

Adjustable floor to ceiling storage unit

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Author's Declaration

I have written the Master's thesis independently.

All works and major viewpoints of the other authors, data from other sources of literature and elsewhere used for writing this paper have been referenced.

Master's thesis is completed under supervision

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Master's thesis is in accordance with terms and requirements “.....”201....

Supervisor signature.

Accepted for defence

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Master's Thesis task

2014/2015 academic year, 4th semester

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Adjustable floor to ceiling storage unit

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This thesis aims at developing a product, allowing tenants to get maximum use of their wall space, without the need of mechanical fastening.

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Abstract

This paper describes the process of developing a product aimed at the specific user group of tenants. Tenants experience limited freedom of possibilities to customize, personalise and alter their home environment, therefore this thesis is aiming at providing tenants with a product giving them freedom, and a sense of ownership over their rented home. Use of wall spaces is identified as a problem area for tenants, and an area of great potential for more efficient use. The floor-to-ceiling storage unit developed enables tenants to get maximum use out of their rented space, without infringing property owners' rules.

Introduction

Almost one third of the European population are living in rented accommodations. Living in a rented home comes with several advantages and disadvantages; in particular, this paper has focused on the lack of freedom a tenant might face during tenancy. Legislations and agreements limits a tenant's freedom to customize, decorate, personalise and in general do changes to their rented home.

This paper describes the development of a product that allow tenants to make changes and to customize their rented home, without infringing these rules. The paper is describing the process of the work from identifying possibilities, through the development of a concept, to the final design. The thesis is structured chronological and starts with a broad perspective research before it narrows down to a development brief, defining the direction for the further development and design work. The outcome described in the end of this paper, is a design ready for prototyping and testing.

Methodology

This master thesis is structured in two main sections, of which both of these contain two phases. The first section is for discovering and gaining knowledge and understanding about the topic of this thesis. Through gaining more knowledge about the topic, the area of focus is narrowed down and defined. The first section ends in a brief statement, functioning as the starting point for the second section. The second section is where the concepts are generated and developed. The generated concepts are developed and evaluated based on the findings in the first section, before it is developed into the final design towards the end of this paper. This working structure, which when laid out graphically forms the double diamond, is a diagram that was introduced by the British Design Council in 2005 (Design Council 2007)

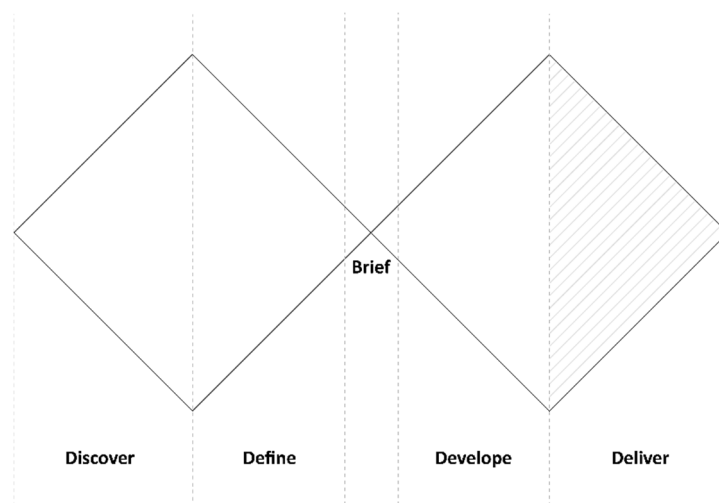


Figure 1 Double diamond diagram

1. Methods

In this chapter, the general working structure, as well as the major methods used are described.

1.1 Discovery phase

In the discovery phase, there was conducted research with a wide perspective, with the purpose of identifying problems, issues or opportunities through gathering and analysing information about the market, users, behaviours and other sources of information relevant to the topic. The discovery phase started with no clear idea of where the project might end up, and most of the early research was done to find a direction for the project. To start with, there was constructed a giga-map, in order to get an understanding and an overview of the topic. The giga-map approach was chosen in order to not only explore and understand the topic itself, but also the areas beyond the horizon of the topic. Only when the areas beyond the horizon is explored, can the boundaries of the work be drawn. (Sevaldson 2011)

In order to get a better understanding of how people use and move around in their homes, and with the aim of identifying additional issues and opportunities, behavioural mapping of users was conducted. A virtual user's day in its home was tracked, and the use of different areas of the home was identified and analysed. (Clyne u.d.) In addition, literature and statistics on relevant topics was gathered and analysed.

1.2 Define phase

The findings from the discovery phase gave direction for what to be research further in this phase. The discovery phase gave a good overview of the area of research, and it also gave a direction for the further work.

As the focus area of the thesis became more defined there was done more specific research on the users and their behaviours. There was conducted picture research and reviews of blog posts, where both the articles themselves were analysed, as well as the readers' response and attitude towards the topic.

1.3 Brief

In the brief section, the opportunities for the development and the user group to be targeted were summarised and described. The brief forms the basis of the further design work, and was written as a short description of expectations for the development phase.

1.4 Development phase

The development phase is where, based on the brief, possible design solutions are explored. In the development phase there were developed several concepts, in several stages. The concepts were evaluated with background in the disciplines of both design and engineering, to develop the concept that most precisely addresses the brief. During this process, the concept was refined, as the number of possible solutions were narrowed down.

As the design became more defined and started to take form, market research on similar products were done to identify where the product would fit in, and who the competitors are. (Design Council 2007) Through rapid prototyping, the proposed principles of the most feasible concepts were tested. (Lahn u.d.) The chosen concept was towards the end of the phase refined and developed further, for the product to be ready for prototyping and testing at the end of this stage.

1.6 Delivery

The delivery stage is where the final concept will be prototyped, taken through final testing, produced and launched to the market. (Design Council 2007) For the scope of this thesis however, the work ends at the development phase, and the prototyping will happen after submission of this paper.

Discover

During the discover phase, the perspective is kept wide to allow for a broad range of ideas and influences. In this phase, information is gathered and analysed in the search for an opportunity, idea, issue or problem to define the further work of this thesis.

2. Research

This master thesis did not start with any concrete brief or topic, but with the general idea of exploring nuisances in the home. This chapter was therefore used to explore the field of nuisances in the home, with the aim of unveiling and finding problems, issues and opportunities, to base the further work on. As interesting issues, problems and opportunities were identified, new and more specified research topics were explored. At the end of this chapter, this all adds up in a section concluding on the findings and setting the direction for the further work.

2.1 Nuisances in the home

In order to get a good overview, the first work done was to create mind maps. The mapping started out with identifying possible nuisances in the home, thereafter more detailed maps of the actual nuisance. The nuisances were looked at because they can suggest possibilities for improvement and further development. Furthermore, other relevant topics as users and locations were mapped out. These mind maps were combined into a complex giga-map, where connections could be drawn, patterns could be seen and observations could be categorised to improve the understanding of the topic.

2.1.1 Giga mapping

The mapping started out with identifying living spaces in a home, users of a home and types of homes. From these sub topics, there were done brainstorming on possible and known nuisances, issues and problems. There was also generated ideas, solutions and opportunities in this map. The map was created with the aim of generating and putting down vast amounts of information and ideas, which thereafter could be analysed to find interesting paths for the project. (Appendix 1)

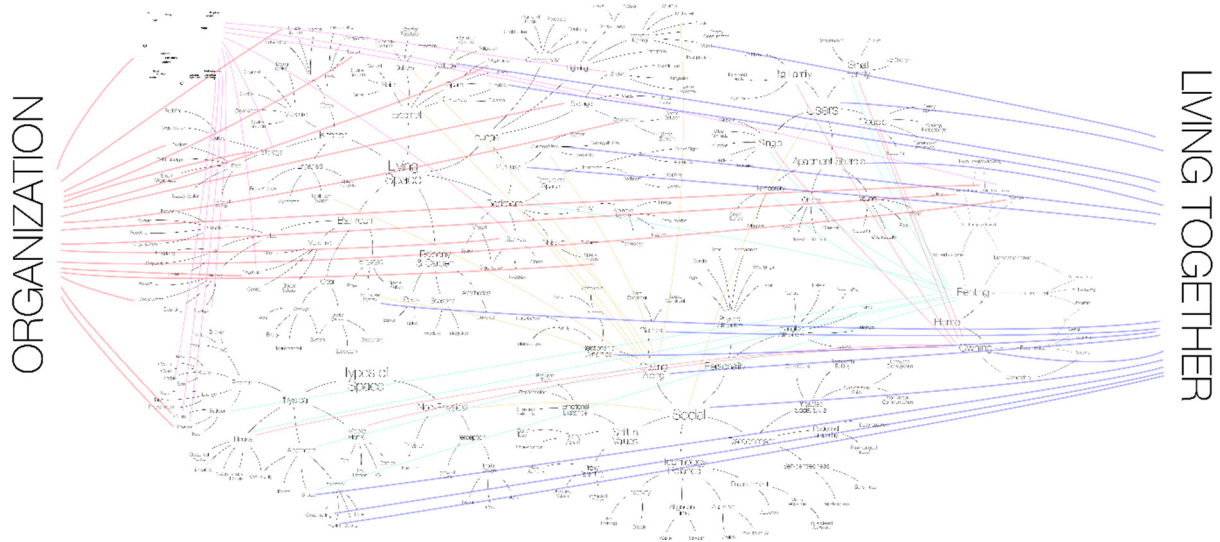


Figure 2 Giga-map

2.1.2 Findings

Through the work of creating the giga-map, there was gained a better overview of the broad topic. By analysing the nodes put down in the map, the information was filtered and interesting connections and patterns was discovered. The two main categories identified as a common factor for many of the generated nodes of the map, was organization and living together. The organization category is in this case identified as the interaction between the users and the environment, in terms of storage, systems and organization of items and spaces. The other category found was the aspects of person-to-person interactions when living together.

Issues relating to organization are related to storage, cluttered spaces, inefficient use of space and lack of organization of rooms and services in the home. The issues relating to living together are of more social character, and relates to getting along in a home, spaces with multiple users and different users duties and responsibilities. In general that is communication between users sharing a home.

One main difference between the two categories, was identified when mapping out the two different situations of renting a home, and owning a home. There are many aspects that are different between the two situations; one interesting connection found in the giga-map was how nearly all nodes related to organization would differ between the two ways of living. Organization of belongings and spaces, showed to be more complicated in the situation of renting a home, as this might come with rules about what sort of changes the tenant can do

to the property. As organization of your space seems to be more complicated when renting your home, the opportunity for developing a product for rented homes was seen as an interesting path.

2.2 Renting home

One of the findings from the giga-mapping process, apart from the main categories of organization and living together, was the observation of the difference between renting a home, and owning a home. When owning your own home, you are making your own rules, when renting, there are owners of your property that sets the rules for your use. In this section, several aspects of renting homes are explored. This section is looking at the relationship between the property owner and the tenant, and aims at finding out who the tenant is and how they act.

2.2.1 Property owners requirements

When renting a place, you will usually write a contract with the property owner. In this contract there might be stated that there should not be any holes in the walls, and that the property should be left in the same condition as when it was rented (apart from 'reasonable wear and tear'). There are of course differences in what property owners states as their requirements in the contract, although there are existing standard contracts and templates. An English agreement template for instance, states that the tenants must obtain written permission from the landlord to apply adhesive or insert hooks or nails to the walls. This requirement also counts for decoration work that would significantly alter the appearance of the property like painting or wallpapering. (Lawdepot 2015)

Some property owners might not allow the tenant to do any changes to the property, while other property owners might allow for more freedom. However, these property owners might still ask for getting the property back in the same shape as when it was rented out. For the more strict cases, that means that the tenant will have to find other ways of customizing the rented home to their likings, while in the case with more freedom, the tenant might have to restore the building to the standard it had when it was taken over. This means that the tenants in both cases would benefit from having 'hole free' or 'low impact' solutions, where even those tenants left with freedom of making changes, would not have to fill in holes and repaint when moving out.

2.2.2 Regulations

Different countries have different rules and regulations stating the tenants and property owners rights during a tenancy. The Norwegian tenancy act for instance states that; “The tenant may not without the consent of the landlord make any alterations to the rented property or to the remainder of the property”¹. In British Columbia in Canada the legislations state that; “A tenant of a rental unit must repair damage to the rental unit or common areas that is caused by the actions or neglect of the tenant or a person permitted on the residential property by the tenant.”²

None of these above mentioned regulations does however stop a tenant negotiate with the property owner about doing changes to the property. One interesting aspect, which often is referred to as ‘reasonable wear and tear’. The tenant must do normal maintenance to the rented property, and repair damages, but the tenant is most often allowed to leave the apartment without repairing ‘reasonable wear and tear’. This is where a problem might occur, a problem of definition, because the definition of wear and tear differs a lot from person to person. You could have the situation of a property owner seeing holes in the walls for hanging shelves, pictures or a TV as reasonable wear and tear to the property. The other scenario could be that you have a property owner seeing such holes in the walls as damage to the rental unit, which according to the Residential tenancy act in British Columbia for instance, would have to be repaired by the tenant. (Queen's Printer 2002)

Other types of permanent changes that one could be tempted to do to their rented home, could be to repaint walls to a colour of their liking. Repainting cannot be seen as damage to the property, but it can still be seen as significantly altering of the appearance of the property, (Lawdepot 2015) and something that does not keep the property in its original condition. Decoration and changes of decorative manner can, just as ‘reasonable wear and tear’, come into the category of problems with definition. If this is not been communicated

¹ Ministry of Local Government and Modernisation, Act No. 17 of 26 March 1999 relating to tenancy agreements (Tenancy Act), Section 5-4. Alterations to the rented property and to the remainder of the property

² Residential tenancy act (SBC 2002) Chapter 78, 32-2 *Landlord and tenant obligations to repair and maintain*

well enough with the property owner, the tenant might have to bring back the property to its original condition, or pay for this to be done by others.

