tr>
<tr>
<td>+ 7.0</td>
<td>+ 1.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>User (Kg)</th>
<th>70.2%</th>
<th>17.8%</th>
<th>PZ1 (N/m²)</th>
<th>PZ2 (N/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>42.1</td>
<td>10.7</td>
<td>4126</td>
<td>2097</td>
</tr>
<tr>
<td>75</td>
<td>52.7</td>
<td>13.4</td>
<td>5165</td>
<td>2626</td>
</tr>
<tr>
<td>90</td>
<td>63.2</td>
<td>16.0</td>
<td>6194</td>
<td>3136</td>
</tr>
</tbody>
</table>
SIMULATION PROCESS AND OUTCOMES

The following order for the simulation process was not intended from the beginning. However, it resulted to be chronologically as it follows:

1. **Low Alloy Steel sheet**

   - **Load:** 60kg
   - **Dimensions:** 400x400 with a 35° angle, t:1mm R:20mm
   - **Weight:** 2480g (Very important and limiting point. Going over 1mm will probably make the product unfeasible).
   - **Performance:** Stress is over Elastic Limit creating permanent deformations.

   - **Load:** 30kg
   - **Dimensions:** 400x400 35° R:20 t:1mm Lightened (basis holes) and Stiffened (x5 top surface ribs with 30mm depth).
   - **Weight:** 2810g
   - **Performance:** No permanent deformation. It doesn’t go as down as intended (5° reduction). Good mechanical performance (much better than in H2).

   - **Load:** 60kg & 90kg
   - **Dimensions:** 400x400 35° R:20 t:1mm Lightened (basis holes) and Stiffened (x5 top surface ribs with 30mm depth).
   - **Weight:** 2810g
   - **Performance:** Stress is over Elastic Limit creating permanent deformations. It doesn’t go as down as intended (10°-20°).

   - **Load:** 90kg
   - **Dimensions:** 400x400 35° R:20 t:0.8mm Lightened (basis holes) and Stiffened (x5 top surface ribs with 30mm depth).
   - **Weight:** 1984g
   - **Performance:** It goes down enough but with permanent deformations.
**Conclusion for Low Alloy Steel Sheet hypotheses:** Even Low Alloy Steel was the chosen material because of the superior properties regarding fatigue and elastic performance, it was found through simulation that the material has 2 main problems for being used as a sheet: The first problem is the weight. When aiming for a product around 2-2.5 kg weight, the steel sheet already goes over it in those hypotheses without permanent deformation. The second main problem is that the sheet is not able to bend down as much as intended (probably because the high Elastic Module). The only case in which it bent down to the horizontal position during FEA was with a 90 kg load (more than the vast majority of the population puts over the seat) over a 0.8 mm sheet. The sheet was obviously lighter but even though, permanent deformation and an excessive pushback effect made it an unfeasible choice.

1. **Low Alloy Steel rod:** After checking that the continuous shell was a non-possible way to go, other possibilities were considered using steel.

Some ideas were still considering using a shell-based strategy but in a discontinuous form as it is shown in the picture. However, either shell-ribs or a shell-corner with a stress dissipater perimeter were not solving the previous issues with a shell-based solution.

The other alternatives considered using steel rod (linear-based strategies) aiming for a better result. The main issue about using steel rod is achieving an easy assembling that doesn’t make the process excessively complex. Within the steel rod proposals, there were two main categories: Bended rod and Torsion spring rod.

- **Bended Steel Rod:** This family of proposals try to solve as much as possible (both mechanically and assembling wise) with a single rod bended.
Findings and Analysis

**Load:** 90kg  
**Dimensions:** 300x300 35º Ø:6mm r:20mm

**Performance:** It goes almost down enough but the rod bends too much and has permanent deformations. This means that a lower load will not make it go as down as intended. Changing the diameter is not going to solve the bending issue while letting it go more down.

One of the problems observed was that the excessive bending related to the need of changing the angle immediately in the corner forcing too much the straight part of the rod structure. In order to solve it, another alternative way of bending was proposed, making the corner part itself bending down and keeping the straight part as it is supposed to be.
Findings and Analysis

(H8) **Load:** 90kg  **Dimensions:** 300x300 35° Ø:6mm r:20mm  
**Performance:** It can be observed that it is easier now for the element to bend down reducing the curvature in the straight part. It goes over yield strength once more.

(H9) **Load:** 90kg  **Dimensions:** 300x300 35° Ø:8mm r:20mm  
**Performance:** Same as H8 but with more problems for bending down. The straight parts remain straight in this occasion.

(H10) **Load:** 30kg  **Dimensions:** 100x100 35° Ø:6mm r:20mm  
**Performance:** A trial was made considering the option E but as it could be foreseen, it remains stiff without bending down that much and once more, exceeding the elastic limit of the material.

