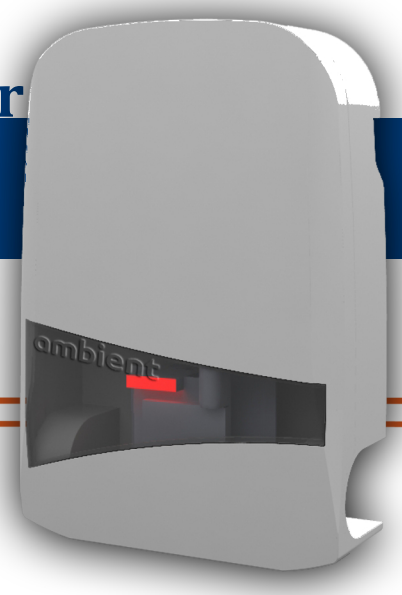
Bachelor assignment

New Design for Ambient Systems MicroRouter



Author: Sanne Eilering

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Author

Sanne Eilering — s0139386
s.eilering@student.utwente.nl

Employer

Ambient Systems — www.ambient-systems.net

Examiners

University	J.P. Thalen	j.p.thalen@ctw.utwente.nl
	Prof. Dr. Ir. A. de Boer	A.deBoer@ctw.utwente.nl
Company	Ir. M.J.J. Bijl	mark.bijl@ambient-systems.net

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Samenvatting

Voor het afronden van de bachelor is er een opdracht uitgevoerd voor Ambient Systems BV. Dit bedrijf specialiseert zich in het ontwikkelen en opzetten van draadloze sensor netwerken.
In deze opdracht is er een nieuw industrieel ontwerp ontwikkeld voor de MicroRouter. De MicroRouter is een van de drie producten uit de huidige product serie '3000'. Het apparaat maakt communicatie mogelijke tussen de verschillende apparaten in het netwerk.
Op het moment wordt er voor de behuizing een 'off the shelf box' gebruikt waar men niet tevreden over is. Er is daarom vraag naar een passend industrieel ontwerp dat praktisch toepasbaar is. De focus bij het ontwikkelen van een nieuwe behuizing lag op de huidige componenten en de praktische toepasbaarheid.
Informatie is opgedaan tijdens het doen van onderzoek naar de verschillende aspecten die bijdragen aan een nieuw ontwerp.
Er is onder andere gekeken naar het bedrijf, de markt en de concurrentie. De analyse van het bedrijf resulteerde in een beeld over het bedrijf zelf, de vooruitzichten en eisen en wensen van het bedrijf.
Door informatie over het functioneren van het draadloze sensor netwerk werd de functie van de MicroRouter duidelijk. Tevens zijn de componenten en de gebruiksomgeving van de MicroRouter bekeken. Deze opgedane informatie is verwerkt in een programma van eisen en wensen.

Door middel van schetsen en de verkregen informatie zijn er concepten gemaakt. Deze concepten zijn geanalyseerd aan de hand van het programma van eisen. Door deze analyse kon een keuze voor een eindconcept gemaakt worden.

Het eindontwerp is een strak en robuust ontwerp die alle huidige componenten bevat. Het resultaat is een functioneel toepasbaar ontwerp dat voldoet aan de gestelde eisen.
De uitstraling van het product past bij het bedrijf en kan met de SmartPoint een productlijn vormen.
Er is tevens gekeken naar hoe de behuizing vervaardigd kan worden en uit welk materiaal. Dit resulteerde in een behuizing van ABS met een los onderdeel van polycarbonaat (PC). Beide zullen worden vervaardigd met behulp van spuitgieten. Hiervoor is ook een kosten schatting gemaakt.
Ook is er een suggestie gedaan voor een toekomstig ontwerp van de MicroRouter waar de huidige componenten vervangen zijn.

Summary

To complete the bachelor assignment is done for Ambient Systems BV. This company specialized in the development of wireless sensor networks. The goal of this assignment is creating a new industrial design for the casing of the MicroRouter. The MicroRouter is one of the products in the current product series 3000. The device communicates between various devices in the network.
The company is not satisfied with the current off-the-shelf casing. They would like a more suitable industrial design. The focus during the development was on the current used components and the functional aspects.
Research resulted in information that was needed for the new design. The company, the market and the competitors were a few of the focus points during the research. The analysis of the company resulted in a better picture of the company's image, the future goals and requirements set up by the company.
The functionality of the MicroRouter became clear when information was gathered about the functioning of the wireless sensor network. Furthermore information of the components of the MicroRouter and the environment where the device operates was gathered. This information was incorporated into a list of requirements.
Concepts were made based on sketches and the gathered information. The concepts were compared with the list of requirement to make a choice for a final design.
The final design looks clean and robust. The design uses all the current components of the current device. Furthermore it is a practical applicable design that meets the requirements. The look of the device suits the company and can form a product line with the SmartPoint. Information on materials, production and costs was also gathered. The result is that the casing will be made of ABS and has a separate part of PC. Both will be made by injection moulding.

There is also a suggestion made for a future design of the MicroRouter. In this design the current used components are replaced.

Preface

To finish the bachelor industrial design an individual assignment is performed. All gained knowledge on product design, during the bachelor education. The results on the assignment to develop a MicroRouter casing for Ambient Systems can be found in this report.

During this assignment I had the support and help from some people whom I would like to thank. First of all I would like to thank my mentors Mark Bijl and Jos Thalen, who guided me during the process. Secondly I would like to thank all other employees of Ambient Systems for their support and visions. Finally I would like to thank the expert on injection moulding, Richard van Ringen.

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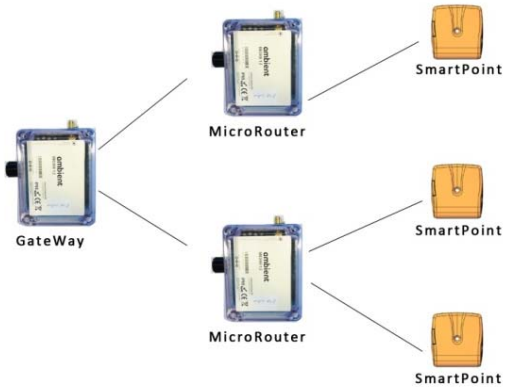
Introduction

Company

Ambient Systems was founded in 2004 by researchers from the University of Twente in the Netherlands.
The company is a Dutch privately-owned technology firm that specializes in the development of innovative active RFID technologies based on wireless mesh networks. Since the foundation in 2004 Ambient Systems has developed itself into a high- potential and award-winning growing company.
The Ambient Systems wireless sensor network offers solutions for supply chain visibility, asset localization and environmental monitoring. The network is used for different purposes and can be placed in different environments. For example in clean hospital surroundings but it can also be used outside. Here the device needs to cope with different extreme influences.



The Ambient Systems 3000 series

The latest product series of Ambient Systems is the product series 3000. This series provides the firmware and three devices for a wireless sensor network. The three devices are a GateWay, MicroRouters and SmartPoints (see Figure 0-1). The SmartPoints communicate with Ambient's wireless mesh networks using MicroRouters and a single GateWay. The SmartPoints gather information and send this to the MicroRouters. The systems strength is the SmartPoint which is intelligent and has automated behaviour. All information received by the MicroRouters is eventually sent to the GateWay. The GateWay provides the interface to corporate IT systems. Together these elements provide a very innovative and cost–effective active RFID solution.

Assignment

The goal of this bachelor assignment is to give recommendations and example design for an industrial design of Ambient Systems MicroRouter. The focus will be on the pragmatic aspects of the enclosure.
The current MicroRouter enclosure has various problems that need to be solved for further improvement of the MicroRouter and the 3000 product series. Problems are producibility, a corporate image and alignment with the other products in the product series. This prevents further development of the MicroRouter and the product series sales.
Research will be done on the use and layout of the device. The design will be determined by the mounting of the device, as well as the associability of the MicroRouter and protecting the component against various environmental influences. The evaluation will lead to a new industrial design for the MicroRouter. The design will be adjusted to the current components and can be used on short term. The evaluation will also lead to a roadmap and an example for a future design. It will show possible changes for the layout, mounting and look of the MicroRouter. The roadmap will be a guide for future changes of the MicroRouter.

Report structure

This report describes the steps that have lead to a new industrial design of the MicroRouter. In the first chapter analyses on the company and their product series are done (1.1, 1.2, 1.3). This is followed by a stakeholder-, market- and environmental analyses (1.4, 1.5, 1.6) to get an overview of the interests and further requirements of the product. At the end of the chapter an overview of the competitors is made (1.7). All analyses result in a list of requirements (2.1).
In the second chapter ideas are created and concepts are made (2.2, 2.3, 2.4, 2.5). Chapter three gives the final concept designs (3.1, 3.2) and a roadmap (3.3). In the last chapter conclusions (4.1) and recommendations (4.2) are given.

1. Research

In this chapter information about the company and their products is gathered. This way the development and future goals of the company become clear. Ambient Systems network is viewed and the underlying network structure is explained (chapters 1.2, 1.3). The devices of the latest product series are described in chapter 1.3.
The Stakeholders of Ambient are described in the stakeholder analysis (1.4). Ambient's current and future markets are shown in chapter 1.5.
The environments where the devices operate are discussed in chapter 1.6. At the end of this chapter (1.7) the competition is analysed.

1.1. Analysis of the company

1.1.1. Company history

The company was founded in 2004 by researchers from the University of Twente in the Netherlands. These researchers are developing wireless sensor network technology for over a decade now. Different European Union funded projects like EYES, CoBIs and e-sense were done.
So far the company launched two product series. The first product series, product series 800, was launched in 2005. The wireless sensor networks that Ambient build with this product series have been proven in more than 100 commercial deployments around the globe. With projects ranging from improving safety and security in warehouse environments to moisture monitoring at golf courses. Networks were implemented at the Great Barrier Reef in Australia in 2006.

In 2007 Ambient Systems received a venture capital funding and a senior management team was appointed.
In 2008 the number of installations of Ambient Systems networks grows to over 100 locations. In the meantime a new product series was developed and was launched in 2008 (see timeline Figure 1-1). This second product series, the product series 3000, is an evolution of the product series 800. This was a logical step in the development of active RFID solutions. The used frequency changed with the new product series, from 868MHz to 2.4GHz. One benefit is that the 2.4GHz frequency is worldwide license free, which is more appealing for an international target market. Another benefit is that more bandwidth will increase the processing speed. The new series supports larger scale networks, has a larger memory (1 MB) and is more robust than the previous series.

The company is still developing and improving its products and strengthening its market position. In 2009 they had a partner network of more than ten partners in seven key European countries. The partners operate in Germany, the United Kingdom, France, Italy and Spain.

Almost all projects where Ambient participates in are done with partners. Partners can be found in various disciplines and are called channel partners. They can address companies and arrange projects where Ambient Systems provides the hardware. Ambient Systems can also adjust a network system for a consumer which is often in cooperation with a channel partner.
In the future channel partners will be playing a big role in making Ambient Systems wireless network large and widely used. Ambient is now a fast growing starting company with great ambitions.

Figure 1-1 Timeline of Ambient Systems

1.1.2. Ambient Systems active RFID sensor network

Ambient Systems provides a wireless sensor network for monitoring, locating and protecting physical assets and people. This system is used by different consumers in distribution, transport and industry. It helps consumers reducing cost and improving the quality and efficiency of their processes. Ambient Systems focuses with their active RFID sensor network on areas like logistics, asset management, safety and security and environmental monitoring. Logistics and asset management implies monitoring perishable goods, logistic assets, process control and locate assets in real-time. Safety and security can imply access control and fire detection. Measuring temperature, humidity, moisture or CO_2 can also be done. These are covered by environmental monitoring.

The wireless network system has tree important functions, *check, track and trace* (the company's motto, Figure 1-2).
Assets will be monitored and temperature or humidity can be *checked.* To determine where these commodities are the system needs to *track* a network. Then it can be determined in which networks the assets are located and where in that network these are located.
Another capability of the product series is saving information and looking up historical information. So information can be *traced*.

A collage which gives an impression of Ambient can be found in appendix chapter 1.2.1.

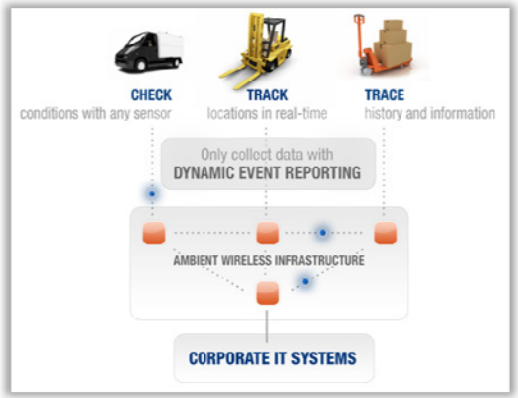


Figure 1-2 Check, Track and Trace

1.2. Background

The wireless sensor network can be branded as active RFID (Radio Frequency Identification). The meaning of this is explained in this section. Furthermore different RFID capabilities and the use of it are described.

