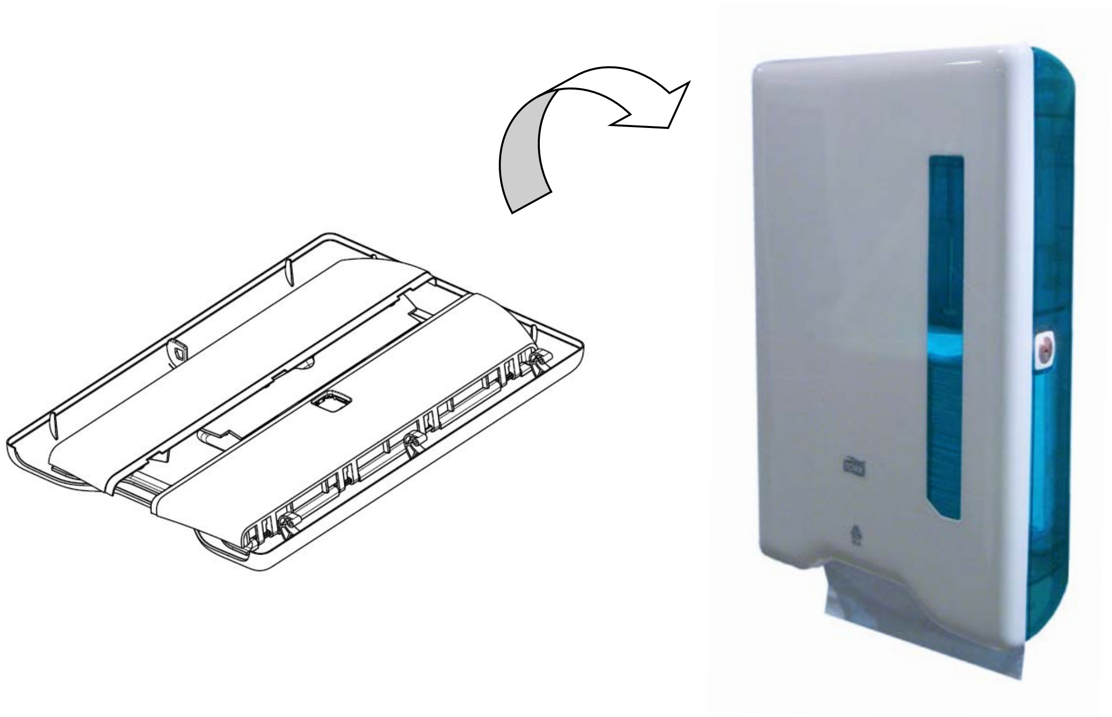

Flat Pack Dispensers

Development of flat packed washroom dispensers, to save space during transportation.

Master of Science Thesis

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Division of Product development

CHALMERS UNIVERSITY OF TECHNOLOGY

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Abstract

This thesis covers the development process of public washroom dispensers that can be flat packed when transported. It was performed on behalf of SCA Hygiene Products, at the department of AFH (Away from home) tissue. On the markets in Asia and South America, potential customers often think existing dispensers are too expensive, especially when shipped from Europe. The purpose of this project was to increase the efficiency of shipping dispensers, i.e. minimize the cost and environmental impact, by reducing its required cargo space. This should be done by developing a well functioning series of dispensers that can be packed flat. Flat packing requires the final assembly to be carried out by the customer, instead of being completely assembled in production. The series should also have a robust design and be aesthetically appealing.

The project was structured into four major phases; Pre-study, Concept development, Detailed design and Project Completion. The Pre-study mainly aimed to identify a number of principles of how to pack products in flat packages. The Concept development phase was structured as a funnel, with a wide inlet for ideas and solutions, followed by a number of screenings and scoring matrices to help select a final concept. The detailed design contained dimensioning and detailed design of all dispensers and their features. In the last phase, Project completion, realistic and functional prototypes were manufactured for visual and testing purposes. The final volume reduction and cost estimation of the product and shipping was also presented.

The project resulted in a promising concept that can be flat packed efficiently while at the same time being fast and easy for the end customer to assemble. The prototypes show that also features as robustness, aesthetics and functionality could be kept at a high quality level. The flat packing method can lead to large total reduction in shipping volume and cost, but for smaller products or for those with more features the reduction is more difficult to attain. Therefore the recommendation is to investigate the possibility to flat pack other dispenser types, to find the most suitable candidates. Furthermore the environmental aspect of flat pack with reduced emissions from transportation can be emphasized in market communication.

Sammanfattning

Detta examensarbete beskriver utvecklingsprocessen av en serie dispensrar för offentliga toaletter, som kan packas platt under transport. Projektet utfördes på uppdrag av SCA Hygiene Products, på avdelningen för AFH (Away From Home) tissue. På marknaderna i Asien och Sydamerika tycker potentiella kunder ofta att befintliga dispensrar är för dyra, speciellt när de tillverkats i och levereras från Europa. Syftet med detta projekt var att öka effektiviteten för transport av dispensrar, dvs. minimera kostnader och miljöpåverkan genom att minska det lastutrymmet som krävs. Detta görs genom att utveckla en väl fungerande serie dispensrar som kan packas platt. Att packa platt kräver att slutmontering utförs av slutkund istället för att produkterna färdigmonteras i produktionen. De bör samtidigt ha en robust konstruktion och vara estetiskt tilltalande.

Projektet var indelat i fyra huvudsteg; förstudie, konceptutveckling, detaljkonstruktion och färdigställande. Förstudien var främst inriktad på att identifiera ett antal principer för hur man kan packa produkter i platta paket. Utvecklingsfasen var uppbyggt som en tratt, med ett brett inlopp för idéer och lösningar, följt av ett antal eliminerings- och poängmatriser för att kunna välja ett slutligt koncept. Detaljkonstruktionen innehöll dimensionering och detaljdesign av alla dispensrar, deras funktioner och delar. I den sista fasen tillverkades realistiska och funktionella prototyper för testning och visuella ändamål. Slutlig volymreduktion och beräkning av produkt- och transportkostnad presenterades också.

Projektet resulterade i ett lovande koncept som kan packas platt på ett effektivt sätt, samtidigt som det är snabbt och enkelt för kunden att montera. Prototyperna visar att också egenskaper som robusthet, estetik och funktionalitet kunde hållas på en hög nivå. Metoden för att packa platt kan leda till en avsevärd reducering av fraktvolym och kostnad, men för mindre produkter eller för de med fler funktioner och delar är minskningen svårare att uppnå. Därför rekommenderas en undersökning av möjligheten att packa andra dispensertyper platt, för att hitta de mest lämpade kandidaterna. Dessutom kan miljöaspekten av platta paket och minskade utsläpp från transporter betonas i marknadskommunikation.

Preface

This 30hp master thesis project was carried out during the fall semester of 2010 as a part of the Product Development master program at Chalmers University of Technology in Gothenburg, Sweden. The project proposal "Flat packed dispensers" was provided by the company SCA Hygiene Products.

The project covers a product development process, from initial research to prototype manufacturing. Some prior knowledge about product development is preferable for good understanding when reading this report.

Acknowledgements

We would like to thank our supervisor Björn Larsson, project manager at SCA, for guidance along the development process. Also, thanks to our supervisor Dag Bergsjö, assistant professor at Chalmers University of Technology, for overseeing the academic part of the project.

Viktor Andersson & Fabian Ingvarsson

Terminology

ABS	Acrylonitrile Butadiene Styrene
AFH	Away from home
CAD	Computer Aided Design
DFA	Design For Assembly
DFM	Design For Manufacturing
FEM	Finite Element Method
LPD	Lean Product Development
HoReCa	Hotels, Restaurants and Catering
MTM	Methods-Time-Measurement
NPD	New Product Development
PS	Polystyrene
SCA	Svenska Cellulosa Aktiebolaget
SLA	Stereolithography

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1 Introduction

This chapter introduces the project with a short background and a description of the need for the product being developed. The project purpose and objective is then presented, followed by its scope and limitations. Finally the environmental aspects are described.

1.1 Background

When acting on a global market developing and producing products, there are logistical challenges that have to be met. The country or continent where products are produced is often different from the location of the customer. Hence, efficient shipping becomes very important. There are of course a number of best practices to apply along the supply chain, but first one can start with space-saving improvements and design changes of the actual product being shipped.

1.1.1 SCA

SCA (Svenska Cellulosa Aktiebolaget) works with development, production and marketing of personal care products, tissue, packaging, publication papers and solid-wood products. It is a global company that sells products in over 100 countries around the world. Tork, Edet, Tena, Libresse and Libero are examples of brands represented in the SCA family.

With its Away-from-home (AFH) tissue segment, SCA can deliver whole hygiene series for high traffic washrooms to companies and institutions. These series, called dispenser series, consists of containers for paper towels, soap, toilet paper etcetera. SCA's dispenser series are mostly sold under the Tork brand and only a very small part are produced for the private label market. The Tissue department is a large organization with production at 36 facilities in 18 countries, and customers in around 80 countries. (SCA, 2010)

In the report, SCA represents the company in general, or SCA Hygiene Products AB, Mölndal, Sweden, unless otherwise stated.

1.1.2 The need for a new product

The production cost of SCA's dispenser series are generally low due to simple solutions and high quantities. This means that the shipping cost largely affects the final cost of the product, and minimization of the package size will directly reduce transportation costs. Largest savings will naturally be made for the longest or most costly distances.

According to SCA, when looking at markets as Asia and South America, potential customers often think existing dispensers are too expensive. In these parts of the world, with lower price levels than in for instance Europe and USA, a product manufactured overseas with the added shipping costs will comparatively be even more expensive.

1.2 Purpose

Today's dispensers are completely assembled in production before being stored or sent to their destination. An empty dispenser packed in a separate carton means a light, but bulky package, which requires an unnecessary amount of space. The purpose of this project was to increase the efficiency of shipping dispensers, i.e. minimize the cost and environmental impact, by reducing its required cargo space.

1.3 Objective

The aim of this project was to develop a well functioning dispenser series that can be packed flat. The flat packing requires the final assembly to be carried out by the customer, in connection with the wall mounting of the product, instead of being completely assembled in production. Thus, the assembly should be simple and easily performed. In line with SCA's existing dispensers, the series should also have a robust design and be aesthetically appealing, which can be more difficult to achieve with a flat pack dispenser. Below one can find the research questions that will be answered in this master thesis, along the development process and through testing of the final prototype.

1. **How can a dispenser be packed flat so that it is easy assembled by the end customer?**
   Minimizing the dispenser's size during transportation requires a well thought-out flat packing method and its parts must be packed in an efficient way. How can this method at the same time be simple enough to let the product be assembled by the end customer?
2. **How can a flat packed dispenser design be well functioning?**
   After being assembled by the customer, will the product be functional in terms of dispensing, robustness, maintenance etcetera? The visual aspect of the assembled product is also important. Will the flat packing affect the dispenser's appearance negatively?
3. **What are the benefits of a flat packed product?**
   Will the packed dispenser fit into a smaller package than corresponding dispensers of today, and how much can be saved regarding shipping space, cost and environmental impact?

1.4 Scope

The project comprises literature research and studies of existing products and principles of how to pack in flat packages, e.g. furniture, the packaging industry and other areas that may be of interest in this context. It also includes development of flat packed dispenser concepts, which consisted of containers for paper towels, soap and toilet paper, and a trash bin. The most promising dispenser concept was further developed and designed in detail, and a functioning prototype was made by an external manufacturer. The scope also covers a cost estimation of the flat packed dispensers, including both manufacturing and shipping.

1.5 Limitations

The product is market-driven in terms of the desire for lower cost, but the product quality must still remain as high as possible. The way of satisfying the customer was already set by SCA, i.e. reducing shipping costs by making a flat packed dispenser, and therefore no market research to analyze the interest for this kind of dispenser was carried out. For the same reason, the investigation of specific potential drawbacks of flat pack design, other than the added customer assembly, were also excluded from the scope.

With the aim of resulting in dispensers that can be packed flat, focus was on the design of the product itself. To get fair shipping cost estimation, wrapping of the product and packing efficiency was also taken into consideration, while other influencing matters within logistics were left out.

As this project is a Master thesis, it aimed to result in a prototype and not a product in production. However, the prototype should be satisfactory and comparable with existing dispensers. Detailed design and prototype manufacturing is time consuming and costly, so for this project only one product, the hand towel dispenser, was selected to be completely developed. The hand towel dispenser was selected as it is often considered to be the main piece of a dispenser series at SCA. The three remaining products were also designed in detail, sufficiently for making renderings and not functional prototypes.

1.6 Environmental aspects

Care for the environment and sustainable solutions have spread, with more companies starting to take responsibility for their own environmental impact. SCA's sustainability policy says: "SCA shall conduct its activities in accordance with the highest standards of corporate best practice and in full compliance with all applicable regulatory requirements." Among the listed environment commitments one could find reduction of carbon dioxide emissions, reduced water use and responsible use of wood raw material. (SCA, 2011)

Environmental aspects are in focus for all product development projects. Size reduction and packaging efficiency go hand in hand with environmental impact reduction. When products can be packed more efficient they require less space during transportation, which leads to lower emissions. This of course applies to all means of transport, from worldwide shipping to local ground transportation. A smaller product also means a smaller package, and a decreased amount of cardboard. Additionally, a further size reduction of the product, reducing the dispenser's capacity, could reduce the total material use.

2 Theory

This chapter presents theory in areas that are related to the project process. The content gives an introduction to new product development and common tools used along such a process. It also covers information about existing theories behind the idea of "flat pack".

2.1 New product development

The demand for superior products drives the companies to make their product development process faster and more efficient with even higher demands on the quality of the end result (Wheewright & Clark, 1992). New product development (NPD) describes the process of bringing a new product to the market. The product development process includes several steps, often starting with an initiating face of market research and ending at production. One widely accepted product development process is presented in the book *Product Design and Development* by Ulrich & Eppinger (2008). Their generic development process includes six phases: planning, concept development, system level design, detail design, testing and refinement, and production ramp-up. In order to fully utilize the potential of their philosophies the process needs to be adapted to each company or project (Ulrich & Eppinger, 2008). According to Johannesson, et al. (2005) the development process is not strictly meant to be a sequentially running process, but the phases are often overlapped in time and iterations are most likely needed.

Through their development funnel Wheelwright and Clark (1992) emphasize the importance of being wide open for ideas in the early stages. Subsequent steps consist of several screenings to eliminate the least suitable ideas. Like the general development process, the screening process can be of various types, and must be adapted to the specific situation. An example of a development funnel is shown in Figure 1. Reality is often more complex, with changing ideas and continuous external influences on the process. (Wheewright & Clark, 1992)

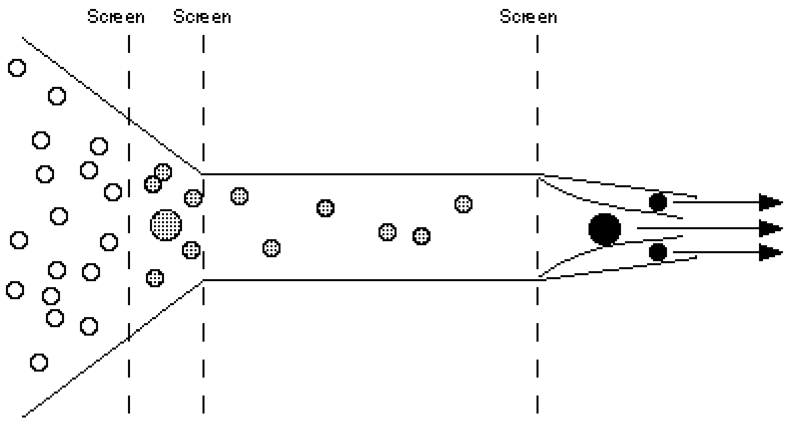


Figure 1: The development funnel with a wide opening and a number of screenings along the process. Source: Wheelwright & Clark (1992)

The screening process is used to improve the probability of selecting and developing successful products, and should therefore be seen as a positive activity. The NPD process will take longer time to complete the more wide-ranging the screening process gets and organizations often tend to keep it as simple as possible.

The process is often based on a hierarchy of criteria used to determine which contestants are most suitable to select and develop further. These criteria should be determined in advance and be based on the most crucial factors affecting the organization's NPD reality. (Rainey, 2005)

One concept screening technique used for evaluation of design alternatives is the Pugh concept selection, based on a method developed by Stuart Pugh. This technique uses a scoring matrix called "criteria-based" or "Pugh" matrix. The method is iterative and effective for comparing alternative concepts. Options are assigned scores relative to criteria and the concept selection is then based on a combined total score. The rating step works as follows; one design is selected as reference and the other concepts are compared to it and rated better, equal or worse. The final score should only be used as guidance in decision making. If the two top scores are almost equal, a further examination of the concepts is recommended. (Brue & Launsby, 2003)

Another method for comparing different variants with each other is a visualization technique developed by Kesselring. Each criterion, which is derived from the design brief, is evaluated and added to a total score. The total score is then expressed as a percentage of the maximum score possible. (Ehrgott et al., 2009)

Hence, in a Kesselring matrix the concepts are scored according to their fulfilment of the stated criteria, while a Pugh matrix compares each concept with a selected reference.

2.2 Lean product development

The term "Lean" became known after Liker (2004) published the book *The Toyota Way*. The book announced Liker's research on Toyota and their philosophies, which today are being adapted and utilized by organizations all over the globe. According to the president of Toyota North America, LPD (lean product development) could be reduced to three basic statements: Make it as simple as possible, Make it visual, and trust your people to do the right thing (Gustafsson, 2010). Lean refers rather to a way of thinking and working than to a set of methods. However, many of the lean tools are useful during a development project. (Womack et al., 1990)

Set-based concurrent engineering means that the development process should be front-loaded in order to reduce redesigns and changes later in the process. By implementing set-based concurrent engineering helps the team to examine and consider broad alternatives within clearly defined constraints (comparing with e.g. the requirement specifications, business strategy etcetera) and gradually narrowing the funnel and eliminating unfeasible alternatives until a superior solution is agreed upon. All the ideas are processed concurrently rather than serially to be as effective as possible which will result to a shorter lead-time. (Morgan & Liker, 2006)

Another important part of LPD thinking is the use of early testing which leads to a knowledge driven process, i.e. learning as much as possible at an early stage in order to find the best solution (Gustafsson, 2010).

2.3 Flat pack

A number of interesting research areas regarding flat pack was found which are presented in the mind map below (see Figure 2). In the box on the top one can also see the main drivers behind flat pack. The most important reason behind flat pack is of course to save space along the whole logistic chain. It is at the same time linked to other drivers, for example minimizing the impact on the environment or to save cost (Fetzer & Aaron, 2009). According to Sullivan et al. (2010) costs are also saved as less assembly is needed to be done in production. In general a flat packed product should lead to lower production costs for the manufacturer. Reduced costs for the production companies should in the end mean that the consumer needs to pay less. (Russel, 2003)

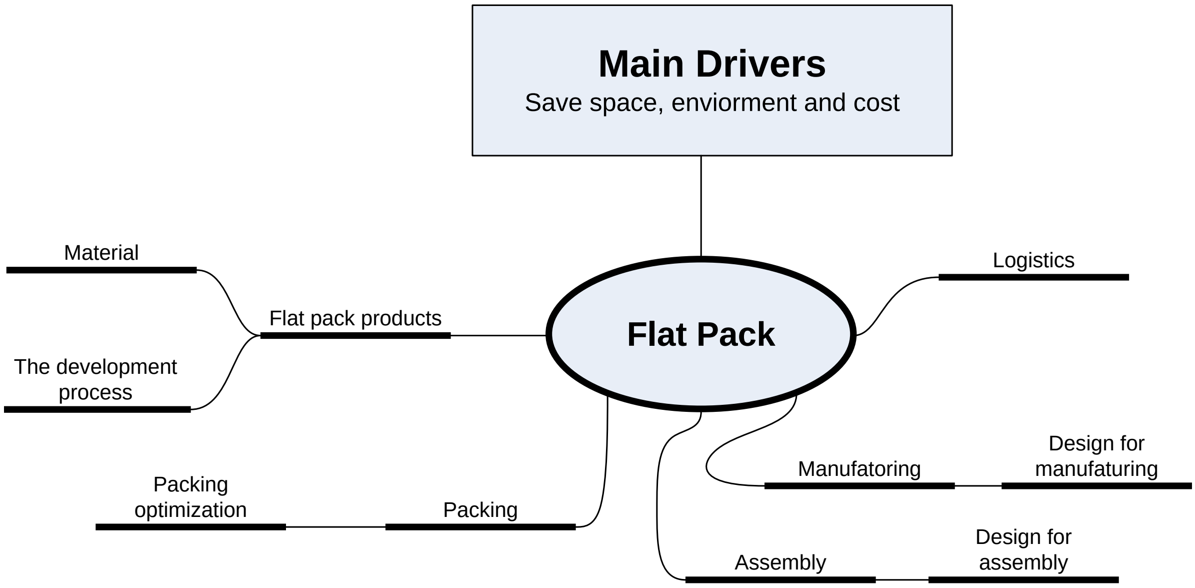


Figure 2: Mind map of interesting research areas concerning flat pack.

The research areas Flat pack products, Packing, Assembly and Manufacturing were found to be most relevant to the project scope. Selected parts of these areas are further explained below.

2.3.1 Flat pack products

There are today a number of flat pack products on the market including everything from children's toys to technical devices. In the book *Collapsible: a design album of space-saving objects* Mollerup (2006) describes products that breaks down, balls up, pulls apart, and stacks together. Flat pack is most commonly used for furniture and particularly objects which will be used for storage in the home or office. The most commonly used materials for flat packed are wood, plastic, metal and glass (Cosway & Fasciato, 2001). The packaging business also uses flat pack principles to minimize transportation volumes of the packaging before the content is added. The most commonly used materials for packaging are paper, metals and plastics. Especially paperboard packaging is used to make different kinds of folded containers. A lot of research is being done in the field of paperboard packaging which leads to new folding techniques that are often quite complex and innovative. (Soroka, 1999)

Flat pack development process

Cosway et al. (2001) describes the different areas that need to be considered when developing a new flat pack product. The process is much like any other developing process but with more emphasis on the design regarding easy assembly and fastening methods.

Selecting the most suitable assembly method is crucial when designing a successful flat pack product. It is also important to select easy to use fasteners as it is going to be assembled by the end customer. When searching for the best method it can be helpful to test a range of fasteners to find out which are most appropriate. In some cases the assembly or joining method can be used to give an extra feature to the overall appearance of the product. It is also very important to accurately position and align each part as it will decide the success or failure of the assembly. (Cosway & Fasciato, 2001) More complicated parts can be built as sub-assemblies in production in order to ensure the accuracy and facilitates the assembly for the end customer (Russel, 2003).

The packaging of the product needs to be designed alongside the product in order to reduce the amount of wasted space. The carton is often designed after the largest parts and the void space can then be used for smaller features. (Russel, 2003)

There has to be an assembly instruction that must be a well thought out. It should also be easy to understand regardless of the country it should be sold in. This should be done using clear and visible drawings with a minimal use of text descriptions. (Russel, 2003)

2.3.2 Packing Optimization

Packing optimization is used in order to avoid the amount of void space in a fixed volume. To do this advanced optimization software based on OR-algorithms has been developed. These programs can solve packing and stowing problems where possible packing schemes are created by systematic permutation of the filling units and their orientation in the fixed space. (Gudehus & Kotzab, 2009)

The packing degree is the share of the fixed volume occupied by filling units. The optimal packing degree can be found by comparing the possible packing schemes. The Software often shows the result as a simulation of the packaging schemas and the resulting packing degree. Packing optimization software can solve problems with both the use of equal filling units and unequal filling units. (Gudehus & Kotzab, 2009)

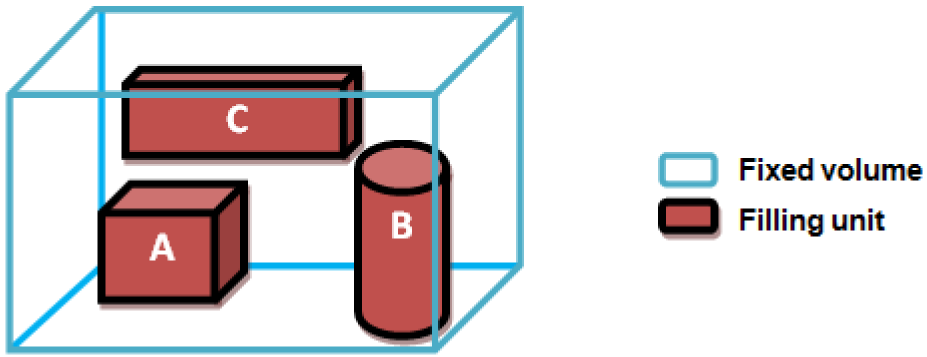


Figure 3: An example of filling units A, B and C in a fixed volume.

Figure 3 shows an example of the three filling units A, B and C in a fixed volume. Packing cartons on a pallet or pallets in a container are typical problems with equal filling units which in this example would mean that only one type of the filling units A, B or C are used. This would result in possible packaging schemes for one of these units in the fixed space and the given packing degree. Placing different parts of a product in a carton is a problem with unequal filling units where the optimal packing scheme is found for a combination of A, B or C.

2.3.3 Design for manufacturing

The manufacturing process is important to generate output, and it has to be competitive. This means that unit labor cost must be held low and customer demands of a quality product must be fulfilled. (Mital, Desai, Subramanian, & Mital, 2008) Design for manufacturing (DFM) is a philosophy used to improve parts and products in terms of simplified production and to a lower cost. With manufacturing input in the initial design stages, the DFM thereafter continues throughout the design process. (Poli, 2001)

There are a number of design guidelines to take into considerations when preparing a part for manufacturing. Most of them help simplify the process and thereby lower the manufacturing cost. The principles vary depending on the selected manufacturing process. In casting, for instance, unnecessary complexity should be avoided to simplify making of the mold. Sharp corners and angles should be kept at a minimum to avoid stress concentration, and section thickness should be consistent to reduce the risk of shrinkage cavities. However, interior walls cool more slowly and should therefore be kept 20% thinner than exterior walls. Also for machined parts, sharp corners and edges should be avoided, as these are hard to achieve. Other examples of features to keep away from for simplified manufacturing are tapers, bent holes and contours. (Mital et al., 2008)

2.3.4 Design for assembly

Like many other tools and guidelines used in today's industry, Design for assembly (DFA) mainly aims to reduce time and costs. DFA should be introduced early in the design process because of assembly cost commitments incurred in the initial product design phase. When developing a generic DFA methodology there are a number of main principles to take into consideration. There are of course many more rules, but they are often intended for a specific domain. (Molloy et al., 1998)

The objective of the first principle, Minimize the number of parts, is to eliminate the number of joining operations and thereby reduce the total assembly time. When minimizing number of parts in an assembly, a common method is to combine existing parts. The challenge is to not increase the complexity of the new part, since that could increase the cycle time instead of reducing it. Next principle is called Design for Ease of Handling, which highlights the importance of good handling features of the part. Both manual and automatic assembly is facilitated if the part has rectangular shape, suitable gripping faces and a rigid body. Components fulfilling these criteria will also eliminate the need for costly fixtures. To avoid insertion problems, Design for Ease of Insertion principle should be applied in the detailed design phase. Insertion is made easier if the components being assembled together are designed with tight tolerances and chamfers. (Molloy et al., 1998) This reduces the resistance to insertion. The part should also have a design that prevents jamming and entanglement, and in general the best way is to assemble from above. (Mital et al., 2008)The fourth rule is Standardization of parts, which can lead to a number of benefits and thus a reduction in assembly time and cost. It requires less assembly process set-up changes, reduced planning and scheduling, less inventory problems and a high probability of getting right design at the first time. The last two principles are Design for current process capabilities and Maintain awareness of alternative process capabilities. (Molloy et al., 1998)

3 Methodology

In this chapter the general project method and the tools used during its different phases are presented. It also covers why and how these methods were used.

3.1 Process method

Each company has its own approach to the product development process and how it is utilized. To optimize the final result, the process should also be adapted to the specific task. (McGrath, 2004) A simplified model of Ulrich and Eppinger's development process was used, but the last phase of the process, production ramp-up, was not utilized as it is not part of the stated scope. As this was a classic mechanical design project, such proven method was desirable. However, it had to be adjustable to suit the scope of this project.

The general project structure and time plan was visualized by a Gantt chart, showing the main steps of the project with approximate start and finish dates. The process has also been iterative, enabling adaptability for possible changes. The time plan is presented in Appendix A. Time plan.

The project was structured into four major phases; Pre-study, Concept development, Detailed design and Project Completion. The Pre-study mainly aimed to identify a number of principles of how to pack products in flat packages. The study was performed from a wide perspective, taking a great number of businesses, designs and materials into consideration. The Concept development phase was structured as a funnel, with a wide inlet for ideas and solutions, followed by a number of screenings and scoring matrices to help select a final concept. Phase three contained dimensioning and detailed design of all dispensers and their features. Tools as DFA (Design for Assembly) and DFM (Design for Manufacturing) played a major part during this step. In the last phase, Project completion, realistic and functional prototypes were manufactured for visual and testing purposes. Photo-realistic renderings showing the concept in washroom environments were also made. The material was presented in the final project presentations at Chalmers and SCA. During the process the cost aspect was also taken into consideration. A simple cost estimation tool was used in the concept development process for comparison, while a more thorough estimation was made for the final concept at a potential production site in Germany, comparing it to existing SCA products in production.

3.2 Project methods

Described below is a wide selection of methods and tools used along the development process, categorized into Information collection and Concept development.

3.2.1 Information collection

The information collection was carried out both externally, through Internet research and patent screening among others, and internally at SCA by interviews, meetings, studies of existing products and more. External research was focused on finding interesting flat pack solutions, and it was held within in areas where these solutions exist. The research was external just because SCA has limited knowledge within that knowledge field. Internet research and field studies were the main methods used, alternated with a patent screening carried out in cooperation with SCA's patent department.

Since SCA has superior knowledge within their field, most information regarding dispensers was searched for internally. The information thereby comes from trustworthy sources, and a successful project is also in their interest. When assembled, the flat packed dispenser should work as the existing ones, which also justifies thorough internal research. Semi-structured interviews, focus groups and meetings were held with people in the organization, to collect requirements and opinions interesting for the project. An online survey was also sent out internally, to SCA offices in Shanghai, Germany and USA, for evaluation of dispensers' aesthetics. Since such opinions often are very individual, a large number of respondents were desired, which made a survey suitable in this context. Having it internal reduces the risk of spreading sensitive information about the project.

3.2.2 Concept development

The idea generation has been a continuous process with an open approach in order to get a wide range of ideas. Several different idea generation methods were used to maximize the number of inputs. A mood board was created to function as inspiration along the development process, see Appendix B. Mood board. Brainstorming sessions were held in order to elicit new ideas, both in general and within specific areas. A workshop was held with the purpose to collect innovative ideas from people with less or no insight in the project and limited knowledge about SCA's business.

