Digital freedom in physical form:

Developing a flexible model for representation of product series

Erik Agermo
Andreas Björklund

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Institutionen för ekonomi, teknik och samhälle
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Acknowledgement

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Andreas Björklund

Erik Agermo
Abstract

This master thesis from Industrial Design Engineering, Product Design, at Luleå University of Technology, has been formulated and assigned by Polardörren AB. Today’s manufacturing companies often display their products by using sample products in physical stores. Polardörren AB is a door manufacturing company located in northern Sweden and have a wish to be experienced as a creative and flexible company. Competitors to Polardörren AB have started using digital software to let their customers experiment with the composition of their products. This provides huge possibilities in representation, however, digital is not always better. Digital representations mean a complete lack of feeling for material or quality. Ideally you would be able to combine the freedom of the digital world with the feeling of the physical world, and this is where our model fits in perfectly. We have developed a prototype that, with the use of modularity, can represent many of Polardörren AB’s products in an effective and compressed way. By using the same type of material as the company use in their regular products, we present the user with a similar feeling as from the real products. Neodymium magnets lets a consumer, in an easy way, create and explore custom-made designs based on their personal needs and wishes. By involving the end-user in the design process, we believe that the number of purchases of the company’s products, and the general opinion towards the company, will increase. This could lead to increased revenue for both resellers and manufacturer. During the development process of this prototype, areas such as industrial design, semiotics, user experience and usability has been explored. Methods used in this project ranges from brainstorming and brainwriting to computer modelling and CNC-milling. If this prototype would replace one of the existing product samples at the reseller today, the cost for representation would be estimated to go down to one third of the cost today. By using material that the company already have in their production today, we make a minimal impact on the environment by preventing excess deliveries from new distributors.

KEYWORDS: Industrial Design, Prototyping, Computer Modelling, User Experience Design, Multifunctional prototype
Sammanfattning


NYCKELORD: Industridesign, Konceptframtagning, Datormodellering, Användarupplevelse, Multifunktionell prototyp
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1. Introduction

This master thesis project has been conducted by two students in 2016/2017. The project is a part of the program Master of Science in Industrial Design Engineering Product Design at Luleå University of Technology, Sweden. The project has been formulated and assigned by the company Polardörren AB in Öjebyn, Sweden. Polardörren AB claims to be the second largest manufacturer of front doors in Sweden. Manufacturing companies generally have a large number of products and a big variety in the appearance of their products. From experience, it is often hard for the companies to show off their products in an effective way, other than using product catalogues or websites. This project will determine how you, understandably in the most effective and compact way, represent a range of products in a user-friendly manner. The products are from Polardörren AB, and the representation should be in the form of a physical model, with the ability to change the appearance without compromising the feeling of the products. The theoretical parts of this report will branch into for example semiotics, user experience, prototyping and manufacturing.

1.1 BACKGROUND
Polardörren AB is a company that manufactures front doors for homeowners and companies. They have a very wide product range and a huge flexibility within their production. This is something they have always wanted to extend to their customers and it is one of their main features in their description of themselves. Polardörren AB claims that they are the second highest selling company, that manufactures doors in Sweden, today. They have retailers from the southernmost to the northernmost parts of Sweden. The manufacturing of their simplest and most selling doors is outsourced to a company in Estonia, which provides the company with the ability to fully focus on their more exclusive models and custom-made doors. This has been a successful business plan for a while and now the company wishes to expand their Swedish production, or rather make the customers aware of the ability to make a totally unique and personalized door. In order to address these wishes by the company, they are now going to release a concept or service called “Build your own door” where it will be easier for the customer to see and visualize the finished door based on their personal wishes.

These visualizations are easily represented in a digital form as part of an application, a program or a web service using a computer, a smartphone or a tablet. The problem however, with digital representations and models, are the inability to physically touch and feel the product. This can contribute to a problem where the customer is imagining their product in one way, from the digital representation, which is not the same as the physical finished product. Computer programs and applications can also be overwhelming for the inexperienced user and they may feel intimidated by the number of possible choices and combinations of all the features of a door. So, to make it easier for their customers the company wishes to create a physical representation of this digital freedom. This product will serve as an aid to all retailers around the country to help them explain and demonstrate the flexibility and near endless customization of the products from Polardörren AB. This is the point where this master thesis begins.

1.2 STAKEHOLDERS
This project and its result will affect several different parties. During the project, we will involve Polardörren AB, Luleå University of Technology, and the employees at these workplaces. We expect to be able to ask said employees for their opinion and thoughts about our work and the ideas we come up with. At the end of this project we also expect to be able to ask for assistance when creating prototypes to assure a high quality of the product.

The final product aims to assist both resellers and customers by acting as an aid to demonstrate the products that Polardörren AB has to offer. This will in turn create a better understanding for the
customer about the company and their products and help every customer to satisfy their unique needs in the product they are looking for. This project will, apart from helping the company, also help us (graduate students) by acting as a reference for future work.

The competitors to Polardörren AB and even companies manufacturing a similar type of products, for example kitchen furniture or similar companies, may be affected by this project and the knowledge developed throughout this project. In summary, we expect this project to result in higher sales and higher revenue for the company, a greater perception of the company and less workload for the customer and the resellers.

1.3 OBJECTIVE AND AIMS
The aim of this project is to develop a physical model which will be able to display the variety of the company’s range of products. This product should provide a consumer with an opportunity to see a representation of the product based on his or her specific needs. In addition to this it will be easier for a reseller to demonstrate and explain the details, appearance, compositions and features of the company’s products.

The objective is to offer assistance in form of this model, to the resellers and customers, and we expect it to increase the understanding of the company’s possibilities and services as well as increase the general opinion and feeling for the company among this audience. This will in turn provide the possibility for increased revenue and income for the company by increased sales.

When developing this product, we will always have the goal for the company to be able to manufacture this product themselves in their own production. This means that by the end of this project we will deliver not only the product, but also the drawings, CAD-files and a report that describes our workflow and reasoning throughout the project.

1.4 PROJECT SCOPE
During this project, there will be some delimitations that needs to be related to:
• The result should be a physical product with instructions for manufacturing.
• When designing the product, it should be kept in mind that Polardörren AB should be able to manufacture the product themselves within their own production.
• It should not be larger than the measurements of a standard A3-paper (297x420mm)
• The budget is limited by the company. Luleå University of Technology will have limited means only suitable to cover for basic material and equipment.
• The time for this project is limited. The end presentation is set to be 19th of January 2017 and we expect to be as near finished as possible, with reservation for completion and correction of the thesis report.

1.5 THESIS OUTLINE
This thesis report has been divided into eight major sections and below is a short overview of what each chapter will contain:
• Chapter 1 is an introduction to the project
• Chapter 2 will explain the context around the project
• Chapter 3 presents the theoretical framework and necessary theory
• Chapter 4 explains theory behind the methods used in this project and how they were used
• Chapter 5 contains the result that has been produced throughout the project
• Chapter 6 is a discussion of the project
• Chapter 7 is a conclusion of the project and necessary future work
• Chapter 8 is a list of references that has been used
• Chapter 9 is a collection of appendices from the project
2. Context

This chapter will explain more in depth the situation the company is in today, how the company manufactures their products and what competitors the company has on the Swedish market and compare the competitors’ products with the company’s products. It will also list the features of Polardörren AB’s products, that the company wishes to include in the finished product that this project will result in.

2.1 POLARDÖRREN AB

The following information is based on our knowledge about the company and the information that the company provides through their website and commercial material.

Polardörren AB is a company that manufactures front doors for homeowners and companies. They have a very wide product range and a huge flexibility within their production. Polardörren AB are today the second highest selling company that manufactures doors in Sweden. They have over 500 retailers from the southernmost to the northernmost parts of Sweden. Polardörren are providing customers with two different product lines;

- Polardörren, manufactured in Sweden with high quality. Most materials used for production are acquired locally in northern Sweden. Possibility to manufacture according to special wishes from the customers.
- Nordic Entré, sold but not manufactured by Polardörren AB, but is a more economical alternative. This line offers several different models, but with fixed sizes, colors and appearances.

The manufacturing of Nordic Entré, their simpler and more selling doors are outsourced to a company in Estonia, which provides the company with the ability to fully focus on their more exclusive models.

Polardörren AB expresses their vision to become the markets most creative and flexible manufacturer of doors. Their ability to manufacture a door to any of a customer’s specific wish, is one of their biggest strengths. Polardörren AB see their manufacturing as a craftsmanship. Each door is manufactured, painted, assembled and shipped by hand to ensure the highest quality in their products. The only step not done by hand is the CNC-milling of the cassettes to ensure that handles, locks, hinges, grooves and overall design is correctly placed. The strength in working in this way is the flexibility within the production line. Every door is already treated separately, so inserting a custom design for a door in the production makes little or no impact on production flow.

The sales at Polardörren AB are managed by the sellers at the company. The sellers are located in three districts: southern, middle and northern Sweden, and they manage orders from resellers, companies and private customers in those respective areas.

"Polardörren wants to change the way you look at a front door. It does more than keep the wind and cold out, a front door creates warmth and comfort! With us there is a great will to learn and develop. Our strength is our ability to adapt to the customers every need and wish." – Polardörren 2016

Figure 1: Logo of Polardörren AB
http://www.polardorren.se
2.2 CONSTRUCTION OF THE PRODUCTS

By knowing more about the products that the company manufactures, you are able to get a deeper understanding of the production and the strengths and weaknesses among the products. When spending time in the production, we have learnt that every door Polardörren AB manufactures are produced around the same principle. Everything starts with a wooden frame made from high quality wood from northern Sweden. This wooden frame is then stuffed with Styrofoam, that is equally thick as the wood, and blocks of wood that will act as a support for mounting the lock in the door. The Styrofoam acts as an isolator in the door to separate the outside climate from inside climate. The wooden frame filled with isolation is then laminated with two aluminium sheets and two HDF-sheets, one of each on either side, and then placed inside a heated press to harden the glue and secure the construction. When the glue is hardened you now have a finished cassette, the foundation and start of what will become a new door.

These cassettes need to be trimmed down along the outer edge to match the exact measurements of the door standards. This is done in a CNC-milling machine, the only step in the production line that is not done by hand. Every model has its own CAD-model and CAM-preparation file that is loaded into the software of the machine. The program then mills the outer edge of the door, makes fittings for locks and hinges, and makes optional grooves and placement for a window, depending on the model of the door. The door is now ready for pre-treatment before painting.

Firstly, every door is primed with one layer of white paint. This helps to spot any damages in the construction. The door now needs to be sanded along every edge and surface to roughen up the surfaces and to grind off any sharp edges or ticks. This is also where you apply putty to fill out any damages or crevices that may have appeared during the former steps in the production. The door is then primed once again with another layer of white paint and again sanded along all edges and surfaces. This usually is enough to make sure that the door is ready for the final coat of paint. Each door is then painted with one of six standard colors, or if requested by the customer it can be painted in any color found in the NCS color system. When the paint has dried, the door is ready for the final assembly before shipment to the customer.

At the final assembly station, all doors are fitted with hinges, locks, handles, optional windows and strips, serial number and any other type of cosmetic accessory that may be part of the model of the door. Ultimately the door is polished and wiped off to make sure everything looks nice prior to being packed and shipped off to the customer.

Figure 2: Product composition. Illustration by: Andreas Björklund
2.3 FEATURES

While communicating with the company we have received instructions of certain standard features that shall be represented in the final model. It would be near impossible to be able to represent every feature from every model in the product line, therefore we are limiting the features to the more common door models. This however still produces a vast amount of possible combinations. The grooves pattern can be seen in figure 3 and the combination between grooves, décor and windows can be seen in table 1. The décor can be seen in figure 4 and the décor in combination with windows can be seen in table 2. The windows can be seen in figure 5 and table 3.

![Figure 3: Grooves from left - Blanco, Norrsken, VertLine, Lapporten & Allegro. Illustration by Andreas Björklund](image)

![Figure 4: Décor from left - Smaragd, Norrsken, Safir & Juvel. Illustration by Andreas Björklund](image)
Table 1: Compositions

<table>
<thead>
<tr>
<th>Grooves</th>
<th>Windows</th>
<th>Décor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allegro (Vertical)</td>
<td>Förnuftig (Rectangular)</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Lapporten (Rectangular)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stripe (Rectangular)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Marin (Round)</td>
<td></td>
</tr>
<tr>
<td>Lines (Horizontal)</td>
<td>Förnuftig (Rectangular)</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Lapporten (Rectangular)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stripe (Rectangular)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Marin (Round)</td>
<td></td>
</tr>
<tr>
<td>Lapporten (Rectangular)</td>
<td>Förnuftig (Rectangular)</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Lapporten (Rectangular)</td>
<td></td>
</tr>
<tr>
<td>Norrsken (Rectangular)</td>
<td>Norrsken (Rectangular)</td>
<td>No</td>
</tr>
<tr>
<td>Blanco (No grooves)</td>
<td>Förnuftig (Rectangular)</td>
<td>Norrsken (Rectangular)</td>
</tr>
<tr>
<td></td>
<td>Lapporten (Rectangular)</td>
<td>Smaragd (Rectangular)</td>
</tr>
<tr>
<td></td>
<td>Stripe (Rectangular)</td>
<td>Safir (Rectangular)</td>
</tr>
<tr>
<td></td>
<td>Marin (Round)</td>
<td>Juvel (Grooved)</td>
</tr>
<tr>
<td></td>
<td>Norrsken (Rectangular)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Juvel (Rectangular)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Smaragd (Rectangular)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lady (Round)</td>
<td></td>
</tr>
</tbody>
</table>
To gain a general insight on the exterior door industry a benchmarking on exterior door manufacturers in Sweden was carried out. The research focuses on answering questions as which door manufacturers are the major competitors to Polardörren AB; what are the strengths and weaknesses among competitive products, and are there any additional services in the industry developed to maintain a good user experience while purchasing exterior doors or relative products. The various companies are named as company A, B and C in order to preserve anonymity.