RFID

RFID tags can be applied on or incorporated into products, animals or persons for the purpose of identification and tracking using radio waves. Some tags can be read from several meters away and out the line of sight of the reader.
Most RFID tags contain at least two parts. One is an integrated circuit for storing and processing information, modulating and demodulating radio-frequency signals, and other specialized functions. The second is an antenna for transmitting and receiving the signal (see Figure 1-3).

Until recently the RFID tags were used on a small scale to track large items like cows, railroad cars and airline luggage. New innovations led to more efficient and less expensive forms of RFID tags. Nowadays there are three different RFID tags namely the passive, semi-active and active RFID tags. Most

of the RFID tags can store information on an internal memory. In case of the semi- and active tag batteries are used. The passive uses none. The tags' antenna receives electromagnetic energy from an RFID reader's antenna. Using this power, or the power of the battery, the tag sends radio waves back to the reader. The reader will pick up the radio waves and interprets the frequencies as meaningful data (see Figure 1-4).

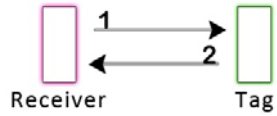


Figure 1-4 Passive RFID

Passive and active RFID

The passive RFID tag is a tag without a battery so it relies on the power of the source. Because of the low production costs this kind of tag is mainly used on less expensive products like disposable consumer goods. Most passive RFID tags cost between 7-20 cents each.
The power source of the active RFID tag is a battery. This battery powers the circuits in the tag and provides power to send out radio waves. These tags are more expensive than the passive tags and are mainly used for more expensive products. The benefit of the battery power is that the tag can be read from a greater distance.

Third generation active RFID

The active RFID tag has been developed in the last decade. Three developments can be distinguished which are called generations of active RFID. The first generation implies a conventional active RFID where a battery provides power to initiate a signal (longer range than passive) and manage a sensor. So the first generation is an improvement on the passive RFID. An example is the locking and unlocking of your car at a distance.
The second generation RFID is the Real Time Locating System (RTLS). This was introduced around the year 2003. This new innovation made it possible to locate objects or people in real time on a geographical map. The RTLS system is based on an active RFID that communicates with several readers at the same time. The communication between the tag and the reader are interpreted and so the location is determined (see Figure 1-5).
But now also a third generation of active RFID is introduced. New systems became available with this new generation. It is the Ubiquitous Sensor Network (USN) also known as the Wireless Sensor Network (WSN). This is characterized by the tag doubling as a reader and the so called mesh network (see Figure 1-6).being used with a choice of sensors on each tag. The strength of this generation is that it can make systems scalable, self-healing, affordable and extraordinarily capable.

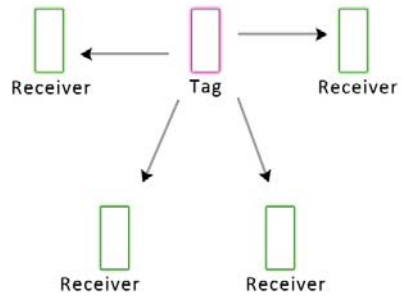


Figure 1-5 RTLS

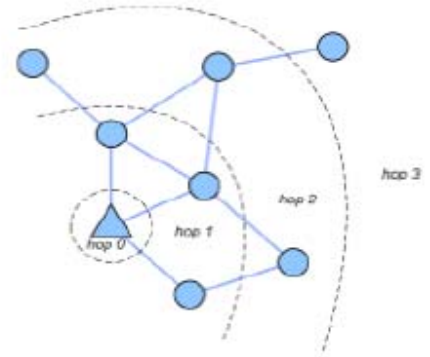


Figure 1-6 Mesh network

1.3. Ambient Systems product series 3000

The product series 3000 is the latest product series of Ambient. This is the series where the new casing has to fit in. The SmartPoint, MicroRouter and Gateways are further explained in this section. There will be focused on the MicroRouter because this device is the subject of the assignment.

1.3.1. SmartPoints

Ambient Systems product series are within the third generation active RFID. Three different devices form a sensor network.
The SmartPoint (SP, see Figure 1-7) is an active RFID tag but it has far more possibilities than traditional tags. By attaching the SmartPoint to an object this object becomes intelligent. The SmartPoint has the capability to do three main things.

First of all it can monitor the environment in which they are located. A temperature sensor is included in every SmartPoint but it can easily be extended with other sensors, such as infrared, motion, humidity, shock, and so on.

Secondly the location of the object can also be determined by the SmartPoints' own real-time locating system. Based on the wireless communication with the ambient infrastructure the SmartPoint can calculate its own location (3Dimensional) in the network. This is done by using an intelligent algorithm based on RSSI (Received Signal Strength Indication) and so the SmartPoint does not need a separate software application.

Finally the SmartPoint has a storage capacity of 1 MB to store historical data and other information. These things make the object intelligent when the SmartPoint is attached.

Figure 1-7 SmartPoints

Dynamic Event Reporting is another feature of the SmartPoint which illustrates the intelligence. Dynamic Event Reporting allows the user to define business rules that defines the behaviour of a specific SmartPoint. The user can set business rules to make the SmartPoint aware of its context. For example determining the location and compare this with a geographical zone. When the SmartPoint moves out of this zone an alert message is automatically triggered. The 'management by exception principle' is supported and only relevant business events are reported. This means that the user will only receive a message when something changes instead of receiving messages on a set time interval.

1.3.2. Communication

The communication between the SmartPoint and the ambient infrastructure is based on Carrier Sense Multiple Access (CSMA). This implies that the SmartPoint will always wait for beacons from the MicroRouter before it will send its message. This is in contrast with traditional RFID systems which will send messages at predefined time intervals. Sending a message will only be done when the SmartPoint is in the Ambient network.
The MicroRouter and Gateway both communicate with the SmartPoint by sending beacons en receiving messages. The information from the SmartPoints is passed onto the Gateway by the MicroRouter. In the next section (1.3.4.) the MicroRouter is explained in more detail.

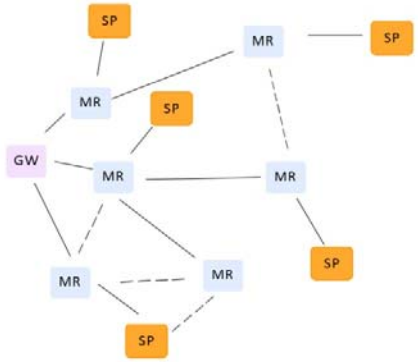


Figure 1-8 The Ambient network

The GateWay (GW) provides the interface to corporate IT systems. The GateWay can also communicate with the SmartPoints nearby. Therefore it is not necessary that the signal is send via the MicroRouter.

Ambient has a user-friendly management console, 'Ambient Studio', to manage the whole system. This PC software is a tool for system integrators and operators to configure, deploy and manage the Ambient network (or even more than one network). Every device in the network runs on its own firmware[1]. In Figure 1-8 Ambient 's network is shown.

1.3.3. ZigBee vs. AmBee

The Ambient network is based on the IEEE 802.15.4 standard. This is a standard that offers the fundamental lower network layers of wireless networks for low cost communication between devices. Some other networks use also the IEEE 802.15.4 standard.

One of these is the ZigBee network. There are some resemblances between the Ambient and ZigBee network, like the 2.4 GHz bandwidth they both operate on. But there are significant differences.
The target market of ZigBee is in contrast with Ambient's target market. ZigBee is more focused on home automation, energy management and building automation. Ambient's focus is mainly on transport and logistics, defence, pharmaceutical, retail, chemical and electronics.

Also the size of the network is different. ZigBee is used for small scale projects and is static. Ambient's network is scalable up to 256 MicroRouters, and therefore more suitable for large scale projects. It is also a dynamic network where SmartPoints automatically can join the network.

The energy consumption is very low for the Ambient network this is in contrast with the mains powered network using ZigBee. The bindings within the network between the SmartPoints and MicroRouters are not fixed and therefore the SmartPoints can be moved easily. The bindings between the endpoint and node of ZigBee are fixed which makes it harder to support moving endpoints.

1.3.4. MicroRouter

The MicroRouter will enable communication with the SmartPoint by sending a beacon messages at regular time intervals. Every time the SmartPoint wants to send a message it will first wait on a beacon message from the MicroRouter.
When the SmartPoint receives multiple messages, from different MicroRouters, it will select a specific MicroRouter based on several parameters such as signal strength.

When this MicroRouter is selected the message containing relevant information will be sent and as response the MicroRouter sends an additional acknowledgement to the SmartPoint (Figure 1-9).
The entire communication between the MicroRouter and SmartPoint takes about 15 milliseconds.

The SmartPoint can find the best MicroRouter to send its message to but the MicroRouter can also find the most efficient way to the GateWay. When a MicroRouter, on the way to the GateWay, is not able to receive messages the MicroRouter itself will find another way to the GateWay.
The MicroRouter is also very energy efficient just like the other network devices. This is done by maximizing their sleep time and therefore increase battery lifetime. For illustration a single light bulb uses more energy than 1000 MicroRouters combined.

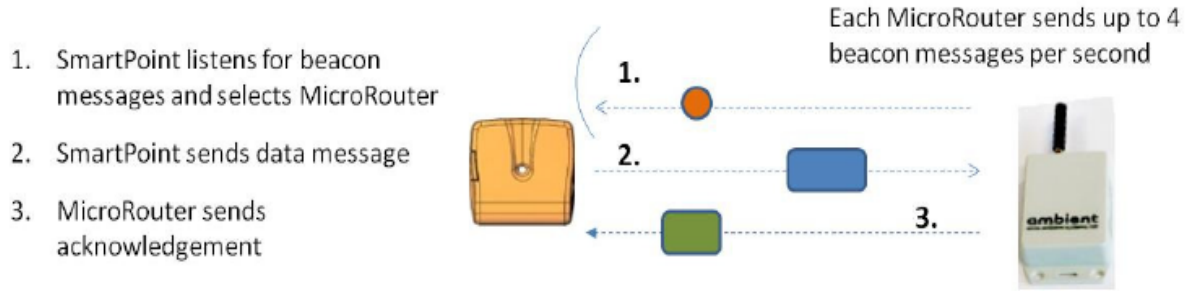


Figure 1-9 Communication between the MicroRouter and SmartPoint

[1] Firmware is the software that runs on the device.

1.3.5. Parts of the MicroRouter

The housing of the MicroRouter is an off-the-shelf box at the moment. Figure 1-10 shows the inside of the MicroRouter.
At the inside of the MicroRouter are two Printed Circuit Boards (PCB's) and a battery pack. It is a pack of three rechargeable AA batteries (Figure 1-10, no. 10).
The antenna is on the top of the MicroRouter. To attach the antenna to the PCB a SMA connector is placed (Figure 1-10, no. 2). This connector connects the external antenna with the internal hardware.
A similar connection is made for the power connector (Figure 1-10, no. 9). This connection is sealed off by a gland (Figure 1-10, no. 8).
On the PCB there are four coloured LEDs (Light Emitting Diodes) which are for visual inspection (Figure 1-10, no. 4).
To protect the components against any radiation they are covered by a shield that can be seen in Figure 1-10, no. 5.
A dip switch makes it possible to adapt some of the MicroRouter settings (Figure 1-10, no. 6).

Some of these parts have a big influence on design of the MicroRouter casing. Some need to be visible or accessible; others determine the shape of the casing because they are relatively large.

The antenna, the power connector, the battery pack, the PCB and the LEDs have the most influence on the casing. Therefore specifications of these components are described and requirements are formulated. This can be found in the appendix chapter 1.1.

1.3.6. Quantity and costs

This year the quantity of MicroRouters was 1500. Next year's expectations are that the quantity will double up to 3000 MicroRouters. This amount is an estimation based on the developments of this year.

The costs of a MicroRouter at the moment are between 65 and 70 euro's. The costs for the casing only are between eight and ten Euros. The other costs are gained by buying components, labelling, licenses, reworking the casing (drilling holes for instance) and labour costs.
The selling price of the MicroRouters at the moment is between 250 and 400 euro's per device.