2.2.3 Survey

A survey conducted by one fellow student, Mohammad Almutawa, for his master thesis, asked questions relevant to my thesis. His thesis is exploring multiple uses of spaces occupied by several users, and through this survey, he amongst other gauged peoples connectivity to their living space. One question in the survey was regarding whether the questioned had done changes to their home, or if they intended to do so. 61 % of the persons asked said that they have not done any permanent changes to their home, and 20 % said that they have not done any changes, and that they do not plan to do so in the future. In total that means that 81 % of those asked had not done any permanent changes to their home. (Almutawa 2015)

2.2.4 Statistical data about tenants

To gain information about who the people that are living in rented properties are, statistics on the topic was reviewed. Europe was chosen as the area for the research, as statistical information from Europe is easily accessible and covers several different countries. Aspects that were interesting to find out about were the demographics of those who rent, the size of their rented properties, occupants in rented dwellings and the share of people living in rented dwellings.

Tenure status

Statistics on tenure status in Europe was gathered from Eurostat. The statistics show that overall for the EU-28 countries, 27,4% are living in a property which they do not own. This includes regular tenants, renting at market price, as well tenants living in accommodation for a reduced price or free accommodation.

The extremes however are Romania and Switzerland, in Romania 96,6 % of the population are living in an owner-occupied dwelling, in Switzerland on the other hand, the majority are tenants, with 56,1 % of the population living in a rented accommodation. (Eurostat 2014)

The tendency is that more people rent in higher cost countries.

Household type

In 2011, the most common household type in Europe was single persons living alone, with 31,4 % of the Europeans doing so. (Eurostat 2011) A report on housing statistics in Europe shows that people that rent their accommodation also are more likely to have fewer housemates. Almost all countries assessed showed the same trend of fewer occupants in rented accommodations. The same paper also shows that tenants, on average will have fewer rooms per person than those in owner-occupied accommodation. (The Hague: Ministry of the Interior and Kingdom Relations 2010)

Income

Eurostat's statistics for distribution of population by tenure status, type of household and income group, gives an insight into what economical condition the tenants of Europe are in. The statistics are showing whether people are below or above the 60% of median equalized income, which is a common method of measuring poverty, where those below are defined as 'at-risk-of poverty'. For tenants overall, which as described earlier, also includes people living in free accommodation or accommodation with reduced rent, the majority of the renters are below the 60% median. This also counts when only measuring tenants renting at market price. For both the groups, the share of people under the 60% of median equalized income is approximately 65 %. For those living in an owner-occupied dwelling however, the majority have an income over 60 % of the equalized median. (Eurostat 2015)

Demography

There could unfortunately not be found any relevant demographic data related to tenure status for Europe overall. There was however found this kind of statistics for specific countries. Statistics from England and Wales show that the age group that are most likely to rent their accommodation are those aged 25 – 35. There are also quite a few renting in the other age groups, but the main trend is that the number of renters decrease in the older age groups. (Office for National Statistics 2011) Data for Denmark, which is a country with a high percentage of tenants, showed the same tendency of people aged 24 – 34 being most likely to be living in a rented accommodation. The most common building type for tenants in Denmark was multi-dwelling housing. (Statistics Denmark 2010)

2.2.5 Insights

With the help of the numbers above, an outline of a group of users could be drawn. The typical tenant is between 25-35, he/she is likely to have an income below 60 % of the equalized median and he/she lives alone in a dwelling where he/she possess just under two rooms on average.

The research described shows that there are many differences in rules for what tenants can, and cannot do to their rented property. Common for most situations though is that tenants would benefit from having solutions allowing them to use their walls and to customize their apartments, without having to make holes, or in general doing permanent changes to their rented property. The survey mentioned also suggest that people do not do, or do not wish to do permanent changes to their homes.

2.3 Use of space

As identified during the work of giga-mapping in the start of this phase, many issues, problems and opportunities relates to how people organize and use their space. This part of the chapter aims at getting a better understanding of how people use their homes, in terms of organization of belongings and space. This is done through tracking virtual users' movements and actions in the home, as well as reviewing articles, pictures and literature related to the topic.

2.3.1 Mapping of use

To get a better understanding of how people are acting in their home, and how they use their space, behavioural mapping of two users' journey in the home was conducted. A standard layout of a 1-room apartment, containing an entrance, bathroom, kitchen and combined living and sleeping area, was established for the mapping. By simulating a full days scenario, and tracking the movements and actions of the user during these hours, maps of two different users' paths of movement was created.

User one for this mapping was a 25 years old man, possessing a full time job, and the mapping takes place from when the user comes home from work until he leaves again the morning after. User two is a 35 years old woman working from home. Her mapping is done from she gets up in the morning until she goes to bed again at night.

On the basis of this map, and the users path, the different areas of the apartment can be put into different categories according to how they are used, as well as how much they are occupied by the user. The categories used for this map was 'pathways', 'passive' and 'active use'. The pathways are the area of the apartment which mainly is being used for getting between the different areas of the apartment. Beside being used for moving around, these areas also gives the user a feel of space, and can therefore not be seen as unnecessary space. The passive areas are defined as areas which store belongings, as well as furniture. The term of storage is in this case used in the broad understanding of the word, where all items which are not physically being accessed by the users, is seen as stored items. The areas for active use are the areas where the user physically is spending time.

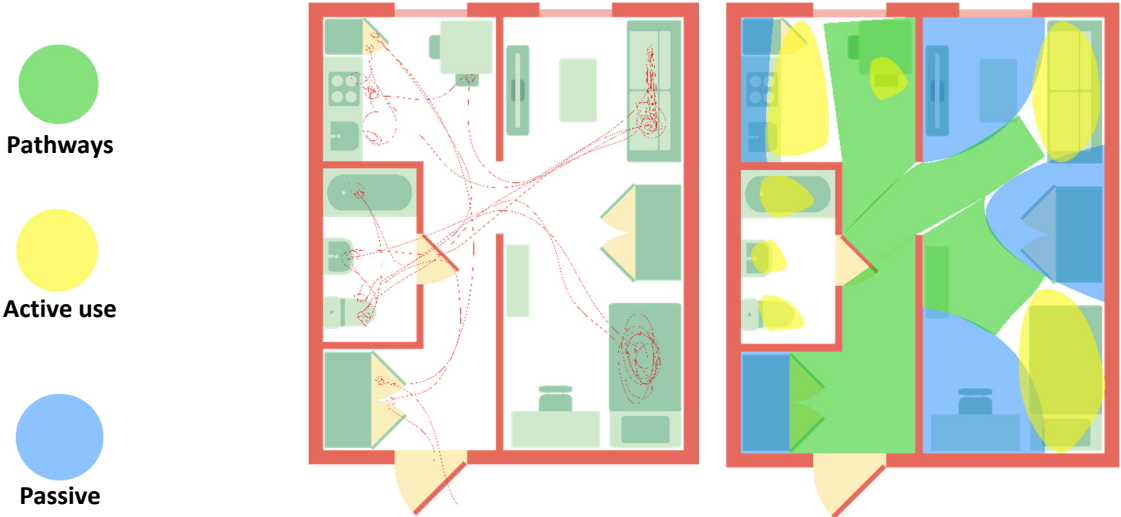


Figure 3 Map of use, user 1

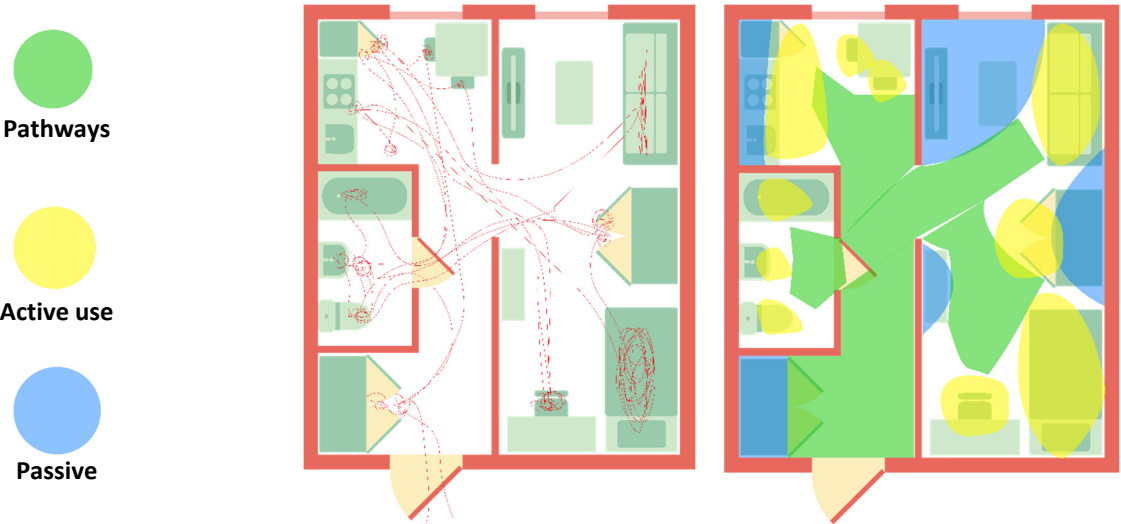


Figure 4 Map of use, user 2

The maps above are showing the two virtual users' movement in the same apartment layout. The colour-coded maps on the right suggest that there are many similarities between the two user scenarios. Especially the green areas for pathways are showing how most of the central part of the apartment is used for transportation purposes only. Although these pathways is helping with giving the users a feel of space in the apartment, there is also a lot of space going to waste in these areas.

Out of the colour coded map, there can also be seen the tendency that all functions and areas of active use tend to be located along the walls. This is also the case for the passive areas. There might therefore be opportunities in exploring how moving storage functions from the passive areas, into the areas identified as pathways, could free up more space for active use along the walls. Judging from how the average home is furnished aswell, people seem to prefer furnishing along the walls, and possibilities for using the walls, without obstructing such furnishing was seen as a possible way to progress.

Section view

The map of use analysed the use of an apartment by mapping the users' activity on a 2 dimensional scale. The two dimensions gave a good overview, but there was also seen a need for the third dimension, to properly see how the space is used. Based on the same plan view as used in the user mapping above, there was drawn section views of the apartment to see how the space were being used. The two users use was mainly similar in the area where the sections cuts was made, therefore the two maps of use are merged together for this section view.



Figure 5 Map of use, section 1

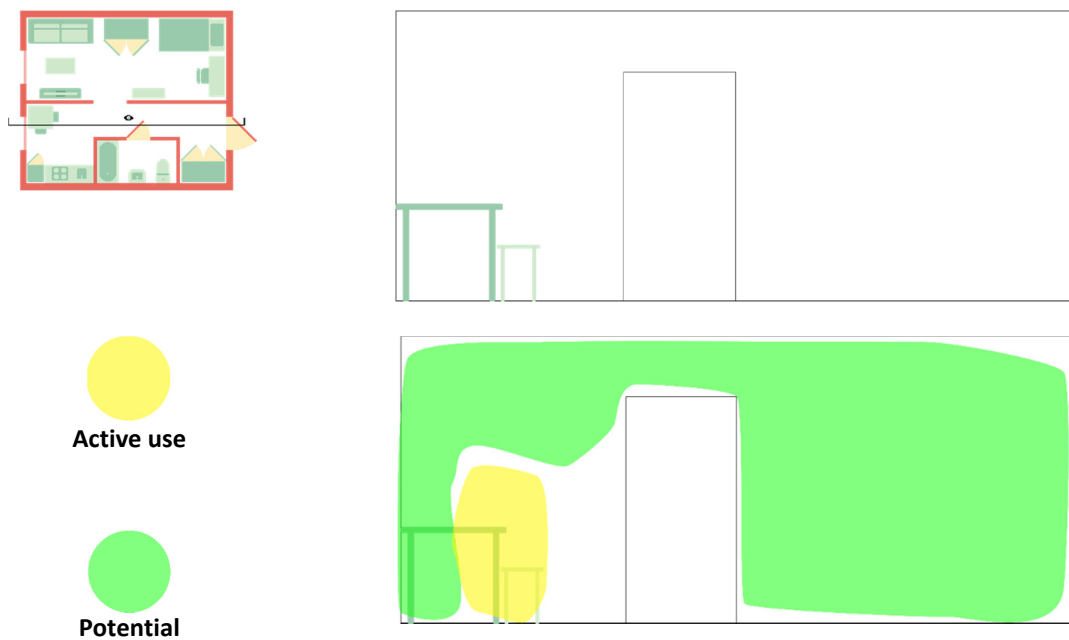


Figure 6 Map of use, section 2

By looking at how the apartment is used, through a section view, there was found a lot of possibilities for more effective use. In both the areas of the apartment illustrated, there is a lot of wall space above the areas of active use that are empty, and therefore can be seen as areas of unused potential. There are also identified unused areas under furniture such as beds, sofas and tables. In the corridor, which earlier was mapped as a 'pathway', there is a

whole wall surface, which is not being used for any purpose. This can be seen as a result of the size of the area, which would be inappropriate for traditional furnishing. Slim storage solutions could although be seen as a good way of moving storage into the pathways referred to in the mapping of use.

2.3.2 Sustainable storage

There was done online research about storage, and mainly storage of clothes. There was reviewed pictures, articles and blog posts on the topic, and the area of sustainable topic showed to be reoccurring. Sustainable storage is in this paper referred to as storage which gives you more use of your belongings, and storage that makes you aware of what you own, enabling you to use more of what you have. Of the several articles and blogposts reviewed, many suggest that you should store your clothes and belongings on display, or at least not hidden. This is said to be a good approach to use more of what you have, and stop you from buying unnecessary new items.