Testing of ideas, mechanisms and concept designs was included at an early stage to reach a more Lean approach. These tests were used for verification of solutions and for comparison between concepts to reinforce elimination processes. Sketches and virtual and physical models were used as basis for the tests. Physical test were also performed on existing products to evaluate functions and mechanisms that could possibly be interesting for the project.

Both virtual and physical models were created since they have own advantages in different context. Virtual tools were preferable for early idea realization, when sketches were insufficient, and for rapid visualization through photo-realistic renderings. Physical models can on the other hand give the viewer an idea of function and product size. Besides testing, the sketches, early prototypes and renderings were valuable as mediating tools during interviews, meetings, presentations and more informal sessions.

The tools used when designing these models and also when designing final concepts and renderings were as follows. CAD (Computer Aided Design) software is an efficient virtual tool for product design. For the development process Catia V5 was used since it is an advanced modeling program that would not be a limitation in terms of design complexity. Early renderings were performed in the relatively simple program Photoview 360, while final renderings were made using Maxwell Renderer. Foam board models of complete concepts were built to be used in a number of tests. This method was selected since it is low cost and a rapid way of building full scale models with the possibility to integrate simple functions. When testing features more in detail, the rapid prototype technique SLA (Stereolithography) was used to create test parts.

A screening process can be large and complex containing many concepts and evaluation criteria. To get a good overview and reduce the complexity, quantitative matrix-based methods as Pugh and Kesselring were used. These tools facilitate concept comparison and provide clear results. On the other hand, a quantitative tool only takes the stated criteria into consideration. Therefore, in complement to the quantitative methods, qualitative judgments were also performed. This opened up for comparison between the two results and it also helped ensure no improper solutions were let through. The qualitative judgment was made in dialogue with people having superior knowledge within the specific subject, e.g. mechanical designers, industrial designers, market department or well-experienced product developers.

4 Pre-study

In this chapter initiating research, both internal and external, is presented. First the process and used source for the study is presented followed by its result.

4.1 Internal research

The internal research was performed using a number of different sources. Firstly key persons on SCA were contacted which provided material from earlier projects and indicated interesting fields to investigate further. The internal database and SCA's webpage also gave more information regarding the Tork brand and the different dispenser families.

4.1.1 Tork brand identity

Tork is SCA's brand for complete systems of AFH products. It is a leading brand in hygiene products, globally known and sold in 67 countries. (SCA, 2011) The Tork design should transmit the following values: attentive, close to customer, open, sharing, caring, warm and generous. Overall the design should be uncomplicated with simple shape that is easy to maintain and understand. The function of the dispenser shall be intuitive and the shape must clearly indicate the content of the dispenser. Across one dispenser family the design should have an apparent common look in order to send out a clear image. A new family of dispensers should strive to have a link to the existing Tork products on the market, in order to be recognized by the millions of people already familiar with Tork's products.

A Tork product is easy recognized by the logo placed in front. The Tork logo has to be placed on the front of the dispenser and the SCA logo can be less prominent placed on the side or the front of the dispenser.

4.1.2 Dispensers

There are a lot of different things that needs to be taken into account in order to make a successful dispenser. Three critical success factors are design, cost and function. SCA have a set of best in class features which should be in focus for technical product development for new dispensers. The best in class features are stated below.

- Ability to function over time (app. 10 years).
- "One at the time" (controlled dispensing consumption by portion control)
- Always product available (assuring that there is always product available for the end user)
- Dispensing function (easy and intuitive dispensing and refill)
- Robustness (Robust construction that maintains high function over time).
- Easy to refill / understand / maintain / clean
- Visual design
- Hygiene

4.1.3 Market segment

Tork has divided the market into four different market segments which are HoReCa (Hotel, Restaurants and Catering), Commercial, Industrial and Health Care. The largest and fastest growing market segment is the HoReCa segment where demands on hygiene and design are mostly emphasized. The second largest market segment is the Commercial segment with focuses on public washrooms where design, hygiene and cost in use are most important. The third largest segment is the Industrial segment which includes everything from heavy to cleaner industries. The most important drivers for this segment are productivity, efficiency, durability, and strength. The health care segment includes hospitals and institutions where the drivers are hygiene and personal care.

Tork dispensers are divided into an Exclusive, Everyday and Robust washroom family. The Everyday washroom family is aiming at the widest market and also stands for the highest sales volume. The Exclusive and Robust family is focusing on the smaller markets on each end of the market range.

SCA divides public washrooms into different environment/customer categories. The categories are divided into Good, Better and Best regarding atmosphere and interior of the washroom. The washrooms are also divided into Low, medium and High traffic. Table 1 below shows what environment/customer categories the different Tork dispenser families are aiming at.

Table 1: Environment/Customer categories.

Environment/Customer categories	Good	Better	Best Performance	Best Image
High traffic				
Medium traffic				
Low traffic				

Robust Everyday Exclusive

4.1.4 Product portfolio

Tork has a range of dispenser series aiming at different market segments. Each series consists of models with different functions for drying hands, dispensing soap etcetera. Some models are also available with different capacities in order to handle the traffic demand. The robust washroom line sold on the market today is called Metal. An example of the paper towel dispenser from the metal series can be seen in Figure 4 below.

Figure 4: The metal dispenser from Tork. Source: SCA

The old Everyday washroom line was internally called Box 2000 which was replaced by the Elevation series in 2009. In Figure 5 below one can see the paper towel dispenser of the Box 2000 series and an example picture of the Elevation series.

Figure 5: Box 2000 paper towel dispenser (left) and the Elevation series (right). Source: SCA

The Exclusive washroom lines are aiming at the customer categories best performance and best image. The Aluminium series seen to the left in Figure 6 is focusing on best image segment. The Performance series is as stated by the name focusing on the performance segment and is shown to the right in Figure 6.

Figure 6: The Aluminum series and the Performance series. Source: SCA

4.1.5 Dispenser types treated in this project

Each dispenser type is built to suit specific products, e.g. hand towel bundles, soap containers, toilet paper rolls or bin liners. To fully understand purpose and function of the dispenser types that will be covered in this project we took a closer look at the existing models. Below one can find a more detailed description of the four different dispenser models that should be included in the new series.

All of these dispensers but the Waste bin has a level indicator which enables the amount of product left to be seen from the outside. Today these dispensers are shipped in a carton box, placed in a plastic bag for protection, together with a mounted lock (key and button functions), screw kit (containing key, screws and plugs) and mounting instruction.

Hand towel dispenser, model H2

The H2 is a dispenser type for Tork's interfold hand towels, holding up to 2.5 bundles. By only having to touch the towel you use, good hygiene is secured for the user. The dispenser is designed for environments such as offices, restaurants and healthcare facilities, and it is compatible with a selection of hand towels with different paper quality. (SCA, 2011)

Soap dispenser, model S1

S1, the soap dispenser, is designed to hold a range of different soap products, alcohol gel and others. The one liter containers, giving around 1000 shots, mean low maintenance and the drip free design minimizes waste. It suits all kinds of washrooms, even the more tough and demanding ones. (SCA, 2011)

Toilet paper dispenser, model T2

T2 is a high capacity dispenser suitable in small to medium sized washrooms with frequent visits, i.e. schools and other public environments. It holds Tork's Mini Jumbo Rolls and it also has a stub roll feature that eliminates waste; when a red mark is visible at the dispenser back, the existing roll can be moved to the stub roll holder which then gives room for a new paper roll. As for H2, a selection of paper types is available. (SCA, 2011)

Waste bin, model B1

With a hidden bin liner, the waste bin B1 gets a clean appearance. The loading system is intuitive and facilitates maintenance. The bin is designed to fit in any environment and it is intended for Tork's 50L bin liner. (SCA, 2011)

4.2 External research

The external research was performed using benchmarking, field studies and a patent screening. Below one can find explanations on how the different researches were carried out. The study resulted in a number of different design areas that are presented later, divided into Flat pack principles, Fastening types, Folding types, Opening types and Materials.

Benchmarking

SCA's two largest competitors in the AFH tissue segment are the two American companies Kimberly-Clark and Georgia-Pacific. There is also a range of other dispenser brands on the market that were investigated to find possible flat pack solutions, e.g. Aster and Kruger.

In the initial research phase, there were no flat pack dispensers to be found in any dispenser manufacturer's product range. However, late in the project an interesting example was found, which was not yet out on the market. San Jamar, a company making dispensing products, had made a flat pack version of their existing "Ocean Ultrafold" hand towel dispenser. By separating the dispenser into an 8 part assembly they had reduced the package size with about 50 percent.

Field studies

Research of existing flat pack solutions and concepts was at an initiating stage performed on the Internet, giving an indication of possible fields to investigate further. To get inspiration of different flat packing methods and to find out the latest design trends a number of visits to different stores and expeditions were done. Interesting solutions were documented and sample products were bought to test different possible solutions. Visits were done to the following furniture stores; IKEA, Mio, BoConcept, Bolagret, Designtorget, Design House Stockholm and Stockhome. Furniture is often flat packed and many similar methods were found at these stores. Most commonly furniture is individually shipped as separate parts that need to be assembled by the end customer. Bulky products that can be shipped together to a store are often stacked into each other in order to save space when being shipped from the production site. Bathroom and kitchen stores as HTH köksforum, Frej Jonsson & Co, Hemma, Yroxxo and Kvänum, were also visited to get input on the latest trends in interior and bathroom design. Especially bathroom and kitchen cabinets gave inspiration both for possible dispenser designs and opening mechanisms. To find possible technical solutions for hinges and door opening mechanisms the following hardware stores were visited; Clas Ohlsson, Jula and Theofils.

Another field that was investigated was packaging. Packaging solutions are most often extremely flat packed before it is being used. Therefore a visit to the Pack & Emballage fair in Stockholm was done where the latest techniques and packaging solutions were presented. A lot of different companies where visited at the fair including FontPac, Flexopac and Pyroll. Some of the most interesting ideas came from the company Schoeller Arva Systems which produces foldable containers for shipping. The containers are made of plastic and have foldable sides enabling the containers to be flat packed when empty.

Patent screening

As a base for the patent screening some investigation was performed in order to find out interesting search strings. This was done using Google patent search with different combinations of possible subjects. The search strings were sorted into five different categories that could be used in different combinations. Below one can find a list of the categories and the belonging search strings.

- Structure (Dispenser/container/box/pack/package/packaging/drawer)
- Minimizing size (Foldable/flexible/collapsible/flat/compact/hinged)
- Material (Plastic/rubber/metal/aluminum/glass/wood)
- Joining (Fastening (Hinge/living hinge/slide/bracket/snap joint)
- Manufacturing (Injection molding/double injection molding/vacuum forming/extrusion)

When performing the Google patent search seven patents were found to be of extra interest and were therefore saved for later investigation (see Appendix C. Patent search for a list of the found patents). A patent screening was then ordered from SCA's patent department along with information regarding the project and the above mentioned search strings. The search was performed in the three main fields Packaging, Furniture and Fasteners. The search was done for existing patents and applications worldwide. It resulted in a large number of hits that efficiently needed to be reduced, which was done by limiting the search in time span and number of search string combinations.

When the number of patents found was down to a manageable level they were quickly scanned through using the Aureka database. The most promising solutions found in each field were saved for further investigation. The Aureka database search resulted in eight interesting patents in the Package field, eight in the Furniture field and twelve in the Fasteners field, all presented in Appendix C. Patent search. A more specified search regarding flat packed dispenser was also performed using the

Thomson database which only resulted in two more patents of interest. All the material was then thoroughly investigated, giving inputs to possible solutions.

4.2.1 Identified flat pack principles

From the pre-study different principles on how to minimize packaging size of dispensers where created. These principles were divided into four main categories named Separate, Foldable, Flexible and Stackable parts. Below one can find descriptions of the different categories.

Separate parts

Separate parts are assembled together by the end customer (see examples in Figure 7 below). The different parts can be fastened using integrated snap joints, separate fasteners or slide in methods. This principle allows a wide selection of materials and flexible packaging. On the other hand it can give a box shape appearance with a lot of visible split lines. This can fairly easily be solved by design features and use of naturally flat materials like wood and metals. The split lines can also be less emphasized by the use of different materials and colors. If separate fasteners are used they can also be used as design features. The principle most likely leads to a large number of parts that needs to be assembled for the end customer.

Figure 7: Examples of the Separate part principle. Source: Make (2011)

Foldable

For the Foldable principle, the different parts are folded by the end customer to form the desired shape (See Figure 8). The different folded parts can be joined by living hinges, integrated hinges, separate hinges, soft hinges or telescopic solutions. This flat pack principle can lead to easy and intuitive assembly that will give a short assembly time. The principle can however lead to advanced solution with unattractive corners. The solutions can though be made easier as the folding joints only has to be used once at assembly and the hinges can be hidden on sides that are not visible on the end product. Some of the joining solutions will also restrict the number of possible materials to be used. This drawback can be avoided by using separate hinges or telescopic solutions. Soft hinges can also work as design features but will often need to be compensated for with other elements to make the product robust.

Figure 8: Examples of the Foldable principle. Source, left to right: The Container Store (2011), Yanko Design (2011), 4discounttravel (2011).

Flexible

The Flexible category comprises Flexible materials are used that can be packed flat and shaped into the desired shape at assembly (See Figure 9 below). This can for example be realized by bending or collapsing solutions. Rather stiff but flexible materials can be used for the bending solutions which gives the opportunity to allow rather round shapes of the final product. The collapsing solutions are made of very flexible materials like fabrics, rubber and leather. This opens up for a whole new range of opportunities where almost any shape or form is possible. There is tough some major drawbacks with the Flexible principle as it will most possibly lead to weak construction with bad robustness. This can be compensated for with stabilizing elements which on the other hand probably lead to difficult assemblies and expensive solutions with a lot of parts. Even if the design can be made more robust the final product will have difficulties to withstand tough environments.

Figure 9: Examples of the Flexible principle. Source, left to right: Normann (2011), IKEA (2011), Incredible Things (2011).

Stackable

The Stackable principle is based on the idea that different parts can be placed inside each other (See Figure 10 below). These parts can either be parts from the same product or whole products shipped together. In the first case the product can for example be divided into two parts which of natural reasons will lead to a reduction in size up to 50%. If the reduction needs to be higher the product must be further divided, which can lead to unwanted split lines. In the second case the final product cannot be sent out to the customer directly but has to be broken down somewhere along the supply chain. There is also the possibility to put a number of products into a larger product that can then be sent out to the customer as a set. However, this option limits the choice for the customer to buy a certain amount of each product.

Figure 10: Examples of the Stackable principle. Source, right: ITV Pensions (2011).

4.2.2 Fastening types

During the pre-study a range of fastening types where found. These types are different possible solutions that are commonly used to join different parts. Below one can see a list of some of the possible fastening types that were found.

- Separate Screws (Philips, Slot, Hex, interlocking & Bolt)
- Separate snap joints
- Integrated snap joints
- Slide in solutions
- Puzzle joints
- Magnets
- Dowels

In Figure 11 one can see examples of different fastening types. The first example (left) shows an integrated snap joint solution in metal used to join the sides of a drawer. The second example shows an integrated puzzle joint solution for plastic box container. The last example shows an interlocking screw system used to join particle boards.

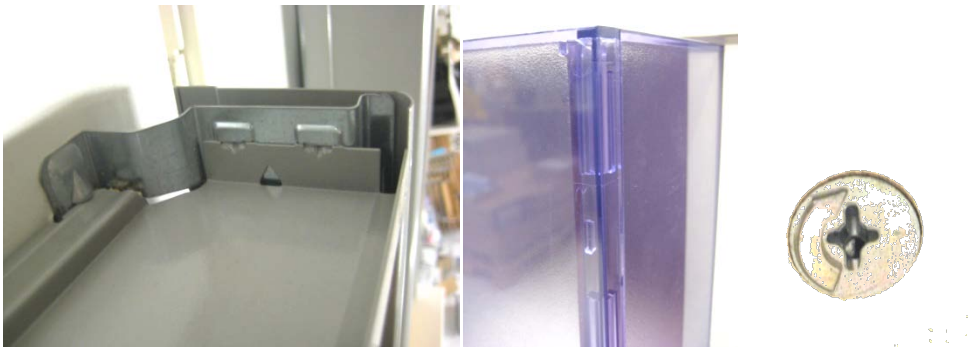


Figure 11: From the left; integrated snap joint, puzzle joint and separate interlocking screw.

4.2.3 Opening types

To enable refilling of the dispensers an opening solution is needed. The opening can be made on almost any side of the dispenser with an almost infinite number of different possible solutions. Below one can see a list of some of these openings types.

- Hinged door (Piano, Pivot, Living, Butt/Mortise, Concealed)
- Sliding door
- Roll up door
- Rotating door
- Drawer

The most commonly opening type used on dispensers are different kinds of pivot hinges, one example can be seen to the left in Figure 12. On the H2 Elevation a version of a pivot hinge is used, internally called a “horse hinge”. Another very simple solution for an opening hinge would be to use a living hinge. This would put high demands on the material as the door has to be well functioning over time. Living hinges also has the drawback with white effect in the folding corner. An alternative option could therefore be to use an integrated piano hinge, which can be made in almost any plastic. To the right in Figure 12 one can see an example of a butt hinge. This could be a good option especially for visible solutions.

Figure 12: From left one can see examples of a pivot hinge, “horse head” hinge, living hinge and a butt hinge that can be used for door opening.

In Figure 13 one can see a range of different concealed hinges in different materials. The second hinge from the left is called a barrel hinge which technology was found interesting as it takes up minimal space on the inside of the product.

Figure 13: The figure shows different types of concealed hinges that can be used for door opening. Source, left to right: Index-d (2011), Macwood (2011), Mapfittings (2011) & Noalit (2011).

There are many different types of sliding doors and some examples can be seen in Figure 14. Roll up doors were first found as an interesting option for a flat packed solution, but it has some drawbacks with advanced and space demanding solutions.

Figure 14: From left one can see an example of a straight sliding, garage sliding and roll up door solution.

Figure 15 shows examples of a rotating solution and a drawer. The rotating opening was found interesting as it is innovative and rather simple. The right picture shows a quite advanced version of a drawer solution that must be made simpler in order to lower the cost. Another challenge with the drawer solution is how to make it rigid and ergonomic to use.

Figure 15: A rotating opening mechanism and a drawer solution.

4.2.4 Folding types

A number of different folding solutions where found during the pre-study and the most commonly used types were hinge solutions as piano, pivot and living hinges. The simplest hinges presented in the previous chapter are thus popular and suitable to use for folding of parts. Quality of these hinges can be held lower since folding probably occurs only a few times, e.g. in production and during assembly.

4.2.5 Materials

The pre-study has given an indication of possible materials that can be used for the product. The fact that the dispenser should be flat packed does not affect or restrict the choice of material in any direct way, but is rather given by the correlation between the choice of flat pack principle, fastening type and door opening etcetera. The promising material groups found were plastics, wood, metals, glass and fabrics. Plastics are commonly used for high volume consumer products as it is highly dependent of fixed tooling costs and is fairly inexpensive per part produced. Plastic also gives the possibility to have almost any shape and allows both integrated and separate joining solutions. Wood, metal and glass are often found in flat packing products with separate fasteners. These kinds of materials are suitable for products and furniture that have a squared shape. One reason for this is that these materials are naturally flat and can even be found strange if manipulated into round plastic like shapes. As an alternative to glass, sheet plastic can be used. It is much lighter and demands less robustness of the total construction.

The change of material on different parts helps creating natural split lines, which will then be less noticeable. Having different colored parts can create the same effect even if it is made of the same material.

5 Concept development

This chapter covers the development process, from setting up a requirement specification to the selection of a final concept. The requirements were early translated into dispenser sub-functions, and thereafter solutions for these could be developed. Based on the sub-function solutions, a number of concepts were generated before a selection process was carried out. It was performed in several different stages, with concept screening, concept scoring and final concept selection as major phases.

5.1 Requirement specification

Collection of requirements and wishes was a continuous process along the project, based on information from internal documents, interviews and more. The most important requirements were stated in the early stages to limit the degrees of freedom to a reasonable level, but to be adaptable to changes and new influences it has been updated several times. The requirements list played a major part in the early concept development and first screening of ideas that did not fulfill all requirements. The list of wishes played a more important role in the later stages, covering concept comparison and evaluation of their different qualities.

The market segment aimed at was “Everyday”, described earlier in section 4.1.3. The existing series representing that segment is Elevation, which was therefore used as baseline when defining the requirements.

General requirements, covering the whole dispenser series, were within robustness, installation and serviceability, patents, and aesthetics. The robustness requirement was simple; take a punch from an average male. Within installation and serviceability, the list mainly involves requirements and wishes similar to those demands on existing Tork dispensers. The dispenser must for instance be easy to clean. Unique for this project was the assemblability time constraint, saying that a new customer should need maximum ten minutes to assemble the dispenser. Patenting of solutions is common at SCA and for their competitors, so no solutions could inflict with current patents. Judging of aesthetics is very individual, but the wish was to make the series as aesthetically appealing as possible, at least in line with Box 2000 series.

Each dispenser also had individual requirements on total cost, dimensions, compatibility with Tork’s products and package size. The maximum cost for each dispenser, including shipping (to another part of the world), was set to today’s total production cost of corresponding Elevation dispenser. Total cost of an Elevation dispenser includes manufacturing, packaging, screw kit and assembly instruction. The developed dispensers were of a specific model type, which means they had to suit specific Tork products, e.g. hand towels and bin liners. At the same time, all dispensers were desired to be as slim as possible. Also, one specific dimension requirement was set for the hand towel dispenser, a maximum depth of 4 inches according to US law. Furthermore, the dispensers must be packed individually to eliminate the need for repacking in the logistics chain. Last but not least, the flat packed dispensers should be as small as possible but at most 50% the size of a corresponding Elevation model. The complete requirement specification is presented in Appendix D. Requirement specification.

5.2 Functional structure

Most important for the dispenser series is of course to work properly as dispensers are intended to, while main focus for the actual project was the flat packing function. Figure 16 shows a simple functional chart of the four dispensers. The red box, representing the flat packing function, is mainly what distinguishes this project from other dispenser development processes. The remaining boxes contain functions necessary for a dispenser to work properly. Since the main goal was flat packed dispensers, changes of capacity, compatibility or function compared to existing dispensers were undesirable. The challenge was rather to keep these as good as possible, because flat packing function adds limitations to the other functions and their solutions.

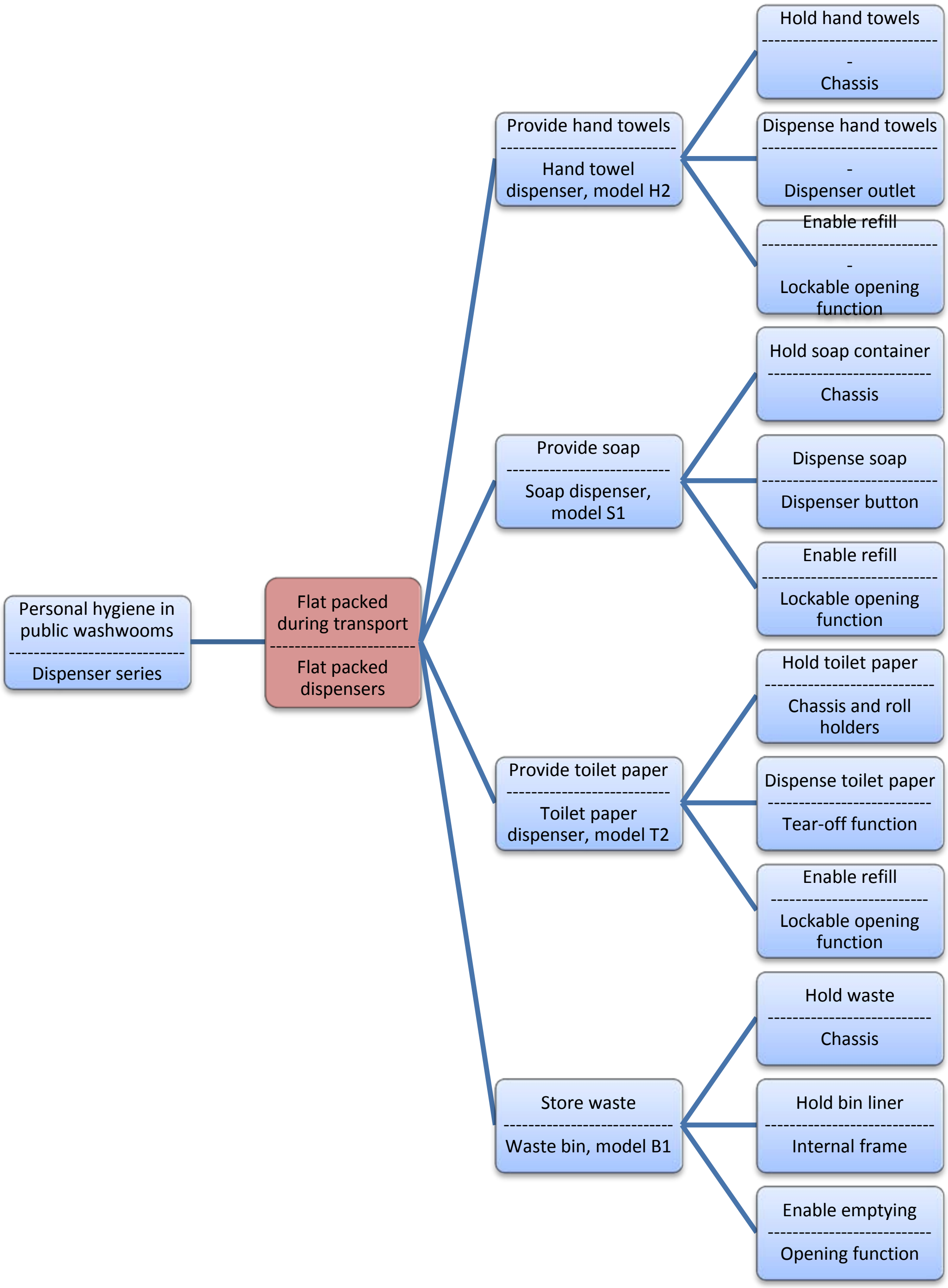


Figure 16: Functional chart of the flat pack dispenser series.

Each dispenser type must have a chassis to hold its content. Refilling and emptying of the products requires an opening function on these chassis. With the waste bin as exception, all dispensers also need a locking mechanism to prevent any content of being stolen. Furthermore, each dispenser has individual interior, or features, giving them its desired function. In H2, a lower shelf works as support for the loaded paper bundles, but also as dispenser outlet. S1 has a lower section providing support for the soap container and for its spout, together with an attached dispenser button. Significant for T2 is the two paper roll holders and the toothed tear-off function. B1's main feature is the holder keeping the bin liner in place.

5.3 Sub-function solutions

This chapter will focus on principles on how to pack the dispenser chassis flat, which was seen as the largest challenge. Interior and individual features for each dispenser are thereby not presented in this section, but will instead be left for detailed design, see chapter 6.

5.3.1 Dispenser chassis and assembly types

In the pre-study a number of flat packing principles were identified, named Separate, Foldable, Flexible and Stackable. The Flexible and Stackable principles were soon eliminated as they were considered not to fulfill all requirements. The Flexible principle was eliminated because of the risk of not handling the robustness and hygienic requirements in a satisfying way. The Stackable principle was argued not only to be in breach with our requirements, i.e. regarding size reduction and individual packing, but also the whole scope of the project. The principle saves space during transportation but not through flat packing of the products. Finally a combination of the flat pack principles Separate parts and Foldable was chosen as these where found most suitable for the task and works well to combine.

After selecting suitable flat packing principles, different possible assembly types with respect to the end customer assembly will be introduced. This means that some dispenser parts can be preassembled in production. The chosen flat pack principles Separate and Foldable have been categorized into a scale of promising assembly types for the dispenser. The assembly types are shown in Figure 17, where each picture represents a general main body for a dispenser with opening in one direction. The seven assembly types range from totally separate to completely foldable solutions. Assembly type 3 and 4 are hybrid solutions that are a combination of the Separate and Foldable principles where some of the parts are joined and other folded at the assembly. It is important to state that there are several other alternatives to these assembly types that have been left out because they were found less promising.

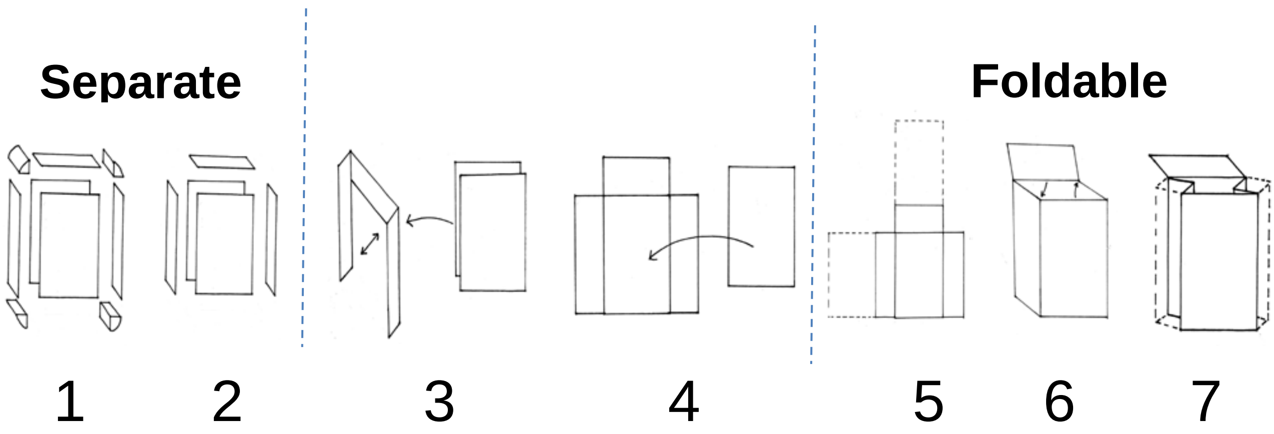


Figure 17: The seven different assembly types.

Assembly type 1 to 5 was found best suitable as the back part needs to be available when the dispenser is being mounted on the wall by the end customer. Assembly type 6 will lead to a design with different folding directions on the parallel comers which can lead to a number of design issues. Assembly type 7 will probably lead to complicated solutions that also have unnecessary split lines either on top or on the sides.

5.4 Concept generation

In the generation of concepts different ideas were created during brainstorming sessions based on the information from the pre study. An idea generating workshop meeting was also held on SCA with other master thesis students. The workshop was divided into three parts were the participants received more information in each step. The students were firstly given a very short presentation of the project purpose from what they were to create at least three ideas. At stage two the main requirements were presented and the participants could either use this information to refine their ideas or come up with totally new ones. In the last stage information from the pre-study was presented to show possible solutions and our way of categorizing them into flat pack principles. All the created ideas from brainstorming sessions, workshop and others (see sketch examples in Figure 18) were broken down into promising concepts. Solutions that did not fulfill all requirements were continuously removed along the concept generation.