(H11) **Load:** 90kg  **Dimensions:** 300x300 35° Ø:6mm r:20mm  
**Performance:** Since bending down to the horizontal position was still a problem, the curvature in the corner was doubled this time intending to make this motion easier. Indeed, it helped to achieve the result but exceeding the elastic limit and having permanent distortion as a result of it.

(H12) **Load:** 90kg  **Dimensions:** 300x300 35° Ø:8mm r:20mm  
**Performance:** The diameter was increased to avoid going over the Yield Limit as in H11, but this made the rod not going down.

**Conclusion for Bended Steel Rod:** In general, the performance was not as good as expected and it would depend on some extra aid coming from the top surface to solve the bending problem, but this would increase the weight and complexity of the solution for a portable version.

- **Torsion Spring Rod:** From the very beginning, torsion spring seemed like a very good mechanical solution for the mechanical problem. The main reason for not using springs is that it involves a complex (and therefore heavier) solution for adapting them to the top and bottom sheet.
Option G keeps having the problems described before regarding complexity. Option H needs of a proper integration in the top and bottom surface to avoid bending the straight parts of the spring. Option I (Double Torsion Springs) seems the most feasible for our purpose, since it might be possible to skip many auxiliary parts because of its own shape. Normally, a main axis with a rod and constrictive elements would be needed for using springs in a proper way but Double Torsion Springs might solve this issue in a not so complex way. No simulation is needed for calculating the torsion spring since it is possible to adjust the number of coils, length and diameter to the desired pushback effect. Only in a later simulation would be necessary to check the integration in the design. In the following page a proposal for Option 1 using Double Torsion Springs is shown.
2. **PA 6/10 sheet**: Because of most of the problems happening while considering steel as the main choice for the project, some facts were discovered: The more Young’s Modulus does not necessarily mean a better performance in a non-linear scenario as it is the case. The exceed of Elastic Module makes the geometries too stiff and not likely to deform elastically, reaching to plastic deformation scenarios in many occasions. Given the previous analysis, it was considered that some simulation trials should be made with a Polyamide sheet to check the performance.

**Load**: 25kg (35% step) **Dimensions**: 400×400 with a 35° angle. **t**: 1mm **R**: 20mm Lightened (basis holes) and Stiffened (×5 top surface ribs with 30mm depth). **Weight**: 502g

**Performance**: The image belongs to an early intermediate step, meaning that the pushback effect is way smaller than 25kg. It doesn’t deform plastically. The stress is quite far from the Elastic Limit.

**Load**: 25kg (60% step) **Dimensions**: 400×400 with a 35° angle. **t**: 2mm **R**: 20mm Lightened (basis holes) and Stiffened (×5 top surface ribs with 30mm depth). **Weight**: 1004g

**Performance**: Once more, the image belongs to an intermediate step, meaning that the pushback effect is smaller than 25kg. It doesn’t deform plastically. The stress is quite far from the Elastic Limit.

**Load**: 25kg (100% step) **Dimensions**: 400×400 with a 35° angle. **t**: 3mm **R**: 20mm Lightened (basis holes) and Stiffened (×5 top surface ribs with 30mm depth). **Weight**: 1506g

**Performance**: The image represents the final step for modelling where it gives a pushback effect of 25kg. It doesn’t deform plastically. The stress is far from the Elastic Limit. Once more, the image belongs to an intermediate step, meaning that the pushback effect is smaller than 25kg. It doesn’t deform plastically. The stress is quite far from the Elastic Limit. These results are suitable with a possible final use of the product.
Findings and Analysis

(H16) **Load:** 25kg (down) + 5kg (size) (100% step) **Dimensions:** 400x400 with a 35° angle. **Weight:** 1506g **Performance:** It was intended to check the effect of side loads, which increases the stress a little but still performs elastically without any significant issue (no lateral displacement).

(H17) **Load:** 30kg (100% step) **Dimensions:** 400x400 with a 35° angle. **Weight:** 1506g **Performance:** This is the optimal performance. The shell bends down exactly as intended and gives 30kg of pushback effect to the user (which might be the most universal aid. Even for a user who weighs 55kg, around 40kg of weight is put down straight over the shell. The main problem for this pushback effect would probably be for people with short legs that don’t reach the floor properly because of the height increment using UPPSVING of around +50mm). The image represents a 100% of the movement and it remains within an elastic behavior. Because of being the desired behavior, a fatigue analysis was done for checking the sheet’s behavior considering x 100,000 cycles (Ikea’s Standard) and no damage was appreciated.
Findings and Analysis

(H18) **Load:** 40 kg (100% step) **Dimensions:** 400x400 with a 35° angle. **t:** 3 mm **R:** 20 mm Lightened (basis holes) and Stiffened (x5 top surface ribs with 30 mm depth). **Weight:** 1506 g

**Performance:** More weight was added to the simulation (even though) this scenario will not be reached to check possible plastic deformations and once more, no one was found.