Table 2: Combinations of décor and windows

<table>
<thead>
<tr>
<th>Décor</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Smaragd</td>
<td>Lady (Rectangular)</td>
<td>Smaragd (Rectangular)</td>
</tr>
<tr>
<td>Safir</td>
<td>Förnuftig (Rectangular)</td>
<td></td>
</tr>
<tr>
<td>Norrsken</td>
<td>Norrsken (Rectangular)</td>
<td></td>
</tr>
<tr>
<td>Juvel</td>
<td>Juvel (Rectangular)</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Window appearance

<table>
<thead>
<tr>
<th>Window</th>
<th>Mullions</th>
<th>Placing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marin (Round)</td>
<td>No</td>
<td>Centered Up &amp; Down</td>
</tr>
<tr>
<td>Stripe (Rectangular)</td>
<td>No</td>
<td>Centered Right &amp; Left</td>
</tr>
<tr>
<td>Förnuftig (Rectangular)</td>
<td>6-Mullion None</td>
<td>Centered</td>
</tr>
<tr>
<td>Lapporten (Rectangular)</td>
<td>6-Mullion None</td>
<td>Centered</td>
</tr>
<tr>
<td>Norrsken (Rectangular)</td>
<td>Antique None</td>
<td>Centered</td>
</tr>
<tr>
<td>Juvel (Rectangular)</td>
<td>Antique None</td>
<td>Double Centered</td>
</tr>
<tr>
<td>Smaragd (Rectangular)</td>
<td>Graceful None</td>
<td>Centered</td>
</tr>
</tbody>
</table>
2.4.1 COMPETITORS

The first company, company A, is a trademark to a larger company based in the USA. According to their webpage\(^1\), they are considering themselves to be the leading supplier of doors in the European market and they have two factories in the southern and middle part of Sweden. According to allabolag.se this company has over 650 employees in Sweden and a revenue that exceeded about 1.3 billion SEK during 2015.

Company B is a family owned company with three different factories that manufactures both windows and doors, according to information gathered from their own webpage\(^2\). They have approximately 377 employees in Sweden distributed on management, sales and marketing, production and product development. They have three factories that manufacture both interior and exterior doors. The retailers that they supply their products to are spread over the whole country but most of them are located in the mid-region and the southern part of Sweden. According to allabolag.se their revenue reached approximately 580 million SEK during the period of 2015.

Company C is, according to their webpage\(^3\), a trademark owned by a larger company that claims to be the largest manufacturer of doors and windows in Europe. Information from allabolag.se is stating that the numbers of employees working with the manufacturing of doors are estimated to 63 people and the revenue exceeded nearly one hundred million SEK during 2015.

To put this in a perspective, information from allabolag.se is stating that Polardörren AB has 16 employees and during the period of 2015 its revenue surpassed approximately 350 million SEK. The revenue is not directly related to the profit or success of a company, but it gives an initial value to compare companies with. Polardörren is manufacturing exterior doors only and while their revenue was lower during the same period as both company A and company B you still have to keep in mind that both of these are manufacturing products as e.g. windows and interior doors in addition to the exterior doors, and therefore the revenue has to be distributed among the company’s products in order to get a fair comparison.

However, when comparing the revenues vaguely distributed on the companies’ products a conclusion can be made that Polardörren, company B and company C are relatively similar in terms of size and company A has a slightly larger revenue of the companies in the exterior door industry in Sweden. A summary of the information gained can be seen in table 4.

Table 4: Summary of competitors

<table>
<thead>
<tr>
<th>Company</th>
<th>Revenue (2015)</th>
<th>Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polardörren</td>
<td>350M SEK</td>
<td>16</td>
</tr>
<tr>
<td>A</td>
<td>1.3B SEK</td>
<td>650</td>
</tr>
<tr>
<td>B</td>
<td>580M SEK</td>
<td>377</td>
</tr>
<tr>
<td>C</td>
<td>100M SEK</td>
<td>63</td>
</tr>
</tbody>
</table>

2.4.2 PRODUCTS OF THE COMPETITORS

The benchmarking has included a research of the products which the different companies are providing. All the information of the products has been found on the websites of each company respectively.

Company A provides a large variety of products that includes exterior doors, interior doors, sliding doors and apartment doors. These products are divided into two different product lines; Advance-Line and Clever-Line.

The Advance-Line offers better quality and the products have been equipped with high quality materials and the best technical solutions that the company can provide. These products are supposed to be associated with keywords as design, innovation and accuracy.

The Clever-Line offers simple and functional doors of good quality. The technical solutions are more of a basic standard compared to the Advance-Line and the customer’s freedom of choice.

1 http://www.swedoor.se/
2 http://www.nordan.se/
3 http://www.diplomatdorrar.se/
e.g. in terms of colours, sizes and glass is limited. Company B is separating their doors into five different series; Dynamik, Galleri, Vision, Harmoni and Favorit:

- **Dynamik** consists of doors that are supposed to have a playful design with characteristic patterns and lines.
- **Galleri** provides modern and timeless doors with glass parts in geometrical shapes. The doors in this series are manufactured to fit with strong colours.
- **Vision** is a door series which is inspired by subtle and futuristic design. Most of the doors lack symmetrical glass parts and some are decorated with aluminium strips. At the bottom the doors have been equipped with kick plates.
- **Harmoni** is a classic series which is inspired by a traditional design. This series can provide double doors to the customer if that is desired.
- **Favorit** offers standard doors with simple design features.

Company C offers a large variety of doors in form of patio doors, garage doors, institution doors, storage doors, interior doors and exterior doors. The exterior doors are divided into two different standards:

- The first standard is more exclusive and offers high quality double doors, single doors or a combination of them both. They are providing an opportunity of customization to meet the needs of the customer. The doors are divided into four different categories to make it easier for the customer to find the right one; Country, Urban, Classic and Nordic.
- The second standard is a basic series which includes simpler doors with different milled basic patterns. They are offered in forms of double doors and single doors. Customers are not able to customize these doors as the sizes, colours and features are fixed. This standard of doors is an appropriate choice when a lower price range is prioritized.

All of the companies are offering a rather similar product line to the two series of exterior doors that Polardörren is providing. Although, when comparing the products from the companies, using information from websites and product catalogues, they are not differing a lot from each other. However, each company uses their own technical solutions and patents to convince the customers that their products are better than the ones manufactured by their competitors. In the sections below, a comparison of eventual strengths and weaknesses of the competitors’ products has been made in relation to the products manufactured by Polardörren.

Company A provides a large quantity of constructions, optional features, designs and technical solutions. It is difficult to find anything particular that gives them an advantage in comparison with their competitors. Although, they have patents that makes them the only manufacturer in the exterior door industry that can use certain technical solutions. One of these is an integrated glass construction which is used on some of the doors. This makes it possible to produce exterior doors without any strips around the glass. This can contribute to an aesthetic advantage in comparison to doors made by Polardörren.

The different door models that company B provides are constructed with two anti-corrosive coated steel plates, unlike Polardörren that uses aluminium plates in the base constructions. The steel plates are, according to company B’s homepage, better than aluminium plates as they do not expand as much during temperature changes and they always strive to return to their original shape which prevents them from bulging.

Company C is, according to information from their homepage, offering a number of construction options. Their most common is the standard construction which is produced in Sweden and described to be of high quality material which can manage tough weather and wind. The second construction they provide is the Extreme version which is designed to be durable and able to withstand rain, wind, humidity and other factors. The construction is equipped with an outer sheet of laminate, and glass frames are made of composites which are resistant to water and humidity. The third is an eco-friendly construction which is an optional feature for the customer. This is designed to reduce heating costs and the isolating characteristics are created in several ways. The door leaf is reinforced with a PIR insulation and a frame with double slots which make it possible to install weather strips in between. To the glass equipped doors they are providing insulating glass which contributes to a low R-value, which contributes to a high thermal performance and
a low leakage of heat. The last construction is called the “Q-series” which is a combination of the previous designs. In this construction, high class materials are provided and the manufacturer claims to experiment a lot with different surface materials and a variety of uncommon glass types as leaded rhombs or mirror glass. The filling foam is equipped with plaster which contributes to a low R-value and adds extra weight to the door. The hinges are hidden and a three-point lock is installed to gain enhanced security.

Polardörren does also use a variety of constructions depending on which door model that is to be manufactured. Although, the strength in company C’s products in comparison to Polardörren is that they can offer a large variety of materials in the construction depending on what is desired by the customer.

In general, the products made by the different companies does not differ too much from each other. Polardörren, as well as the three competitors, provide an opportunity to the customer to choose among optional features which can be added to the door to improve desired properties from the customer. This makes it possible for the companies to create a very large variety of different doors. And what makes a certain company better than others depends on many variables, which in the end makes it is difficult to point out the strengths and weaknesses on companies’ products in the exterior door industry. In other words, to gain an advantage in the exterior door industry, a company will need to use unique ways to reach out to the customers. And that is what our product will provide.

2.4.3 ADDITIONAL SERVICES

In addition to product catalogues, in which the company can illustrate and give information about their products, company A provides a digital service with the purpose to makes it as intuitive as possible for the customer to understand the aesthetics of their products.

This service is a digital-based platform, which can be found on their own website. This platform gives the customers the possibility to choose a door they are interested in and put it in a rendered environment. The style of the door can be chosen as either modern or classic. The next step gives the customer an opportunity to select the design of the door and choose from the base colours, the colour that might fit the best. As the customer presses on these different variables the selected door automatically appears on a rendered house in real-time. The service also gives the opportunity to change the style and colour of the house to provide an environment in which the customers easily can visualize how the door will look like on a house that looks like their own.

The benchmarking also included an investigation of digital-based platforms that are used in other industries as well and how they are used and one interesting service that was found is developed by Lundqvist Trävaru AB, a manufacturer of building kits, located in Öjebyn. This company provides an online service that helps the customer to build their own house from scratch to give both a good visualisation of the house and an overview of the total cost. Initially, when using this service, you can choose between five different products you want to build; Garage, carport, stable, machine hall or holiday cottage. After you have chosen a category you will proceed to the next step which lets you choose which type of wooden panel you want and lets you modify different dimensions as width, length, wall height and roof pitch. When the construction of the base is finished, you proceed to the next step in which you can choose among a variety of doors, windows and gates and drag them onto the house and put them wherever they might fit. When you are happy with the design of the house, you continue to the last step which lets you choose among additional features. After the three steps are done a visualization of the final product is shown and the customer can easily rotate the model and get an overview of the house and the final cost.

As manufacturers in different industries are developing online services that is letting their customers to easily modify and visualize their products, a conclusion can be made that there is a need to fulfill this in order to improve customer satisfaction. Although, while researching this area there was not found any physical representations of a similar concept as the two described above. And the advantages and disadvantages a physical concept can bring will need further research and is to be explored in this project.
3. Theoretical framework

This chapter will present what was determined to be necessary theory for this project to be credible and scientific. This includes theory behind the term industrial design and the industrial designer, and theory behind user experience. The concept of user experience also makes it necessary to touch on the topics of usability and semiotics, in order to create a more understandable bigger picture. The theory in this chapter is partly based on our own experience and partly from other sources, and to ensure that the theory is qualitative we have tried to mainly use peer-reviewed sources.

3.1 INDUSTRIAL DESIGN

When you talk about design, it can have several meanings. One meaning could be the process of designing, the way you develop new products. Another meaning could be the design of a product, the expression it presents. The word industrial fills in with the purpose of designing towards the industry and the industrial mass production. The industrial designer is therefore working towards a better relation between the product and the human in industrially manufactured products. (Österlin, 2007)

“Industrial Design (ID) is the professional service of creating products and systems that optimize function, value and appearance for the mutual benefit of user and manufacturer.” – (IDSA, 2016)

The work tasks for an industrial designer are many, everything from designing a new product to designing a new production line. The industrial designer also possess knowledge about graphical design and computer modelling, which opens up the possibility for the industrial designer to work with tasks like rebranding companies or CAD-modelling. However, there are still a few main areas in which an industrial designer usually works, them being the carpenter’s industry and the automotive industry (Österlin, 2007).

The World Design Organization (WDO) describes an industrial designer as someone who has a human-centered approach to problem solving and that the industrial designer gains understanding of the user needs through empathy (WDO, 2017).

“Industrial Design is a strategic problem-solving process that drives innovation, builds business success, and leads to a better quality of life through innovative products, systems, and experiences.” – (WDO, 2017)

Wikberg Nilsson, Ericson & Törlind (2015) describes design as a natural part of the human life, that design is knowingly simplifying or enhancing. They also mean that a designer should aim to develop reliable and usable products by not forcing the human to adapt to the products, rather the products should be adapted to the human.

The reason this is important for this project is that this prototype are to be used by resellers and customers. They need to immediately understand how to use the prototype to create a better experience. There is also the possibility for this model to be put into production by the company, which means that it needs to be adapted for manufacturing.

3.2 USER EXPERIENCE DESIGN

In this project, we aim to build a product that shall be easy for users to understand, and in order to achieve this a theoretical basis of user experience design will be of relevance. According to the ISO standard (9241-210:2009), user experience is defined as the perceptions and responses from a person that result from the use or expected use of a product, system or service. Kujala et.al (2011) suggests that the objective of user experience design is to achieve customer satisfaction, ease of use
and pleasure provided in the customer-product interaction.

