Roominess Adaption System - Development of kitchen units for disabled people.

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Submitted by José Abel Romero Gallardo and Manuel Jesus Fernández Sánchez to University of Skövde as a Bachelor Degree Project at the School of Technology and Society.

We certify that all material in this Bachelor Degree Project which is not our own work has been identified and that no material is included for which a degree has previously been conferred on us.

ABSTRACT.

This report covers a Bachelor degree project, where a new concept of kitchen for disabled people has been developed. In addition, this report describes the design process employed in the project as well as the details of the design work.

In order to develop a successful product, technical data like requirement specifications, materials currently used by the company and the manufacture of such products were considered throughout the progress of the project.

In addition, we carried out a market research and visited the fair “Leva & Fungera” in order to analyse the current situation of this market field and what disabled people would think about kitchen modules that completely adapts to their requirements. This research gave us an understanding of the user’s needs and provided us with valuable help for an ergonomics evaluation study.

Different creative methods were used to come further with new ideas, as well as different and more economic solutions than the existing ones.

Finally, CAD models were made with Pro Engineer Wildfire 4 and evaluated with Jack 5.1 in order to visualise and evaluate the final concepts. The ultimate result is presented in detail in a video made in 3D Studio Max.
ACKNOWLEDGEMENTS.

The development of this Bachelor degree project would not have been possible without the support of INCACSA S.L. We would like to show our sincere gratitude to Alberto Gil, for the opportunity he has offered to us and to all assistant staff at INCACSA, Spain.

This report would not have been written without the help of Dan Högberg who, thanks to his experience in this field and his exigency, made us put the maximum effort in the development of this report, as in the entire design process.

Finally, we want to show our appreciation to University of Skövde for the access to its facilities and staff that has made this project possible.
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Chapter 1. INTRODUCTION.

Nowadays, the kitchen is considered one of the most important areas at home and the integration of the kitchen inside the home environment is something indispensable. Kitchens manufacturing companies try to fulfil this need in the best way possible, introducing constant innovations in different fields to make the user more comfortable inside it.

The aim of this project is to enable this integration of the kitchen in the home of people with limited mobility. In order to do that, a wide anthropometric study has been carried out to understand the needs, as well as the limitations, of wheelchair users inside today’s kitchen, considering that all the different kitchen units as well as all the basic domestic appliances are totally integrated inside the kitchen. To obtain a space in which wheelchair users feel comfortable, all the phases of the design for this project will be based on the anthropometric study before mentioned.

Before going deeper into the project the term disability will be defined as follows:

Disability is taken to mean the socially produced barriers that are the result of wider attitudes and structures that limit a person with a physical impairment. In this way it views disablement as a socially constructed oppression, and not as a personal problem. A social barriers approach (as the name suggests) identifies barriers in wider society, and the way in which these same barriers limit the everyday lives of the people with impairments. This approach is not a departure from the established social model of disablement; it does, however, strongly emphasize the need to address the specific barriers that continue to disable people with impairments (Roulstone, 1998).
Chapter 2. PROBLEM DESCRIPTION.

To get a clearer view of what the goal of the project is and to get some limitations, there are different methods that can be used. These tools help the company and the design team to come to an agreement and to get the same specifications in the beginning of the project. In this project was been used a design brief and a mission statement as the tools for describing the work to be realized.

2.1. Design Brief.

The company, INCACSA S.L.

The development of the task carried out in this project is a wish of the Spanish Company INCACSA S.L. placed in Casariche (Sevilla, Spain) with more than 30 years of experience in kitchen manufacture. Its activity focus mainly in kitchen manufacturing and kitchen complements. The range of kitchens consists in wood models, lacquer and laminated. The main aim of INCACSA is to offer the latest trends of design to its clients, without diminishing quality and incorporating modern materials to the last technologies of manufacture, all of this with the continuous collaboration of experienced craftsmen. Owing to this, INCACSA wanted to develop a kitchen for disabled people in order to cover the needs of all users, since nowadays disabled people represent a high percentage of the active population.

Background.

The degree project consists of the design of kitchen units (different parts of a kitchen, e.g. glass-ceramic hob unit, sink unit, storage unit, etc.) for people with mobility disability (wheelchair users). Due to the problems or limitations these people have to overcome inside common kitchens, the company wanted to develop a project that allows them to solve these limitations and be able to manufacture the product afterwards. For the development of these kitchen units, the company required simplicity in the composition of the kitchen units - which must be also functional and economic in order to make the final product as affordable as possible. Clearly, the project had to be based on the materials and kitchen fittings currently available in the market. Furthermore, it is necessary to keep in mind that the units have to adapt to the production system of the factory.

It is imperative to undergo a study of the minimal acceptable mobility that these persons should have in relation to the space of a common kitchen, and two of the reasons are:

1. To support the development of the modules on this preliminary study and to cover all the needs with the maximum functionality possible.

2. To provide the sellers with enough information to sell this set of kitchen units.

INCACSA wants to focus in the following kitchen units considered basic in a kitchen:

- Sink Unit.
- Glass-Ceramic Hob Unit.
- Storage Unit.
- Drawer units.
In a common kitchen, the domestic appliances are part of the basic kitchen. Therefore, it is necessary to bear in mind the following domestic appliances during the development of the product.

- Glass-Ceramic Hob.
- Sink.
- Tap.
- Oven.
- Microwave.
- Dishwasher.
- Fridge.

This project was divided in several phases, described in Table 2.1. Some phases of the development of the product were extended in order to obtain more information in the field of the disability, consequently the original table of tasks was not faithfully followed.

**Table 2.1. Timetable (table of tasks).**
2.2. Mission Statement.

All of the company requirements and requests are gathered in a single document, the requirement specification. The purpose of this document is to guide the designer in the development of the project. The design team established a list with the requirements stated by INCACSA, and complemented by the specifications exposed after several meetings with the supervisor at the University of Skövde.

The kitchen units should be adapted to kitchens from 8 to 12 m² and any type of domestic appliance must be included in the kitchen units and, once again, baring in mind that any design must adapt to INCACSA's manufacturing processes.

At the beginning of the project, INCACSA established a list of basic requirements that eventually increased after researching the needs of wheelchair users. Facility of use and cleanliness, maximum comfort and maximum accessibility in the working area are some of the requirements that where considered to increase the quality of the final product. Figure 2.1 shows the development process established at the beginning of the project.

![Development process of the project](image_url)
Chapter 3. RESEARCH.

In order to get some background information about the product and the possible users, an exhaustive research was necessary. Internet, specialised publication and INCACSA were the major information sources used.

3.1. Market research.

There is not much competition in the market of the kitchens for disabled people since all the existing kitchens for disabled people are based in similar solutions. We must highlight companies like the Italian Scavolini, the first to produce kitchens with these characteristics on an industrial scale based on an original design of the architects Renzo Baldanello and Bernardino Pittino. The Project was born in 1998 as a consequence of a contest held in Pesaro by the Foundation Don Gaudiano. The following pictures (Figure 3.1) show some of the solutions of the “Utility System” by Scavolini.

Another innovative company in this area is the German Company Küchen Quelle, which, unlike Scavolini, only has two models adapted for disabled people. The solutions chosen for those models are similar to the Italian company: electrical motors for high furniture and worktop, safety zones and some of the solutions for the storage units. The following pictures (Figure 3.2 and 3.3) show some of the solutions integrated by Küchen Quelle.

Figure 3.1. Solution for high furniture and sink unit. Scavolini Utility System (Scavolini online catalogue).

Figure 3.2. Solution for high furniture with electrical motor. Küchen Quelle catalogue. (Küchen online catalogue).
Finally, the Swedish Company Granberg, which manufactures working spaces for disabled people, also use electrical motors as a solution for high furniture.

In short, the solutions proposed by the current manufacturers consist of measures incorporated into common kitchens, as can be seen in the following pictures (Figure 3.4 and 3.5).
3.2. Exhibition of assistive technology for disabled people “Leva & Fungera”.

The visit to the exhibition “Leva & Fungera”, held in Gothenburg from the 22nd to the 23rd of April, 2009 was extensively enlightening about the needs of wheelchair users. Leva & Fungera is an exhibition on assistive technology for disabled people with a total average of 12,000 visitors and comprises a wide range of products: rehab – technical equipment, personal assistance, training, literature, transport, buildings, installations, etc. This trade fair, held every two years, is the most important event of these characteristics with several activities, seminars and conferences. This event allowed us to get in contact with a great number of wheelchair users and listen to their opinions about existing solutions, as well as their impressions about our project.

We decided to realize a questionnaire in order to obtain more information from the users. The questionnaire was handed out to around 30 people of a range age of 25 – 55 years old. The majority of the people consulted punctuated accessibility, functionality and the working space as the most important aspects to take into account when designing a kitchen for disabled people. We could also get first-hand information about the kitchen units that wheelchair users generally find more inconvenient: storage units and the units for drawers. All the information obtained in the questionnaires as well as in the exhibition was included as a key part inside the project. The content of the questionnaire as well as the results can be seen with more detail way in Appendix 1. The Figures 3.6 show some of the interviewed people attending the exhibition.

![Figure 3.6. Interviewing people in exhibition of assistive technology for disabled people “Leva & Fungera”.

3.3. Anthropometric and ergonomic study.

In order to pursue the best outcome possible in this project, an anthropometric study was carried out. A number of specifications were established with the intention of fixing accurate measures for the different kitchen units according to the users’ limitations. Different studies in ergonomics and anthropometry executed in universities and biomechanical institutes, were considered in this study. In addition to this, we carried out our own study with small number of different people with different heights. Taking different measures to obtain different data, allowed us to get hold of a more solid and trustworthy study.
According to the book “The human dimensions in interior spaces”:

...is difficult to find a lot of information of persons in wheelchairs of a trustworthy way, due to the fact that in a study of these characteristics it is necessary to consider many factors, as types of disability, members or affected parts of the body, extent of paralysis, degree of muscular dysfunction, and so on. When the extension, roominess, and other parameters are measured, it is necessary to include the joint user – wheelchair system (Panero & Zelnik, 2007).

This approach demands knowledge on the peculiarities of the wheelchair, some of the basic ones can be found in Figure 3.7:

![Figure 3.7. Basic measures of the wheelchairs. (B) Radius of alternative draft. Wheelchair dimensions (A.N.S.I. 1971).](image)

According to the different consulted studies, it is necessary to consider the measurements of the smallest percentil for women in some areas of the kitchen as well as the measures of
the highest percentil of men for other areas, owing to the fact that a design based on the average of the measurements, would exclude about a half of the wheelchair users (Panero & Zelnik 2007) (De la Vega, 2004).

Figures 3.8, 3.9 and the Table 3.1 show the user and the wheelchair with anthropometric measures of men and women (Panero & Zelnik, 2007). They correspond to the 2.5 percentile in order to accommodate the users of minor corporal size. For the roominess, 97.5 percentile of the men is used in order to obtain a working space adapted to a larger proportion of the targeted users. Worth noticing is the fact that the majority of wheelchairs are not built to support the body to 90° (this was considered in the Jack analysis, see Section 6.3), consequently, any parts of the body do not have a strict vertical position or horizontal position, according to the following note of the Dr. Hernan L. Kamenetz:

In this imaginary position only the ankles support an angle of 90°. The legs rise to 15°, forcing to the knees to form an angle of 105°: the back inclines 10°, for what the joint of the knees stays to an angle near to 100°. The resultant effect is similar to the one that would give an inclination backward of the chair of 5°, fixing the seat to 5° of the horizontal plane, legs to 20° and back to 15° respectively of the vertical plane. (Herman, 1969).

<table>
<thead>
<tr>
<th>Position</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>158,1</td>
<td>144,1</td>
</tr>
<tr>
<td>B</td>
<td>41,3</td>
<td>44,5</td>
</tr>
<tr>
<td>C</td>
<td>22,2</td>
<td>17,8</td>
</tr>
<tr>
<td>D</td>
<td>47,0</td>
<td>41,9</td>
</tr>
<tr>
<td>E</td>
<td>65,4</td>
<td>58,4</td>
</tr>
<tr>
<td>F</td>
<td>73,0</td>
<td>66,0</td>
</tr>
<tr>
<td>G</td>
<td>48,3</td>
<td>48,3</td>
</tr>
<tr>
<td>H</td>
<td>130,8</td>
<td>119,4</td>
</tr>
<tr>
<td>I</td>
<td>148,0</td>
<td>135,2</td>
</tr>
</tbody>
</table>

In the frontal view, we can observe the most important anthropometric measures of both the user and the wheelchair. (Figure 3.9).
Another anthropometric study from the University of Guanajato, Mexico, was considered for this study. In this study, the main measures of the man/woman on wheelchair were taken and classified in a table in 5%, 50% and 95% percentil. For this study were measured a total of 108 persons, aged 18 to 60, in which 51, 85% were men and 48, 15% women. The Tables 3.2, 3.3 and the Figure 3.10 show the average measures of men and women, sorted by different parts of the body.

Table 3.2 and 3.3. (De La Vega, 2004). Average of the measures of women and men from the anthropometric study by the University of Guanajato. Measurements in cm.
In order to achieve a deeper study, we decided to carry out our own study about women and men with different statures, focusing on the minimum measures of women and on the maximum measures of men. The University of Skövde provided a wheelchair for this study. The results obtained in this study are shown in Figure 3.10 and Tables 3.4 and 3.5, while Figure 3.12 illustrates some pictures taken during the measurement session.