1	Mounting hole	6	Dip switch
2	SMA connector	7	Mounting PCB
3	Mounting top	8	DC gland
4	LEDs	9	Power connector
5	Metal plate	10	Batteries

Table 1-1 Parts inside the MicroRouter

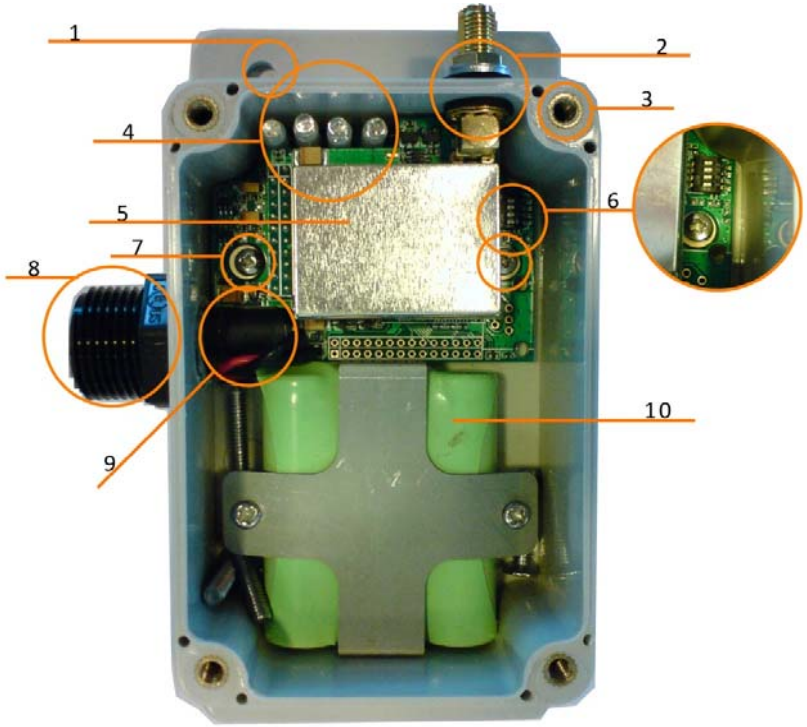


Figure 1-10 The inside of the MicroRouter

1.4. Stakeholders analysis

More than one factor influences the development of the MicroRouter. Not only new technical opportunities and improvements of the MicroRouter can stimulate the development but also the design can do this.
The influences come from the company itself as well as the customers, users and market of the products. Below the most important stakeholders are listed.

List of stakeholders

Internal stakeholders (within the company):	**External Stakeholders**
Sales	Customers
Support	Suppliers
Supply chain management	Channel Partners

Table 1-2 List of stakeholders

Brainstorm session

The company itself is an important stakeholder. They have ideas and goals for the future of their product. Because of the lack of information about the Ambient look and feel a brainstorm session was planned.
Ambient has not got a product line yet. The company does not have a prescribed vision on how their products should look. It is however clear that almost everyone at the company dislikes the current of the shelf enclosure. The question arises: what would the participants and therefore the company like?

The brainstorm session was held with a few employees from ambient. The people who joined are aware of the concerns and they are experts on different disciplines.

The session was divided into four different steps. The first step was mainly for helping the participants getting started in creative thinking. After that the questions were more focused on Ambient and the MicroRouter. The steps (step two, three and four) will answer the following questions:

- *What is the look and feel of Ambient and their product? What is the appearance of the company? How should the Ambient products look according to the employees? (step 1-3)*
- *Why is there a need for a new design? What are the issues at the moment? Are there different requirements needed in case of an ideal MicroRouter compared with the current requirements? (step 4)*

The brainstorm was planned in four steps:

I. **Introduction and warming up:**
After a short introduction, the participants had to place different images in a diagram. On the x- and y-axis were the terms ugly (unattractive) versus beautiful placed and functional versus non functional.

II. **Filling in the axis for Ambient:**
After they filled in the diagram with images the participants were asked to place the products of Ambient in the same diagram.

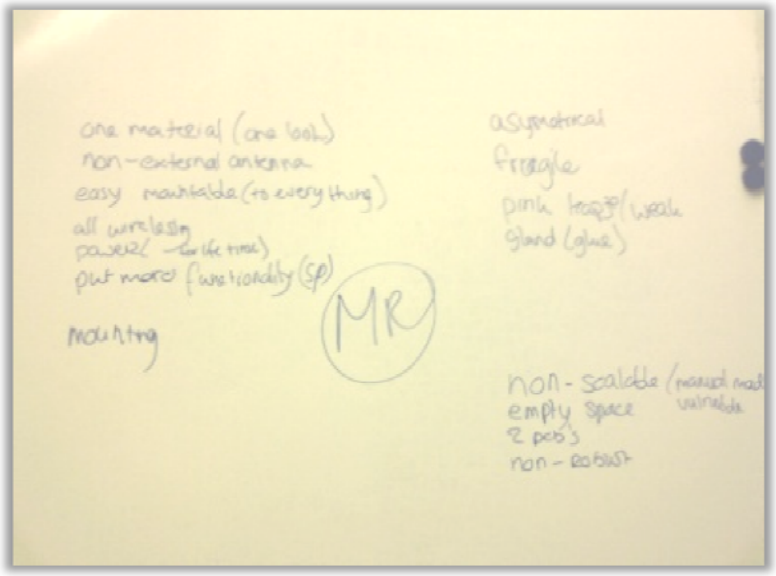
III. **Imagining an ideal situation:**
Here they had to think about where to place their products in an ideal situation. Where would that be and would that be different comparing it to the previous step? What are the similarities with the surrounding images? What needs to be changed to the current products to match the ideal images?

IV. **Future perspective:**
When you look at a next generation of Ambient products in the cold chain (this will be explained later on in chapter 1.5) and all wireless market. What functions should an ideal MicroRouter have? What are the flaws at the moment and what is needed to solve this? During this part of the brainstorm every participant was given a different role than they usually have. This means that the marketing person gets an engineering role, the engineer gets a marketing role, and the others were given a visionary and pessimistic perspective.

Results

From the brainstorm can be concluded that the participants see a more professional, cleaner looking product to represent the look and feel of Ambient. They refer to the SmartPoint which is already designed and is generally liked. This casing is especially made for the SmartPoint in contrast with the off the shelf boxes for the other devices. For the MicroRouter they also like to see a robust and designed product.
It was noticed that the size of the MicroRouter may refer to the important and central role it has within the network. It is preferred that some of the Ambient Systems' colours will be visible on the casing.

The conclusion is that the MicroRouter needs to be redesigned, especially the casing.
Most of the critical points are related to the off the shelf box. This casing is causing many problems for the different users of the MicroRouter, from the production up to the end-user. With a new enclosure all users should be taken into account.
The device should be watertight and the fragile antenna needs to be supported.



In the future perspective there is thought of several changes. For instance changing the two PCB's to one PCB and using larger batteries to be able to make the network wireless. These points are consistent with earlier findings.
An extended report on the brainstorm can be found in appendix chapter three.

Internal stakeholders

There can be concluded that the different departments have different wishes.
Overall Ambient would like a new design which is cost-effective and has improved functionality. They would like a design which can be implemented in short term. In this case the design should be suitable for the currently used electronics.
Initially the production of the MicroRouter will be small and manually performed. This process has to be made as easy as possible. This is in the interest of the production department.

A well designed product will be more representative for the company and their other products. Although in this case the interest of the consumers is focused on the technology. This is an important issue for the sales and marketing department.

The visuals and first impressions of the device will be more important in the prospect of direct sales. A more representative design can help compete with other models on the market. This way Ambient's marketing position can be strengthened.

The current promotion of the network is visualised by the SmartPoint. A network without the GateWay and the MicroRouter is not a functional network. In the future, when all products have a unique design, the whole network can be promoted. The consumer gets a better idea about Ambient and their network products. Using the same design features for all products the product range can be unified.

The sales department would like an attractive, easy to sell product which is cheap to make and has interesting margins.

The support department would like a reliable, durable and low-maintenance product. Finally the supply chain management wants to ensure the product is easy to make, and that little resources and time are required.

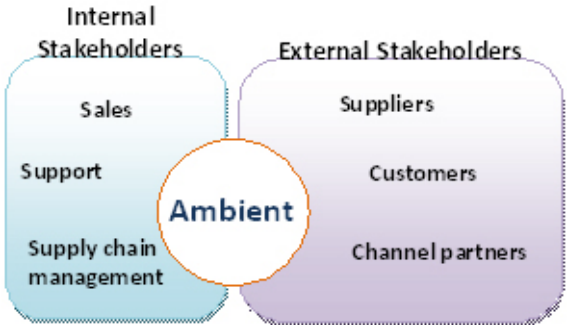


Figure 1-13 Stakeholders

External stakeholders

The MicroRouter should be easy to install for mechanics when it is mounted before use. The more time this will cost the more money is lost.
The product needs to be produced that means that the production of the casing and the supply of parts depend on suppliers. With the production the possibilities of manufacturing of the supplier should be taken in account.

The customers are important stakeholders. The MicroRouter should be reliable, clean and should be able to withstand the different rough environments.
A company depends on their market and therefore their consumers. The product should be appealing and functional to encourage the sale. When there is no sale, there will be no profit.

Investors will also have interest in a new design because of the growth opportunities of the company. A company growth increases the profit.
Ambient cooperates with several channel partners, which sell the Ambient products. When Ambient offers a better looking and functioning design they increase profit. Furthermore the cooperation will be strengthened. Figure 1-13 shows the stakeholders.

1.5. Market Analysis

Until now Ambient has had different international projects over the years. As mentioned before for instance a network to monitor water in the Great Barrier Reef. This was a special project using the product series 800.
The other projects that have been done are all in the categories, food and retail, Pharma (pharmaceutics) en healthcare, transport and logistics and environmental monitoring. In the future Ambient Systems wants to focus only on two categories, the 'cold chain' market and the 'all wireless sensor network'.
With the introduction of the third generation active RFID, they entered a large market. They had to compete with many competitors offering similar products. The name 'third generation active RFID' will no longer be used, so they compete with fewer companies in that niche.

1.5.1. Current markets

In food and retail is it about improving process efficiency and customer service, particularly to ensure food safety and optimize the food supply chain.

In the Pharma and Healthcare categories Ambient offers services to improve environments and organisation of assets and help to ensure the quality of different assets. Ambient works with both pharmaceutical companies and hospitals.
The third generation active RFID and RTLS helps making the supply chain visible on a new level. This is the approach for category transport and logistics. With the Ambient product series companies can monitor and track their products and stay aware of problems. This helps improving the quality and efficiency of their business process.

Besides these markets other projects have been executed. The network can be used outdoors what makes it possible to monitor the natural environment. To improve the environmental quality control temperature and humidity can be monitored. Most of these projects are in cooperation with channel partners.

Figure 1-15 Quality and safety for medicine

1.5.2. Cold chain

Ambient Systems already works within the cold chain for two years now. In the future they want to grow in this market. In this market companies are dealing with climate-sensitive products.
This is a so called temperature–controlled supply chain. An unbroken cold chain is an interrupted series of storage and distribution activities which maintain a given temperature range. This is to help proper preservation and extend and ensure the shelf life of the products.
The main participants on this market are pharmaceutical and food industries. Products in these industries are medicine (Figure 1-15) and agriculture products (Figure 1-14).

To ensure the safety in the food sector hygiene is a very important issue.
Therefore rules were set up to this. One of these rules is HACCP were Ambient needs to cope with. This is short for Hazard Analysis and Critical Control Points.
The rule states that all companies which are dealing with the preparation, processing, treatment, packaging, distribution and transport of victuals should analyse all aspects of their processing, and analyse the risks (Microbiologic-, chemical- and physical dangers).
The European Union wants reduce the risk of infection with this process control. Continuous checking and reporting of fridges and freezer installations is needed if this rule is applied.

In this market Ambient wants to increase the direct sales. This means that the sales will not be done by channel partners but by Ambient itself. Ambient will provide an end-user application. The contact between Ambient Systems and the potential companies is direct and the focus will shift more to the products. Therefore the design of the product will be of greater importance.

1.5.3. All Wireless

For the ‘all wireless sensor networks’ category the market is not set. In the past few years Ambient was confronted with a need for this type of sensor network in different projects. Such as a project where many gas pipelines were transported to Russia. These pipelines are very sensitive therefore they had to be transported and stored under special conditions. This project needs a registration of the location of the pipes but also information on the environmental conditions where the pipes are in.

Now they want to take this opportunity. With the 'all wireless sensor networks' the company focuses on big projects via partners which are already in various niches.
The key focus of these projects will be the technology. The low power infrastructure allows the network to run on only batteries or solar energy.

There can be concluded that the consumers needs a reliable product which they can trust. A hygienic easy-to-clean product will appeal in a proper hospital environment as well in an environment of a supermarket. For transport of products the MicroRouter should be robust so it will survive a rough transport and still be reliable. The MicroRouter can be used in and outdoors which will affect the rate of protection against external influences.