User experience design is often associated with human-computer interaction (HCI) and how to improve the users’ experience of using interactive products, web-pages or digital systems according to Hassenzahl and Tractinsky (2006). Although there are characteristics which may be of use in other product development processes as well. Hassenzahl and Tractinsky argue that user experience goes beyond the traditional approach of HCI by providing aspects such as attractive aesthetics, fun pleasure and growth that satisfy general human needs in a product. In other words, enjoyability plays an equally essential role as usability in user experience design.

Enjoyability is an undefined term, but generally it is about creating a product or service that satisfies psychological needs of the user in order to enhance the positive impression in the product experience. Since the users, in most cases, are human beings, we have learned from experience of previous courses that the designer need to know the psychological impacts of a human during its interaction with a product. Norman (2005) suggests that there are three levels of processing that plays a role in the total functioning of people; visceral, behavioural and reflective. Each of these phases of the human brain requires different methods of design approaches.

User experience design, as stated earlier, is about fulfilling attributes in a product, service or system in order to achieve user satisfaction. Although, every product development process is unique and what is to be developed depends on the context. Norman (2005) suggests that there are three different approaches of design depending on the purpose of the product. The first approach is visceral design. The visceral level of the brain is dominated by physical features as look, feel and sound, and the objective with this approach is to put a lot of focus on the aesthetics of a product. The second aspect is behavioral design where the priority is usability and performance. According to Norman (2005) there are four key components of good behavioral design: function, understandability, usability and physical feel. The third approach is reflective design which is all about message, culture and the meaning of the product or its use. To put this in a context, these three levels of design will be applied on regular products. In the stage of visceral design, it is all about the initial reactions from the user. Examples of visceral design are children’s toys and clothes as they often have bright and highly saturated colours. They are not great art, but is visually enjoyable. In the behavioural design level, a cellphone can be used as an example. Before someone invented the cellphone, no one thought we needed them. Today, it is for every day conversations. In other words, the function of a product can be discovered after designing it, and what a need is can sometimes be defined after the user has interacted with the product. In the reflective level of design one example of a product is a luxurious wrist watch. The function is the same as on any other watch, but on a reflective level the product provides high status and respect.

To achieve a good usability and enjoyability in a product we have learned from earlier experience in our education program that the designer need good knowledge of the context of the problem and understand what is required to fulfill the needs of the user. According to Vermeeren (2010) user experience explores how a person feels about a product in different aspects and these approaches of visceral, behavioral and reflective design gives an example of what kind of aspects that can contribute to a wider contextual understanding of the user and achieve customer satisfaction in the final product.

3.3 USABILITY
In an evaluation of SME’s (Small Medium Enterprises), a study showed that many SME’s claimed to involve end users throughout their entire design process. However, it also showed that the same SME’s mainly relied on informal qualitative methods. This study points out five potential problems by involving end users in the design process (Woodcock Fielden and Bartlett, 1995):

- Finding the right representatives for the tasks.
- Managing the representative’s expectations in early stages.
- Building a relationship with the representatives to make them trust the designer to not be afraid of telling what they think.
- Managing the costs for these evaluations.
• The SME’s perception of the value of the information gathered from the representatives. Usability could be described as designing to complement the human strengths and abilities. Something so well adapted that we do not pay attention to it, also called good design. This mean that you need to design for as many as possible, not only focusing on the regular person, but incorporating a variety of users in the design. This is because different users have different needs that needs to be satisfied in different ways (Wikberg Nilsson et al, 2015).

3.4 SEMIOTICS

Semiotics is the foundation for any visual or graphical communication. Semiotics define the theory and general ruleset for how to deliver a message to a receiver and have the receiver interpret the message correctly (Crow, 2010). In the online Cambridge Dictionary, semiotics is defined as:

“The study of signs and symbols, what they mean, and how they are used.” - 2016

The areas of application of semiotic analysis are many, and not the least in analysing products. In the book, Interactive Media: The Semiotics of Embodied Interaction (O’Neill, 2008) there is a reference to an author named Susan Vihma that has conducted research on semiotics in products. O’Neill means that Vihma has managed to link together two major areas of science to approach them in a different way. Further Vihma implies that people do not perceive the objects in their environment as examples of good form or good design, rather they perceive the objects as places to sit or places to walk etc. This way of viewing semiotics in products are not unlike affordance in products, that people understand what to do with a product simply by looking at it. This is something every designer should aim for in all their work. David Crow talks about one of the pioneers of semiotic research, Pierce, who stated the three categories of signs (Crow 2010);

• Icons – Something that looks like the sign itself.
• Indexes – Something that links directly to the object like smoke to fire.
• Symbols – Signs that in order to understand we need to learn the meaning of.

If you consider a door and think of what could be an icon, it is hard at first to give an example. However, a model of a door would be an example of an icon for a door. It is something that looks like what it is supposed to signify, even though it does not have to function like a door.

Indices in this context could be the hinges, handles and locks, which would indicate that this object is openable, hence could be a door. The milled grooves in a door is often characteristic and is hard to find in other products, but it is something that you have learnt from experience when seeing different doors, and would be an example of a symbol.

By incorporating semiotics in a product development environment, we believe that the overall quality of the products will increase, especially in development of products that are supposed to communicate visually with a user. We intend to make use of the knowledge about semiotics that we have gathered throughout our education, and incorporate that knowledge in the product we are designing by carefully thinking and experimenting on how the user perceives our product. This is to be done in a controlled fashion with the use of facilitated workshops or focus groups. An example of how we used semiotics in our project is when we experimented with representation of windows. Most of the time a window are transparent and have a glossy reflective surface. This meant that it was necessary to find an alternative way to represent a window. Therefore, different materials and different colour representations were evaluated against each other as seen in figure 6.

Figure 6: Color representation
Photograph by Andreas Björklund
4. Method and Implementation

In this chapter, we will present overall theory for each method used in the project and how we have implemented these methods. These methods will provide an adequate and scientific ground for the actions and decisions we have made throughout the development process of this model. The following sections will also serve as evidence that our planning and implementation has followed a scientific and industrial design process.

4.1 PROCESS
Given that we, from the beginning, had a rather clear goal of the project and that the project does not seem to differ too much from previous projects we have experience from, we decided to use an approach very similar to a stage-gate process. The workflow is in general linear, going from start to finished product, with several gates in between. These gates have goals that we aim to achieve, but these goals are not set in stone if we do not meet the required goal. This means that whenever we reach one of the gates, we make an evaluation of the work and what we have produced and compare that to the goal that we set up in the beginning of the project. If we decide that we are too far away from the goal, we keep working until we reach a satisfying result. When the result is satisfying we proceed on to the next stage of the project, this repeats until we reach the end of the project. An illustration of the process can be seen in figure 7 below.

The workflow within the stages are iterative, meaning that we test and evaluate the work along the way until we reach the satisfying result. This could look something like in figure 8 below.

![Figure 7: Process used in the project. Illustration by Andreas Björklund](image1)

![Figure 8: Workflow in stages. Illustration by Andreas Björklund](image2)

4.2 PROJECT PLANNING
With support from the knowledge about the task at hand and from a project guide, we sat down and started mapping out the 22 weeks of work we had before us. As with many projects we had done before this has a similar approach, but over a greater timespan and with higher demands on the result. Therefore, we started with planning the gathering of understandable information from the context and the theoretical framework. From experience, we have noticed that the more thorough you are in the early ideation phase, the better quality of the end results you get. That is why we planned a lot of time for the ideation phase. Lastly, we made sure to plan enough time for the implementation phase to be able to construct everything we could possibly need, and with enough time to change and redo parts if we need to. Everything has been visualized in a Gantt-scheme that has been attached in appendix 1 for a more detailed view of the project. In short this is the different phases for the project:
4.3 LITERATURE REVIEW
A literature review is an essential feature of any academic project since an effective review creates a basis for advancing knowledge, facilitates theory development and uncover areas where research is needed, Webster & Watson (2002).

We have understood from personal experience of previous projects that literature review is an important part since it contributes to a stable basis of theory for the project. In this case, we have focused to receive the information from peer reviewed sources to obtain a reliable theoretical basis. We have gathered the information mainly from databases where peer reviewed sources can be found such as Google Scholar which provides public scientific articles and the database at Luleå University of Technology that includes peer reviewed academic journals and papers. If it has been too difficult to find peer reviewed information about a specific subject or, we have used course literature and books as a basis of information and then confirmed the facts with additional sources that has either strengthened or disproved certain claims made by authors of various scientific papers.

Keywords used: Industrial design, user experience design, prototypes, models, rapid prototyping, brainstorming, brainwriting, benchmarking, usability, workshop, semiotics, interview methodology.

4.4 CONTEXT IMMERSION
To achieve a deeper knowledge of the exterior door industry, we have used methods that we deem to be of use while finding general information about a specific area, how the market looks like today and how the process works when customers are purchasing products.

4.4.1 BENCHMARKING
Fridley et.al (1997) are stating that benchmarking is a process used to compare companies’ best practices in for example business operations, customer relations, product design and manufacturing. Although, Elmuti and Kathawala (1997) claims that “the process of benchmarking is more than just a means of gathering data on how well a company performs against others. Benchmarking can be used in a variety of industries, both services and manufacturing. It is also a method of identifying new ideas and new ways of improving processes and, therefore, being better able to meet the expectations of customers” (p.229).

The term of benchmarking has neither a clear definition, nor is there a general approach of the method. The context of the problem has to be determined in order to adapt the benchmarking method in a proper way. As stated by Elmuti and Kathawala (1997) there are four types of benchmarking; internal, competitive, functional or industry and process or generic benchmarking. This means that it can be adopted in various businesses with the purpose of gaining competitive advantage. In this project we have used the method of competitive benchmarking since it contributes to a collection of information from different aspects about the competitive companies. We are certain that this can give us knowledge of the exterior door industry in general. This can contribute to the information needed to compare competitors to Polardörren with the purpose of finding eventual strengths and weaknesses among their products and sale services which can be of inspiration to us.

Benchmarking has been recognized as a sustainable method to improve product design, Lamancusa (1996), and it has been used in various design projects and studies. The best known example of a company using benchmarking is Xerox based in the USA. According to Omachonu
and Ross (1994) they have in fact been known as the “pioneers” of benchmarking. The company invented the photocopier in 1959 and had a monopoly on the market for decades. When the sales started to decrease during 1981 they started a benchmarking process on their competitors and their products. This resulted in positive and dramatic improvements which made sure that the company still exists today, Omachu and Ross (1994).

As stated by Fridley (1997) modern methods to quality improvement in a perspective of new product design, study and experience in benchmarking is valuable.

Lamancusa (1996) performed a project in which students were supposed to find critical design features on hand held mixers and give suggestions on improvements using dissection and benchmarking as methods. The project concluded that “the combination of benchmarking and dissection process is highly effective for teaching students about product design at the conceptual, implementation and detailed design stages.” Lamancusa (p.1320).

Although benchmarking does have limitations and disadvantages as lacking proper implementation, losing focus on the customers and employees and lacking clarity on where the data originated. Although they are outweighed by its benefits, Elmuti and Kathawala (1997). In other words, “benchmarking can be a very good intervention technique for positive change”, Omachonu and Ross (1994) (p.143).

In order to find out where to start looking for information about the industry, an initial research was made to discover which companies that are the major competitors to Polardörren AB. According to Polardörren’s webpage they are supplying their products to numerous retailers. While looking at the range of different manufacturers of exterior doors from which these retailers are supplying, a list could be made of a number of competitors to Polardörren. To reduce the list a comparison of the sizes of the companies, in terms of employees, revenue and profit margins, was made in order to find out which of them that are the major competitors to Polardörren. According to information gathered and compared from allabolag.se, three companies or trademarks were selected to be furtherly researched in detail. The information that was of interest were general data of the door manufacturers, the weaknesses and strengths of their products in comparison with products manufactured by Polardörren. Also, we wanted to find if companies in similar industries have developed a service or created a solution to ease the sales of their products, which might be of inspiration in our development project.

4.4.2 FIELD RESEARCH

Field research is a type of contextual technique which is used when data gathering from customers in the field, where people are working and living, lies in focus. According to Beyer and Holtzblatt (1997) contextual inquiry is a field–data gathering technique that studies selected individuals in depth to receive a deeper understanding of the work practice among all customers. Although, Beyer and Holtzblatt claims that contextual inquiry is based on various principles that makes it possible to meld it into each situation a project encounters:

• Context – go to the customers’ workplace and observe them do their own work
• Partnership – talk to them about their work and engage them in uncovering unarticulated aspects of work
• Interpretation – develop a shared understanding with the customer about the aspects of work that matter
• Focus – direct the inquiry from a clear understanding of your own purpose

These principles show that the field research is a flexible data-gathering method that can be adapted in numerous situations. In this project we have collected information through general observations at the field, which in this case is various retailers of exterior doors. This method is usable in this project since a field research at retailers makes us understand how exterior doors are displayed in physical stores. This is of high relevance as the aim of the project is to create a physical representation of a door in a smaller scale.

To receive an understanding of how the customers are buying their doors, how the doors are presented at stores and to get general inspiration we decided to perform a field research at
several exterior door retailers which are located in the Luleå region. We decided to visit retailers that provides exterior doors from Polardörren in their range of products, and retailers that only provides exterior doors from competitors. The retailers in this section are anonymous and are not to be confused with the anonymous door manufacturers described in the benchmarking. During the visits we observed the range of products that each retailer provides and in which way the exterior doors are displayed.

We began by going to retailer1, which is a rather newly opened hardware store. At first sight of the range of exterior doors we got the impression that doors from Polardörren were of a majority. The doors are installed in prism-shaped booths in which them contains one door on each side, three doors in total per booth. The doors in the booths are fully functioning prototypes of full sized models, figure 9.