Figure 3.10. Measures obtained in the Tables 3.2 and 3.3. (De la Vega, 2004).

Figure 3.11. Reference of the measures for Tables 3.4 and 3.5.
Table 3.4. Measures taken to the women taking part in our anthropometric study.

<table>
<thead>
<tr>
<th></th>
<th>Ananda</th>
<th>Géaëlle</th>
<th>Anna</th>
<th>Alison</th>
<th>Viktoria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>166</td>
<td>162</td>
<td>162</td>
<td>157</td>
<td>165</td>
</tr>
<tr>
<td>A</td>
<td>66,5</td>
<td>65</td>
<td>64</td>
<td>62</td>
<td>63</td>
</tr>
<tr>
<td>B</td>
<td>27,5</td>
<td>25,5</td>
<td>26</td>
<td>27</td>
<td>26</td>
</tr>
<tr>
<td>C</td>
<td>71</td>
<td>71</td>
<td>63</td>
<td>66</td>
<td>67</td>
</tr>
<tr>
<td>D</td>
<td>135</td>
<td>132</td>
<td>128</td>
<td>128</td>
<td>127</td>
</tr>
<tr>
<td>E</td>
<td>16</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>17</td>
</tr>
<tr>
<td>F</td>
<td>84,5</td>
<td>83,5</td>
<td>83</td>
<td>83</td>
<td>82</td>
</tr>
<tr>
<td>G</td>
<td>97</td>
<td>100</td>
<td>89</td>
<td>101</td>
<td>92</td>
</tr>
</tbody>
</table>

Table 3.5. Measures taken to the men taking part in our anthropometric study.

<table>
<thead>
<tr>
<th></th>
<th>Luis</th>
<th>Jorge</th>
<th>Nico</th>
<th>Jose</th>
<th>Alex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>187</td>
<td>180</td>
<td>194</td>
<td>188</td>
<td>188</td>
</tr>
<tr>
<td>A</td>
<td>77</td>
<td>72,5</td>
<td>74</td>
<td>72,5</td>
<td>74</td>
</tr>
<tr>
<td>B</td>
<td>28,5</td>
<td>27</td>
<td>28</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>C</td>
<td>79</td>
<td>77</td>
<td>80</td>
<td>76</td>
<td>75</td>
</tr>
<tr>
<td>D</td>
<td>148</td>
<td>151</td>
<td>151</td>
<td>151</td>
<td>148</td>
</tr>
<tr>
<td>E</td>
<td>26</td>
<td>21</td>
<td>27</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>F</td>
<td>87</td>
<td>87</td>
<td>84</td>
<td>84</td>
<td>84</td>
</tr>
<tr>
<td>G</td>
<td>102</td>
<td>107,5</td>
<td>116</td>
<td>108</td>
<td>105</td>
</tr>
</tbody>
</table>

Picture 3.12 Taking measures for Table 3.4 and 3.5.
With the results obtained by the different methods previously described, and with the help of the software "PeopleSize Pro 2008" (Open Ergonomics Ltd, 1993-2008), Table 3.7 was completed with the most suitable measures for every unit of kitchen, which are described in Table 3.6 and can be observed clearly in Figure 3.13. Provided that this project is aimed at a Spanish company, the measures of the Spanish people would be the most accurate data to consider if the kitchen is to be sold only in Spain. Unfortunately, the software above mentioned does not consider such information. Therefore, the measures of the French people were used instead, since French population is considered to be similar to Spanish people.

![Figure 3.13. Main measurements of the kitchen according to the reference to wheelchair users.](Image)

**Table 3.6. References of the measurements showed in Figure 3.13.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Max. Height of the worktop.</td>
</tr>
<tr>
<td>B</td>
<td>Depth of the worktop.</td>
</tr>
<tr>
<td>C</td>
<td>Depth of the Sink.</td>
</tr>
<tr>
<td>D</td>
<td>Depth of the tap.</td>
</tr>
<tr>
<td>E</td>
<td>Max. Height of the furniture (high furniture).</td>
</tr>
<tr>
<td>F</td>
<td>Max. Length of furniture when it is open. (drawers)</td>
</tr>
<tr>
<td>G</td>
<td>Min. Height of the furniture.</td>
</tr>
<tr>
<td>H</td>
<td>Min. Depth of the base of the furniture.</td>
</tr>
</tbody>
</table>
Table 3.7. Table with the most suitable measures to be considered for the wheelchair users in a kitchen. It was done with the results obtained in the anthropometric study. (1) Range women 2.5% percentile, (2) Bearing in mind arm length of the 2.5% percentile of women, (3) It can vary depending on the work space, (4) Bearing in mind height feet men 97.5% percentile.

<table>
<thead>
<tr>
<th></th>
<th>(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sink Unit</strong></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Range 70-85 cm. (1)</td>
</tr>
<tr>
<td>B</td>
<td>63 cm. (2)</td>
</tr>
<tr>
<td>C</td>
<td>Standards models. (2)</td>
</tr>
<tr>
<td>D</td>
<td>Max. 63 cm. (2)</td>
</tr>
<tr>
<td><strong>Glass-ceramic hob unit</strong></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Range 73-100 cm (1)</td>
</tr>
<tr>
<td>B</td>
<td>63 cm. (2)</td>
</tr>
<tr>
<td><strong>Storage unit</strong></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>125 cm. (+40 – 45 cm from the worktop for high furniture) (2)</td>
</tr>
<tr>
<td>F</td>
<td>It depends on the Kitchen fittings (3)</td>
</tr>
<tr>
<td>G</td>
<td>26 cm. (4)</td>
</tr>
<tr>
<td>H</td>
<td>18 cm. (3)</td>
</tr>
<tr>
<td><strong>Unit for drawers</strong></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>125 cm. or depending on the worktop(2)</td>
</tr>
<tr>
<td>F</td>
<td>It depends on the kitchen fittings (3)</td>
</tr>
<tr>
<td>G</td>
<td>18 cm. (4)</td>
</tr>
</tbody>
</table>

3.3.1. Kitchen Design Study.

Nowadays, when designing a current kitchen there are different guidelines to bear in mind in order to obtain a comfortable workplace and a suitable disposition of the different units. These guidelines match the theory of “the golden triangle”. A kitchen has at least three areas or indispensable sectors which shape a triangle that determines the most frequent displacements of the user: cooking area, washing area and food storage area.

Taking into consideration the type of movements the user needs to perform in the kitchen, the best distribution will be the one that facilitates the work, avoiding unnecessary displacements and facilitates that everything is in order and in close proximity to to the user.

- **Cooking area.** This zone includes the glass-ceramic hob, the oven and the microwave. In addition, this zone integrates the extractor hood, kitchen utensils, among others. It is necessary to keep in mind the power points for electricity or gas.
- **Washing area.** This zone encloses the sink and dishwasher. It is necessary to plan the inlet of water, pipelines of outlet and specific sockets. In addition, it is necessary to add the bucket of garbage and products and utensils of cleaning to this area.
- **Food storage area.** This area is destined for the storage and food conservation. The fresh and perishable food must be placed in the refrigerator. Non-perishable food, like beverages and conserves, should be placed in different furniture or baskets that will do the functions of a pantry.

Another important area inside the design of a kitchen – inside the Golden Triangle –, is the area of preparation of food.

- **Area of Preparation of food.** It comprises the work surfaces. A worktop on both sides of the glass-ceramic hob, the sink facilities, the preparation of the food and the utilization of small domestic appliances (Montes, 2003).
Figure 3.14 describes the Golden Triangle according to the different examples of dispositions of kitchens.

3.4. **Materials.**

In order to explain the most important characteristics of each material, we underwent a brief research in which we found more information about all the materials that make up the kitchen for disabled people. It has divided the research in the different parts that consists the kitchen furniture. The divided parts are the following ones.

- Body (framework) of the furniture.
- Doors and Front Parts.
- Legs of Furniture.
- Hinges.
- Drawers.
- Kitchen fittings.

All the materials are explained in more detail in Appendix 2.

3.5. **Manufacturing processes.**

Firstly, it is interesting to say that INCACSA, in its plant in Casariche, has a leading-edge technology in CNC machines with which obtain an optimum result in their products. In addition, it is good to say that INCACSA can develop any kind of kitchen furniture of kitchen that is based in a body-and-door structure. They use a mass production system
(Flexible manufacture system based in CNC machines), divided in seven stages, using different CNC machines in each of them. The stages are described in a more graphic approach in Appendix 3.


After finishing the ergonomic study and being present at the fair “Leva & Fungera”, we built a table of requirements in which both, INCACSA’s main desires for the project as well as our criteria were included.

The requirement specifications were taken into consideration for every kitchen unit, since not all of them have the same potential. Finally, thanks to the results of the ergonomic study and the experience lived in the fair “Leva & Fungera”, we included a wide range of useful data for the next step. All the requirements can be seen in detail in Appendix 4.
Chapter 4. Concept Development.

4.1. Concept Generation

This chapter aims to describe the different stages of the concept generation. Creativity methods were used to generate many different solutions. The solutions then contribute to the development of new concept ideas that were eventually evaluated to further improve the product.

4.1.1. Brainstorming

The most widely known creative method is brainstorming. This is a method for generating a large number of ideas, most of which will subsequently be discarded, but with perhaps a few novel ideas being identified as worth following up... The most important rule here is that no criticism is allowed from any other member of the group. The usual responses to unconventional ideas, such as “That’s silly” or “That will never work”, kill off spontaneity and creativity... The group session should not last more than about 20-30 minutes, or should be wound up when no more new ideas are forthcoming (Cross, 1994).

Because of the depth of the task, both members of the designing team decided to hold a brainstorming session, focusing on the different kitchen units. There were no timeframe or restrictions established, just one of the students taking notes about all the new ideas.

When the brainstorming finished, the new ideas were analysed and discussed. Finally, the team elaborated a list with the most interesting ideas of every kitchen unit to consider for subsequent design activities. Table 4.1 shows some of the most interesting ideas for each kitchen unit. Table 4.2 shows some extra suggestions for the different units in order to achieve a better integration of the wheelchair user in the kitchen.
Table 4.1: List with the most important ideas extracted from the brainstorming session.

<table>
<thead>
<tr>
<th>Kitchen Unit</th>
<th>For Concept Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sink Unit.</td>
<td>Accessible to all the wheelchair users</td>
</tr>
<tr>
<td></td>
<td>Suitable distance to the glass-ceramic hob.</td>
</tr>
<tr>
<td>Glass-Ceramic Hob Unit.</td>
<td>Accessible to all wheelchair users.</td>
</tr>
<tr>
<td></td>
<td>Safety zones.</td>
</tr>
<tr>
<td></td>
<td>Near to the kitchen utensils.</td>
</tr>
<tr>
<td>Storage Unit.</td>
<td>Accessible to all wheelchair users.</td>
</tr>
<tr>
<td></td>
<td>Vertical drawers for high furniture.</td>
</tr>
<tr>
<td></td>
<td>Detachable unit from the upper part.</td>
</tr>
<tr>
<td></td>
<td>Storage unit with wheels for dustbin drawer.</td>
</tr>
<tr>
<td></td>
<td>Sliding unit for island.</td>
</tr>
<tr>
<td></td>
<td>Units with circular-rotary kitchen fittings.</td>
</tr>
<tr>
<td></td>
<td>Storage unit with hooks.</td>
</tr>
<tr>
<td></td>
<td>Storage unit with rotary-circular kitchen fitting and hooks</td>
</tr>
<tr>
<td></td>
<td>Safety zones inside the storage units.</td>
</tr>
<tr>
<td></td>
<td>Fan-storage units.</td>
</tr>
<tr>
<td></td>
<td>Furniture with wheels with circular-rotary kitchen fittings.</td>
</tr>
<tr>
<td></td>
<td>Big bodies with kitchen fittings for pantry.</td>
</tr>
<tr>
<td></td>
<td>Detachable unit with mechanism.</td>
</tr>
<tr>
<td></td>
<td>Storage unit below the oven with safety zones.</td>
</tr>
<tr>
<td>Units for drawers.</td>
<td>Accessible to all wheelchair users.</td>
</tr>
<tr>
<td></td>
<td>Vertical drawers.</td>
</tr>
<tr>
<td></td>
<td>Not too deep drawers.</td>
</tr>
<tr>
<td></td>
<td>Drawers in corner (find a solution).</td>
</tr>
<tr>
<td></td>
<td>Narrow drawers.</td>
</tr>
<tr>
<td></td>
<td>Use kitchen fittings for storage.</td>
</tr>
</tbody>
</table>

Table 4.2: List with some interesting suggestions for each unit extracted from the brainstorming session.

<table>
<thead>
<tr>
<th>Sink Unit.</th>
<th>Shower-tap for kitchens. (Figure 4.1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Less deep models of sink.</td>
</tr>
<tr>
<td>Glass-Ceramic Hob Unit.</td>
<td>Front control buttons for the glass-ceramic hob.</td>
</tr>
<tr>
<td></td>
<td>Lengthened glass-ceramic hob. (Figure 4.1)</td>
</tr>
<tr>
<td>Storage Unit.</td>
<td>Doors with a 180º opening.</td>
</tr>
<tr>
<td>Other suggestions</td>
<td>Fridge with a max. height of about 1.20 m.</td>
</tr>
<tr>
<td></td>
<td>Specific shape for worktop (described in Section 5.18).</td>
</tr>
<tr>
<td></td>
<td>Smaller freezer.</td>
</tr>
<tr>
<td></td>
<td>Oven with laterals doors.</td>
</tr>
<tr>
<td></td>
<td>Big handles for the furniture.</td>
</tr>
</tbody>
</table>
All ideas and suggestions achieved in the brainstorming as well as the result of the brainstorming sessions can be viewed in Appendix 5.

