Summary.

Merlin Systems Corporation have been a pioneering force in the field of robotics for the last 12 years. They offer flexible ‘bespoke’ robotic solutions from initial design though to manufacture and implementation. Merlin robotics presents lots of innovative ideas. Some examples of previous ‘custom’ projects include creation of a ‘two-meter high Robot Snake’ moving in harmony with an English National Ballet dancer. Merlin System Robotics has given the Nottingham Trent University the opportunity to conduct research projects working with the Miabots. Firstly investigating artificial swarm intelligence and for a portable charging station for the Miabots. This report considers the latter. Swarm robotics has the ability to complete complex and impossible tasks that one expensive robot can never be able to do, for this reason swarm robotics were created to reduce costs and change the impossible to possible.

The aim of the principal project is design a new system for the Miabots. They are controlled with Artificial Intelligent, this means that you can order a task and the Miabots complete it without any further instructions. The other part of the project is develop a portable charge station, make a prototype, check its functionality, ease of assembly and the design. This kind of portable charge station is not current on the market. The function of it is to charge the Miabots when away from the main power supply. This is in order to allow them to continue the task without returning to the main charging point. This charge station should not have a wire to a power supply because the robots need to carry it in a stage so they can charge anywhere.
The results of this report will give indication to the best options for making a portable charge station considering materials, design, batteries, costs and marketing the final product.
Acknowledgements.

I would like to personally acknowledge the academic and technical staff within the School of Architecture, Design and the built environment at Nottingham Trent University, especially Alan Crisp, Phil Breedon, David King and Leslie Arthur.

This acknowledgement also extends to all the staff of the workshop for their help and dedication in the project.
Illustration Index.

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**Glossary.**

*Figure G1: Parts of miabot.*

1. Aluminium anodized structure
2. Lower support bracket.
3. Upper support bracket.
4. Led’s support plate.
5. Rim.
6. Tyre.
7. Led’s*
8. Expansion connection.
10. Microchip.
11. Charger point.
12. Microchip.
14. 16 way header
15. Electric motor*.
• Electric motors*: The robot has two motors one for each wheel as the robot needs to turn left and right. This can do it through the different speeds of the wheels.

• Batteries*: The robot has 6 batteries in total, each rechargeable battery has 1,2V.

• Led’s*: The robot has 13 led’s in total. 1 blue led to identify the position of the robot (\((x,y)\) coordinates). 4 red led’s 1 of which expresses the angle of the robot. 6 green led’s that make the ID of the robot.

*Note: The use of asterisks indicates that the components are proprietary or licensed materials.

Figure G2: Colour led’s from miabot.
Acronyms and abbreviations.

ABS: Acrylonitrile Butadiene Styrene
ASIMO: Advanced Step in Innovative Mobility.
GHz: Gigahertz
IA: Artificial Intelligence.
mAh: Milliampere-hour
NiMH: Nickel Metal Hydride
PDS: Project Design Specifications.
PLC: Product Life Cycle.
PVC: Polyvinyl chloride.
R.U.R: Rossum’s Universal Robots.
UAV: Unmanned Aerial Vehicle.
UFO: Unidentified Flying Object.
USB: Universal Serial Bus.

Unimate: In 1961 the first industrial robot, Unimate, joined the assembly line at a General Motors plant to work with heated die-casting machines. Unimate took die castings from machines and performed welding on auto bodies.

Eliza: Eliza was born in 1966 by a Massachusetts Institute of Technology Professor Joseph Weizenbaum who wrote Eliza -- a computer program for the study of natural language communication between man and machine.

Asimov: Isaac Asimov was a Soviet-born American author and professor of biochemistry at Boston University, best known for his works of science fiction and for his popular science books. He is widely considered a master of the science-fiction genre.

Tilden: Tilden is a robotics physicist who produces complex robotic movements from simple analog logic circuits, often with discrete electronic components, and usually without a microprocessor.
**ASIMO:** Asimo is a humanoid robot created by Honda. The robot resembles a small astronaut wearing a backpack and can walk or run on two feet.

**KUKA:** KUKA Robotics offers a broad range of highly modular robots, covering all common payload categories, from 3 kg to 1000 kg.

**Miabot:** The MIABOT Pro is a fully autonomous miniature mobile robot.

**Swarm:** Swarm describes a behaviour of an aggregate of animals of similar size and body orientation, often moving en masse in the same direction.

**Bluetooth:** is an open wireless technology standard for exchanging data over short distances (using short length radio waves).

**Roomba:** is an autonomous robotic vacuum cleaner made in China and sold by iRobot.

**Omni wheels:** Omni wheels or poly wheels, similar to mechanical wheels, are wheels with small discs around the circumference which are perpendicular to the rolling direction.

**Solid works:** Solid works is a 3D mechanical CAD (computer-aided design) program that runs on Microsoft Windows.
Chapter 1

Perspective View.

1.1 Introduction.

1.2 Aims and Objectives.

1.3 Project.

1.4 Validation.

1.5 Historical Perspective of Robots.

1.6 Types of Robots.

1.7 Swarm Robotics.

1.8 The Product in Context.

1.9 Project Management Process.

1.10 Gantt chart

1.11 Conclusion.
1 Perspective View.

1.1 Introduction.

This chapter gives a perspective of the project; it provides information about the history, types of robots and the control mechanisms that are found. At the end a table describes the planning of the project.

1.2 Aims and objectives.

‘Failure comes only when we forget our ideals and objectives and principles.’ (Nehru, 1889-1964).

This report collects the Final Year Project of Mechanical Engineering and shows part of all the skills acquired during the previous years. The report is an academic requirement to complete the degree.

The project objectives contain three main components as outlined below:

- Provide and prove the opportunity and responsibility of creating, finding or selecting, formulating, planning, carrying out and reporting on a challenging project.
- Develop personal skills of initiative, independence, enterprise, planning, research and communication.
- Use, develop and integrate knowledge and skills acquired earlier during the course.
1.3 Project.

The project that is found in this report was studied for the design and build a portable charge station. This report was developed in the 3rd year of Engineering Mechanical Career as a final project of career, the work was taken from Merlin Robotics to design and build a portable charge station so their robots can go to it to charge their batteries when they are low. In this report all the necessary documentation for building a portable charge station simply and effectively can be found.

1.4 Validation.

History has shown lots of stories about artificial companions and artificial helpers, and attempts to create them but the fully autonomous machines didn’t appear until the 20th century. The first programmable robot guided by digital form was the Unimate, it was installed in 1961 to lift warm pieces from a ink machine. In general the people react positively when they see a robot because a lot of public have domestic robots for cleaning or maintenance of the house. The figure 1.0 below shows the robot Roomba cleaner (Iberobotics, 2010).
1.5 Historical perspective of robots.

The world met the word robot during the dramatic work of R.U.R (Rossum’s Universal Robots) by Karel Capek, who was a Czech playwright. The premier of R.U.R. was in 1921. The word was written as ‘robotnik’, but Capek didn’t invent the word. He wrote a letter to editorial Dictionary of Oxford stating that inventor of word robot was his brother Josef. The article appeared in the year 1933 in the Czech magazine Lidové noviny, where he explained the history of the word. He wanted to call to his creatures ‘labori’ (in Latin this means ‘work’) but he did not like the word. He asked his brother for another word and his brother suggested “roboti”. The word robota means work, servitude or task in Czech and in a lot of Slavic languages.

The first time the word ‘robotics’ was used was in the Runaround story. Runaround is a science fiction story published in 1942 by Isaac Asimov (Born in 1920). The equivalent of Isaac Asimov’s fictional robot is Eliza. Eliza was
made in 1966 in the Technology Massachusetts Institute, where it was programmed to simulate a psychotherapist answering questions with questions.

The Three Laws of Robotics for Asimov: (Asimov, 1942):

1. A robot may not injure a human being, or, through inaction, allow a human being to come to harm.
2. A robot must obey the orders given it by human beings except where such orders would conflict with the first law.
3. A robot must protect its own existence as long as such protection does not conflict with the first or second law.