Polardörren display a selection of their exterior doors, of which some of them belong to the more expensive price range and the others belong to the economic product range. In addition to these display booths, Polardörren presents a variety standard colours in the shape of small doors which has magnets attached on the back of them that makes it possible for a customer to put it on the side of a door model they are interested in. As the customer can choose between several glass types on the window Polardörren display cut-outs of a variety of these on a board which is hanging right beside on of the doors. The colour examples and the glass cut-outs are shown in figure 10 and figure 11 on the next page.
The second store we went to was retailer 2 which is not a retailer to Polardörren. In here Swedoor is the head supplier which could be understood as most of the exterior doors that were displayed in the store were manufactured by them. Instead of being showed in booths these doors were displayed in a context which contribute to a realistic expression. The doors are embedded in a façade of which a roof is built upon with downpipes added to it, and beneath on the ground there are tiles of different rock types. The doors manufactured by other door suppliers are shown in display booths which contains one door model of original size each. In addition to this all the different door suppliers provides some sort of cross-section visualisation of their doors. This gives them an opportunity to show the customer the construction of their products and the variety of patterns and colours that they provide on their models.

The third store we visited is retailer 3. This company mainly sells exterior doors from Polardörren and Swedoor but also doors from other manufacturers, although in a lesser quantity. All of the exterior doors are presented in original sizes and are standing in separate display booths, figure 12.
This makes it easy for the customer to open the doors and feel the quality of the materials and other characteristics that eventually can be necessary to investigate when buying a door.

The fourth and last store we went to was retailer 4. We chose to go here since this store has existed longer than retailer 1, which belongs to the same company chain as retailer 4, and we wanted to explore if these differs from each other when it comes to product range and how they have chosen to show their products. This store has chosen to display its assortment of exterior doors in a similar way as at retailer 2. The door models are of original size and embedded in a tree façade with a roof upon, downpipes and stone tiles beneath to simulate a realistic expression. The majority of exterior doors are represented by Polardörren and also here they show a variety of glass types and standard colours to the customer. The different glass types are cut into rather small squares embedded in a wood board which is hanging by one of the doors. The standard colours are displayed on small door-like wooden boards that are attached with magnets on the back just like at retailer 1.

We also took the opportunity to look at the assortment of interior doors at the different retailers to get eventual additional inspiration. They are commonly displayed in a flipchart-looking solution in which the doors are hung in their hinges, which lets the customer to flip through the different door models of original sizes.

4.4.3 INTERVIEWS

Interviews is method which can be used to gather information about the users and their needs. As stated by Patniak and Becker (1999), it is commonly known among designers that needs of the user are important to understand while solving problems with focus on the user. And by that, interviews are a method that can be used to identify the needs of the users.

However, an interview can be structured in different ways, as stated by King (1994), and knowing which one to use depends on the context of the problem. DiCicco (2006) also mentions different structures of interviews and categorizes them as unstructured, semi-structured and structured. DiCicco argues that structured interviews often provide quantitative information, meanwhile the unstructured and semi-structured interviews provide qualitative information. During the field research, we held unstructured interviews with two employees at the retailers we visited. We decided to use an unstructured version as it is known to contribute to qualitative information, recko and as stated by Rosenthal (2016) “qualitative research provides a way to get an in-depth understanding of the underlying reasons, attitudes and motivations behind various human behaviours” (p.2).

The underlying reason that employees were interviewed during the field research is mainly that the final product in this project will be aiding through the purchase of exterior doors at a physical store. And during this process the employees are expected to interact with it a lot. Therefore, we used them as preferences when asking for personal opinions about a theoretical system where the customers are able to build and design their own door. In addition to this we asked the employees of how the process works in general when a customer is buying a new exterior door, what the most time-consuming part is during this process and how it works today when a customer want a special designed door (appendix 2).

The purpose of the interview process varies according to the research question and the disciplinary perspective of the researcher, DiCicco (2006). In other words, interviews can be implemented in various phases during a product developing project which provides an opportunity for the researcher to gain a personal opinion from the user, depending on the context, when that is desired.
4.5 IDEATION
In this section, we will present our methods and approach when creating and forming ideas for concepts and solutions. We have used a variety of different methods to increase the amount of ideas to have a satisfying ground for clustering and evaluation of all ideas to be able to narrow them down into feasible and creative concepts.

4.5.1 BRAINWRITING
Brainwriting is a method created by Rohrbach (1969) which was published in the German sales magazine Absatzwirtschaft. The idea of the process is similar to brainstorming, although, instead of orally presenting the ideas, the concept is to first let a group of people sit by themselves and generate ideas in silence by writing them down on paper. Afterwards the ideas are supposed to be shared and introduced to the other members of the group. VanGundy (1984) claims that brainwriting techniques can play an important role in the product development process by adding other new product idea sources and by helping companies increase their odds of producing innovative ideas. Therefore, this method is expected to be reliable in the context of generating unique and useable ideas. In addition to this, Heslin (2009) is stating that brainwriting potentially minimizes the effect of status differentials, personal conflicts, domination by one or two group members, pressure to conform to group norms, and digression from the topic. In addition to this he also claims that this method might eliminate production blocking, reduce free riding and encourage careful processing of shared ideas. In this idea generating phase braindrawing was included. According to Usability BoK (2010) braindrawing is a type of visual brainstorming in which the participants sketch ideas for designs, icons, screen layouts or other visual concepts. The layout of the method is similar to brainwriting which is why they are suitable to combine. The major difference is that the participants draw their ideas instead of writing them down.

During this session, we began to sit by ourselves in the same room trying to generate ideas through a limited amount of time. While coming up with ideas, they were drawn and written down on paper with markers to delete the possibility to erase and change the ideas to encourage a high flow of ideas and decrease the detail work. We also tried to avoid to fix our thoughts in a specific direction or use any specific catchwords while generating the ideas as we wanted to limit ourselves as little as possible. When the time ran out we stopped the session and started to present the ideas we had generated to each other to be able to explain how each of us were thinking during the session. This gave us an opportunity to give feedback on the ideas. Paulus and Yang (2000) concluded in an expriment that exposure to ideas from other people followed by a recall period is cognitively stimulating, or in other words, contributes to a higher productivity. When we had analysed the ideas, we realised that some of them were quite similar but most of them differed from each other, and we chose to continue with the brainwriting method. After the break, we continued a new session with the same approach as earlier to generate more ideas.

When the second attempt of the brainwriting was finished, we realised that it was hard to think outside the box and generate ideas that is not like the ones we had already come up with. When you allow yourself to think in any direction you want in an extensive field as this it is easy to think narrowly. Therefore, we chose to try a new approach to avoid getting stuck and letting us think outside the box.

4.5.2 BRAINSTORMING
Brainstorming is a creative idea-generating method created by Alex F Osborn in the publication of his book Applied imagination. According to Osborn (1963) brainstorming is a method used to achieve a high amount of ideas during a short period of time without the effects of self-criticism or criticism from the other participants.

VanGundy (1984) claims that brainwriting is neither better or worse than brainstorming. Instead he suggests that the choice of method will depend on a number of factors, and the method chosen should “be the one that maximizes its strengths for a particular situation” (p.68). And therefore, we began with a warm-up exercise to prepare ourselves into getting open minded and to
get the habit of not thinking in a restricted way. Research has found a positive connection between total amount of ideas and total amount of good ideas (Diehl and Stroebe 1987). Another Study has shown that a quantity of ideas is positively associated with unique ideas (Rietzschel et al. 2006). In addition to this Osborn (1963) claims that a quantity of ideas raises the quality in ideation. This exercise was based on a random input method in which a random word was chosen to open new lines of thinking as the purpose was to come up with random associations to this word. In this case, the word “Apartment” was written in the middle of a whiteboard and both participants started to come up with anything that we felt had a connection to this in any way. The associated words were directly documented on the whiteboard and connected to the initial word with lines drawn between them. The warm-up session continued until the amount of ideas decreased significantly and the participants eventually felt ready to move on to the planned brainstorming session.

When the warm-up session was complete the brainstorming method began, which was constructed in a similar way, but what differed was that the participants focused on a stricter way of thinking. This was performed by using two different categories that were assumed to be reasonably relevant to the problem. The first initial category we used was “Objects that can be opened”, and the reason this was chosen is because the aim was to achieve a quantity of ideas of different ways to open any object that could be thought of that exists in the modern society. In similarity to the warm-up session the initial category was written in the middle of the whiteboard and the associated ideas were connected to this with lines drawn between them. The second category was “How you can put things together” and this time the session was also performed the same way as earlier. This category was considered to have a relevance to the problem since a major purpose will be about how you can attach a variety of objects to each other in the most efficient way possible. Both categories were chosen because they would help generate ideas which can be of inspiration or be developed during a later phase. The ideas generated early in the brainstorming session are doubtfully the best ideas.

In general, the brainstorming method is suitable to use in a product developing project where a quantity of ideas is needed. However, there are psychological aspects that can prevent productivity during the session. As stated by Diehl and Stroebe (1987), brainstorming may cause three theoretical factors of productivity loss; Production blocking, evaluation apprehension and free-riding. Production blocking occurs when participants are not allowed to verbalize their ideas or suppresses them because they are believed to be less relevant during a later time. Evaluation apprehension means that a member of the brainstorming session can fear negative evaluations from other participants which will prevent the member of presenting its more original ideas. The term of free riding means that participants are not contributing to the group as they feel that their involvement in the group is unnecessary.

Although, as these factors will affect the result in a negative way, the knowledge of them will make it possible to prevent most of them from happening and will contribute to a stable and reliable method. A general visualisation of how the method can be used is presented in figure 13 on the next page.

4.5.3 CREATIVITY WORKSHOP
A great method of making sure to address these concerns mentioned in section 3.3 regarding usability appropriately, is by conducting facilitated workshops. A facilitated workshop is a group of participants that are being led by a facilitator to work together towards a specific goal. This type of workshop is often used to evaluate products, and although this method can be used for several other purposes, the basic procedure is the same (Harkness 2006).

- The purpose of a workshop must be clear.
- The attendees must be able to contribute.
- The workshop must be directed towards a specific outcome.
- It is important that the workshop is interesting and fun for everyone participating.
When working in groups there is a reason to work with smaller groups. Large groups have a tendency to be dominated by a couple of people, leaving many afraid of expressing their opinions. By working in smaller groups everyone will have the time and space to express their own opinions and contribute to the process (Yayasan IDEP, 2006). When working with usability tests it is recommended to have between five to ten participants. Any larger number of participants tend to lead you into using a summative approach where your aim is to measure a specific task or ability. By keeping the number down, you have the opportunity to have a formative approach instead. A formative approach is often beneficial for collecting data to improve a design or a concept in an early stage of development (Kaufmann 2013). In section 4.15 we describe how we have used facilitated workshops in our project to gather understanding and inspiration from other sources than our project group.

When facilitating our workshop, we wanted to make sure everyone felt confident to express themselves and present all their ideas they could come up with during the workshop. The workshop was planned to take about two to three hours to complete. We invited everyone to the workshop with the use of social media and by spreading the word around the students at the university. At
first, we greeted everyone welcome and presented the plan for the day and then we continued to
tell the participants what we expected from them and their participation. We also briefly talked
about the company that we work for and what we do in our thesis project, although keeping in
mind to not expose any classified information to not compromise the secrecy of the project.

To get the participants of the workshop into the right mindset we used an exercise we called
“What can you do with a A4-paper?”, this encouraged the participants to come up with as many
ideas as possible without thinking about feasibility. When everyone was in the right mindset we
presented the main task of the workshop. We wanted the participants to brainstorm influenced by
words and themes. We used three themes; Shapes, Patterns and Attributes. These themes should
be incorporated in some way into the idea that they formed. We wanted the participants to think
of ideas inspired by multifunctionality or multipurpose, items or things that serve more than one
purpose like for example a swiss army knife.

This proved to be a difficult task for the participants without knowing the overall subject
that our thesis work is focused on, and this would have worked better around a subject where you
are able to disclose all details. So, for the next round of brainstorming the approach was altered. This
time it was set up similar to a focus group, where one facilitator would lead the discussion. By using
metaphors, the facilitator was able to talk more freely about the subject and the participants got
a better understanding of what kind of solutions and ideas we sought for. This way of facilitating
generated more concrete ideas, partly from the participants but also from the facilitators. We as
facilitators were forced to think differently than what they were used to, which meant that they also
gained a deeper understanding for the task at hand.

4.5.4 IDEA SELECTION
From the methods used for generating ideas we ended up with close to 50 ideas, which was one of
our goals. However, not all of those 50 ideas were reasonable or even feasible for this project. This
meant that we needed to exclude ideas that did not really fit the project. By looking back at the
objective of the project and the delimitations and directions we had set for the project, we had good
rules for which ideas were good or not. We discussed and evaluated every idea and decided if we
should keep it or discard it and eventually narrowed them down into eight feasible ideas.
4.5.5 FORMING CONCEPTS
From the eight remaining ideas, we formed five concepts that matched the objectives and directives that were set for the project. This was done by trying to distinguish what was special and unique with the ideas, and trying to elaborate on those qualities. Despite this, some concepts felt a bit too simple and needed another level of function. To make up for that, we tried to use some properties from the other ideas, and we eventually ended up with five concepts that we felt were detailed enough to be made into a prototype. These five concepts can be found in section 5.1.1.