(H19) **Load:** 100 kg (40% step) **Dimensions:** 400x400 with a 35° angle. **t:** 3 mm **R:** 20 mm Lightened (basis holes) and Stiffened (x5 top surface ribs with 30 mm depth). **Weight:** 1506 g

**Performance:** A extreme case scenario considered for the limit position of the sheet and once more, no plastic deformations.

(H20) **Load:** 25 kg (100% step) **Dimensions:** 400x400 with a 35° angle. **t:** 4 mm **R:** 20 mm Lightened (basis holes) and Stiffened (x5 top surface ribs with 30 mm depth). **Weight:** 2008 g

**Performance:** The first analysis for a sheet with thickness 4 mm shows that the corner is now way stiffer without bending down as intended. It still performs elastically.

(H21) **Load:** 30 kg (100% step) **Dimensions:** 400x400 with a 35° angle. **t:** 4 mm **R:** 20 mm Lightened (basis holes) and Stiffened (x5 top surface ribs with 30 mm depth). **Weight:** 2008 g

**Performance:** Same case as (H20). For the intended pushback is not reaching the necessary position.

(H22) **Load:** 40 kg (100% step) **Dimensions:** 400x400 with a 35° angle. **t:** 4 mm **R:** 20 mm Lightened (basis holes) and Stiffened (x5 top surface ribs with 30 mm depth). **Weight:** 2008 g

**Performance:** It still doesn’t deform to the original position, but it doesn’t go over the yield strength either.

(H23) **Load:** 40 kg (100% step) **Dimensions:** 400x400 with a 35° angle. **t:** 4 mm **R:** 20 mm Lightened (basis holes) and Stiffened (x5 top surface ribs with 30 mm depth). **Weight:** 2008 g

**Performance:** It still doesn’t deform to the original position, but it doesn’t go over the yield strength either.

Figure 68. Images Nylon F.E.A.
**Load:** 60kg (100% step)  
**Dimensions:** 400x400 with a 35° angle.  
**t:** 4mm  
**R:** 20mm  
Lightened (basis holes) and Stiffened (x5 top surface ribs with 30mm depth).  
**Weight:** 2008g  

**Performance:** For getting closer to the sitting position, it is necessary to place over 60kg over the seat (around 90kg and over) and even though, the pushback is excessive.

---

**Conclusion for a Nylon 6/10 (polyamide) sheet:** From all the studies conducted until now, it is the solution that brings the best results by far (pushback, weight, fatigue and elasticity) in the simplest way (integration and production). A 3mm PA 6/10 sheet seems to be the way to go.

---

Despite of all the Finite Element Analysis developed until this stage, the process will continue along the whole ideating and prototyping process. The previous one is then just an example of the initial F.E.A for validating ideas.
4.3.4 Locking system ideation

Expected Motion:

There are many ways of facing the lock design but for this case, the design process starts from the user side. It was already defined the aimed position and motion (pressing a button) and that already defines the first steps for the development of the lock.

The operation is very simple: The button is connected to a rod that reaches a spring in the end. The locked position is 0 and the spring forces it to remain like that. Only after the user presses the button, we have a small displacement that compresses the spring to the position 1. It is in this position when a mechanism needs to be released. One of the biggest difficulties within this logic of functioning is that the user shouldn’t need to keep pressing while standing, forcing the solution into a binary alike one. This specific description of the motion doesn’t necessarily need to be the end result, but it represents the initial aim for it.
Findings and Analysis

Figure 72. Lock v.01

Figure 71. Lock v.02
Figure 73. Lock v.03
This version of the solution would fit with most of the requirements. However, it is placed in the back, it is a high-impact solution and it is quite complex to manufacture and integrate.
Figure 75. Lock v.05
The final solution is a sliding low impact one. It is placed in the exact spot where it is wanted to be, and it is possible to integrate within the design.

Several elements needed to be designed in order to possibly test by building a prototype. Using a Solid CAD modelling software (Solidworks), these pieces were modeled and adjusted on size to achieve the desired effect in the intended scale.
These were the initial pieces that were designed for testing when prototyping. They were later on 3D printed in the most resistant possible plastic for this purpose.

Figure 77. CAD modelled Lock pieces
4.3.5 Upholstery Ideation

Adapting the solution to the human body requires from an upholstery solution that helps the user to be as comfort as possible during the time spent over it. There are several ways of achieving this effect and the following images show the seek for an solution.