Tilden’s Laws of Robotics (Tilden, 2002):

1. A robot must protect its existence at all costs.
2. A robot must obtain and maintain access to a power source.
3. A robot must continually search for better power source.
4. Protect thy ass.
5. Feed thy ass.
6. Move thy ass to better estate.

1.6 Types of robots.

The world has different kinds of robots and these robots complete many tasks but are divided in to three types.
1.6.1 Androids.

These robots try to replicate the human form and the human behaviour. In reality they are not developed fully and they do not have practical utility. Now the only way the androids is through study and experimentation. Example of a Android is ASIMO this robot is the culmination of two decades of humanoid robotics research by Honda. ASIMO\(^5\) was designed to help people at home and to aid disabled people. The next Figure 1.1 shows the ASIMO robot from Honda (Willis, 2010).

Figure 1.1: (Willis, 2010).

1.6.2 Industrial robots.

Industry often requires many identical pieces to be made and processed. Industrial robots are mechanical and electronic tools that complete repetitive tasks in the fabrication or manipulation of materials and components.
These robots are programmed to do the same task every time with the same precision.

Habitual tasks of them:

- Welding robots.
- Assembly robots.
- Robots to paint application.

The Brand KUKA\(^6\) is one of the more important builders of Industrial Robotics. They have a range of small robots to heavy robots. The figure 1.2 shows a KUKA welding robot (Robotics, 2010).

*Figure 1.2. (Robotics, 2010).*
1.6.3 Mobile robots.

Mobile robots have a great capacity to move on their own. They have a structure or platform with a motor system to move the wheels. They work with a manual commander or react to their environment through sensors. These robots are the best option for development because they can be made with low cost and less size than the others because they need less material.

An example of a small robot is the Survevor SRV-1 Mobile Robot. It can be controlled with Wi-Fi from a computer and can navigate around obstacles. This kind of robot is the easiest way to build a robot because is cheaper and all the people with some knowledge can build one. The following Figure 1.3 gives an example of a mobile robot (Karthick, 2009).

![Figure 1.3: (Karthick, 2009).](image-url)
1.7 Swarm robotics.

Miabot Pro is an autonomous mobile robot. It has features such as bi-directional Bluetooth communications, which provides a wireless communications protocol of 2.4 GHz. The Miabots are perfect for technological tutorials, for research and development, like swarming and mobile navigation experiments. Miabots can work in swarm this is where a large number of simple individuals can interact to create collectively intelligent system, before one robot would not be able to perform these tasks but now with swarm robots can have more than one robot performing the same task that the old robots found difficult to perform. Swarm robots are relatively cheap compared to older versions of robots as a result of this many can be afforded for experimentation.

At the moment this system is difficult to use because you need to know a lot about robotics and programming, but in the near future it is believed that this knowledge will be a common part of life and therefore it will be easy to use for all. The Figure 1.4 below show a Miabot Pro (merlinsystemscorp, 2009).

![Miabot Pro](image)

*Figure 1.4: (merlinsystemscorp, 2009).*
1.8 The product in context.

When working in the robotics laboratory completing experiments or studying the robots and the battery of the robots runs down they need to be taken to the charge point to have their batteries recharged. The current method to charge these robots is difficult because they are on a large and when one of the batteries is depleted the Miabot stays in the middle of the stage and needs collecting. This was the first reason that pushed the development of this project. The second reason was because if the robots were working automatically and did not have someone to watch when the battery is depleted, nobody can collect them to charge. In this situation the robots can only can work for one time instead if there is a potable charge station the robots do not need to stop as soon.

1.9 Project Management process.

The process of Project Management is divided in four important parts:

1.9.1 Defining.

Defining the Project goals.

1.9.2 Planning.

Planning how the team need to complete the goals with the tools, time, money and all the necessary things that are needed to do it.
1.9.3 Monitoring.

This point means compare the finished work with the programated works to know about the corrective things that were changed.

1.9.4 Completing.

Ensure that the finished design is realistic considering manufacture and materials and has a place on the market.

1.10 Gantt chart.

‘The secret of all victory lies in the organization of the non-obvious.’ (Marcus, AD 121-180).

The best option to start one Project is start to do the plan of the work, for this we need to think in the steps to follow and the time of each step. When we have the steps, the time for each steps and the position of each task, this is a important thing because we can’t build the object if we didn’t design it. We can take all information and put into a one easy graph that name is Gantt Chart. With this graph is easy to know which task we need to do and the time that we have to do it. We can have an approximation of the duration of the project.
**Brief:** A brief is a summary where it needs to has all the steps that it should to do in the general Project.

**Research:** Research information needed to complete the Project and consider all the possible ways to do so.

**PDS:** In this point contends all necessary things to build the object and all of relative information about the object.

**Testing:** Build the product and check the product.

**Fault Testing:** Things to correct in the product.

**Write up thesis:** Write all the things that were done to design and build the product.
The next Table 1.1 give the information of the Gantt Chart Graph.

<table>
<thead>
<tr>
<th>Works</th>
<th>Start</th>
<th>Duration (days)</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brief</td>
<td>08 March</td>
<td>6</td>
<td>15 March</td>
</tr>
<tr>
<td>Research</td>
<td>11 March</td>
<td>73</td>
<td>28 June</td>
</tr>
<tr>
<td>PDS</td>
<td>22 March</td>
<td>8</td>
<td>01 April</td>
</tr>
<tr>
<td>Testing</td>
<td>05 April</td>
<td>34</td>
<td>24 May</td>
</tr>
<tr>
<td>Fault testing</td>
<td>24 May</td>
<td>5</td>
<td>28 May</td>
</tr>
<tr>
<td>Write up thesis</td>
<td>30 May</td>
<td>20</td>
<td>28 June</td>
</tr>
</tbody>
</table>

*Table 1.1.*
1.11 Conclusion.

In the first chapter the objectives of this report are stated. In order to start the report it is necessary to know the topic area well. The first pages talk about history, types and mechanisms of robots that exist. The Gantt Chart shows the estimated time that it will take to finish this project.
Chapter 2
The Design Process.

2.1 Introduction.

2.2 Methodological Design Process.

2.3 Mind Map.

2.4 Ethnography.

2.5 Brief.

2.6 Conclusion.
2 The design Process.

2.1 Introduction.

The most important thing in a project is the structure of it. This chapter describes the best methodology to follow for this project and the important aspects to think about in a project.

2.2 Methodological design process.

When starting to design anything the correct methodology needs to be identified. For example, it is not the same to design a motor and to design a chair. For this the methodology is the most important step to follow, if the methodology is wrong probably so will the design.

2.2.1 This diagram is for a product that was made previously but for this project is still valid, by removing the start word ‘people’ it is easy methodology to follow. This methodology gives the principal ideas that need to be studied.

2.2.2 Is a really easy diagram that only has five words but these word have a lot of meaning because they suggest a lot of questions. For example:

ASK: What I need to do? What are the constraints?

IMAGINE: Brainstorm ideas. What are some solutions?

PLAN: Draw a diagram. Make a list of materials you need.

CREATE: Test it.

IMPROVE: Modify you design you design to make it better.
2.3 Mind map.

This part has two important aspects that need to be presented to the model because it is better and comfortable to the operator. In the next points explains these aspects.

2.3.1 Ergonomics.

The Ergonomic work is defined for good postures to reduce unnecessary work on the body and the risk of injuring the users. Here are two important things in the ergonomics:
• The work activities should permit the worker to adopt a lot of different healthy postures.
• When muscular force has to be used it should to be used by the largest muscle groups.

2.3.2 Anthropometrics.

Anthropometrics literally means man (anthro) measurements (metric). It is the measurements of the size and portions of the human body. The anthropometrics is concerned with the sizes and shapes of people. Looking around the world the different sizes between populations can be seen. For this consideration of the object for the correct zone is needed if not the object will be out of the market because no one will want it. The Figure 2.1 below shows the measurements of people (Panero, 1979).

Anthropometrics have three big groups and inside of them we find the things that we need to think about.