1.6. Environmental analysis

The device is used in different surroundings, both in- and outdoors. Therefore the MicroRouter should be capable of protecting the components under various conditions. One of these conditions is the temperature.
The device is meant for surroundings with a high temperature as well as surroundings with a temperature far below zero. Low temperatures are used in for example a freezer in a restaurant, where the temperature is around minus twenty degrees. There is chosen for a wide temperature range for the casing of the MicroRouter, from minus forty (-40) to plus eighty (80) degrees Celsius. This will mainly affect the material of the casing. To illustrate the different environment which the devices are used see the collage (Figure 1-16, and the appendix chapter 1.2.2.).

Another factor is the protection of the components by the casing against moisture and dust. The protection is expressed in an IP-code (International Protection rating) that classifies the degree of protection provided against intrusion of solid objects, dust, accidental contact, and water in electrical enclosures. This is defined in the international standard IEC 60529. The code helps defining how for example 'waterproof' or 'dustproof' the enclosure is.

The code is build up from the letters IP followed by two digits. Next to the two digits an additional letter can be placed. Each digit corresponds with a set condition.
The first digit indicates the level of protection that the enclosure provides against access to hazardous parts (e.g. electrical conductors, moving parts) and the penetration of solid foreign objects.
The second digit indicates the protection of the equipment inside the enclosure against harmful penetration of water.

Figure 1-16 Collage Environments

The IP-code at the moment is IP65, which indicates the following:
The six indicates the object is dust tight, meaning there is no penetration of dust.
The five indicates the objects are protected against water jets. This means that water projected by a nozzle against the enclosure from any direction will have no harmful effects.
In the future the company would like to see this IP-code improved up to an IP-67 code. The seven indicates that the enclosure is protected against immersion up to one meter. When the enclosure is immersed in water, up to one meter and under defined conditions of pressure and time, the ingress of a harmful amount of water should not be possible. There can be concluded that the most important requirements for the casing are:
* Various temperatures, -40˚C to +85˚C
* Humidity (0 – 100 % Relative Humidity) and dust, IP65

1.7. Competitors

1.7.1. Overview

Until recently Ambient used the term 'third generation active RFID'. This term is not unique and is also used by other companies. Often the term is incorrectly interpreted and too often associated with previous generations of active RFID. This not only causes confusion but also more competition.
In the future Ambient will no longer use the term 'third generation active RFID'. This will stop the confusion among the consumers. The technological mismatch will no longer be a problem and it gives Ambient a market to focus on. Dynamic wireless sensor network is at the moment the preferred name.

Another competition arises from the RTLS possibility of the sensor network. RTLS has been used longer than the third generation RFID. RTLS can be used for many purposes and the market is still growing. More companies see RTLS as a way to keep an eye on their assets. Companies can track their assets at any time. This makes it harder to lose assets and, for example, it can make their process more efficient.
The future prospect of RTLS within Ambient is that it will not be offered directly. This means less direct competition with other companies in the RTLS business.

As mentioned earlier, Ambient will focus on the cold chain market. This is one of the largest markets in the world. There are many different companies involved in the cold chain market, like companies which distribute products but also companies which monitor the cold chain. Despite the competition in this broad market there is an opportunity for Ambient to establish its name and grow.

Ambient Systems has an idea who their direct competitors are. Important competitors are Sensitech, Aeroscout, Wisensys, Rmoni and Dyzle. These are illustrated in collages in the appendix (chapter 1.2.3.).

Aeroscout

Aeroscout is an American company that has a wireless sensor network comparable to the network of Ambient. They also use active RFID, sensors and RTLS to monitor assets. The company is most active in the RTLS market.
In the future Ambient will take a step back from this market as was mentioned before.
Aeroscout has its main business in the healthcare sector, for example asset tracking in hospitals.
The Areoscout network does differ from the Ambient network. It is based on another IEEE standard than Ambient's network. Aeroscout uses IEEE 802.11 standards or Wi-Fi (Wireless Fidelity) for a more user-oriented network. Ambient is using the IEEE 802.15.4 standard. That was designed for low–cost communication between devices.

Wisensys

A Dutch company named Wisensys is also a competitor. This company also offers wireless sensor network solutions. The most important difference is that it is a fixed network, in contrast with Ambient's network which is dynamic. The sensor points in the network are not moving and furthermore the network operates on another frequency than Ambient.

Rmoni

Rmoni is a Belgium company that offers wireless network solutions like Ambient. They offer solutions in hardware and software to make a network. The company uses the ZigBee network for connecting the appliances. The ZigBee network is compared to Ambient's network in chapter 1.3.3. This company's focus is on farming, pharma (pharmaceutics), food and facilities. They monitor different assets with different sorts of sensors.

Dyzle

A former customer of Ambient Systems is Dyzle. They wanted complete control of their products and are now selling their own products. These products are just like the Ambient products. Dyzle focuses on healthcare, food and retail, transport and logistics, machine and equipment, energy and environment, government and public services. They focus on locating and monitoring assets, mainly temperature monitoring. The difference with Ambient is the market segment. Although they are both in the cold chain market, Ambient focuses more on larger projects than Dyzle. Ambient and Dyzle are one of the few companies that offer a sensor network system.

Sensitech

The major competitor at this moment is the market leader Sensitech. They provide instruments, information and analyses for cold chain monitoring to various clients in the food-, foodservice- and life science industry.

The focus of Sensitech is on measuring and monitoring humidity and temperature around goods. For important in-transit applications they have a wide range of products. With Ambient's focus on the cold chain market they have to compete with Sensitech. The difference between the Ambient system and Sensitech system is based on the frequency that is used. Sensitech uses four channels within the 900 MHz band or the 868MHz band.

The combination of the various possibilities of the Ambient network provide a unique network system. These combinations create unique selling points that differentiate the network from other companies (Table 1-3).

The unique selling points	
Low costs	Due to low hardware cost, ease of installation and low energy usage. Total costs are estimated on a quarter of the traditional active and RTLS solutions
Easy to install	Only the GateWay and MicroRouter are main powered. The whole network could work on batteries (until now on a short period of time).
Large scale networks	The network is suitable for large scale networks (many SmartPoints and MicroRouters per GateWay).
Self organizing	The network setup is completely automated. MicroRouters and SmartPoints are automatically recognized when they join the network. This means the network can be used in dynamic environments.
Self locating	RTLS is done by the SmartPoint itself so no engine is needed. The SmartPoint can determine its own location within the network.
Dynamic event reporting	SmartPoints can define relevant information based on sophisticated user-determined business rules.
Sensors	All SmartPoints have an integrated temperature sensor, but can easily be extended with other sensors.
Storage of information	All devices have the capability to store information up to 1Mb.
Robust and secure data communication	The network includes different mechanisms to ensure reliable data communication
Low network traffic	The SmartPoints selects relevant information and only forwards this specific information

Table 1-3 Unique selling points

1.7.2. Analysis of the casing of others companies

If the exterior of the device is more attractive it becomes easier to sell. This is the added value of the design. Looking at the products of the competition it can be seen that most products do not differ much from the Ambient products.

See also collage III in the appendix chapter 2.3.

Dyzle has the most stylish design of the mentioned competitors. Their network products have a smooth exterior in black and white. All components of the product are on the inside. Therefore the products look clean. Aeroscout uses product casings which are more sturdy looking. Although functionality is the first priority, the products look simple and good.

Also Sensitech has functional and robust looking devices (Figure 1-18).
Rmoni has clearly one recognizable line in their products. All devices have quite the same appearance. Again these boxes are more inspired on functionality than on styling.
The products of Wisensys are the most simple and industrial looking of all. The casings look like 'off the shelf boxes' like Ambient has at the moment. Looking at all products it can be said that Dyzle focuses the most on appearance and design. The focus of Wisensys is not on the appearance but on the functionality. It has to be considered that the market of these products is not the 'normal' consumer market. It is more specified to the industrial-businesses. This will influence the look of the product.

The internet routers (appendix chapter 1.2.4., collage IV) do not look that different from the sensor network devices. Almost all routers are angular shaped boxes, with or without antennas and one is even shinier than the other (internet router see Figure 1-17).

Figure 1-17 Sitecom router

Figure 1-18 Senitech products

1.8. Results

Conclusions can be drawn from the made analyses on Ambient Systems and their products. The functioning and the purpose of their devices became clear. The MicroRouter fills in an important role in the network. By analyzing all parts of the MicroRouter the specific requirements per part were pointed out. This all to make sure the router is functional and can operate well.
Demands and wishes of the company and others emerged from the analysis of the stakeholders. The overall ideas about the look and feel also became clear. The result should match the company profile and should be better producible and salable. Future markets will influence the future design. By analyzing these markets the device can be adapted to specific requirements. The different environments also set requirements for the protection and durability of the device. Eventually the product will be marketed and therefore the company must be aware of its competition. By analyzing the main competitors there can be said that most professional, clean looking products will fit in this market. The analyses that are done result in requirements for the MicroRouter design. These requirements are listed in the next chapter (see chapter 2.1).

2. Concepts

The conclusions from chapter are translated to a list of requirements. These requirements help developing a MicroRouter concept (chapter 2.1).
Before the concepts are made important issues of the MicroRouter were analysed. This resulted in a morphological analyses were various solution are listed (chapter 2.2). These solutions help creating new ideas for the MicroRouter. Design possibilities have been explored with sketching (chapter 2.3). The first concepts that followed were combination of the morphological analysis and the sketched ideas. These concepts were used in a survey to gain more input on the design from Ambient (survey chapter 2.4). Dimensions for a new PCB need to be taken in account for designing two future designs. Therefore two options are created (chapter 2.5). All information was taken into account when creating four final concepts (chapter 2.6). Two concepts with the current components and two concepts for a future design. These concepts are reviewed based on the requirements in chapter 1.1.

2.1. Requirements

Below the requirements gathered from the analyses are listed. These requirements need to be followed to achieve a new functional design for the MicroRouter.
Not all requirements have the same importance and therefore a number is placed before the requirements (column two in the table). This number indicates the importance of the requirement. Most important are rated with 1 and the least important with 5.

To make clear where the requirements are the gathered from the source is written down behind the requirement (column 4 of the table).

Requirements list

Antenna:	**3**	Enclosure may not influence the connectivity of the antenna	MR part analysis
	2	The antenna needs to be placed vertically in or on the enclosure for best connectivity	MR part analysis
	4	The range and strength of the signal should be maintained.	MR part analysis
	1	The antenna should be protected from external influences	MR part analysis/ Environmental
	3	The antenna should be stabilized/ supported	MR part analysis
	3	The antenna should not be blocked and should be	MR part analysis
Power connector	**1**	The connection should be watertight	Environmental analysis
	3	The connection should have enough strength(when there is pulled on the cord it may not come	MR part analysis
	3	Logical orientation of the power connector	Brainstorm

Batteries:	1	There should be room for the battery pack	MR part analysis
	2	The battery pack should cope with vibration	Market analysis
LEDs:	3	Four LEDs	MR part analysis
	1	Should not be blocked by anything (e.g. casing)	MR part analysis
	2	Visible from a height	MR part analysis
	4	Visible in a dirty environment	MR part analysis
	3	Visible when it hangs in a room full of lights	Environmental analysis
PCB:	1	PCB needs to be supported	MR part analysis
	2	Protection of the PCB	MR part analysis
	3	A standard PCB should fit in (in a future redesign)	Brainstorm and MR part analysis
	1	The PCB should be reachable	Brainstorm
Labelling:	2	The label should be put on a flat surface	MR part analysis
	2	A standard sized thermal label should be used	MR part analysis, environmental
	4	A mark should be placed to locate the power connection and antenna (on casing or label)	MR part analysis
	2	Should be visible at all times regarding the serial- and model number	MR part analysis
Design:	1	All current components should fit in	MR part analysis
	4	Extra space for adjustments, e.g. the PCB	MR part analysis
	2	It should be easily mounted on for example a wall	Stakeholder analysis
	1	It should be opened and properly reclosed/ resealed	Stakeholder, environmental
	2	Ambient logo or private label should be visible	MR part analysis
	1	Fit in with the other devices in the product series 3000	Analysis of company
	4	Not being inferior to products from others	Competitor analysis
	3	Look and being reliable	Market analysis
	4	The colour should be adaptable for private labelling	MR part analysis

Conditions:	1	Various temperatures, -40˚C to +85˚C	Environmental analysis
	1	Humidity (0 – 100 % RH) and dust, IP65	Environmental analysis
	1	Easy to clean	Market analysis
	1	Sturdy, should survive a rough trip	Market analysis

'Nice to have' requirements MicroRouter

Batteries:	* Room for larger batteries, C-cell (3x) or D-cell (2x)	Market analysis
Other:	* IP67 casing	Analysis of company

1.1.1. Requirements labeling (information that should be on):

* CE mark, Conformité Européenne
* RoHS mark
* Power en antenna input/output, if not put on the casing itself
* IP 65
* Barcode
* Serial number
* Model number
* Easy to read

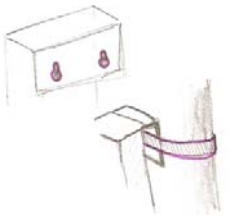
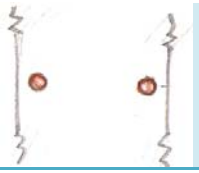
Sizes current components:

PCB:		* Radio board:	25mm (width) x 39,5mm (length) x 17,5mm (height)
		* Carrier board	59mm (w) x 41,5mm (l) x 14,5mm (h)
		* Total area of the PCB	3436 mm^2
Batteries:	* Battery pack (3x AA)		3 x 13.5 - 14.5mm (diameter) x 50.5mm (height)
		* C-cell battery (3x)	25.5 mm (d) x 50.0mm (h)
		* D-cell battery (2x)	32.2mm (d) x 61.5mm (h)
Antenna:	* Swivel Antenna,	SubMiniature version A (SMA) Connector	
		* 110mm (l) x 8.5mm (Ø)	
Label:		* 76,2 (mm) x 48 (mm)	
		* Thermal transfer Labels	

2.2. Morphological analysis

Important issues on the MicroRouter are the mounting, LEDs, closing/sealing and the antenna- and power connection. Before concepts can be created there must be thought of possible solutions. The different closing options, for example, need to make the device watertight, IP65. Different aspects of the created options are viewed. The practical aspects as sturdiness of the solution, tools and actions that need to be performed listed. Furthermore the costs and look of the solutions are viewed. This is all combined and can be found in the tables on the next pages.