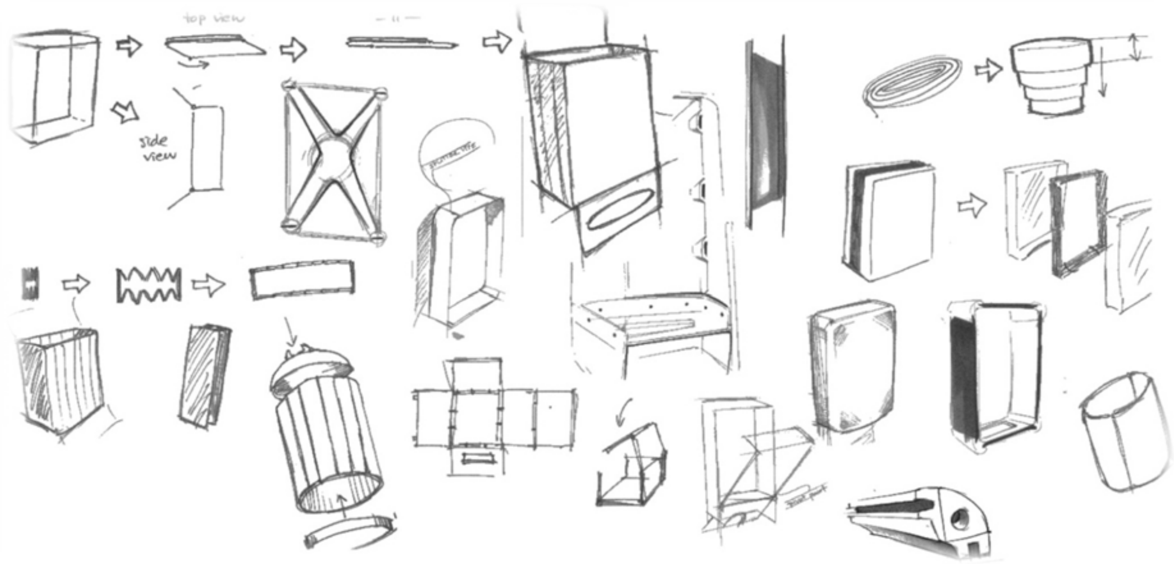


Figure 18: Idea sketches from brainstorming sessions, workshops and others.

As stated in the limitations section the dispenser focused on is the H2 paper towel dispenser. Therefore each concept description are firstly intended for H2 and only rough thoughts for the rest of the series was taken into account at this stage. Lock and interior is the same regardless of concept and hence left out for detailed design, as mentioned earlier.

5.4.1 Generated concepts

As all the concepts are based on the Separate and Foldable flat pack principles it is natural that they will all be of a similar construction and have comparable parts. In order to make it easier for the reader a simple picture of a H2 dispenser with all included parts can be seen in Figure 19. The parts are called Front, Back, Right side, Left side and Top. Whenever H2 dispenser parts are mentioned later in the report it will always refer to this structure. The H2 also has one interior part called Shelf which holds and dispenses the paper.

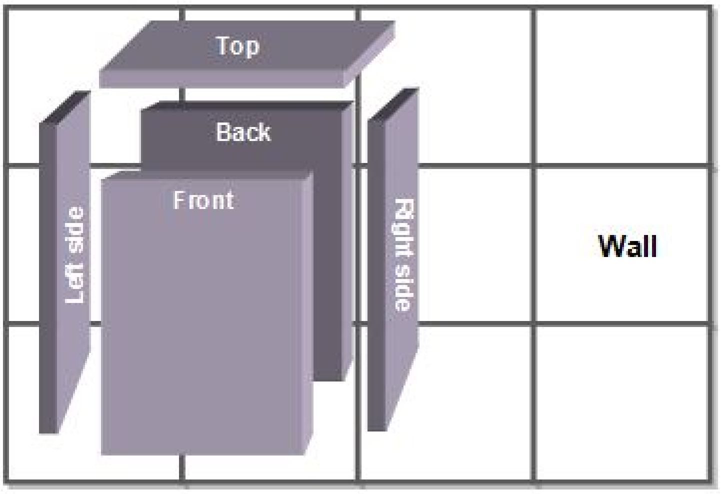


Figure 19: Names used for the dispenser parts.

Six complete concepts were generated to visualize and combine the large number of ideas generated. Initially each concept was based on the most promising assembly types, and thereafter suitable features were added to give each concept an identity. The different features are stated in a morphological matrix, see Table 2 below. Instead of favoring any concept, ideas were spread out more fairly between them.

Table 2: Morphological matrix

Assembly type	Type 1	Type 2	Type 3	Type 4	Type 5	
Material 1	Wood	Metal	High Quality Plastic	Low Quality Plastic	Rubber	Glass
Material 2	Wood	Metal	High Quality Plastic	Low Quality Plastic	Rubber	Glass
Material 3	Wood	Metal	High Quality Plastic	Low Quality Plastic	Rubber	Glass
Fastening type	Snap joint	Slide inn	Puzzle joint	None		
Foldable type	Piano	Living	None			
Opening type	Rotating	Drawer	Pivot hinge	Butt/Mortise hinge	Piano hinge	
Concept	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5	Concept 6

The chosen features are not to be seen as final and can be changed later in the process. The options are though put together to make a good combination and are sometimes even dependent of each other in order to work well. The material choices are in this stage only made as proposals. Below each concept is described in detail.

Concept 1 – Spillikin

The concept idea was inspired by a rather common way of assembling furniture where the corners hold the assembly together (see Figure 20). The design is based on assembly type 1 where extruded aluminum corners are joining the wooden sides and top together. The sides and the top slides into the corners and at the end customer assembly. They are then secured by screws and the shelf is also mounted with screws. The front in glass is mounted to one of the corners with a rotating hinge. The materials used, wood and glass, are naturally flat materials. Wood, glass and aluminum are commonly used in Nordic design which emphasizes the Tork brand origin and the wood also gives a connection back to the source of paper. A list of the most important flat packing features of the concept can be seen in the list below.

- Assembly type 1, with separate extruded corners holding the assembly together
- Sides and top slides into corners, parts screwed together
- Front held by rotating hinge

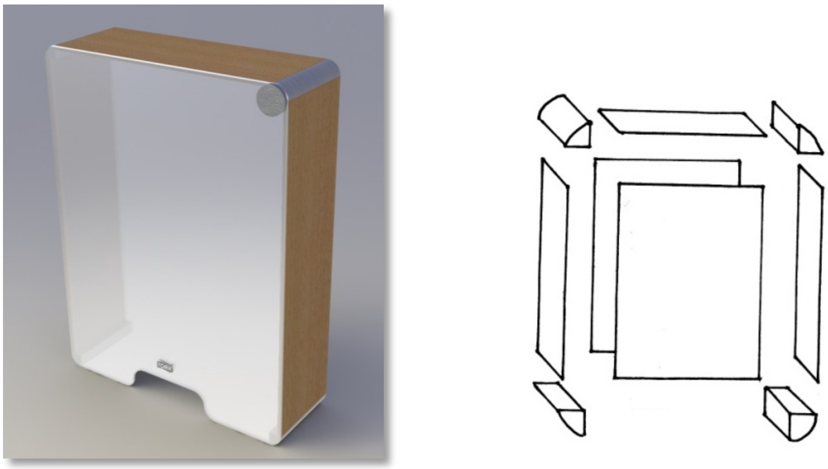


Figure 20: Rendering and assembly type of the Spillikin concept.

Concept 2 – iBox

The design of this concept, see Figure 21, was inspired of modern bathroom and kitchen appliances. Sides and top are made in brushed extruded aluminum and they are slid into each other at assembly. The back and front are made in sheet plastic where the back is slid in from the bottom. The front is held by the shelf which then works like a drawer. The design gives a modern look where all the main parts are made of extruded and sheet material parts. A list of the most important flat packing features of the concept can be seen in the list below.

- Assembly type 2
- Extruded sides slid into each other, and back slid in from bottom
- Front opens like a drawer

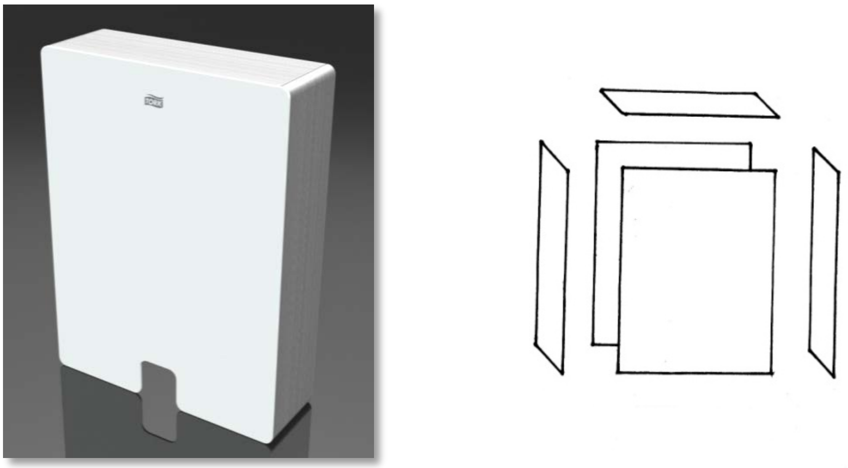


Figure 21: Rendering and assembly type of iBox concept.

Concept 3 – Stealth

Figure 22 shows a concept that was created with the goal of making a flat packable design that would appear thinner and be more eagerly shaped. The design is based on assembly type 2 and all parts are made of plastic and will be joined by snap joints. The sides and top are slightly angled from the wall to make thinner appearance. This also gives the design a less box like appearance without using round, bulky parts. The fact that the front is covering all sides together with the angled sides makes the design very smooth and almost no split lines will be visible. The split lines between the sides and the top will be placed on the topside which gives the dispenser very clean sides. A list of the most important flat packing features of the concept can be seen below.

- Assembly type 2, with angled sides and top to make a thinner appearance
- Parts joined by snap joints
- Front opens sideways, with “horse head” hinges

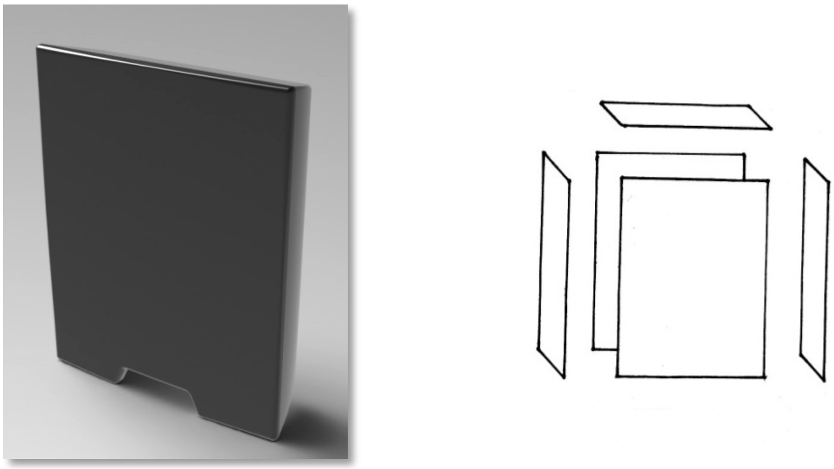


Figure 22: Rendering and assembly type of the Stealth concept.

Concept 4 – Bumper

The design of “Bumper”, see Figure 23, was inspired from a mobile phone protection casing. The Sides, top and open bottom are made of plastic and joined by rubber in the corners which allows the construction to be folded together. This part should be produced as one using multiple injection molding. The front is inserted from rear and the shelf snapped into place. The whole dispenser is opened forward, connected with pivot hinges to the back part. The design uses the folding parts as design features giving it a unique look. A list of the most important flat packing features of the concept can be seen in the list below.

- Assembly type 3
- Sides and top joined by soft corners enabling folding
- Front inserted from backside, whole dispenser opens forward

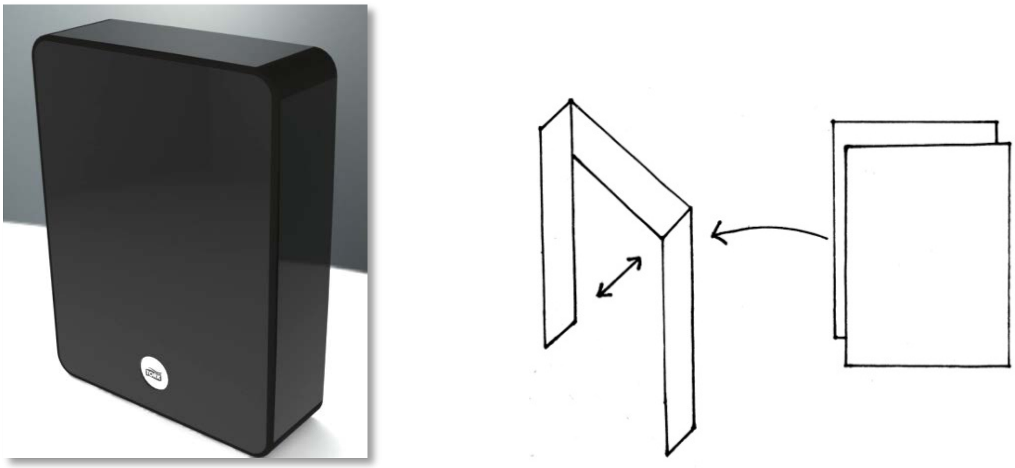


Figure 23: Rendering and assembly type of Bumper concept.

Concept 5 – Barbie

This concept's design reminds somewhat of a bathroom cabinet with a large glass front held by visible hinges, see Figure 24. A bathroom cabinet is often rectangular and flat packed which makes it a natural option for a flat packed design. The back, sides and top are made as one part in polypropylene joined by living hinges. The sides and top are folded and snapped together at the end customer assembly. The shelf is then also snapped into place. The front is mounted with two stainless steel butt hinges which open sideways. Overall the design is meant to have simple box shaped container part and a fancier front which is most visible part to the end user. A list of the most important flat packing features of the concept can be seen in the list below.

- Assembly type 4
- Sides, top and shelf folded from back (living hinges) and snapped together
- Front opens sideways, with visible butt hinges

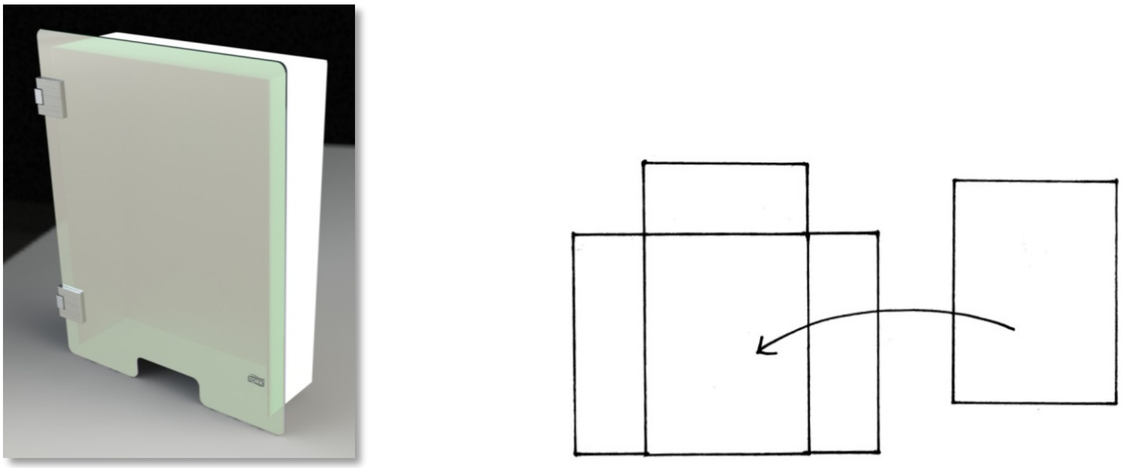


Figure 24: Rendering and assembly type of Barbie concept.

Concept 6 – Mailbox

This concept (see Figure 25) is sent to the end customer as only one unit but is produced in several simpler plastic parts. All the parts are joined with integrated hinges which are folded from the back and snapped together at the end customer assembly. The front is attached to the shelf with integrated hinge which allows it to be folded forward. The hinge is placed on a calculated distance from the bottom in order to open the wanted distance before it hits the wall. This means that the front hinge works both as a folding feature and opening mechanism. The design can be made slim and it has a simple look that does not stand out.

- Assembly type 5
- Sides, top, shelf and front folded up (integrated hinges) and snapped together
- Front opens forward with piano hinges

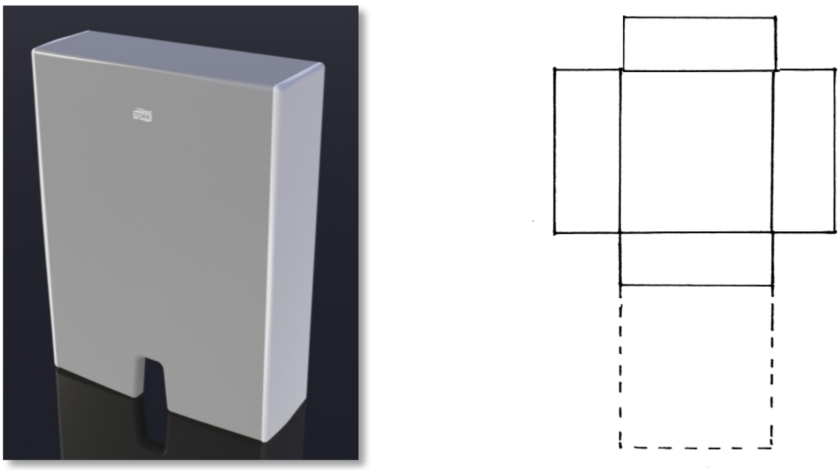


Figure 25: Rendering and assembly type of Mailbox concept.

5.5 Concept evaluation 1

In the first concept evaluation a screening process and further development of the concepts will be presented. In this process the six concepts presented above were to be funneled down to three promising concepts.

5.5.1 Concept screening

Quantitative and qualitative methods were used, represented by a Pugh matrix and a focus group meeting respectively, and both results were taken into consideration before eliminating any concept. Before continuing with the next step of the selection process, all concepts' features were studied in detail to ensure that no good ideas were left behind. These ideas could be useful in the continuous development and improvement of remaining concepts which also played an important role in the selection phase.

Pugh matrix

The quantitative judgment was performed using a Pugh elimination matrix. The six evaluated concepts are presented in Table 3 were concept 3 was randomly selected as reference concept.

Table 3: The concepts

Concepts	Name
Concept 1	Spillikin
Concept 2	iBox
Concept 3 (Ref.)	Stealth
Concept 4	Bumper
Concept 5	Barbie
Concept 6	Mailbox

Eight important criteria's were created based on the requirement specification, presented in Table 4.

Table 4: Elimination criteria used in the Pugh matrix

Criteria	Name	Description
Criteria 1	Package	Size of package
Criteria 2	Cost	Manufacturing method, materials, opening mechanism
Criteria 3	Assemblability	Assembly time: Number of parts, fool-proof, tools, wall mounting
Criteria 4	Functional	Refilling/emptying
Criteria 5	Hygienic	Easy cleaned surfaces, tight design
Criteria 6	Aesthetics	Shape, materials, split lines, Tork
Criteria 7	Compatibility	Compatibility with the complete dispenser series
Criteria 8	Robustness	Stability and durability

In Table 5 one can see the complete elimination matrix and how the different concept scored in comparison to the reference concept. Also note that the weight was set to one for all criteria's which means that they all have the same influence on the end result.

Table 5: The Pugh elimination matrix

Pugh Elimination Matrix							
Criteria	**Weight**	**Reference**	**Concept 1**	**Concept 2**	**Concept 4**	**Concept 5**	**Concept 6**
Criteria 1	1	Reference	-	0	-	+	0
Criteria 2	1		-	-	-	0	0
Criteria 3	1		-	0	+	+	+
Criteria 4	1		0	-	-	0	-
Criteria 5	1		-	0	+	-	0
Criteria 6	1		+	0	0	0	-
Criteria 7	1		-	-	-	-	0
Criteria 8	1		+	+	-	0	0
Total			-3	-2	-3	0	-1
Ranking		1	5	4	5	1	3
Continue with concept		**Yes**	No	No	No	**Yes**	**Yes**

Concept 3, 5, and 6 scored highest in the Pugh elimination matrix with Stealth and Barbie on shared first place and mailbox on second. As one can see in Table 5 the score was quite even for the remaining three concepts.

Qualitative method

A qualitative judgment of the concepts was performed trough a focus meeting with industrial and mechanical engineers from Dacat. A set of pros and cons were listed for the different concepts. Several of the concepts were found interesting however less feasible. For example Bumper was found to be highly innovative but as the rubber corners are to be folded in different directions it will be complicated to store without having to deal with aesthetical issues. The design of Spillikin was found promising although considered having to expansive materials based on the cost requirement. IBox was also found to expensive and hard to produce, as the extruded parts are very wide. Without any previous information from the quantitative result Stealth, Barbie and Mailbox were found most promising. Some minor issues were found also regarding these concepts that will be further explained in section 5.5.2.

Result

The result from concept evaluation 1 was clearly that Stealth, Barbie and Mailbox were found most suitable, as the qualitative result was precisely in line with Pugh matrix result.

5.5.2 Evaluation and Further development of concepts

In this section the selected concepts are presented with the modifications that were done in the further development process. More information about each concept will be presented in section 5.6.1, regarding package size, end customer assembly, cost etcetera.

The main ideas of Stealth with the sides and top angled from the wall, and the rather round shapes was decided to be kept. The end customer assembly for the concept was though slightly changed from assembly type 2 into a hybrid solution, were all parts are separate except the sides that now fold up from the back. This resulted in a much easier assembly as it will become more intuitive and have less loose parts. In Figure 26 below one can see a conceptual drawing of Stealth made by a design engineer. The drawing also shows a possible indicator window for the concept.

The Barbie concept was decided to keep its large front that covers sides and top. The material choice of the front was changed from glass to sheet plastic material to lower the weight. The rest of the dispenser is made of plastic, and withstanding the weight of a glass front would be troublesome. A glass front would have weighted approximately 1.4 kg. The assembly of the concept was also changed with inspiration from the Spillikin concept to make the construction more rigid. This means that the assembly still has one part of plastic for the back, sides and top, but with corners that holds the folded parts together and hides corner split lines. A conceptual drawing of the concept can be seen in Figure 26 below. The drawing also shows some examples on how the aesthetics of the dispenser can be altered. Here an asymmetric design with visible hinges is presented. The wave shaped cut out was found especially interesting as it gives the flat large surface an interesting expression.

The compactness of Mailbox was considered one of the most important features for this concept. The concept had one major drawback with highly visible split lines on the front, which made the construction very sensitive to small variations. Therefore the front was made larger above the hinges in order to cover the sides. This allows the concept to have the same opening with the front folding forward. Figure 26 shows a conceptual drawing of the concept with an example indicator window. The hinges have also been made visible which is another option for this design.

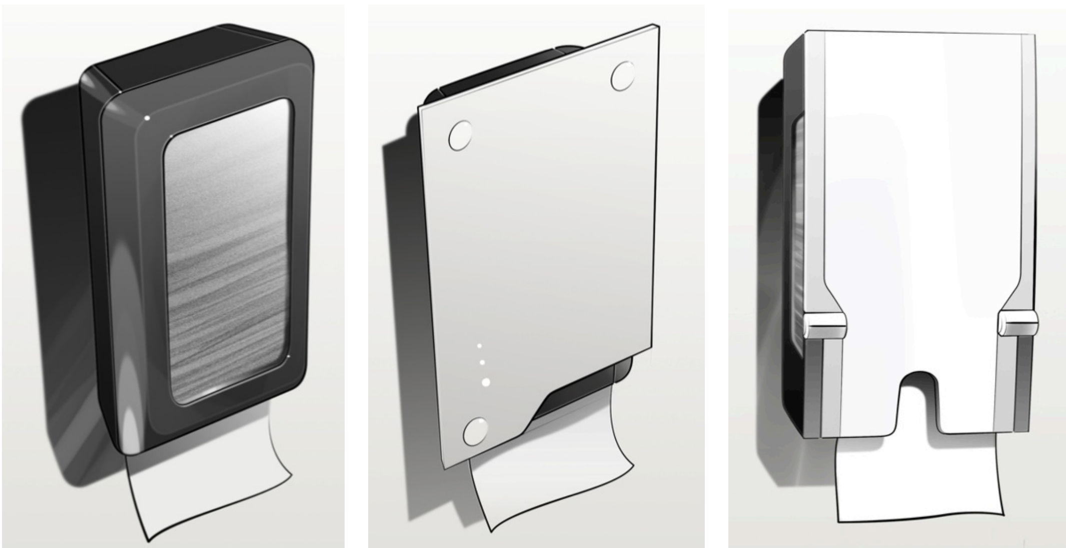


Figure 26: Conceptual drawing of Stealth (left), Barbie (middle) and Mailbox (right).

5.6 Concept evaluation 2

With only three remaining concepts, the second evaluation could be carried out more thoroughly. A Kesselring scoring matrix was performed based on a number of criteria in which the concepts were tested. The scoring matrix results together with qualitative judgments were taken into consideration before selecting a final concept.

To better visualize the three concepts, physical full scale models of them were built out of foam board, see Figure 27. Appendix E. Foam board models, shows additional pictures of the models. Functionality of the dispenser concepts had to be evaluated before the final selection, requiring the models to have a functioning opening mechanism and like the H2 Elevation fit the hand towel bundles. Having aesthetics as another important criterion, a lot of effort was put in to making the model correspond to the actual concept idea and its features. Therefore factors like roundness, robustness etcetera was created in the best way possible.

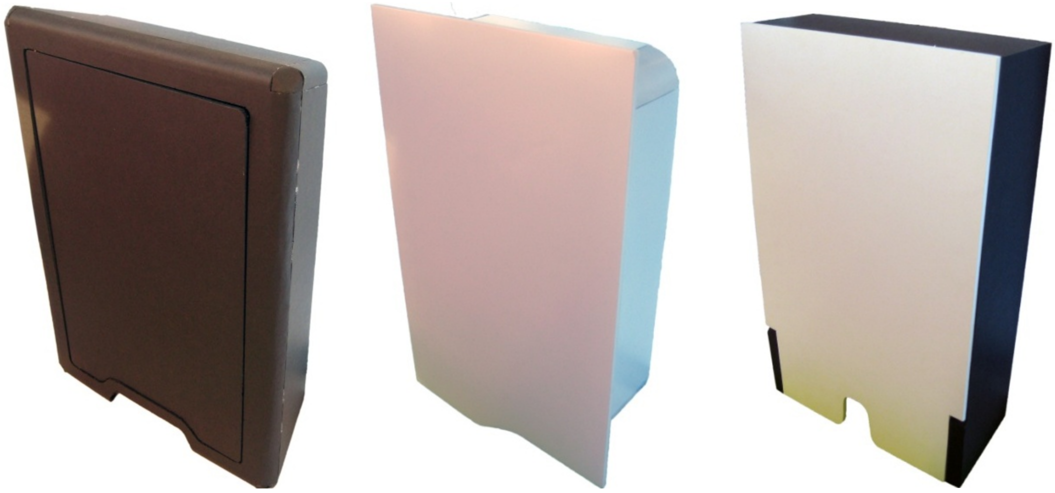


Figure 27: Foam board models of Stealth, Barbie and Mailbox. Here Stealth had an alternative design, with a stabilizing front frame and door split in front. However, this design was soon remodeled since that kind of solution increases the number of parts and gives a visible dirt trap in front.

5.6.1 Evaluation criteria

The three remaining concepts had to be evaluated in more detail to ensure validity of the final concept scoring process. This was done by applying measuring methods to the different evaluation criteria from the previous chapter. Robustness was among the criteria in earlier stages, but it was excluded from the Kesselring scoring matrix presented in next chapter. The reason was that all three concepts were considered to be possible to make robust enough in detailed design, through structural support and individual design solutions. The robustness would also be difficult to evaluate, without advanced Finite Element Method (FEM) calculations. The seven remaining criteria together with selected measuring methods are presented below. The concepts' score (ranging between 1 and 7) from each stage was transferred to the final scoring matrix.

Package size – Dimensioning and calculations

Same part dimensions used when building the foam board models were now reused to calculate total dimensions of the dispensers in a packed state. Concept parts were virtually packed in an efficient way to get the smallest package possible, see Figure 28. More explanatory figures are presented in Appendix F. Concept assembly.

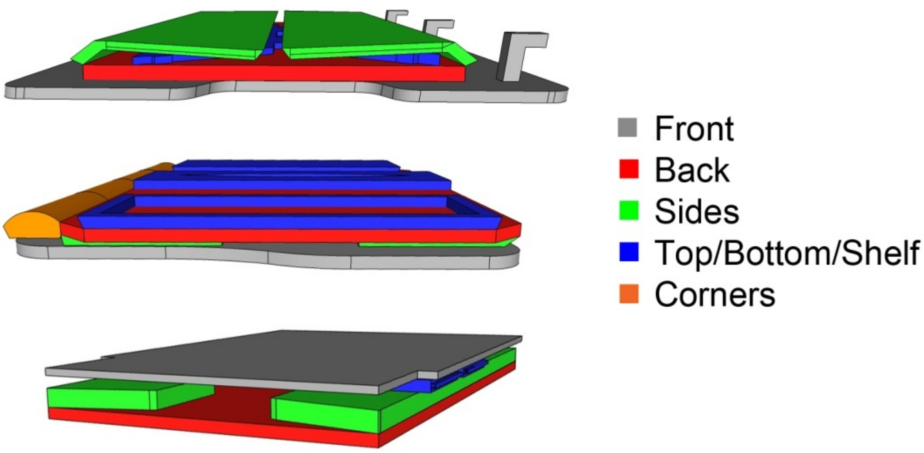


Figure 28: Stealth (top), Barbie (middle) and Mailbox (bottom) in packed state.

Each package finally ended up with four layers, represented by front, back, top and shelf, and sides. For the Barbie concept, additional parts as bottom and corners could be efficiently packed in empty spaces without adding any package volume. The score is based on total package volume, see Table 6.

Table 6: Result from the package size estimation.

PACKAGE SIZE	Height (mm)	Width (mm)	Depth (mm)	Volume (dm^3)	Score
Stealth	420	285	40	4.8	**4**
Barbie	430	275	32	3.8	**6**
Mailbox	420	255	40	4.3	**5**

Cost – Manufacturing cost estimation tool

The manufacturing cost for the concepts with its varying number of parts, size, and surface finish etcetera was evaluated by using an online tool for cost estimation of injection molded parts. The tool let the user enter approximations of the part's size, material volume, complexity and so forth, before presenting an estimation of its manufacturing cost. (Custompartnet, 2011)

The estimation tool's validity was tested by first entering H2 Elevation's manufacturing data and then comparing the result with the known costs of the product today, i.e. cost of manufacturing at SCA's own production plant. As expected, the results did not coincide, which led to the decision of only using the tool for a comparison between the three concepts.