4.5.6 EVALUATION OF CONCEPTS
To determine which concepts we should move forward with we decided to evaluate the five concepts similarly to how we evaluated the ideas. We started by discussing each concept and weighing pros and cons in regards to for example manufacturing, innovatory, complexity and feasibility. We came to the conclusion that some concepts were too simple and not flexible enough to suit our needs and would in reality be too big and clumsy to handle for the user, while others were seemingly too flexible and gave the user total freedom in their decision-making and creation of door designs. We also introduced our early concepts for people outside of the project who is not influenced by the project and who would judge the concepts unbiased from the likability of the concepts. This give a similar result to how we discussed ourselves within the project group. To further strengthen the decision of which concepts to move forward with, we used the Pugh controlled convergence method and compared each concept to a reference concept that acted as a benchmark.

4.5.7 THE PUCC METHOD
"The purpose of any method of evaluation is to allow design principles to emerge visibly in a context and to be articulated."
– Stuart Pugh 1991

Stuart Pugh has been a renowned person when it comes to design methods, and especially concept evaluation. In 1981 he constructed a method called The method of controlled convergence, also known by other names such as The Pugh controlled convergence method, The decision-matrix method or simply The Pugh method. This method (PuCC for short) is one of the first methods to evaluate concepts by alternating convergent and divergent thinking. In a paper published by (Frey et. al 2008) they made an evaluation of the method and came to the conclusion that PuCC can improve the creative aspects of a project. You start by narrowing down the number of concepts by comparing them to a benchmark. By continuous discussion and evaluation of the concepts, new ways of thinking and seeing the problem emerges and this gives you the opportunity to create new concepts from that point of view. These two processes are then iterated until you reach a satisfying level of completion of your concepts. From experience, as in this case where there are no existing product to use as a benchmark, then an alternative is to use one of the concepts as the benchmark for the matrix.

The PuCC uses a matrix to evaluate concepts, where on the vertical axis you formulate a number of criteria (these criteria are preferably already formulated from earlier phases in a design project) which the concepts need to fulfill. The horizontal axis is then where you line up the concepts you are about to evaluate and compare to the benchmark (the best concept or most likely to succeed). The evaluation of the concepts is then carried out by grading each concept as the following (table 5):
• (+) if the concept is better than the benchmark at some criteria
• (-) if the concept is worse than the benchmark at some criteria
• (0) if the concept is the same or similar to the benchmark at some criteria
As seen in the table above in the example matrix, Concept #1 is the concept evaluated to be the best concept in comparison to the benchmark and with all criteria in mind, and Concept #3 was the concept evaluated to be the worst in relation to the stated criteria. You should then reflect and learn from the evaluation, create new concepts and evaluate the new concepts according to the same principle as before. Designing by selection is further strengthened as a method that works by (Nagesh Kuppuraju, Prawit Ittimakin & Farrokh Mistree 1985) where they implicate that it is a simple and practical way of weeding out among concepts. Since there is no existing solution like the one we are developing, we chose one concept that we thought were the best and smartest as our benchmark. The result of the method can be found in section 5.4.2.

### Table 5: Simplified example of a PUCC-matrix

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Concept #1</th>
<th>Concept #2</th>
<th>Concept #3</th>
<th>Concept #4</th>
<th>Concept #5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (+)</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total (-)</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Total score</td>
<td>3</td>
<td>2</td>
<td>-2</td>
<td>0</td>
<td>-1</td>
</tr>
</tbody>
</table>

4.5.8 PROTOTYPES AND MODELS IN THE PRODUCT DESIGN PROCESS

Yang (2005) claims that the building of prototypes is an important method in the product design and development process. The use of prototypes can decrease design risk without contributing to time and cost of full production. Yang also states that prototypes can be an effective way to compare alternative designs, features and aid during the concept selection phase. This means that prototypes can be used in various ways depending on what kind of evaluation of the product is planned.

According to Houde and Hill (1997) there are three categories of prototypes; look and feel prototypes, implementation prototypes and integration prototypes. Houde and Hill suggest that a look and feel prototype is built to explore and demonstrate the aesthetic characteristics and the concrete experience of a product idea. In this project, we have initially used look and feel prototypes in the form of mock-up models of paper. We have used these to first decide which dimensions of the door leafs that would look most natural when representing a door in a small scale, and to create quick representations of the modules. These can be seen in figure 15 and figure 16.

Figure 15: Door leaf dimensions.
Photograph by Erik Agermo
Thereafter, simple constructions of cardboard were made which had the purpose to help us visualise the parts that are supposed to be included in the final product and to aid us during the development of concepts. It simulates what it would be like to look at and interact with but ignores the potential of technical solutions. These are represented in figure 17 and figure 18.
Furthermore, Houde and Hill claims that implementation prototypes are used in a design process to evaluate the potential of technical solutions and specifications of a product in order to find out how the concept will be made to work. During the concept testing phase we have used implementation prototypes based on HDF (High Density Fibre), the material which will be included in the final product, in order to try out if technical solutions will work in a physical state. These prototypes have helped us to decide the thickness on the strips, the basic structure of the final model and which production method that will be suitable while producing the various parts in the model. These models can be seen in figure 19 and figure 20.
Lastly, Houde and Hill suggests that integration prototypes are built to represent the complete user experience of a product. They are made to enhance the understanding of a concepts design as a whole, to visualize a close approximation of the final product and to easier receive feedback from users about the design in general.

Building physical prototypes has the potential to give the designer, as stated earlier, many advantages during a product development process. Although, technology has brought an opportunity to create and explore prototypes in new ways. Bordegoni and Cugini (2006) is claiming that virtual prototyping (VP) is becoming a commonly adopted design and validation method in various industries. Virtual prototyping is a method used by designers in which prototypes are modelled in a computer aided design (CAD) system. The advantages of VP in comparison with physical prototypes are that they cost less, easier to rearrange, allows the developer to make repeatable tests and the results of validations are often quickly accessible. Therefore, we have used this method to construct every part included in the final product in a digital environment to ease the testing process and to give ourselves a good understanding of how the physical model will look like when assembled. These models can be seen in figure 21, figure 22 and figure 23.

Figure 21: CAD-model of a door leaf.
Photograph by Erik Agermo

Figure 22: CAD-model of a window.
Photograph by Erik Agermo

Figure 23: CAD-model of a décor.
Photograph by Erik Agermo
However, according to Bordegoni and Cugini (2006), virtual prototypes cannot completely substitute the characteristics of physical models, but it is worth combining the two methods considering that both can contribute with advantages in different aspects.

Building models and prototypes is relevant in this project since the final result will be a physical model and it eases the work as it gives an opportunity to test ideas and technical solutions if they work as physical representations. In this project, we have built simple representations of the components that shall be contained in the final model and tried different ideas on how to visualise them as physical objects. This gives us a good basis of information and contributes to a good understanding of the model during the development process.

4.5.9 RAPID PROTOTYPING
The reasons for using rapid prototyping are many; more effective communication, less time needed for development and product complexity and variance just to name a few (Efunda, 2016). Rapid prototyping is a collection of methods to quickly produce a model or scale model of a product using computer aided design and manufacturing using 3D-printing. Rafiq Noorani (2006) further describes the areas of application of rapid prototyping as a way of testing function and presenting products for clients and customers. The main difference between rapid prototyping and normal prototyping is the fact that rapid prototyping relies mainly on additive methods, such as 3D-printing, while traditional prototyping relies on subtractive methods, such as CNC milling. This means that the designer has increased flexibility when making models as the designer can try out different versions of the same model in a shorter amount of time. The possibility of making more advanced models with less work is also a big factor for using rapid prototyping and that leads to a decrease in development costs.

Almost every time you work with rapid prototyping it follows the procedure of the following five steps:

• Create a solid model of the prototype in a CAD or CAID software
• Convert the model into STL-format
• Slice the model into layers using a software
• Manufacture the prototype using a suitable method
• Post processing of the prototype

This project has not used 3D-printing as a method, but some parts of the project could have benefited from said method. We feel that it is necessary to bring up this method because of the possibilities and the power of this method of prototyping.

4.6 IMPLEMENTATION & MANUFACTURING
In this section, we will present our methods and thoughts regarding the implementation of our prototype. Firstly, we will present how we designed the final prototype. Secondly, we will describe our methods for manufacturing the prototype. Lastly, as an increasingly number of companies are exposed because of dirty production and big environmental impact, we will also analyse the cost and the environmental impact of our prototype.

4.6.1 IMPLEMENTATION
When working on the completion of our final concept and turning it into a working prototype we mostly had to focus on the fitting between parts. The design and looks of the door models that we are able to represent in our concept are already designed and developed, which means that we could rely on the company's drawings to replicate all parts. However, we still had to decide the size of the prototype, what size the magnets needed to be and how many we needed, and how we should represent the windows. When deciding the size of the prototype, we had to stay within the upper limit of an A3-paper, which is 297x420mm due to the delimitations that were set. We drew up different sizes of the doors on paper and taped them next to each other so that we could evaluate which one that felt most natural and easy to look on (figure 24). We asked a few bystanders of their opinion and this eventually mean that we settled for a 10x20-door in scale 1:5.
When deciding what kind of magnets we needed for the project, we started by ordering a few different sizes so that we could experiment with the force they applied. We ordered magnets of the following sizes as seen in Table 6:

<table>
<thead>
<tr>
<th>[mm]</th>
<th>( D = 5 )</th>
<th>( D = 10 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T = 1 )</td>
<td>2 pcs</td>
<td>2 pcs</td>
</tr>
<tr>
<td>( T = 2 )</td>
<td>2 pcs</td>
<td>2 pcs</td>
</tr>
<tr>
<td>( T = 3 )</td>
<td>2 pcs</td>
<td>2 pcs</td>
</tr>
</tbody>
</table>

We then made a test piece in HDF where we drilled three holes with different depth (1, 2 & 3 mm) to evaluate the magnetic force (Figure 25). After some evaluation we came to the conclusion that the 5 mm magnets were too small to be effectively handled when manufacturing. This meant that we had to settle for the 10 mm magnets, and when testing we found that the 10x1 and the 10x2 magnets applied a sufficient amount of force to hold the pieces in place.

Since we planned to mount the magnets into the material we needed to come up with a clever solution on how we should manufacture the windows. After some back and forth discussion we decided to print pictures of windows on self-adhesive vinyl which then would be mounted on HDF as seen in Figure 26.

With the details decided we then began by looking over every drawing for each door model and divided each model into the following parts:

- Grooves
- Decor
- Windows

All of the parts were then created using a CAD-software and imported into the same file so that we could overlay every part and find common attachment points where we could place our magnets.
In order for this solution to work, we also needed to have a base where we could place each part. Due to the complexity and size of the windows, we decided it was best not to make the mullions as a physical feature. We instead decided to print images of the windows on self-adhesive vinyl, which could be placed on parts made from HDF matching the outer shape of the windows. A suggestion from us to the company was that the prototype should be complemented with a display stand to be used by the resellers. The prototype should also be able to be used with and without the display stand. Since our main objective were to design the use and function of the prototype we settled with a very simple, yet functional, design for the stand; a cabinet on wheels where we can store all parts for the prototype inside.

4.6.2 MANUFACTURING

Considering that this prototype that we have developed will be used to represent the company’s products, the quality of the prototype is very important. This means that we want the parts and the fitting between parts to be as good as possible, with a satisfactory deviation due to the fact that we are working with living materials such as wood. Because of these limitations, we chose to manufacture the majority of the parts in machines such as a milling machine (figure 27) to eliminate the human factor of an unsteady hand. The manufacturing of the parts can be divided into these steps:

1. Modelling
2. Pre-processing
3. Rough shaping
4. First step assembly
5. Pre-finishing
6. Finial finishing

All parts have been modelled in a CAD-software to define all measurements and fitting and points of attachment. Following that we have prepared all parts for manufacturing by deciding where and how each part should be produced and made necessary preparations for each case. The windows, for example, have been printed onto a self-adhesive sheet of vinyl and therefore required a high-quality image-file for each model. Most other parts have been made from HDF-sheets and therefore needed to be processed in a CAM-software before being put into a CNC-milling machine.

When we have all the parts cut out from each material respectively we moved on to a first step assembly as seen in figure 28 on the next page. Here we attach all the magnets to each part using glue to fix them into place. After the glue has hardened and all magnets are attached, we fill in every crease and hole, that are not part of the design, with a two-component putty before sanding and priming each part.

The last step before the final assembly is to sand each part again (figure 29) before applying the top paint. All these steps above have led up to the part where all that is left to do is put everything together into a finished product. All vinyl stickers need to be mounted on their painted wooden counterpart and all other parts needs to be inspected to verify quality and fittings.
Figure 28: Components ready for prime coating.
Photograph by Andreas Björklund

Figure 29: Components ready for top paint.
Photograph by Andreas Björklund
4.6.3 COST ANALYSIS
Keeping in mind that this prototype could lead into a product that the company decides to put into production, which means that it will be manufactured and shipped out to their resellers, the cost of the prototype is a big concern. In order to keep the cost down we have chosen to, for the majority of the parts, use materials that the company already use within their production. For the materials and components that they do not already use, we have tried to find the cheapest alternative, as a private customer, while still trying to maintain a high level of quality. We estimate that the cost of this prototype is 743,43 SEK. This cost is excluding the cost of further development, production, and shipping of the product. For a more detailed cost calculation see appendix 3.

4.6.4 ENVIRONMENTAL IMPACT
With an increasing awareness about the impact the humans have on the environment (Stocker et al. 2014) and the increasing focus on carbon footprints, it is important as a company to be aware of how your products impact the environment. For this reason, when developing the prototype for this project, we have purposely tried to exclusively use materials that the company already have at hand within their production. There are, however, still a few components that the company needs to purchase in order to be able to manufacture the prototype, these include:
• hinges and plastic sheet for the hatch
• wheels for the cabinet
• windows printed on self-adhesive vinyl
• magnets
5. Results

In this chapter, we will present general results of the various phases in this project. These results will be shown in chronological order from context immersion to the final implementation.