• Gender: height, size, weight, strength and body proportion.
• Age: height, size, weight, strength and body proportion.
• Ethnicity: height, size, weight, strength and body proportion.
2.4 Ethnography.

“Ethnography is a discovery science, not a validating one.” (Dalal, 2007).

The ethnography is a study that is used to know about traditions and customs of one region or culture, through several observations of different levels, perspectives and times, the investigator can arrive to know structures with the
sense and meaning to understand the likes and the preferences of the customer. For this reason the ethnography maybe the most important part of the Project because it is important to know about a lot of factors like design, color, utility, etc. By knowing about customs, likes, kinds of think and climate the Project will be easier and there will be a lot of information to make the perfect object for the region of work that it needs to do.

One of the best studies known is “Los argonautas del Pacífico occidental” (Malinowski, 1922). This is about rituals and social practices of the people of Trobriand Islands.

2.5 Brief.

The Project starts because when the operators were working with the Miabots each time that the Miabots batteries ran out, the operator needed to switch it off, carried it to another place and plug in the charger. The operator needed to do this with all the Miabots, eight in total. The operator started to think about a station where the Miabots could go to charge for themselves. If this could be possible would save a lot of work.

The objective was to design and build a charge station for Miabots with all the necessary components and materials required for it to work.

The charge station needed to satisfy:

- It needed to be small and simple.
- Easy to assembly.
- The batteries can be removed
- Position lights.
- Easy method of charge.
- Wireless.
- Easy for the Miabots to move.
- Minimum 10 times of charge for Miabots.
• Easy to work with it.
• Price in scale with the price of the Miabots.

With all these clear objectives, the project could start.

2.6 Conclusion.

This chapter has all the necessary aspects for the internal structure of the Project and three points that need to be clear to allow the project to be successful. The ergonomy and the anthropometry are closely linked because are thought for the worker. The ethnography is for the zone that the product needs to be thought.
Chapter 3

Specification and literature designs.

3.1 Introduction.

3.2 Product Design Specification (PDS).

3.3 Designs.

3.4 Types of Materials.

3.5 Charging Systems.

3.6 Battery types.

3.7 Mobile platform – wheel options.

3.8 Latch.

3.9 Power button.

3.10 Conclusion.
3 Specification and iterative designs.

3.1 Introduction.

The first step to design something is to organize the principal points and then start to research the market to know which materials, mechanisms or solutions can be used to build the final product.

3.2 Product design specification (PDS).

Figure 3.0 gives the principal points of the PDS.

*Figure 3.0 gives the principal points of the PDS.*
3.2.1 Functional:

- *Overall geometry:* All the measures of the product.
- *Motion of parts:* The mobile parts in the product.
- *Forces involved:* The forces that the product will suffer.
- *Energy need:* The energy that the product needs to work.
- *Materials used:* The materials and components that we will use to build in the product.

3.2.2 Safety:

- *Human:* The security that it needs to be present for the safety of for operators.
- *Operational:* The security that it needs to be present when it is working.

3.2.3 Quality.

- *Quality in the control:* The product has to be easy and quick to control.
- *Reliability:* The confidence of the quality.

3.2.4 Manufacturing.

- *Production of components:* The building process for each component.
- *Assemblage:* The assemblage of all components to build the product.
- *Transport:* The process of packaging the product.

3.2.5 Timing.

- *Design Schedule:* How much time need for design.
- *Development Schedule:* How much time need for development.
• *Production Schedule:* How much time need for building.

### 3.2.6 Economic.

- *Marketing analysis:* Analysis of the market around the product.
- *Design costs:* The cost of the design.
- *Manufacturing costs:* The costs of building the product.
- *Development costs:* The cost that the product needed to be developed.
- *Distribution costs:* The cost for the distribution.

### 3.2.7 Ergonomic.

- *User needs:* The ergonomics that it requires for the operators.
- *Ergonomic design:* The best ergonomic design possible.

### 3.2.8 Ecological.

- *Material selection:* The selection of the materials considering the environment.
- *Working fluid selection:* The ecological liquid of the batteries.

### 3.2.9 Aesthetic.

- *Product appeal:* The appeal of the product says a lot about it.
3.2.10 Life-Cycle.

- **Distribution:** The packaging should protect the product against shock loading during storage and shipping, including onsite storage. The cost of shipping should be relative to the quantity and unit cost.
- **Operational:** The operative life that the product will have.
- **Maintenance:** Periodic maintenance that the product requires.

3.3 Designs.

‘Everything is designed. Few things are designed well.’

(Reed, 2010).

The below pages show the initial concepts of the design of the portable charge station. These designs were made quickly without the correct measurements with the program Solid Works. There were many design sketches but only the best ideas are shown.
3.3.1 Iteration 1.

The first sketch was designed based around a car parking method, it has a very primitive shape with sharper forms. The station was designed with the possibility to extract the batteries from the top side with the possibility of charging them separately from the station. The most important aspect was to change the method of charge for the robots. Because of this fact, the charge station incorporated a platform with two small connections to charge and two guides for the wheels of the Miabots, so they fit in the right position.

*Figure 3.1: Iteration 1.*
3.3.2 Iteration 2.

This sketch has the same system to extract the batteries but the design looks better because the shape is rounded in comparison to the first sketch. This model is divided in two parts the first part is the top, the most important thing about the top part is the holes for the batteries that you can put to remove it. And the bottom part has the place to charge the Miabots that conserve the first method of charging. Another aspect is that the bottom part has a negative angle to give to the operator a easy way to pick it up.

Figure 3.2: Iteration 2.
3.3.3 Iteration 3.

This iteration is interesting because the charge station is small, compact and simple. It is positive because this station’s modular design gives the freedom to charge any number of robots required. If you want two robots charging at the same time you only need to have two charge stations like this and stick one with the other with the mechanism that it has on the sides. The method of charge is basically the same that the previous designs.

Figure 3.3: Iteration 3.
3.3.4 Iteration 4.

With this design the old shapes get broken because now the design is totally symmetric. With this iteration we can have more spaces to charge robots in a really small place. It can be divided into four important parts the first is the top part that it does not have any use over than to improve the appearance of the item, the second one is the charge method, the same as the previous sketches. In the third part is the spaces next to the platforms were designed for the Miabot, because with this sides is more easy to be pushed by the robots. And the fourth part is the same as the third iteration that has a small negative angle for a easy gripping.

Figure 3.4: Iteration 4.
3.3.5 Iteration 5.

At first it appears that this iteration does not have a charge method or is different than the others. The method of charge is different because it uses a wireless charger. It works only if the Miabot is near it but the robot does not need to be touching the charge station. The design is the same except that it cannot have the same number of charge points because the wireless system needs a lot of space.

*Figure 3.5: Iteration 5.*
3.3.6 Iteration 6.

This model has a innovative shape, the design is more stylized than the others. The first difference is the top led light, this is to show if the charge station is on or off and it changes completely the style of the station. The method of charge is different; there are now two copper compressive springs one positive and another negative. The new method of charge is a little bit inside of the station to protect from possible hits from the Miabots when they move the station to another place.

![Figure 3.6: Iteration 6.](image-url)
3.3.7 Iteration 7.

The next iteration looks like an UFO, this model does not incorporate any charge method because it can be able to use all the anterior methods. The exterior design has the easiest shape for an operator to pick up. The top part has a partially transparent lid so the interior of the charge station is visible and has a few led’s that light all the transparent housing. The lid can be removed easily to replace the batteries quickly.

Figure 3.2: Iteration 7.
3.3.8 Iteration 8.

This model has a mix shape of a star and a crystalline form because the shape is very sharp. The tendency of the led’s light continue with a circular transparent shape. The method of charge is the same but we can change for another one if needed. With the shape of this model it has more space to be pushed by the robots.

Figure 3.8: Iteration 8.
3.3.9 Iteration 9.

When you look this model you can think of the shape of a star, it can be seen that this shape is totally rounded, looks really nice in the middle of station has a hole for design shape. It can have any charge method installed and has space to be pushed for the robots. The top has shape of a star that be illuminated with led lights when the station is on.