Figure 79. Upholstery with push buttons and foam

Figure 78. Upholstery with Velcro
Findings and Analysis

One of the final solutions that were found for the upholstery is to use pocket springs instead of foam. When using foam, no matter if viscoelastic, MD or HD, more thickness is needed for getting a good enough support. If viscoelastic is used, another problem is the changes in the temperature and stiffness when using it. Because of all these problems, pocket springs would be an optimal solution if it is possible to retail in an acceptable price (It is an innovative technology, so it will need certain time until it gets more available and affordable). Pocket springs consist on sheets of approx. 22mm height that contain compression springs separated into different sacks that form the sheet. They are starting to become popular in air and train transportation for optimizing the number of places (specially in planes). Advantages with pocket springs are:

- No decrease in the performance of the support during the service life of the product.
- Minimum possible thickness <30mm
- Not affected by temperature.
- Fits with different weights
- Light and hygienic.
4.3.6 Manufacturing Ideation

Creating a new product when there are not others in the market using the same technology has a double complexity: Inventing + Developing
Making sure that the product can be produced easily and affordably requires from a deep manufacturing intention since the very beginning.
For the plastic sheet solution, there are 2 main ways of manufacturing: Either vacuum forming or injection molding. Vacuum forming is cheaper for a lower number of unit and more optimal for prototyping. It is easy to switch from vacuum forming to injection molding but not the other way around. On the other hand, injection molding can be faster, cheaper, more flexible and better quality. However, it was decided that vacuum forming could adapt to the needs for developing the product in the initial stage and later one it could be changed into injection molding.

The first approach consists in a 3 stages process:

*Vacuum forming, laser cutting and bending.*

This way we could get a testable prototype. Even though this alternative is probably not the best for a massive production, it would reach to an eventual prototype.

Figure 81. Manufacturing v.01
A simple change in the design allows for a draft angle than can insert and remove a mold, either for vacuum forming or for injection molding. The main advantage from the previous manufacturing proposal is that it is more direct and less complex. It is also more flexible and could lead to getting x10 units per machine cycle, increasing the mass production possibilities for vacuum forming.
A mold was designed for being able to reach the final form. The mold design was discussed with people from the Vacuum forming company Prioplast and included the necessary vent holes, draft angles and design for reducing the shrinkage rate to the minimum possible. Several books and guides of vacuum forming were consulted for achieving this solution.
4.4 Prototyping

In the current project, prototyping is closely connected with ideating, and there are several ways forward and backwards in order to optimize before finalizing the development cycle. Three prototypes have been built during this project with three different intentions:

1. Lock prototype: It was the first one to be done and it was used for validating the Lock design and optimizing it.
2. Functional prototype: Produced for testing the lifting force, the material resistance and the user’s experience.
3. Aesthetical prototype: Created as a way of evaluating from a visual perspective the proportions and aspect of the product.

4.4.1 Lock prototype

The prototype of the lock focused mostly in visualizing and testing the movement in the best possible way. The resistance has not been checked and it is expected to be produced in the future. Acrylic panels were used for increasing the visibility.

4.4.2 Functional prototype

The functional prototype started with the selection and purchase of the adequate material for thermoforming while having good enough mechanical properties.
The selected material is Ertalyte PET-P from Quadrant Plastics, which is an expensive material. Because of this, it is not feasible at all for mass production, just for testing, since it performs over minimums required without reaching permanent deformation in the simulation (Yield Strength and Young Modulus are the main Mechanical properties to consider). This price limitations invites to consider injection molding as the only serious possible development for the product. Despite it is not the final manufacturing material or method, PET-P will be used as the best alternative for testing according to the budget. Other material alternatives for injection molding, cheaper and with better mechanical properties would be the Platic blends of PA with GF30-40 like Akroloy.

When the preparations were ready for vacuum forming, certain logistic problems related to it occurred. There was no possibility in the end of building the mold that I had designed (It exceeded the available time in Ikea’s workshop for being manufactured and subcontracting it would just go to much over the budget). This situation forced into looking for other alternatives. After considering all the possibilities, it was concluded that the best would be to make a functional idealization using ribs instead of the complete formed sheet. This way we could have an approximated idea of the spring effect of the plastic sheet when constricting the corner.