In a series of documentaries on Norwegian television, about architects' homes, the viewers get an insight into how the architects themselves live. In an article from this program, architect Cecilie Wille tells about how she managed the challenge of living in a small apartment in the middle of Oslo with her family of four. Her best tips for living in small areas is to keep only what you need, assign all items to their own place, build tailored storage solutions for all rooms and to hang things on the walls. She also points out that shallow shelving is more efficient, as it takes up less space, and it displays the stored items more prominently so that you always have an overview of what you have, and nothing will get lost in deep shelves or drawers. For the same purpose, she also suggest making storage units as open as possible, meaning with no doors, or at least semi open. (Wille 2015)

Some refer to the well-known 20-80 ratio, in this case meaning that people use 20 % of their wardrobe, 80 % of the time. Many of the sources mentioning how little we use our clothing also propose solutions to the problem. Although the solutions are different, most of them aim at making it visible for you what you wear and what you do not wear. The solutions also suggest that what you can see, you are more likely to actually use and wear. There are methods suggesting that you should store all clothing you have been using in the most remote corner of your closet, allowing new items to be more visible. (Karol 2012) Another solution that comes up often when reading about this issue is to use your hangers to keep

control over what you have been wearing lately. The method is to hang all your clothing with the hanger the 'wrong way', and put back everything you have been using with the hanger facing the 'correct way'. In this way, you can easily see what have been worn, and maybe consider getting rid of items that have not been used for a certain period. (Santoro 2015)

There are many opinions about how storage should be done, some recommend closed storage to give your space a more tidy look, others recommend open and easily accessible storage, for the reasons mentioned above. In the search for practical, open storage solutions, there were found several smart and good looking solutions, and by looking at the comments under the articles and pictures, there was also seen a general positivity towards the open storage. Readers seem to value things as simplicity, displaying of belongings and accessibility. (Wong 2014) (Kim 2010)



Figure 7 Accessible storage (Wong 2014)



Figure 8 Erika Kitchen System (BLTD 2007)



Figure 9 Open storage (Kim 2010)

Not only are people posting online about how you should store your clothes in an efficient way, there are other more creative souls out there that also suggest that your wearable items can get an additional use as decoration. (Gerstein 2014) By doing some simple searches on the picture sharing site pintrest.com, several more instances of wearable and usable items used for decorative purposes was found. Using items you already own, and that have a useful purpose, for decoration, could fit for, and promote a more sustainable and economical lifestyle.



Figure 10 Pinterest pictures of wearable items as decoration (Pinterest 2015)

2.3.3 Insights

The mapping of use described at the start of this section, shows that there is a lot of unused potential in the space of a home. The mapping unveiled possibilities for freeing up more space for active use, by moving spaces designated to storage to other areas of the home not adequate for use by persons. Specific areas that can be seen as possible for storage purposes in the home could be wall spaces, space used as 'pathways', or even space close to the ceiling, above the areas of active use.

The topic of storing belongings on display to keep them more accessible and to get more use of them was reoccurring while doing online research. The combination of storing on display, for the purpose of getting more use out of belongings, and the thought of using stored items as decoration is also seen as highly interesting.

2.4 Direction

The giga-mapping done at the early stages of the research suggested that there are several nuisances, issues, problems and opportunities related to organizing belongings and spaces in the home. There was also found that such organization might be more complicated when living in a rented home. This observation was supported by the findings described in the part of renting home.

The mapping of use unveiled possibilities for freeing up more space for active use, by storing smarter and more efficiently, in areas not suitable for active use. One specific area fitting for such storage showed to be wall spaces. Use of wall spaces was also identified as a problem area for tenants, and the opportunity for providing low impact wall storage for renters was seen as an interesting direction.

Define

The define phase takes in all the information and findings obtained through the previous phase, and works as a filter where the most interesting, and highest potential areas are looked at more closely. The define stage is used for obtaining more knowledge about the topic, in order to be well prepared for the coming development phase.

3. Defined research

To continue within the topic of tenants' changes to a rented property, there was a need for more specific research in the field. There was looked at smart solutions people use to bypass the rules when they rent homes, allowing them to make changes and customize their rented homes. Inspiration drawn from smart solutions that tenants use to make non-permanent changes to their rented homes could also be useful for the further development.

3.1 User behaviours

The internet unveils a huge amount of forums, blogs and articles where people show of, and show each other how to customize and decorate a rented home, without interfering with the property owners rules. There are solutions for decorating, without leaving a mark after yourself when you eventually move out, and there are solutions for hanging and storing items without mechanically fastening anything that would leave holes.

3.1.1 Tension rods

The most traditional and well-known use of the tension rod, is for hanging shower curtains, without having to penetrate the water tight membrane in a bathrooms walls. In this part there are shown other smart usages of the tension rod. People have found smart uses for tension rod of all sizes, for both storing smart and efficiently, decorating, and for dividing spaces without putting up conventional walls. They are being used in their intended horizontal orientation for storing light weight items like children's clothing, or like a shelf for food items or even for the decorative purpose of hanging lamps of it. They are also being used vertically for organizing storage, as well as in larger scale for making room dividers, or even storage units. (Isobel King 2012)

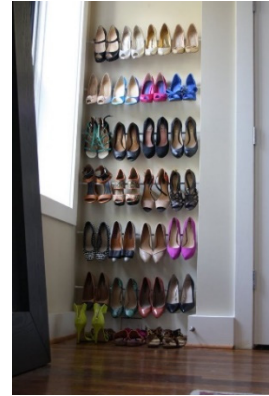


Figure 11 Smart uses for tension rods (Isobel King 2012) (Pinterest 2015)

3.1.2 Tape decoration

Decorating, customising and making a home feel like yours can often be a challenge if your property owner puts you under strict rules. There are a lot of pictures, blogposts and articles online showing how people are using tape in many different ways for decorating their home, without painting or having a permanent impact on the building. There are two main directions for tape decoration of walls; one is to use simple coloured tape to make your own decoration on the walls (Figure 12) (WashiTapesNL u.d.), while another approach is wall stickers, which comes in many different designs. (Figure 13) (Adelina u.d.)



Figure 12 Washi tape on wall (WashiTapesNL u.d.)



Figure 13 Wall sticker (Adelina u.d.)

3.1.3 Wall attachments without nails

A common way of customizing, personalizing and decorating a home is to put up items on the wall, such as pictures, posters and shelves. There has even become a trend in recent years to put up more heavy items, like bicycles as decorative items on the wall. The internet unveils many smart solutions for putting up such decoration, without doing an impact on the buildings construction. There are several instances where 'wall friendly tape' is being used (Jordan 2014), which is claimed to be gentle, and not to leave any mark or damage any wall surface. Such tape is being used to hang pictures on walls (Figure 15), and there are even examples of other bigger items being held up by such tape (Figure 16) . (Pinola 2013) (Pinterest u.d.)

The products featured in the articles read were the Command™ refill strips, which originally are made for use with other products from the provider, such as wall hooks. (3M Command u.d.) The comments under this article (Jordan 2014) are mostly very positive, and commenters are much excited about trying out these products, or they are telling about their good experience with the products. Especially people talk positively about the benefits in the situation of renting a home, as well as the freedom this solution gives of changing around their decoration without filling the wall with unwanted holes. Although most of the comments are positive, and suggest that this kind of product is gentle to all surfaces, there are comments warning about how the tape damaged their walls, or about how careful you have to be when removing such tape of the wall.

Other solutions found were solutions where the wall is not even touched, but an extra structure is put in front of the actual wall. Such extra structures serves as an extra wall structure on top of the actual wall. There are both simple solutions where frames of wood simply are placed along the wall (Figure 14) , and there are solutions with floor to ceiling constructions held up by tension. (Combiths 2014)



*Figure 14 Picture stand
(Combiths 2014)*



Figure 15 Picture with command strips (Jordan 2014)



Figure 16 Shelf hung by adhesive (Combiths 2014)

3.2 Conclusion

As mentioned in the paragraph about property owners requirements in the previous phase, there are not all property owners that prohibit you from making holes in the walls.

According to the articles researched, it still seems like many rather would prefer not having to fix up their mistakes when moving out. With ‘hole free solutions’, like those described above, the users are also more free to do changes to their homes more often, and the commentary fields under the articles shows enthusiasm from the readers about these smart, practical and easy solutions.

4. Brief

By summarising what was found in the research section, problems, issues and opportunities are collected and analysed. By analysing these findings, the projects further direction can be decided, and the brief is formed in order give direction for the further development of the project.

4.1 Target user

In the discovery phase, statistics on who are renting their accommodation in Europe was gathered and analysed. The results were used to define who the user group are. The main features of the user group is that it consist of about an equal amount of men and women, that for the most part are single, between 25 – 35 years old and is likely to have an income below 60 % of the equalized median. Their rented properties are usually small with an average just under two rooms, where most of them live alone. The share of people renting their home is also highest in high cost countries. (Eurostat 2014) The research also shows that most of the tenants does not want, or are not allowed to do permanent changes to their rented property.

4.2 Opportunity

The research shows that there is a great potential in using wall space in different parts of a building for storage purposes. The research also shows how wall storage, and permanent changes, can be a problem for tenants, as their property owners might have rules against making holes in walls, or in other way changing or damaging the property. Research on how tenants go about to get full use of their space, while not infringing with their property owners rules, also suggest that the users wants to customize their space, and could also be used for inspiration for the further work. Comments from the readers of the reviewed articles also show great excitement for these smart solutions. The research also suggest that storing items on display is beneficial for those that want to get more use out of their belongings, and this fits well with the interesting phenomenon identified, of using wearable items as decoration.

4.3 Development brief

This project will aim at developing a storage solution for tenants, allowing them to get maximal use of their wall space, without making an impact on their building and infringing their property owners' rules. The product should allow for visible storage, allowing stored items to work as decorative pieces, as well as giving the users good accessibility to, and overview over, their belongings.

Develop

In this phase, the knowledge and insights obtained in the previous two phases will be implemented into the development of a concept addressing the brief described above. The development will go through several stages where the early concepts are presented and evaluated at the start, before the development progresses as the concept increasingly is defined through evaluation of possible solutions. This phase aims at coming out with a final design, ready for prototyping, that addresses the issues stated in the brief in the best possible manner.

5. Concept development

This chapter describes the development of the concepts for 'low impact' storage on walls. In this chapter, conceptual ideas for further development are presented and evaluated. The solutions proposed looks at how items could be stored on the wall, in terms of how they physically are placed on or along the wall. Through evaluating the generated concepts based on set criteria's, one concept will be chosen for further development.

The research suggest that important keywords for the chosen concept are accessible, adjustable, customizable and decorative. There was established a mood-board consisting of solutions reflecting these features, to set the direction for what values the chosen concept should communicate.

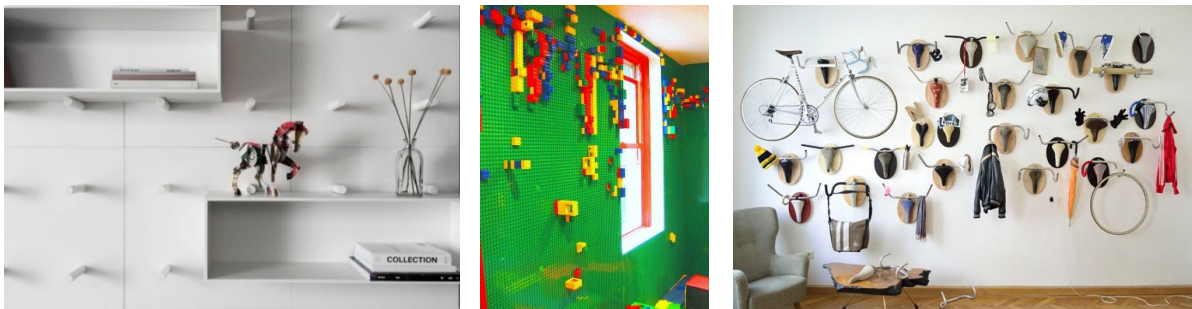


Figure 17 Concept mood-board (Pinterest 2015)

5.1 Hung

To make the wall storage a versatile product, which could be used in any home, there was looked for features most homes has, that could be used for the wall storage. One element that most homes has are mouldings, both in the joint between floor and wall and between wall and ceiling. With the hung version of the wall storage, the storage would hang form the mouldings, leaving no screw or nail holes in the wall.

There was explored different ways of using the mouldings to carry the wall storage. The concept illustrated in the pictures below shows how the concept consist of hooks or brackets at the top, of where the storage is hung. These hooks can be placed anywhere along the wall, allowing for great scalability and customizability. Of these hooks there can be hung systems of ropes or ridged material that could be used for hanging clothes or other items.



Figure 18 Concept model of storage system hung from mouldings

5.2 Wall attached

For the earliest generated concept, the wall storage consisted of clothes hangers with integrated suction cups or adhesive parts to attach them directly onto the wall. This concept takes inspiration from the picture gallery mentioned in the define chapter, where users were hanging pictures of their walls with tape. The commenters of the article seemed to be very happy to be able to place items wherever they wanted on the wall, and they also seemed to desire the freedom of changing around the position of their decorative items.

The concept developed further into detaching the fixing point (suction or adhesive) from the clothes hanger, and making individual hooks that could be attached wherever desired on the wall. Further on adding string or rope to allow for the user to make their very own layout, and customize the wall storage to their needs. With this concept, the users can use either the hooks themselves, or the rope in between for hanging stuff on.