5.1 CONTEXT IMMERSION

This section is presenting the outcome of the methods used in the context immersion phase, such as benchmarking, field research and interviews.

5.1.1 BENCHMARKING

The benchmarking contributed to a general overview of the competing part of the exterior door industry. Although, we have focused to gain information about the three major competitors to Polardörren in order to find as specific and valuable data as possible.

Initially we performed a research about the competitive products in the exterior door industry. This concluded that there are rather many differences among the construction and materials of the doors. Each manufacturer uses their own technique to develop what they believe to be the best product for their customers.

While performing a research of additional services that companies in the door industry and closely related industries provide to ease the experience of the customers during selection of which product to buy, we only found digital versions. The interactive services contribute to providing the customer an opportunity to visualise a great quantity of the products manufactured by the company.

From what we have understood from the information gained during the benchmarking there are no physical representations of small doors that can be used as an aid to the customer which provides an opportunity to design a door from scratch.

Although, the benchmarking was entirely based on information collected from the internet. Therefore, we chose to perform a field research to expand our knowledge of how the industry works in a customer’s and a seller’s perspective.

5.1.2 FIELD RESEARCH

The field research gave us a good understanding of how exterior doors are displayed various ways in physical hardware stores and we gained general knowledge of the industry from the customer's perspective.

Overall the displays at the exterior door department of the stores showed fully working prototypes in natural sizes. The doors are displayed in various ways and every reseller have their own way of showing the products to its customers. All of them were displayed in models of original size in some sort of display booth which makes it possible for the customer to feel how good the door works while being able to open and close it, as well as explore the quality of the material on the door and its different parts. Although, the display booths differ from each other depending on which store you visit and from what we could see the exterior doors were shown in three different ways in these. Some of the display booths are installed with a single door model to basically show the customer what it looks like in reality. Other display booths are built in a prism-shaped way in which one door are installed on each side. In the third way, the exterior doors were embedded in a façade with a context that includes a roof, downpipes and stone tiles which contributes to a natural look and gives a realistic impression.
In addition to this, the different door suppliers differ when showing the customer what options they provide when it comes to patterns, decors, glass types and colours. Most of the manufacturers refers to their product catalogue as a visual aid to show their total product assortment. Other combines this with showing the customer a variety of cut-outs from other door models to ease the understanding of what other door models look like in reality. In addition to this some manufacturers also provide a small cross section of their doors to show how they look like on the inside and how they are constructed.

The field research also gave us inspiration from other departments of the hardware stores as well. We looked at how the products are displayed for example in the kitchen section. In comparison to exterior doors, a kitchen is rather complex and contains many parts that shall be put together. Although, the complexity of a kitchen and how the various parts that it contains are displayed to the customers is what interests us. We will, to simplify the project, create a prototype that can show a large variety of products. Therefore, we find it suitable to gain inspiration from a complex module based setup of in which kitchens are displayed.

To get an even better understanding of the purchase procedure of exterior doors in physical resellers we also performed unstructured interviews with salesmen that are responsible for the exterior department at the hardware store they are working at respectively.

5.1.3 INTERVIEWS
During the interviews, we got general information of how the market looks like today and the common ways of how customers buy their exterior doors today. In total 2 participants were interviewed in an unstructured way. This is a summary of the information gained from the interviews and the complete interviews can be seen in (appendix 4).

According to the interviewees, there are several ways that exterior doors are ordered and purchased through. Private customers can buy exterior doors at either hardware stores or from webpages that provides the desired products.

The private customers are grouped in two categories and both of these groups uses their own technique in the procedure of selecting and purchasing exterior doors. The first group of customers initially perform a research among door models online to get a hint of what they are interested in and when they have decided what to buy they either purchase it online or goes to a store to buy it. The second group of customers goes directly to a physical reseller of exterior doors and talks to a salesman to get the guidance they need to get the exact characteristics on the door they desire.

The most time-consuming process is when the customer is insecure about which door model to choose and asks the seller about guidance. This can take from half an hour to an hour depending on the situation, and a decrease of this time would be appreciated.

According to the sellers, a product that makes it possible for the customers to build their own doors would be a tremendous feature, although it would be a burden since they think it would contribute to a longer decision process from the customer’s perspective. These are only speculations, and what a physical product designed to aid customers and sellers in the purchasing process is to be decided.
5.2 IDEA GENERATION
This section will present the results of each method in the ideation phase and which ideas that was selected to proceed furtherly in the project.

5.2.1 BRAINDRAWING & BRAINWRITING
From the braindrawing and brainwriting session approximately 20 ideas were generated. Since we did not focus our way of thinking in any specific direction the characteristics of the majority of the ideas were different. Although, some of the ideas were similar to each other and these were considered as duplicates and therefore ignored. Some of the ideas are represented in figure 30.

Figure 30: Ideas generated from braindrawing and brainwriting.
Photograph by Erik Agermo

5.2.2 BRAINSTORMING
In this session, we directed our ideas in specific ways that we considered would give us a wide spectrum of ideas. The topics were “How to attach things” and “Objects you can open”. All of them put together, over 30 ideas were generated and they can be seen in figure 31 and figure 32 on the next page.
Figure 31: Mindmap of the ways to attach objects. 
Illustration by Erik Agermo

Figure 32: Mind map of objects that can be opened. 
Illustration by Erik Agermo
5.2.3 WORKSHOP
Additionally, we performed a workshop with participants that is not connected to the project in any way. The ideas generated during this session were rather similar to the ideas generated previously. The majority of them were focusing on contributing to multifunctionality, based on the characteristics which was handed to the participants. The rest of the ideas were directed to on how to display a large variety of products as efficient as possible. As a total, a great amount of ideas was generated during the two sessions. Unfortunately, the results were affected negatively since the thesis work is classified and therefore we did not receive as many usable ideas as we expected.

5.2.4 IDEA SELECTION
During the end of the ideation phase the amount of ideas had exceeded over 50 unique ideas. Initially they were sorted and grouped into categories in which the ideas most similar to each other were placed. The categories are presented in the list below:
- Functions
- Patterns
- Inspiration
- Different ways to change
- Different ways to visualise patterns

Thereafter, the ideas were sorted into two groups; “Yes” in which we put ideas that would be of use later on and “No” in which we put ideas that would not be of use due to the directions and delimitations we have set for the project. The grouping of the ideas can be seen in figure 33.

Figure 33: Selection of ideas.
Photograph by Erik Agermo

When the first sorting of ideas was done we evaluated and discussed furtherly which of the ideas from the “yes” group that we should keep and which we should discard to eventually narrow them down into eight achievable ideas:
- Draw your own design
- Plastic film in layers
- The notebook
- Tetris-zones
- Panels in holder
- Modules
- Magnetic surface
- Plates with tabs

These eight ideas will serve as the platform on which our concept will be developed upon by choosing, combining, and/or elaborate different ideas.
5.3 CONCEPT GENERATION
In this section, we will present the concept developed from the idea generation, show the results of the evaluation of the concepts, present the main concept and the implementations made.

5.3.1 EARLY CONCEPTS
With inspiration from the selected ideas, five concepts were developed. The common characteristic among the concepts were the ability to be able to show a large variety of products as compromised and efficient as possible.

5.3.2 THE THICK CATALOG
The first concept is a version of a regular product catalogue, but instead of using pictures on paper this concept uses miniature versions of doors. These miniatures would be made out of HDF-sheets. Grooves are milled into the sheets to represent the different designs the company has within their product range. The sheets are then painted and details are attached to it to form a replica of the real doors. This would take the catalogue into another dimension and would allow the consumers to touch and feel the material of the product.

5.3.3 MAGNETIC IMAGES
The second concept is made entirely out of magnets. You will have one large surface with a picture of a door without any form of details. Each feature for the door is also printed onto magnets which allows you to apply any detail you want, anywhere on the door. This will give the user total freedom of creating any version of a door, with the only limit being that the part needs to exist.

5.3.4 MODULES
The third concept is built up out of modules. Everything originates from one base, or centrepiece, where everything else is applied. Each pattern, window and any other feature is made from material similar to the real versions. These modules can be fitted onto each other in several ways, but one way that seem superior to any other would be to use magnets embedded in the pieces. This leaves no marks on the surface, but will add complexity to the manufacturing of these modules. This allows for creation of designs that differ from the standard models.

5.3.5 PANELS
The fourth concept is several panels manufactured as miniature versions of the real doors. The panels are made from material similar to the real versions of the doors and each panel can be fitted to a centrepiece and is then proudly presented to the customer.

5.3.6 DIVIDED BY THREE
The fifth concept works similarly to a puzzle. Door panels would be manufactured in HDF-sheets that will be sliced into three parts equally divided along the horizontal axis on strategical points on the door. These parts can then be combined freely, meaning, you can have one part from three different doors assembled into one new door. For instance, you would be able to have the top piece from one door, the middle piece from a different door, and the bottom piece from a third door different from the other two. This could lead to interesting and fun designs, but at the same time keeping the process very simple.

5.3.7 CONCEPT EVALUATION
This is the result from the concept evaluation that decided which of the five concepts that were decided to be the strongest. Below in table 7 you see the PuCC-matrix of the five concepts, where one concept was used as a benchmark.
Table 7: PuCC-matrix of the concepts.

<table>
<thead>
<tr>
<th>Criteria #1</th>
<th>Benchmark</th>
<th>Concept #2</th>
<th>Concept #3</th>
<th>Concept #4</th>
<th>Concept #5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Criteria #2</td>
<td>0</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Criteria #3</td>
<td>0</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Criteria #4</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Criteria #5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Criteria #6</td>
<td>0</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Criteria #7</td>
<td>0</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Total (+)</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Total (-)</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Total score</td>
<td>0</td>
<td>0</td>
<td>-1</td>
<td>0</td>
<td>-1</td>
</tr>
</tbody>
</table>

A more detailed description of the criteria and the concepts is shown in appendix 2. As it can be seen in the matrix, concept 2, the catalogue concept, and concept 4, the panel concept, received equal results in comparison with the module concept which was the benchmark in this matrix. Therefore, we chose to move forward with all three of them. Although, after internal discussions in the project group it was decided that the benchmark concept was the best one among those three and this is the one that was decided to proceed as the main concept.

5.3.8 MAIN CONCEPT

The main concept is a module based model which will include a number of different parts. Firstly, the base of the concept is a core in which the other parts will be attached to. The core is a hollowed piece of material that is thicker than the rest of the including parts. In addition to this, the core is also visualizing the frame of a door. Furtherly, panels will be placed into this core. These panels will represent the door leafs and most of them have milled patterns which is simulating the patterns of the original door models, but in a smaller scale. When the panel is put on place the user will be able to choose among the windows and decors that are available and place them on top of the panel. The total amount of parts included is presented in table 8 below.

Table 8: Parts included in the main concept.

<table>
<thead>
<tr>
<th>Part</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core</td>
<td>1</td>
</tr>
<tr>
<td>Panels</td>
<td>5</td>
</tr>
<tr>
<td>Windows</td>
<td>19</td>
</tr>
<tr>
<td>Décors</td>
<td>9</td>
</tr>
</tbody>
</table>

The panels, the windows and the decors will represent each part of the original door models that are included in the project. The models that will be included is presented in table 9.

Table 9: Models that will be included.

<table>
<thead>
<tr>
<th>Model</th>
<th>Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allegro</td>
<td>Panel + Window</td>
</tr>
<tr>
<td>Blanco</td>
<td>Panel</td>
</tr>
<tr>
<td>Förnuftig</td>
<td>Window + Décor</td>
</tr>
<tr>
<td>Juvel</td>
<td>Décor</td>
</tr>
<tr>
<td>Lady</td>
<td>Décor</td>
</tr>
<tr>
<td>Lapporten</td>
<td>Panel + Window</td>
</tr>
</tbody>
</table>
The door models that do not have any parts listed will use parts from other door models with a similar design.

The various parts will be constructed with magnets that will be used to attach them to each other. The magnets will be put inside each part and covered with a two-component putty to prevent them from falling out.

In addition to this a stand and a storage cabinet will be manufactured. The stand will be placed on top of the cabinet and will keep the core in a standing position, and the storage cabinet will work both as a showcase for the model and as a storage unit in which all the parts will be sorted as well as hidden.

5.4 IMPLEMENTATION
When the final concept was decided, further tests and development was performed in order to decide the final details. What has been decided is the depth of the milled patterns, the thickness of every detail and which material the parts of the product shall contain.

The testing of the depth of the milled patterns resulted in which depth that looked most natural in relation to the windows and the decors. As an outcome, the patterns on the panels and the decors will be milled at a depth of 1 mm. In table 10 beneath, the thickness of each group of parts and the material that is chosen to be used while creating the various parts is presented.

The material chosen is based on which material that Polardörren already have at the factory. Therefore, even the thickness of the parts is decided based on this since the original HDF sheets are 4 mm thick from the beginning.

As a result of this project what we will deliver to the Polardörren is a fully constructed and functional model that will be used as an aid at the retailers to the company as well as detailed drawings of each of the components included. The drawings can be found in appendix 5. In addition to this a completed thesis report will be delivered to our examiner and supervisor which will be published to the public after it has been peer reviewed.

5.5 FINAL PROTOTYPE
In this chapter we will present the final product that has been developed in this project. The final product is a module based model that provides a possibility for the users to design a door from scratch. The module based system is made out of physical parts created by the same material as the original door models. In the sections below the design and the functionality of the product and they will be presented in pictures.
DESIGN AND APPEARANCE

The complete product consists of the modular system, a stand and a storage cabinet. Figure 34 illustrates the complete product and examples of parts that are included in the modular system. The base of the product that is developed in this project is a core which stands on top of the storage cabinet and is mounted to a stand in a slightly tilted position. The core itself, designed to represent the frame of a door, is a hollowed rectangular shape of HDF (High Density Fibre) material. In figure 35 the core can be seen with a panel fitted into it, to give an example of the appearance of the product.