Table 7 shows the cost for each part of the concepts. A higher Total means a more costly product, and one can see that none managed to get lower than the total cost of H2 Elevation. A table of the input data and the detailed result, presenting material, production and tooling costs separately, is shown in Appendix G. Concept cost scoring.

Table 7: Assembly costs for the parts of Elevation and each concept.

H2 Elevation			
Front upper	Front lower	Back	**Total**
3,2	2,0	4,8	**10,0**

Stealth							
Side R	Side L	Top	Front	Back	Shelf	**Total**	**Score**
1,4	1,4	1,1	3,5	2,6	1,0	**11,2**	**3**

Barbie					
Box	4xCorners	Front	Shelf	**Total**	**Score**
4,9	1,2	2,9	1,0	**10,0**	**5**

Mailbox						
Side L	Top	Front	Back	Shelf	**Total**	**Score**
1,6	1,1	2,8	2,7	0,93	**10,8**	**4**

Assemblability – Methods-Time-Measuring

Assemblability comparison between the concepts was performed using a simplified version of MTM (Methods-time-measuring). Activities as grip, fold, snap, slide and mount used when mounting the dispensers, were separated into steps representing a short time interval. A mounting sequence for each dispenser was defined (see Figure 29) and all mounting steps were added to get a total assembly time which the concept score was based on. Stealth's assembly process was divided into the following steps; Fold up the pre-mounted sides, snap in top and shelf, and mount the door. With separate corners, the Barbie concept had a couple more moves. First top and bottom are folded up, followed by both sides. The box is then strengthened by the four slide-in corners. Thereafter the shelf is put in place, before the final step of mounting the door takes place. Mailbox is assembled by folding up the sides, snapping the top in place and finally mounting the door, which the shelf is pre-attached to.

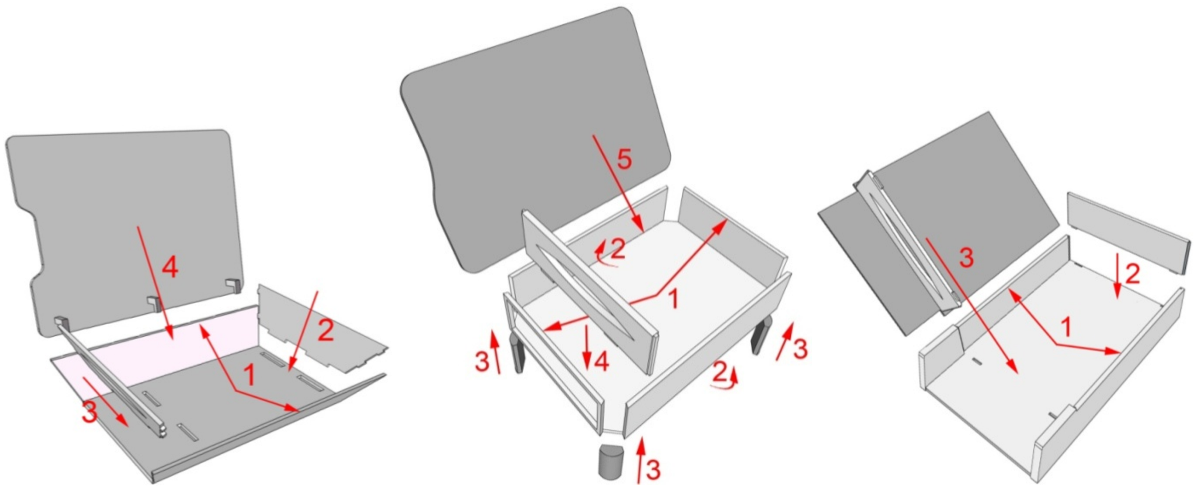


Figure 29: Mounting sequences for the three concepts, from left to right: Stealth, Barbie and Mailbox.

Table 8 shows that Mailbox has the most efficient assembly sequence, according to the simple method used. However, mounting of the door-shelf combination can be troublesome. Stealth placed second and Barbie got the longest mounting time, much because of the separate corners.

Table 8: Result from the assemblability comparison.

ASSEMBLABILITY	Grip (3)	Fold (1)	Snap/slide (4)	Mount (6)	Total (points*value):	Score
Stealth	3	2	2	1	25	**4**
Barbie	6	4	5	1	48	**2**
Mailbox	2	3	1	1	19	**5**

Functional – Physical opening and refilling test

A functional test focused on opening mechanism and accessibility when refilling hand towels was carried out. There are of course other functions that has to be fulfilled and that are even more important to test, e.g. to dispense hand towels, but such function was considered to be a basic requirement and therefore similar between and fulfilled by all concepts. The Opening function test included unlocking and opening of the dispenser door, which are affected by location of the lock and opening mechanism respectively. Refilling was tested by simply putting a hand towel bundle into the dispenser. The foam board models were used as test objects, placed on normal installation height for hand towel dispensers. Since people of different height could perceive the dispensers' functionality differently, the test was performed by two persons, one shorter (Test person 1=165cm) and one taller (Test person 2=187cm), who then rated the dispenser functions between 1 and 7. Table 9 shows that Stealth and Barbie got high score in this test, with good result in both opening and refilling.

Table 9: Functionality test result

FUNCTIONALITY	Opening (TP1+TP2)/2:	Refilling (TP1+TP2)/2:	Total:	Score
Stealth	(5+6)/2=5,5	(6+6)/2=6	5,75	**6**
Barbie	(4+5)/2=4,5	(7+7)/2=7	5,75	**6**
Mailbox	(3+5)/2=4	(3+5)/2=4	4	**4**

Hygienic – Dirt trap evaluation & physical wiping test

In the hygienic design test, two factors were taken into consideration; dirt traps and cleaning easiness of the dispensers. The first was judged by the number of split lines and other dirt traps, while the second category was determined through a physical test. The same test persons doing the functionality test now wiped the foam board dispensers with a cloth in a cleaning easiness test where the accessibility played a major part. The highest total score was assigned to Stealth, with its round shapes and rather few inaccessible areas. Results from both tests are presented in Table 10 below.

Table 10: Result from the hygienic design evaluation.

HYGIENIC DESIGN	Wiping (TP1+TP2)/2:	Dirt traps:	Total:	Score
Stealth	(5+6)/2=5,5	6	5,75	**6**
Barbie	(4+4)/2=4	4	4	**4**
Mailbox	(6+5)/2=5,5	4	4,75	**5**

Aesthetics – Survey

After asking people at SCA which dispenser design they prefer, one could see that opinions about aesthetics often are very individual, and can vary depending on the respondent's age, sex, culture etcetera. Therefore, to get a useful result and a fair judgment of the remaining concepts, the desire was to collect opinions from a large number of people. Since there is a global market for this kind of products, it was also preferable to ask people from different parts of the world. A survey was sent out to three different local SCA offices. Each office published the survey on their local intranet page, making it accessible to employees at their site. The respond frequency was as follows: Shanghai - 14, USA - 115 and Germany - 45 respondents.

The survey was made short, taking only a few minutes to complete, to maintain focus and mood of the respondents throughout all questions. Most of the questions let the respondent select between two concepts or designs and instinctively mark the one they preferred. Table 11 shows the survey result, with Stealth and Barbie as preeminent winners in most categories. The score is based on number of wins in each category. In the "White concepts" and "Black concepts" categories, renderings of the dispensers in white and black plastic respectively, were compared to each other. Under "Competitors" they were compared with existing competitor products, and in the "Tork" category the concepts' suitability into Tork's portfolio were evaluated. The complete survey and its result are presented in Appendix H. Aesthetics survey. The survey also included detailed questions about each concept's individual design, but this information was used in a later stage.

Table 11: Number of wins in each survey category and the concepts' total score.

AESTHETICS	White concepts	Black concepts	Competitors	Tork	Total	Score
Stealth	3	2	2	2	9	6
Barbie	3	3	3	1	10	6
Mailbox	0	0	0	1	1	2

Compatibility – Assessment

Concept compatibility, i.e. the possibility to apply the design to the whole dispenser series, was evaluated based on concept ideas and sketches. The concepts were also compared with existing soap dispensers, toilet paper dispensers and waste bins, to find benefits and drawbacks with the different designs. Their individual judgment and overall score was as follows.

Stealth (Score: **6**)

\+ Uniform expression of series

- + Relatively round shape possible
- + Partly hidden split lines
- + Space for hidden hinges and lock
- – Front larger than necessary

Barbie (Score: **4**)

- + Uniform expression of series
- + Flat front – works as natural opening & hides hinge
- – Less suitable for S1 and B1 (bulky appearance)
- – Front larger than necessary

Mailbox (Score: **2**)

- + Slim series
- – High demands on visible split lines
- – Product expression and door opening are coupled

5.6.2 Concept scoring

The scores from the preceding tests were collected and inserted in a Kesselring scoring matrix. Its result was combined with a qualitative judgment in order to select a final concept.

Kesselring matrix

Table 12 shows the seven criteria used for evaluating the concepts. Weights were added to each evaluation criteria to give the most important factors the highest influence, see Table 13. Package size, cost and compatibility, given weight 5, were considered most important. Assemblability and aesthetics got weight 4, while the functionality and hygienic criteria were given weight 3.

Table 12: Evaluation criteria for the Kesselring scoring matrix.

Criteria	Type	Description	Measurement
Criteria 1	Package	Size of package	Calculations
Criteria 2	Cost	Manufacturing method and materials	Cost estimation tool
Criteria 3	Assemblability	Mounting sequences	Mounting sequencing
Criteria 4	Functionality	Refilling/Emptying	Physical test
Criteria 5	Hygienic	Easy cleaned surfaces, tight design	Physical test
Criteria 6	Aesthetics	Product expression	Survey
Criteria 7	Compatibility	Compatibility with complete dispenser series	Concept ideas/sketch evaluation

Scores in all criteria were added when calculating the total score, which the ranking was based on. The bottom row of the scoring matrix in Table 13 also shows each concept’s percentage of an ideal solution. The scoring matrix announces Stealth as the best concept.

Table 13: Kesselring scoring matrix.

Kesselring Scoring Matrix									
	Weight	Ideal		Stealth		Barbie		Mailbox	
Criteria 1	5	7	*35*	4	*20*	6	*30*	5	*25*
Criteria 2	5	7	*35*	3	*15*	5	*25*	4	*20*
Criteria 3	4	7	*28*	4	*16*	2	*8*	5	*20*
Criteria 4	3	7	*21*	6	*18*	6	*18*	4	*12*
Criteria 5	3	7	*21*	6	*18*	4	*12*	5	*15*
Criteria 6	4	7	*28*	6	*24*	6	*24*	2	*8*
Criteria 7	5	7	*35*	6	*30*	4	*20*	2	*10*
Total:		49	*203*	35	*141*	33	*137*	27	*110*
Ranking					**1**		**2**		**3**
% of ideal				71,43	***69,46***	67,35	***67,49***	55,10	***54,19***

Qualitative judgment

Both Stealth and Barbie have scored high during the process, and so did they in the final screening matrix. Stealth may not be the most exiting alternative when compared to existing dispensers, which of course is arguable. But by being the neutral concept, one can show how the flat packing principles can be applied without changing the appearance to any great extent, e.g. not completely flat parts as in the Barbie concept. Below is a pros and cons list for the Stealth concept. The general judgment is that the advantages outweigh the disadvantages.

+ Possibility to show "round" flat pack concept
+ Robustness – no splits in corners and curved surfaces
+ Partly hidden split lines, on top and around front
+ Part in part possibilities
+ Suitable for Tork's portfolio
– Less suitable for different materials
– Large space-consuming front

Result

The Kesselring matrix, including all test results, and the judgment stated above together designates Stealth as winner. It is therefore selected as final concept, for further development, detailed design and prototype manufacturing.

5.6.3 Evaluation and further development of final concept

Before setting the final parameters for the concept a few changes and improvements were made. Not yet implemented in the concept design was a level indicator window. A number of designs were evaluated, before a vertical elongated window was selected and implemented. Elongated non-symmetrical designs were namely popular according to the survey mentioned earlier, where the respondents also answered questions about level indicator designs, see Appendix H. Aesthetics survey.

Even though Stealth was the winning concept, it did not score highest in the aspect of cost and package size, which were two of the most important criteria for this project. Hence, a list of actions was set to improve these parameters. A slight reduction in size means a smaller package, but also less material. The depth of the front was increased to get a more rigid design, with less need of space demanding stiffening ribs. This helped, in combination with a number of other actions, to slim down the total thickness of each part layer. A further description of the final concepts and their features is presented in the detailed design chapter below, section 6.

From the cost estimation one could see that all concepts had difficulties competing with the price of today's Elevation. Besides the improvements stated above, solutions of how to cut down on other expenses were suggested, e.g. cheaper versions of the lock and screw kit. These proposals are presented more thoroughly in section 8.2.

6 Detailed design

Detailed design of the final concept, including all four items in the dispenser series but with focus on H2, is covered by this chapter. Moreover, at the end the potential size reduction of each dispenser is presented. This phase started with a great number of unknown parameters, regarding size, shape and features. However, the product the dispenser is intended to house, e.g. paper or soap, is fix and therefore it was used as base when designing the dispenser parts. This gives a minimum size requirement, but one could still choose to design a dispenser larger than necessary. A large product would on the other hand inflict with the main purpose of the project; making shipping more effective by reducing dispensers' cargo space. Though making a product as small as possible is not always the best solution, they have to be efficiently packed on pallets and in containers. The final size of H2 was partly adjusted to maximize the number of units on a pallet. This is further described in section 8.2.

One can also see that the part designs are coupled in a number of ways. The design was internally coupled, i.e. each dispenser part is dependent on other parts, as they together form a total product. On top of this, the dependencies doubles since the dispenser has both a packed and an assembled state. The part fit was most important for the assembled product, where a rigid design was desired. However, in packed state there had to be good part-in-part fit to get the slimmest and most optimized package possible. This finally gave the most complex relations and proved to be the principal factor influencing the detailed part design.

Design for manufacturing and assembly

Since the dispensers are assembled by the end customer, the assembly process had to be intuitive and uncomplicated, fulfilling the requirement of not having to read an assembly instruction. Simple fold and snap solutions were developed, and parts were designed to make the assembly fool-proof, i.e. only possible to put together in on one way. Virtual assembly tests were performed to avoid clash between parts. The assembly process for each dispenser type is described in more detail later.

A lot of effort was also put into making parts and their features ready for production. All plastic parts were intended to be injection molded, so initially a suitable tooling direction was set. Then the following rules were applied as far as possible for each part:

- Avoid undercuts to minimize the number of side-cores, i.e. additional mold pieces.
- Constant material thickness on every main surface to prevent cavities and other defects. Thicker features would also increase the maximum cooling time.
- Minimum 1 degree draft angle, reducing friction between part and tool.
- Avoid sharp corners by a 0,3mm general fillet radius.
- No all-flat outer surfaces, since defects would be more noticeable. Curvature also helps strengthen the part.
- Thickness of ribs: About 75% of the main surface's thickness, minimizing the risk for sink marks.
- Ribs and other features in line with each other, letting plastic flow easier in the injection molding process.

6.1 H2 dispenser

The final H2 dispenser concept consists of six plastic parts; back, front with window, left and right side, top and shelf. Figure 30 shows the dispenser in packed and assembled state. Drawings of the packed and assembled dispenser can be found in Appendix I. Drawings. As mentioned earlier the Stealth concept has a design with angled sides. This enables efficient packing with the front holding all the other parts, and when assembled it also gives room beside the paper bundle for door hinges at the left and a lock at the right side. The back piece is the part holding most of the other components together. Both sides are attached to it in production through a hinge solution. Also the lock unit is preassembled on the right side, and to avoid adding extra space when folded down, the lock fits into the dispensing hole of the shelf.

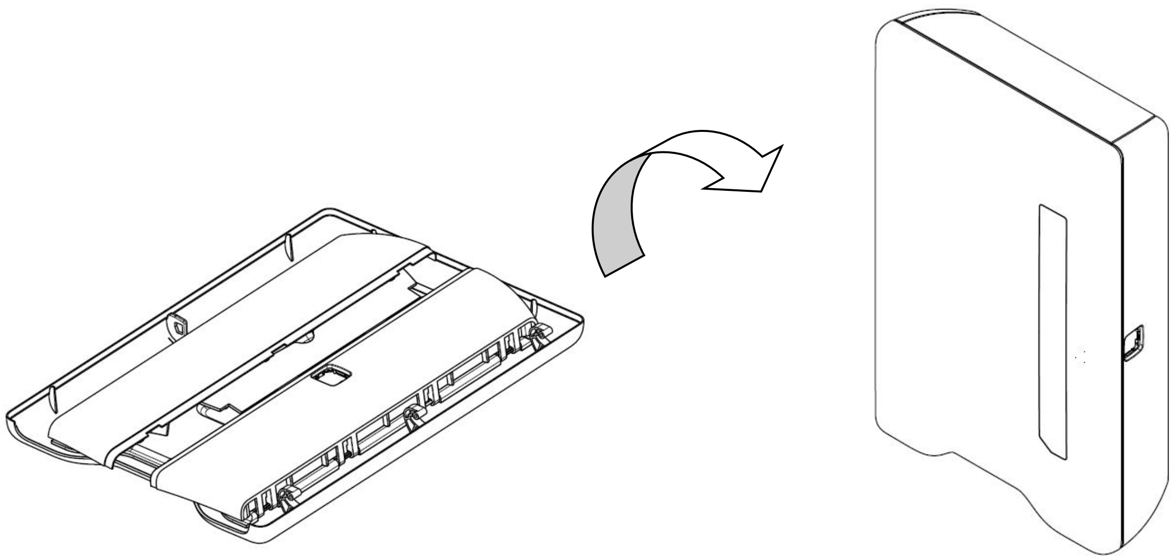


Figure 30: The packed and assembled H2 dispenser.

6.1.1 End customer assembly

The mounting sequence to be performed by the end customer has three main steps; fold up sides, mount shelf and top, and install the door. Top and shelf are hidden under the folded sides, requiring the sides to be folded up as a first step, see Figure 31. A small "Click" tells the customer that the side is in place. By placing top and shelf under the two folded sides the assembly is made fool-proof, preventing parts of being mounted in the wrong order.

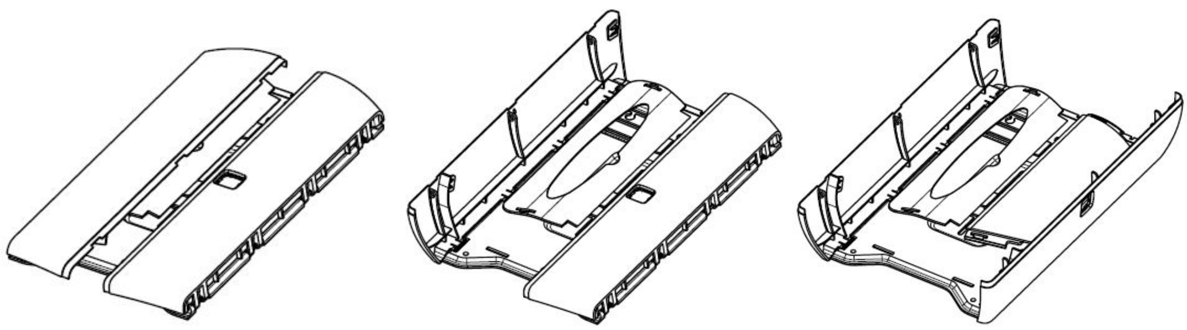


Figure 31: First assembly step; fold up sides.

Next step is to mount top and shelf, which can be done in any order. The top has an edge in rear that is first placed over the back part's upper edge, see Figure 32. Thereafter the front of the part is pushed upwards, towards two snap joints that snap when the part is in place.

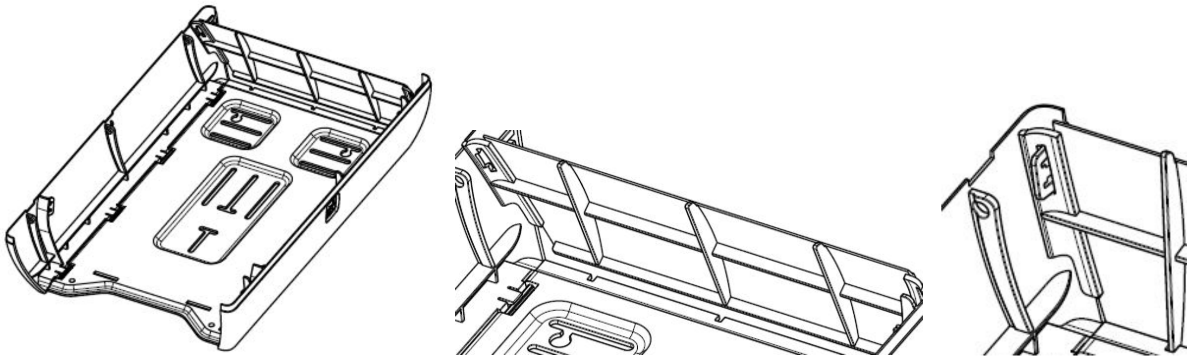


Figure 32: Mounting of the top part.

Similar to the top, the shelf is first connected to the back part before it snaps in place through two snap joints. Here one aims for two holes in the back, see Figure 33, before snapping the part in place.

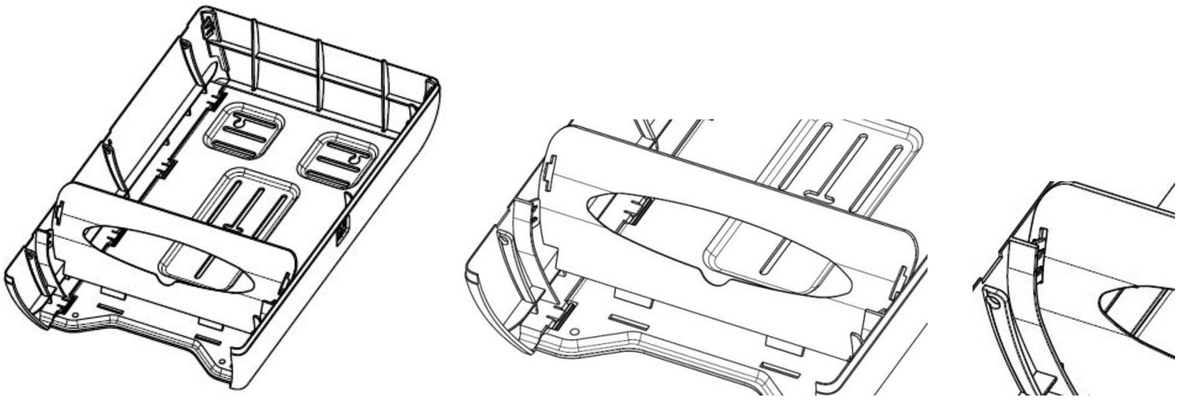
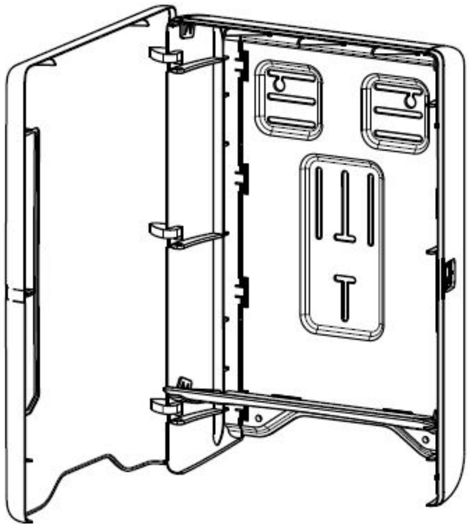


Figure 33: Mounting of shelf.

The final step is to mount the dispenser door, as seen in Figure 34. It can be done instantly, or one could mount the dispenser body on the wall first, before hanging on the door. The later alternative can be advantageous since the dispenser body is easier to handle without the door attached. The door has to be in open state and all three hinge pins must be inserted at the same time.



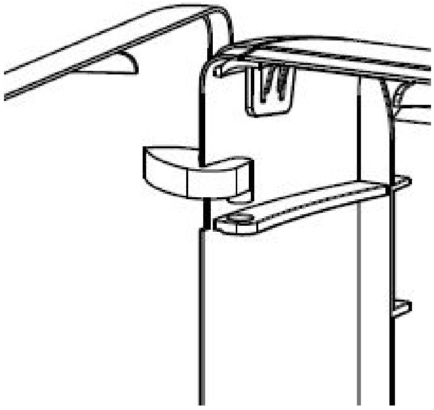


Figure 34: The final assembly step; mounting the door.

6.1.2 The H2 parts

The following is a detailed description of each dispenser part and its features. A few features are made with inspiration from H2 Elevation since it is a well functioning dispenser. All parts are in plastic, for specific plastic types, see section 8.1. The general material thickness is kept at 2,5mm. Drawings of all the parts are presented in Appendix I. Drawings.

Back

The back component (see Figure 35) has a total thickness of only 7 mm. Stiffness is generated by an outer spline and through level difference at top and bottom, and around the hole patterns. The hole pattern is comparable with the holes on H2 Elevation and is therefore suitable for screws used when mounting existing dispensers, i.e. Phillip head, as stated in the requirement specification. The horizontal holes give the option of screwing the dispenser into old holes in washroom walls, which can have varying spacing and height. Extra screw holes were added at the bottom, giving customers the option of having more screws for better stability. There are also two rectangular holes in the lower section where the shelf is attached. The whole design is strengthened by a grid network covering the backside.

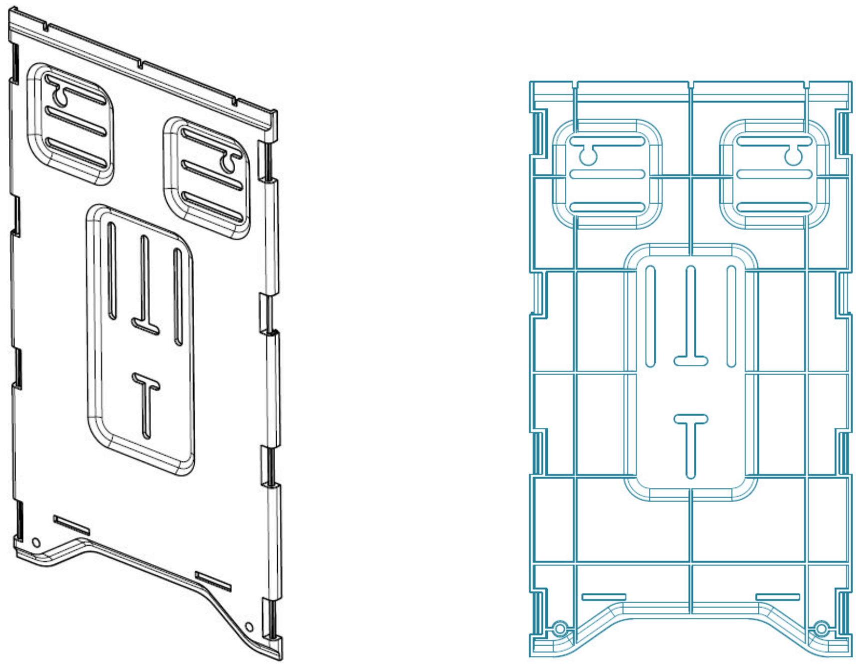


Figure 35: Isometric and rear view of the Back part.

The back has hinge pins at four locations on each side, to which the sides are connected. Three of them has cross-section in form of a cross inside a circle, keeping material thickness at 2,5mm. The fourth has the form of a circle with a small bump, to get a snap function when folding up sides in place. The height of each pin is 25mm, 2mm more than the hinge unit, giving it 1mm spacing over and under. Since there are four hinges, this extra space may compensate for possible variations. A fulcrum is placed at one location to steer the side to its desired location when it folds up. The walls next to the hinge pins have a specific angle, working as a stop for the side when folded up.

A cutout is made at the bottom, which saves unnecessary material, but most importantly it gives the component good fit into the front when packing the parts.

Front

Being the most visible part for the users, the front (see Figure 36) had to be elaborate and have an attractive design. The front surface may look flat at first sight, but it has a small curvature in two directions. The curved edges help strengthen the design and give the dispenser a more round appearance. The bottom cutout gives more space for users when gripping the hand towels and it is also important for the product's expression. All major edges are curvature-continuous to avoid disruption of highlights falling on the product and to get an overall smooth design. Furthermore, the amount of additional features is kept to a minimum, reducing the risk of getting visible sink marks in production.

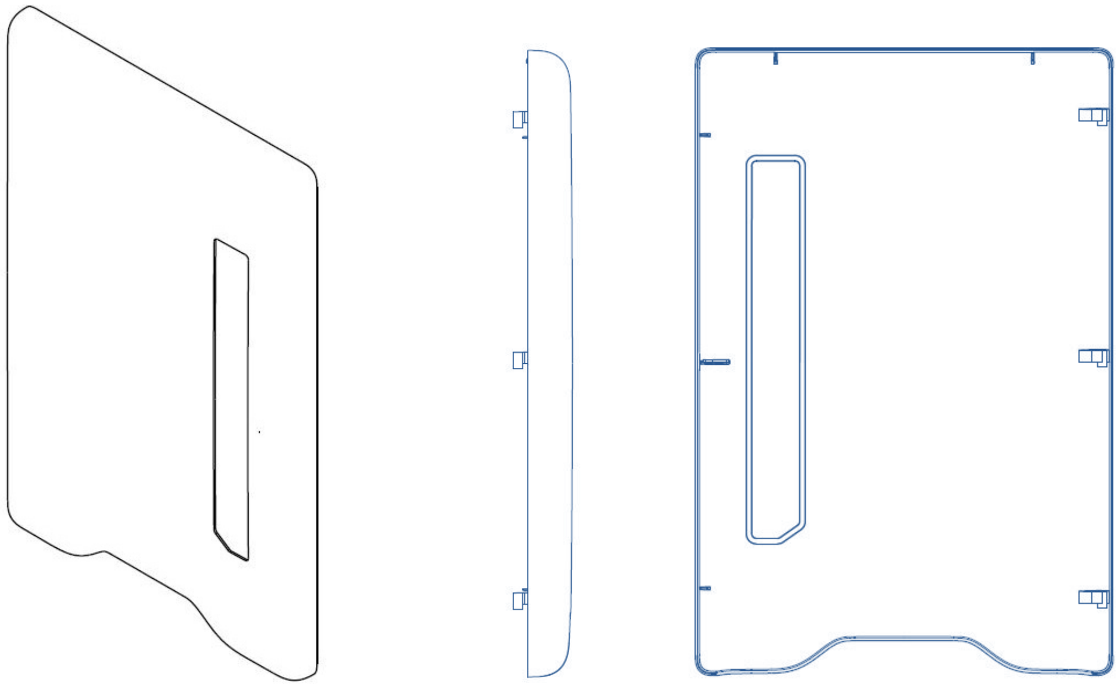


Figure 36: Isometric, side and rear view of the Front part.