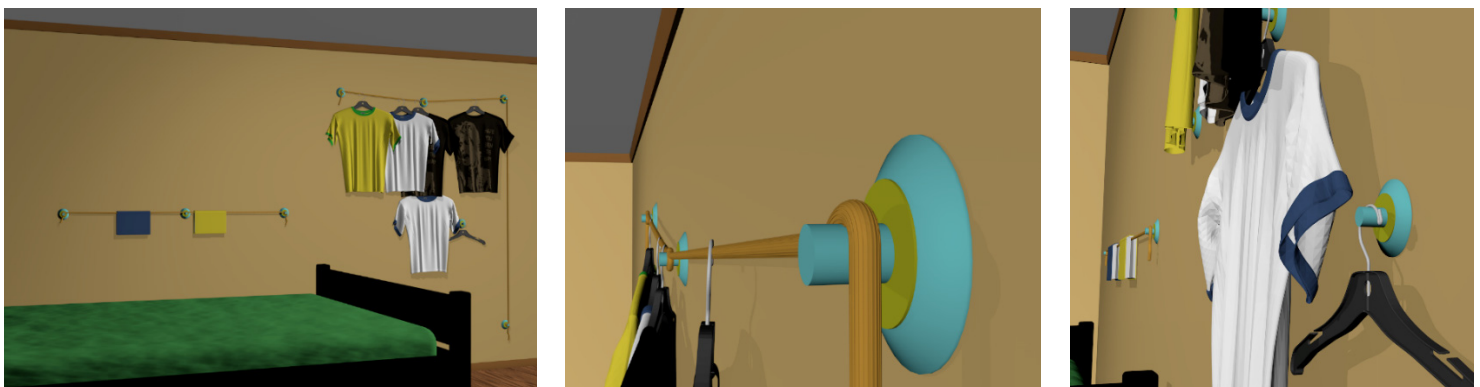


Figure 19 Concept model of wall hung storage

5.3 Floor to ceiling

Taking use of what all buildings has, which is floor and ceiling, the concept of the floor-to-ceiling storage unit creates an extended wall outside the actual wall. There can be placed multiple uprights along the wall to expand the unit, these uprights are adjustable to fit for various ceiling heights. For customizability, the horizontal rods can be placed at any height, and there can be used as many as desired. This concept gives the user their very own wall, on top of the original one, that they can use for what purpose they want, without touching the actual wall. By using tension based uprights, this storage unit can stay securely in position, without the need of mechanical fastening.



Figure 20 Concept renders of floor to ceiling storage unit

5.4 Evaluation and conclusion

These three concepts all showed to be addressing the brief, and to have a potential to be taken into further development; however, for the scope of this thesis, only one were worked further on. To decide on which concept to take into further development, a weighted matrix was used to evaluate the concepts based on relevant parameters. A weighted matrix uses different parameters, also known as design objectives, to measure the concepts relative to each other. (Cross 2000) Each parameter is weighted to take into consideration each parameters rate of importance. In this case, each parameter is given a weight between 1 and 3, where 1 is of least importance and 3 is a parameter of high importance. The concepts are then given a score between 1 and 5 for each parameter, where 1 is worst and 5 is best.

The parameters measured for this evaluation were as follows:

Risk of damage

Used to measure how likely each concept would be to do any damage to the property it is installed. This parameter was given the highest weight, as the product to be developed should not do any damage to rented property.

Customizability

Customizability was measured to ensure that the chosen concept would provide the users with good possibilities for customizing their home according to their wishes.

Adjustability

In this case, adjustability is in the meaning of how easily a user can rearrange, change and adjust their products layout after installation.

Scalability

Scalability is measuring how well the product allows for the wall storage to be expanded.

Versatility

Versatility is measuring in what degree the concept is fit for different types and sizes of rooms and buildings.

Size

The parameter of size is measuring the footprint of each concept, in terms of how much space the product would take up in a room.

Capacity

This parameter reflects the projected load capacity of the concepts.

More specific parameters, such as cost and ease of production was not taken into consideration when doing this assessment. The concepts evaluated were seen as not being defined and developed enough for such evaluation to take place at this stage of the development.

Table 1 Weighted evaluation matrix

	Weight 1 - 3	Hung 1 - 5		Adhesive 1 - 5		Floor to ceiling 1 - 5	
		Score	Weighted	Score	Weighted	Score	Weighted
Risk of damage	3	2	6	2	6	4	12
Customizability	2	3	6	5	10	3	6
Adjustability	3	3	9	2	6	5	15
Scalability	2	4	8	5	10	5	10
Versatility	3	1	3	4	12	5	15
Size	2	5	10	5	10	3	6
Capacity	2	3	6	2	4	4	8
Total		<u>48</u>		<u>58</u>		<u>72</u>	

All these three solutions showed to have their strong points; however, the floor-to-ceiling concept ended up as the preferred one out of the three. The hung solution was found as the weakest of the three proposals, as it is the solution that is predicted to have the highest potential of damaging the property. There is also the fact that all buildings have walls, floor and ceilings, but not all buildings has mouldings fit for such use, thus the low score for versatility for the hung concept.

The wall attached solution gives the most freedom in terms of placement, and with the adding of string, it gives a nice playfulness. It is however on the point of strength and ease of change where the floor-to-ceiling solution is found as a better option than the wall attached concept. The wall attached hooks can be placed virtually anywhere on a wall, however if there is a wish to move the hook to a new position there might be some issues, in terms of reuse of tape, potential damaging of the wall finish and so on. The floor-to-ceiling concept is seen as the concept most fit for further development because it can fit into virtually any building, it is highly adjustable, it has the least probability of damaging the property and it can be built as a strong construction that can support a lot of payload, which makes it versatile for different contexts of use.

6 Market research

A research of the market was done to obtain more knowledge about what similar products are available. By conducting a market research, there was obtained knowledge about similar products, sources of inspiration was found, and possible gaps in the market was identified.

6.1 Similar products

In the search for similar products on the market, there came up several products, which either share a similar aesthetic approach to the floor-to-ceiling concept, or products sharing similar technical approaches and solutions. There are also looked at product that share neither of these with the floor-to-ceiling concept, but rather provides the users with some of the same values.

6.1.1 Single pole storage

The products described below are storage units held up by a single tension pole between the floor and ceiling. The single pole storage products are products that mainly share similar technical solutions to the floor-to-ceiling concept, they do however also allow the users to do changes without mechanically fastening anything to the walls, floors or ceilings.

Oxo – Lift & lock pole caddy

A product that bases itself on the convenient solution of using tension to fix its position is oxo's lift & lock pole caddy. This is a product for use in bathrooms, an environment where avoiding to drill into walls and floors are especially desirable, as walls and floors in bathrooms usually has watertight membranes that should not be broken.

The oxo – lift & lock pole caddy consists of three posts + one additional extension pole for adjustment. The posts are screwed together to form a pole reaching from floor to ceiling. A locking mechanism on the foot of the pole is used for fine adjustments and to lock the pole into position.

Another interesting solution used for the lift & lock pole caddy is the solution for attaching trays and baskets to the pole. In a very neat and easy manner, the trays and baskets are attached securely to the pole with a simple and easy movement. This also makes it easy to change the position of these items, and makes it very adjustable. (OXO n.d.)



Figure 21 Lift & Lock pole caddy (Bed bath and beyond u.d.)

Dual-Touch™ Bike Stand

The Dual-Touch™ bike stand share similar approach to both purpose and technical solution. The bike stand serves as a practical and interesting solution for storing bikes on display, indoors, without having to use mechanical fastening and doing an impact to the property. The product consists of a telescopic pole that is extended and fixed in the height of the room, before it is extended additionally via a pedal on the foot, to secure its position. (Topeak u.d.)



Figure 22 Dual Touch Bike Stand and foot lock mechanism (Topeak u.d.)

Gear-up floor to ceiling bike storage rack

This product is a product very similar to the previously described Dual-Touch™ Bike Stand, although this product differ some in terms of technical specifications and technical solutions.

This company also provides these bike racks in several materials and different iterations of their technical solution. The main difference between this and the above mentioned bike storage is how it is expanded to secure its position. The Dual-touch™ product is using a pedal to secure the bike racks position, while this product requires the user to use a wrench to turn a nut at the base to expand the pole and secure it in position. (etrailer.com 2014)



Figure 23 Two versions of Gear-up bike rack and fixing method (etrailer.com 2014)

6.1.2 Floor to ceiling storage units

The products described below are product that are similar both technically and aesthetically to the floor-to-ceiling concept. There are products in different price groups, products that does not require any mechanical fastening, and products that does.

IKEA – Stolmen

IKEA – Stolmen is a furniture system that has a similar aesthetic approach to the floor-to-ceiling concept. Stolmen is a modular furniture product, which in similarity to the floor-to-ceiling concept is using vertical poles as the main structure of the product, ant the user can attach horizontal units as desired, making this a highly customizable piece of furniture. The main point where Stolmen is different from the floor-to-ceiling concept, as well as the above-explained products is that Stolmen requires mechanical fastening. The shelving on this product is not made for rapid change of layout, although it is possible to change the position of the shelves, the product is not made for this to be done regularly. (IKEA u.d.)



Figure 24 Variations of IKEA Stolmen (IKEA u.d.)

Premium floor to ceiling storage units

There have been designed several products based on the idea of having a storage unit which is supported by a pole from floor to ceiling. There are both single pole designs, like Aicodesign's Totem (Figure 26) (AicoDesign u.d.), Porada's Domino (Porada 2013) and Gianfranco Frattini's Albero (Figure 25) (Poltrona Frau 2014), as well as system designs where several poles and shelves forms the storage unit, such as The Compressed System by Nonuforum (Nonuform u.d.), Zenit by Giuseppe Bavuso (Rimadesio u.d.) and the K2 system by Kryptonite (Figure 28) (Kryptonite u.d.). Some of the designs are done for storage along the wall, some are done for the purpose of room dividers, and others as freestanding furniture. There are also examples of floor to ceiling storage units which speak the same language in terms of aesthetics, but that are mechanically fastened, one example of these mechanically fastened solutions are Albero designed by Gianfranco Frattini (Poltrona Frau 2014)

Most of these solutions are tailor made for specific locations, and does therefore not give the user the possibility to move the furniture to a new location with different dimension needs. One exception though is Extendo's system collection, which comes with poles adjustable for room heights between 210 cm and 340 cm (Figure 27) (Extendo 2013) One common thing for the mentioned products are that they seem to have being designed for staying stationary, and not for being adjusted and moved around from time to time.



Figure 25 Albero (Poltrona Frau 2014)



Figure 26 Totem by AicoDesign (AicoDesign u.d.)



Figure 27 Extendo system (Extendo u.d.)

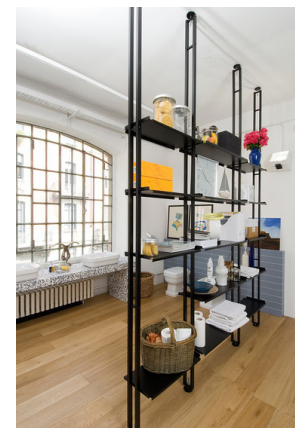


Figure 28 K2 System by Kryptonite (Architonic u.d.)

6.1.3 Leaning storage units

In this section, there are presented products that does not share either similar looks or technical approach to the floor-to-ceiling concept, but still provides the same value of wall storage without mechanical fastening. Products described in this section are storage units that serve the same function as products that are traditionally mounted to the wall, by being placed leaning up against the wall without mechanically fastening.

Leaning shelves

The leaning shelves is a practical solution for providing shelving on a wall, without making holes in it. There are several producers and designs for leaning shelving, and there are even homemade solutions made out of existing structures such as old ladders or doors. Some

products even replaces several services that usually are wall hung, like Valentin Bussard's L/M/N furniture, which replaces both mirror, shelf and hooks. (Figure 30) (Bussard 2014)



Figure 29 Leaning shelves (French connection u.d.)

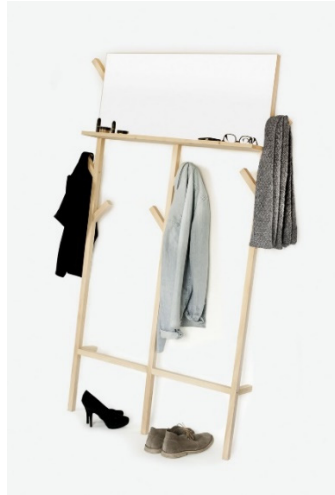


Figure 30 Mirror/coat rack/shelves (Bussard 2014)



Figure 31 Talbot raw oak towel ladder (Cox & cox u.d.)

Two bike gravity stand

The company Delta Cycle has after coming up with a gravity based storage for bikes, got into the field of storage, and are now providing several storage solutions based on their gravity concept. They call it the art of storage, and they focus on practical but still interesting way of storage. Their bike stands uses the weight of the payload to stabilise the stand, and they have models that go along the wall, as well as freestanding racks. The gravity stand from Delta Cycle also uses a similar fastening mechanism for their hooks as the Oxo – Lift & Lock Pole Caddy. (DeltaCycles u.d.)



Figure 32 DeltaCycle gravity bike racks (DeltaCycles u.d.)

6.2 Conclusion

Several of the floor to ceiling storage units researched, are not designed for being as adjustable and customizable as the floor-to-ceiling concept is aimed to be. Most of the single pole solutions did show to be good examples of adjustable and versatile 'low impact' products. Many of the above-mentioned floor to ceiling storage units are built for specific cases, meaning that they are not very adjustable and versatile. Some of the storage units mentioned above are adjustable in terms of different ceiling heights, but few of them are easily adjustable in terms of layout after installation. This suggest that there is an opportunity for providing more adjustable and customizable storage unit, that does not need mechanical fastening, and by that having less impact on the building.