Figure 34: The complete product.
Photograph by Andreas Björklund
The storage cabinet has the feature to both work as a storage unit for the parts of the modular system, and as a podium on which the base of the product is standing on. The cabinet is mainly made from HDF-material, with exception of the door that is made from acrylic plastic, which can be seen in figure 36. This transparent material lets the user see the parts easily through the door, and maintains an appealing design of the cabinet. The inside of the cabinet is divided into two levels on which the parts can be kept in order. The lower shelf is constructed in a way that makes it possible for the panels to be kept in a standing position. Figure 37 shows the lower shelf with milled tracks, designed to keep an adequate distance between the panels. The upper shelf is a flat surface on which the rest of the parts can be stored. As an addition, a magnet construction is installed in this shelf that keeps the door closed. In figure 38 a closer view of the upper shelf and the magnet construction can be seen, and in figure 39 a close-up picture on the door in a closed position is illustrated.
To make the windows look authentic, pictures printed on self-adhesive vinyl have been attached onto dimensioned cut-outs of HDF to visualise both the window itself and the reflection of the glass, and this is exemplified in figure 40.

The complete product will be placed in various environments and to give examples of how it looks proportionally in comparison to other objects. Figure 41 and figure 42 shows a more general representation of the product in everyday surroundings.
Figure 40: Window close up.  
Photograph by Andreas Björklund

Figure 41: Product placement.  
Photograph by Andreas Björklund

Figure 42: Product in lounge.  
Photograph by Andreas Björklund
In this section we will describe how the product works, and the technical functions of the product. Initially when the user approaches the product he or she will see a hollow and empty core. In figure 43 you can see a demonstration of how the product looks like without any parts attached to it. Inside of this core there are hidden magnets placed in strategical positions that will keep the different parts at a static spot and guide the user to put the parts on the right place.

Figure 43: Placing the core.
Photograph by Andreas Björklund

When the user has chosen a panel, it will be attached on top of the core inside of the edges. The panels have magnets that fits the magnets that are built into the core. In figure 44 it shows how the panel shall be attached to the core. From this position the magnets in the panel and the core will attract each other and the panel will be guided to the position where it is supposed to fit.

Figure 44: Placing a panel in the core.
Photograph by Andreas Björklund
When the panel has found its place, the door is ready for mounting décors and windows. The user will be able to choose among several parts and attach them on top of the panel. The placement of the décors and the windows is slightly controlled. Due to the magnets positions in the core and in each of the parts, they can only be placed on certain points of the door. In figure 45 it is demonstrated how a décor can be attached upon the panel on a specific position and in figure 46 two additional décors and a window is attached on the same panel to give an example of one combination that is possible. The delimitations of possible positioning of the parts are beneficial from a manufacturing perspective. If the user is not happy with the outcome of the design it is easy to restructure the appearance of the door. In order to create a new design, the user simply need to detach the parts on top of the panel by pulling them from the surface and place them in the storage cabinet. Thereafter the panel can be detached easily by using the gap at the bottom of the core that is shown in figure 47, and simply remove the panel from the core. When the panel is detached and placed in the storage cabinet, a new panel can be attached to the core in the same way as the old panel. Figure 48 shows a new example of a panel attached to the core.

Figure 45: Panel with a décor.
Photograph by Andreas Björklund

Figure 46: Panel with three décors and a window.
Photograph by Andreas Björklund
The new panel that is attached to the core has a rather subtle look. This invites the user to combine additional décors and windows, and rearrange them to achieve a desired design. Figure 49 shows an example of the possibility to attach additional windows next to each other, in this case two long ones. Another example of the possibilities of this product is the placement of smaller windows. As seen in figure 50, a round window is placed at a normal position on the door. If the user wants to put on an additional round window beneath, it is shown in figure 51 that it is possible as well. It is in other words very easy to customize the door in order to find different designs.
Figure 49: Panel with two long windows.
Photograph by Andreas Björklund

Figure 50: Panel with one round window.
Photograph by Andreas Björklund

Figure 51: Panel with two round windows.
Photograph by Andreas Björklund
This product is developed as a complement to the displays of the door models that are displayed in the stores today. With this product, the seller will be able to use it as an aid in order to show the customer that the variation of door designs is almost limitless. This product is developed to ease the work for both seller and customer, and as an addition contributes to make the purchase process of exterior doors a little more fun.

The design of the whole product strives to be as easy to use as possible from the user’s perspective. In this project we have used behavioural design with the user in focus, in order to create a product that can be related to by the users as easy to understand (Norman, 2005). For example, what needs to get enhanced from trial and error when using this product is the understanding of where to place the décors and the windows to attach them properly to the panel. This is to be explored furtherly by the users of the product. In other words, this product is designed with the purpose to let the user furtherly explore the possibilities of it and to find out what kind of limits it contains.
6. Discussion

In this part, section 6, we will discuss all parts of the project. This section has been structured so that we will discuss each section separately. This discussion is based on the facts that we have found and the knowledge that we have attained throughout this project, and we aim to analyse what lead to positive outcomes and what could have been done better to prevent questionable results.

6.1 CONTEXT

You could say that the context is the core of a project, without knowing the context for your project you will not know what type of theory or what kind of methods to use. This is, according to Vermeeren (2010), also important for usability. We think that we have a good understanding of the context in this situation. We spent roughly eight weeks over the summer, before this project, at the company, working on every station throughout the production line and were somewhat involved in the administrative section as well. This gave us a solid understanding for the mentality of the workplace and the company, and we also received knowledge of how each step of the production is performed and potential problems that could arise for each area. Further we also gained insight in what material and tools the company already have at hand in their production. We believe that by spending time at the company ourselves, we built our own understanding of the context and we were not simply told how the company perceive the situation. However, not all information was attainable by our own means. For instance, the list of features of the products that were necessary to incorporate in the project, were provided to us by the company and reviewed together with us. This was to prevent that the prototype in the end became too complex for the end user to understand. Due to the modularity of our prototype, each new entry or group of features would increase the number of possible outcomes that the prototype would be able to represent.

Since we had developed the understanding of the context from our own point of view, we also had to complement this understanding with more fact-based knowledge in form of a benchmarking. We wanted to know how our company compared to their main competitors, who these competitors were and how the different companies’ products differ from one another. This benchmark was performed by comparing the size of the companies, number of resellers, the size of the product samples at the resellers and by reviewing each company’s website and how they describe themselves and their own products. Important to keep in mind in this situation is to be objective and not buy everything the companies express on their websites. However, we believe that the information about composition of the products and the way the companies manufacture their products is true enough to be seen as facts for this project. One could argue that you could do this more thoroughly, but we consider that if you were to go even deeper into investigating the competing companies, this could be borderline industrial espionage. Even though we (the students) are not a company, we have received this assignment from a company, and they are in the end our employer for the time being. What we found out though as a result of this benchmarking were that the differences between the companies did not lie among the products, but rather the knowledge and means of production. The overall appearance of the products was very similar across all the companies, with slight differences for some models and in the size of product range. One could argue then that the issue here is that the level of technology of a front door is not very high, and that the development of these products has been rather slow. This means that all the companies have had the chance of catching up to the latest technology despite the economic wealth of the company. The companies then try to find an edge over the others in a different area, namely sales and product display. Here we find examples of digital representation of the products, similar to other close areas such as kitchen manufacturing companies. Digital representation, in some ways, provide an advantage when displaying products in comparison to the physical representation of the same products. All you need is a sophisticated and well prepared software where all products
have been modelled and rendered into, whereas when representing the physical products, you need to physically have one of each product. There are advantages with both ways of representation, the physical representation provides the user with an authentic feel of the product, whereas the digital representation provides the user with the possibility of viewing any product in a desired environment. Which representation, the physical or digital, that is most effective depends on the target user and the intended application.

6.2 THEORETICAL FRAMEWORK

The theoretical framework in this project is heavily influenced by the interaction between human and product. Österlin (2007) means that this is the purpose of an industrial designer, to be aware of the relation between the human and the product. We see this fitting since the type of interaction, human and product, is the main purpose of the project. The aim is to develop a model that will assist resellers and consumers to create and visualize products influenced by the user. This type of theory is also something that we have earlier experience from and have been working with throughout our education. In this project, we have two users of the model, the reseller and the consumer, both with different needs to fulfil. The reseller needs the model to be easy to use and flexible, while the consumer needs the model to be easy to understand and be able to adapt to their specific requests. These needs are derived from Hassenzahl and Tractinsky’s (2006) argument about incorporating enjoyability in user experience, and from interviews and our own understanding. This puts high emphasis on understanding the users and their needs and that the model in the end is developed with the user in mind. This is strengthened by Norman (2005) and his definition of the three approaches to design, and the key components to behavioural design. We see this model as a type of interface, where the user can make choices and receive different outcomes for different choices. By incorporating the consumer in the process of designing a product suited for their needs we believe that we can increase the chance of the customer buying the product. This design process is an experience for the consumer and it is therefore important to know how to measure this experience in some way that is understandable to us as developers and to the company that we develop the product for. That is the reason for incorporating theory about user experience design, semiotics and usability. By relating to the theory behind semiotics we can also develop this product to not only be functional, but also look aesthetic and be functional. Another thing to have in consideration is to ensure the ability to mass produce this product in an effective way, from a cost and time perspective, hence the theory behind industrial design in general. Industrial design, to us, is to develop a product that is cost effective, easy to manufacture, appealing to the company and user and to have a low environmental impact. In conclusion, we feel like we have covered the necessary theoretical framework for this project, although being able to go deeper into the theory we do not find it necessary from a time and cost standpoint.

6.3 METHODS

Looking back at the methods that we have used during this project, we would say that we are satisfied with our approach. Nothing is ever perfect and everything can be improved, the same goes for our project, but considering the timeframe and the extensive task at hand we would rate this as over expectation. We would like to point out that our strengths in this project has been the earlier experience from working with similar projects throughout our education. The process for the project has been based on experience and some estimation, since neither of us has been working in a project of this magnitude before, but we have been working in many shorter projects with successful outcomes. A new feature in this project was also the fact that we aimed to invent a new product, not improve an existing product, because such a product did not exist. The stage-gate model is comprehensive and easy to follow, it is in general a linear workflow from start to finish. We chose to incorporate flexibility and width to the project in form of allowing iterative work within the stages. This proved to be successful and felt less monotonous, and it gave us the chance to constantly improve on ideas, concepts and other results continuously to increase overall quality of the project. This way of working requires that everyone involved in the development is
constantly up to date to the most recent revisions and decisions, and that was no problem given that we were two developers. We can however see problems arise if the project group would consist of more members or of members with a more diverse area of expertise. In a bigger picture, the project was divided into four parts: inquiry of theory, context immersion, ideation and implementation. For each part, we set up objectives that we strived to achieve, providing something to always work towards, and that helped keeping the project moving forward at all times.

The theoretical framework and the context has been discussed in the two previous parts of this section and we will instead move on to discuss the ideation and implementation in this part.

The early ideation phase is where we put in a lot of time. We felt that it was important to explore every possible angle of the problem, given that we could not find any similar products that exist today. The products that we found were either completely digital (a software) or a non-changeable physical model, which most of the time were a product sample. We could establish that what we were planning to develop were something new and belonged to an area that needed to be explored further and that has great potential. This early part of the ideation phase was also very essential since we were working under very strict secrecy at the time and were not able to seek help or input from other sources like course colleagues or resellers. We tried to work around the secrecy by holding a workshop where we did not expose any information of the project other than at what direction we wanted them to brainstorm towards. This proved to be quite ineffective and for the second run of the workshop we changed approach to use metaphors and discussion instead of brainstorming, which worked much better. This also forced us as facilitator to think in different ways, and this together with some inputs from the workshops led to new ideas that we could incorporate in the development of concepts. Brainstorming and brainwriting are methods that worked well when working in a group, and by using both of them we felt that we could widen the range of ideas. As put by Osborn (1963) and VanGundy (1984), these methods let you take advantage of all members individual thinking and complement that with the reflection on each other's ideas to generate a high amount of ideas. We could possibly gather even more ideas from the methods if we were more members in the project group, but considering that we were two members it still gave us an advantage, because we actually had the ability to perform them in comparison to if you were to work alone. When we felt that we had exhausted our brains and that we had a sufficient range of ideas, we moved on to clustering and forming bigger concepts.

When creating concepts, it seemed natural to use the ideas that we had developed in earlier stages. It was very hard to not at an early stage evaluate the concepts, and it quickly led to that we saw more potential in some concepts and some concepts felt like dead ends. However, we felt that it was important to try to elaborate all concepts, even if they felt like dead ends, to not leave any potential masterpiece in the dust. When we later evaluated the concepts, we relied on information from the company and the delimitations that we had set up for the project. Given that a big focus in the project were flexibility, this became a criterion that were very valued. We think that it could have been advantageous to put more time in the development and evaluation of the concepts, but at the time we felt like that was something we were unable to do to keep the project moving forward and to reach the deadline in time.