4.1.2. Sketching.

With a lot of ideas obtained from the Brainstorming session, we started the sketches in order to have a clearer vision of the ideas from the brainstorming. To get through this sketching session, the team first worked with the previous classification based on the type of module. Later, we analysed the functionality of each module and, therefore, we created a second classification and to be able to evaluate each concept. In the following page (Figure 4.2), are included the results of the sketching session in a broad view. Appendix 6, provides a more detailed view of all the sketches.
Figure 4.2 All sketches done in the sketching session. In Appendix 6, all the sketches are showed in a bigger size for a clearer view.
4.2. Concept Evaluation.

When the sketches for each kitchen unit were developed, there were many doubts about how the evaluation would be realized. After a meeting with the university and a conversation with the contact in INCACSA, it was decided to do a classification with the kitchen units, focusing on the functionality of each one. For it, all the sketches were put on a table to discuss and to analyze which of them were related. So, in the following list, the classification for the evaluation can be viewed:

- Solution for glass-ceramic hob unit.
- Solutions for sink unit.
- Solutions for corner.
- Solutions for low furniture.
- Solutions for high furniture.
- Solutions for mobile furniture.

To evaluate each group, it was decided to use a matrix of punctuation for each one. In this way, solutions for glass-ceramic hob unit, solutions for sink unit, solutions for corner, solutions for low furniture and solutions for high furniture were evaluated by means of the concept screening matrix in which every concept was compared with the current existing solution for each one inside its group. The process will be explained more detailed in Section 4.2.1. For the evaluation of the last group, solutions for mobile furniture, the concept scoring was used, a method almost the same as the concept screening but with a little difference in the way of punctuation. A reference concept is not used in this method since this kind of furniture is not very common in the kitchens of today. The progress of this method will be showed in Section 4.2.2.

4.2.1. Concept Screening

*Concept screening is based on a method developed by the late Stuart Pugh in the 1980s and is often called Pugh concept selection. The purposes of this stage are to narrow the number of concepts quickly and to improve the concepts… the team rated the concepts against the reference concept using a simple code (+ for “better than,” 0 for “same as,” – for “worse than,”) in order to identify some concepts for further consideration (Ulrich and Eppinger, 2007).*

*Solutions for glass-ceramic hob unit.*

Firstly the evaluation was started with the different concepts developed such as possible solutions for glass ceramic hob unit. The concept screening method developed by Stuart Pugh was used to identify the most feasible idea for this kitchen unit was identified. *Figure 4.3* shows the different concepts developed in the brainstorming session according to the numbers of the concepts in *Table 4.3*, which shows the evaluation matrix for this kitchen unit. The concept nº 5 in the table is the reference concept; for this kitchen unit the worktop adjustable by electrical motor was chosen as the reference concept, since this is the solution commonly used in the market of kitchen for disabled people.
**Figure 4.3** Sketches for the description of the concepts of the Table 4.3.

**Table 4.3** Selection matrix for glass-ceramic hob unit.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Simplicity</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Functionality</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Adapted to manufacturing processes</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Comfortable</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Economic</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Easy to clean</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Accessible</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Adapted to the kitchen fittings</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Easy to assemble</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Safety</td>
<td>0</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Sum +’s</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Sum 0’ s</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Sum –’ s</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Net Score</td>
<td>0</td>
<td>-1</td>
<td>-2</td>
<td>-3</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Rank</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Continue?</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

2. Adjustable height of the worktop by crank.
3. Detachable Glass-Ceramic Hob.
4. Detachable with Storage unit.
5. Reference (adjustable worktop by electric motor).
6. Fixed in the wall with a specific height for each user.
The evaluation gave that concept nº 6 got highest score. This solution was proposed by the supervisor of INCACSA in order to try to obtain the maximum possible saving in this kitchen unit, as well as more nearby treatment to the client. For it, it was established a range of height between the height of the legs of each user and the height of the worktop. This concept will be cleared up in Section 5.18.

Solutions for Sink Unit.

For this unit three main ideas were developed. This since a kitchen unit for the sink is simple and the possible innovations are limited. As the reference concept was chosen a worktop adjustable by electrical motor like in the glass-ceramic hob unit, because in a current kitchen the sink and the glass-ceramic hob are placed in the same worktop. Figure 4.4 shows the most important ideas in a graphic way (sketches) in order to understand better each idea. Table 4.4 shows the result of the evaluation matrix for the sink unit.

Table 4.4. Selection Matrix for sink unit.

<table>
<thead>
<tr>
<th>Selection Criteria</th>
<th>Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Simplicity</td>
<td>-</td>
</tr>
<tr>
<td>Functionality</td>
<td>0</td>
</tr>
<tr>
<td>Adapted to manufacturing processes</td>
<td>0</td>
</tr>
<tr>
<td>Comfortable</td>
<td>-</td>
</tr>
<tr>
<td>Economic</td>
<td>+</td>
</tr>
<tr>
<td>Easy to clean</td>
<td>0</td>
</tr>
<tr>
<td>Accessible</td>
<td>0</td>
</tr>
<tr>
<td>Adapted to the kitchen fittings</td>
<td>0</td>
</tr>
<tr>
<td>Easy to assemble</td>
<td>0</td>
</tr>
<tr>
<td>Safety</td>
<td>+</td>
</tr>
<tr>
<td>Sum +’s</td>
<td>2</td>
</tr>
<tr>
<td>Sum 0’s</td>
<td>6</td>
</tr>
<tr>
<td>Sum −’s</td>
<td>2</td>
</tr>
<tr>
<td>Net Score</td>
<td>0</td>
</tr>
<tr>
<td>Rank</td>
<td>2</td>
</tr>
<tr>
<td>Continue?</td>
<td>NO</td>
</tr>
</tbody>
</table>
1. Adjustable height of the worktop by crank.
2. Detachable base for sink.
3. Worktop fixed in the wall with a specific height for each user.
4. Reference. (Adjustable worktop by electric motor).

The result of the selection matrix was the same for the glass-ceramic hob that is the concept a worktop fixed in the wall with a specific height for each user. This solution was also suggested by Alberto Gil, the supervisor of INCACSA, as the most feasible solution for these units, due to the fact that one of the most important requirements established in the beginning of the project was to obtain the most economic kitchen.

Solutions for corners.

For the solutions for corners, two concepts were evaluated. The first one is big a furniture with a kitchen fitting inside which allow a better accessibility to the storage unit, and the second one is a drawer for corners which is a different solution for the corner, but it could be a nice concept to make the most of the space in this zone of the kitchen. So, in Figure 4.5 both concepts can be viewed in the sketches. The reference taken to evaluate this concept was a current furniture in corners with shelves inside which is one of the more common solutions in the kitchens of today. In Table 4.5, the result of the evaluation is showed in the concept screening matrix.

![solutions for corners](image)

**Figure 4.5.** Sketches for the description of the concepts of the Table 4.5.
Chapter 4. Concept Development.

Table 4.5. Selection matrix for corners.

<table>
<thead>
<tr>
<th>Selection Criteria</th>
<th>Concepts</th>
<th>1</th>
<th>2</th>
<th>3 (reference)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simplicity</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Functionality</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Comfortable</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Adapted to manufacturing processes</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Economic</td>
<td>-</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Easy to clean</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Accessible</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Adapted to the kitchen fittings</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Easy to assembly</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Safety</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sum +’s</td>
<td>6</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sum 0’s</td>
<td>2</td>
<td>5</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Sum –’s</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Net Score</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rank</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Continue?</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td></td>
</tr>
</tbody>
</table>

1. Storage unit with gyratory kitchen fitting.
2. Drawers for corner.
3. Current storage unit with different shelves (Reference).

After the evaluation, both concepts obtained a good score compared with the reference concept. This result was discussed and analyzed with INCACSA and it was decided to keep both concepts because of the possibilities that they could contribute to subsequent design activities.

Solutions for low furniture.

In this point, six ideas were evaluated by means of Pugh’s method. As the reference concept (number 7) was chosen normal furniture with shelves that we can found in a current kitchen. In the following page, Figure 4.6 shows the different solutions developed in the brainstorming session for low furniture. Table 4.6 shows the selection matrix for low furniture.
## Chapter 4. Concept Development

### solutions for low furniture

**Figure 4.6.** Sketches for the description of the concepts of the Table 4.

**Table 4.6.** Selection matrix for low furniture.

<table>
<thead>
<tr>
<th>Selection Criteria</th>
<th>Concepts</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7 (Reference)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simplicity</td>
<td></td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Funcionality</td>
<td></td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Adapted to manufacturing processes</td>
<td></td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Comfortable</td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Economic</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Easy to clean</td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Accessible</td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Adapted to the kitchen fittings</td>
<td></td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Easy to assembly</td>
<td></td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Safety</td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td><strong>Sum +’s</strong></td>
<td></td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>2</td>
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<td>5</td>
<td>3</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td><strong>Sum –’s</strong></td>
<td></td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td><strong>Net Score</strong></td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>-1</td>
<td>3</td>
<td>-4</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Rank</strong></td>
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<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Continue?</strong></td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td></td>
</tr>
</tbody>
</table>

1. Fan Storage Unit.
2. Vertical Drawer.
3. Big furniture with kitchen fitting for pantry.
4. Storage unit with circular-rotary kitchen fitting with hooks.
5. Storage unit with hidden safety zones.
6. Storage unit with mechanism of extraction.
7. Storage unit with shelves (reference)
The concepts selected in the selection matrix were the concepts nº 2, nº 3 and nº 5; the vertical drawers, the big furniture with kitchen fitting for pantry and storage unit with hidden safety zones respectively. This result was positive for INCACSA because these concepts solve a lot of solutions for the different dispositions of the current kitchen.

**Solution for high furniture.**

In this point, the selection was developed in a more thoroughly way because the high furniture are where wheelchair users often experience problems. Five main ideas were selected for this furniture and they were evaluated by means of the Pugh’s methods. Figure 4.7 shows the sketches developed for these storage units for high furniture in order to understand better the selection matrix (Table 4.7). Normal high furniture with shelves was chosen as the reference concept.

**Figure 4.7. Sketches for the description of the concepts of the Table 4.7.**

**Table 4.7. Selection matrix for high furniture.**

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Selection Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Simplicity</td>
<td>0</td>
</tr>
<tr>
<td>Functionality</td>
<td>-</td>
</tr>
<tr>
<td>Adapted to manufacturing processes</td>
<td>0</td>
</tr>
<tr>
<td>Comfortable</td>
<td>0</td>
</tr>
<tr>
<td>Economic</td>
<td>-</td>
</tr>
<tr>
<td>Easy to clean</td>
<td>0</td>
</tr>
<tr>
<td>Accessible</td>
<td>0</td>
</tr>
<tr>
<td>Adapted to the kitchen fittings</td>
<td>+</td>
</tr>
<tr>
<td>Easy to assemble</td>
<td>0</td>
</tr>
<tr>
<td>Safety</td>
<td>0</td>
</tr>
<tr>
<td>Sum +’s</td>
<td>1</td>
</tr>
<tr>
<td>Sum 0’s</td>
<td>7</td>
</tr>
<tr>
<td>Sum −’s</td>
<td>2</td>
</tr>
<tr>
<td>Net Score</td>
<td>-1</td>
</tr>
<tr>
<td>Rank</td>
<td>5</td>
</tr>
<tr>
<td>Continue?</td>
<td>NO</td>
</tr>
</tbody>
</table>
1. Furniture with fixed hooks.
2. High furniture with door opening 180°.
3. Storage unit with revolving kitchen fitting.
4. Vertical drawers for high furniture with kitchen fittings or without them.
5. Bars over the worktop (specific kitchen fitting).
6. High furniture with different shelves (reference).

The concepts selected in the selection matrix were the concepts nº2, nº4 and nº5; the high furniture with door opening 180°, the vertical drawers for high furniture with kitchen fittings or without them and the bars over the worktop (specific kitchen fittings). These solutions were described by the company as the most feasible solutions for this kind of kitchen.

4.2.2. Concept Scoring.

Concept scoring is used when increased resolution will better differentiate among competing concepts. In this stage, the team weighs the relative importance of the selection criteria and focuses on more refined comparisons with respect to each criterion. The concept scores are determined by the weighted sum of the ratings (Ulrich and Eppinger, 2007).

As it mentioned in Section 4.2, for the evaluation of this group the concept scoring, the second part of the Pugh concept selection, was chosen because there was no previous reference with which to compare the concepts. The weight of each factor was done thinking in the importance that each one would have in this kitchen unit and after consulting INCACSA to know if it had approval. Thus, in Figure 4.8, sketches of different concepts are showed. Concept A is a mobile kitchen unit with detachable drawers in the upper part, concept B is circular furniture with kitchen fitting and the last one, concept C, is a current furniture with wheels with the possibility to include a kitchen fitting inside or simply some drawers. In Table 4.8, the result of the concept selection can be observed more detailed.

**Figure 4.8.** Sketches for the description of the concepts of the Table 4.8.
1. Mobile kitchen unit with detachable drawers in the upper part.
2. Circular furniture with kitchen fitting.
3. Furniture with wheels with the possibility of includes kitchen fitting inside or simply some drawers.