2.2.1. Mounting systems:

	Pro's	Con's	
1. Hook (with screwing holes)	- **Quick** mounting (one tool and two screws or one belt) - **Ability** to mount this device in two different ways (with screw or belt) - **Easy** mountable on poles	- **Hook** sticks out - **Less** stability - **Additional** belt is needed (extra part) - **Taking** de device of the wall takes time (in case of screw mounting)	
2. External holes (for screws)	- **Sturdy** mounting - **Quick** mounting (one tool is needed and screws)	- **Taking** de device of the wall takes time - **Not** good looking (screws are visible)	
3. Internal holes (for screws)	- **Sturdy** mounting - **Invisible** mounting - **Quick** mounting (one tool and screws)	- **Taking** de device of the wall takes time	

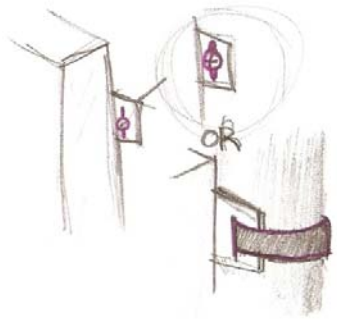
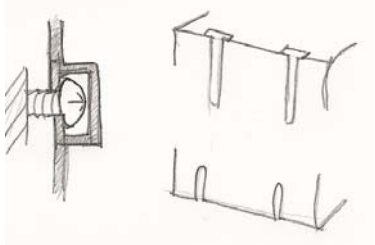
4. Hanging on screw Error! Reference source not found.	- **Quick** mounting (one tool and screws) - **Invisible** mounting - **Device** can be taken of the wall easily	- **Screws** need to be mounted in advance	
5. One hole for screw and belt	- **One** hole for all - **Quick** mounting (one tool and screws or one belt) - **Easy** mountable on poles	- **Screws** or belt are visible - **Additional** belt is needed (extra part)	
6. Slots for screws	- **Quick** mounting (one tool and screws) - **Invisible** mounting - **Device** can be taken of the wall easily	- **More** difficult to injection mould - **Screws** need to be mounted in advance	
7. Glue	- **Sturdy** mounting - **Quick** mounting (only glue is needed, but is not quick when the glue does not dry fast)	- **Device** cannot be taken of the wall - **Enough** surface to put glue on - **Durability** of the mounting is questionable	
8. Magnets	- **Mountable** to metal surfaces - **Easy** to add as mounting possibility - **Quick** mounting (only magnet is needed and hangs itself)	- **Only** suitable for metal surfaces (limited option) - **Magnet** needs to be mounted on the device in advance	

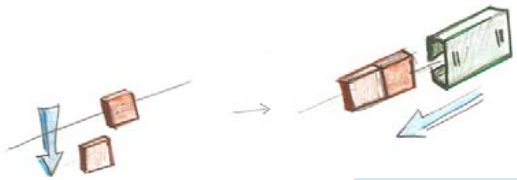
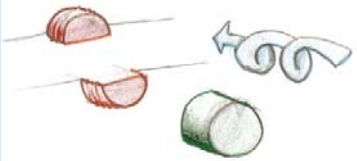
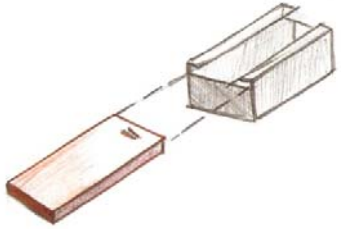
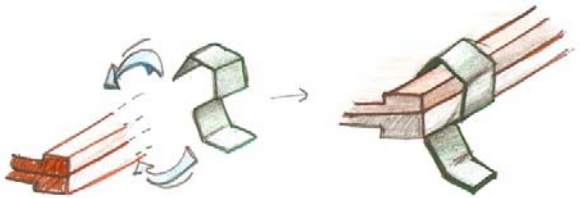
Table 2-1 Mounting systems

2.2.2. LED options:

	Pro's	Con's	
1. Thin casing (light is shines through)	- **One** material can be used - **Only** LEDs are visible	- **Not** all material colours will let Light (from LEDs) trough - **Not** suitable for all materials	
2. Edge with light	- **Subtle** light source	- **Strip** of another material should fit in the casing (during production) - **Adding** a additional part will increase the costs	
3. Glowing casing	- **Light** is visible (entire casing glows) - **Can** be seen as special feature	- **Entire** casing should be (semi) transparent. - **Not** all material are suitable - **Not** all colours are suitable	
4. Only LED transparent	- **Good** LED visibility - **Components** are not visible	- **Extra** part is needed (of different material - **Part** needs to be mounted in (costs increase)	
5. Whole top is transparent	- **Good** LED visibility - **Visible** from many perspectives	- **All** components in the MicroRouter are visible - **No** unity (top and rest of the casing are different materials)	

Table 2-2 LED options

2.2.3. Closing options:

	Pro's	Con's	
1. Screw top on	- **Tight** and sturdy - **No** extra parts (no screws e.g.) - **No** tools are needed	- **Shape** is determined (otherwise you cannot screw, round shape)	
2. Slide part to close Error! Reference source not found.	- **Simple** operation - **Quick** closing (one action)	- **Extra** part is needed - **Watertightness** of the device is questionable	
3. Rotate part to close	- **Simple** operation - **Quick** closing (one action) - **Sturdy** connection - **No** tools are needed	- **Extra** part is needed - **Watertightness** of the device is questionable	
4. Slide top on	- **Simple** operation - **Quick** closing (one action) - **No** extra parts (no screws e.g.) - **No** tools are needed	- **Watertightness** of the device is questionable	
5. 'Weck pot' mechanism (clamping)	- **Simple** operation - **No** tools needed	- **Extra** parts are needed - **Sturdiness** is questionable (over time) - **Watertightness** of the device is questionable	

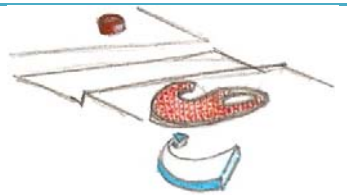
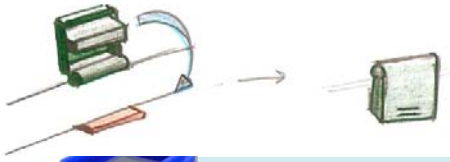
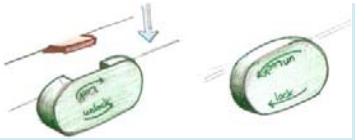
6. Hook	- **Simple** operation - **Quick** closing - **No** extra parts - **No** tools needed	- **Watertightness** of the device is questionable - **Strength** of the connection is questionable (will it open to easily?) - **Extra** actions during production (part need to be attached) - **Attaching** part increase cost	
7. Latch (clipping)	- **No** extra parts - **Sturdy** connection - **Proven** functionality - **Quick** closing (one action) - **No** tools needed	- **Not** good looking - **Extra** actions during production (part need to be attached) - **Attaching** part increase cost	 
8. Latch	- **Easy** to close - **Quick** closing (one action) - **No** extra parts - **No** tools needed	- **Connection** becomes too loose after a wile - **Hard** to open - **Reliability** of sealing decreases over time	
9. Locking by rotation	- **Easy** to close - **Quick** closing - **No** tools needed	- **Rotating** part is relatively big - **Extra** actions during production (part need to be attached) - **Attaching** part increase cost	

Table 2-3 Closing options

2.2.4. Antenna options:

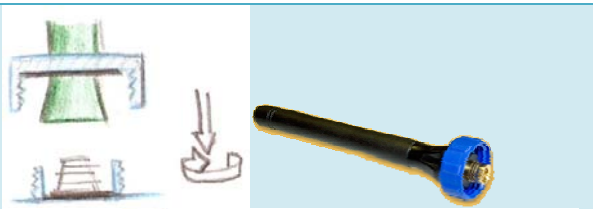
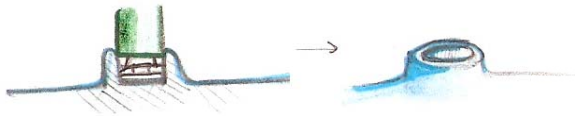
	Pro's	Con's	
1. Seal antenna with screwed on cap	- **No** metal can be seen - **Antenna** is strengthened	- **Extra** actions during production (part need to be attached) - **Attaching** part (to screw cap on)increase cost	
2. Make flange around the antenna	- **No** metal can be seen - **Nice** shaped - **Fits** to casing - **No** extra parts are needed	- **Antenna** is still fragile	
3. Lower the screw-thread	- **No** metal seen - **No** adjustments need to be made to the casing	- **More** difficult to seal - **Antenna** is still fragile	
4. Sticking it out (like current MR)	- **No** adjustments need to be made to the casing	- **Metal** can be seen - **Difficult** to seal - **Antenna** still fragile - **Does** not look nice	
5. Lower the casing near the antenna	- **No** metal can be seen - No adjustments need to be made toe the casing	- **Difficult** to seal - **Antenna** still fragile	
6. Antenna inside the casing	- **Antenna** is not visible - **Antenna** is protected - **More** easy to seal	- **The** size of the casing increases	

Table 2-4 Antenna options

2.2.5. **Antenna** (for the new PCB)

For a new design another antenna can be used. There are at least two options for the antenna. The first option is a small block antenna which can be mounted on the PCB. The other option is a antenna with a small cylinder. Further antenna specifications can be found in the datasheets in appendix chapter 2.2., antenna.