Figure 3.9: Iteration 9.
3.3.10 Iteration 10.

Maybe this iteration is the most compact design of all the anterior interactions, the station looks really simple and functional. It is divided in two parts, the first one is the top part that has a interior transparent plastic that is illuminated when the station is on. Around this plastic the shape is very rounded to improve the appearance and to make it easier to handle. The second is the bottom part that has negative angle in the side to facilitate the movement. The places where the Miabots go to charge are really big and rounded to help them charge.

Figure 3.10: Iteration 10.
3.4 Types of materials.

3.4.1 More of 100 years since the introduction of celluloid, plastics are still widely used. Plastic can perform any form and colour; it can be found in many solid designs like a chair or like a mobile phone. This material has a lot of positive points:

- Plastic is cheaper than wood, metal or any industrial material.
- Plastic is so strong like as weak metals like copper or aluminum. We can find unbreakable plastics.

Plastic is a perfect material to use in robotics because the design of a robot is divided in different structures and then they are all put together into a single finished piece. The following points are the most used plastics in robotics:

- **ABS**: Short for ‘Acrylonitrile butadiene styrene’ this is a translucent plastic that can take any color and texture.
- **Epoxies**: very durable plastic is often used as the binder in fiberglass. The easiest way that come epoxie is liquid form.
- **Nylon**: Plastics distributors also supply nylon in rods and sheets. Nylon is flexible, which makes it moderately hard to cut.
- **Phenolics**: The only application of phenolics in robotics is for circuit board material.
- **Polyethylene**: Polyethylene is lightweight and translucent and is often used to make flexible tubing. You can reform the material by applying low
heat, and when the material is in tube you can cut it with a knife.

- PVC: Short for polyvinyl chloride, is extremely versatile plastic best known as the material used in outdoor plastic patio furniture.
- Silicone: Is a large family of plastics all in its own right because of their elasticity.

3.4.2 Maybe wood is not an advanced technology but is ideal to build hobby robots because we can find it easily and it is cheap. Wood is a good material to work with because the mistakes in the work can be hidden. To build a robot does not require a lot of types of wood. The most used are as follows:

- Plywood: The best overall Wood for robotics use, especially for a foundation platform. This common building material comes in many grades and is made by laminating thin sheets of wood together.
- Planking: An alternative to working with plywood is planking. Use ash, birch, or some other solid hardwood. Stay away from the less meaty softwoods such as fir, pine and hemlock.
- Dowels: Most dowels are made of high-quality hardwood, such as birch or ash. The dowel is always cut lengthwise with the grain to increase strength.

3.4.3 Metal is the best option of all the materials that can be chosen to build a robot because it gives more resistance than the plastic or Wood. A lot of metals can be used:
• **Extruded aluminum:** Extruded stock is made by pushing molten metal out of shaped orifice. As the metal exits it cools, retaining the exact shape of the orifice. Extruded aluminum stock is readily available at most hardware and home improvement stores.

• **Steel:** is an alloy of iron and carbon, where the carbon does not exceed of 2,1% of the total weight. The steel in robotics field does not use normally because the weight of its is three times more than aluminum.

• **Stainless Steel:** Is a steel alloy with a minimum of 10% chromium content by the total mass. Similarly to steel, it is not use because the weight is heavier than the others.

• **Titanium:** Has a big corrosion resistance and mechanical resistance but is more expensive than steel and heavier than aluminum, because of this it is not widely used.

3.4.4 Fiberglass is resistant to high temperatures and is a good thermal insulator. For their proprieties and the cheap price of the material it has popularity in a lot of industrial applications.

3.5 Charging Systems.

In the beginning the objective is to preserve the Miabots charger because it is preferred not to modify the Miabots, but it will be shown how impossible it is to preserve the original design. The reason for that is simple: it is not possible to connect the Miabots to the original method of charge automatically, because the Miabots need to be plugged in to
the connector perfectly. This is the reason why the method of charge has been modified and new methods of charge have been considered.

3.5.1 USB.

The picture A of the Figure 3.12 shows two methods of USB connection that the market has but this method is equally or more difficult to connect automatically than the original.
3.5.2 3.5mm Jack plug.

This method comes from audio plugs with an easy connection and disconnection. The best way to connect and disconnect is manually because it is really easy and practical. The picture B of the Figure 3.12 shows an example of 3.5mm Jack plug (Pixmania, 2010).

3.5.3 Apple charger.

The method to charge from Apple gets a great aspect very helpful because the connections are magnetic, this helps an automatic connection. It can be seen in the ‘C’ picture in the Figure 3.12 (Dealeroutlet, 2009).

3.5.4 Audio conexión.

The part ‘D’ from the Figure 3.12 show a method is the same than Apple connection with the difference that the connection shape is rounded and has a positive point that it can be connected with any position (Apple, 2008).

All the previous methods are good but the method of charge is the same as the original. The method needs to change completely so that it is easy from the Miabot to charge their batteries automatically.

Research about robots and electronic mechanisms revealed three interesting charger types:

### 3.5.5 Platform.

This method was taken from the roomba\(^{11}\) website; with this method it would be easier to charge the Miabots, if compare with the original one. The Miabot would come to the charge station and, when it touches the connections the charge function would start, showing tolerance enough to this process. Certainly the only tangible problem is the small ground clearance of the Miabot, so the mechanism would be very slim.

*Figure 3.12: Charge platform for Roomba (IRobot, 2007).*

### 3.5.6 Powermat.

Powermat is a new technology that it appeared on the market a few months ago. The mission of it is to charge mobile phones without wires but could be modified to charge the Miabots.
3.5.7 Custom connexion.

This kind is a custom method with a compressive copper springs, it would be the easiest way to connect automatically and it can be modified and built with a lot of shapes with a reduced cost.

3.6 Battery Types.

The charge station needs a battery to charge the Miabots about ten times. To know which battery can be used the battery capacity of the Miabots need to be known. The Miabots have two packs of batteries with three cells AA, in total it has six batteries of 1,2V each one and 1300mAh.
Each robot needs 7.2V and 1300mAh if the charge station needs to charge ten times one Miabot it needs a big battery with a minimum potency of 8V and 13000mAh.

The market has two kinds of batteries, they can be differentiated by the components that they have inside.

### 3.6.1 Gelled Electrolyte Sealed Lead Acid 12V Batteries.

Lead-acid batteries are composed of a Lead-dioxide cathode, a sponge metallic Lead anode and a Sulphuric acid solution electrolyte. It has 35% sulphuric acid and 65% water solution. This heavy metal element makes them toxic and improper disposal can be hazardous to the environment.

These kinds of batteries are used for a lot of applications like automotive, submarine or emergency power.

One good battery for this application is from the CAMDEN brand the model BEG121200 with 408 x 173 x 227 mm of size and 35kg of weight.

![Gelled Battery](Figure 3.15: Gelled Battery (Focus Technology Co., 2010).)
3.6.2 Lithium Polymer Lipo Battery.

Lithium polymer batteries are now being widely used in hobby and UAV applications. They work well because they can hold a large amount of current and are lighter than nickel metal and ni-cad batteries. The primary difference is that the lithium-salt electrolyte is not held in an organic solvent but in a solid polymer composite such as polyethylene oxide or polyacrylonitrile. The advantages of Li-ion polymer over the lithium-ion design include potentially lower cost of manufacture, adaptability to a wide variety of packaging shapes, and ruggedness.

A battery is needed that meets the requirements but this battery does not exist now. It is necessary to connect three batteries in parallel, with this the 11.1V is maintained and increases the mAh. If each battery has 4700mAh and two more are added this is equivalent to one battery with 14100mAh.

Three batteries of the TurBORIX brand are required. the specific model is 11,1V 20c 4700mAh 3S2P RC Lithium Polymer Lipo Battery, the size of the battery is 136 x 44,5 x 38,9 mm and it has a weight of 412g.
3.7 Mobile platform-wheel options.