Once every factor was valued for each of the concepts, the result of the matrix was very clear, in the way that one of the concepts had almost the double score than the others and this one did not have the limitations that the others two concepts had. For example, concept A or B would be limited just to one function whereas concept C could be use like a place for the garbage or a place for storage.

*Table 4.8. Selection matrix for high furniture.*

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Weight factor</th>
<th>Concept A Score Value</th>
<th>Concept B Score Value</th>
<th>Concept C Score Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simplicity</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Functionality</td>
<td>15</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Adapted to manufacturing processes</td>
<td>8</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Comfortable</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Economic</td>
<td>10</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Easy to clean</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Accessible</td>
<td>15</td>
<td>3</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Adapted to the kitchen fittings</td>
<td>8</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Easy to assembly</td>
<td>7</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Safety</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Possibility to incorporate the garbage</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Sum</td>
<td>100</td>
<td>228</td>
<td>238</td>
<td>411</td>
</tr>
</tbody>
</table>
When the evaluation of every idea was done and the final concepts for each kitchen unit group were chosen, the CAD modeling in Pro Engineer was started. Each kitchen unit was developed individually and with all of them totally finished, a combination of the kitchen units with the domestic appliances was made to distribute the function of each one in the different parts of the kitchen and do it as accessible and ergonomic as possible.

One of the requirements that were thought for that combination was to keep the same height for all of them, for it, the height of the biggest of them was considered and the others were designed in relation to this one. The biggest kitchen unit was the furniture intended for the GOURMET kitchen fitting and the height of this one was 1452 mm. Another requirement was to keep a minimum height of 260 mm from the floor for every kitchen unit to do it accessible for every wheelchair user. This measure was established with the ergonomic study developed in Section 3.3. In Appendix 8 the drawings for every kitchen unit are showed. The format of these drawings has been established following the format used by INCACSA in their manufacturing processes. Finally, for the system of extraction of the every drawer a specific technology will be used. That technology belongs to the Swedish company BLUM, which is subcontractor of INCACSA, and it consists of an extraction system that allows closing drawers softly and silently, without these bouncing or moving back. Independently of the force with which they are closed, if they are full or empty, BLUMOTION allows closing them softly and silently. More information about this extraction system is showed in Section 10 in Appendix 7. Therefore, in the following points every combination of the kitchen units will be explained in more detail.

5.1. **Kitchen unit for oven with safety zone and a big drawer**

For this kitchen unit, it was used a common oven, specifically the model BALAY 3HT628XD which is an oven with door of lateral opening. The height of the oven was based on the question 6 of the questionnaire done in the fair “Leva & Fungera” (see Appendix 1) and the results of the ergonomic study (see Figure 3.13, Tables 3.6 and 3.7). These criteria will be used to account for the height of the oven-microwave (Section 5.2) as well as the microwave in Section 5.3. Below the oven a safety zone was established to interact with the oven providing that it is necessary. Finally a high drawer was placed in the below part making it into in a storage place, for example to keep big pots or pans. In Figure 5.1 the final renders can be viewed in more clearly way.

![Figure 5.1. Final renders for Kitchen unit for oven with safety zone and big drawer](image)
5.2. Kitchen unit for oven-microwave with safety zone and two vertical drawers of 30cm.

To measure the niche for the oven-microwave, the model BOSCH HBC 84K553 was used as a reference from INCACSA. The height was defined in the same manner as in the Section 5.1 and, as in the previous kitchen unit, a safety zone was placed below the oven-microwave to increase the security of the user. For the storage in this unit, two vertical drawers in the low part was the solution. In those drawers, kitchen fittings will be used to increase the accessibility to the storage unit. The kitchen fittings can be viewed in Section 1 in Appendix 7, Figure 5.2 shows the finals renders of this kitchen unit can be viewed in detail.

![Figure 5.2. Final renders of kitchen unit for oven-microwave with safety zone and two vertical drawers of 30cm.](image)

5.3 Kitchen unit for microwave, a drawer-safety zone and two vertical drawers of 30cm.

This unit is quite similar to the previous one. The only difference is that in this kitchen unit there is a drawer that can be used as a safety zone also but it enables the possibility to be used as a drawer for storage. In the low part, the vertical drawers used are the same as in the previous kitchen unit (see Section 5.2). So in Figure 5.3, the final renders show the shape of this kitchen unit.

![Figure 5.3. Final renders of kitchen unit for microwave, a drawer-safety zone and two vertical drawers of 30cm.](image)
5.4. Kitchen unit for dishwasher.

To develop this kitchen unit, the model BALAY 3VF543XD of a dishwasher was used as a reference to take measures. The dishwasher was placed in a height adapted for an easy of use of it. Below the dishwasher a drawer was added to make the most of the space. In Figure 5.4, the final renders can be viewed in detail.

Figure 5.4. Final renders of kitchen unit for dishwasher.

5.5. Kitchen unit for fridge.

This kitchen unit was the only one in which it was not possible to keep the height of 1452 mm because of the size of the fridges. It was possible to take another fridge with a lower height but no so much people place a fridge of this size in a current kitchen. The model as reference was BOSCH KIR 24V00 FF. In the below part as well as the top part of the kitchen unit a hollow of 200 cm² has been left as a requirement of the BOSCH factory for the ventilation of the electrical motor of the fridge. In Figure 5.5 the final renders of the kitchen unit are showed.

Figure 5.5. Final renders of kitchen unit for fridge.
5.6. **Kitchen unit for freezer.**

This kitchen unit consists of the niche for freezer and, like in fridge; it has hollows for the ventilation, and a kitchen unit with doors opening of 180 degrees for storage in the top. The depth of this one is shorter than the freezer to allow for air circulation. The freezer reference model used to measure the kitchen unit was BOSCH GID14A20. In Figure 5.6, the final renders of the model can be viewed in more detailed way.

![Figure 5.6. Final renders of kitchen unit for freezer.](image)

5.7. **Mobile kitchen unit for dustbin.**

The design of this kitchen unit is quite different to the others. This one is designed as mobile furniture to be placed under the worktop but it might be moved to another place in case of needing to work at its place of origin thanks to the wheels placed in the base. Kitchen fittings for the dustbin were used for this kitchen unit. It would allow the user to place the dustbin, handling the furniture from the handle placed in the top, near to him/her when preparing food. The reference of the kitchen fittings and the wheels used can be viewed in *Section 11 and Section 15 in Appendix 7*. The final concept is showed in Figure 5.7.

![Figure 5.7. Final renders of mobile kitchen unit for dustbin.](image)
Chapter 5. Concept Combination. Overall Examples.

5.8. Mobile kitchen unit for storage.

This kitchen unit is the same as for the dustbin. The only difference is that in this one two drawers will be used for storage. So this kitchen unit might be combined with the previous one to take advantage of the space under the worktop or of a table for example. In Figure 5.8, the final model can be viewed.

![Figure 5.8. Final renders of kitchen unit for freezer.](image1.png)

5.9. Storage unit with two vertical drawers, a drawer for cutlery and a normal storage unit with opening doors 180°.

This unit is a storage unit whose main function is the storage of food or items for a kitchen. In the lower parts there are two vertical drawers, one of them with 300 mm of width, and the other one with 150 mm of width. For these vertical drawers two different kinds of kitchen fittings are used supplied by Xoivan Distribución, which are described in the Section 1 and 2 in Appendix 7. In the middle of the unit there is a drawer for the cutlery. For this drawer a cutlery tray for placing the cutlery is used, this kitchen fitting is also described in Section 7 in Appendix 7. In the upper part of the unit a normal storage unit with doors opening of 180 degrees has been placed. In Figure 5.9, the final model can be viewed in detailed way.

![Figure 5.9. Final renders of kitchen unit with two vertical drawers, a drawer for cutlery and normal storage unit with opening doors 180°.](image2.png)
5.10. **Storage unit with a big drawer for storage, two small drawers for cutlery and a normal storage unit with opening doors 180°.**

This unit is similar to the previous one. It is a combination of three drawers; one of them is bigger than the other because it is for storage of big pots or pans. The other two drawers are for storage of the cutlery. These drawers have the BLUMOTION technology developed by BLUM as in all the drawer of our kitchen. The drawers for cutlery use the same kitchen fittings (cutlery tray) as the Storage unit with two vertical drawers, a drawer for the cutlery and a normal storage unit with opening doors 180° (*Section 5.9*). In the upper part of the unit a normal storage unit with doors opening of 180° degrees has been placed like the previous one. Both units have the same height as all the furniture of the kitchen in accordance with the anthropometric study done in the beginning of the project. *Figure 5.10* shows the final model of this unit.

![Figure 5.10](image)

*Figure 5.10. Final renders of kitchen unit with a big drawer for storage, two small drawers.*

5.11. **Storage unit with circular-rotary kitchen fitting for corners.**

This unit was designed specially as a solution for corners. This solution, as the other solutions for corners, has a specific height (862 mm) and was designed for the end of the worktop. A specific circular-rotary kitchen fitting from Häfele with two trays was the best solution for this unit due to this kitchen fitting provides more accessibility for the user. This kitchen fitting is described in *Section 8 in Appendix 7*. *Figure 5.11* shows the final model of this unit in more detailed way.

![Figure 5.11](image)

*Figure 5.11. Final renders of kitchen unit with circular-rotary kitchen fitting for corners.*
5.12. **Storage unit with circular-rotary kitchen fitting and a drawer for corners.**

This unit is another solution for corners and is similar to the previous one. The unit has similar circular-rotary kitchen fittings as the unit previously described; in addition this storage unit has a special drawer for corners. The height of this unit is the same as the other solution for corner in order to obtain a homogenous look in the kitchen. The circular-rotary kitchen fitting is described in Section 8 in Appendix 7. The following figure (Figure 5.12) describes this unit in more detailed way.

![Figure 5.12](image)

*Figure 5.12. Final renders of kitchen unit with circular rotary-kitchen fitting and drawer for corners.*

5.13. **Storage unit with safety zone hidden inside the unit.**

This solution for storage is like a big drawer with a detachable tray in the middle of the furniture (it is described in the Section 6 in Appendix 7) and it also has a safety zone in the upper part of the interior of the furniture. This unit is designed for the end of the worktop (as the solutions for corners) and has the same height as the solution described in the previous Sections 5.11 and 5.12. Figure 5.13 shows the final model of this unit.

![Figure 5.13](image)

*Figure 5.13. Final renders of kitchen unit with safety zone hidden inside the unit.*
5.14. **Storage unit for pantry (SWING kitchen fitting of Xoivan).**

This storage unit is one of the solutions for pantry; for these solutions a serial of special kitchen fittings of Xoivan for pantry is chosen. The difference between these solutions is the distance between the floor and the furniture, which is smaller than the other furniture (150 mm.) because all the kitchen fittings chosen for pantry are detachable and the user do not have to move closer to the furniture to gain access to the things that are inside the furniture. This unit uses the SWING kitchen fitting from Xoivan, which is described in the Section 3 in Appendix 7. Figure 5.14 describes the unit in a graphic way.

![Figure 5.14. Final renders of unit for pantry (SWING kitchen fitting of Xoivan).](image)

5.15. **Storage unit for pantry (TANDEM kitchen fitting of Xoivan).**

This unit is the second solution for pantry. It has the same characteristics as the previous one according to the distance between the floor and the furniture. For this unit the TANDEM kitchen fitting of Xoivan is chosen, which is described in Section 4 in Appendix 7. In Figure 5.15, the final model can be viewed in detail.

![Figure 5.15. Final renders of storage unit for pantry (TANDEM kitchen fitting of Xoivan).](image)
5.16. **Storage unit for pantry (GOURMET kitchen fitting of Xoivan).**

This is the last solution for pantry. It has the same characteristics as the previous ones. For this storage unit the GOURMET kitchen fitting of Xoivan was chosen. This kitchen fitting is the biggest one of the three solutions and was chosen because in this unit it is possible to store all the provisions of the kitchen inside one only furniture. The GOURMET kitchen fitting is described in *Section 5* in *Appendix 7* and *Figure 5.16* shows the final CAD model of this unit.

![Figure 5.16. Final renders of storage unit for pantry (GOURMET kitchen fitting of Xoivan).](image)

5.17. **Bars over the worktop.**

This is not a kitchen unit, it is simply a kitchen fitting. The idea is to place them over the worktop to be able to keep some kitchen utensils or whatever. The reference of this kitchen fitting is explained in more detail in *Section 9* in *Appendix 7*. The CAD model is showed in *Figure 5.17*.

![Figure 5.17. Final renders of the bars over the worktop (Linero and Linero 2000).](image)
5.18. **Specific Worktop for corners.**

Finally the worktop for the kitchen was designed giving special attention in the L-shape kitchens because it is the most complex shape for the company at the time to manufacture it. So the design in Figure 5.18 is just for an L-shape kitchen, for a distribution in line the minimal width will be used uniformly along the whole worktop.

Firstly it is necessary to mention about the height of the worktop. Since this worktop lacks electrical motor, it was decided to establish a range with the different heights that might be offered (see Appendix 2). This solution may be the cheapest one and it can provide a treatment nearer to the client, as well as a kitchen made to measure. To obtain this and do it as easy as possible, a specific legs for worktop is used with the aim of, to take measurements of the client and to be able to cut the legs to the necessary height, hereby, to be able to place the worktop to the appropriate height to the client. In Section 12 in Appendix 7 more information about the legs can be found. To fix the worktop to the wall, bars supports were used. The information about those bar supports can be viewed in the Section 13 in Appendix 7.