	Pro's	Con's	
1. Current swivel antenna	- **Bendable** - F**unctionality** is proven	- **Long** - **Fragile** (needs to be carefully protected)	
2. Antenna (new) cylinder	- **Small** - E**asy** to protect	- **Functionality** for the MicroRouter needs to be tested	
3. Antenna (new) block Error! Reference source not found.	- **Small** - **Easy** to protect	**- Functionality** for the MicroRouter needs to be tested	

Table 2-5 Antenna options

2.2.6. Power connector:

	Pro's	Con's	
1. Through hole in casing seal with rubber	- **No** glands are sticking out	- **Large** edge is needed (this is needed for the sealing) - **Cable** needs to be put in place (every time the casing is opened)	
2. Use a smaller cable gland (wired directly on to the PCB).	- **Small** gland (compared to current) - **Less** visible - **Watertight** - **Quick** mounting (one tool maybe needed to tighten the connection) - **Sturdy**	- **Cable** cannot be plugged out (in case of the current power connection) - **Hole** needs to be made in the casing	
3. Watertight cable gland (mounted on casing)	- **Watertight** - **'Relatively'** good looking - **Simple** in use - **Quick** mounting (only tool to tighten the connection is needed) - **Sturdy**	- **Components** are expensive - **Hole** needs to be made in the casing	

4. Klikseal	- **Watertight** - **Easy** to assemble - **No** tools are needed	- **Cable** cannot be plugged out (is attached to the PCB) - **Hole** needs to be made in the casing (during production)	
5. Rutaseal	- **Watertight** - **Easy** to assemble	- **Cable** cannot be plugged out (is attached to the PCB) - **Hole** needs to be made in the casing (during production)	
5. Use current cable gland	- **Quick** mounting (one tool maybe needed to tighten the connection) - **Cable** can be plugged in and out - **Sturdy**	- **Gland** sticking out - **Hard** to make watertight (in case of modification, as in current use) - **Hole** needs to be made in the casing	

Table 2-6 Power connector

2.2.7. Serial connection:

	Pro's	Con's	
1. Watertight connection (mounted in the casing)	- **Simple** in use - **Watertight** - **Relatively** good looking - **Sturdy**	- **Components** are expensive - **Hole** needs to be made in the casing	
2. Through hole and seal with rubber	- **No** gland is sticking out	- **Large** edge is needed (this is needed for the sealing) - **Cable** needs to be put in place (every time the casing is opened)	
3. Use cable gland	- **Small** gland (compared to current) - **Less** visible - **Watertight** - **Quick** mounting (one tool maybe needed to tighten the connection) - **Sturdy**	- **Cable** cannot be plugged out (in case of the current power connection) - **Hole** needs to be made in the casing	

4. Use big cable glad (as current power connection)	- **Quick** mounting (one tool maybe needed to tighten the connection) - **Cable** can be plugged in and out - **Sturdy**	- **Gland** sticking out - **Hard** to make watertight (in case of modification, as in current use) - **Hole** needs to be made in the casing	
5. Klikseal	- **Watertight** - **Easy** to assemble - **No** tools are needed	- **Cable** cannot be plugged out (is attached to the PCB) - **Hole** needs to be made in the casing	
6. Rutaseal	- **Watertight** - **Easy** to assemble - **No** tools are needed	- **Cable** cannot be plugged out (is attached to the PCB) - **Hole** needs to be made in the casing	

Table 2-7 Serial connection

2.3. Sketching

Different sketches are made to discover possible shapes for a new enclosure. Inspiration is found in different surroundings and existing devices. Simple shapes, straight lines, curved lines and combinations were drawn. In Figure 2-2 some of the sketches are shown.
A product line needs to be formed and the MicroRouter should fit in. Therefore sketches inspired on the SmartPoint were created. Some sketches have the same curves as the SmartPoint or have other recognizable features. The most recognizable features of the SmartPoint are and the rounded corners and the rounded shape and hole in the middle of the device. In combination with the earlier sketching new shapes were drawn. In chapter 2.3.1. of the appendix more sketches are shown.

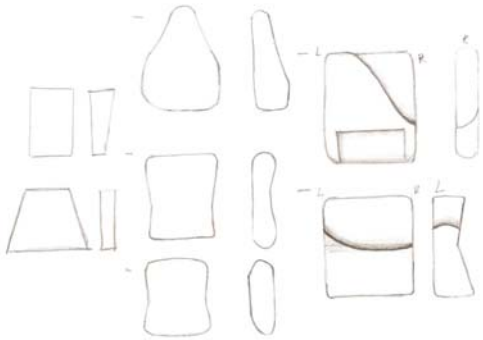


Figure 2-2 Sketches

After the first sketching several ideas for concepts were made. These ideas are based on the options shown in the morphological scheme and the sketched shapes.

There is chosen for various shapes for the concepts. In Figure 2-1 the different ideas are shown. Most shapes have straight lines and are sturdy shapes. This can be related to the current routers on the market. Some of the ideas have more unusual shapes which are partially determined designed around the components inside. Furthermore features and shapes which refer to the current look of the SmartPoint are used.
A shape can support the functionality of the device. This is also shown in a concept. There was chosen for a big variety so there will be a good view on the possibilities for the MicroRouter casing. In chapter 2.3.2. of the appendix some more sketches can be found.

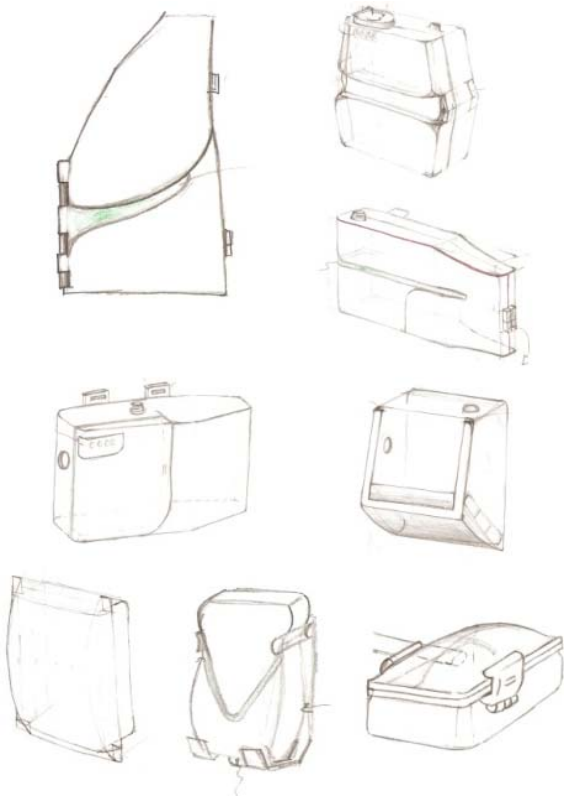


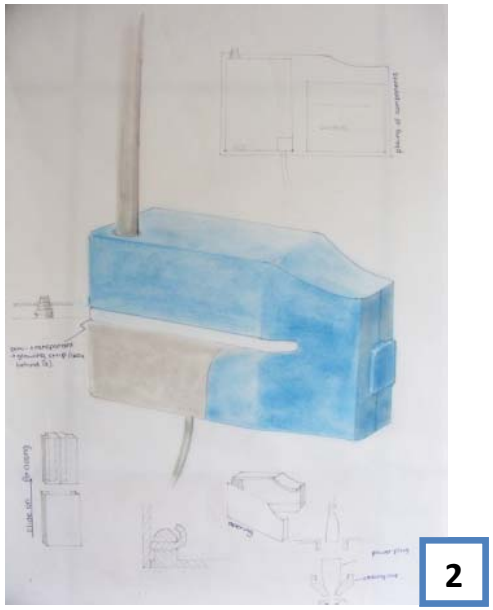
Figure 2-1 Ideas for the concepts

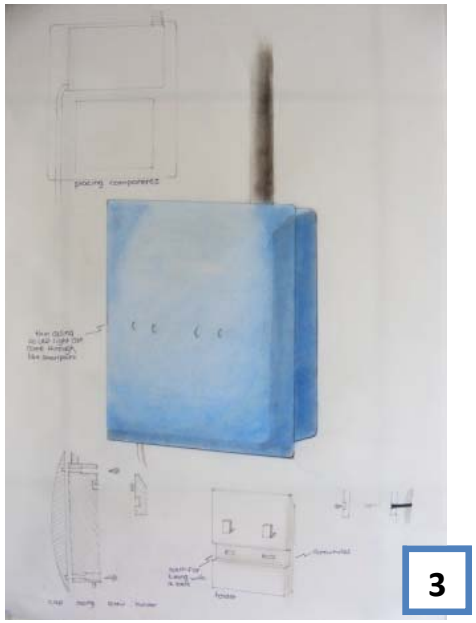
2.4. Survey

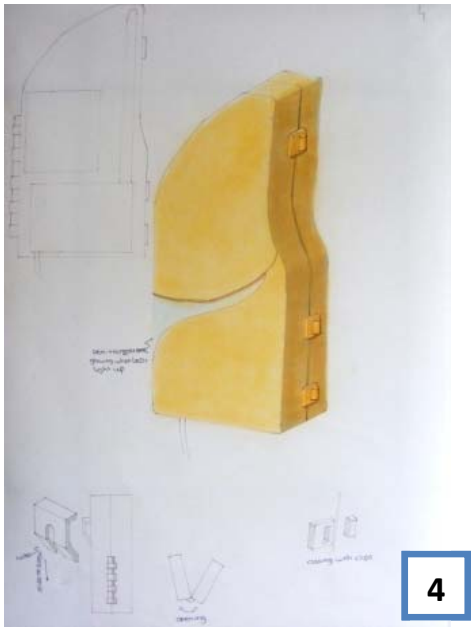
Five ideas for the concepts are chosen. These are chosen because of the various shapes. Number one is a very functional shape and number three looks very simple. The shape of number two and five refer to the SmartPoint. Number four has a quite unusual shape. Furthermore every idea has its own functional features.
The opinion of the Ambient employees about these ideas for the concepts was asked. Presentational drawings (Figure 2-3) of the concepts were presented in the hallway. In a short presentation instructions for the survey were given. For the next ten days the employees could analyse the concepts and hand in their opinion.
Ten employees of Ambient gave their opinion about the five concepts.

The conclusions can be drawn as follows: According to the employees, not all shapes matched with the appearance of Ambient. Most appreciated by its shape is concept number two followed by concept number five. Most of the issues are seen in the closing options. There are doubts about how watertight some ways of closing will be. It became clear that most participants have confidence the closing options of number three. It is also assumed that number three will be the easiest to produce. The yellow colour (the green and orange were also seen as yellow) is not supported by anyone. Positive aspects are the semitransparent LED visibility and placing the antenna inside the enclosure.

Some employees came up with some ideas of their own for the MicroRouter. One mentioned creating a product line by bringing back the shape of the SmartPoint into the MicroRouter. Another idea was to replace the two coloured casing by one colour and put a sticker on it (concept number two).
More on the survey (and larger images) can be found in the appendix chapter 2.4.







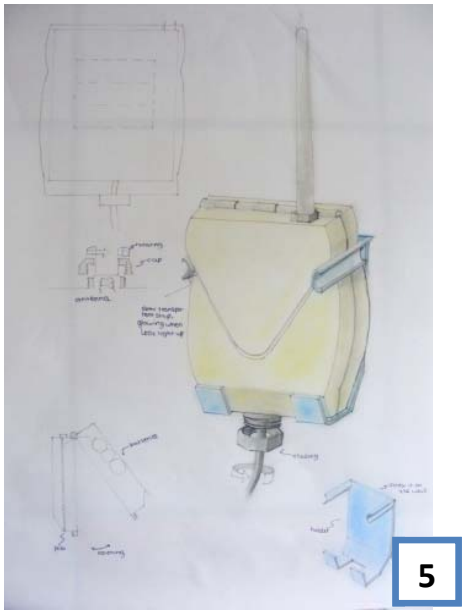


Figure 2-3 Presentational drawings used in the survey

2.5. Orientation and size for new PCB

The PCB is an important basis for the design of the casing. When using the current PCB no changes are made to the dimensions of the PCB and the orientation of the components on the PCB. In case of the new design the dimensions and orientation can be changed. The orientation and dimensions are 'free' as long as the requirements are met. All current components have to fit on the PCB. Therefore the needed space of the current PCB is measured (see requirements chapter 2.1.). The area needed for the new PCB is 3436 mm^2.

Furthermore the requirements are set by the antenna. There needs to be enough distance between the batteries and antenna to ensure good connectivity.

In the list of requirements is mentioned that the batteries need to be supported. This can be done by placing them on the PCB. In this case it would be nice to create enough space for batteries of different dimensions (this can be found in the requirements 'nice to have' list in chapter 2.2.). A conversation with the company's expert on this issue (Eugen Moldovan) resulted in a clear image of the possibilities. After that a few designs were made. Two designs for de PCB are chosen and used for concepts 2-1 and 2-2.

Both PCB designs have enough space for all components. Beneath PCB concept 2-1, batteries can be placed. Different sized batteries can be placed underneath the PCB and will not bulge out.
PCB concept 2-2 holds different battery sizes on the PCB itself. The batteries are placed on the back and at the front all components can be positioned.

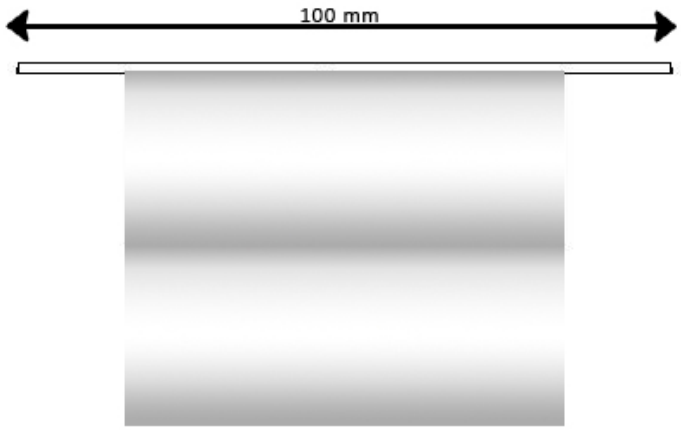


Figure 2-5 Concept 2-1 (100x50 mm)

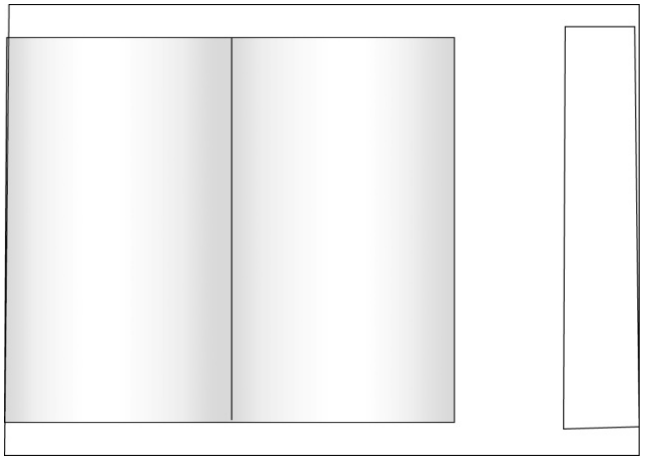


Figure 2-4 Concept 2-2 (100x 70 mm)

2.6. Concept ideas

The survey gave an idea of the preferences by the employees. Together with the brainstorm session a better focus for the design was gathered. After additional sketching and designing, four concepts were made.
The first two concepts are designed for applying the current used PCB. The other two concepts have a whole new PCB (see chapter 2.5).
In both cases an optimal configuration of the PCB and batteries inside the casing is sought. In Figure 2-6 the concepts are shown. Each concept is reviewed and design choices are explained.