Several steps where required for building this prototype:

![Figure 87. CNC PET-P sheets](image)

The first step is to CNC the plastic sheets for having the intended shape before proceeding to bend it in the easiest way possible. A hole is made for the handle, so as 4 supports and some holes for assisting the bending process.
The first attempt to bend the plastic sheet was a failure. A foam mold was built and screwed to the plastic sheet while warming the plastic up with the help of a pair of heat guns. Once the sheet was bent, clamps were placed to constrict any possible movement during the cooling down process. Even though aluminum foil was placed between the plastic sheet and the mold, the heat and the pressure deformed the mold and therefore the sheet. This failure invited me to rethink possible issues with this strategy. The conclusion was that the piece must be completely constricted from any movement but in the bendable area, which means, placing the ribs before applying heat for keeping the shape as intended once it is applied.
Figure 89. Bending trial 2
Using the new strategy, with hard foam constricting the movement, the bending process was way simpler and more accurate than before and the material behaved exactly as intended when warming it up. Once the material was cold with the ribs attached to it, it was already possible to feel how springy it was without any undesirable issues. The force released was a little weaker than expected, probably because of not being completely formed as a sheet (just below 15kgf released measured on a scale). For reinforcing an reaching +20kgf, a 0.5mm steel plate was added. It would also help to improve the behavior towards fatigue and it could be imbedded as an insert in a possible injection molded process.

Once the steel plate was placed, the effect was instantly noticed, increasing the released force to values over +20kgf measured with a scale. Once this effect was tested, it was considered good enough for a further testing process with users, safe enough and providing an acceptable extra aid for standing up and sitting down.

Figure 90. Functional prototype without steel
4.4.3 Aesthetical prototype

The aesthetical prototype didn’t have to deal with the mechanical requirements of the functional one, but it was also challenging. The image of a thermoformed sheet product was supposed to be achieved without proceeding into thermoforming everything in one single step. The process for building it explained in the following pictures.
Findings and Analysis

Figure 93. 3D Printed + Mechanized pieces

Figure 94. Top ribs before sanding
The Ribs were milled with a CNC machine. Meanwhile, the process for bending the plastic sheet was exactly the same as for the functional process.

Figure 95. Main shell with lower ribs

The lower ribs were also milled with the CNC machine and properly glued to the main bended shell for applying the first layers of paint afterwards.

Figure 96. Painting Main Shell
After sanding the upper ribs, and the small pieces for the lock (Mechanized from nylon with the workshop tools), all of them were painted as well for screwing them together later on with the preset holes for it (that were designed for minimizing their visual impact).
Figure 99. Aesthetical prototype i.03

Figure 100. Aesthetical prototype i.02
Findings and Analysis

Figure 101. Aesthetical prototype i.04

Figure 102. Aesthetical prototype i.05
The upholstery has not been prototyped since there were some logistic problems for Ikea for producing the cushion on time. The pocket springs did not arrive on time either, so it was decided to postpone the upholstery part for a later stage of development since it can be done independently from the sheet work.

4.5 Testing

4.5.1 Lock prototype

When testing the prototype of the locking system some conclusions were made: The overall performance was correct but the lever arm for locking the top part into the bottom one had to be way shorter for reducing the maximum momentum on it. It can be seen in the aesthetical prototype how this correction in the design was applied. Another improvement was to minimize the number of extra pieces needed... trying to consider as many as possible as injection molded together with the main shell.

4.5.2 Functional Prototype

Five users tested the prototype in different occasions without the metal sheet, with it or both. The feedback was mostly positive. As an advantage, the main comment was that it felt safe because of the gradual way of releasing the force.
Findings and Analysis

Users with short legs could have problems with them hanging when placing the Upplyft over high surfaces. This effect, together with a low weight, multiply the effect of the lifting force and must be controlled from a safety perspective. Light weight people tended to notice more the help that the product provides. This means that probably two different force ranges of the product should be developed: 250N and 350N. For heavy weight people, the functional prototype was not helping that much while for others was a big help.

5. Result

A brochure has been designed in order to summarize the project, so as for communicating the final result of it. The images follow in the next pages:
Figure 105. Brochure 01
Context

In most of Western countries we assist to a phenomenon of dramatic increase in the elderly population because of the baby-boom generation that was born after the Second World War and the increase in the life expectancy. This is a phenomenon expected to expand worldwide. There is a growing market that is starting to demand products that fit with nowadays’ elderly from a functional and cultural perspective.

The OMTÄNKSAM family of products is the answer from IKEA to this new demand in the market, focusing in designing products that can help elderly, but also fit in every home.

Figure 106. Brochure 02
Portable Assistive Lifting Seat

Aging involves malfunctioning in the human body that reduces the person's capabilities. There are several products out in the market that try to compensate the declining human body's performance for improving the life quality of elderly people.

A Portable Assistive Lifting Seat is a lightweight object that can be easily transported, provides extra lifting force to the user when standing up and helps users when sitting down by making the movement more progressive and safe. This kind of product can be used in most armchairs allowing a more autonomous and mobile life for those who need it.