To obtain a major accessibility to the sink and between the sink and the glass-ceramic hob, a specific cut was designed for the corner of the worktop. With this cut, zones are obtained, besides the major accessibility mentioned previously, of prepared or free spaces that enable different possibilities.

![Figure 5.18. Final renders of specific worktop for corners (L-shape).](image-url)
Chapter 6: FINAL CONCEPT EXAMPLE (L-SHAPE KITCHEN).

6.1. Introduction.

Although human model features for ergonomic design, such as checking reach, accessibility, clearance, field of view, etc., have existed in numerous computer systems since the 60’s, earlier systems often had limited features that are of great importance here: realistic visualization of 3D models and interactive and flexible manipulation techniques. Furthermore a system for our application should support various presentation techniques, e.g. images, animations and multimedia movies (text and images/animations combined) and different media such as paper prints or video-tape to supplement the computer-screen (Eriksson and Johansson, 1996).

One of the requirements for the Bachelor Degree Project is to make a mock-up or a virtual 3D model in which a reproduction of the work, can show how the final product looks and function as well as display the feeling of the user when it is for example in his/her hands.

For this Degree Project, a virtual 3D model will be used to show how the different kitchen units can work together and become a real kitchen. There are some advantages and some disadvantages in comparison with a physical mock-up. Perhaps the main advantage is the cost of each one since a mock-up of a kitchen should be made in a suitable scale otherwise it would be very difficult to show how the kitchen works.

- Use of full-scale modelling in design research.

In full-scale modelling, people demonstrate the use of an environment or product under conditions similar to naturalistic situations. The impact of spatial configurations, space sizes and the location of objects in a space can be studied by comparing different environments, or through systematic variation of parameters in a model, a technique called “fitting trials” (Steinfeld, 2004).

- Benefits of full-scale modelling.

For wheelchair users, the intrusion of the fixtures is significant but it has an impact even for ambulant individuals… This plot demonstrates that preferences can be used to uncover a comfort zone by modelling interactions with the environment. There are two basic approaches to full-scale modelling: discrete parts of the environment or whole rooms and spaces (Steinfeld, 2004).

- The challenge of computer modelling.

It is very useful to include full-scale modelling activities as part of the design process. For example, during the design of an assisted living facility, it would be desirable to test out several optional designs for the bathrooms in full scale, but such a research activity is usually beyond the means of the design team because full-scale modelling is a time-intensive, expensive activity. Virtual modelling methods like SAMMIE and Mannequin Pro could provide a low cost efficient substitute for designers.

But, at the present time, such models do not contain accurate information on the anthropometry of people who use wheelchairs. To address this deficiency, data on large samples of wheelchair users are needed.
Chapter 6. Final Concept Example (L-shape kitchen).

Existing modelling programs do not realistically simulate the behaviours of people with disabilities in architectural spaces. This group has a more complex interaction style due to the limitations on their body movements and their use of assistive technology like wheelchair.

We also need information on the difficulty and acceptability of tasks under different spatial constrains. This information can only be generated from full-scale modelling studies (Steinfeld, 2004).

With today’s prototype certain operations, such as manipulating viewpoints, rearranging furniture, adjusting postures, etc., were carried out quite easily and directly, but several improvements can be made to simplify operations and increase speed.

Future research and development should also include improved measurement control, collision detection and a simplified position/orientation control of viewpoints and objects. It is also necessary to further find out how much details and what rendering quality are required among the different categories of participants, versus what is optimal regarding modelling effort (Eriksson and Johansson, 1996).

6.2. L-shape kitchen.

As commented in the previous Section the mock-up or prototype of this project will be done by 3D Modelling programs, specifically 3DStudio Max of Autodesk®. A new and revolutionary render motor called V-Ray has been used by us, which is able to do very realistic pictures due to its magnificent configuration of lights and reflection of these on the materials. V-Ray also has a specific gallery of materials that improves the final results or renders when the combination between the materials and the lights options are applied.

The 3D prototype is based on a combination of some of the nineteen developed kitchen units. After studying the different dispositions of the current kitchens and after discussion with INCACSA, our Company Supervisor recommended to us to develop the combination based in the L-shape disposition. In this kitchen-example all the domestic appliances that we can find in a current kitchen (oven, microwave, fridge, and so on) are incorporated. The selected kitchen units for the kitchen-examples are the following ones:

- Kitchen unit for the oven with safety zone and a high drawer. (see Section 5.1).
- Kitchen unit for microwave, a drawer-safety zone and two vertical drawers of 30 cm. (see Section 5.3).
- Kitchen unit for the dishwasher. (see Section 5.4).
- Kitchen unit for fridge. (see Section 5.5).
- Mobile kitchen unit for dustbin. (see Section 5.7).
- Mobile kitchen for storage. (see Section 5.8).
- Storage unit for pantry TANDEM kitchen fitting of Xoivan. (see Section 5.15).
- Specific worktop for corners (see Section 5.18).

The current kitchen models of INCACSA were considered for choosing the look and materials of the kitchen-example, choosing the modern line of kitchen of INCACSA as the best solution for the renders. The following pictures (Figures 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8 and 6.9) show the final renders of the final kitchen-example.
Chapter 6. Final Concept Example (L-shape kitchen).

Figure 6.1. L-shape kitchen-example, green colour.

Figure 6.2. L-shape kitchen-example, green colour.
Chapter 6. Final Concept Example (L-shape kitchen).

Figure 6.3. L-shape kitchen-example, green colour.

Figure 6.4. L-shape kitchen-example, green colour.
Chapter 6. Final Concept Example (L-shape kitchen).

Figure 6.5. L-shape kitchen-example, green colour (detail of the skirting board).

Figure 6.6. L-shape kitchen-example, white-blue colour.
Chapter 6. Final Concept Example (L-shape kitchen).

Figure 6.7. L-shape kitchen-example, brown-white color.

Figure 6.8. L-shape kitchen-example, red colour.
Chapter 6. Final Concept Example (L-shape kitchen).

6.3. Jack Analysis.

With the example kitchen fully designed, the software Siemens/UGS Jack 5.1 was used to evaluate the comfort of the user working in it. RULA, Rapid Upper Limb Assessment, (McAtamney & Nigel, 1993) and Porter’s comfort analysis (Porter, J.M & Gyi. D.E. 1998) was the perfect tool to evaluate the postures of the user for each kitchen unit.

RULA is a survey method developed for use in ergonomics investigations of workplaces where work-related upper limb disorders are reported. This tool requires no special equipment in providing a quick assessment of the postures of the neck, trunk and upper limb along with muscle function and the external load experienced by the body. A coding system is used to generate an action list which indicates the level of intervention required to reduce the risks of injury due to physical loading on the operator. It is of particular assistance in fulfilling the assessment requirements of both the European Community directive (90/270/EEC) on the minimum safety and health requirements for work with display screen equipment and the UK Guidelines on the prevention of work-related upper limb disorders (McAtamney & Nigel, 1993).

Once the necessary knowledge to interpret the RULA analysis was learned, there are some things to consider before evaluating the results. As it was described previously, the RULA analysis is a method to use mainly in workplaces, so RULA interpret each posture like a posture which will be repeated constantly many times per day thus the results are not trustworthy when a kitchen units are evaluated. On addition to RULA, a Porter’s comfort assessment was done Jack 5.1 which will give us another interpretation of the posture of the user. (Kang, L. et al. 2006).
The analysis was realized in the drawer below the oven, in the sink, in the vertical drawer as well as in the TANDEM furniture. It was done for a man of 95% percentile according to stature and for a woman of 5% percentile according to stature. So in the following page the analysis for man and woman is started and in Figure 6.10 and Figure 6.11 a man and a woman respectively working in the sink are represented.

- Sink Analysis.

Figure 6.10. View of man working in the sink and eye view of him.

Figure 6.11. View of woman working in the sink and eye view of her.

In Figure 6.10 and 6.11, a different colour for the worktop can be observed. The blue worktop in Figure 6.10 represents the worktop for man with a height of 850 mm and the green worktop in Figure 6.11 represents the worktop for woman with a height of 750 mm. In Figure 6.12, the results for the analysis of a man are showed and in the Figure 6.13 for a woman.
Chapter 6. Final Concept Example (L-shape kitchen).

Figure 6.12. From the left to the right: RULA analysis and Comfort assessment for man.

Figure 6.13. From the left to the right: Comfort assessment and RULA analysis for woman.
From the RULA analysis for each one, the different scores can be noted, since the posture of the back is different in each of them. The result of the Comfort assessment show that in both postures, the user can work without problem, so the height of the worktop might be emphasized positively.

- Drawer below the oven.

In Figures 6.14 and 6.15, the posture of man and woman in the drawer below the oven can be viewed.

The results of these analyses are showed in Figure 6.16 and the Figure 6.17 for man and woman respectively.
Chapter 6. Final Concept Example (L-shape kitchen).

Figure 6.16. From the left to the right: Comfort Assessment and RULA analysis for man.

Figure 6.17. From the left to the right: Comfort Assessment and RULA analysis for woman.
In these results, a bad result for the RULA analysis is given for both users since, perhaps this posture is not very ergonomic but, as it was described previously, it will not be very governing due to this posture will not be repeated a lot of times and it is not dangerous for the user. The Comfort assessment gives us a result a little bit different the conclusion might be the same than for the RULA.

- Vertical drawer.

In these analyses, the accessibility for the vertical drawer is evaluated for man (Figure 6.18) as well as for woman (Figure 6.19).

Figure 6.18 View of man opening the vertical drawer and an eye view of him.

Figure 6.19 View of woman opening the vertical drawer and an eye view of her.

In Figures 6.20 and 6.21, the results of the analyses for both users can be viewed in detailed way.
Chapter 6. Final Concept Example (L-shape kitchen).

Figure 6.20. From the left to the right: RULA analysis and Comfort assessment for man.

Figure 6.21. From the left to the right: RULA analysis and Comfort assessment for woman.
Chapter 6. Final Concept Example (L-shape kitchen).

The results for this kitchen unit are quite similar for both analyses. A bad score given by RULA, but like in the previous kitchen unit, it is a momentary posture and it will not be repeated a lot of times during the day, so it is not dangerous for the user. The result of the Comfort assessment is quite good for the upper parts of the body.

- **TANDEM.**

Finally, the kitchen fitting TANDEM as well as the furniture made for it will be evaluated but this time two analyses will be done, one for the upper part and another one for the lower part. In Figure 6.22 and Figure 6.23 the postures for the lower part are represented for man and woman.

![Figure 6.22](image1.png) **Figure 6.22.** View of man reaching to the lower part and an eye view of him.

![Figure 6.23](image2.png) **Figure 6.23.** View of woman reaching to the lower part and an eye view of her.

Now the evaluation for these postures will be showed in Figure 6.24 for man, and Figure 6.25 for woman.
Figure 6.24. From the left to the right: Comfort assessment and RULA analysis for man.

Figure 6.25. From the left to the right: Comfort assessment and RULA analysis for woman.
Chapter 6. Final Concept Example (L-shape kitchen).

As in the previous kitchen units, a bad result is obtained by RULA in this posture because the user is reaching to the lower limit of the kitchen unit. Anyway the Comfort assessment is quite similar for both users and the result might be interpreted as positive.

Another analysis for this kitchen unit is made in order to evaluate the upper part of this one. Figure 6.26 and 6.27 show the posture for man and woman respectively.

Figure 6.26. View of man reaching to the upper part and an eye view of him.

Figure 6.27. View of woman reaching to the upper part and an eye view of her.

In the following pictures, Figure 6.28 and Figure 6.29, the results of the analyses for these postures can be observed in detail.
Chapter 6. Final Concept Example (L-shape kitchen).

Figure 6.28 From the left to the right: Comfort assessment and RULA analysis for man.

Figure 6.29 From the left to the right: Comfort assessment and RULA analysis for woman.
Chapter 6. Final Concept Example (L-shape kitchen).

The results in this posture are quite similar to the last one, since the users are reaching to the limit upper part of the kitchen unit. Furthermore, the Comfort assessment gives a bad result as well.

As a conclusion of these analyses, it must be emphasized that the RULA analysis is a method for evaluating work, as it was said before, and the results are not governing the results of the ergonomics evaluation of the kitchen units but it was great to learn a new method to evaluate the relation between the human and the objects.

In the other hand, the comfort assessment shows a clearer view of the posture of the human and the evaluation of each part of the body in this posture. So, this analysis might be considered more valid than RULA for this kind of application.
Chapter 7. ROOMINESS ADAPTATION SYSTEM LOGOTYPE.

After concluding the kitchen units and including and evaluating the final concepts, it was decided to name the set of kitchen units as Roominess Adaption System. The word Roominess was chosen for its wide meaning inside the world of wheelchair users due to its literal meaning is space or spaciousness, comfort, capacity, and so on.

The logotype of Roominess aims to represent the elegance and the seriousness by the shape of the logotype and it was achieved by means of the font SF Square Head in combination with two circles with different sizes that represent the wheels of the wheelchairs. The use of the surname Adaption System was chosen in order to understand better the meaning of the set of kitchen units for wheelchair users, in addition, the logotype of INCACSA is added to give more identity to the company.

It was used one tone of green, black and white as the colours of the logotype in order to represent calm and peace to the user. In Figure 7.1 and 7.2 the logotype can be viewed in the different combinations of colours.

Figure 7.1. Roominess Adaption System Logotype, white background version.
Finally this logotype, as well as the colours and shapes, were used in the look of the folder that INCACSA ordered to provide to the sellers the enough information for selling this set of kitchen units, which was one of the first requirements in the beginning of the project. The folder can be viewed in Appendix 9.
Chapter 8. DISCUSSION.