2.6.1. Concept 1-1

The first concept is based on the current PCB. The PCB is placed on the back of the casing (see Figure 2-7, no. 3). The batteries are placed below the PCB (*see Figure* 2-7, no. 5). This orientation ensures a flat enclosure.

Antenna (Figure 2-7*, no.2):* The fragile antenna is placed inside the casing. This prevents the antenna from being damaged. It is no problem to make the connection watertight. In the morphological analysis (chapter 2.2, Antenna options) more positive aspects of this solution were mentioned.

Power connection *(Figure* 2-7***,*** *no. 4)*:
There is chosen for the current cable gland that is used for the MicroRouter at this moment (chapter 2.2.6, power connector). Although it is not good looking it is functional. In this new design the gland will be mostly hidden in the casing. To achieve this tubes at both sides of the PCB are made (see also Figure 2-6 no. 3).

Closing: The casing is closed with four screws. These screws will be inserted from behind. Therefore no screws will be visible at the front. This closing option is mentioned in the morphological analysis in chapter 2.2.3, closing options. There is chosen for this option because it is proven that it works and therefore very reliable. A rubber seal is needed on the closing edges to make this closing method watertight.

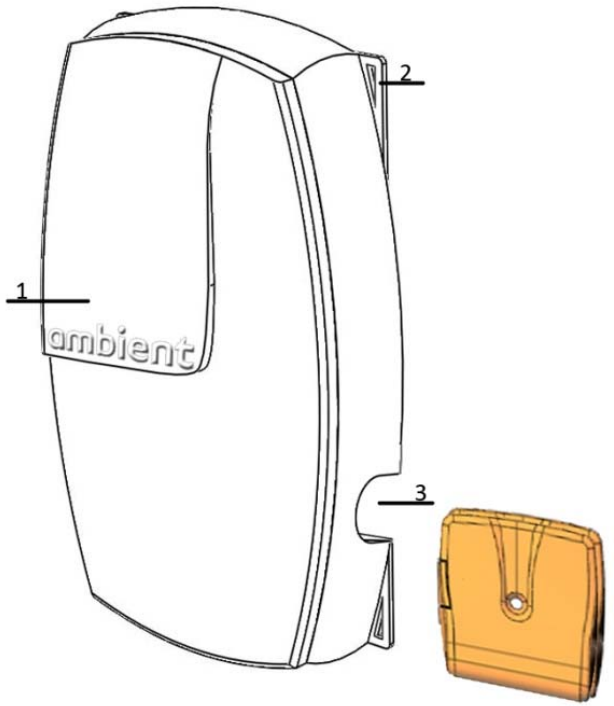


Figure 2-6 Concept 1-1 and the SmartPoint

Mounting *(see* Figure 2-6*, no. 2):* The mounting can be done with screws or a rubber mounting band at the four corners of the casing (chapter 2.2.1, mounting systems).

LED *(see* Figure 2-7*, no. 1):*
The chosen shape is based on the shape of the SmartPoint. The shape at the front of the casing bulges out and will function as a semi-transparent display for the LEDs (Figure 2-7 no. 1). This is done to make sure the LEDs will be visible at all times. This option is a combination of the option three (chapter 2.2.2, LED options) and the choice of making a part semi-transparent instead of the whole top or casing. Figure 2-6 shows the concept and SmartPoint. The dimensions of this concept and other images can be found in the appendix chapter 2.5.2.

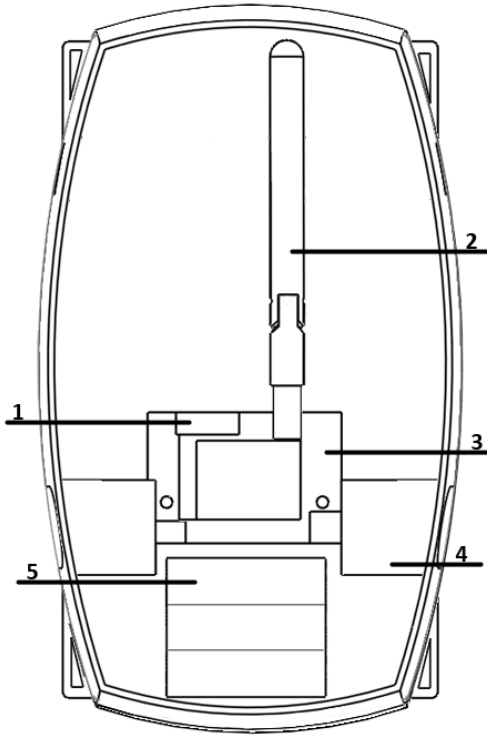


Figure 2-7 inside concept 1-1

Numbers	Parts
1	LEDs
2	Antenna
3	PCB
4	Tube
5	Batteries

Table 2-8 Explaining numbers figure 2-7

2.6.2. Concept 1-2

The second concept is also based on the current PCB and its orientation. The PCB is placed perpendicular on the wall (see Figure 2-9, no. 4). The batteries are placed underneath the board and will be clamped beneath the PCB (Figure 2-9, no. 1). The PCB will be mounted (with screws) on the lower part of the casing.

Antenna *(Figure 2-9, no.6 and , no. 1):* The bending part of the antenna and the connection between the PCB and antenna are protected by the casing. A recess at the front of the casing makes bending the antenna possible. This is in line with lowering the casing near the antenna to protect the antenna. This idea is mentioned in the morphological analysis in chapter 2.2).

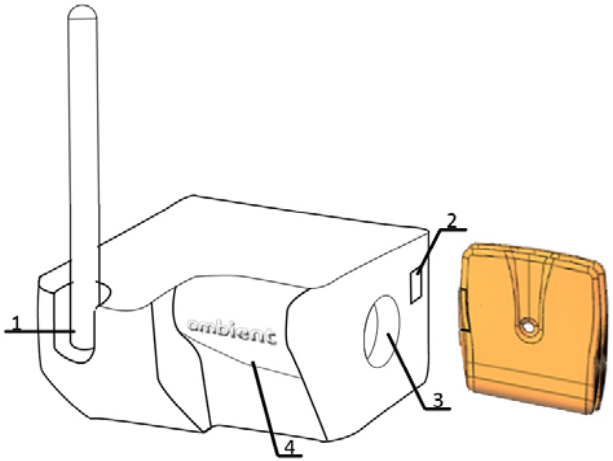


Figure 2-8 Concept 1-2 and the SmartPoint

Power connection *(Figure 2-8 and Figure 2-9, no. 3):*
The power connection is located at the side of the casing. A smaller gland is used and is partially covered by the casing (chapter 2.2.6). There will be less space needed to hide the gland, compared to concept 1-1.

Closing: The top can be mounted from above with four screws. A seal is needed to make the casing watertight (chapter 2.2.3, closing options).

Mounting (*Figure 2-8 and Figure 2-9, no. 2**)**:*
The mounting is done by screws or a strong rubber belt. There is a tube in the back of the casing where a belt can be pulled through. Screws can be mounted in the wall and fit in the holes at the back. This is the combination of options one and four described in the morphological analysis (chapter 2.2.1, mounting systems).

LEDs *(Figure 2-9, no. 5):* The LEDs are visible through semi transparent part of the casing (Figure 2-8, no. 4). This part is rounded and sticks out a bit. When looking from below the lights are still visible.

A top view is shown in Figure 2-9. In the concept is placed beside the SmartPoint. The dimensions of this concept and more images can be found in the appendix chapter 2.5.3.

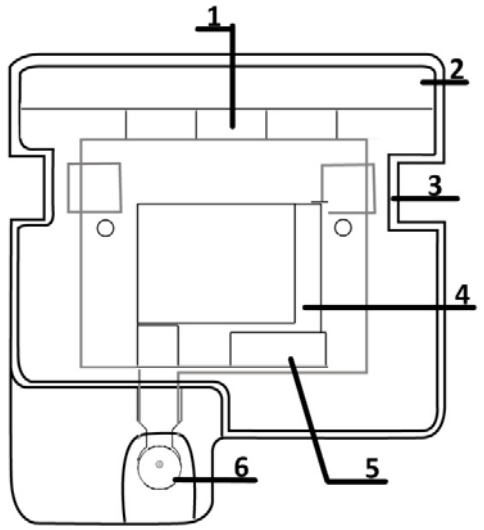


Figure 2-9 The inside of concept 2-1

Numbers	Parts
1	Batteries
2	Mounting tube
3	Tube
4	PCB
5	LEDs
6	Antenna

Table 2-9 Explaining numbers figure 2-9

2.6.3. Concept 2-1

In this design there was chosen for a PCB of one hundred by fifty millimetres. This is based on minimum dimensions for the PCB and space that can be created for the batteries (see chapter 2.5).

The PCB is placed horizontal in the casing *(Figure 2-11*, no. 2). It is held in place by clips which are located at the sides of the casing around the PCB. The PCB can be shoved in. The batteries are placed below the PCB. They are held in place by a plate which is mounted on the back of the casing. Different sized batteries fit in so that the device can be made wireless.

Antenna: A new antenna will be used which is only a few centimetres long. The antenna will be placed on the PCB and within the casing. This way the current reasonable doubt whether the device will work or not, is solved (the antenna needs to be intact and well mounted for the function of the device). Furthermore the problem concerning the watertight connection between the MicroRouter and antenna is hereby solved. It also helps decreasing the dimensions of the router. Here is chosen for the cylindrical antenna (see chapter 2.2.5, Antenna (for new PCB).

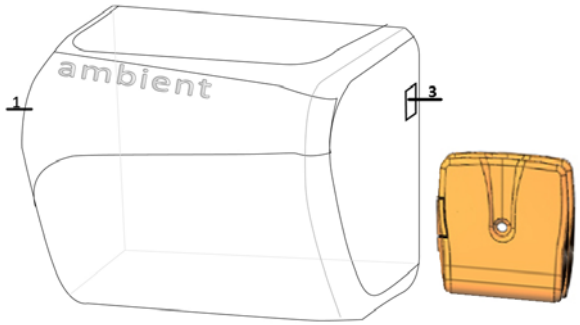


Figure 2-10 Concept 2-1 and the SmartPoint

Power connection: When a power or serial connection is needed a small gland will be placed at the bottom (chapter 2.2.6, power connection). Therefore a hole is needed at the bottom.

Closing (*screw hole Figure 2-10 no. 1****):***
To close the casing a lid will be mounted on the front. No screws will be visible because these will be screwed in from the back.

Mounting (*Figure 2-10 and Figure 2-11, no. 3****):***
The mounting to the wall can be done by a rubber band and screws. A tube is placed at the back of the casing. Screws fit in the holes that are made in the tube (like in concept 1-2 and see also chapter 2.2.1).

LEDs: The shape of the front part is related to the SmartPoint shape. The LED lightning will shine through a semi transparent shape on front of the casing (Figure 2-10, no. 1). The LEDs are therefore located in a row at the front of the casing. The casing is slightly curved at the front, so that the lights are visible from beneath the MicroRouter (see Figure 2-10).

The dimensions of this concept and images can be found in the appendix chapter 2.5.4.