Figure 107. Brochure 03
Figure 108. Brochure 04
BORING
INSTITUTIONAL
MEDICAL COMPLEX
FRAGMENTED
CONFUSING
ASEPTIC

ORTHOPEDIC
“To create a better everyday life for the many people”

Figure 110. Brochure 06
€24,99/ea

Democratic Design
This project involves a multidisciplinary approach, going from Ergonomics and Anthropometry to Mechanical Engineering and Materials Science but everything is coordinated from a Product Design perspective that matches with the IKEA’s Democratic Design principles:

Quality • Low-cost • Form • Function • Sustainability

Figure 111. Brochure 07
Optimization
A long study was conducted for finding a concept and shape that could perform as intended. One of the focus points for the project was to find a good balance between what the user needs and the most simple concept for a further development.

There were two main strategies to follow: either using springs or working on a sheet-based solution. The sheet solution was chosen because of fitting better with the simple development and holistic design approach. The strategy for achieving a stiffer shape that would not bounce was based in folding the surface and getting curvature. Once again, there were two possible paths to follow: a saddle shape or a sheet warped into ribs. The second alternative was chosen because of being a more universal fitting and a concept easier to optimize.

Figure 112. Brochure 08
**Mechanical design**

The design of the main shell consisted on an iterative F.E.A. process for shaping the material in order to get the desired push up effect. The range of force that can be released goes from 250N to 300N and it depends on the material and the thickness. The range of thickness that do not suffer from plastic deformation are 3 to 4 mm and they normally correlate with 1.5kg and 2.0kg of weight. There are several feasible materials for manufacturing. On the one hand, there are semi-crystalline engineering thermoplastics like NYLON (issue: too hygroscopic) and PET. They are more ecologically friendly but also more expensive. On the other hand, there are thermoplastic blends with fiberglass like ABS+30FG, PA6+30FG and PET+30FG. They are cheaper and more efficient mechanically (bigger range of forces) but they are not recyclable.

Figure 113. Brochure 09
Production

Several strategies for production were considered like cold bending or vacuum forming. However, in order to minimize the cost, time, and complexity of the final product, the best alternative is injection molding. Injection molded was allowed by a small change in the design, creating a draft angle that allows to remove the injection mold easily.

The injection molding process for manufacturing the shell includes placing some brass inserts for certain parts of the lock so as a side action motion for being able to embed other parts of the locking system. This way, the final shell that is manufactured satisfies the majority of the requirements in a holistic and simple way.

Figure 114. Brochure 10
Safety

The user is supposed to be sit without experiencing the released force from the shell. This extra aid is only needed while standing up. This behaviour is allowed by the integration of a locking system that allows the user to release the force just by pressing a button momentary. Several requirements were defined for developing this locking mechanism:

• Low force needed for triggering.
• No need of keep holding the button during the standing up process.
• Locking system placed in the most protected area close to the corner.
• Avoiding increasing the stress in the top part of the shell where the stress is the highest.
• Smooth and low impact locking system for increasing the service life of the product.

Figure 115. Brochure 11
Simple and catchy name. Swedish but internationally understandable.
Figure 117. Brochure 13
Findings and Analysis

User interaction

- A portable product is supposed to have a handle and in this case it has been integrated in the most simple and affordable manner by having a hole in the back part of the shell. This decision also helps to reduce the weight.

- The button for the lock has been placed and designed in a way that is intuitive and easily understandable from a cognitive point of view, allowing an easy recognition user experience.

Figure 118. Brochure 14
Figure 119. Brochure 15
**SHELL**

**Form**
This project is a clear case of "Form follows function". Every single variation in the shell answers to a need or requirement. The design approach has made an especial emphasis on keeping the whole product as simple as possible and because of this, the main challenge has been to keep the functionalism in a clean and clear way without stepping into the orthopedic semantics. This means:

Merged & Simple *vs* Fragmented & Confusing

Figure 120. Brochure 16
**Function**

There are four ribs in the top part of the shell. Four is the minimum amount of them that allow to have a gap in the center for the locking arm while providing enough support (two ribs are not enough). The shape of the ribs is strictly connected with having the maximum stiffness and minimum stress concentration while allowing for an easy mold removal.

The small nerves in the bottom part of the shell avoid the bending of the product when in contact with the armchair surface.

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*Figure 121. Brochure 17*
Figure 122. Brochure 18
Mechanism

The locking system consists of a locking arm that pivots around an axis attached to the top of the shell. When sitting down, this arm climbs a mobile piece reaching to a lock position in the end of the movement.

For releasing this lock, the user presses a button that move the piece and allow the arm to get liberated. Then, a spring located in the same axis as the mobile piece pushes back the button to the original position.

This lock keeps placed in the safest area (close to the corner) and separates the anchoring point in the top part from the most stressed areas. There is almost no impact in the way it works because the system is based in sliding rather than in the pressing contact.