The development of a kitchen for disabled people is a hard work considering that it was our first work in this kind of design assignment and with this specific user group. It was even more difficult taking into consideration the market today in this area, since all the kitchens are focused in electrical motors that solve any problem of accessibility. For solving these limitations, perhaps the most difficult problem was to elaborate an ergonomic study to find the problems to be targeted when developing the kitchen units.

It was complex to design something for a kind of user who has a problem that you cannot feel, and about consequences you cannot think. Nevertheless, the wheelchair given by the University of Skövde was a great help as we tried to put ourselves into a disable person’s shoes, as well as the visit to the fair “Leva & Fungera”, which allowed us to communicate with a wide number of wheelchair users and to know, first hand, what they thought about the project.

The idea of adapting the worktop based on the height of every user might seem like a poor solution in comparison with the worktops with electrical motors, since it is not focused in a single and global design. Nevertheless, this new approach to their daily problem is based on the idea of being as near as possible to each wheelchair user. The design of Roominess Adaption System is focused entirely on people that feel left out of the current design trends and therefore, wants to treat each user individually.

Finally, it is difficult to asset the parts of this project that have been more enlightening since the development of this project in its all has been an eye-opener for every member of the design team, who had no previous knowledge on this field whatsoever. For that reason, we can state that this project’s outcome was been a remarkable experience for our future career as designers.

Firstly, it is good to say that during the development of this project, a lot ideas developed were considered by INCASA as a future commercial product to be sold by company. They believe that Roominess Adaption System can continue to be developed in order to make the wheelchair user feel the maximum comfort possibly in his or her kitchen at an affordable price. One of the aims of INCACSA is to continue investigating the needs of its clients and therefore, improving the demand for its products. Obtaining the closest solution possible for each user is an aim that has always played a key part in the philosophy of INCACSA.

One of the Sections to be develop further in the future would be the complete adaption of the project units to the kitchen models of INCACSA, in regard to the sizes of the furniture (i.e., drawers, worktops, etc).

One of the ideas developed during the creative sessions, the concept of “Island with sink, glass-ceramic hob and table for eating” has been selected by the company as one of the best ideas to develop in the future, including the initiative of integrating it in all of its kitchen models.

According to INCACSA, it is essential to continue developing different types of modules besides the ones included in this project. INCACSA has confirmed their will to continue the research for the development of new kitchen units, as well as to improve the ones developed in this project, always keeping in contact with us due to the extensive knowledge that we have obtained during the creation of Roominess Adaption System.
Chapter 10. REFERENCES.


José Abel Romero Gallardo.
Manuel J. Fernández Sanchez.

University of Skövde, 2009.
Appendix Index

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Appendix 1. Questionnaires.

Questionnaire for a kitchen for disabled people (users of wheelchairs).

We are compiling information for our final project in Design Engineer with the Spanish Company INCACSA, it consists to design a "kitchen for disabled people", exactly, for wheelchair users. We propose you this questionnaire in order that you answer some questions to us, or you give us some ideas about the limitations that you can find in a kitchen. We are ready to hear all the possible opinions to be able to fulfil in a best possible way our goal.

Age………………………………………………………………………………………
Gender…………………………………………………………………………………
Disability………………………………………………………………………………

1. Which are the most limitations that the user of wheelchair can find in a kitchen? Value from 1 to 4. (1 minimal limitations - 4 maximum limitations).
   - Space.
   - Mobility.
   - Security.
   - Heights.
   - Accessibility.
   - Others……………………………………………………………………………

2. What importance have the following characteristics in a kitchen adapted for users of wheelchair? Value from 1 to 4. (1 minimum importance - 4 maximum importance).
   - Comfort.
   - Easy to clean.
   - Accessibility.
   - Aesthetics.
   - Functional.
   - Others……………………………………………………………………………

3. In which of following kitchen units does the user of wheelchair find more difficulties? Value from 1 to 4. (1 minimal limitations - 4 maximum limitations).
   - Sink Unit.
   - Glass Ceramic – Hob Unit.
   - Unit for Drawers.
   - Storage Unit.
Appendix 1. Questionnaires.

- Others............................................................................................................................................... 
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4. What elements are those that you believe that they are not bore in mind in the current designs of adapted kitchens? (Mobility, accessibility, functionality, etc).

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5. Is the high furniture really indispensable in a kitchen of these characteristics? Could they suppress for other solutions?

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6. What heights would be the suitable ones for the placement of the domestic appliances in a kitchen of these characteristics? (Oven, Microwave, Dishwasher, etc.)

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7. Any suggestions about models or brands of domestic appliances? (Removable doors, lateral doors, etc).

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Appendix 1. Questionnaires.

8. Would it be interesting to establish surer spaces near in the zones with more danger? (Oven, microwave, glass ceramic-hob, etc.). Any suggestions?

9. Would it be interesting to place a bar in the end of the work surface in order to help to the user's mobility? (Bar that user would use to move without using the mechanisms of mobility of the wheelchair -- motor or manual mechanism --).

10. Suggestions or ideas.

Thank you for your collaboration.

University of Skövde. 2009
**Results.**

**Question 1.**

80% of the interviewed ones chose the heights, the space in the kitchen and the accessibility as the most limitations that the user of wheelchair finds in a kitchen.

**Question 2.**

90% of the interviewed ones chose the functionality and the accessibility like the most important areas to bearing in mind in the design of a kitchen for disabled people. The comfort and the aesthetics was others areas with good punctuation.

**Question 3.**

80% of the interviewed ones chose de the drawers units and the storage units as the units of the kitchen where they find more limitations.

**Question 4.**

In this question was the functionality, accessibility and the mobility the options with more punctuation.

**Question 5.**

The majority of the interviewed ones believed that the high furniture are not really indispensable in a kitchen of these characteristics and that it would be interesting to look for other solutions to the existing ones.

**Question 6.**

The majority of the interviewed ones chose the height of the head and the sitting height as the perfect height for the domestic appliances.

**Question 7.**

100% of the interviewed ones chose the lateral doors as the best solution for the domestic appliances.

**Question 8.**

80% of the people interviewed believed that put a security zones near to the more dangerous zones of the kitchen was a good idea in order to increase the security of the users in the kitchen.

**Question 9.**

50% of the interviewed ones believed that put a bar for helping the mobility of the user in a kitchen was a good idea. The other 50% believed that this idea is not necessary for the user.

In order to explain all the most important characteristics of each material, it has realized a brief research where it is possible to find more information about all the materials that make up the kitchen for disabled people. It has divided the research in the different parts that consists the kitchen furniture. The divided parts are the following ones.

- Body (framework) of the furniture.
- Doors and Front Parts.
- Legs of Furniture.
- Hinges.
- Drawers.
- Kitchen fittings. (see Appendix 7)

Body (framework) of the furniture.

In this first part, body, is the framework of the furniture. This part supports all the load of the furniture as well as the weight of the furniture. It consists of:

- Boards of 16 mm of thickness finished with melamine in both faces. Front ledges finished with PVC of 1 mm of thickness. Back, top or low ledges finished with PVC of 0.4 mm of thickness everything stuck with thermo fuse gum at 190’. The back of the body, which incorporates a board of 6 mm of thickness, is also finished with melamine in both faces. The structure of the body is built by union with screws-thread for agglomerated of 5x50 with reinforcement of bolt of wood of 8 mm of diameter for 35 mm of length. For the low or high cupboards with shelves are included two positions in all of the standards models. The physicist - mechanics and superficial characteristics of the boards are based on the standard rule UNE-EN 14322. Figure A2.1 describes some examples of bodies.
Doors and Front Parts.

The doors are made with board P3 of 19 mm of thickness, finished with melamine in both faces. The ledges are finished with PVC of 1 mm of thickness with a similar color of the door and stuck with thermo fuse gum at 190°.

The specification of quality of the boards corresponds to the values that they are reflected in the standard rule UNE-EN 312.

Legs of Furniture.

Leg made of injected reinforced plastic. Automatic anchorage and exterior regulation with a maximum load of 200 kg/unit. (Usually 4 legs for each furniture).

Hinges.

Hinges with absorption system. Elbow and small pan made of nickel-plated steel with base of triple regulation. It fulfils the standard rule ISO9001.

Drawers.

Drawers of total extraction, made of boards finished with melamine and steel with guides of ball bearings, with a retention in the entry and a dynamic load of 50 kg Sides of steel in gray colour. The dressers incorporate a rod in the sides.
The bases and backs of the drawers are of board of 16 mm finished with melamine in both faces and painted in gray color or aluminium.

Kitchen fittings.

The kitchen fittings were supplied by the followings companies: Häfele, Hettich, Salice, Blum and Xoivan. Each kitchen fittings selected for each kind of furniture will be explained in the final description of the final concepts and also they are showed more detailed in the Appendix 7.
INCACSA in its plant in Casariche had a leading-edge technology in CNC machines in order to obtain optimum results in the production of their kitchens. In addition, it is good to say that INCACSA can develop whatever furniture of kitchen based in body and door. They use a serial production (Flexible manufacture system based in CNC machines) divided in seven phases, using different CNC machines in each phase. The phases are described in a graphic way in order to understand better the processes.

1. The manufacturing process starts in the store of raw materials (boards), where each board is selected according to each kind or model of furniture.

2. The second phase is the process of cut of the boards; INCACSA usually uses two kinds of CNC machines in this phase. The Figure A3.1 shows the different CNC machines used in the process of cut.

   ![Figure A3.1](image1.png)

   **Figure A3.1.** Pictures of the CNC machines used in the process of cut the boards.

3. The third process in the assembly line is the process of finishing the boards. In this process is applied the melamine on the surfaces of the boards and the PVC on the ledges of the boards. The Figure A3.2 shows the CNC machine used in this process.

   ![Figure A3.2](image2.png)

   **Figure A3.2** Picture of the CNC machine used in the process of finishing the boards.

4. The fourth process, the process of mechanized of the boards, is the process where the drills holes and others processes of mechanized are done. The following picture (Figure A3.3) shows the CNC machine used in this phase.

![Picture A3.3](image)

*Picture A3.3* Picture of the CNC machine used in the process of finishing the boards.

5. Process of union of pieces, in this process all the boards, kitchen fittings and other pieces are assembled using the following CNC machine. The CNC machine used in this process is showed in the Figure A3.4.

![Figure A3.4](image)

*Figure A3.4* Picture of the CNC machines used in the process of assembly of the pieces.
6. Process of packing. In this process INCACSA also uses another CNC machine for doing this task, which is showed in the Figure A3.5.

![Image of CNC machine](image)

*Figure A3.5. Picture of the CNC machines used in the process of packing.*

7. Logistic store of distribution. This is the final phase of the assembly line, in this phase the furniture is ready to go to the home of the costumer.
### Appendix 4. Requirements Specifications.

<table>
<thead>
<tr>
<th>Changes</th>
<th>Specification</th>
<th>Requirements</th>
<th>Responsible</th>
</tr>
</thead>
<tbody>
<tr>
<td>D=D Demanded Or W=W Wished</td>
<td>For Kitchen Units for disabled people.</td>
<td></td>
<td>Page 1</td>
</tr>
</tbody>
</table>


- Development basic Units of Kitchen:
  - Units for Sink.
  - Units for Glass – Ceramic Hob.
  - Units for Storage.
  - Units for drawers.

- Simplicity.

- Functionality.

- Adapted to the manufacturing processes:
  - Adapted to the Assembly line of INCACSA.
  - To provide drawings for the CAD Machines.

- Ergonomic Study for achieving a perfect kitchen for disabled people according to the measures and the comfort. (anthropometric study)

- To provide to the sellers of all the necessary information to sell the products by means of folders, explicative videos, and so on.

- Not to use engines of elevation (increase) to regulate the heights of the units.

- To adapt the units of kitchen to the following domestic appliances:
  - Glass – Ceramic Hob.
  - Sink.
  - Tap.
  - Dishwasher.
  - Oven.
  - Microwave.
  - Fridge.

- For the composition or distribution of the kitchen furniture should be adapted to the kitchen of 8 to 12 m².

- Materials. *(Appendix 2)*

#### 2. Requirements for each Unit.

##### 2.1. Unit of Sink.

Accessible to all the users of wheelchair, women and men of different heights.
### Specification

For: Kitchen Units for disabled people.

<table>
<thead>
<tr>
<th>Changes</th>
<th>D= Demanded Or W= Wished</th>
<th>Requirements</th>
<th>Responsible</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td></td>
<td>- Height: 70 – 85 cm. (depending of the user’s height).</td>
<td></td>
</tr>
<tr>
<td>W D</td>
<td></td>
<td>- Depth of the work surface: Max. 63 cm.</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td></td>
<td>- Depth of the Sink: Standards models. Dept of the tap: Max. 63 cm.</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td></td>
<td>- Min. 60 cm of separation with the Glass Ceramic Hob.</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td></td>
<td>- To consider “the Golden Triangle”.</td>
<td></td>
</tr>
</tbody>
</table>

### 2.2. Unit of Glass – Ceramic Hob.

| W       | Accessible to all the users of wheelchair, women and men of different heights. |             |
| W       | - Height: 75 – 85 cm. (depending of the user’s height). |             |
| W       | - Depth of the work surface: Max. 63 cm. |             |
| W W     | - To establish safety zones near to the Glass – Ceramic Hob. |             |
| W       | - To place the extractor hood to 65 cm. from the work surface. |             |

### 2.3. Unit for Storage.

#### 2.3.1. High furniture.

| W D     | Max. Height: 45 cm. from the work surface. |             |
| W W     | - According to the Ironworks existing in the market. |             |
| W       | - Detachable units. |             |
| W       | - Vertical Drawers for high furniture. |             |

### 2.4. Unit for Drawers.

| W       | Max. Height: 75 – 100 cm. (Depending of the work surface). |             |
| W D     | Min. Height from the floor: 26 cm. |             |
| W D     | Depth: Depending of the ironworks. |             |
| W W     | Min. Depth of the base of the furniture: 18 cm. |             |
| W       | According to the ironworks existing in the market. |             |
| W       | Detachable units. |             |
### Appendix 5. Brainstorming.