Necessary features are however door hinges and steering ribs in top and side. The ribs, two in top and three on the right side, are helpful in a case where a door is hard to close, due to for instance a small skewness. Integrated in the middle rib on the side is the counterpart for the lock. The left side holds three hinges, which have a design inspired by the H2 Elevation hinges. However, the hinges' size and shape are specially adapted to parameters as front height, angle of side, and total package thickness among others. Moreover, the front has a slot in sides and top to make a closed split line to meeting parts.

For the prototype the level indicator window was designed as a separate part, inserted and fastened from the rear. An alternative solution possible in production is presented in section 8.1.

Left side

The left side is a slightly curved part with a number of features integrated on its inside, shown in Figure 37. Upper and lower corners are both curvature-continuous, matching the front's profile. The side's front edge was made thinner to get the desired closed split line to the front part. A 0,25mm outer edge was made in the rear, to lift the back part from the wall, in an attempt to hide small variations of the wall the dispenser is mounted on.

The second main part of the side is the rear section, which strengthens the design and links it to the back part through the four hinge units. Design of these hinges was limited by the total back thickness of 7mm in terms of dimensions and flexibility. Two hooks and a counterpart hold the hinge pin when assembled. Their opening is designed to facilitate joining of the parts. Cutouts are made around the mid part, giving it ability to flex, which also makes the pre-mounting easier. The mid part is also what meets the bump on one of the back's hinge pins, providing the snap function mentioned earlier. Next to the rear section is a longitudinal rib placed in order to meet the paper bundles and hold them in place. A more logic way of placing that rib would be on the back section, but that would not be in line with the tooling direction.

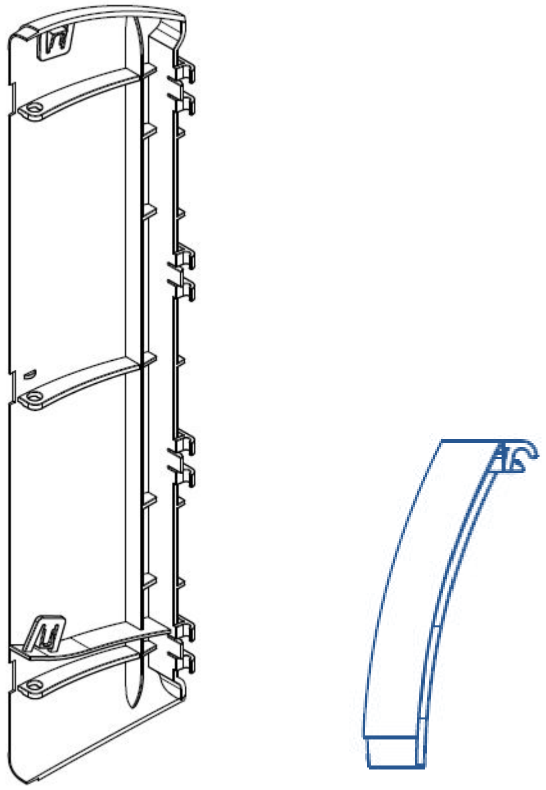


Figure 37: Isometric and top view of Left side.

There are three supports on the side with holes for door hinges. A ditch under the support along the side was made to reduce the risk for sink marks. In height with every hinge support is a cutout in the wall that gives space for the hinges to rotate around. Other important features on the side are two snap joints, one in top and one in the lower section, functioning as fasteners for top and shelf respectively. The chosen snap joint design lets the attached part snap close to the joint's base. This was advantageous in this case, since a more space requiring solution would increase the total thickness of the top or shelf. A desired snapping force was calculated and size and thickness of the snap joint was adjusted thereafter. The lower snap joint is placed on a rib with a profile similar to the shelf, giving it support when mounted.

Right side

The right side (see Figure 38) is symmetry of the left side, except the hinge supports. Additional features are also three steering ribs, two small doorstops and hole for the lock unit. The steering ribs have the same function as those in the front part, and like the hinge supports on the left side they also strengthen the design. Doorstops were added to meet the door in only two points, instead of trying to match two surfaces. They also facilitate in production if the door fit is unsatisfactory, by only having to make adjustments at two positions. The lock hole has the exact same geometry as in the Elevation dispensers, allowing use of the existing lock or new versions with same interface.

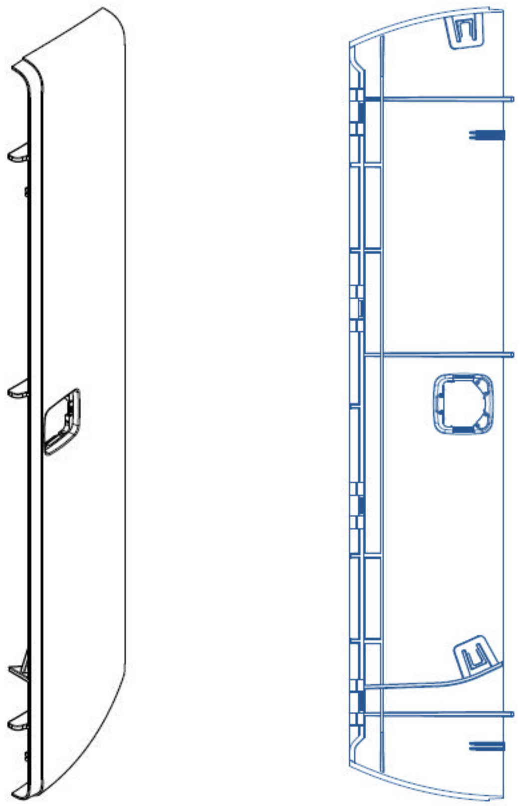


Figure 38: Views of the Right side.

Top

Like the sides, the top has a curved design, with a bridge meeting the front part and steering ribs that help stiffening the design. The top is presented in Figure 39. The edge in back also strengthens the top, but more importantly it connects the part to the back in assembly. The body of the top is intentionally made a few millimeters less wide than there is room for between the two sides of the assembled product. This gives a more forgiving split line, but also a visible gap between the parts. Hiding this gap was done by adding a bridge, which extends up to the side and therefore also work as support. Moreover, this bridge holds a hole for the snap joint connecting top and side together. The hole profile allows the middle part of the snap joint to bent backwards during mounting and it is at the same time tight enough to hold the top in place in all directions when mounted.

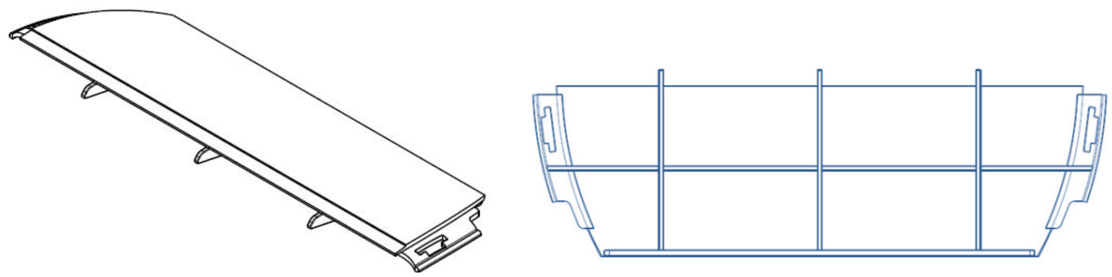


Figure 39: Views of the Top part.

Shelf

The shelf in Tork's existing dispensers has a well developed shape and function, optimized for good dispensing of hand towels. Thus, the main shape of the shelf is made similar, see Figure 40. Edges of the shelf, holding the paper towels in place, were minimized to keep the total thickness as low as possible. Reducing the size of these edges was considered to be safe, because the paper bundles are relatively stable, which lowers the risk of paper towels getting stuck or being incorrectly inserted.

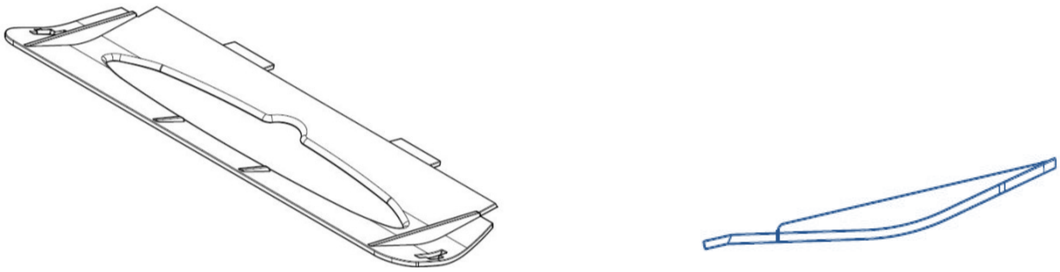


Figure 40: The shelf, isometric and side view.

The shelf also has two pins at the rear, inserted in the back part when assembled. The two holes in each side are similar to those in the top part, and intended for the lower snap joint on each side of the dispenser.

6.2 The dispenser series

The three remaining dispensers, S1, T2 and B1, are now presented. The concepts have been designed in line with H2 to give a uniform expression and to facilitate assembly for the end customer. As mentioned earlier, the products were not designed in full detail and therefore each concept has missing features. Hence, the part-in-part possibilities and packing efficiency may be changed when further developing the concepts.

6.2.1 S1 Dispenser

The soap dispenser concept consists of eight parts. As the H2 concept it has two sides, back, top and shelf, and these parts are also here placed into the front in its flat packed state, see Figure 41. The two additional parts, dispenser button and soap container spout support, are placed at the short side. Next to these parts is also room for the lock, which for this concept is not pre-assembled in production.

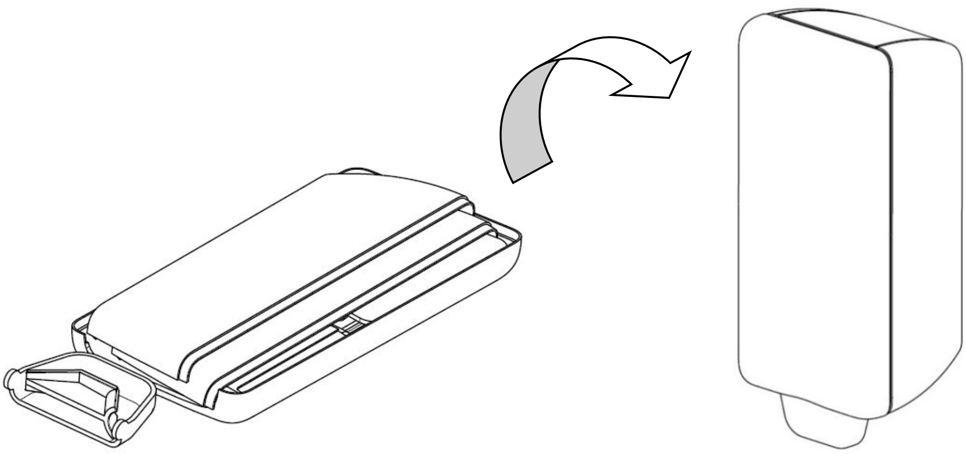


Figure 41: Flat packed and assembled S1 dispenser.

Due to the size of the dispenser, with sides larger than the back piece, the folding principle applied to H2 was not suitable for this concept. Therefore the intention is instead to snap all parts together in assembly. First, the sides are attached to the back, followed by top and shelf. Then the spout support and dispenser button are snapped in place, and lastly the front is mounted through pivot hinges in both sides. The result can be seen to the right in Figure 41.

As seen in Figure 42 below, the dispenser is opened by folding the front forward. Not included in the picture is the lock, which is then naturally placed on top. Instead of having the spout support integrated in the bottom part, it was designed as a separate part to facilitate the flat packing (to the right in Figure 42). This amplifies the need for a rigid design and snapping function.

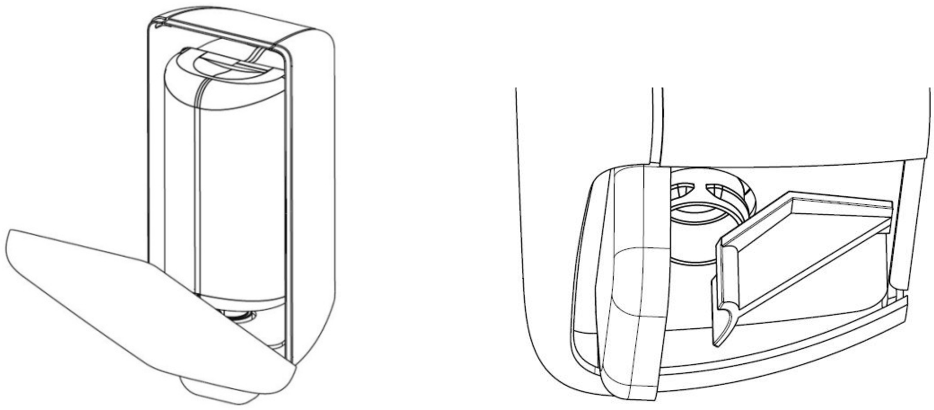


Figure 42: Opened S1 dispenser to the left showing the soap container. The right picture shows the dispenser button and spout support (the spout is not visible in the picture).

6.2.2 T2 Dispenser

As the S1 dispenser, this concept has eight parts. Besides the general chassis parts it has two roll holders and a toothed frame in bottom. Similar to the H2 concept, the sides are attached to the back in production, and folded down when packed. This setup, together with thorough dimensioning of the parts, gives room for top and bottom frame in the middle, see left of Figure 43. The front encloses most parts, except the two roll holders, which are efficiently placed along the long side. Assembly of the T2 dispenser chassis is performed in the same manner as H2. Lastly the two roll holders are turned and snapped in place, and will thereby be difficult to detach.

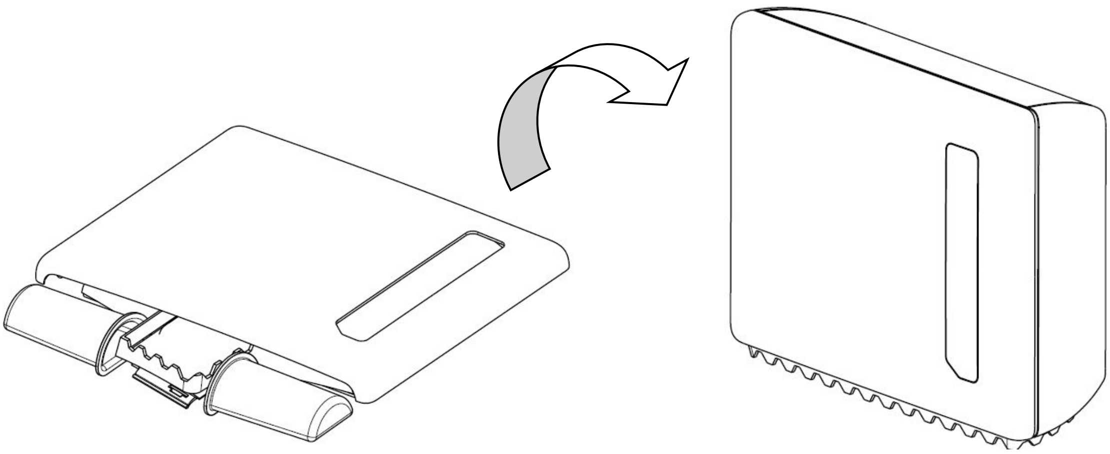


Figure 43: Packed and assembled T2 dispenser.

The assembled and opened T2 dispenser is shown in Figure 44. It has a similar opening mechanism as S1, with the front folding forward. As mentioned earlier the toothed frame is a separate part which helps stabilize the assembled dispenser body, instead of having teeth at the bottom of front and sides. Paper roll and stub roll hang on two similar roll holders, which at this stage have no additional features that can be seen on existing Tork dispensers.

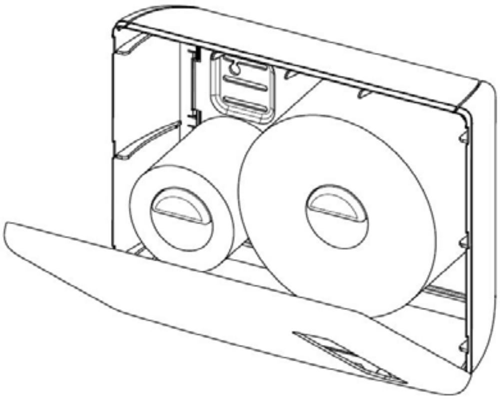


Figure 44: The interior of T2 dispenser.

6.2.3 B1 Dispenser

In Figure 45 one can see the packed and assembled bin concept, consisting of seven parts. The sides are attached to the back, and when packed they are folded down, overlapping each other. Unique items for this model are the solid bottom, openable top and the wire frame holding the bin liner. These parts are placed between the folded sides, and the whole package is partly enclosed by the front.

The assembly sequence for B1 is a bit different from the previous concepts. First the sides are folded up, followed by the bottom part being snapped in place. Since the top is the openable part for the bin, the front is next to be attached, which is done through a number of snap joints along sides and bottom. Finally the wire frame and top are put in place. These are attached through snap joints that also work as hinges, allowing them both to be folded up.

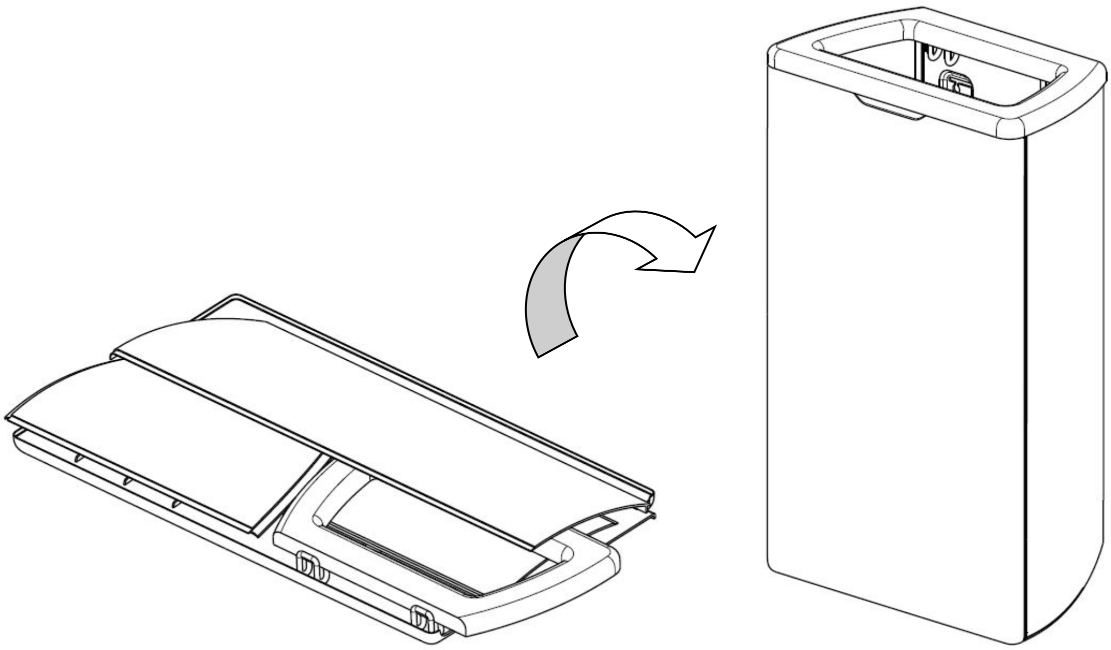


Figure 45: B1 dispenser in packed and assembled state.

When mounted the fixed front gives the assembly a rigid design. The front has an inward bend in top to facilitate opening of the top part. When emptying the bin, the top is opened upwards followed by the wire frame, see Figure 46, before the bag can be removed. The new bin liner is threaded around the frame and locked in place when the top is closed.

The wire frame and its supports (the hinges in back and possible additional supports in sides and front for the frame to lie on) can be dimensioned to handle necessary amount of weight, without adding any particular size to the flat package.

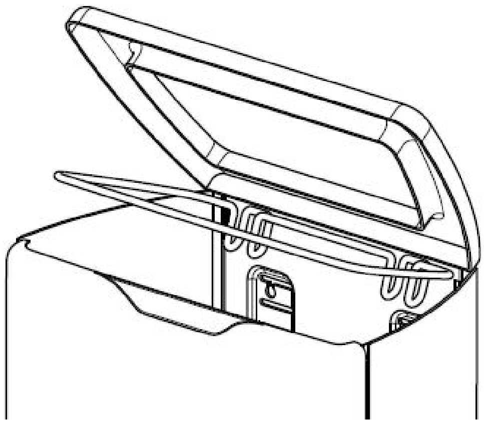


Figure 46: Opened B1, showing the bin liner holder.

6.3 Package size of final concepts

In Table 14 the final size reduction of the Stealth dispensers are presented in relation to Elevation, based on drawings of the packed assemblies, see Appendix I. Drawings. One can see that all of the dispensers reached below 50% in volume. The carton thickness used is the same for both series which means that it relatively adds more to the smaller flat packed products. The Stealth B1 dispenser had the largest reduction down to 24.3% and the T2 dispenser the least to 45.5%.

According to the result H2 and B1 are most promising to pack flat. However the B1 dispenser has not been designed in full detail and since it is a relatively large product, it may need more space-consuming stiffening ribs to strengthen the design. S1 and especially T2 are less promising as they are smaller products with a lot of parts and features. This could possibly be solved by investigating different packing options and further develop the concept and its parts. For instance, T2's two paper roll holders and toothed frame can be better optimized in order to minimize the flat pack product size.

Table 14: The size of the Stealth dispensers in comparison to Elevation series.

Size reduction		Elevation				Stealth				Result
		Length (mm)	Width (mm)	Height (mm)	Volume (dm3)	Length (mm)	Width (mm)	Height (mm)	Volume (dm3)	Volume ratio (Stealth/Elevation)
H2	Product	444	302	102	13,7	393	260	37	3,8	**27,6%**
	Shipping Carton	458	314	114	16,4	399	266	49	5,2	**31,7%**
T2	Product	338	272	127	11,7	340	333	44	5,0	**42,7%**
	Shipping Carton	352	284	139	13,9	351	340	53	6,3	**45,5%**
S1	Product	291	114	112	3,7	276	110	40	1,2	**32,7%**
	Shipping Carton	303	121	118	4,3	288	117	46	1,6	**35,8%**
B1	Product	629	389	289	70,7	711	364	60	15,5	**22,0%**
	Shipping Carton	651	401	313	81,7	723	371	74	19,8	**24,3%**

7 Final concept visualization

In addition to the conceptual figures presented in the previous chapter, the final concepts were also visualized by physical prototypes and photorealistic renderings. The prototypes were also tested in a number of ways. As mentioned earlier, no physical prototypes of the bin, soap and toilet paper dispenser were made, but instead renderings of them to show the proposed design.

7.1 Prototypes

In this development project, prototypes of the final product were valuable for several reasons, both visual and functional purposes. Most important was testing of the flat packing, to verify the actual size of the dispenser in packed state. Also the assembly of the dispenser was a critical step, where snap joints, folding functions and more could be thoroughly tested. When having an assembled product it could be wall mounted and tested in terms of robustness, refilling and dispensing. A prototype was also important for exhibition purposes, to provide better understanding of the product for people with less or no insight in the project. It can also be used to promote the concept and the idea of flat packing internally at SCA.

To fully visualize and enable testing of the H2 concept a complete prototype was made, including the dispenser, its packaging and an assembly instruction, see Figure 47. Other extras put into the package were also lock, screw kit and a protective plastic bag.

Figure 47: Packed prototype.

7.1.1 Silicone mold prototypes

Initially, a full scale rapid prototype of the product was made. But to be able to see what the dispenser would look like in different colors, transparent plastics and color combinations, eight silicone molded prototypes were also made. A range of plastics were possible to use for the silicone mold and one with similar properties as ABS (Acrylonitrile Butadiene Styrene) was selected. The models were assembled and tested, and necessary adjustments were made to the parts to ensure they had desired fit.

White and black plastic dispensers were obvious to make, since they according to SCA are neutral and sellable, and most popular among customers. The other colors and combinations were chosen based on the colors in the Tork brand's color palette, for color codes see Appendix J. Silicone prototypes. All prototypes were as existing dispensers equipped with Tork and SCA logotypes. Six of the prototypes are shown below, see Figure 48.

Figure 48: Six final dispenser prototypes.

7.1.2 Packaging

A fair judgment of the actual space saving for the flat packed dispenser could only be done by measuring the outer dimensions of the carton of which the dispenser is packed in during transport. When promoting the concept it was also important to have a complete package containing the dispenser and supplied accessories. Therefore a cardboard prototype was made with help from SCA Packaging, see Figure 49.

Figure 49: The cardboard prototype on top of Elevation H2 shipping carton.

7.1.3 Assembly instruction

An assembly instruction for the end customer was put together. It has a minimum amount of text to work for different languages in most countries. Only one word, "click", is used to visualize parts being snapped together. The complete assembly instruction is presented in Appendix K. Assembly instruction.

7.2 Prototype testing

As mentioned earlier the prototypes were used to test the end customer assembly, functionality, robustness and appearance among others.

The overall appearance got good response from people within and outside the organization. The dispenser was perceived as simple, slim and attractive. Initial tests showed that the flat packed dispenser was easy and fast to assemble, with folding and snap joints working as expected. Also persons with no insight in the project tested to assemble the product and they required only a couple of minutes to complete the mounting sequence. The individual parts and the assembled product are robust, giving a quality impression. With the top and shelf parts attached the dispenser body is rigid with no play between the parts. It also proved to be well functioning in terms of refilling and dispensing.

7.3 Rendering

Here the dispenser series is presented in a washroom environment, see Figure 50. The rendering shows a possible arrangement for the four developed units.

Figure 50: Washroom environment rendering.

8 Cost estimation

This chapter covers cost estimation for shipping and production of the final concept, Stealth H2 dispenser. Shipping cost estimation has also been performed for the three other units that can be found in Appendix L. Cost estimation, Table 4. Costs are represented by an index, a percentage scale where 100% equals the total production cost of an Elevation H2 dispenser.

8.1 Production cost

In order to get a realistic price estimation of a Stealth H2 dispenser, Gebrüder Schmidt, one of SCA's production plants was contacted. The company is today already producing many dispensers in the Elevation series including H2. The company was provided with as much information as possible including CAD-files of the product.

Table 17 shows the production cost which includes both manufacturing and additional costs. The manufacturing cost includes all the plastic parts for the dispenser and the additional costs are for extra features as printing, lock, screw-kit, plastic bag, carton and mounting instruction. One can see that 76% of the cost of a H2 Elevation dispenser comes from the manufacturing and the remaining 24% are additional costs.

The extra features are kept the same for the Stealth H2 dispenser. The manufacturing cost for the Stealth dispenser is 68% giving a total production cost of 92%. This means that the production cost of the Stealth dispenser is estimated to be 8% lower compared to Elevation. A more detailed calculation of the production cost received from Gebrüder Schmidt can be found in Appendix L. Cost estimation, Table 1, 2 and 3.

The calculation was based on the following criteria. All parts are to be made of injection molded ABS plastic using in total four different tools. The front part and window is made using multiple injection molding which gives a good final result with less needed production assembly. Since the back part is not visible from the outside of the dispenser it was decided to be made in natural ABS to lower the cost. Natural ABS also has the benefit of being transparent making the wall mounting for the end customer easier. The top and shelf, and right and left side are to be made in family tools, which will minimize the needed number of tools. One requirement stated that the product should be individually packed so that in can be separately sent to the end customer. Therefore each product will be packed in a carton similar to how the Elevation dispensers are packed today.

8.1.1 Further potential cost reduction

A further reduction of the production costs was made to show a low cost alternative to the above stated cost estimation. However, some of the proposals are in breach with the project requirements.

Table 15 below shows the production cost of the low cost alternative of the Stealth H2 dispenser. The manufacturing costs for the plastic parts are lowered to 64.5% and the additional costs to 9%, giving a total cost of 73.5% compared to an Elevation H2 dispenser. This means that 26.5% on only production costs can be saved.

Table 15: Production costs for Stealth H2 and the low cost option for Stealth H2.

Estimated production cost			
Product	Manufacturing cost	Additional cost	Production cost
Elevation H2	76%	24%	100%
Stealth H2	68%	24%	92%
Low cost Stealth H2	64,5%	9%	73,5%

The low cost alternative calculation was based on the following criteria. All parts are still to be injection molded using a total of four tools. The front will also remain the same with ABS plastic in order to have a rigid surface with an appealing finish. The remaining parts will instead be made in PS (Polystyrene), which is somewhat less scratch resistant but costs less. The additional cost where dramatically lowered by removing and changing the extra features. In Appendix L. Cost estimation, Table 3 one can see that position 6, 7, 9 and 10 have been changed. The lock is replaced by a lock made of only two plastic parts, which was calculated to lower the cost by half. Also, the requirement of individual packing was violated in order to see the full potential of cost reduction that could be made. The dispensers will be packed together, six in each carton. This means that only one large carton is needed. Also only one key and assembly instruction is delivered with each package. The screws and plugs are totally removed from the package.

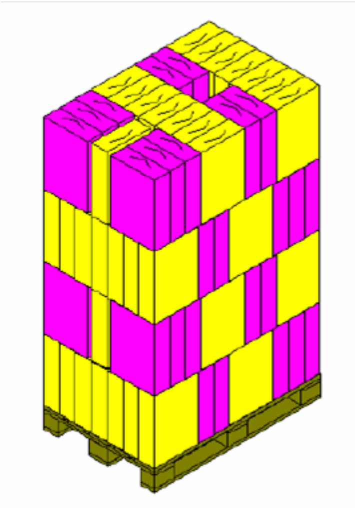
8.2 Shipping

One of the main goals with this project is to reduce the cost of shipping the dispensers by packing them flat. To reduce the shipping cost it is of course not only important to make the package as flat as possible but also to pack as many products as possible on each pallet. The Stealth H2 dispensers would be shipped on Euro pallets, which measures 1200mm by 800mm. This has therefore been taken into account from an early stage of the development and was perfected during the detailed design. In Table 16 below one can see the final measurement of the dispenser and the shipping carton. The length of the shipping carton is one third of the length and one half of the width of a Euro pallet. The width of the package is almost on third of the width of a Euro pallet. This means that there is a whole range of possible ways of stacking the cartons in an efficient way.

Table 16: The final size of a Stealth H2 dispenser.

Stealth Size	Length	Width	Height
Product	393mm	260mm	37mm
Shipping Carton	399mm	266mm	49mm

The packaging department at SCA was contacted in order to calculate the number of cartons that could be fitted on a Euro pallet. This was done by using packing optimization software. One promising way of packing the cartons can be seen in Figure 51 where 342 cartons are fitted onto one pallet. This is almost 3.5 times more than the number of Elevation H2 dispensers that are being shipped on one pallet today. There are other ways of fitting the same amount of cartons, which could optimize pallet stability and others, but these are not presented here. Also, packing a number of dispensers together in one carton would enable even more products to be shipped on each pallet.