Having some information about the battery, the housing and the structure it is considered that the Miabots may not be able to move the station. For the weight maybe the charge station was in need of wheels in it to reduce friction of it with the floor. Looking for displacement mechanisms revealed many of them but basically there are four major kinds shown in the next section.

3.7.1 Industrial wheels.

Industrial wheels are the most common wheels in the factories because they can be mounted on anywhere.

*Illustration 3.17: Common industrial Wheel. (Accesscasters, 2010).*
3.7.2 *Lefts wheels of the Figure 3.18.*

This are double Omni wheels have strong steel shafts supporting the rollers and are very sturdy. They are perfect for the big heavy robots.

3.7.3 *Central wheels of the Figure 3.18.*

The single Omni wheels have smaller rollers and a finer shaft but are still more than strong enough for the lighter robots.

3.7.4 *Right wheels of the Figure 3.18.*

The all steel construction of the ball casters make them very strong, perfect for heavy robots.

*Figure 3.18: Multidirectional wheels. (Jones, 2009)*
3.8 Latch.

The word latch is a very broad term because the market has a wide variety of mechanisms but only two kinds are interesting for the station.

3.8.1 Push Latch.

The push latch has a locking mechanism that will not allow the cabinet door to open unless the mechanism is unlocked with a push action.

![Figure 3.19: Example of Push latch (WorkSafe, 2010).](image)

3.8.2 Magnetic Latch.

Magnetic latch Works with magnetic metal, this system locks the door with a little magnetic force.

![Figure 3.20: Example of magnetic latch (Yau, 2010).](image)
3.9 Power button.

Power buttons are wide and varied but the best option for the station is a big and colourful button like the start buttons from the latest cars.

![Figure 3.21: Example of a Button (Sobrecoches, 2008).](image)

3.10 Conclusion.

The first step was the classification of important aspects to know about through an investigation of the market. When the aspects were identified the research started searching for interesting materials for product building but the research was reduced for only the really important materials.
Chapter 4

Detail Design.

1.1 Introduction.
1.2 Iteration choice.
1.3 Frame development.
1.4 Material Choice.
1.5 Charging Method Choice.
4.6 Batteries Choice.
4.7 Wheels.
4.8 Latch Choice.
4.9 Anthropometric Aspects.
4.10 Connection Development.
4.11 Stress Analysis of Contender Materials.
4.12 Applicable Standards.
4.13 Final Detail Design.
4.14 Conclusion.
4 **Detail Design.**

4.1 **Introduction.**

To produce a great final product it is advisable to build a prototype to see the mistakes or the problems that it can have. With this information it is possible to modify the model to do a better model to be built or to work on it.

4.2 **Interaction Choice.**

To choose a charge station design from the lasts ten interactions lots of aspects were taken into account like the ease of assembly, the final cost or the machines that are required to build the design.

The two firsts interactions were discarded instantly because the designs looks like old designs and if they went into the market would seem obsolete. The third interaction shows an individual station and the principal problem of it is that the station cover the top part of Miabot and Miabots cannot be covered for the led’s signalling.

The fourth and fifth interactions show a few problems with functionality because one has lots of places to charge but it needs a lot of space as the station is really big. The other was designed to charge only four Miabots with wireless method and wireless method has been discarded for low benefits.

The sixth and eighth interactions show a common problem, their designs are really new and shocking but they have unsuitable shapes for the Miabots. With these interactions the
Miabots cannot move the stations because of their flat and sharp shapes. These stations would be impossible to work with the Miabots.

The seventh and ninth interaction have a really beautiful and futuristic designs. This design feature maybe helps the life cycle of the product because it could remain in the market for more time. The common problem is the difficult construction and assembly of them for their rounded shapes.

The last interaction is the tenth and is the elected design to continue to the finished portable charge station design because it has a rounded shape and can be easy for Miabots to move the station. The design is realistic and the assembly would be easy.

**4.3 Frame development.**

The first model of the housing was designed with SolidWorks to make an idea to the future shape of the station. This stage can be seen in the Figure 4.1.
In the Figure 4.2 below show is modified to give a good look and ergonomic technology thinking of the operator.

![Figure 4.2.](image)

The follow Figure 4.3 shows that the shape was changed totally from the first one to give it a positive angle in the bottom part and rounding the shapes of the housing.

![Figure 4.3.](image)
The top of housing was modified to accommodate led’s. It needs a circular groove and small holes in the circular grove to accommodate the led’s and to fix the transparent housing has shown at the Figure 4.4.

![Figure 4.4.](image)

The last Figure 4.5 shows the charge station with all details, for example the connections, the switch and the lights on the top.

![Figure 4.5.](image)
4.4 Material Choice.

The easiest material to build the station from is ABS because it has a reduce weight, is cheap and satisfies all requisites.

With wood or metal the station should be too heavy.

4.5 Charging method Choice.

To choose the charge method presents lots of possibilities but the first four methods are quite similar to the original one. These methods can be really complicated to be automatically connected to the charge station. These methods are out of the list of potential methods and the next ones are considered.

- **Platform.**

  This method counts on a great skill because it is an easy and cheap method to be developed. A good design can be an easy way to connect the Miabot to the charge station. For example, if the platform is equipped with guides for the Miabot. But there is a problem because the Miabot does not have enough space for the connection on its bottom and that is why this design was discarded.

- **Powermat.**

  Powermat is a method that is being currently developed; it was released into the market six month ago. It is a really good method because no connection is needed to charge, but this method is really expensive and the benefits are poorer than copper connection ones.

- **Custom connection.**

  This is the best option because it is the cheap and easiest one to be developed. In the next chapter the
custom charge will be modified to be more innovative and functional.

4.6 Battery Choice.

There are only two kinds of batteries, but the choice is easy because if their characteristics are compared only one of them can be applied to the charge station requirements.

- **Gelled Electrolyte Sealed Lead Acid 12V.**

  The size is 408 x 173 x 227 mm and the weight is 35Kg. For this battery it would be necessary to have a charge station bigger than the current one.

- **Lithium Polymer Lipo.**

  The size 136 x 44.5 x 38.9 mm and the weight is 412 grams, but to achieve the precise power it needs to have a pack of three batteries together with a different size: 136 x 44.5 x 116.7 mm and a weight of 1236 grams. With these batteries the station is perfect because the charge station can allocate them.

4.7 Wheels.

- **Industrial wheels.**

  These types of wheels were discarded because they increase the height of the station and it cannot work properly, plus the appearance is really awful.
• **Double Omni wheels.**

The double Omni wheels present several problems. The main one is that it is needed to design a mechanism to equip the wheels. The mechanism cannot be fit on the batteries and the height of the station can also be a problem.

• **Omni wheels.**

Omni wheels similar to double Omni wheels, the only difference is the size, and Omni wheels are smaller. This mechanism presents the same problems previously described for double Omni wheels.

• **Ball casters.**

This is the best method from the four options because it is small and can be set in any place of the station’s bottom part without height modification and not interfering in battery placement.

The weight of the charge station with all of components is approximately 2Kg, if some plugs are equipped on the bottom where the charge station is in friction with the floor they can reduce the fiction coefficient and the station can work without wheels.

4.8 **Latch Choice.**

The choice for latch was between two methods. The first method was a magnetic latch but for this method the design needed to be adjusted, the design needed some additional part to remove the housing easy. The second method was a push latch, which did not have the same problem as the first
method. To remove the housing it only needs to be pushed down and with this the station will be separate into two parts.

Finally the charge station does not use a latch because the batteries do not need to be removed quickly. The parts of the charge station will be attached with screws.

4.9 Anthropometric aspects.

The design considered anthropometric shapes to facilitate the operators use with it. These aspects can be separate in three important points.

4.9.1 Rounded shapes.

All shapes from the station were rounded to facilitate the lifting or moving of it for the operator without difficulties. Another aspect was the movement of the station by the Miabots, with the rounded shapes it is easier for them to move it.

Figure 4.6.
4.9.2 Positive drop.

The exterior part of charge station was designed with a positive angle to aid better grip for the operator. Only with a little angle it can get more than 34% of grip with the station.