#### KITCHEN UNIT

<table>
<thead>
<tr>
<th>SUGGESTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sink unit</strong></td>
</tr>
<tr>
<td>Accessible to all the wheelchair's users</td>
</tr>
<tr>
<td>Nearby plate rack</td>
</tr>
<tr>
<td><strong>Faucet of shower</strong></td>
</tr>
<tr>
<td>Extending sink</td>
</tr>
<tr>
<td>Dustbin below the sink</td>
</tr>
<tr>
<td><strong>Suitable distance to the glass-ceramic hob</strong></td>
</tr>
<tr>
<td>Adjustable height with crank</td>
</tr>
<tr>
<td>Less deep model</td>
</tr>
<tr>
<td><strong>Glass-ceramic hob unit</strong></td>
</tr>
<tr>
<td>Accessible to all the wheelchair's users</td>
</tr>
<tr>
<td>Detachable glass-ceramic hob</td>
</tr>
<tr>
<td>Induction glass-ceramic hob</td>
</tr>
<tr>
<td>Adjustable height extractor hood</td>
</tr>
<tr>
<td>Adjustable height with crank</td>
</tr>
<tr>
<td><strong>Safety zones</strong></td>
</tr>
<tr>
<td>Isle (Sink Unit, Glass-ceramic hob and table)</td>
</tr>
<tr>
<td>Front controls</td>
</tr>
<tr>
<td>Circular-rotary base for glass-ceramic hob</td>
</tr>
<tr>
<td>Nearby kitchen staff</td>
</tr>
<tr>
<td>Lengthened glass-ceramic hob</td>
</tr>
<tr>
<td><strong>Storage unit</strong></td>
</tr>
<tr>
<td>Accessible to all the wheelchair's users</td>
</tr>
<tr>
<td>Vertical drawers for high furniture</td>
</tr>
<tr>
<td>Detachable units</td>
</tr>
<tr>
<td>Furniture with wheels</td>
</tr>
<tr>
<td>Extractor of storage</td>
</tr>
<tr>
<td>Sliding units for the islands</td>
</tr>
<tr>
<td>Detachable furniture</td>
</tr>
<tr>
<td>Detachable furniture on the top</td>
</tr>
<tr>
<td><strong>Units of gyratory iron-works</strong></td>
</tr>
<tr>
<td>Fan Furniture</td>
</tr>
<tr>
<td>Doors hidden inside the furniture</td>
</tr>
<tr>
<td><strong>Gyratory and fixed hooks</strong></td>
</tr>
<tr>
<td>Try to find solution for the high furniture</td>
</tr>
<tr>
<td>Doors with opening 180º</td>
</tr>
<tr>
<td>Zone hides safety in storage units</td>
</tr>
<tr>
<td><strong>Units with drawers</strong></td>
</tr>
<tr>
<td>Accessible to all the wheelchair's users</td>
</tr>
<tr>
<td>Vertical drawers with different sizes</td>
</tr>
<tr>
<td>Detachable drawers from the upper part</td>
</tr>
<tr>
<td><strong>Not very deep drawers</strong></td>
</tr>
<tr>
<td>Fan drawers</td>
</tr>
<tr>
<td>Drawers for corner</td>
</tr>
<tr>
<td>Narrow drawers</td>
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<tr>
<td>Utilization of iron-works for storage</td>
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1. Sketches of Sink Unit.

Figure A4.1. Sketches of glass-ceramic hob unit.

2. Sketches of glass-ceramic hob unit.
Figure A4.2. Sketches of sink unit.

[Sketches of vertical drawers, storage units, and kitchen furniture]

Figure A4.3. Sketches of storage unit.

4. Sketches of units for drawers.

Figure A4.4. Sketches of units for drawers.

In this appendix it will do a more detailed description of each one of the kitchen fittings used for the different kitchen units developed. The main suppliers and manufacturers of the chosen kitchen fittings are Häfele, Xoivan and Blum.

1. **Xoivan. Detachable units for furniture of 30 cm.**

   This kitchen fitting is a detachable unit for furniture of 30 cm. with total extraction with angle of 90 degrees. It has three baskets inside of the kitchen fitting to place different things and supports a load capacity of 24 kg. *Figure A7.1* shows different pictures of this kitchen fitting.

   ![Figure A7.1. Xoivan. Detachable unit for furniture of 30 cm. (Xoivan online catalogue.)*](image)

2. **Xoivan. Detachable units for furniture of 15 cm.**

   This kitchen fitting is similar than the model of 30 cm. It has two options according to number of baskets (two or three baskets) inside of the kitchen fitting. It supports a load capacity of 12 kg. *Figure A7.2* describes this kitchen fitting in a graphic way.

   ![Figure A7.2. Xoivan. Detachable units for furniture of 15 cm. (Xoivan online Catalogue.)*](image)
3. **Xoivan. Dispensa SWING.**

This kitchen fitting is a special unit for pantry with a technology of extraction and oscillation that supports a load of 70 kg. It also has the option to put from 4 to 6 baskets inside of the kitchen fitting. This kitchen fitting was the winner of the Reddot Design Awards in 2004 and the Interzum Awards in 2005. *Figure A7.3 and A7.4* shows the kitchen fitting and its function.

*Figure A7.3. Xoivan. Technical description of the Dispensa SWING. (Xoivan online catalogue).*

*Figure A7.4. Xoivan. Movement of the Dispensa SWING. (Xoivan online catalogue).*
4. Xoivan. TANDEM.

This kitchen fitting is other kitchen fitting for pantry, which has a serial of basket placed in
the door of the furniture and another detachable serial of basket inside of the furniture
with a new technology of extraction. The baskets of the doors have a load capacity of 20 kg
and the detachable baskets have a load capacity of 50 kg. The following pictures (Figure
A7.5) describe the movement and the function of TANDEM.

![Figure A7.5](image1)

Figure A7.5. Xoivan. Description of the kitchen fitting TANDEM. (Xoivan online Catalogue)

5. Xoivan. Unit for Pantry GOURMET.

This kitchen fitting is biggest kitchen fitting for pantry of Xoivan. Is a combination of two
units of the TANDEM kitchen fitting, and uses the same technology. It has a load capacity
of 100 kg and 20 kg in both doors of the furniture. Figure A5.6 shows the unit for pantry
GOURMET in a more detailed way.

![Figure A7.6](image2)

Figure A7.6. Xoivan. Description of the unit for pantry GOURMET. (Xoivan online Catalogue)
6. **Xoivan. Detachable basket ARENA.**

This kitchen fitting is a detachable tray or basket for placing inside of the furniture. Exist two kind of detachable baskets, which are described in the following picture (Figure A5.7).

![Figure A7.6. Xoivan. Description of the unit for pantry GOURMET. (Xoivan online catalogue)](image)

7. **Häfele. Cutlery tray wh.**

This kitchen fitting is for inside of the drawers, for placing the cutlery and kitchen utensils. It was chosen a cutlery tray that is possible to cut to size for placing better in the drawer. Figure A7.7 shows this cutlery tray of Häfele.

![Figure A7.7. Häfele. Different pictures of the cutlery tray. (Häfele online catalogue)](image)

8. **Häfele. Three quarter circle carousel fitting set.**

This kitchen fitting is a special kitchen fitting for corners. It has two baskets that can be moved independently. It has two kinds of size for this kitchen fitting, for furniture of 800 mm. and for furniture of 900 mm. The version of 900 mm was the chosen option. Figure A7.8 shows this kitchen fitting in a more detailed way.

Figure A7.8. Häfele. Some pictures of the Three quarter circle carousel fitting set. (Häfele online Catalogue)


Linero 2000 is an iron-work that consists of bars placed in the wall, on the encimera, with numerous kitchen fittings to place them in the bars as kitchen fittings for roll of paper, kitchen fittings to place plates, kitchen fittings with hook, kitchen fittings for spices, and so on. Figure A7.9 shows both models of this kitchen fitting (Linero and Linero 2000), and in Figure A7.10 shows some of the different kitchen fittings used over the worktop.

Figure A7.9. Xoivan. Linero and Linero 2000 kitchen fittings. (Xoivan online catalogue)
10. **BLUM. Drawer and pull-out systems BLUMOTION.**

Pull-out systems of BLUM are used in the kitchen, the bathroom, the living room and bedroom as well as in the office. BLUM provides the right solutions for these different living areas – runners for wooden drawers and complete pull-out systems made from metal.

It doesn't matter whether pull-outs are heavily laden or empty, pushed gently or with force thanks to BLUMOTION, they will close silently and effortlessly every time.

More design possibilities: The pull-out systems from Blum.

- **TANDEMBOX:** The box system with concealed runners for metal drawers and high fronted pull-outs.
- **TANDEM:** The concealed runner system for wooden drawers.
- **METABOX:** The economical box system for metal drawers and high fronted pull-outs.
- **STANDARD:** The economical runner system for wooden drawers.

*Figure A7.10. Xoivan. Different kitchen fittings for Linero and Linero 2000 of Xoivan. (Xoivan online Catalogue).*

*Figure A7.11. From right to left: Tandembox, Tandem, Metabox and Standard. (www.Blum.com).*

In *Figure A7.12*, a graphical illustration of the braking system and dulling to avoid blows and rebounds of the drawers can be observed.

This kitchen fitting works like a drawer, it has three compartments (3x10 liters) for placing the different kinds of garbage that help to do the division for recycling. In addition, it has a total extraction with system of cushioning. Figure A7.13 shows this kitchen fitting in more detailed way.

![Figure A7.12 Braking system and dulling of the drawers. (Blum online catalogue).](image)

![Figure A7.13 Häfele. Description of dustbin for hooking in Hailo Cargosoft. (Häfele online catalogue).](image)


This table legs is for fixing the worktop in both front ends of the worktop. There are two models of legs in the Häfele catalogue, Square and Rondella, which are perfect for our worktop. Both are for cutting size with maximum height of 1300mm. Figures A7.14 and A7.15 shows these different solutions for fixing the worktop.
13. Häfele. Breakfast bar support for mounting to cabinet side or wall (steel tube 30 mm.).

This kitchen fitting is another system for fixing the worktop in the kitchen. Each one supports a load capacity of 30kg. It is recommendable put from 3 to 6 breakfast bar supports according with the size of the worktop. These kitchen fittings together with the stainless steel legs previously described will provide a perfect and safe fixing to the worktop. Figure A7.16 shows this kitchen fitting in a graphic way.

This hinge has an integrated soft close system, for cabinets with extending compartments and shelves. The soft close mechanism is not visible when installed. This is the perfect solution for the furniture with opening of 180º. The following picture (Figure A7.17) shows this hinge.

![Figure A7.17. Häfele. Description of the hinge Duomatic Premium opening angle 155º of Häfele. (Häfele online Catalogue).](image)

15. Häfele. Twin wheel castor (without brake).

The wheel showed in Figure A5.18 which has been used in the mobile furniture (4 wheels in each one) is specially design for this king of furniture. It is made in plastic and it is used in soft running surface.

![Figure A7.18. Häfele. Description of the twin wheel castor without brake of Häfele (Häfele online catalogue).](image)

References.


- Blum (2009). BLUMOTION.


  VRL: http://easylink.hafele.com/is-bin/INTERSHOP.enfinity/WFS/HDE-INT-EasyLink_HDE-INT-Site/en_EN/-/EUR/Haefele_BrowseCatalog-Category;pgid=gAE.1U82eY00004A_J60OmDn.0000Co7aNaiN?CatalogCategoryID=9APAqBlZuhAAAEeDKMHXCr7 (access date 7 March 2009).

  VRL: http://easylink.hafele.com/is-bin/INTERSHOP.enfinity/WFS/HDE-INT-EasyLink_HDE-INT-Site/en_EN/-/EUR/Haefele_ViewOfferDetail-StartSavePageable;pgid=gAE.1U82eY00004A_J60OmDn.0000Co7aNaiN?CatalogCategoryID=QiPAqBlZuhYAAAeDKMHXCr7&ProductUUID=yBLAqBlZG0kAAAAeetA4HXCtH&SingleObjectPageableID=Z5HAqBI0YBUAAEhHzAMtCrM&OrigProductContext=Haefele_BrowseCatalog-Category&GlobalIndex=0 (access date 7 March 2009).