Most of the product mentioned above are not priced very high, this is except of those products mentioned under 'Premium floor to ceiling units' which are designer products mainly aimed at a premium market. It is although these products that shares most aesthetical similarities with the product in development. Knowing that the majority of the target group are not premium costumer, relying on statistical data on income, there is a good opportunity for providing the target group with a functional, customizable and adjustable floor to ceiling storage unit at a reasonable price. The further development can take inspiration from the functional solutions showed by the single pole storage products, in terms of versatility, adjustability and technical solutions. There can also be taken inspiration from the premium floor-to-ceiling storage units in terms of aesthetics and form.

7. Design development

As the concept of a tension pole based, floor to ceiling storage unit was found as the desired solution after the preliminary concept evaluation and market research was done, the further development of this concept is described in this section. Different iteration of the floor-to-ceiling storage unit are presented and evaluated in this section, to end up at the final design. The chapter starts out with specifying the products objectives, before design decisions are done based on these specifications. At the end of this chapter, the final design is presented and described.

7.1 Proposal

Based on the market research done, there can be set out criteria's and objectives for what the floor-to-ceiling storage unit should be, what values it should provide and what features it should have. The market research shows that there exists a variety of similar products, but that there still are points where the floor-to-ceiling storage unit can differentiate itself from the competitors.

The floor-to-ceiling storage unit shall put emphasis on being versatile, fitting into virtually any room in any building, and adjustability, allowing the user to convenient alter, transform and change their space to their needs. The minimal footprint of the storage unit should enable use in spaces traditionally seen as not adequate for conventional storage or furnishing. As the storage unit is designed for the specific user group of tenants, the most important feature of the final product is that it can be installed without any mechanical fastening, and without doing any harm to the building it is installed in.

7.1.1 Aesthetics

The design of the storage unit itself should be minimalistic and unobtrusively, in order not to be the main eye-catcher, and rather let decorative objects stored on it stand out. To allow the unit to be used both as an extended wall and as a freestanding piece of furniture, it is important that the unit looks as good from all sides, and that it does not have a 'back side'.

The product is aimed at people who rent, which research suggest are not those who can afford premium design. The final design should therefore not aim at being premium, or pretending to be more than what it is, but rather be honest, but still elegant in a minimalistic way.

7.1.2 Values

The main value of the product, is to let tenants take control over their home environment, allowing them to do changes and alter their space with no worries of damaging rented property. By giving the user freedom to make changes to their home environment; they shall be given a feel of ownership over their space, and not feel like they are living in a borrowed home. The units' motive is to act as an extension of the wall, which give the user maximum use of their wall space, with no need for mechanical fastening. The final design should be highly adjustable, to allow the user to do changes depending on their needs, as often and as drastic as they desire, with the least amount of effort.

7.1.3 Requirements

The storage unit should also be fit for use in different contexts, holding various items one would wish to store on it. The most relevant areas of use is seen as storage for clothes, both hung and folded, as well as other decorative or utility items fit for storage on shelves. Heavier items such as TV's are not taken into consideration for the scope of this thesis, although this cannot be disregarded as a possible use.

For ease of use, it is important that the horizontal parts are easy to place in the desired position, and they can be moved easily, without the need of any tools. These horizontals should be strong and stable enough, for nothing stored on them to fall off. The storage unit should also be easy to install, requiring a minimal amount of tools, and be a task possible for one person.

7.2 Technical

With a general concept for the adjustable storage unit set, this chapter will decide the technical solutions of the product, as well as describing how and why the different solutions were chosen. Possible solutions for the different parts and aspects of the product are described and evaluated, in order to come out with a final solution. The decisions for the technical design of the product, is done both on the basis of design and engineering, as these solutions not only will decide how the product works, but also how it will be used, and how the final product will look.

7.2.1 Evaluation of possible solutions

Upright

To decide on the design of the uprights, different possible solutions were proposed, reviewed and evaluated. The important aspects for the upright is to make it strong enough to hold the weight of the payload, as well as making sure that it is easy to install, and that it stays levelled and safely in position. In the following paragraphs the proposed solution for the different aspects of the vertical studs are described and evaluated.






Figure 33 Uprights

Extension

To make sure that the product is versatile and can be used in buildings with various ceiling height, the uprights need to be easily adjusted. The aim is to allow the studs to be adjusted for ceiling heights between 230 cm and 340 cm. The area possible for use (meaning possible for attaching horizontals) is the part of the upright that is not adjustable, therefore the method of extending will not only have an influence on the installation of the upright, but also have an influence on the everyday use of the product.

The three general methods proposed are extension on both top and bottom, extension only on the top and extension only at the bottom. The main aspects that are looked at are how the different solutions allow for easy installation and the strength of the stud.

Table 2 Evaluation of technical solutions 1

Solution	Illustration	Pros and cons
<p>Option 1 Extendable top and bottom</p>		<ul style="list-style-type: none"> + More freedom of placement - Hard to install levelled - Weaker construction
<p>Option 2 Extendable at top</p>		<ul style="list-style-type: none"> + Always level + Easy to install + Strong construction -No storage over 230 cm
<p>Option 3 Extendable at bottom</p>		<ul style="list-style-type: none"> + Always level + Easy to install - Weaker construction

Out of these three solutions, option 2 was chosen as the most desirable solution. Although this is the solution that allows for the least area of use, storage over the height of 230 cm (which this solution offers), is not seen as an issue of high importance. Option 1 was initially seen as the more desirable solution, as it is the most flexible, but this assessment shows that this solution can be too hard to install levelled. This means that because there are two adjustment parts, two uprights placed beside each other might not be placed at the same height. Both option 1 and option 3 might be weaker constructions than option 2, as all the payload put on the upright will have to be carried by the adjustment part of the stud.




Adjustment method

The adjustment method determines how the telescopic part of the upright is expanded and how it is held in position. What is important for the final solution of adjustment is that it is easy to install the stud, that it ensures that the stud stays in position and that the stud easily can be adjusted for different ceiling heights.

The three proposed solutions for adjustment are tension/spring, quick release and step. All three solutions consist of an outer pipe attached to the foot, and an inner pipe that can be

extended for adjusting the height of the upright. The tension rod solution, also known as spring rod, uses a compressed spring to expand the stud, and hold it in position. The quick release solution uses a locking mechanism on the top of the outer tube to hold the adjustment part in position, similar to what seen on the saddle of newer bicycles. For the step solution, incremental fixing points are provided for the adjustment part to lock into.

Table 3 Evaluation of technical solutions 2

Solution	Illustration	Pros and cons
<p>Option 1</p> <p>Tension/spring</p>		<ul style="list-style-type: none"> + Good adjustability + Flush look - Questionable strength
<p>Option 2</p> <p>Quick release</p>		<ul style="list-style-type: none"> + Good adjustability + Proven strength - Not optimal aesthetically
<p>Option 3</p> <p>Step</p>		<ul style="list-style-type: none"> + Strong - Not optimal adjustment - Complicated



Out of these three proposed solutions, the solution with quick release lock was chosen as the most desirable. The solution with tension/spring might although be the most preferable as it is as adjustable as the quick release, and might result in an aesthetically better end result. The reason why the quick release still is preferred is that this is a tested solution in similar use, (Topeak u.d.) while the tension/spring would need some testing for strength. The quick release lock will be placed at 230 cm above the floor, and will therefore not be very visible. The step solution is the least favourable as this solution offers less adjustability, and more work will need to be done, in terms of production, to make this solution work. The step solution also would require an additional adjustment method for fine adjustment, as the main adjustments only would be possible at set increments.

Locking

The locking mechanism decides how the upright is fixed securely in position. The fixing should be done without the use of any mechanical fastening, and therefore expansion is used to lock the upright in position. The two proposed solutions for fixing the uprights position is pedal and screw. The pedal solution is a proven solution in similar products that when used expands the stud additionally with up to 12 mm. (Topeak u.d.) The screw solution uses a bolt on the foot to lock the upright in position, this is also a solution used for similar products. (etrailer.com 2014)

The parameters taken into consideration when choosing a solution for the fixing mechanism is how easy it is in use, its ability to secure the stud and aesthetical aspects.

Table 4 Evaluation of technical solution 3

Solution	Illustration	Pros and cons
<p>Option 1</p> <p>Pedal</p>	 <p><i>Figure 34 Foot-lock (Topeak u.d.)</i></p>	<ul style="list-style-type: none"> + Proven solution + Easy in use - Not optimal aesthetically
<p>Option 2</p> <p>Screw</p>	 <p><i>Figure 35 Screw-lock (etrailer.com 2014)</i></p>	<ul style="list-style-type: none"> + No 'back side' + Proven solution - Requires tools

Evaluation

Of these two solutions, the pedal was initially seen as the most favourable option. The drawback of having the pedal visible at all time, is however what makes the second option most favourable. Option 2 is the most complicated in terms of installing, as it would require extra tools. The pedal which does not require use of tools, and also allow for very easy installing, would give the unit a 'back side', and by that not match the requirements set earlier in this chapter. The screw is a proven solution and looks neat from all angles, and is therefore the chosen locking mechanism.

The final design of the uprights will be further developed through deciding on the solution for the horizontal parts. At this point, it is set that the uprights height will be adjusted with an extension tube of the top, this extension tube will be locked into position with a quick release clamp, and a nut on the base of the upright will have to be tightened to lock the upright in position.

Horizontal

For the horizontals going between the uprights, there were explored a variety of solutions. For these solutions it was seen important that they could carry payloads safely and that they allowed for easy change of position. The final decision for the horizontals would also predict the design of the uprights, as they will have to be designed in a manner that they can allow for the different mechanisms of the horizontals.

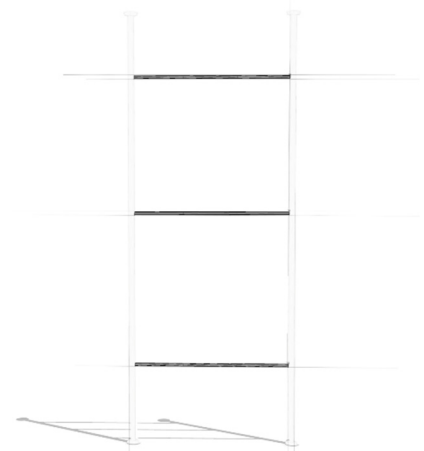


Figure 36 Horizontals

Option 1

The initial thought behind the concept was to have multiple holes straight through the uprights, in which the horizontal sticks or rods could be placed. Its simplicity made it highly desirable, however as the development went on, there were identified several issues with this concept. The two main issues with this solution is the ease of use and the aesthetics. In the attempt of giving good adjustability to the product, whit holes in several different heights, also means that when the holes are not in use, they will be there and be visible, something that might infringe the desired aesthetics. The other issue with this solution is

that it not give the user full freedom of placement, and the action of changing height of the horizontal is not as easy as wanted. As the illustration below shows, the solution would require free space on the side of the upright, the length of a horizontal, for changing of placement to be possible.

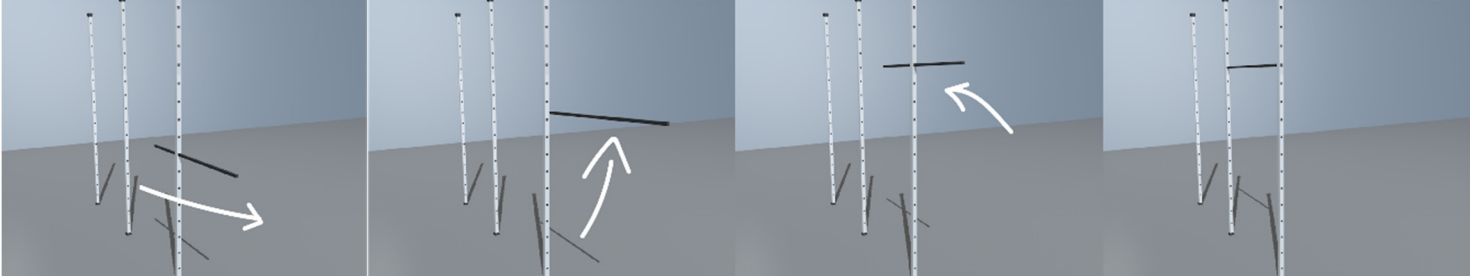


Figure 37 Change of horizontal placement - Option 1

Option 2

With this option, there was attempted to work out a solution that would hide all holes and moving parts, to give the final product a flush look. The horizontals are put into the rail at the bottom of the upright, and can be moved freely in the vertical direction. Depending on the rotation of the horizontal it can be fixed in position or be movable. When the horizontal is rotated into fixing position, the part hidden inside the railing box is resting on indents on both sides, securing its position.