Figure 123. Brochure 19
Basic attachment solution, cheap, user-friendly and effective.
Findings and Analysis

The multi-layered cushion can be easily removed for cleaning by pulling it from the hook and loop patches attached to the plastic shell. After cleaning the cover of the cushion, everything can be easily assembled together by pressing the cushion back into the original position.

Figure 125. Brochure 21
As little parts as possible but without endangering price or quality. Easy to separate for cleaning it.
Figure 127. Brochure 23
Easy packaging, low cost and keeping the product’s identity. Meanwhile an extra safety piece avoids any possible accident.
Logistics and Retail

The product can be directly picked at the shop and should be connected with the cushions' area. Because of this, the packaging strategy goes for a light and simple solution consisting on a wrapping cardboard band. For avoiding stressing the lock while in stock, a possibility would be to use plastic cuffs around the shell. For safety purposes, a temporal piece protects the button from being triggered. This way, it cannot be released when it is in the shop or during the transportation.

Figure 129. Brochure 25
The color is an important part of the retail strategy. Neutral/easy blending colors like grey or blue and another one more outstanding but easier to see: Yellow (for those with a different taste or just bad vision). All together set a retail image that is attractive to the customer (the yellow one plays an important role here).
The product is supposed to be sold in the same area as the cushions are nowadays as an easy to grab and go selling strategy.
Figure 132. Brochure 28
The price has been always an important goal from the beginning. It is only good if it is feasible for the many people.
UPPLYFT

Figure 134. Brochure 30
Findings and Analysis

Figure 135. Brochure 31
Figure 136. Brochure 32
6. Discussions and Conclusions

6.1 Discussion of method

It has been very interested to apply the Bootcamp Bootleg methodology to a Real Case Scenario of Product Development. I started the project applying sort of in a stiff way. However, with the flow of the project I sort of went into a process of owning the methodology, applying it in the way that could fit better to my project and performing in a way more flexible way. A big learning of this M.Sc. Thesis has been that it is not enough to know and apply design thinking methodologies. It is also required to mold them into the specific user and project.

6.2 Discussion of findings

Research questions:

- What is the most suitable material and shape for a light, affordable, resistant and easy to transport product? This RQ has been deeply treated during the whole project. The shape, if it still needs some optimization will not have big changes from the actual one. When it comes to the material; there are still 3 possible ways to go:
  1. Using a Glass Fiber blend either with PET or Nylon (PA GF30/PA GF40/PET GF 30/PET GF40) like for example the Akroloy products. This way the weight can be reduced, and the mechanical properties increased dramatically. It seems for me like an optimal solution.
  2. Imbedding a Steel plate insert in the corner of the plastic sheet during the injection molding process. Probably more expensive but likely to optimize fatigue behavior, so as allowing a possibility to easily adapt the released forced to different ranges by changing the thickness of the plate.
  3. A combination of 1 with the steel plate form 2 (seems excessive).

- How to avoid an institutional-orthopedic perception in favor of a more Scandinavian one? Of course, this is highly subjective to the user but the strategy of reducing complexity aiming for a clean and merged design instead of a fragmented one seems to cause that effect in most of the people that has checked the project.

- How to make the product comfortable and easy to use for elderly? The final weight is supposed to be under 3kg if following the manufacturing process designed until now. This means that weight will not be a problem for transporting and the handle might help for this purpose. The handle is not ergonomically optimal, but it is a balancing sacrifice on behalf of price and simplicity. When sitting down, the dimensions will ensure enough space for the hips and buttocks that will be supported with a cushion. The button for releasing the locking system is easy to use and involves almost no risk. Even though a lot of the work has been pointing at this 3rd RQ, it is mainly a need to test on users for optimizing issues regarding comfort. The theoretical analysis reaches to a limited point of development.
6.3 The Way forward

After analyzing the whole product, some changes need to be made:

- Redesign of the bottom ribs, for increasing the stiffness in the pre-corner area. Otherwise it won’t release force, bending in that area instead.
- Double safety system for the lock. There are some simple possibilities for increasing the safety of the lock button by adding an extra degree of conscience and interaction needed for releasing the mechanism (mostly thinking on children).
- As a matter of protection for children and pets, a fabric accordion system could be implemented all around the open area of Upplyft.

Despite of the previous points to be solved, other ones are also needed for bringing the project closer to a production stage:

- Functional prototype of the lock exposed to functional conditions.
- More tests with different steel plates thicknesses.
- Evaluating possibilities of creating a prototype in a GF blend.
- Refining mechanical design in the shell for a stiffer behavior.
- F.E.A. for refining the concept with a special emphasis on the fatigue performance.
- Adding highly skilled professionals from the polymers field to the development process.