The implementation of the final concept felt obvious. We decided early on to try to use material that the company already had in their production, to reduce environmental impact and cost by not forcing the company to order new types of material from other suppliers, which would also force the company to have to rearrange their storage to fit the new material. We think that the way we developed and experimented with manufacturing made us understand potential improvements for further work and is something that will favour the company if they decide to continue developing this prototype. Examples of lessons learned while developing this prototype is that automated processing is not always faster, nor better, than manual processing. If you are working with simple shapes its more advantageous in relation to time, to do the work manually. However, if precision is of importance you should still consider sacrificing time for the precision of automated processing. In conclusion, there are improvements to be made to the methods used in this project, but we still believe that our choices of methods our implementation has contributed to a trustworthy result in the end.
6.4 RESULTS
We are very happy with the results from this project. Even though the display stand was not initially part of the project, we still feel like it complemented to the overall impression of the prototype. There are some minor details in appearance that could be improved now that new knowledge about manufacturing the parts has surfaced. When testing the finished prototype, some issues with feedback from placing the windows and decors on the model were found. We believe that this could be improved, partly by using stronger magnets, which would center the pieces more effectively, and partly by trying to distinguish which side of the parts that are up and down. Alternatively make all the pieces fit both ways, as well as on the left and right side (if there are left and right versions of the part). The problem, we think, with making a more universal fit to the pieces would be that there would arise situations where they would be able to be placed in spots where they should not be able to. That is something that would need to be investigated further when developing this product. This problem could very well have been avoided if more time were spent researching semiotics and usability and testing the concept more, but that was something that the time frame did not allow in this case. The finish of the surfaces and the fitting between all non-mounted parts were over expectation. Another issue that appeared when developing the prototype were the thickness of the windows. The design had already been changed from several layers of plastic and images to one layer of HDF and a self-adhesive piece of vinyl. Further we had to compromise again and go with a thickness of 4 mm instead of 3 mm due to limitations of the CNC-milling machine that were unable to planar mill on such low tolerances as 1 mm. This resulted in that the HDF-pieces for the windows were all manufactured manually by cutting out the pieces and drilling holes for the magnets. This worked surprisingly well for most parts, since they were rectangular, but some pieces were circular or had rounded sides and those were cut out using the CNC-milling machine. Again, if we had done some research regarding these issues beforehand we could have avoided some time that went wasted. In the end the increase in thickness of 1 mm of the windows did not impact the overall appearance, and considering that everything cannot be perfect when looking at handmade items, we believe that the not so perfect appearance contributes to a feeling of craftsmanship.

If you compare the cost of our prototype with the several product samples that the company send out to the resellers today, you can drastically reduce these expenses. Our prototype is not a replacement for the product samples today, but rather a complementary, meaning it could replace maybe one or two samples. We think that this could be beneficial, given that our prototype can represent several different products. At the same time this prototype can be used to demonstrate the possibility for flexibility in the products. These product samples that the company send to their resellers today, are the same products that are being sold to customers for prices starting around 15 000 SEK. We would estimate the material cost for these samples to approximately a fifth of that amount, 3 000 SEK. So, when comparing the material cost of a sample product, 3 000 SEK, and the material cost for our prototype, 743,43 SEK, we can see that there are room for several replacement units to our prototype, if any were to be damaged or misplaced by the resellers.

In regards to the issue of environmental impact of our prototype, we think that we have kept the environmental impact of this prototype down to a minimum. The reason is that our prototype is mostly made out of HDF-sheets and wood, which the company uses regularly when manufacturing their ordinary products. Looking at the items that the company does not already have at hand, for example the hinges, plastic-sheet and magnets, then the environmental impact is controlled by the company, in the sense that they can choose from what distributer they buy these products. By using a local or national distributer instead of a global distributer, you can reduce the impact and the necessity for additional extensive shipments.
7. Conclusions

In this section, we will present our final conclusions of this work, in relation to the objectives and aims that were set up for this project. We discuss the functionality of the prototype, and the impact it has on sales and development, as well as the strain the development of this prototype has on the environment. Lastly, we present our recommendations for future work and development of this and similar prototypes, and future research within the area.

7.1 PRODUCT DESIGN & IMPACT

We have created a physical prototype that, through flexibility and modularity, can aid resellers and consumers of front doors, in understanding the possibilities and flexibility for customized designs based on the consumers' special requests. This prototype is, in this context, first of its kind. The flexibility of the prototype is due to the construction choices of using modules and attaching them to each other with the use of neodymium magnets, embedded within the modules. This opens up for a high quality and surface finish of the entire prototype. The positions of each module are controlled by the strategically placed neodymium magnets in the core of the prototype. This provides the manufacturer of the products with the ability to control the possible outcomes for designs in a way that is beneficial to them and simplifies their production of these customized designs.

We predict that this model will help resellers demonstrate the products from Polardörren AB in a more effective and appealing way to the consumer. By also allowing the consumer to be part of the design process, we believe that the chance of a customer buying a product will increase, due to the connection and feeling of involvement that the consumer gets by using this model. By increasing the chance of purchase, we also increase the number of sold products. This leads to increased revenue for both resellers and manufacturer and may require an expansion of the manufacturing company. This means more job opportunities for the surrounding society which lowers unemployment in the area.

We believe that this prototype and the knowledge that has been acquired through this project, and presented in this report, can simplify the further development of this and similar modular prototypes.

By shining a light on the environmental impact of our product, we hope that we contribute to an increased awareness of dirty production, and that companies in the future are more conservative of their choice of distributors and place of purchase.

7.2 RECOMMENDATIONS FOR FUTURE WORK

Despite the satisfaction from the project, we still need to be realistic. This is just a first prototype and there are still potential for further development. Some thoughts about improvements surfaced while manufacturing the product, and some have surfaced after the prototype had been assembled and tested.

We would recommend putting a few prototypes in nearby stores of resellers and evaluate how well they work. This would mean using them for the purpose of selling custom-made door designs to real customers. To be able to measure or evaluate the performance, you could then ask the customer what their opinion towards the model are, or ask them to fill out a questionnaire with questions regarding their experience and thoughts. After a period, the company would summarize the results from these questionnaires and they would then be able to see what the customers have thought have been working well, and what could be improved.

First, we recommend further experimentation with the magnets. The strength of the magnets seemed to be sufficient during the project, but after all parts were painted, it turned out that the friction between two painted parts was so low that the magnets had trouble keeping some parts in
place. This could probably be solved by using stronger magnets, more magnets or roughing up the surfaces in contact, we would recommend the first option. As mentioned in the discussion, there needs to be further planning for the placement of the magnets, as some parts now exist as a right and left version. The display stand for the model needs to be looked over, as it is far from optimized in regards to storing the model and its parts. There are also room for potential extra utilities, such as holders for product catalogues or price lists, to be incorporated in the design.

When the functional and aesthetic properties have been decided, then there are a few points that we would like to point out in preparation for if the company decides to put this into production. All planning for manufacturing the product within the company production line needs to be addressed. This is something we have not put any effort behind, since it has been outside the range of our project. Similarly, all resellers need to be introduced to the model and they need to be instructed on how to use it together with a customer. There are potential for marking each part of the model with prices corresponding to the real counterparts to give the customer a better understanding of the price of their custom-made design.
8. References


### Appendix 1. GANTT Scheme

<table>
<thead>
<tr>
<th>December</th>
<th>January</th>
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<tbody>
<tr>
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<td>Week 18</td>
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<tr>
<td>T F S S</td>
<td>M T W T S S</td>
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<td>M T W T F S S</td>
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### Week 15

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### Week 20

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<td>M T W T F S S</td>
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Appendix 1. GANTT Scheme
Visit to the building supplier

We have performed spontaneous and unstructured interviews on two sellers of exterior doors. These persons are independent of each other and works at separate companies. In this interview the interviewees are mentioned as seller 1 and seller 2, and us who have performed the interview are mentioned as A&E.

At the first retailer
A&E: How often does customers request special manufactured doors based on their own needs?

Seller 1 means that it happens that the customer asks about it, but it often leads to some kind of standard model anyway because of extra lead time for the manufacturer and an increased cost on the product.

A&E: How would the customers react if they could be able to combine and create their own door?

Seller 1 reckons they would really like it. They had an event during the inauguration of the store where Polardörren held a contest in which the customers were able to ‘design’ their own door. The winner, the best design, won a full sized door made from their design.

A&E: What would you think of that concept?

Seller 1 means that it would have been fun to match the requests of the customers and give them exactly what they want.

A&E: Will it be worth it?

Seller 1 thinks that it will not be worth it from a seller’s perspective. Since it takes about 20 minutes per customer today, it would probably take about 60 minutes per customer and then other customer can get tired of waiting and that they would think it takes too long to get the help they want.

A&E: What is the competitive relationship between physical stores and e-commerce?

According to seller 1 physical stores compete a lot with e-commerce, where it can be hard to match their prices since the e-commerce do not have the same approach while selling doors and they do not need store their doors anywhere. Therefore, they can decrease the costs of the doors they are selling, but maybe on the cost of decreased quality and treatment of customers.

A&E: What opinions would you have as a seller if the customer where able to order doors directly from the manufacturer?

Seller 1 says that he would dislike it as the manufacturer would be able to reduce the cost of the door of the same reasons as the e-commerce.

A&E: If the customer is looking for help from you as a seller, how does the process work?

Seller 1 means that he initially tries to match the customer with their main manufacturer. If they cannot find a model that is interesting enough he moves along to the next series of doors manufactured by another company. If they still would not be interested in a door model he has shown, he refers to the manufacturer itself where they can ask about special manufactured doors. Although, it is very rare since it takes longer time to receive the product and the cost of the product also increases.
At the second retailer

A & E: How is the general process when the customer comes in to buy a door of you?

Seller 2 says that the customers have a general idea of what type of product they want. They have made an initial research on the internet and compared the different manufacturers and the products. The customers then come to the store to get advice and ask about the cost. He continues to say that they have the opportunity to go and measure the exact dimensions the customer needs, which is something that the e-commerce cannot do.

A&E: What is your opinion about the competition with e-commerce?

Seller 2 means that he does not really have any opinions about of how it affects the competition, but it affects in some way. The advantage with a physical store is that the customer has an actual person to ask questions to instead of an e-mail address.

A&E: How does you as a seller see on the customer's possibility to order special manufactured doors?

Seller 2 means that he does not have experienced that the customer has requested special manufactured doors. It would have been great to fulfill the customers’ needs to 100% but it would probably not be workable as it would be too time consuming.

In general

According to the experience of the both sellers when it comes to the process of how the customers do when they buy their exterior doors there are generally two scenarios:

1. The customers come to the store and look at the door models placed in displays to create their own opinion of the range of products and what interests them. Thereafter, they contact the seller in the store and asks general questions like; “what should I think of when I buy a new door”, “which doors are good?” and so on. Furtherly the seller helps the customer when watching in the catalogues and tries to match the customers’ requirements with a product that can be found in any of the manufacturers’ catalogues.

2. The customers know what they want and contact the seller directly, and the seller helps the customer to find the product that best matches the customers’ requirements with the models presented in the catalogues of the manufacturers.

Conclusion

The customers would like to decide their own design on a door, but it can be too much to choose between or too complicated, since it can feel too overwhelming for the customer. It shall not take too much time for the seller to sell a special product as time equals money. If the time of the sales process increases the seller will potentially miss out of other customers. And a longer production time is often not sustainable since the cost of the product increases.

Reflection

Our model shall have the purpose to show the customer that there are opportunities to create something completely special made. The customer can use a digital design tool as an aid to create its own design and thereafter go to a retailer and make an order.
### Appendix 3. Cost Analysis

<table>
<thead>
<tr>
<th>Product</th>
<th>Amount</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDF (4mm)</td>
<td>2m²</td>
<td>137 SEK</td>
</tr>
<tr>
<td>Mangets (10x1)</td>
<td>69 á 0,52 SEK</td>
<td>35,88 SEK</td>
</tr>
<tr>
<td>Mangets (10x2)</td>
<td>41 á 0,75 SEK</td>
<td>30,75 SEK</td>
</tr>
<tr>
<td>Vinyl stickers</td>
<td>0,16 m²</td>
<td>100 SEK</td>
</tr>
<tr>
<td>Castors</td>
<td>2 á 26,9 SEK</td>
<td>53,8 SEK</td>
</tr>
<tr>
<td>Castors (brakes)</td>
<td>2 á 29,9 SEK</td>
<td>59,8 SEK</td>
</tr>
<tr>
<td>Hinges</td>
<td>1 pair á 31,75 SEK</td>
<td>37,75 SEK</td>
</tr>
<tr>
<td>Plastic sheet</td>
<td>½ sheet á 349 SEK</td>
<td>174,5 SEK</td>
</tr>
<tr>
<td>Wood studs</td>
<td>1 (50x55x1000mm) á 15 SEK</td>
<td>15 SEK</td>
</tr>
<tr>
<td>Glue</td>
<td>0,01 L á 95 SEK / L</td>
<td>0,95 SEK</td>
</tr>
<tr>
<td>Putty</td>
<td>0,1 L á 35,9 SEK / L</td>
<td>4 SEK</td>
</tr>
<tr>
<td>Paint</td>
<td>Prime &amp; Top Coat</td>
<td>100 SEK</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td><strong>743,43 SEK</strong></td>
</tr>
</tbody>
</table>
Criterion

Criteria #1: Shall be able to combine in various ways.
Criteria #2: Shall be able to give the same material feeling as the real product.
Criteria #3: The user shall receive a realistic impression of the product.
Criteria #4: The model shall be easy to use.
Criteria #5: The model shall not be larger than an A3 paper.
Criteria #6: The model shall not give free choice in combination opportunities.
Criteria #7: The customer shall get an understanding of the flexibility of the company.

Concepts

Benchmarking concept: Modules
Concept #2: The Catalogue
Concept #3: Magnetic Images
Concept #4: Panels
Concept #5: Divided by three
Appendix 5. Drawings

BLANCO_PANEL

TOP
183.6

FRONT

Dimensions: L 394

Drawing sheet: Blanco_panel_R0.png

Company: LIVER UNIVERSITY OF TECHNOLOGY
Drawing Number: 1 (1)
Appendix 5. Drawings

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Appendix 5. Drawings

SCALE 1:2