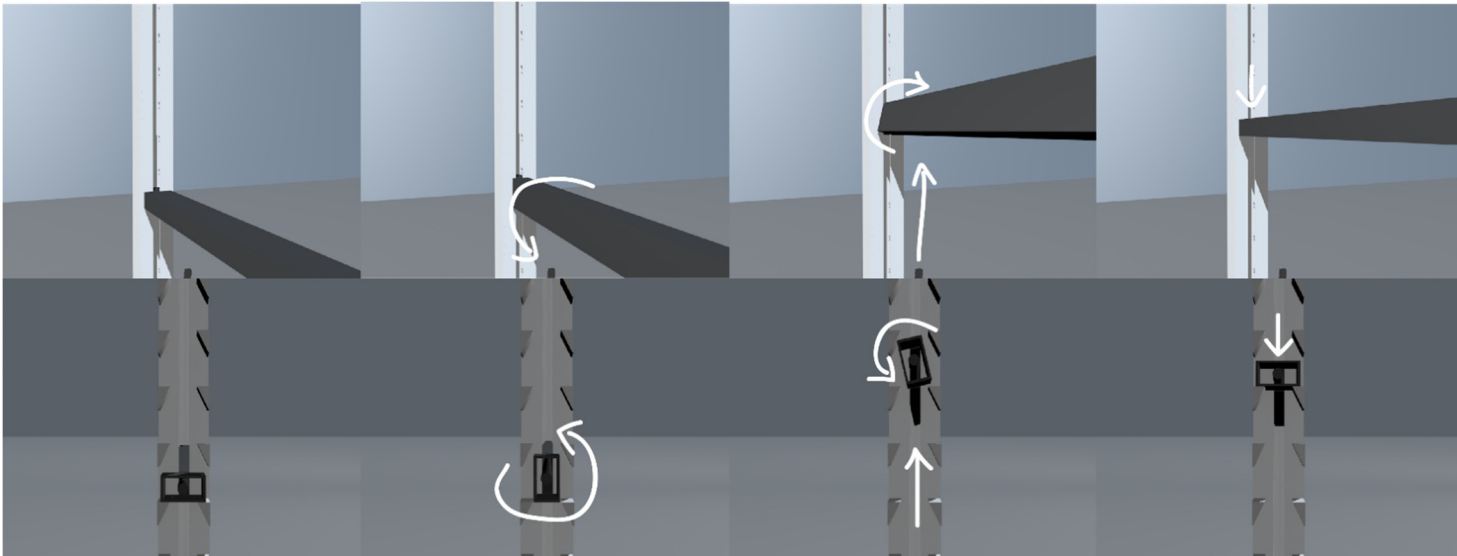


Figure 38 Change of horizontal placement - Option 2

Option 3

Aware of the problems faced with the solution of option 1, there was attempted to recreate the same simplicity of the design and the mechanism, while still keeping with the clean look without visible holes. By putting the holes on the back of the upright, they will not be visible

when not in use. The action of changing the position of the horizontal also seemed to be more desirable with this solution than with option 1, as it did not require free space on the sides of the uprights.

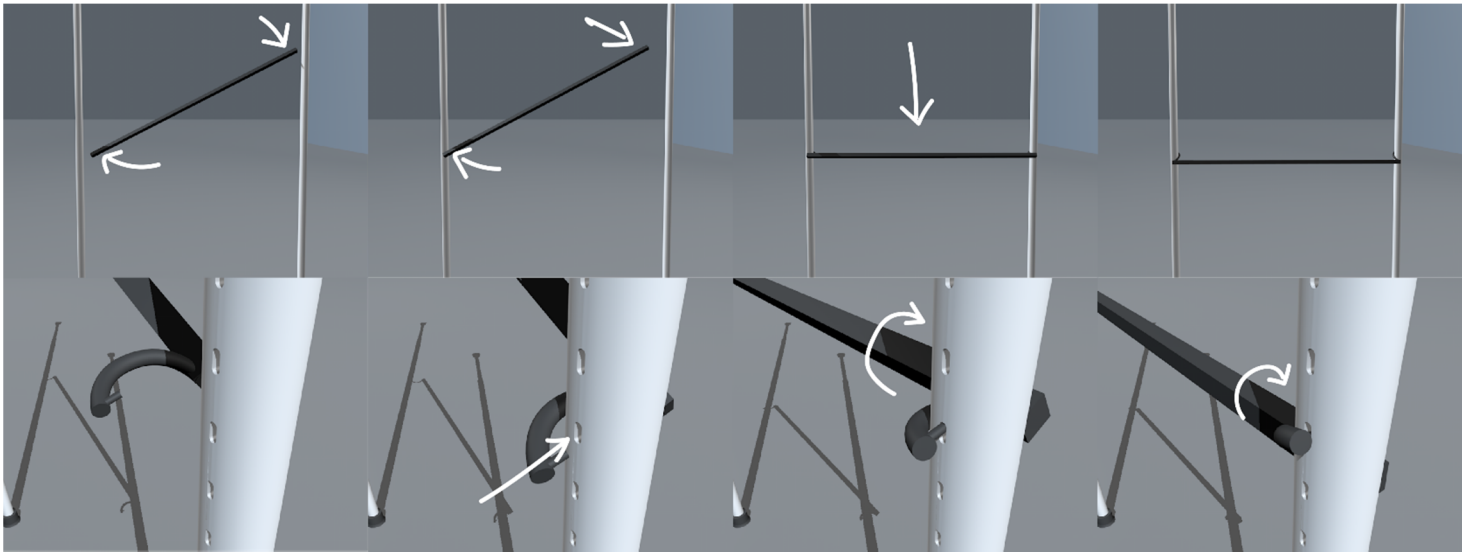


Figure 39 Placement of horizontal - Option 3

Conclusion

The proposed solutions were compared with an evaluation matrix, measuring three main parameters. These were the final aesthetics of the storage unit, stability of the horizontal and the assumed ease of use in terms of placing and changing position of the horizontals.

Table 5 Evaluation matrix

	Option 1 1 - 5	Option 2 1 - 5	Option 3 1 - 5
Aesthetics	3	5	4
Stability	5	3	4
Ease of use	2	4	3
Total	10	12	11
Testing	No	Yes	Yes

Option 1 is seen as the most stable solution, as it would sit in square holes in the uprights, and by that have no chance of rotating or falling down. This option did however score low in aesthetics, because of the many holes it requires in the upright, and it scored low for ease of use. The second option is the highest scorer out of the three proposed solutions. As there would be no holes in the upright, but only a narrow rail, this solution gives the cleanest look, with no 'back side', and would also work as well as a freestanding storage unit, as a storage

unit along a wall. The only drawback for this option is the stability, but this is seen as something that could be solved with the attachments described in the attachment chapter. The third option also scores high, although the holes on the back of the unit causes it to be less favourable as a freestanding storage unit, thus the deduction in aesthetic score. The solution is also seen as less convenient in use, as the motion required for placement of the horizontal might restrict the users' freedom of adjustability.

Based on this evaluation of the three options, there was decided to take option 2 and option 3 further into rapid prototyping, to get a feel of how they work, and identify potential drawbacks or positive sides with the solutions.

7.2.3 Rapid prototyping

The two concepts for the movable horizontal parts that were found most desirable of the proposed concepts were brought through to testing, in order to come to a decision for a final solution. The two concepts were prototyped as 'work as' prototypes, meaning that the aesthetical aspects are not taken into consideration, but that it rather is the working aspect, and the user experience of the concept that is tested. Out of the material at hand, two prototypes were produced and tested as described below.

Option 3

The uprights for the prototype was built out of cardboard pipes, where holes were made in the back, and a cut-out of a foam board with mouldable glue functioning as the 'hooks', as horizontal part. The main aspect to test out for this concept is whether the non-visible holes in the back of the uprights would make it hard to insert the 'hooks'. It was also looked at whether it was easy to place the horizontals levelled, and if the movement of placing and adjusting the horizontal was pleasant.



Figure 40 Prototype back



Figure 41 Prototype back 2



Figure 42 Placement of horizontal

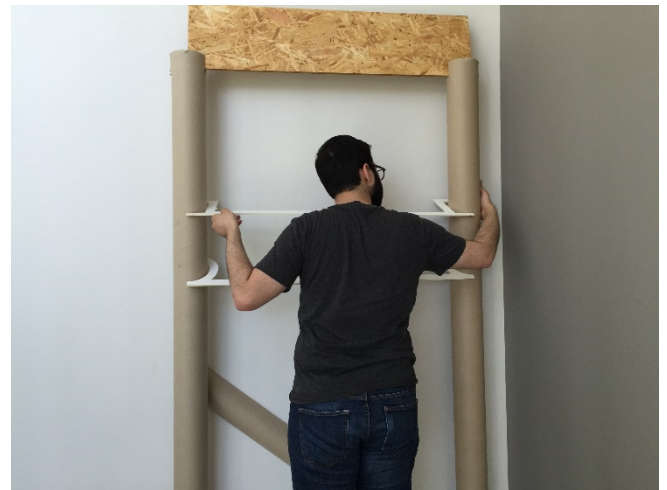


Figure 43 Placement of horizontal 2

Option 2

For this prototype, both the uprights and the horizontal part was made out of foam board cut-outs. There were made several catches for where the horizontal could rest, inside the rail of the uprights. One aspect that was interesting to test out was whether there would be easy to change position of the horizontal, as the catches to rest it on not are visible to the user. The general motion and method of use was also an aspect that was looked at during the testing.



Figure 44 Sliding in from bottom



Figure 45 Adjusting position



Figure 46 Sliding in from bottom



Figure 47 Fixing position

Outcome

Both the solutions showed to be fairly intuitive and easy in use. There was however some issues with placing horizontals on option 3. As illustrated in Figure 42, the horizontal will have to be brought in at an angle, which might cause problems if there already are several horizontals mounted. It also showed to be a bit difficult and clumsy to fit the horizontal in the holes at the back, which can be seen in Figure 43, where the test person is using his fingers to find the holes.

Option 2 showed to be very easy in use, and even with a quick prototype, made with some imperfections, the horizontals were easy to slide inside the rail, and also easy to place in position. The only drawback compared to option 3, is that option 2 does not allow free

placement of horizontals. The horizontals are slid in at the bottom of the rail, and therefore they can only be placed under, and never between or over two previously placed horizontals. (Figure 46 and Figure 47)

7.3 Final design

The previous chapter have decided on, and specified the different parts and functionalities of the frame of the storage unit. This chapter will present attachments developed for use with the frame, the possibilities the product offers, and illustrations of the final product in use.

7.3.1 Attachments

The early concepts was first developed as a simple system of vertical and horizontal rods from where items could be hung. As the development went on, the possibility of extending the ways of use was discovered. Taking inspiration from what people normally would want to store, hang on their walls, or decorate with, additions were designed to allow for such use of the product. The possibility for using the product not only as storage along the wall also led into developing additions that would work well also in a freestanding position, as well as attachments serving as room dividers. Appropriate sizes for stored items was searched for to make attachments as functional as possible. (Butchko 2014) (The Architecture Student 2013)

To continue to build upon the strong points of adjustability and customizability for the product, attachments for several room types as well as storage items was developed. The freedom of where and how many items to place on the unit was seen as an essential feature of the product, and the attachments were developed to strengthen this customizability.

Shelf

The first and most natural attachment developed for the storage unit was the shelf. Shelves can be used for storage of all sorts, from wine bottles, pictures and candles to purses, towels and shoes. The shelf is fitted on top of one of the standard horizontal rod, and is stabilized by the “wings” around the uprights, stopping it from tipping backwards or forwards. With the shelves encapsulating the uprights, they also gives a nice flush look when fitted next to each other. The shelf depth was set to 20 cm, although many suggest to make shelves deeper than 20 cm, it was decided to keep the shelves shallow, and rather let larger items be stored on the deeper attachments. Shelves 20 cm deep are large enough to accommodate items such as paperback books and DVD’s. (Brezlin u.d.)

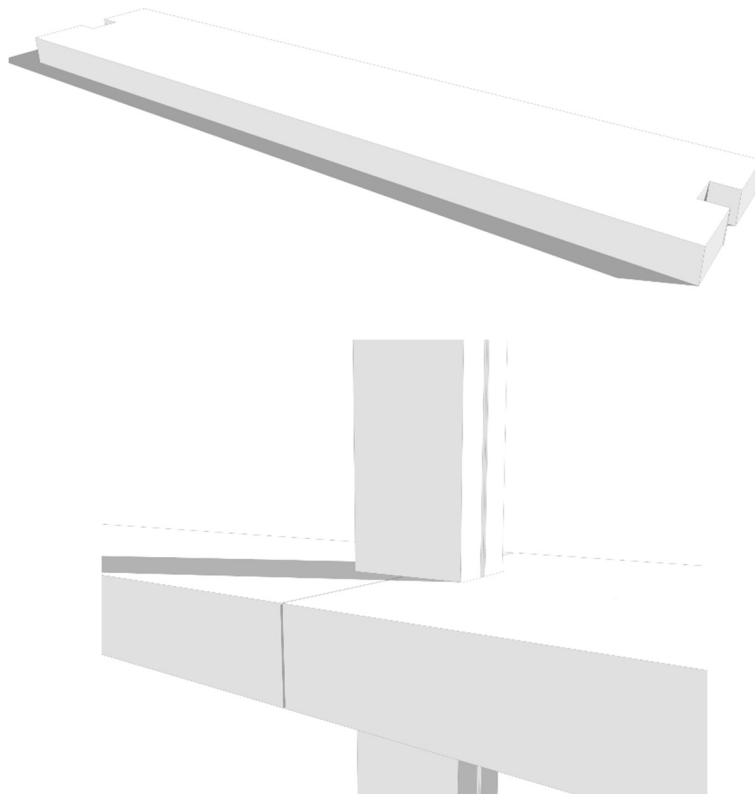


Figure 48 Shelf alone and in place

Hanging shelf

The hanging shelf is a shelf with a back wall, hung of the horizontal part. The hanging shelf can be used instead of the shelf mentioned above when the storage unit is placed very close to the wall, which might not give enough space for the normal shelf. Similarly, to the normal shelf, the hanging shelf has 'wings' on the front to make sure it stays stable, as well as creating the same flush look as with the shelf. The hanging shelf is 30 cm deep, which is depth enough to accommodate items like hardcover books or even shoes. (Butchko 2014) (Brezlin u.d.)