6.4 Conclusions

This project has changed many of my previous views about design. The Democratic Design principles, even from Ikea, can be extrapolated to any other project. Applying those principles implies directly considering a Real Product development scenario with all the risks, stakeholders, potentials…. A common problem that is likely to be seen more and more in the design-related fields is the split between the Design of the Formal elements and the Design of the Technical solutions for bringing it to the market. That way of working is a high risk one for developing products. I found a way of working and approaching the Product Development process which fits better with my understanding of products and life. The Thesis process has been intense and demanding but highly rewarded.

Another interesting learning has been how to deal with frustration when solutions are not found to certain problem. Frustration is a project itself and it must be attacked with resting, creativity and invitations to other minds to participate in your struggling moments. Understanding those stressing moments in that way help to keep performing well without getting rationally or emotionally stuck.

I would like to use these last sentences for thanking once more to the fantastic people from Ikea of Sweden and to those colleagues sharing with me this intense year.
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8 Attachments

8.1 Questions for Interviews

**EXPERTISE FIELD:** Materials and manufacturing

<table>
<thead>
<tr>
<th>Name:</th>
<th>Occupation:</th>
<th>Project description: The reason why this interview is conducted is the design of a foldable sheet that can assist users when standing up from a seat.</th>
</tr>
</thead>
</table>

Q1. One of the problems with the idea is the bouncing effect when bending because of the shape. There are different proposals for solving this effect. Which one do you consider better and why?

A  
B  
C
Q2. Other existing problem is the side movement that creates an unstable feeling. Is there any specific strategy you would follow to solve it?

Q3. The main properties considered now for the material selection are: Young Modulus / Elastic Limit / Fatigue Strength at $10^7$ cycles / Density / Price. Is there any other property you would take into consideration (excluding ecological ones)? Which one?

Q4. Based on the previous information (before testing/checking by FEA) what would you say is/are the most appropriate material/s based on your previous experience? Why?

Steel alloy / Aluminum / Polyamide / Laminated veneer / Other:

Q5. Would you consider using different materials for building the mechanism? If so, what positive (e.g. easier to change the thickness) and negative (e.g. stress concentration in the joint) aspects do you see on it?

Q6. Is there any specific design strategy you would follow regarding the material fatigue to avoid permanent distortion in the form of a ductile failure?

Q7. Is there any comment you would like to add?
EXPERTISE FIELD: Ergonomics and Biomechanics

Name:

Occupation:

Project description: The reason why this interview is conducted is the design of a foldable sheet that can assist users when standing up from a seat. The dimensions for it are around 50x50x5cm. The design must be easily transported by the user, which in most of the cases is going to be an old person or an adult with mobility issues.

Q1. What weight limit would you establish for an old person to carry it?

Q2. Which one would you choose as a way of carrying the product considering elderly restrictions? Why?

A. Hanging from a band or strap
B. Hold using a handle
C. Just grabbing the whole product (50x50x5cm)
D. Other:
Q3. Which one would be a better combined strategy (cushion shape + sheet form) for reducing the pressure in the user’s body?

A. Flat sheet + Flat cushion
B. Flat sheet + Saddle cushion
C. Saddle cushion + Saddle sheet
D. Flat cushion + Saddle sheet

Q4. What are the main aspects to consider for releasing pressure on the user while sitting down?

Q5. What would be the minimum cushion thickness you would consider aiming for an acceptable comfort?

Q6. What cushioning solution for the corner would you prefer and why?

A. Sharp angle
B. Curved corner
Q7. What locking triggering motion would be better for an elderly user?

A. Rotating  B. Sliding  C. Pushing/Pulling

Q8. What would be the best position for the locking system from an elderly ergonomics point of view?

Q9. What are the possible problems of using this hypothetical solution for long time? Would it be possible to solve it through cushioning? How?
<table>
<thead>
<tr>
<th>Question</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q10. Is lateral support beneficial for an elderly user?</td>
<td><img src="image1.jpg" alt="Image" /></td>
</tr>
<tr>
<td>Q11. Is there any specific need for users suffering from Arthritis in their hips and lower back?</td>
<td><img src="image2.jpg" alt="Image" /></td>
</tr>
<tr>
<td>Q12. Is there any ergonomic design feature from the following product you would consider skipping?</td>
<td><img src="image3.jpg" alt="Image" /></td>
</tr>
<tr>
<td>Q13. Which of the following cushioning design do you think would fit better with the product and the general elderly needs? Why?</td>
<td><img src="image4.jpg" alt="Image" /></td>
</tr>
<tr>
<td>Q14. Is there any comment you would like to add?</td>
<td><img src="image5.jpg" alt="Image" /></td>
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<tr>
<td>Postadress:</td>
<td>Besöksadress:</td>
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</tr>
<tr>
<td>Box 1026</td>
<td>Gjuterigatan 5</td>
</tr>
<tr>
<td>551 11 Jönköping</td>
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</tbody>
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