![Figure 4.7.](image)

4.9.3 Button On/Off.

The ON/OFF switch was built on the top side of the station because it is the easiest place to place it to allow the station to be switched on and off.
4.10 Connection development.

The charge method of the Miabot needed to be adapted because the charge station was designed with another method. The Miabot could not be redesigned so an accessory for the Miabot was designed to change the method of charge.

The first idea was a platform with the connections placed on the bottom side of the Miabot. To fix into the platform required a support, this idea can see it in the Figure 4.8.

![Figure 4.7](image)

4.11 Stress analysis of contender materials.

The only stress that could be possible in the station was on the base because it hosts three batteries of 500 grams each one and the housing weight. The base has only two options but the second option was in case that first fail. The first option was
ABS plastic and the second was anodized aluminum. With COSMOSXpress Solid works can be used to check if the material can resist the weight. The design gave a security coefficient of 253.234 and the minimum coefficient is 2.5, so the base could be build from ABS.

### 4.12 Applicable standards.

There are no applicable standards for this kind of robot accessory because never has been produced before. Only exist applicable standards for welding robots and automatic robots but some standards can be applicable to the charge station.

- The BS 50174-2:2009 title is “Information Technology and Cabling Information” that it gives the correct specification to cabling and their symbology.
- The BS EN 61800-7-203:2008 title is “Adjustable speed electrical power drive systems”; it gives information about the maximum speed that the robot is able to drive.
- The BS EN ISO 14644-7:2004 title is “Cleanrooms and associated controlled environments”: it gives the correct directions that the environment need for the robots to work properly and safety.
- The BS EN 60335-2-107 title is “Household and similar electric appliances – Safety”; It gives information about the safety that the operator needs to have for the manipulation of a robot.

These applicable standards are very large and can be modified for the charge station product.
4.13 Final detail design.

The next picture shows the model in two colours the matte black and the White, maybe the White looks a Little bit more pretty but the miabots are matte black, the station and the robots need to be related for this point the station will be matte black.

![Figure 4.8.](image)

The left picture of the Figure 4.9 shows the electric connections strip that it has two missions: the first one is to make itself a general connection point, and the other one is when the equipment need to be separated it only needs to disconnect the electric strip and the equip can be split up in two parts. The right picture of the Figure 4.9 shows the lighting system of the station that it gives information to the computer camera to know the position of it; the lighting ring is to protect the led’s and for a better visual design.

![Figure 4.9.](image)
The left part of the Figure 4.10 shows the connections form the station to the miabots. This system has a nude electric conductor that gives electricity to the miabots and has a mechanism with spring that it works when the miabot come to charge. The miabot push the connector, like a compressive connector this improve the connection; and when the miabots finish the spring return the connector to the initial position. The picture shows a protection system that it work doing the protection for a possible fake hits with the miabots and has a magnetic part to attract the miabot to the correct position to charge. The other part from the Figure 4.10 shows the bottom of the station with a little parts to give less contact resistivity with the floor to facility the movement for station. And we can see the screws into their gaps to protect it from the exterior.

![Figure 4.10.](image)

![Figure 4.11. Top look.](image)
Figure 4.12: Charge station with the Miabot.
4.14 Conclusion.

This chapter is related to the third one because in the third relate with are the options that we have to build and in this we need to choose one of the options and explain why is the best option to choose for the model.

The part on the connection mechanism development for the Miabots was not very developed; the mechanism is simple and could be improved.

Once the materials and the mechanisms were chosen the next point is to design final details that show how the design could be a product in the future.
Chapter 5

Production of Prototype.

5.1 Introduction.
5.2 Framework.
5.3 Assembly Stages.
5.4 Weight of the Model.
5.5 Electric Circuit.
5.6 Measurements of the Prototype.
5.7 Conclusion.
5 Production of a Prototype.

5.1 Introduction.

Once all the things were prepared a prototype was built with the same measurements and shapes as a theoretical model: with this it can be seen if the model will work properly and if the product has a viable production method.

5.2 Framework.

Two models were built; the first model was built to half the scale using the rapid prototype machine. This is because the machine cannot accept the full-size. Model 1 was built to see the mistakes and make improvements before the full-size model was made, and is shown in Figure 5.0.

![Figure 5.0.](image)

To do the full-size model the CNC wood machine was used but the model was cut into three pieces because it was too big for the machine. When the pieces were built, each one needed to be smoothed with sand paper and following this the three pieces were stacked and stuck together with glue. Figure 5.1. below shows CNC machine and gluing the model.
The CNC machine doesn’t build the pieces perfectly, the pieces needed to be sanded and the gaps covered with cement. The next step is to sand the model with fine sandpaper, and then prime the model and sand another time. This process was repeated three times before the model was painted. Figure 5.2. below shows sanding the model and priming it.

Once the model has been painted, the led’s are added but only two leds will be placed for the lighting ring because the model
is completely solid. To place the led’s need to take a drill of 5mm of diameter one millimeter less than the diameter of one led and drill the marked places through the model. Then with the dremel and debase until the LED’s fits into the hole spacing. On the bottom part needs to be placed the battery part; we mark the place and drill and rebase with the dremel the place. To connect the holes to the place of the battery pack we need to do a little track with the dremel because for here need to pas the wires from the LED’s to the batteries.

Figure 5.3.

Once the station is painted only leave put all the components together. The first step is install the electric LED’s into the gaps of the top of station and cross thought the station with the wires. We’re going to place the illumination system in the top part and on the bottom we’re going to connect them all together, after that we’re going to fix them with glue. Now
we’re going to fix the wooden bottom on the top of the station with its plastic ring and the bigger plastic ring. The Figure 5.4 shows the led’s and the plastic ring.

![Figure 5.4.](image)

After all we’re going to the bottom of the station, when are the connections for the robots, fist of all we’re going to measure where the connections have to be placed and the protection system with magnetism and stick it one by one. The Figure 5.5 and the Figure 5.6 show the connections and the complete charge station.

![Figure 5.5.](image)
5.3 Assembly stages.

The building of a charge station needs to be separated into two parts because it is the easiest way to assemble the model. The first part is the most important one and is easy to assemble. This is the bottom part that supports all of the weight of the model and the batteries. Place each battery in its slot and use wires to bridge these together and then to connect to the electric strip; the Figure 5.7 below shows the bottom part with the batteries.
Once the bottom part is completed, move on to the top part. In the housing we begin with the most important part, which are the connectors. These are fixed to the housing by screws but before this is done, we need to install the springs to connect the copper connectors in order that they can make contact with the miabots. The next Figure 5.8 gives an idea that the top part with the connections.
When the connectors are in place they need to be bridged with wires and terminal connectors. Then connect the main wire with the general electric strip and with a multi-meter, check the continuity of the circuit to make sure that the circuit will work properly. In the Figure 5.9 show the transparent charge station to gives an idea of the place of the wires.

![Figure 5.9.](image)

The next step is to place the On/Off button on the center of the housing and the ten LED’s around the button, this is easy work because the housing has a pre-made place for them. Now one only needs to connect the wires with the button and with the LED’s, and check that all is connected with a multi-meter. If all is connected, the next step is to connect the wires to the electric strip. The next Figure 5.10 shows the building of the Led’s, the button and connections with the wires in the top part of the station.
When all the wires were connected to the electric strip we can join the two parts of the model with ten screws located on the support’s bottom. In the left part of Figure 5.11 shows the join of the station with screws and in the right part shows the transparent station with all the components put inside.

With all the anterior steps fixed, only the details of the charge station are lacking. Fix the lighting ring on the top to cover the
LED’s and fix the magnetic protections with glue between the electric connectors we can see this into the Figure 5.12.

Figure 5.12.

5.4 Weight of the model.

This part show which is the weight of a real future charge station but it is an indicative weight because the weight was divided into the parts of the charge station and calculated each one in Solid Works and then joined all the results into the next table.
Weight charge station.