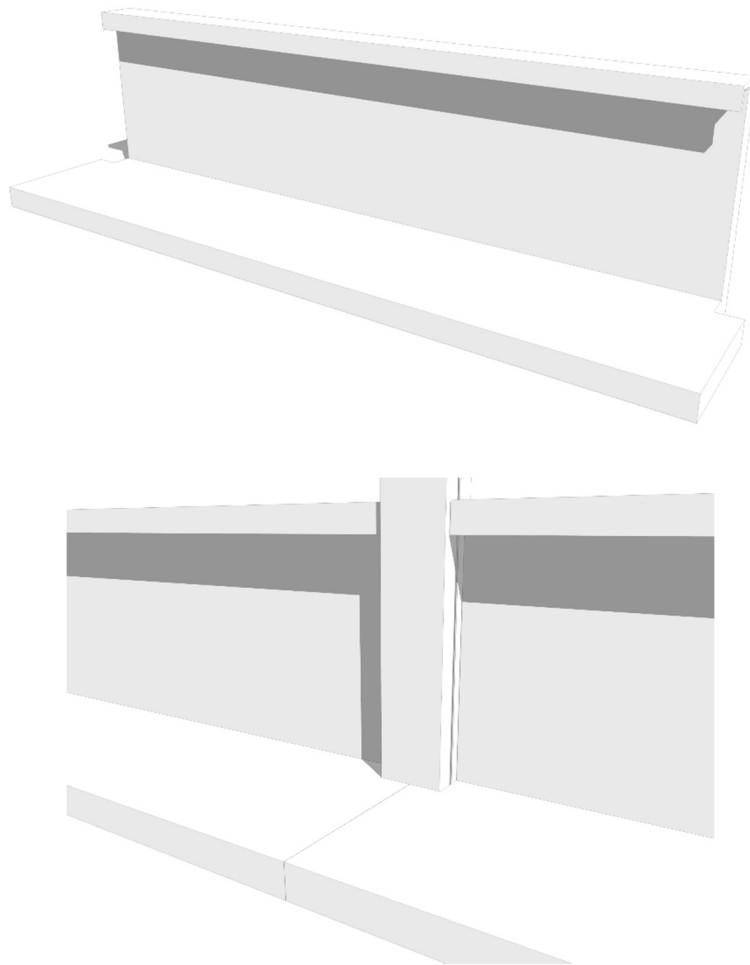


Figure 49 Hanging shelf alone and in place

Screen

The screen attachment emerged when the possibility of different uses were discovered. In the section of user behaviours there can be seen how people tend to use products in many different ways than intended. This is why the screen attachment was developed, for the possibility of using the floor to ceiling unit, not only as an extended wall, but also as a room divider or a wall. The screen is put on top of a horizontal piece, and held securely in place by another horizontal rod on the top.

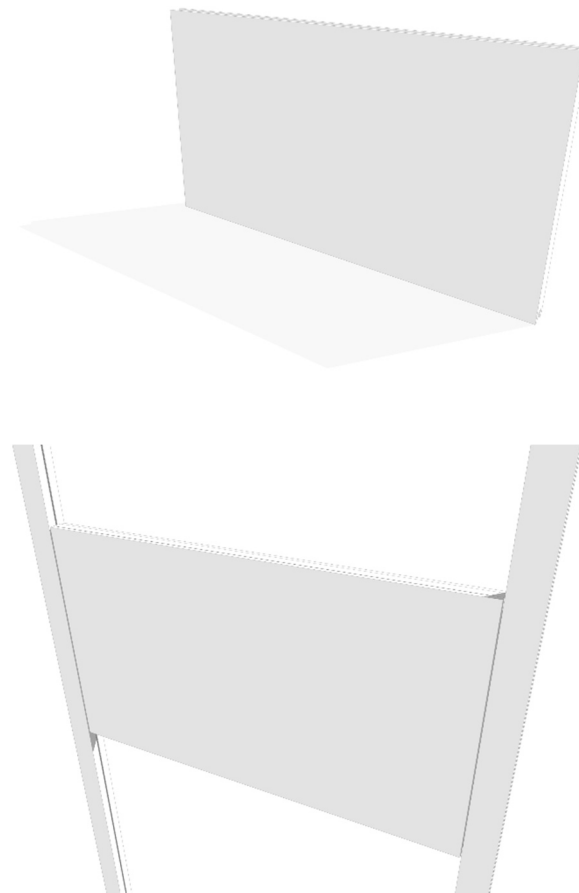


Figure 50 Screen alone and in place

Hook

The horizontal rods were initially meant for hanging clothes of by clothes hangers, by further thought, there was seen a need for an easier and more effortless way of hanging items of the unit. Hooks are widely used for hanging stuff of, everything from keys and scarfs in the entrance to towels and soap in the bathroom and clothes and bags in the bedroom. The hook would have to be easy to place, and easy to move, in order to play along on the strong features of easy adaptability of the storage unit. The hooks should be made out of elastic material, which would fit around the horizontal rods, and allow for easy attachment and easy movement or removal.

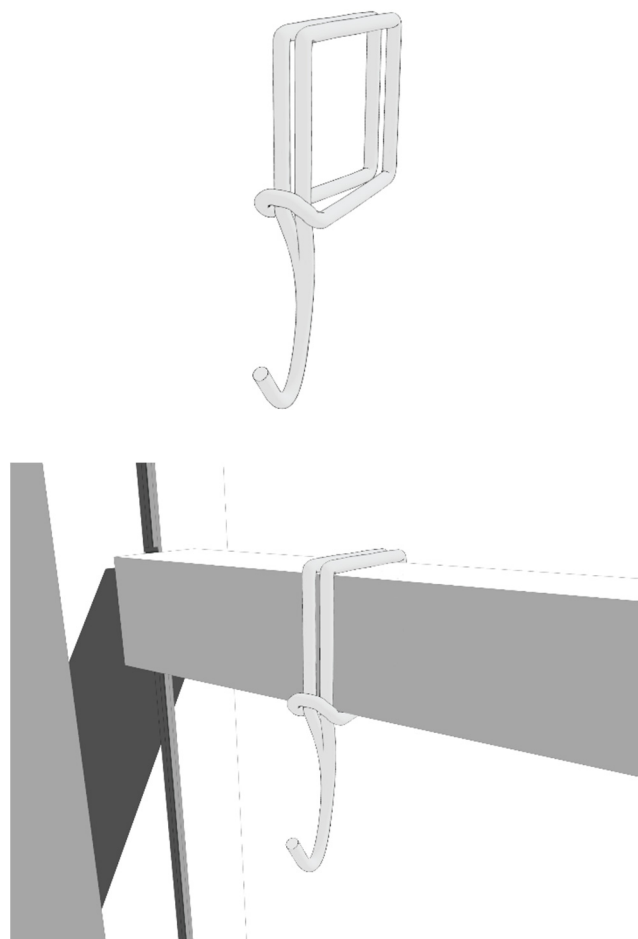


Figure 51 Hook alone and in place

Box

The above-mentioned attachments are all very open solutions, also reflecting the finding in the research phase of the benefits and desire to store clothes on display, and as decorative items. There was although seen a need for some items not to be as much on display as others. Items such as underwear is for example items that many would not want to be displayed. For such items there was designed a box structure, that still is very accessible for the users. To provide the user with the possibility of deciding the depth of their storage unit, none of the attachments were given the same depth. The box is the largest and deepest attachment; it contains of three compartments, and is 40 cm deep. 40 cm depth is enough for items like folded clothes and records. (Brezlin u.d.) (Butchko 2014)

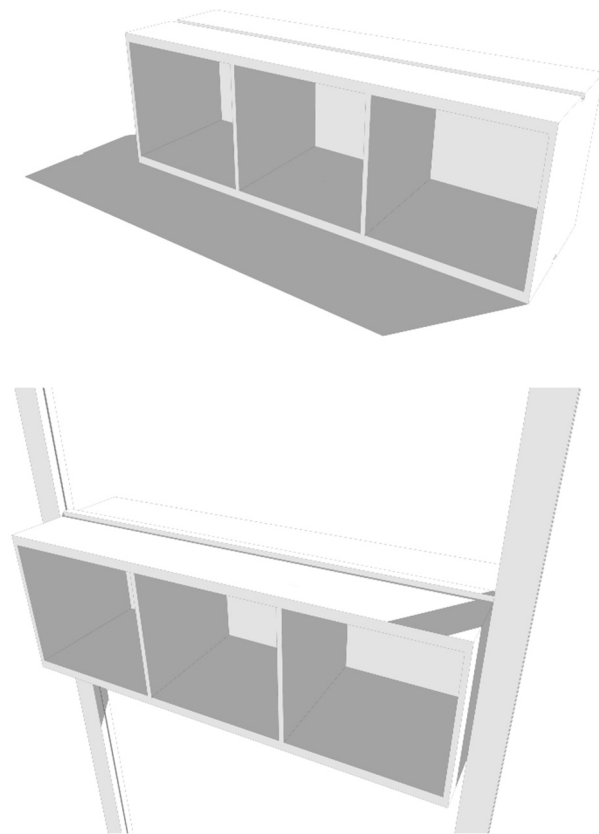


Figure 52 Box alone and in place

There are no doors or hatches on any of the above-mentioned attachments. This is done to make the attachments as simple and versatile as possible, and any kind of door would be seen as an item adding complexity to the product. The most closed of attachment is the box, if placed close to the floor, the content will not be very visible, but still very accessible.

In terms of materials for these attachments, it was seen as important that they are lightweight, for making instalment and adjusting easy for the user, and also for not putting too much weight on the structure. Core composites, like laminated honeycomb panels was found as a fitting material for all the larger attachments. It is lightweight, got adequate structural properties and have many possibilities in terms of finishing. It is also a reasonable priced type of material, suiting well for the target user group.

7.3.2 Floor-to-ceiling storage unit

The outcome of the process described in this thesis, is a highly adjustable, versatile and customizable piece of furniture, requiring no mechanical fastening. The final design can function as an extension of a wall, it can be a room divider, walk-in-closet, a bookshelf or whatever the user desires it to be. The unit can be installed in any size desired, and with any layout, this gives the user maximum freedom, and no unit will look the same.



Figure 53 Floor-to-ceiling storage unit as wardrobe

Possibilities of use

The unit can function as a room divider, for dividing areas of a room and to provide visual privacy. The unit can be installed solely as a dividing wall, with screens placed in desired position for dividing spaces, or as a storage unit functioning as a partition wall. When the uprights are installed into position, the layout can easily be changed and altered infinitely.



Figure 54 Partition wall with screen attachments



Figure 55 Room divider with shelf and box attachments

As a storage unit along the wall, the unit functions as an extension of the wall. The users get maximum use of their wall space, without having to drill holes, or even touch the wall. This makes the unit a highly desirable solution for people that rent their accommodation.

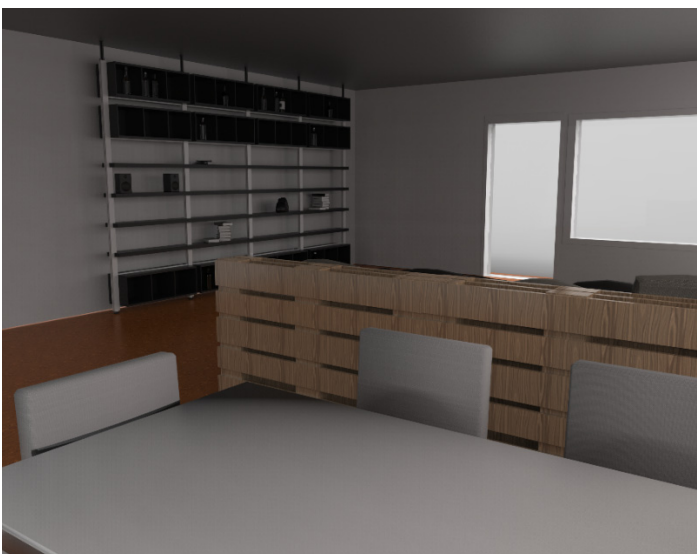


Figure 56 Storage along the wall in a living room



Figure 57 Open wardrobe

All sorts of items can be stored with the unit, and the way it is designed, allows for all items to be visible to the user. The slim design gives the users accessibility, and a good overview over their belongings, and helps them getting more use out of what they have.

Dimensions

Making sure that the uprights will be supported by the construction of every building, the unit is designed in line with construction standards. The uprights are placed with a centre-to-centre distance of 120 cm, which allows the unit to be supported by structural beams that usually are placed with the standard distances of c/c 30 cm, c/c 60 cm or c/c 120 cm. For buildings with ceilings of heavier constructions such as concrete slabs, the unit can be placed freely in the room. The storage unit is slim, and if placed against the wall, the frame itself sticks out only 4 cm.

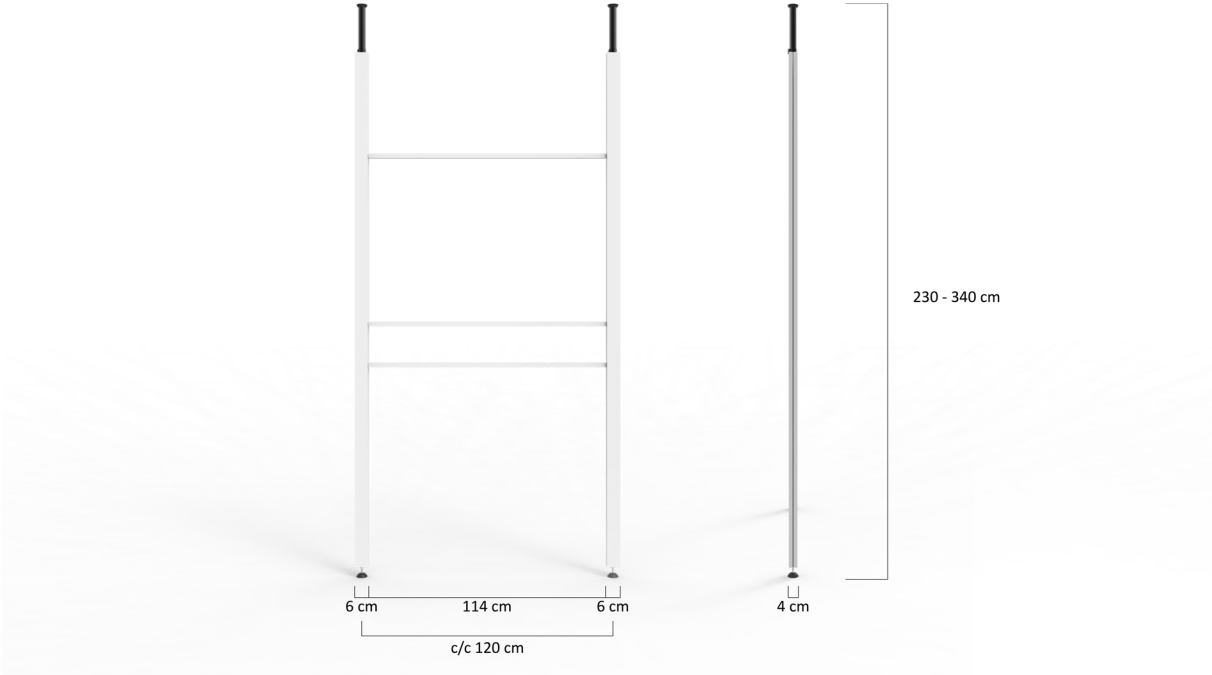


Figure 58 Main dimensions

With the use of the horizontals for hanging items of, or the hanging shelves, the unit can be placed right up against the wall, with the box and shelf attachment however, the unit will have to be placed a bit out from the wall. (Figure 59)



Figure 59 Dimensions with attachments

Installation

The storage unit can be acquired in any size desired, although a minimum of two uprights is required for the storage unit to function. To install the storage unit, the extending part of the upright will have to be extended all the way up to the ceiling, and locked into position with the quick release clamp. It is important that the uprights are installed perfectly vertical, for the unit to function properly. When the unit is perfectly vertical, and the distance between the uprights is controlled, the nut at the base of the uprights is used to secure the upright into position.