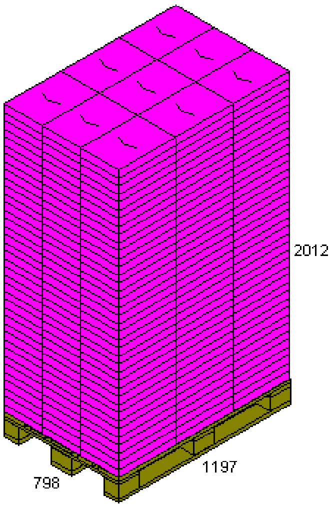


Figure 51: Elevation H2 (left) and Stealth H2 cartons (right) with 100 and 342 packed dispensers on a pallet, respectively.

The estimated shipping cost between Europe and Asia is based on a 40 feet container. It includes transportation between Rotterdam and Hong Kong, port costs, custom clearance and inland transportation. Each 40 feet container can hold a maximum of 25 Euro pallets. Table 17 shows how the shipping cost of the H2 dispenser is lowered according to the amount of units that can fit on each container.

Table 17: Estimated shipping cost for Stealth in relation to Elevation H2.

Estimated shipping cost			Europe-Asia	Asia-Europe
Product	Volume	Units/container	Shipping cost	Shipping cost
Elevation H2	100,0%	2500	12,8%	27,7%
Stealth H2	29,2%	8550	3,7%	8,1%

The shipping cost to end customers will of course also be lowered as a consequence of the reduced package size. Also, when products are being stored along the transportation chain they will require less space. The possible savings from these kinds of costs has not been taken into account, as they are hard to predict. They are also relatively small in this context and can thus be seen as negligible.

8.3 Total cost

The cost requirement stated that the price of the dispenser including shipping costs should be equal to or lower than the production cost of the Evaluation dispensers. Table 18 shows the potential cost reduction of a Stealth H2 dispenser in comparison with an Elevation H2 dispenser. The column Total (production + shipping) for Europe-Asia shows that both versions of Stealth H2 are below 100% which means that the cost requirement is met. Even when shipping the more expensive version of Stealth from Asia to Europe the maximum allowed cost is almost exactly in line with the requirement.

The table column Indexed total cost, is differently indexed where 100% now equals total cost of both manufacturing and shipping cost of an Elevation H2. This gives an indication on how much cost that could be saved when the dispensers hits the final market. The cost of a Stealth H2 dispenser when shipped from Europe to Asia would be 82.9% of the cost for an Elevation H2 dispenser. From Asia to

Europe it would be down to 72.4%. With the low cost version of Stealth the cost would be 64.4% for Europe to Asia and 53.9% when shipped from Asia to Europe.

Table 18: Shows the potential cost reduction of a Stealth H2 dispenser in comparison with an Elevation H2 dispenser.

Total cost estimation		**Europe-Asia**			**Asia-Europe**		
Product	Production cost	Shipping cost	Total (production + shipping)	**Indexed total cost**	Shipping cost	Total (production + shipping)	**Indexed total cost**
Elevation H2	100,0%	12,8%	112,8%	**100,0%**	27,7%	127,7%	**100,0%**
Stealth H2	92,0%	3,7%	95,7%	**82,9%**	8,1%	100,1%	**72,4%**
Low cost Stealth H2	73,5%	3,7%	77,2%	**64,4%**	8,1%	81,6%	**53,9%**

9 Discussion

This chapter contains a discussion of the methods used and around the project result, in relation to the early stated research questions.

Method

The chosen methods and development process was overall considered to be functioning well along the project, leading to a satisfying final result. The early preparation with a strict timeline and milestones helped guiding the project, keeping the focus on the important factors, i.e. answer the research questions and to reach the established goals. The lean approach with early testing was found to be successful as the potential of each concept could be quickly identified. Using other lean product development methods could have lead to an even more front loaded process.

The project scope was rather wide in relation to the limited time frame, leading to compression of time-consuming phases, e.g. the detailed design part. A faster concept selection phase would have given more time for refinements. However, this kind of development projects requires a thorough early investigation, with a well-founded elimination of ideas and concepts, to reach a satisfying result.

Collection of customer requirements and wishes within the project has mostly been based on earlier knowledge within SCA. More external research could have been done in order to get an even better understanding of the customer related factors. But, the internal knowledge and prior market research were considered sufficient to keep a high costumer value of the product, since it was the cost and not the product itself causing dissatisfaction.

SCA's market department stated that there is a demand for cheaper dispensers especially in Asia and South America. This was never further investigated which could have given interesting details about the real need for a cheaper dispenser series. It could also have given more information about the less important product features that could have been changed in order to reach a lower price.

Ease of assembly for a flat pack product

The flat packing and end customer assembly was found to be strongly interconnected. Placement of parts was in this project used as a way of making the assembly foolproof, to prevent mistakes of being made by the end customer.

When packing a product flat, it is easy to fixate on making the individual parts flat. The project has shown that efficient packing is at least as important, making it possible to keep curvature and complex shapes. Efficient packing in a combination with relatively flat parts will in most cases lead to a very slim package.

A drawback for the end customer with a flat pack dispenser is obviously the need for assembly. Thus, this was considered to be of highest importance in order to satisfy the customers. The end customer assembly requirement was set to 10 minutes maximum assembly time, which probably could have been reached with a simpler flat pack solution. Instead, a lot of work was put into making the assembly simple and intuitive, requiring the smallest amount of time possible. Tests showing that the product's assembly time is at most a couple of minutes may mean that ease of assembly has got too much attention. But since also the other requirements are fulfilled, it may have been a too easy set requirement or just a well established goal.

Dispenser functionality and aesthetics

Functions are not necessarily affected when flat packing a dispenser. One could see that robustness and aesthetics are more coupled with the flat packing than for instance dispensing and maintenance, which were kept as good as possible compared to existing dispensers.

The robustness requirement, to withstand a punch, was never tested because of the risk of destroying expensive prototypes. Such a test would however not be reliable since prototypes are often less durable and in this case it was not manufactured in the material intended for the final product. With relatively stiff parts and rigid body when assembled, the robustness of the final product was not considered to be a problem.

How the dispenser is separated into parts is also affecting the robustness. Split lines are often negative for several reasons; in addition to robustness also hygienic and visual aspects. The development process showed how these split lines can beneficially located, e.g. moved from natural part splits like corners, giving a more robust and clean design.

Bearing in mind that this is a product development project, the aesthetical aspects were early in focus. This could possibly have been left out for later but was taken into account as function and design are closely coupled. The project goal was not only finding a flat packed solution but to find a solution satisfying to the customer. Opinions about appearance are very individual, but we are convinced that the final concept stands up well in comparison with Tork's Box 2000 series, as required.

Benefits of flat pack

The space saving potential was found to be satisfying for the flat pack products, with more than 50% volume reduction for all dispenser types and more than 70% reduction for two of the concepts. The result shows that a large reduction is hard to get with products being small or having many features. Here one has to evaluate if it is worth the effort to flat pack these products. Since only the hand towel dispenser was completely designed in detail, the design of the other concepts should only be seen as proposals. A redesign could lead to either increase or decrease in volume of the package.

The first cost calculation of the final concept showed that the product passed the initial cost requirement, with the product being shipped from Europe to Asia. Through the second cost calculation one could see the full potential saving, especially on the product itself. There are of course other possible savings than those included in the estimation. The side parts can for instance be made equal, leading to a more complex part, but reducing the number of part types in production.

The flat packing method is useful when long distance or high cost transportation is needed. When the production is close to the market region the savings will be insufficient in comparison to the demanded design work to make a new dispenser series.

An alternative to flat pack would be the earlier mentioned method of stacking products in transportation. Based on the chosen stacking method the products then need to be repacked one or several times before final shipment to the end customer.

No environmental requirements were set for the project, though flat pack can be seen as a step in right direction. The reduction of emissions from transportation is almost direct proportional to the volume reduction, since flat packed dispensers require less cargo space.

Others

In the final selection concept Stealth won over concept Barbie by a small margin. The fact that Barbie is a hybrid between an exclusive and a low cost dispenser may have been an unwanted combination. The concept would possibly been better off with either a low cost alternative in simple plastic, or as an exclusive product in for instance wood and glass. Stealth was considered more suitable for Tork's portfolio and the concept also shows that a flat packed solution can be made with rather curved shapes. The Stealth concept is however less suitable for different material options compared to Barbie, but due to the tight cost limit in this project most concepts would probably have ended up being in plastic nevertheless.

In the second screening step some direct customer investigation was done through the survey which gave the indication that the dispenser aesthetics were satisfying to almost all participants in relation to both the brand identity and competitors. However, the survey would probably have been more reliable if the participants would have been more carefully selected, for instance targeting responsible purchasers. Unfortunately this could not be done as the survey had to be made in-house. The survey got a fairly good response from both United States and Germany, but only 14 people took the survey in Shanghai, which also is a smaller office. As Asia is one of the possible target markets for the product it would have been interesting with more respondents from that region.

10 Conclusions

The used method resulted in a flat packed dispenser series that fulfills all of our stated requirements. At the same time it keeps the value for the customer high by meeting our wishes well.

There are a number of different possibilities on how to flat pack a dispenser. Based on our requirements we found that the best suited flat packing principle was to use a combination of separate and foldable parts in plastic. The result shows a promising concept that can be flat packed efficiently while at the same time being fast and easy for the end customer to assemble.

The final concept clearly shows a flat packed dispenser that is both well functioning and aesthetically appealing. Rather round shapes can be used if the placement of the individual parts is optimized for packing. A flat packed dispenser using separate parts is made robust with the use of stiffening ribs and strategically placed split lines. The product interior is made as separate parts that preferably also are used as stabilizing elements.

The flat packing method can lead to large total savings in shipping volume, cost and environmental impact. The reduction possibility was found very promising surpassing our initial expectations. Volume and thereby also shipping cost are reduced up to 75% percent in comparison to existing dispensers. However, for smaller products or for those with more features the size reduction is more difficult to attain.

11 Recommendations

With a promising result showing possible volume reduction, our recommendation is a further investigation of feasibility and actual savings of flat pack dispensers. The detailed designed hand towel dispenser can be used as case in point when looking into other dispenser types and their flat pack potential. The folding and packaging principles found during this project can be reused in other SCA products. Some of the dispensers were found easier to pack efficiently, while other types may be difficult to reduce in size. This is something SCA needs to investigate further in order to find the dispenser types most suitable to pack flat.

It is also important to look into the other areas where improvements can be made, than minimizing volume of the packed product. More cost can for instance be saved by shipping the dispensers together and by saving on extra features for the dispenser, as shown in the cost estimation. Furthermore, when looking at different potential flat pack dispensers, one should explore the possibility to share parts between different products.

The developed products in this project aimed for a specific segment and cost requirements also limited the degrees of freedom regarding material selection among others. A low cost series is possible, and we recommend looking into if also an exclusive range of dispensers could be flat packed. During the project a lot of interesting solutions were found using new and naturally flat materials that would be more suitable for an expensive product. There is thus a range of different possibilities for flat pack and one must decide where on this cost verses performance range to aim at.

Finally we recommend an evaluation of the environmental aspect of flat pack, which can be emphasized in market communication. The reduced emissions from transportation in combination with for instance an environmentally friendly material can together form a relatively green product.

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Appendices

Appendix A. Time plan

Project time plan

Number	Task	Start	End	Duration
1	Planning/ Organizing	8/30/2010	9/15/2010	13
1.1	Time plan, PDM system	8/30/2010	9/3/2010	5
1.2	Planning report	8/30/2010	9/15/2010	13
1.3	Requirement specification	9/1/2010	9/9/2010	7
2	Research, solution mapping	8/30/2010	10/5/2010	27
2.1	Research	8/30/2010	9/15/2010	13
2.2	Focus group	9/13/2010	9/17/2010	5
2.3	Patent search	9/15/2010	10/5/2010	15
3	Concept generation	9/20/2010	10/27/2010	28
3.1	Generate solutions	9/20/2010	10/5/2010	12
3.2	Evaluate solutions	9/28/2010	10/19/2010	16
3.3	Final concept selection	10/15/2010	10/27/2010	9
4	Detailed design	10/26/2010	11/26/2010	24
4.1	Concept improvement	10/26/2010	11/15/2010	15
4.2	CAD	11/2/2010	11/26/2010	19
6	Project Completion	11/22/2010	1/19/2011	43
6.1	Renderings	11/22/2010	11/27/2010	5
6.2	Prototype	11/22/2010	1/18/2011	42
6.3	Presentation	1/10/2011	1/19/2011	8
7	Report writing	11/22/2010	1/27/2011	49

Appendix B. Mood board

Appendix C. Patent search

Table 1: Patents of interest from the patent screening performed. The exact used search strings and classes are not included as this was performed by the patent department under confidentially.

Database	Number of hits	Patent
Google	7	US2515071 (July 11, 1950) US3232478 (Feb. 1, 1966) US4704970 (Nov. 10, 1987) US5946774 (Sep. 7, 1999) US2557716 (June 19, 1951) US4332053 (June 1, 1982) US4913302 (Apr. 3, 1990)
Aureka Package	2387→1346→42→8	EP0573729A1 (1992) US4591065A (1986) US20070145053A1 (2007) WO9518047A1 (1995) EP1010625A1 (2000) US5370758A (1994) WO0194214A1 (2001) WO2007058613A1 (2007)
Aureka Furniture	1477→1016→32→12	EP1038477B1 (2003) US4295693A (1981) US5310242A (1994) US6139567A (2000) US7014384B2 (2006) WO2002055892B1 (2002) EP1869999A1 (2007) US4600252A (1986) US5613746A (1997) US6209976B1 (2001) US20050168115A1 (2005) WO2006107220A1 (2006)
Aureka Fasteners	1362→845→420→38→13	EP0496025A1 (1991) EP0948921A1 (1999) EP1932448A2 (2008) US5713649A (1998) US20090072691A1 (2009) WO9410462A1 (1994) WO2008150234A1 (2008) EP0685403A1 (1995) EP0961039A1 (1999) GB2445954A (2007) US20020105252A1 (2002) WO0108536A1 (2001) WO9504228A1 (1995)
Thomson Dispensers	2	DE202009007779U1 (2009) JP 2002112921A (2003)

Appendix D. Requirement specification

Table 1: Requirement specification

All			
	Technical		
	Robustness	Take a punch from an average male	R
	Installation & Serviceability		
	Mounting	Possible/Easy to mount on wall	R/W
	Assembly time	Max 10 min/As fast as possible	R/W
	Refilling	Easy accesability to refill	W
	Cleaning	Prioritize surfaces and joints that are easy to clean	W
	Assembly tools	Only Philip head/Use to a miminum extent	R/W
	Lock	Possible to lock with Tork key	R
	Assembly instruction	Intuitive + Well explanatory instruction	R
	Laws & regulations		
	Patent	Can not inflict with current patents	R
	Environment effect	As low as possible	W
	Others		
	Aesthetics	In line with Box 2000/As aesthetically appealing as possible	R/W
	Shipping	In individual package to end customer	R
H2: Hand towel			
	Technical		
	Compatibleness	Tork Hand Towel Interfold (WxD: 212x85mm, 130mm stack)	R
	Dimensions	Max 4 inches depth (US req.) = 101,6 mm/As small as possible	R/W
	Dimension when packed	<50% of assembled Elevation dispenser	W
	Financial		
	Product cost	Max *** EUR incl. shipping/As low as possible	R/W
S1: Soap			
	Technical		
	Compatibleness	Tork Soap Liquid (RxH: 92x240mm)	R
	Dimensions	As small as possible	W
	Dimension when packed	<50% of assembled Elevation dispenser	W
	Financial		
	Product cost	Max *** EUR incl. shipping/As low as possible	R/W
T2: Toilet paper			
	Technical		
	Compatibleness	Tork Toilet Paper Mini Jumbo Roll (DxR:100x188mm)	R
	Dimensions	As small as possible	W
	Dimension when packed	<50% of assembled Elevation dispenser	W
	Financial		
	Product cost	Max *** EUR incl. shipping/As low as possible	R/W
Bin			
	Technical		
	Compatibleness	Tork Bin Liner 50L	R
	Dimensions	As small as possible	W
	Dimension when packed	<50% of assembled Elevation dispenser	W
	Financial		
	Product cost	Max *** EUR incl. shipping/As low as possible	R/W

Appendix E. Foam board models

Figure 1: Foam board models of Stealth (top), Barbie (middle) and Mailbox (bottom).

Appendix F. Concept assembly

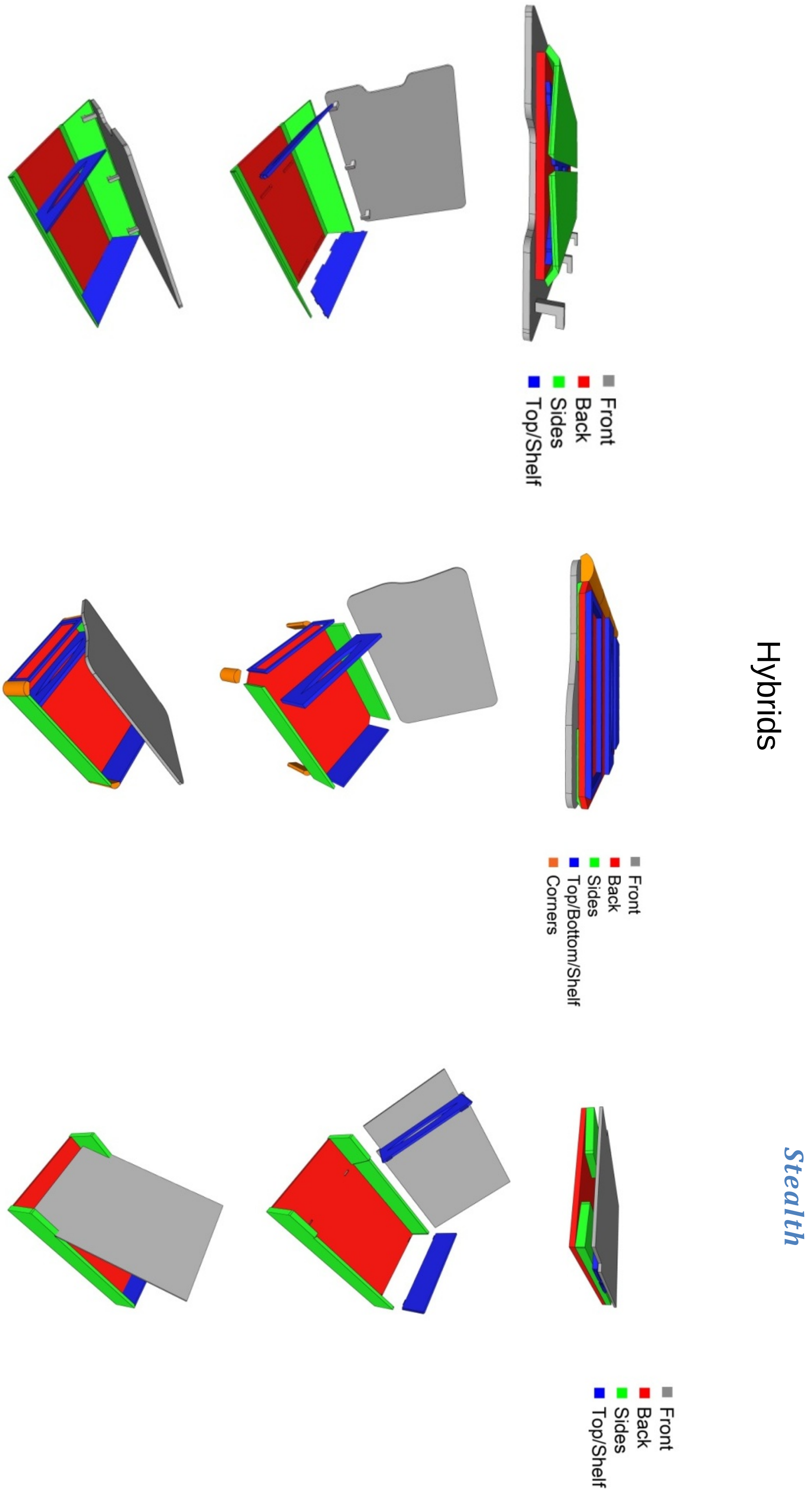


Figure 1: The three concepts, packed and assembled.

Appendix G. Concept cost scoring

Table 1: Elevation cost estimation.

Elevation	Part	Front top	Front bottom	Back
Data	Material	ABS	ABS	ABS
	Envelope X-Y-Z (mm)	300-290-60	300-150-60	300-440-93
	Max. wall thickness (mm)	3	3	3
	Projected area (mm²)	87000	45000	132000
	Projected hole area (mm²)	0	0	4800
	Volume (mm³)	339300	162000	554400
	Surface roughness (µmm)	Ra<= 50	Ra<= 50	Ra<= 50
	Complexity	Moderate	Moderate	Very Complex
	Tolerance	0,25	0,25	0,25
Part cost score	Quantity	100000	100000	100000
	Material	1,40	0,68	2,07
	Production	0,92	0,58	1,26
	Tooling	0,91	0,71	1,48
	Part score	3,23	1,97	4,81
Product cost score	Number of parts	1,00	1,00	1,00
	Score	3,23	1,97	4,81
Sum	**Total score**	**10,01**		

Table 2: Stealth cost estimation.

Stealth	Part	Side R	Side L	Top	Front	Back	Shelf
Data	Material	ABS	ABS	ABS	ABS	ABS	ABS
	Envelope X-Y-Z (mm)	89-390-8	89-390-8	260-89-8	290-420-12	230-360-8	260-89-10
	Max. wall thickness (mm)	3	3	3	3	3	3
	Projected area (mm²)	32300	32300	20700	121700	82800	15900
	Projected hole area (mm²)	0	0	0	0	0	4800
	Volume (mm³)	96900	96900	62100	365100	248400	47700
	Surface roughness (µmm)	Ra<= 400	Ra<= 400	Ra<= 400	Ra<= 400	Ra<= 400	Ra<= 400
	Complexity	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
	Tolerance	0,25	0,25	0,25	0,25	0,25	0,25
Part cost score	Quantity	100000	100000	100000	100000	100000	100000
	Material	0,41	0,41	0,27	1,51	1,02	0,21
	Production	0,46	0,46	0,35	1,06	0,82	0,35
	Tooling	0,58	0,58	0,50	0,92	0,79	0,47
	Part score	1,44	1,44	1,12	3,49	2,64	1,03
Product cost score	Number of parts	1,00	1,00	1,00	1,00	1,00	1,00
	Score	1,44	1,44	1,12	3,49	2,64	1,03
Sum	**Total score**	**11,16**					

Table 3: Barbie cost estimation.

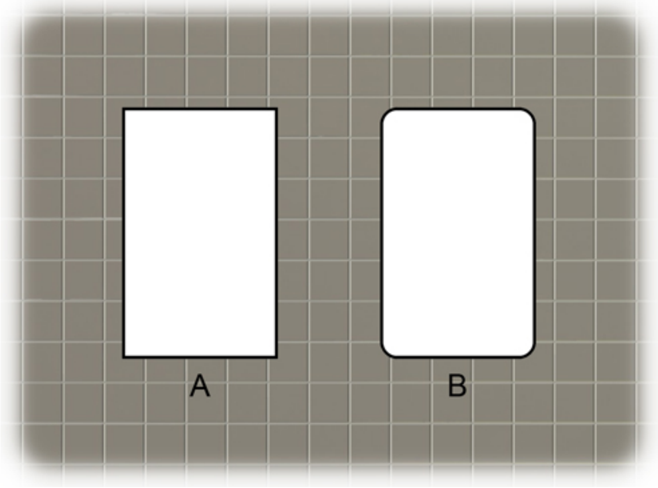
Barbie	Part	Box	Corners	Front	Shelf
Data	Material	PP	ABS	ABS	ABS
	Envelope X-Y-Z (mm)	415-550-8	25-25-95	275-440-8	225-90-10
	Max. wall thickness (mm)	3	3	3	3
	Projected area (mm²)	173400	400	110000	15500
	Projected hole area (mm²)	14850	300	0	4800
	Volume (mm³)	520200	38000	330000	46400
	Surface roughness (μmm)	Ra<= 800	Ra<= 400	Ra<= 100	Ra<= 400
	Complexity	Simple	Very Simple	Very Simple	Moderate
	Tolerance	0,25	0,25	0,5	0,25
Part cost score	Quantity	100000	400000	100000	100000
	Material	2,35	0,16	1,36	0,21
	Production	1,75	0,05	0,98	0,35
	Tooling	0,84	0,10	0,53	0,46
	Part score	4,94	0,30	2,87	1,02
Product cost score	Number of parts	1	4	1	1
	Score	4,94	1,21	2,87	1,02
Sum	**Total score**	**10,03**			

Table 4: Mailbox cost estimation

Mailbox	Part	Side R	Side L	Top	Front	Back	Shelf
Data	Material	ABS	ABS	ABS	ABS	ABS	ABS
	Envelope X-Y-Z (mm)	100-420-8	100-420-8	230-90-8	250-425-8	240-390-8	230-89-10
	Max. wall thickness (mm)	3	3	3	3	3	3
	Projected area (mm²)	40800	40800	20700	104500	93600	15700
	Projected hole area (mm²)	0	0	0	0	0	4800
	Volume (mm³)	122400	122400	62100	313500	280800	47100
	Surface roughness (μmm)	Ra<= 400	Ra<= 400	Ra<= 400	Ra<= 200	Ra<= 400	Ra<= 400
	Complexity	Moderate	Moderate	Moderate	Very simple	Moderate	Moderate
	Tolerance	0,25	0,25	0,25	0,25	0,25	0,25
Part cost score	Quantity	100000	100000	100000	100000	100000	100000
	Material	0,51	0,51	0,27	1,29	1,16	0,21
	Production	0,52	0,52	0,35	0,98	0,82	0,35
	Tooling	0,63	0,63	0,49	0,56	0,67	0,37
	Part score	1,65	1,65	1,11	2,83	2,65	0,93
Product cost score	Number of parts	1,00	1,00	1,00	1,00	1,00	1,00
	Score	1,65	1,65	1,11	2,83	2,65	0,93
Sum	**Total score**	**10,81**					

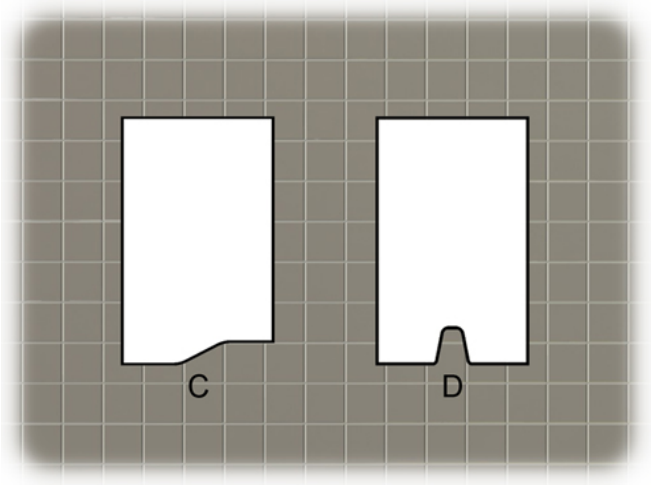
Appendix H. Aesthetics survey

1. Which hand towel dispenser shape do you prefer?



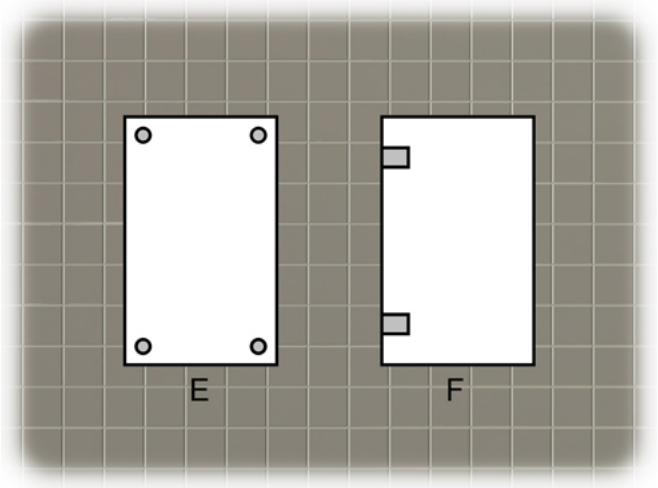
US	Percentage	Count
A	2.6%	3
B	97.4%	113
Respondents		116
No response		2
Germany	Percentage	Count
A	9.5%	4
B	90.5%	38
Respondents		42
No response		0
Shanghai	Percentage	Count
A	0%	0
B	100%	14
Respondents		14
No response		0

2. Which dispenser shape do you prefer?



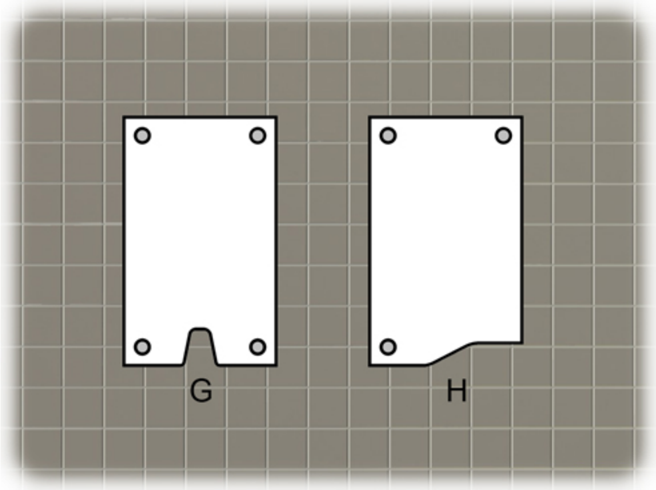
US	Percentage	Count
C	45.3%	53
D	54.7%	64
Respondents		117
No response		1
Germany	Percentage	Count
C	48.8%	20
D	51.2%	21
Respondents		41
No response		1
Shanghai	Percentage	Count
C	50%	7
D	50%	7
Respondents		14
No response		0

3. Which dispenser shape do you prefer?



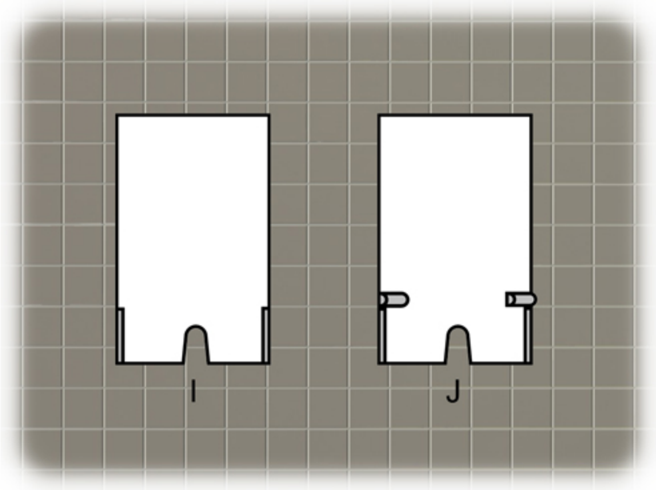
US	Percentage	Count
E	49.1%	56
F	50.9%	58
Respondents		114
No response		4
Germany	Percentage	Count
E	40%	16
F	60%	24
Respondents		40
No response		2
Shanghai	Percentage	Count
E	46.2%	6
F	53.8%	7
Respondents		13
No response		1