<table>
<thead>
<tr>
<th>Part</th>
<th>Weight</th>
<th>Number of parts</th>
<th>Total Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>2.58gr</td>
<td>x1</td>
<td>10.85gr</td>
</tr>
<tr>
<td></td>
<td>0.17gr</td>
<td>x1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.1gr</td>
<td>x1</td>
<td></td>
</tr>
<tr>
<td>Battery</td>
<td>412gr</td>
<td>x3</td>
<td>1236gr</td>
</tr>
<tr>
<td>Button</td>
<td>4.44gr</td>
<td>x1</td>
<td>4.44gr</td>
</tr>
<tr>
<td>Wires</td>
<td>18.42gr</td>
<td>x1</td>
<td>18.42gr</td>
</tr>
<tr>
<td>Contacts</td>
<td>2.15gr</td>
<td>x10</td>
<td>21.5gr</td>
</tr>
<tr>
<td>Button mechanism</td>
<td>14.68gr</td>
<td>x1</td>
<td>14.68gr</td>
</tr>
<tr>
<td>Housing</td>
<td>839.2gr</td>
<td>x1</td>
<td>839.2gr</td>
</tr>
<tr>
<td>Led</td>
<td>0.2gr</td>
<td>x10</td>
<td>2gr</td>
</tr>
<tr>
<td>Spring</td>
<td>0.03gr</td>
<td>x10</td>
<td>0.3gr</td>
</tr>
<tr>
<td>Protection</td>
<td>0.94gr</td>
<td>x5</td>
<td>4.7gr</td>
</tr>
<tr>
<td>Electric connections</td>
<td>0.83gr</td>
<td>x1</td>
<td>2.63gr</td>
</tr>
<tr>
<td></td>
<td>0.09gr</td>
<td>x20</td>
<td></td>
</tr>
<tr>
<td>Screws</td>
<td>0.54gr</td>
<td>x10</td>
<td>7.8gr</td>
</tr>
<tr>
<td></td>
<td>0.12gr</td>
<td>x20</td>
<td></td>
</tr>
<tr>
<td>Suport</td>
<td>201.72gr</td>
<td>x1</td>
<td>201.72gr</td>
</tr>
<tr>
<td>Charge station</td>
<td>______</td>
<td>______</td>
<td>2364.24gr</td>
</tr>
</tbody>
</table>

*Table 5.0.*
The process of knowing the weight of the charge connection for miabots was the same as to know the weight of the charge station with Solid Works.

<table>
<thead>
<tr>
<th>Part</th>
<th>Weight</th>
<th>Number of parts</th>
<th>Total weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platform</td>
<td>6.5gr</td>
<td>x1</td>
<td>6.5gr</td>
</tr>
<tr>
<td>Wire</td>
<td>0.45gr</td>
<td>x1</td>
<td>0.45gr</td>
</tr>
<tr>
<td>Conductor</td>
<td>1.15</td>
<td>x2</td>
<td>2.3gr</td>
</tr>
<tr>
<td>Accessory miabot</td>
<td>______</td>
<td>______</td>
<td>9.25gr</td>
</tr>
</tbody>
</table>

*Table 5.1.*
5.5 Electric circuit.

The charge station needs a simple electric circuit with few wires. The Figure 5.5 shows the electric circuit.

![Diagram of the electric circuit](image)

Figure 5.13.

The station circuit is simple, it uses a double button that it open or close the circuit. The circuit have ten LED’s with one resistance each because if the LED’s don’t use resistance the LED’s cannot work properly, these LED are connected to the charge contact for miabots. The contacts were drawn into the electric circuit like resistances. All the components are connected with the batteries; these are bridged and bridged to the external alimentation because when the external alimentation is connected, the batteries start to charge directly.
5.6 Measurements of the prototype.
5.7 Conclusion.

This chapter shows the building the charge station prototype with all the steps that it need to have and the steps that the station needs to have to build for the market with all the weights and the real measurements drawings of the real charge station.
Chapter 6
Business Considerations.

5.1 Introduction.
5.2 Direct Cost Incurred.
5.3 Marketing Mix.
5.4 Product Life Cycle.
5.5 Conclusion.
6 Business Considerations.

‘Business has only two functions -- marketing and innovation.’

(Drucker, 1992).

6.1 Introduction.

The Ducker topic defines perfectly which is the business that the marketing needs to think in the best way as possible. Helps a lot at the time to sell it and obtain benefits for it if the product is a good product and has low cost.

6.2 Direct costs incurred.

This point is divided in two parts because the model could not be built because the rapid prototype machine cannot build models bigger than 25 cm; the prototype was built with the CNC wood machine. The following table 6.0 shows the price of necessary components to build a real charge station. In the last part of the table gives the total price of a charge station.
<table>
<thead>
<tr>
<th>Part</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid prototype housing</td>
<td>£120</td>
</tr>
<tr>
<td>Batteries</td>
<td>£70</td>
</tr>
<tr>
<td>Copper wire 0.7</td>
<td>£2</td>
</tr>
<tr>
<td>Led’s and resistances</td>
<td>£6</td>
</tr>
<tr>
<td>Wire connections</td>
<td>£12</td>
</tr>
<tr>
<td>Copper connectors</td>
<td>£21</td>
</tr>
<tr>
<td>Springs</td>
<td>£5</td>
</tr>
<tr>
<td>Magnetisms</td>
<td>£10</td>
</tr>
<tr>
<td>Screws</td>
<td>£5</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>£251</strong></td>
</tr>
</tbody>
</table>

*Table 6.0.*

The prototype price is indefinite because all the materials used are taken from the workshop but the next table shows all the materials used to build the prototype.
### Table 6.1.

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td>Three pieces of 30x30cm</td>
</tr>
<tr>
<td>Wire black/red</td>
<td>40 cm</td>
</tr>
<tr>
<td>Copper stripes</td>
<td>0.5 x 60cm</td>
</tr>
<tr>
<td>Acrylic transparent plastic</td>
<td>20 x 20cm</td>
</tr>
<tr>
<td>Led’s</td>
<td>2 units</td>
</tr>
<tr>
<td>Batteries</td>
<td>2 batteries of AAA</td>
</tr>
<tr>
<td>Batteries Housing</td>
<td>1 unit</td>
</tr>
<tr>
<td>Sandpaper</td>
<td>20 units of 5 x 10cm</td>
</tr>
<tr>
<td>Black paint</td>
<td>Spray of 250ml</td>
</tr>
</tbody>
</table>

6.3 Marketing mix.

‘Marketing is not about providing products or services it is essentially about providing changing benefits to the changing needs and demands of the customer’

(Taylor, 2000)
The product in this case is a charge station called Michar, this product needs to be presented to prospective buyers like an accessory for the miabots because the Michar only works with the miabots.

If the promotion is good the Michar could have success because the operators could eliminate the original methods of charge and replace them for only one station.

The station only could buy to operators that they works with Miabots because the Michar only works with Miabots.

**6.4 Product life cycle.**

The Product Life Cycle (PLC) is based in the biological life cycle. For example, a seed is planted (introduction); it sprouts (growth); it shoots out leaves and puts down roots as it becomes an adult (maturity); after a long period as an adult the plant begins to shrink and die out (decline). The Figure 6.1 below shows a stages of the life.

The life cycle begins when a country has a new product to satisfy consumer needs. The duration of the product depends from lots of factors like, the quality of design, if is easy to come into the market, the saturation from same products, among other factors.

The Charge station for Miabots product has the best aspect that it can have because actually the market does not have products like this. This is a really good point because this product opens the market and has the opportunity to improve it as soon as the other competitors.
6.5 Conclusion.

This chapter has three very important parts because with them we can know if the product will have exit. If the results of each point have a good result the product can be in a good position in the marked versus the other competitors.
Chapter 7
Testing and Summative Research.

5.1 Introduction.
5.2 Ethnographic Testing.
5.3 Laboratory Testing.
5.4 Proposals for Further Development.
5.5 Development of Name.
5.6 Conclusion.
7 Testing and Summative Research.

7.1 Introduction.

To realize this model successfully we have to think and make a test of the Project and their surroundings to obtain the necessary information to know how is the best direction and we have taken the wrong direction modify it or change it completely.