  VRL: http://easylink.hafele.com/is-bin/INTERSHOP.enfinity/WFS/HDE-INT-EasyLink_HDE-INT-Site/en_EN/-/EUR/Haefele_ViewOfferDetail-StartSavePageable;pgid=gAE.1U82eY00004A_J60OmDn.0000Co7aNaiN?CatalogCategoryID=dTTAqBlZBmAAAAEhKWgY7Bla&ProductUUID=0OvAqBlZOGkAAAAEhPu4Y7Bli&SingleObjectPageableID=1O_AqBlORaEAAAeSDoMrCuo&OrigProductContext=Haefele_BrowseCatalog-Category&GlobalIndex=0 (access date 8 April 2009).
  VRL: [Link to product page](http://easylink.hafele.com/is-bin/INTERSHOP.enfinity/WFS/HDE-INT-EasyLink_HDE-INT-Site/en_EN/-/EUR/Hafele_ViewOfferDetail-StartSavePageable;pgid=gAE.1U82eY00004AJ60OmDn.0000dijexidu?CatalogCategoryID=YnPAqBIz6qEAAAEhrYy7D1m&ProductUUID=dDrAqBlZcxIAAEhCB07yD1x&SingleObjectPageableID=1SdAqBLOeqYAAAe60QUtEOH&OrigProductContext=Haefele_BrowseCatalog-Category&GlobalIndex=0) (access date 23 May 2009).

  VRL: [Link to product page](http://easylink.hafele.com/is-bin/INTERSHOP.enfinity/WFS/HDE-INT-EasyLink_HDE-INT-Site/en_EN/-/EUR/Hafele_ViewOfferDetail-StartSavePageable;pgid=gAE.1U82eY00004AJ60OmDn.0000dijexidu?CatalogCategoryID=YnPAqBIz6qEAAAEhrYy7D1m&ProductUUID=2uzAqBlZcxYAAAeHCB07yD1x&SingleObjectPageableID=Q2nAqBlO4eIAAEh7kUtEOB&OrigProductContext=Haefele_BrowseCatalog-Category&GlobalIndex=1) (Access date 23 May 2009).

  VRL: [Link to product page](http://easylink.hafele.com/is-bin/INTERSHOP.enfinity/WFS/HDE-INT-EasyLink_HDE-INT-Site/en_EN/-/EUR/Hafele_ViewOfferDetail-StartSavePageable;pgid=gAE.1U82eY00004AJ60OmDn.0000dijexidu?CatalogCategoryID=GavAqBlZ9yYAAAeMaHXCr7&ProductUUID=nfzAqBZxYAAAe3PqHXCtG&SingleObjectPageableID=_gXAqBLOMj8YAAAe5FAUtEOv&OrigProductContext=Haefele_BrowseCatalog-Category&GlobalIndex=0) (access date 23 May 2009)

- Häfele (2009g). Steel Breakfast bar support 30mm.
  VRL: [Link to product page](http://easylink.hafele.com/is-bin/INTERSHOP.enfinity/WFS/HDE-INT-EasyLink_HDE-INT-Site/en_EN/-/EUR/Hafele_ViewOfferDetail-StartSavePageable;pgid=gAE.1U82eY00004AJ60OmDn.0000dijexidu?CatalogCategoryID=6dHAqBIZ0DgAAAEeO6MHXCr7&ProductUUID=qQnAqBIZUlkaAAAEH1HXCrH&SingleObjectPageableID=snzAqBIOBQAAAeHmrsUtEOz&OrigProductContext=Haefele_BrowseCatalog-Category&GlobalIndex=0) (access date 23 May 2009).
Appendix 8. Drawings.

The drawings of each kitchen unit are in a specific format for the company. They are classified with the same numeration as they are in the report (Chapter 5 of the report).
5.1. Modulo para horno con zona de seguridad mas cacerolero. (Kitchen unit for oven with safety zone and high drawer)

Herraje: Guias correderas de cajon standard para tabla de seguridad. (Standar drawer runners)
Guias correderas standard para cacerolero. (Standard drawer runners for big drawers)

A= Distancia del suelo al mueble (Distance from the floor to the furniture) 260 mm.
B= Distancia del frontal al zócalo (Distance from the front parto of the furnitute to the skirting board of the furniture) 180 mm.
5.10. Modulo de almacenamiento con cacerolero, dos cajones para cubertería y una unidad de almacenamiento con apertura de puertas 180°

(Storage units with a big drawer for storage, two small drawers for cutlery and a normal storage unit opening doors 180°)

Herraje Häfele:
- Guias correderas para cajones estandar (Standard running drawers).
- Guias correderas para caceroleros estandar (Standard running drawers for big drawers).

A= 260 mm. Distancia minima del suelo al mueble (minimum distance from the floor to the furniture)
B= 180 mm. Distancia del frontal al zocalo. (distance from the front part of the furniture to the skirking board of the furniture).
5.11. Modulo de esquina con herraje giratorio (Storage unit with circular-rotary kitchen fitting).

Herraje Häfele:
- Cesta giratoria en 3/4 de vueltas (three quarter circle carousel fitting set) . Ref: 542.42.210
- Eje tubular. (axis for the baskets) Ref: 542.42.290
- Bisagras de cazoleta standard (Standard concealed hinges)

A= Distancia del suelo al mueble (Distance from the floor to the furniture) 260 mm.
B= Distancia del frontal al zócalo (Distance from the front parto of the funiture to the skirting board of the furniture) 180 mm.
5.12. Modulo de esquina con cajon para esquina (Storage unit with circular-rotary ironwork and drawer for corners).

Herraje Häfele:
- Cesta giratoria en 3/4 de vueltas (three quarter circle carousel fitting set). Ref: 542.42.210
- Eje tubular. (axis for the baskets) Ref: 542.42.290
- Bisagras de cazoleta standard (Standard concealed hinges)
- Guías correderas para cajón Standard. (Standard drawer runners)

A= Distancia del suelo al mueble (Distance from the floor to the furniture) 260 mm.
B= Distancia del frontal al zócalo (Distance from the front parto of the furniure to the skirtting board of the furniture) 180 mm.
5.13. Modulo de almacenamiento con zona de seguridad incluida dentro del cacerolero (Storage unit with safety zone hidden inside the unit).

Herraje:
- Guías correderas para cajones (y zona de seguridad) estándar. (Standard running drawers).
- Guías correderas para caceroleros (Standard running drawers for big drawers).

A= 260 mm. Distancia mínima del suelo al mueble (minimum distance from the floor to the furniture)
B= 180 mm. Distancia del frontal al zócalo. (distance from the front part of the furniture to the skirking board of the furniture).
5.14. Casco para herraje SWING de Xoivan. (Storage unit for SWING of Xoivan)

Herraje Xoivan SWING:
- Bastidor (altura interior 1076-1276). Ref. 00 4431
- Guía de sobree extensión. Ref. 01 4430
- Guías frontales (1107-1307). Ref. 00 4432
- Soportes frontales (armario ancho 300). Ref. 00 4366
- Ángulo de fijación. Ref. 00 4350
- Cesta para colgar ARENA (armario ancho 300). Ref. 04 4385
- Cesta para colgar EXCELLENT (armario ancho 300). Ref. 00 1990
- Separador para botellas (armario ancho 300). Ref. 00 4393

La distancia del suelo al mueble para muebles dispensers es de 150 mm.
(The distance between the floor and the furniture for the furniture for pantry is 150 mm.)

Distancia del frontal al zocalo standard.
(Standard distance from the front part of the furniture to the skirting board of the furniture)
5.15. Casco para herraje TANDEM de Xoivan. (Storage unit for TANDEM of Xoivan)

Herraje Xoivan: TANDEM
- Cesta para colgar (armario ancho 500 mm). Ref.04 3439
- Elemento Extraible Interior (altura a partir de 1100 mm y ancho de 500mm) Ref. 00 3435
- Amortiguador Softstop. Ref. 01 6211
- Estantería de puerta ARENA. (ancho 500 mm). Ref. 04 3439

La distancia del suelo al mueble para muebles dispenseros es de 150 mm.
(The distance between the floor and the furniture for the furniture for pantry is 150 mm.)

Distancia del frontal al zocalo standard.
(Standard distance from the front part of the furniture to the skirting board of the furniture)
5.16. Casco para herraje GOURMET de Xoivan. (Storage unit for GOURMET of Xoivan)

Herraje Xoivan GOURMET:
- Herraje (armario ancho 900). Ref. 00 3307
- Cesta maciza. Ref. 00 3306 y 00 2008

La distancia del suelo al mueble para muebles dispenseros es de 150 mm. (The distance between the floor and the furniture for the furniture for pantry is 150 mm.)

Distancia del frontal al zocalo standard. (Standard distance from the front part of the furniture to the skirting board of the furniture)
5.18. Forma específica de encimera para rincones. (Specific Shape for worktop for corners)

Herraje Häfele: Rondella. Ref:635.11.970 / Square with plate. Ref:635.02.067
5.2. Modulo para horno-microondas BOSCH HBC 84K553 (Kitchen unit for oven-microwave BOSCH HBC 84K553)

Herraje Häfele:
- Guías correderas para cajones (tabla de seguridad) estandar. (Standard running drawers).

Herraje Xoivan extraible para armario bajo de 30 cm extraccion total con angulo de 90.
(Detachable unit for funiture of 30cm)
- Bastidor COMFORT de extracción total. Ref.01 5169 (izquierdo) y 015170 (derecho)
- Soporte frente 90 grados. Ref. 01 5147
- Cesta para colgar con fondo ARENA (228 x 470 x 88). Ref. 04 5142

A= Distancia del suelo al mueble (Distance from the floor to the furniture) 260 mm.
B= Distancia del frontal al zócalo (Distance from the front parto of the funiture to the skirting board of the furniture) 180 mm.
5.3. Modulo para microondas integrado, mas zona de seguridad/cajon para cubiertos, mas dos cajones verticales de 30 cm. de ancho (Kitchen unit for microwave with safety zone and two vertical drawers of 30 cm.)

Herraje Häfele:
- Guías correderas para cajones (tabla de seguridad) estandar. (Standard running drawers).
- Herraje Xoivan extraíble para armario bajo de 30 cm extracción total con angulo de 90. (Detachable unit for furniture of 30cm)
- Bastidor COMFORT de extracción total. Ref.01 5169 (izquierdo) y 015170 (derecho)
- Soporte frente 90 grados. Ref. 01 5147
- Cesta para colgar con fondo ARENA (228 x 470 x 88). Ref. 04 5142

A= 260 mm. Distancia minima del suelo al mueble (minimum distance from the floor to the furniture)
B= 180 mm. Distancia del frontal al zocalo. (distance from the front part of the furniture to the skirting board of the furniture).
5.4. Modulo Lavavajillas para el modelo BOSCH 3VF543XD (Kitchen unit for dishwasher)

Herraje:
- Guias correderas de cajon estandar. (Standard drawer runners)

A= Distancia del suelo al mueble (Distance from the floor to the furniture) 260 mm.
B= Distancia del frontal al zócalo (Distance from the front parto of the furniture to the skirting board of the furniture) 180 mm.
5.5. Modulo Frigorífico para el modelo BOSCH KIR 24V00 FF (Unit for fridge).

A = 260 mm. Minima distancia del suelo al mueble (minimum distance from the floor to the furniture)
B= 180 mm. Distancia del frontal del mueble al zocalo (distance from the front part of the furniture to the skirting board of the furniture.)
5.6. Modulo Congelador para el modelo BOSCH GID 14 A20
[Unit for freezer).

Espacio para Ventilación 36x560 mm.
(Space for ventilation)

Herraje Häfele:
- Bisagra Duomatic premium, Angulo 155. (Duomatic premium Hinge) Ref: 329.29.200 / 329.29.300 / 329.29.342

A = 260 mm. Minima distancia del suelo al mueble (minimum distance from the floor to the furniture)
B= 180 mm. Distancia del frontal del mueble al zocalo (distance from the front part of the furniture to the skirting board of the furniture.)
5.7. Modulo movil para basura. (Mobile kitchen for dustbin)

Herraje Häfele:
- Capacidad 1 x 15 litros mas 2 x 10 litros Hailo CargoSoft (Capacity 1 x 15 liters and 2 x 10 liters Hailo CargoSoft) Ref: 502.73.952
- Rueda doble para Mueble sin freno (Twin wheel castor without brake) Ref: 661.54.901
5.8. Modulo movil para almacenamiento. (Mobile kitchen unit for storage)

Herraje Häfele:
- Rueda doble para Mueble sin freno (Twin wheel castor without brake) Ref: 661.54.901.
- Guías correderas para cajones estandar (Standard running drawers).
5.9. Modulo de almacenamiento con 2 cajones verticales de 30 y 15 cm, cajon cubertero y mueble de almacenamiento con apertura de puertas de 180° (Storage unit with two vertical drawers, a drawer for the cutlery and a normal storage unit with opening doors 180°)

Herraje Häfele:
- Guías correderas para cajones (tabla de seguridad) estandar. (Standard running drawers).
- Bisagra Duomatic Premium Angulo 155. (Hinge Duomatic Premium Angle 155).

Herraje Xoivan extraible para armario bajo de 30 cm extraccion total con angulo de 90. (Detachable unit for furniture of 30cm)
- Bastidor COMFORT de extracción total. Ref.01 5169 (izquierdo) y 015170 (derecho)
- Soporte frente 90 grados. Ref. 01 5147
- Cesta para colgar con fondo ARENA (228 x 470 x 88). Ref. 04 5142

Herraje Xoivan extraible para armario bajo de 15 cm extraccion total con angulo de 90. (Detachable unit for furniture of 15cm).
- Extraíble 2 niveles. Ref. 03 5297

A= 260 mm. Distancia minima del suelo al mueble (minimum distance from the floor to the furniture)
B= 180 mm. Distancia del frontal al zocalo. (distance from the front part of the furniture to the skirting board of the furniture).