4. Which dispenser shape do you prefer?



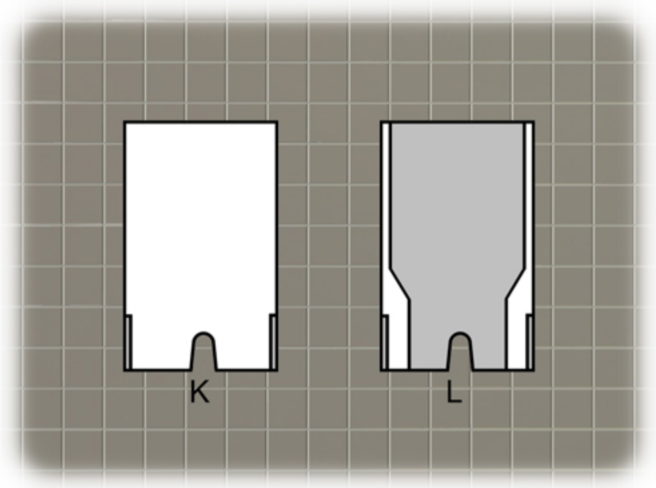
US	Percentage	Count
G	49.6%	57
H	50.4%	58
Respondents		115
No response		3
Germany	Percentage	Count
G	50%	20
H	50%	20
Respondents		40
No response		2
Shanghai	Percentage	Count
G	41.7%	5
H	58.3%	7
Respondents		12
No response		2

5. Which dispenser shape do you prefer?



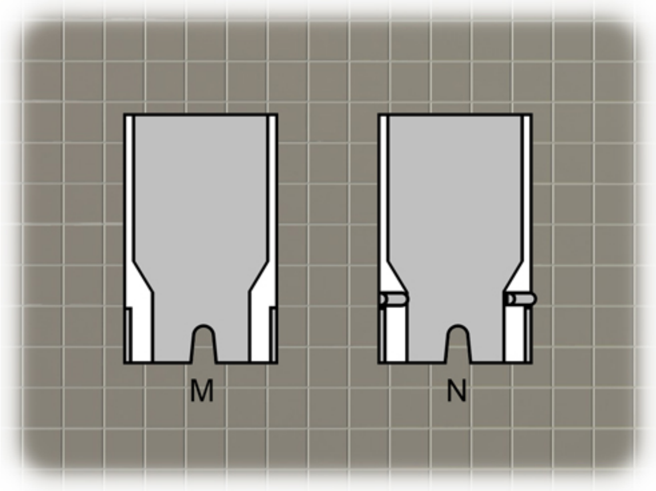
US	Percentage	Count
I	73.7%	84
J	26.3%	30
Respondents		114
No response		4
Germany	Percentage	Count
I	61.5%	24
J	38.5%	15
Respondents		39
No response		3
Shanghai	Percentage	Count
I	58.3%	7
J	41.7%	5
Respondents		12
No response		2

6. Which dispenser shape do you prefer?



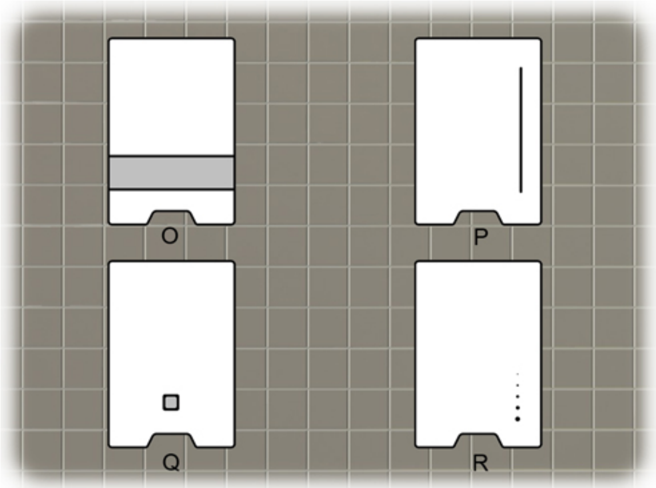
US	Percentage	Count
K	57.9%	66
L	42.1%	48
Respondents		114
No response		4
Germany	Percentage	Count
K	52.6%	20
L	47.4%	18
Respondents		38
No response		4
Shanghai	Percentage	Count
K	63.6%	7
L	36.4%	4
Respondents		11
No response		3

7. Which dispenser shape do you prefer?



US	Percentage	Count
M	78.8%	89
N	21.2%	24
Respondents		113
No response		5
Germany	Percentage	Count
M	72.2%	26
N	27.8%	10
Respondents		36
No response		6
Shanghai	Percentage	Count
M	63.6%	7
N	36.4%	4
Respondents		11
No response		3

8. Rank these level indicators from 1 (Best) to 4 (Not so good)



US	1	2	3	4	Average	Respondents	No response
P	33.3%	37%	19.4%	10.2%	2.94	108	10
R	33.6%	19.6%	27.1%	19.6%	2.67	107	11
O	27.1%	27.1%	21.5%	24.3%	2.57	107	11
Q	5.6%	16.8%	31.8%	45.8%	1.82	107	11
Total					2.5	108	10
Germany	1	2	3	4	Average	Respondents	No response
R	47.1%	17.6%	17.6%	17.6%	2.94	34	8
P	26.5%	26.5%	35.3%	11.8%	2.68	34	8
O	17.6%	23.5%	20.6%	38.2%	2.21	34	8
Q	8.8%	32.4%	26.5%	32.4%	2.18	34	8
Total					2.5	34	8
Shanghai	1	2	3	4	Average	Respondents	No response
O	54.5%	9.1%	27.3%	9.1%	3.09	11	3
R	44.4%	22.2%	22.2%	11.1%	3	9	5
Q	10%	30%	30%	30%	2.2	10	4
P	0%	40%	20%	40%	2	10	4
Total					2.57	11	3

9. Which dispenser do you prefer?

a

b

US	Percentage	Count
a	66.7%	72
b	33.3%	36
Respondents		108
No response		10
Germany	Percentage	Count
a	65.7%	23
b	34.3%	12
Respondents		35
No response		7
Shanghai	Percentage	Count
a	63.6%	7
b	36.4%	4
Respondents		11
No response		3

10. Which dispenser do you prefer?

b

c

US	Percentage	Count
b	19%	20
c	81%	85
Respondents		105
No response		13
Germany	Percentage	Count
b	11.4%	4
c	88.6%	31
Respondents		35
No response		7
Shanghai	Percentage	Count
b	27.3%	3
c	72.7%	8
Respondents		11
No response		3

11. Which dispenser do you prefer?

c

a

US	Percentage	Count
c	49.1%	52
a	50.9%	54
Respondents		106
No response		12
Germany	Percentage	Count
c	40%	14
a	60%	21
Respondents		35
No response		7
Shanghai	Percentage	Count
c	36.4%	4
a	63.6%	7
Respondents		11
No response		3

12. Which dispenser do you prefer?


d


e

US	Percentage	Count
d	50%	53
e	50%	53
Respondents		106
No response		12
Germany	Percentage	Count
d	54.3%	19
e	45.7%	16
Respondents		35
No response		7
Shanghai	Percentage	Count
d	72.7%	8
e	27.3%	3
Respondents		11
No response		3

13. Which dispenser do you prefer?


e


f

US	Percentage	Count
e	83%	88
f	17%	18
Respondents		106
No response		12
Germany	Percentage	Count
e	94.3%	33
f	5.7%	2
Respondents		35
No response		7
Shanghai	Percentage	Count
e	54.5%	6
f	45.5%	5
Respondents		11
No response		3

14. Which dispenser do you prefer?


f

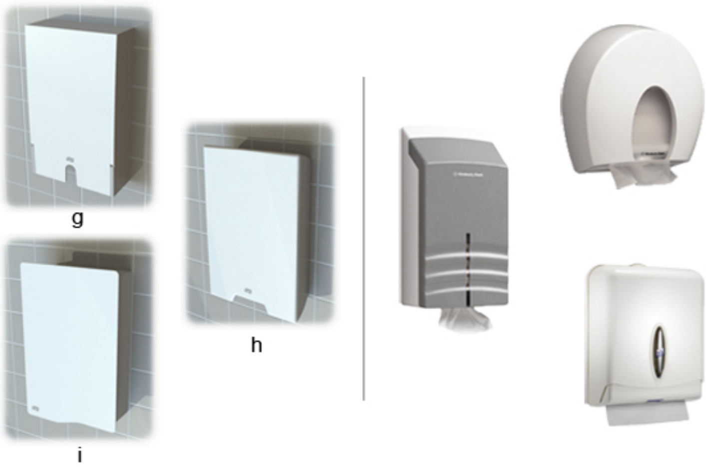

d

US	Percentage	Count
f	34.3%	36
d	65.7%	69
Respondents		105
No response		13
Germany	Percentage	Count
f	31.4%	11
d	68.6%	24
Respondents		35
No response		7
Shanghai	Percentage	Count
f	27.3%	3
d	72.7%	8
Respondents		11
No response		3

15. Could any of the dispensers on the left side compete with competitors' products?

US	Percentage	Count
Yes	77.1%	81
No	22.9%	24
Respondents		105
No response		13
Germany	Percentage	Count
Yes	82.9%	29
No	17.1%	6
Respondents		35
No response		7
Shanghai	Percentage	Count
Yes	81.8%	9
No	18.2%	2
Respondents		11
No response		3

16. Rank which dispenser that would be most competitive, 1 (Best) to 3 (Not so good)

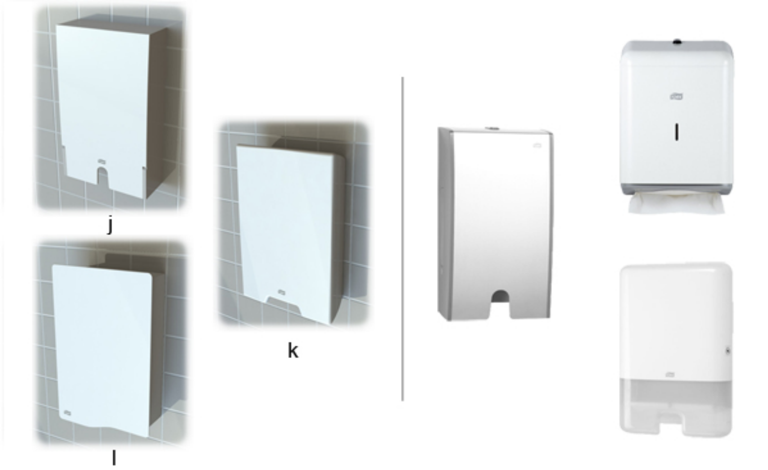


US	1	2	3	Average	Respondents	No response
h	32%	61.2%	6.8%	2.25	103	15
i	52%	17.6%	30.4%	2.22	102	16
g	17.5%	20.4%	62.1%	1.55	103	15
Total				2.01	104	14
Germany	1	2	3	Average	Respondents	No response
i	65.7%	11.4%	22.9%	2.43	35	7
h	25.7%	74.3%	0%	2.26	35	7
g	8.6%	14.3%	77.1%	1.31	35	7
Total				2	35	7
Shanghai	1	2	3	Average	Respondents	No response
i	60%	10%	30%	2.3	10	4
h	30%	40%	30%	2	10	4
g	10%	50%	40%	1.7	10	4
Total				2	10	4

17. Could any of the dispensers on the left side fit into Tork's product portfolio?

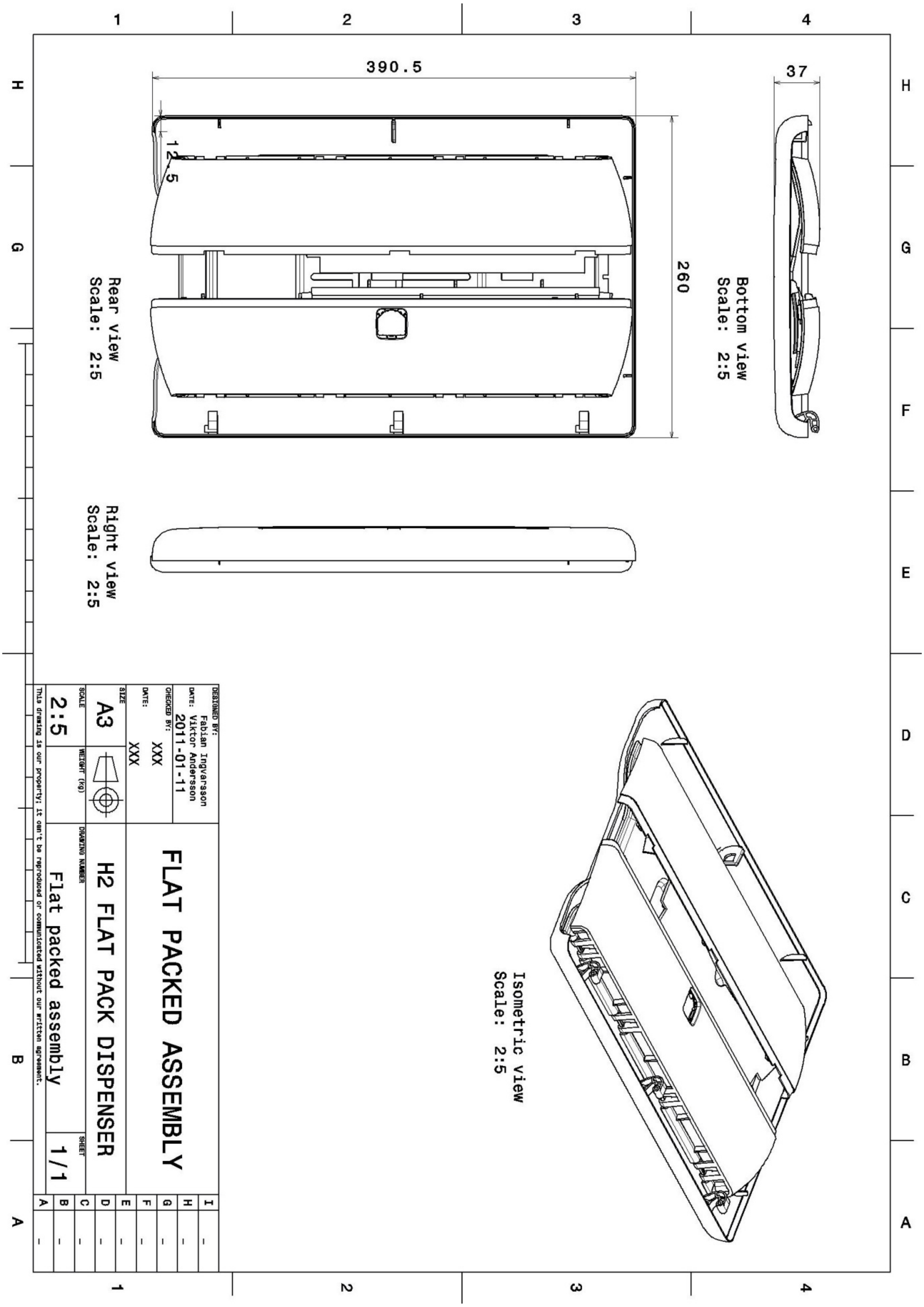
US	Percentage	Count
Yes	86.5%	90
No	13.5%	14
Respondents		104
No response		14
Germany	Percentage	Count
Yes	93.9%	31
No	6.1%	2
Respondents		33
No response		9
Shanghai	Percentage	Count
Yes	88.9%	8
No	11.1%	1
Respondents		9
No response		5

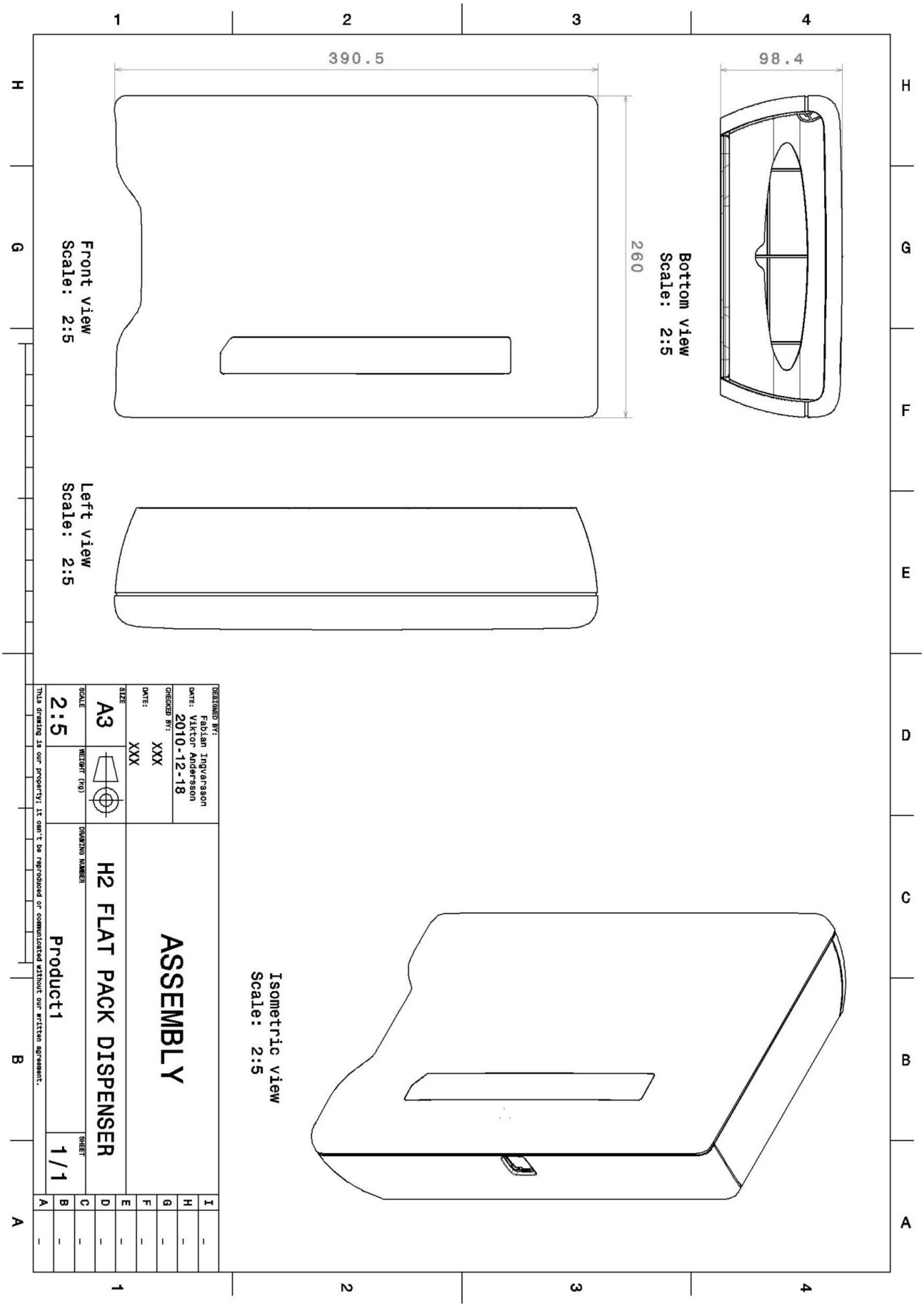
18. Rank which dispenser that would fit best into Tork's portfolio, 1 (Best) to 3 (Not so good).

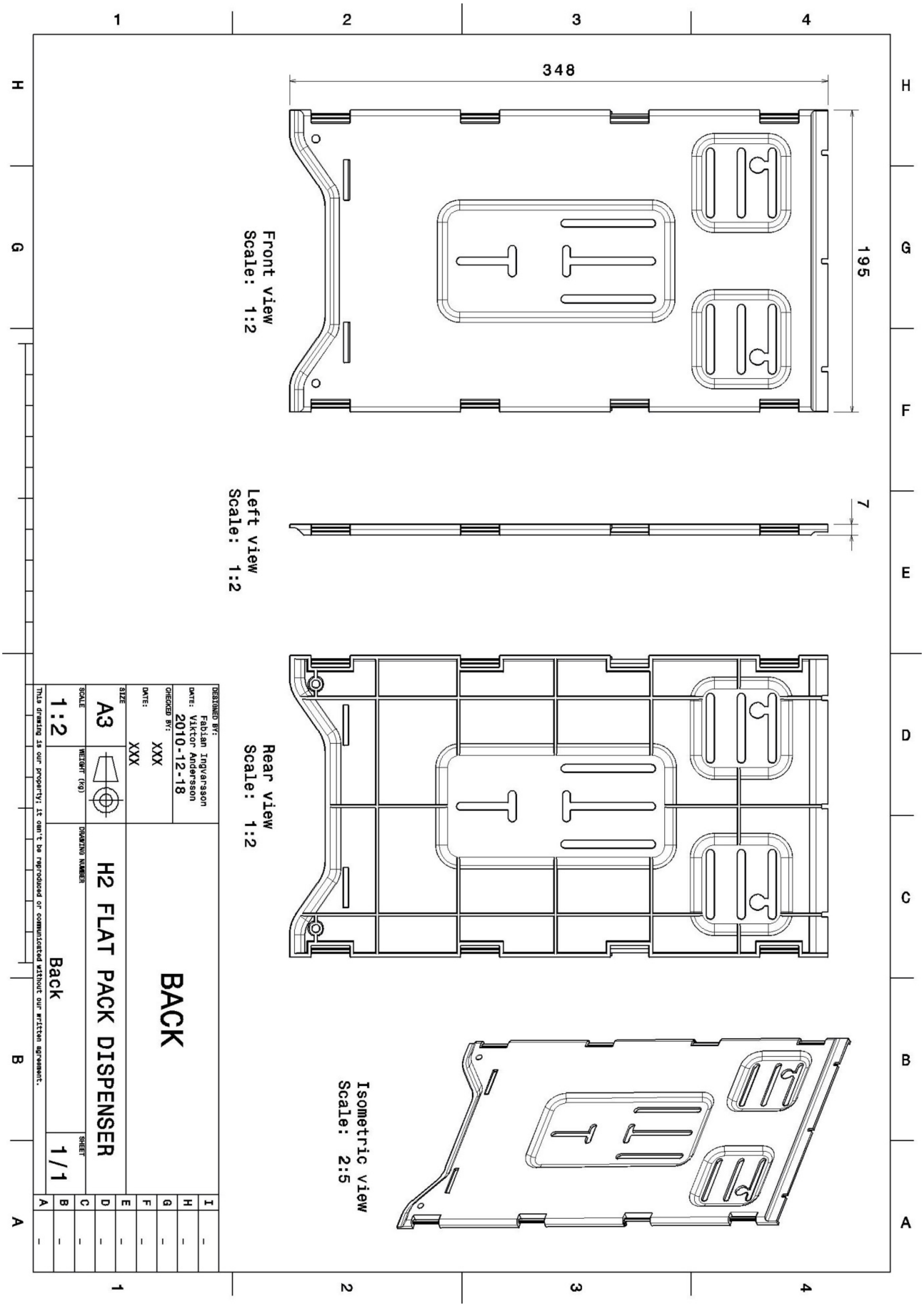


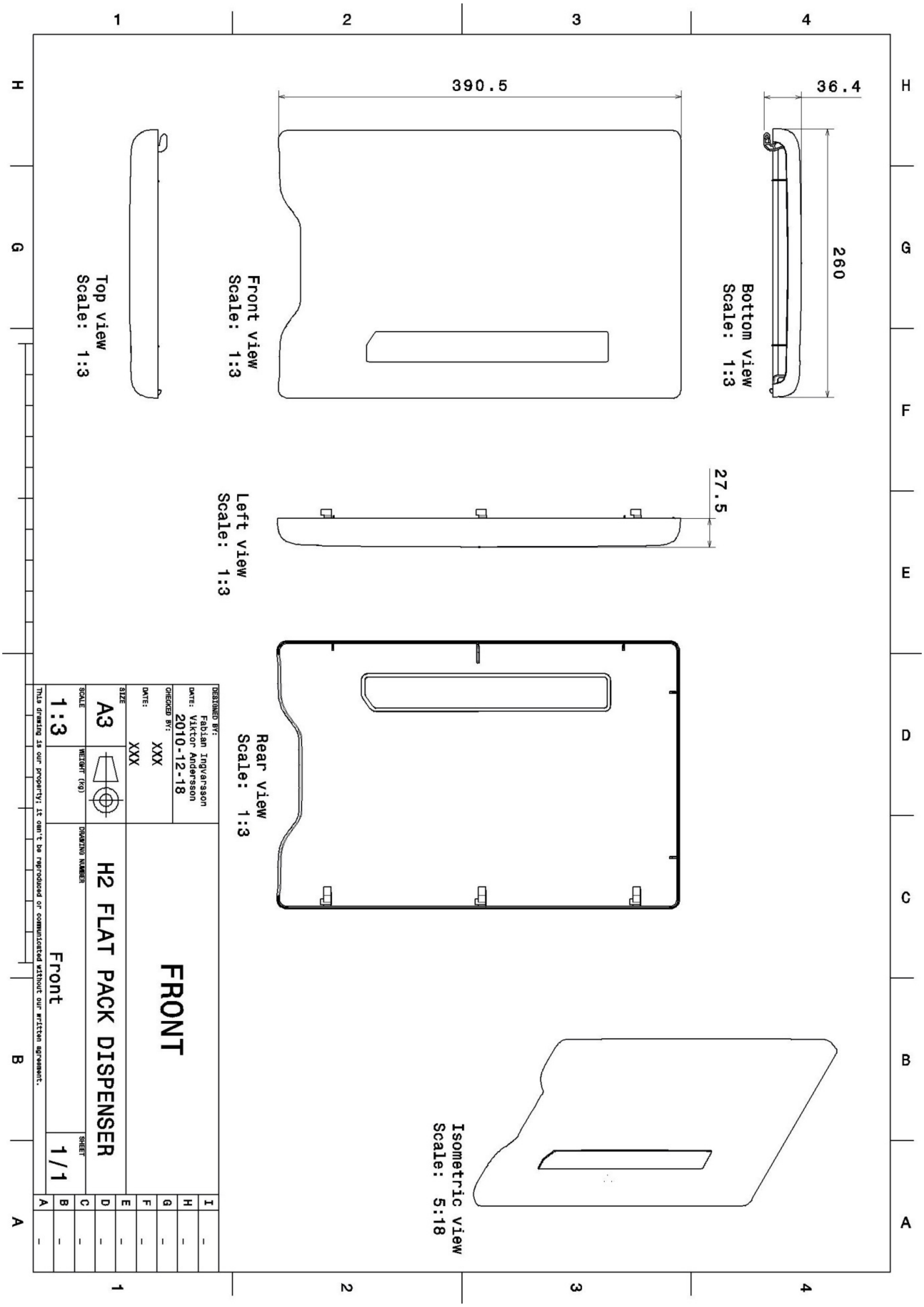
US	1	2	3	Average	Respondents	No response
k	35.9%	53.4%	10.7%	2.25	103	15
j	32.7%	24%	43.3%	1.89	104	14
l	32%	22.3%	45.6%	1.86	103	15
Total				2	104	14
Germany	1	2	3	Average	Respondents	No response
k	33.3%	60.6%	6.1%	2.27	33	9
l	39.4%	15.2%	45.5%	1.94	33	9
j	27.3%	24.2%	48.5%	1.79	33	9
Total				2	34	8
Shanghai	1	2	3	Average	Respondents	No response
l	44.4%	22.2%	33.3%	2.11	9	5
j	44.4%	22.2%	33.3%	2.11	9	5
k	11.1%	55.6%	33.3%	1.78	9	5
Total				2	9	5

Appendix I. Drawings

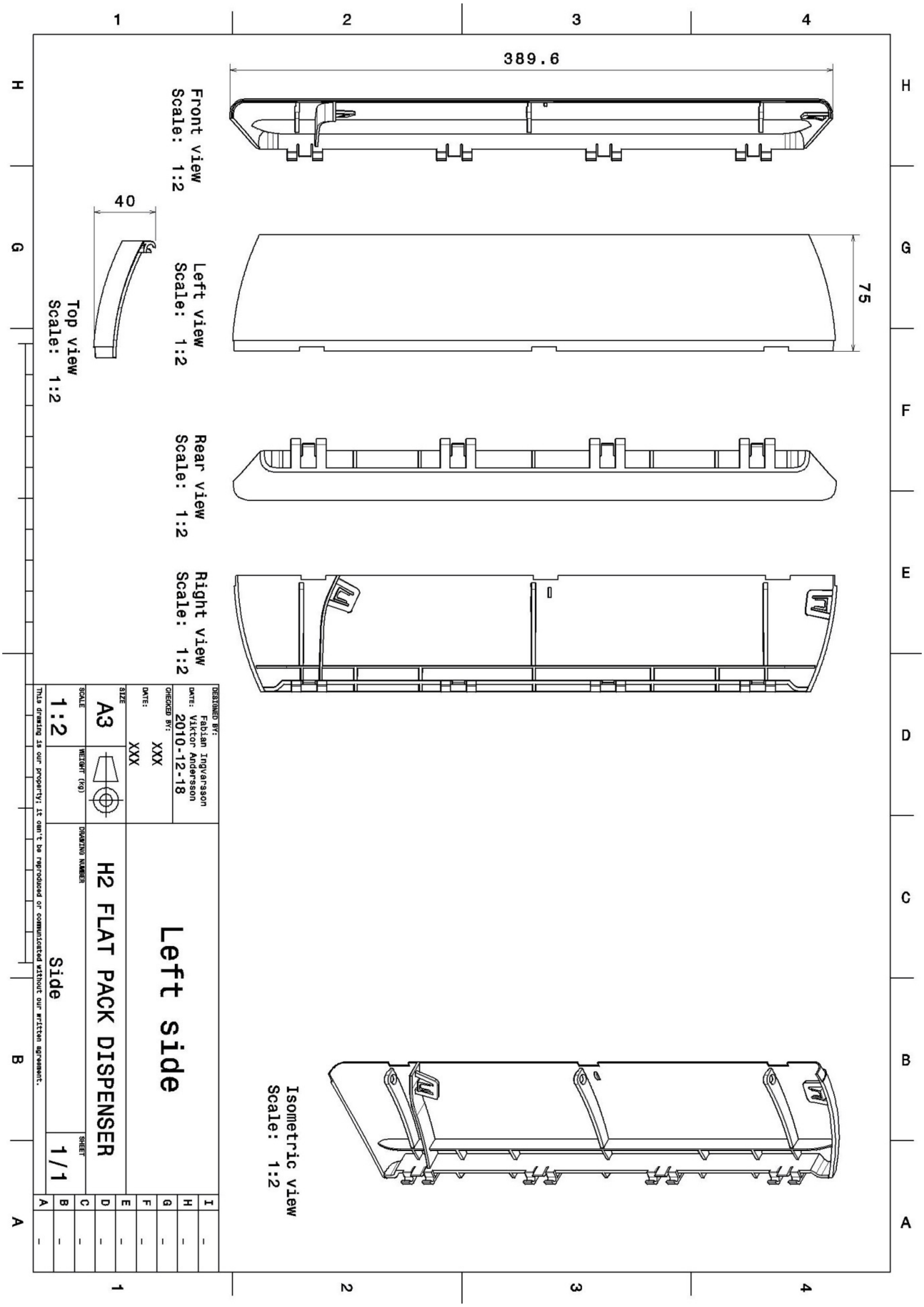



390.5
98.4
260
Front view
Scale: 2:5
Bottom view
Scale: 2:5
Left view
Scale: 2:5
Isometric view
Scale: 2:5
DESIGNED BY:
Fabian Ingvarsson
Viktor Andersson
DATE: 2010-12-18
CHECKED BY: XXX
DATE: XXX
SIZE A3
SCALE 2:5
WEIGHT (kg)
DRAWING NUMBER
ASSEMBLY
H2 FLAT PACK DISPENSER
Product1
SHEET 1/1
This drawing is our property; it can't be reproduced or communicated without our written agreement.