7.2 Ethnographic test.

“Market research and focus groups aren't telling us anything we don't know. We must drop the notion that consumers can tell you what they want.”

(FutureLab, 2010)
The world's robot density is highest in Europe, although Japan makes use of robots at twice the rate of any other country. There are now one million industrial robots working around the world, and Japan is where they are the thickest on the ground. Japan has 295 of these electromechanical marvels for every 10000 manufacturing workers. The robot density almost 10 times the world average and nearly twice that of Singapore (169), South Korea (164), and Germany (163).

The last picture can help us to know where we have more possibilities to success and where the charge station has more possibilities to be accepted.
7.3 Laboratory testing.

Each robot contains two 3AA - cell battery packs (nominal 1.2v per cell, 1300mAh). The robot is supplied with a NIMH fast-charger that can charge these completely in about 1-2hrs. But we wanted to check the exact time that the miabots needs to charge the full batteries, for this we did few experiments with the batteries of the miabots and with the two different ways to charge and the three different ways to discharge. In the next step we show you the graphs of the each experiment.

7.3.1 The first experiment we did is charge the robots with the charger in mode of 500 mAh but we discard the first because the robots didn’t work the robots had long standing and the results maybe are wrong results. For this we repeat the experiment and we changed the charger of the robot to compare results between robots and chargers and we can know if one robot or one charger does not work in a good mood. In the next part we can see the results of the experiments realized.
Experimental table of charge with 500mAh.

<table>
<thead>
<tr>
<th>Robot</th>
<th>1</th>
<th>8</th>
<th>7</th>
<th>14</th>
<th>2</th>
<th>5</th>
<th>15</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Charger 1st time</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Number of Charger 2nd time</td>
<td>6</td>
<td>1</td>
<td>8</td>
<td>2</td>
<td>7</td>
<td>15</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Time to charge 1st time (minutes)</td>
<td>65</td>
<td>54</td>
<td>62</td>
<td>26</td>
<td>66</td>
<td>68</td>
<td>59</td>
<td>53</td>
</tr>
<tr>
<td>Time to charge 2nd time (minutes)</td>
<td>66</td>
<td>59</td>
<td>53</td>
<td>49</td>
<td>60</td>
<td>63</td>
<td>63</td>
<td>53</td>
</tr>
</tbody>
</table>

*Table 7.0: Charge with 500mAh charger.*

In the next graph we can see that all the batteries didn’t have the same results, we see that more or less the results follow a line but the charger number fourteen we can appreciate that the time of charge is less than the others. The difference is a 30% less time to charge and the charger did the same through different miabots for this we can think that the charger number fourteen has a problem.
Graph 7.0: Graph form the table 7.0.

\[ \eta = \text{___________________________} \]

The average take for the miabots to charge with a 500 mAh charger is 54 min.

7.3.2 The next step of the experiment is change the method of charge, the position of the charger was changed from 500mAh to 1000mAh. Now the graph show changes about the charge time form the old one.
Experimental table of charge with 1000mAh.

<table>
<thead>
<tr>
<th>Robot</th>
<th>1</th>
<th>8</th>
<th>7</th>
<th>14</th>
<th>2</th>
<th>5</th>
<th>15</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Charger 1st time</td>
<td>4</td>
<td>3</td>
<td>6</td>
<td>1</td>
<td>7</td>
<td>2</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Number of Charger 2nd time</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Time to charge 1st time (minutes)</td>
<td>78</td>
<td>84</td>
<td>86</td>
<td>48</td>
<td>86</td>
<td>53</td>
<td>60</td>
<td>88</td>
</tr>
<tr>
<td>Time to charge 2nd time (minutes)</td>
<td>85</td>
<td>81</td>
<td>84</td>
<td>59</td>
<td>74</td>
<td>68</td>
<td>68</td>
<td>84</td>
</tr>
</tbody>
</table>

Table 7.1: Charge with 1000mAh charger.

If new table is compare table with the old one you can look that the charge time change with 20 minutes more of charge. But the time of charge of each miabot did not grow up uniformly. The charge time of one miabots grows up a lot and another is insignificant.
Graph 7.1: Graph from the table 7.1.

\[ \eta = \text{________________________} \]

The average of the charge times was grew a 30% than the other but the next graph shows that the times was not growing at the same time.

Graph 7.3: Comparsion graph for the last to tables.
7.3.3 This part show the time that spends the miabots to the completely discharge with different velocities. To realize this experiment the miabot was commanded from the computer that it turn around itself with different velocities until it cannot have enough power to continue the task. Periodically the power of the miabots was checked.

Graph 7.4. Graph of discharge of the batteries.

Table 7.3: Time to spend each robot to discharge.
The graph 8.3.3 shows that the miabot do not spend the same
time discharging, the difference between the first miabot to
stop and the last one is about 50% more. Maybe this problem is
for old uses, if the miabot was used a lot it has a poor battery
and if the miabot was used a little bit it has a strong battery. It
is true that this results are experimental and they go away
about the theory results.,

7.4 Proposals for further development.

One product always can be improved because it is never
perfect. The technology advances at high velocity and the
newest product today, tomorrow is obsolete. In a few months
this product may be improving with lots of modifications.

Some ideas to think about of this product in the future are:

- The design of the charge station because it could be
  smaller and lighter for commodity of the operator.
- An important thing are the batteries because if the
  batteries can be lighter and smaller the design has to
  be totally changed but it depends on the efficiency of
  the batteries, it needs to improve the efficiency not
decrease it.
- Charge point for miabots could be changed for other
  like wireless method because something like this could
  make the difference against other competitors.
- The movement method because now the charge station
  needs the miabots to be moved but it could be moved
  from itself with a mechanism.
7.5 Development of the name.

To develop the name for the station was thought about the origins and the use of it. It provides from the Miabots robots because it is an accessory for them. The name was thought to relate it with the miabots, the Word miabot is composed for two. The idea was take the original word and take one syllable and add other syllable. Miabot was cut and the syllable ‘mi’ keep it and to add another syllable of one word relative to the charge station. The word was ‘charge’ because the mission of the charge station is charge, from this word was cut the syllable ‘char’ and joined with the other syllable forming ‘Michar’.

The insigne of the brand needed to be something about electricity because the only work that the Michar needs to do is recharge of electricity the Miabots.

![Insigne from the brand](image)

*Figure 7.1: Insigne from the brand.*
7.6 Conclusion.

To devolve the product were done a few tests about the original model; the first test was ethnographic to know which countries could be interested in the product and adapt the product to different zones and different likes of the customers.

Other one was the time that the batteries of Miabots need to be in charge because of this we have more or less facilities to build and design the model.

For the possible output of the model to the market a name and an insignie was though for it.
Chapter 8

Final Conclusion.
8 Conclusion.

The present investigation was realized about the building and the development of a wireless electric charge station for the miabots.

The Project covers many topics but the three most important aspects are the functionality, the components and design. The largest part of this research document covered the first and the second topic. This is the case especially due to a strong link between them. Given good quality new components with the latest features, the life cycle and the performance of the equipment can be significantly increased. These two aspects appear in the entire project.

The design was of a less priority. The charge station model design is very limited, it is however customizable, but only as long as the new features do not interfere with the charge station’s functionality. The charge station offers a variety of safety features, which ensures a highly safe working environment for the operator given an appropriate instruction workshop. The present protection features implemented in this project, exclude the possibility of mistakes and unwanted harmful events.

The following investigation proved to accomplish all primary objectives of the project in the first chapter.

This project is however not finished because it opens endless possibilities to improve or modify the charge station. Furthermore, this kind of product is in a constant development because of new solutions coming out to the market everyday. These can be adapted to the charge station and produce a next step, much superior version of the product.
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revolutionshop. (2010). *Ebay Uk*. From http://cgi.ebay.co.uk/11-1v-20c-4700mAh-3S2P-RC-Lithium-Polymer-Lipo-Battery-/110537605961?cmd=ViewItem&pt=UK_ToysGames_RadioControlled_JN&hash=item19bc8e0349


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