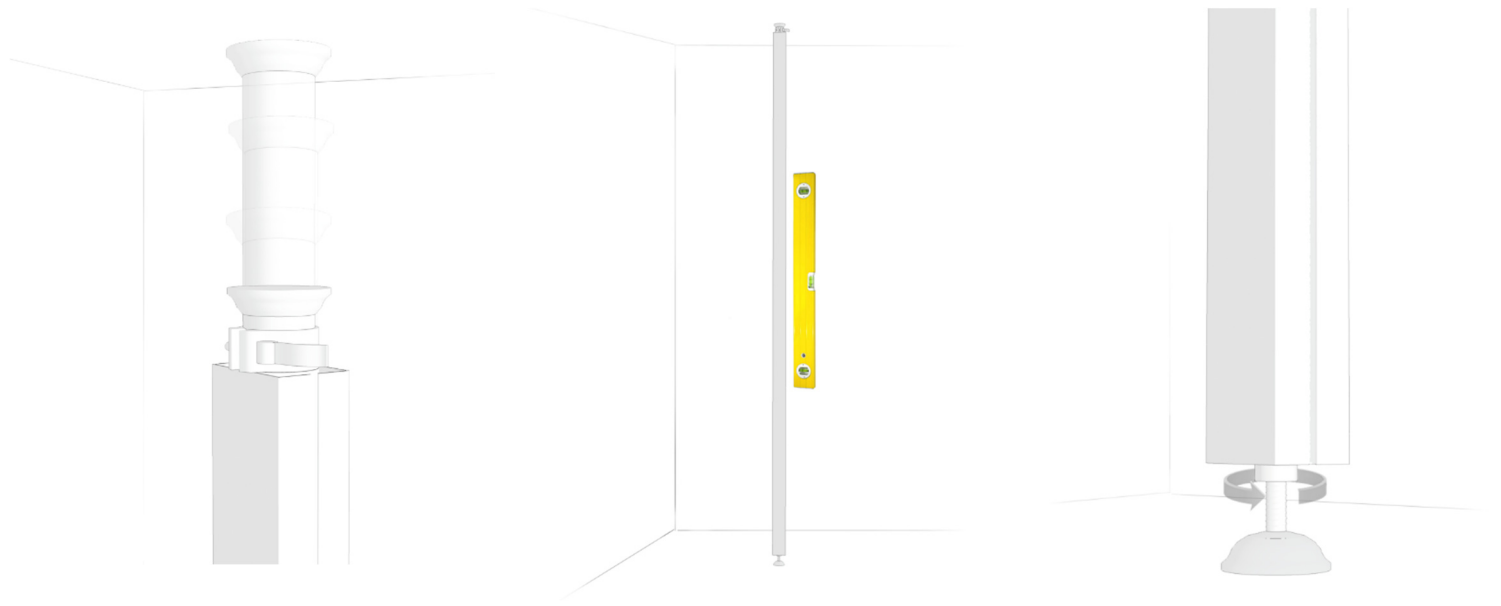


Figure 60 Installation of uprights

Once the frame of the unit is in place, horizontals can be slid in from the bottom, and placed at desired height. Of these horizontals the user can hang items, or they can be used to hold attachments.

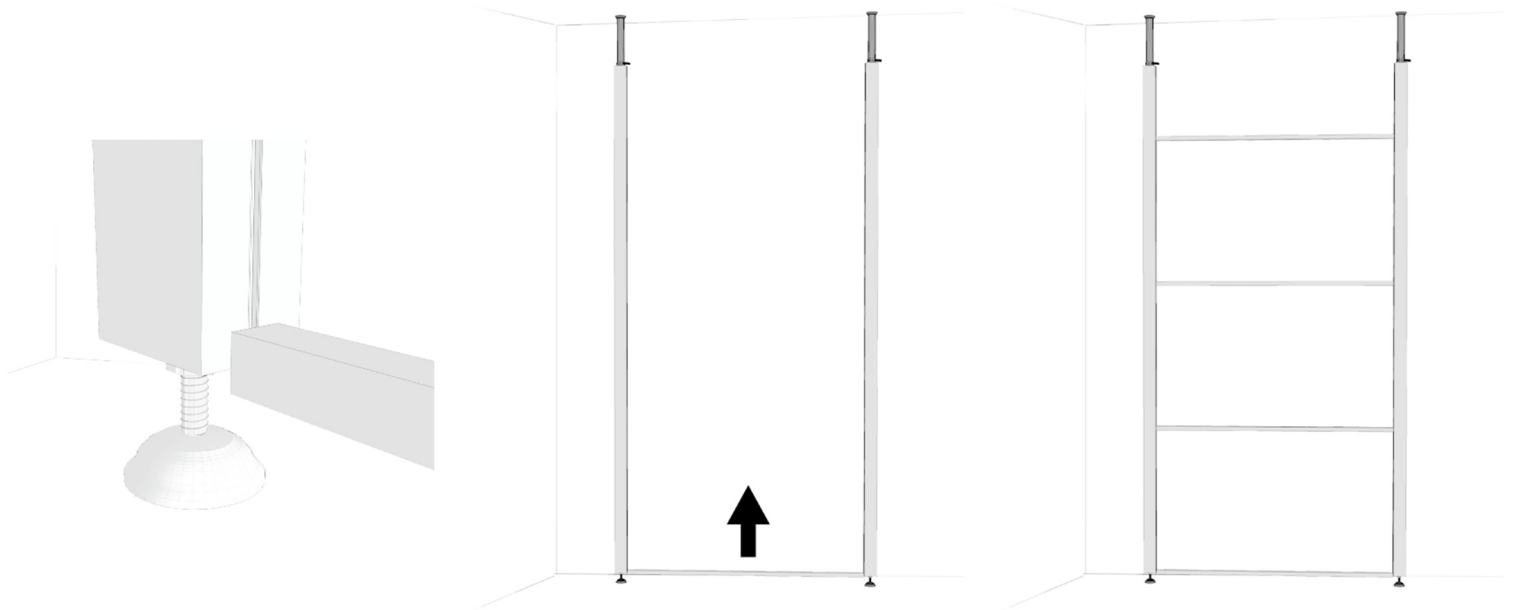


Figure 61 Inserting horizontals

Conclusion

The expectations for the outcome of this thesis was based on the research, and stated in the development brief. The final design is addressing the brief quite precisely, by enabling the user to get maximum use of their wall space, without the need of any mechanical fastening. Moreover, the final design allows the tenants to make further changes to their rented home by using the product as a freestanding piece of furniture or as a partition wall.

One important finding in the statistical research about the users, found that tenants generally are people with relatively low purchasing power, there could therefore be applicable to conduct cost analysis, making sure that the final product could be made available at the target users price level. The scalability and modularity of the final design does however appeal to costumers with lower purchasing power, as this allows them to choose at what scale and with which attachments they want to acquire the storage unit, which also would determine their price.

The attachments designed for the storage unit provides possibilities for storage of most relevant items. There could also be seen as a future development to extend the possible uses of the floor-to-ceiling storage unit for applications such as for instance wall hung TV's.

The floor-to-ceiling storage unit addresses the needs of the target users, and provides them with a solution that conveniently lets them take control over, and make changes to their home environment. There is however, a need for further development and testing, before the product could be ready for production and be launched to the market.

Summary

This thesis started out with identifying areas of possibilities for the development of a product to take place. There was early on identified a possibility to address the nuisances tenants experience related to making changes to their rented homes. Through getting knowledge about who the tenants are, and how they behave, assumptions done in the early stages of the research were confirmed. Based on the research, the expectations for the outcome was set to be a solution allowing tenants to get maximum use of their wall space, without the need of mechanical fastening. By displaying their belongings, the tenants should also be given the possibility to decorate, customize and personalize their home environment.

Conceptual solutions for wall storage, based on the expectations set in the brief, were presented and evaluated. These included storage systems hung of mouldings, adhesive and suction based solutions for attachment directly on the wall surface, and a system of floor-to-ceiling tension poles acting as an extended wall. The concept of floor-to-ceiling tension poles was found as the most feasible concept and taken into further development.

In the development phase, more specific design decisions for the floor-to-ceiling storage unit was done. By comparing and evaluating the proposed solutions, the development phase ends with the presentation of the final design. Possible attachments for the storage unit, allowing for extended use are also presented.

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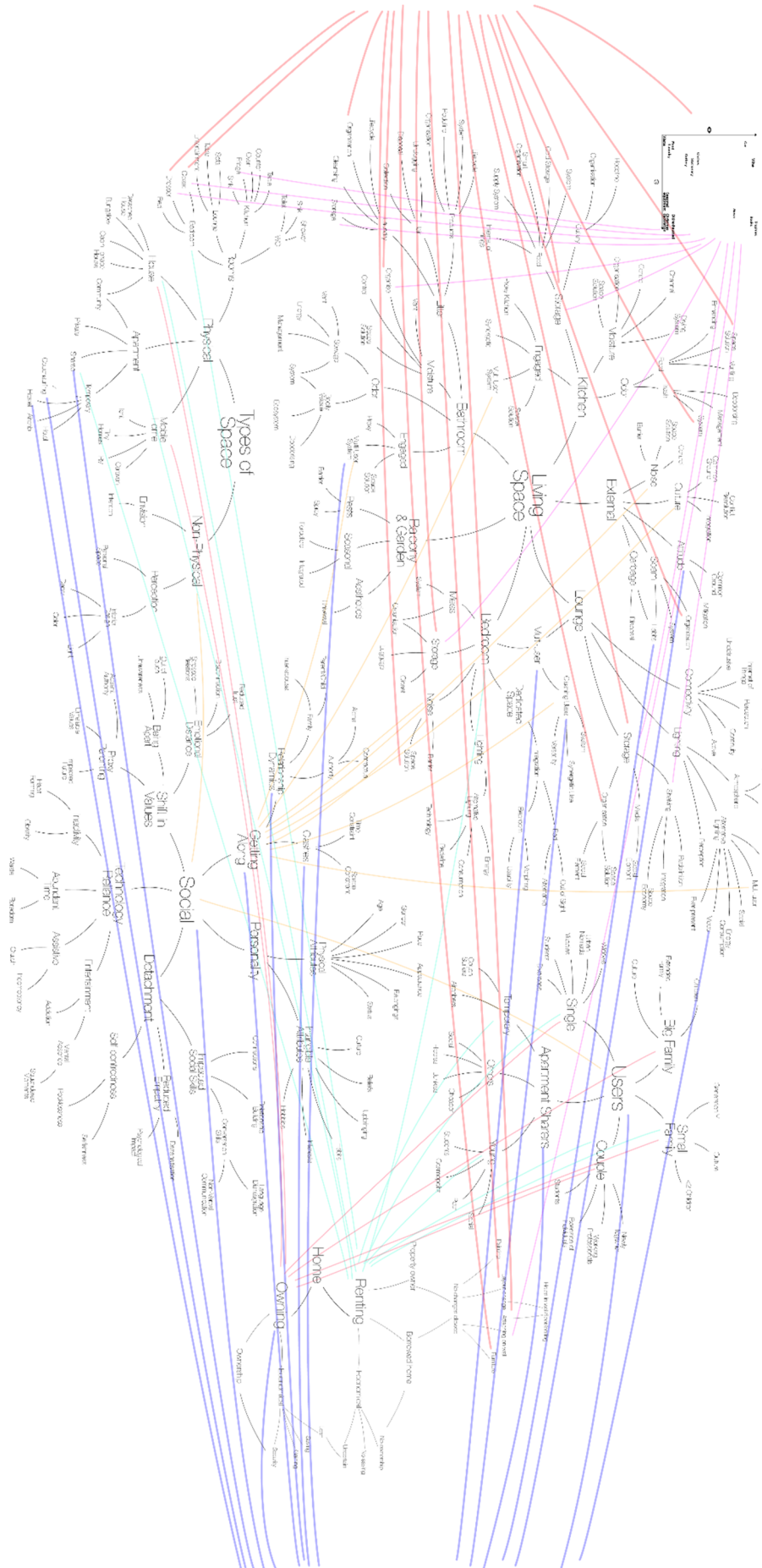
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