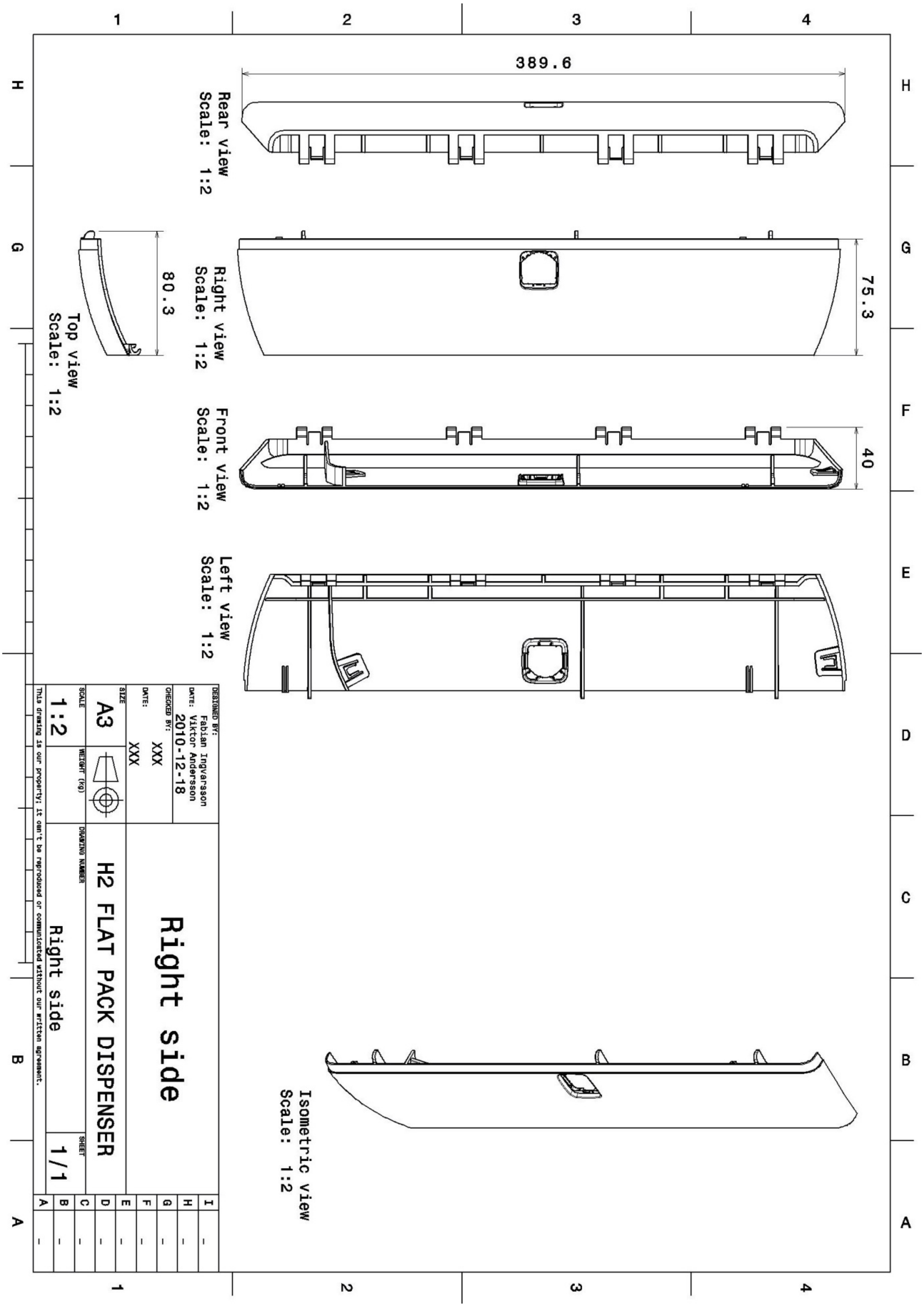

Front view
Scale: 1:2
348
195
Left view
Scale: 1:2
7
Rear view
Scale: 1:2
Isometric view
Scale: 2:5
BACK
DESIGNED BY:
Fabian Ingvarsson
Viktor Andersson
DATE: 2010-12-18
CHECKED BY: XXX
DATE: XXX
SIZE A3
SCALE 1:2
WEIGHT (kg)
DRAWING NUMBER
H2 FLAT PACK DISPENSER
Back
SHEET 1/1
This drawing is our property; it can't be reproduced or communicated without our written agreement.

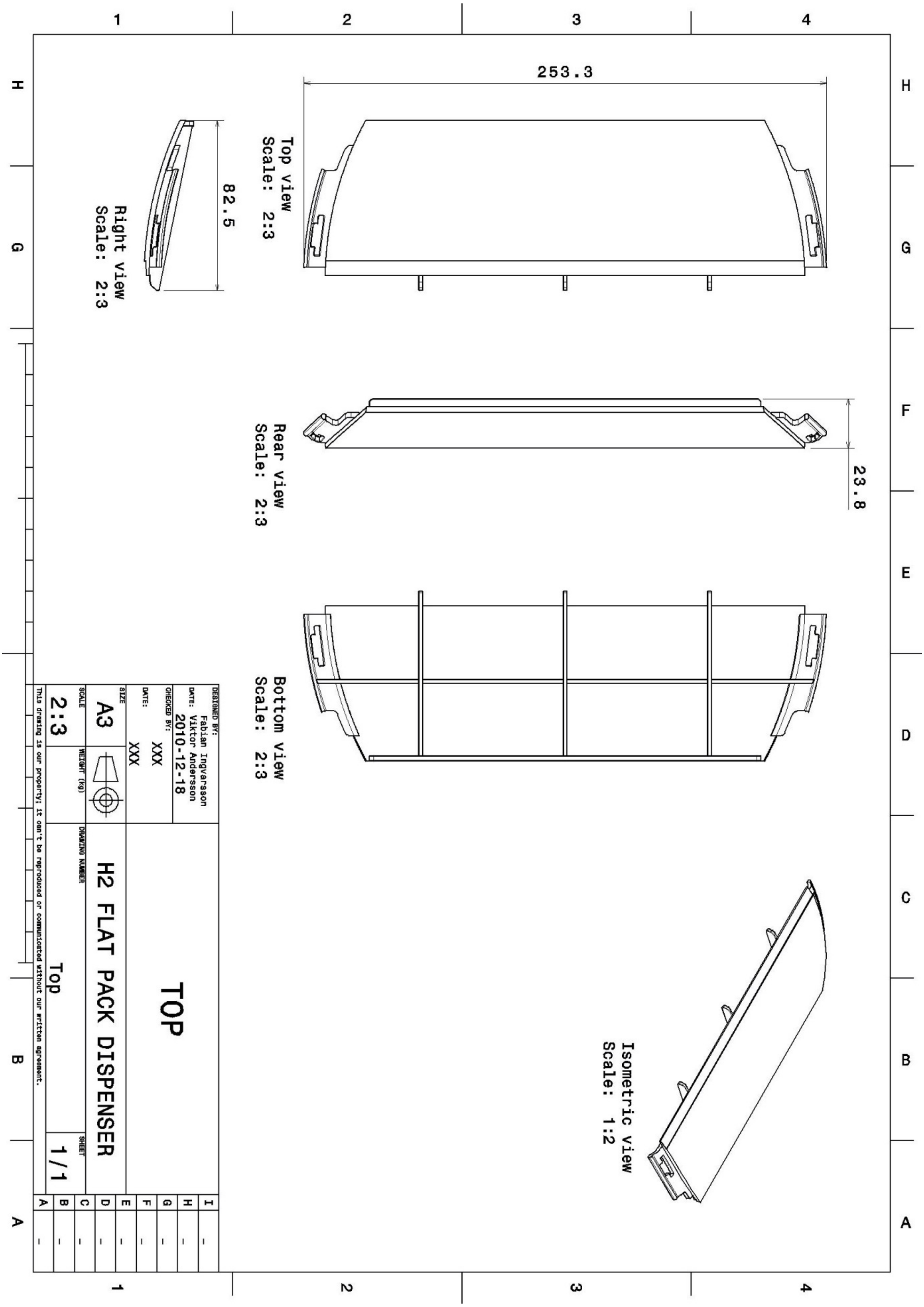


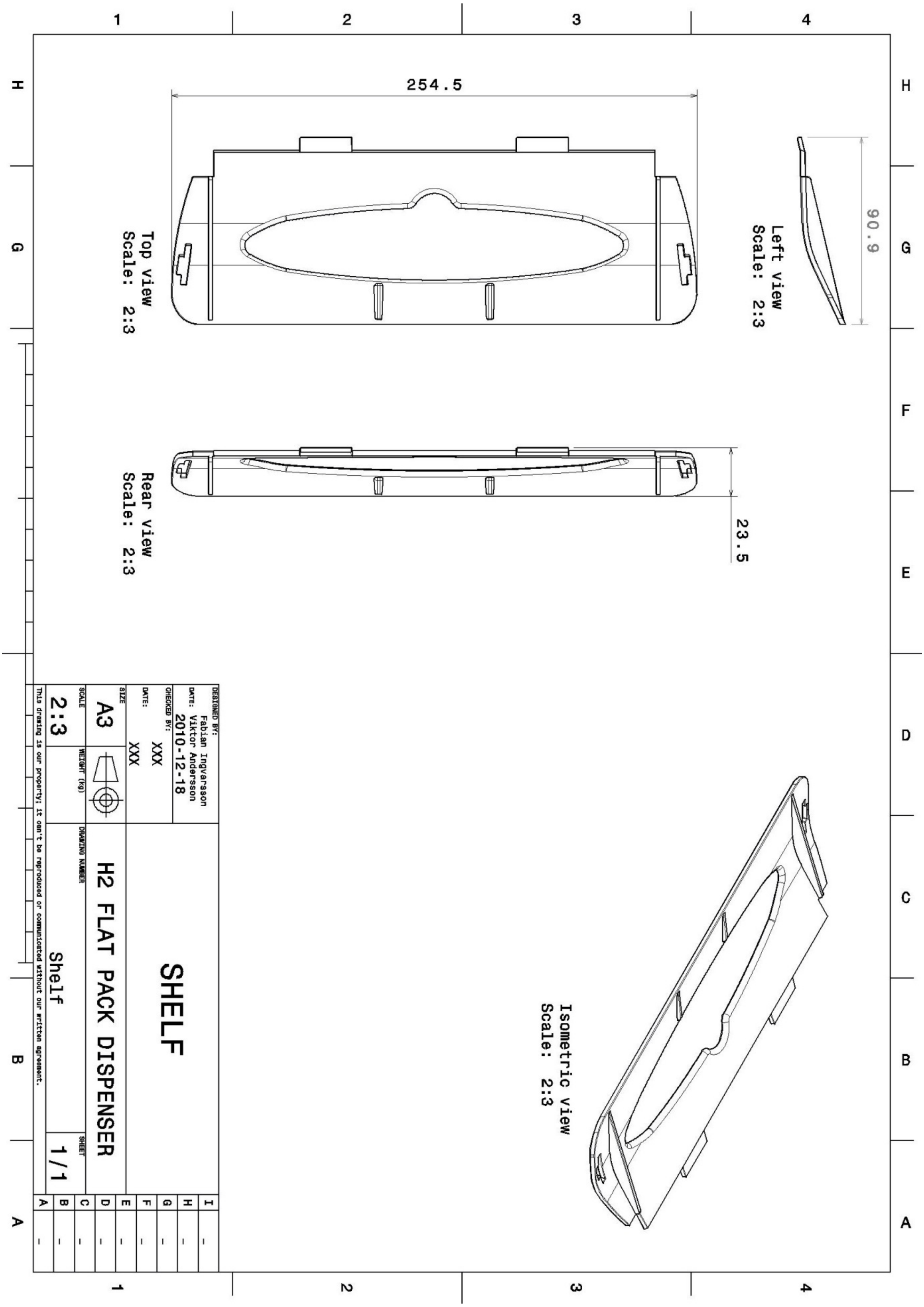
FRONT
H2 FLAT PACK DISPENSER
DESIGNED BY: Fabian Ingvarsson Viktor Andersson
DATE: 2010-12-18
CHECKED BY: XXX
DATE: XXX
SIZE A3
SCALE 1:3
WEIGHT (kg)
DRAWING NUMBER Front
SHEET 1/1
This drawing is our property; it can't be reproduced or communicated without our written agreement.
Front view Scale: 1:3
Top view Scale: 1:3
Bottom view Scale: 1:3
Left view Scale: 1:3
Rear view Scale: 1:3
Isometric view Scale: 5:18
390.5
36.4
260
27.5

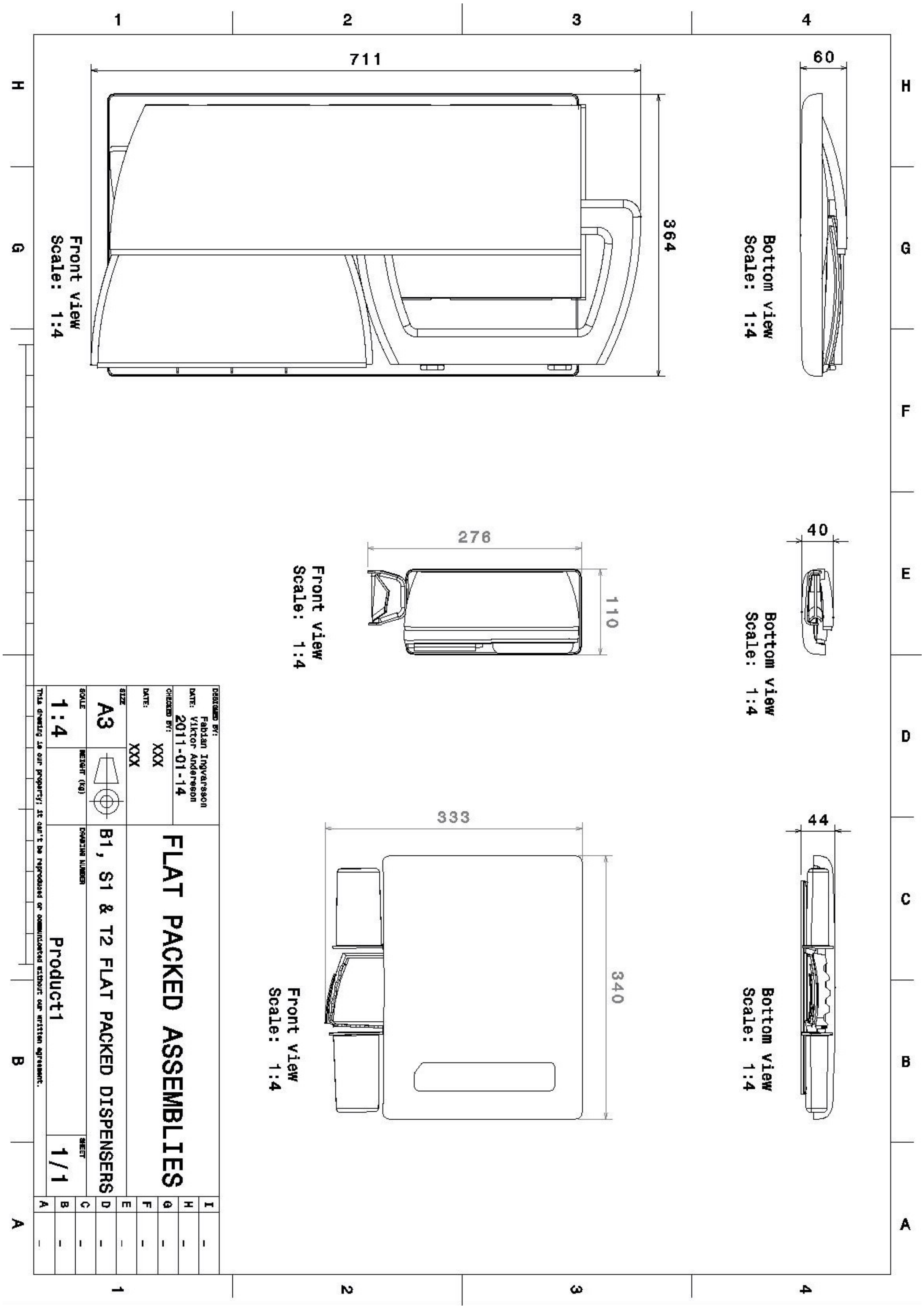


389.6
Front view
Scale: 1:2
40
Left view
Scale: 1:2
75
Top view
Scale: 1:2
Rear view
Scale: 1:2
Right view
Scale: 1:2
Isometric view
Scale: 1:2
DESIGNED BY:
Fabian Ingvarsson
Viktor Andersson
DATE: 2010-12-18
CHECKED BY: XXX
DATE: XXX
SIZE
A3
SCALE
1:2
WEIGHT (kg)
DRAWING NUMBER
Side
SHEET
1/1
Left side
H2 FLAT PACK DISPENSER
This drawing is our property; it can't be reproduced or communicated without our written agreement.


389.6
Rear view
Scale: 1:2
80.3
Top view
Scale: 1:2
Right view
Scale: 1:2
75.3
Front view
Scale: 1:2
40
Left view
Scale: 1:2
Isometric view
Scale: 1:2
DESIGNED BY:
Fabian Ingvarsson
Viktor Andersson
DATE: 2010-12-18
CHECKED BY: XXX
DATE: XXX
SIZE
A3
SCALE
1:2
WEIGHT (kg)
Right side
DRAWING NUMBER
H2 FLAT PACK DISPENSER
Right side
SHEET
1/1
This drawing is our property; it can't be reproduced or communicated without our written agreement.


253.3
Top view
Scale: 2:3
82.5
Right view
Scale: 2:3
Rear view
Scale: 2:3
23.8
Bottom view
Scale: 2:3
Isometric view
Scale: 1:2
DESIGNED BY:
Fabian Ingvarsson
Viktor Andersson
DATE: 2010-12-18
CHECKED BY: XXX
DATE: XXX
SIZE A3
SCALE 2:3
WEIGHT (kg)
TOP
H2 FLAT PACK DISPENSER
DRAWING NUMBER
Top
SHEET 1/1
This drawing is our property; it can't be reproduced or communicated without our written agreement.


254.5
Top view
Scale: 2:3
90.9
Left view
Scale: 2:3
Rear view
Scale: 2:3
23.5
Isometric view
Scale: 2:3
DESIGNED BY:
Fabian Ingvarsson
Viktor Andersson
DATE: 2010-12-18
CHECKED BY: XXX
DATE: XXX
SIZE
A3
SCALE
2:3
WEIGHT (kg)
DRAWING NUMBER
Shelf
SHEET
1/1
SHELF
H2 FLAT PACK DISPENSER
This drawing is our property; it can't be reproduced or communicated without our written agreement.


FLAT PACKED ASSEMBLIES
B1, S1 & T2 FLAT PACKED DISPENSERS
DESIGNED BY: Fabian Ingvarsson
Viktor Andersson
DATE: 2011-01-14
CHECKED BY: XXX
DATE: XXX
SIZE A3
SCALE 1:4
WEIGHT (kg)
DRAWING NUMBER
Product1
SHEET 1/1
This drawing is our property; it can't be reproduced or communicated without our written agreement.
Front view Scale: 1:4
Bottom view Scale: 1:4
711
364
60
Front view Scale: 1:4
Bottom view Scale: 1:4
276
110
40
Front view Scale: 1:4
Bottom view Scale: 1:4
333
340
44

Appendix J. Silicone prototypes

Figure 1: Rendered concepts in the prototype colors.

Table 1: Prototype colors of each dispenser part.

	White	Black	White/ Green	White/ Blue	Red	Grey metallic	Purple/ White	Orange/ White
								
Back/ Shelf	White	Black	Green transp.	Blue transp.	Red	Black	White	White
Sides/ Top	White	Black	Green transp.	Blue transp.	Red	Grey metallic	White	White
Front	White	Black	White	White	Red	Grey metallic	Purple	Orange
Windo w	White transp.	Black transp.	Green transp.	Blue transp.	Black transp.	Black transp.	White transp.	White transp.

Table 2: Color codes and number of units of each color.

Color codes & No. of units of each color	Back	Shelf	Left side	Right side	Top	Front	Window
White, NCS: S 0502-Y	3	3	3	3	3	3	
Black, S 9000-N	2	2	1	1	1	1	
Green transp., NCS: S 1080-G30Y (clear)	1	1	1	1	1		1
Blue transp., NCS: S 2060-B (clear)	1	1	1	1	1		1
Red, NCS S 1580-Y90R	1	1	1	1	1	1	
Grey metallic (Pantone 8400C metallic)			1	1	1	1	
Purple, NCS: S 6030-R30B						1	
Orange, NCS: S 1070-Y50R						1	
White transparent, NCS: S 3000-N (not clear; see sample)							3
Black transparent, NCS: S 8000-N (not clear; see sample)							3

Appendix K. Assembly instruction

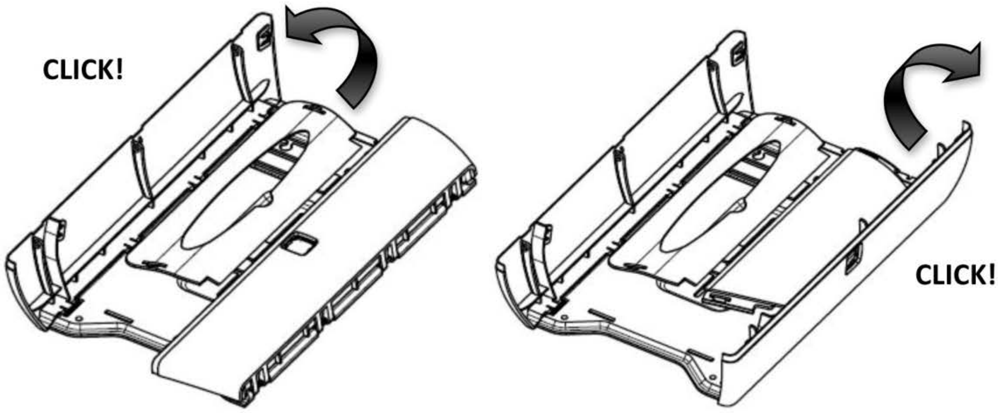
Dispenser

Hand towel

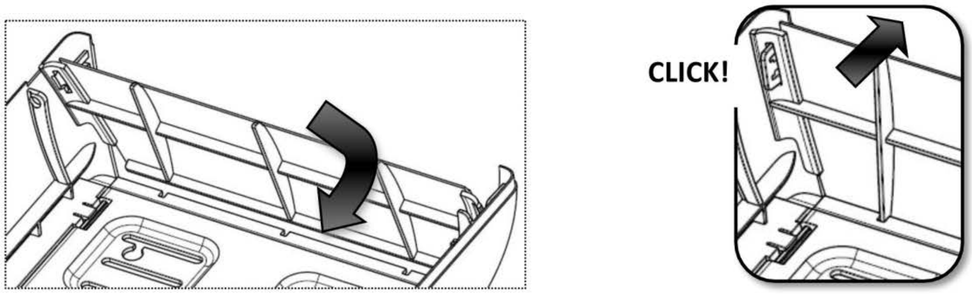
H2 System

Designed by Fabian Ingvarsson & Viktor Andersson
Prototype 2011

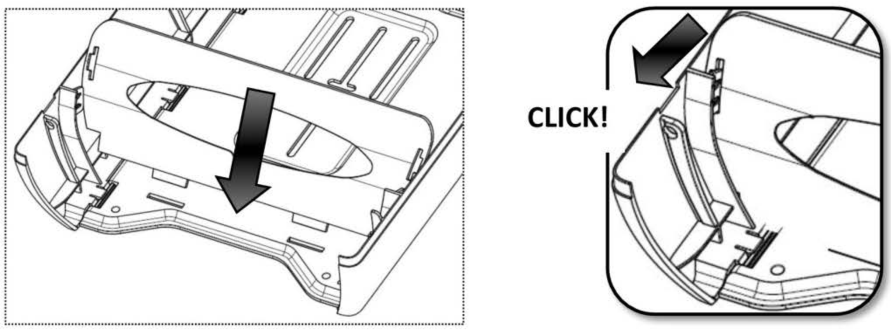
1



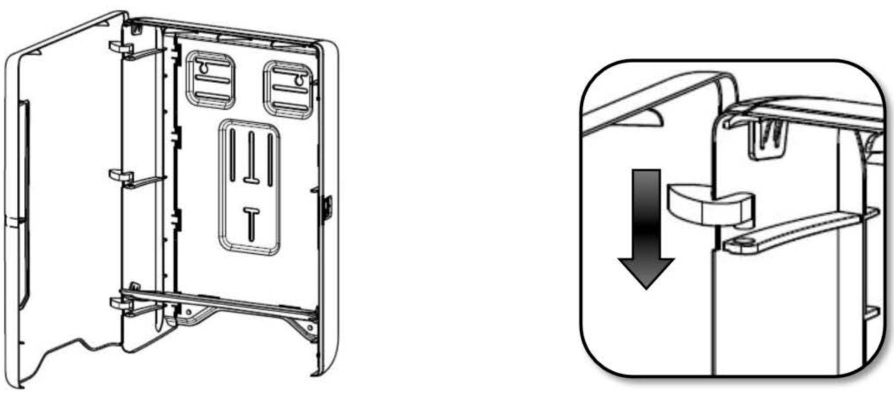
2



3



4



Appendix L. Cost estimation

Table 1: Production costs of an Elevation H2 dispenser. The figures were provided by the production company Gebrüder Schmidt.

Production Cost estimation, Elevation H2				
Pos.				**Cost**
	Production cost:			**76.0%**
		Unit cost	Quantity	
Pos.5	Printing	0.3%	3	1.0%
Pos.6	Lock	9.1%	1	9.1%
Pos.7	Printed plastic bag for Key, Plug, Screw	3.5%	1	3.5%
Pos.8	PE-bag for dispenser	0.7%	2	1.3%
Pos.9	Carton	7.6%	1	7.6%
Pos.10	Mounting Instruction	1.5%	1	1.5%
	Additional costs expected:			**24.0%**
	Total			**100.0%**

Table 2: Production costs of a Stealth H2 dispenser. The calculation was performed by the production company Gebrüder Schmidt. The Material is a standard ABS with a standard white Masterbatch.

Production cost estimation, Stealth H2								
Pos.	Name	Wight(gr)	Material	Cavity no.	Machine(to)	Operator	Cyl.time(sec)	**Cost**
Pos.1	Front/window	294/26	ABSwhite /transp.	1+1	450to 2-K	1	47	26.3%
Pos.2	Back	195	ABS natur	1	350	1	47	17.9%
Pos.3	Top/shelf	75/45	ABS white	1+1	270	0.5	42	9.5%
Pos.4	side left/right	114/114	ABS white	1+1	350	0.5	42	14.1%
	Production cost:							**68%**
					Unit cost		Quantity	
Pos.5	Printing				0.3%		3	1.0%
Pos.6	Lock				9.1%		1	9.1%
Pos.7	Printed plastic bag for Key, Plug, Screw				3.5%		1	3.5%
Pos.8	PE-bag for dispenser				0.7%		2	1.3%
Pos.9	Carton (Elevation quality)				7.6%		1	7.6%
Pos.10	Mounting Instruction				1.5%		1	1.5%
	Additional costs:							**24.0%**
	Total							**92.0%**

Table 3: Production costs of a low cost option for the Stealth H2 dispenser. The calculation was performed by the production company Gebrüder Schmidt.

Low production cost estimation, Stealth H2								
Pos.	Name	Wight(gr)	Material	Cavity no.	Machine(to)	Operator	Cyl.time(sec)	**Cost**
Pos.1	Front/window	294/26	ABS white/transp.	1+1	450to 2-K	1	47	26.2%
Pos.2	Back	195	PS natur	1	350	1	47	16.6%
Pos.3	Top/shelf	75/45	PS white	1+1	270	0.5	42	8.6%
Pos.4	side left/right	114/114	PS white	1+1	350	0.5	42	13.2%
				Production cost:				**64.5%**
					Unit cost		Quantity	
Pos.5	Printing				0.3%		3	1.0%
Pos.6	Lock				4.6%		1	4.6%
Pos.7	Printed plastic bag for Key				0.3%		1	0.3%
Pos.8	PE-bag for dispenser				0.7%		2	1.3%
Pos.9	Carton (Elevation quality)				1.6%		1	1.6%
Pos.10	Mounting Instruction				0.2%		1	0.2%
				Additional costs:				**9.0%**
				Total				**73.5%**

Table 4: Estimated shipping costs for the Stealth series in relation to the Elevation series. The last column shows the maximum allowed cost for a dispenser, according to the requirement saying that total cost (production + shipping) could not exceed the production cost of an Elevation dispenser.

Estimated shipping cost				Europe-Asia		Asia-Europe	
Product	**Line**	Volume	Units/container	Shipping cost	**Maximum allowed cost**	Shipping cost	**Maximum allowed cost**
H2	**Elevation**	100,0%	2500	12,8%	87,2%	27,7%	72,3%
	Stealth	29,2%	8550	3,7%	**96,3%**	8,1%	**91,9%**
S1	**Elevation**	100,0%	8100	7,0%	93,0%	15,2%	84,8%
	Stealth	35,8%	22626	2,5%	**97,5%**	5,4%	**94,6%**
B1	**Elevation**	100,0%	450	23,0%	77,0%	49,7%	50,3%
	Stealth	24,3%	1852	5,6%	**94,4%**	12,1%	**87,9%**
T2	**Elevation**	100,0%	2700	11,4%	88,6%	24,7%	75,3%
	Stealth	45,5%	5934	5,2%	**94,8%**	11,2%	**88,8%**