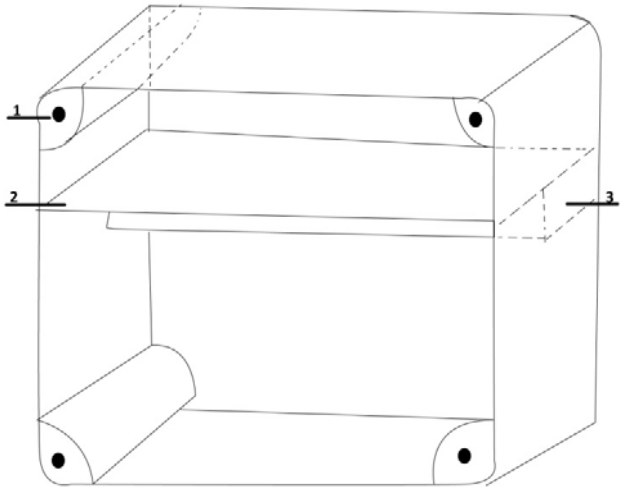


Figure 2-11 Inside concept 2-1

Numbers	Parts
1	Screw hole
2	PCB
3	Mounting tube

Table 2-10 Explaining numbers figure 2-1

2.6.4. Concept 2-2

The dimensions of the PCB placed in this concept are: hundred millimeters in length and seventy millimeters in width (Figure 2-12no. 3). On the back of the PCB the batteries are placed Figure 2-12, no. 2 and see also chapter 2.2). On the front the components will be placed. The space on the PCB is big enough for different battery sizes.

Antenna (*Figure 2-12, no. 1):* There is chosen for a smaller antenna of only a few centimeters. This is the block antenna that can be found in the morphological analysis (chapter2.2.5, Antenna (for new PCB)). The antenna will be located on top of the PCB and is protected by the casing.

Power connection: If there is chosen for a power connection a hole is made at the bottom of the casing. A Klikseal (see chapter 2.2.6, power connector no. 4) is used to seal the wire.

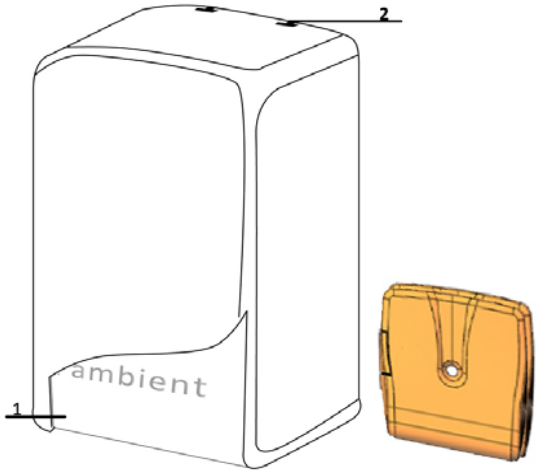


Figure 2-13 Concept 2-2 and SmartPoint

Closing (*Figure 2-12, no. 4****):***
The casing is closed by mounting on a lid at the front. No screws will be visible because these will be screwed in from the back.

Mounting (*Figure 2-13, no.2****):***
The MicroRouter will be mounted by four screws. At the back of the router four slots are made where the screws will fit in. First the top screws will be shoved in followed by the lower screws on which the casing rests (chapter 2.2.1, mounting systems).

LEDs: The LEDs are placed at the bottom of the router (on the PCB) so that the light can be seen from below. The light shines through a semi transparent shape at the bottom. The shape is inspired on the SmartPoint (*Figure 2-13* no. 1). Dimensions of this concept and more images can be found in the appendix chapter 2.5.5.

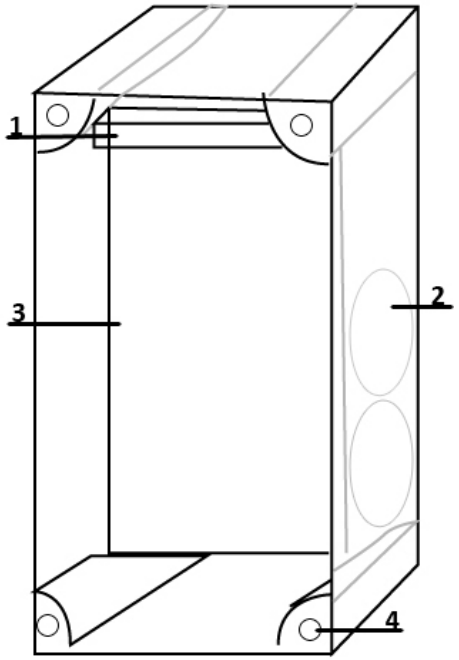


Figure 2-12 The inside of the casing

Numbers	Parts
1	Antenna
2	Batteries
3	PCB
4	Screw hole

Table 2-11 Explaining numbers figure 2-12

2.7. Review concepts

To come up with final concepts, the concepts were compared. This review shows how well the concepts meet the requirements (Table 2-12). An extended review on the requirements can be found in the appendix chapter 2.5.6.
In the table the requirements are rated by – and +. - - is very bad and ++ is very good.
Below the – and +, extra notes are made.

Requirements	Concept 1-1	Concept1-2	Concept 2-1	Concept 2-2
Antenna	++ (entirely protected)	+ (partially protected and still bendable)	++ (protected by casing)	++ (protected by casing)
Power connector	+ (current gland, watertight and less visible, but takes a lot of space)	+ (watertight, smaller gland, but cannot plug in and out as current connection)	+ (watertight, smaller gland, but cannot plug in and out as current connection)	+ (watertight, smal seal, but cannnot plug in and out as current connection, quick mounting)
Batteries	+ (current batteries fit in, need to be mounted to casing)	+ (current batteries fit in, clamped in casing)	+ (different sizes fit in, need to be mounted to casing)	++ (different sizes fit in, all can be mounted on PCB)
LED	+ (visible, orientated to the front)	+- (more difficult to make it visible)	+- (visible, but LEDs orientated other way)	++ (visible, LEDs orientated to front and at bottom)
PCB			++ (easy to adapt to different batteries, and orientations)	+- (less adapting possibilities)
(current)Label	+- (will fit on the front, but disrupt the clean look)	+ (will fit at the bottom)	++ (will fit on the side or bottom)	+ (will fit on the side or top)
Design	+- (good mounting possibilities, but takes time and visible screws)	++ (good and quick mounting options, no screws visible)	++ (good and quick mounting options, no screws visible)	+ (quick mounting, four screws are needed for mounting, invisible mounting).
Conditions	+ (sturdy because antenna is inside)	+- (fragile antenna and more edges less easy to clean)	++ (sturdy and easy to clean)	++ (sturdy and easy to clean)

Table 2-12 Review concepts

This comparison shows that the concepts achieve all requirements. There are no negativities that exclude one concept right away. Some aspects of the concepts meet the requirement better than others. The review will not be complete without reviewing the concepts on the company's interests. The functionality, look and design are important for company.

Comparing concept 1-1 and 1-2

The first concept has a clean and simple shape. This is also what resulted from the brainstorm and survey. It is a relatively large casing.
The employees of ambient noted that the casing should be robust and sturdy because the MicroRouter is the leading element of the system. A large casing in this perspective is no problem.
The idea of a lighted area was also appreciated by the company. The mounting of the casing is visible, what makes it less attractive.

The shape of the second concept is more curved. The shape is designed to fit in the PCB, antenna and LEDs. This causes the various widths. The casing protects the antenna connection. Still the rest of the antenna is fragile looking.
The study and robust look is not applied here. The area that is mounted to the wall is smaller than the area that is sticking out. This is not very elegant. The mounting of the casing is covered. So this does not disturb the look of the casing.

Comparing concepts 2-1 and 2-2

The shape of concept 2-1 is simple and robust. The rounded shape at the front softens the square shape of the box. The shape at the front shows similarity with the SmartPoint. This is in line with the company's wish to create one line in their products.
An area of the casing will be lightened by the LEDs. The antenna is protected and it will be no problem to make the casing watertight.

Concept 2-2 is a longer shaped casing. It looks a bit more rectangular caused by the straight lines. The shape at the front is derived from the SmartPoint and helps creating a product line.
The mounting is done on the back so no screws are visible. It is relatively easy mounting with four screws. The batteries are mounted on the PCB so no extra part is needed. This makes the assembly easier.

2.8. Results

The requirements resulting from the research are listed and form the basis for the new MicroRouter design. The analysed options in the morphological analysis explored the options for important issues the MicroRouter has. The analysis resulted in a clear picture and helped starting the development of concepts. Together with the sketching ideas for concepts were created.
These concept ideas were rated by the employees. This helped clarify the companies view. With all this information four concepts are made. Each concept is compared the companies wishes and the list of requirements. This results in the choice of two concepts.

The first concept that is chosen is concept -1-1. This concept came out well in the review. The most important requirements (see rating first column, chapter 2.1) are met quite well.
The concept can be made watertight very easily and protects the whole antenna. This way no difficult sealing needs to be made at the connection between the antenna and the casing.
It has a sturdy and robust look that indicates the importance of the device. Less attractive is the mounting of the device. This is a point of improvement.

The second concept that is chosen is concept 2-2. The comparison with the requirements shows that this concept meets the important requirements quite well.
It is no problem to make the device watertight and making the LEDs visible. For mounting the batteries clips on the PCB will be enough. This forms a compact package of all inner parts.
The rectangle shape of the casing differs the casing from the SmartPoint casing. This could be a characteristic for the new look of the SmartPoint. The shape at the front helps creating one product line.
The mounting is a questionable part of this concept and is a point of improvement.

3. Final concepts

The result of the review of the concepts is the choice for two concepts, concept 1-1 and concept 2-2. These concepts met the requirements and suited the interest of the company. Both concepts were further developed into final concepts.

The design of the final concept is described in section 3.1.1. Furthermore information on the production, like material and the production method can be found (section 3.1.2). The colour choice is explained in section 3.1.3. The costs are calculated to give a estimation on the money that needs to be invested (section 1.1.1).
In paragraph 3.2 the future concept 2-2 is viewed. At the end of the chapter a roadmap can be found (paragraph 3.3). Here the device is placed in Ambient's perspective.

3.1. Final concept 1-1

3.1.1. Shape

Due the modified orientation of the PCB and batteries, the shape of the original concept is changed. The PCB is lifted so the batteries will fit underneath it (see figure Figure 3-1 and Figure 3-4).

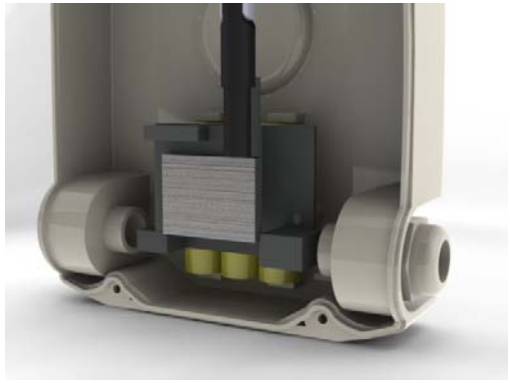


Figure 3-1 Batteries and PCB

The final shape gives a clean, simple but professional impression. The products of Ambient are brought together by similarities in the shape of the casing. Shapes of the SmartPoint are applied the shape of the MicroRouter. The shape has also a functional purpose.
The LEDs are positioned behind the semi transparent shape. The LEDs need to be visible at all times therefore the shape is bulges out a bit (see Figure 3-3).
The rounded shape is kept because this gives the impression of a smaller casing. Nevertheless it has a robust and study appearance.

In this concept the current gland is used. The current gland will not be modified, this means it is screwed on. No glue is needed and the IP rating is secured. The gland will be partially covered by the casing. The gland will not be entirely covered. The part that can be seen is not disturbing the appearance.

The mounting of concept 1-1 is changed. The free space inside the casing makes an invisible mounting option is possible. This mounting option is based on the idea of concept 1-2. The mounting method needed adjustment after it was discussed with an expert on injection moulding. The adjustment makes the idea better suitable for injection moulding (further discussed in section 3.1.2).
The closed tube is replaced by an open part, see Figure 3-2. An extra mounting option will be added by making a embossing in the back of the device. This embossing gives the opportunity of placing a magnet (chapter 2.2.1,

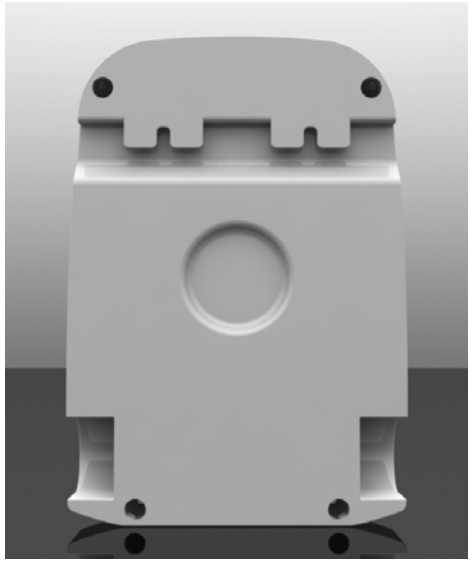


Figure 3-2 Back of final concept

mounting systems).
The top and PCB need to be mounted on the casing. Therefore holes are made on the casing. The holes for the top will be positioned outside the sealing. The sealing is done by a rubber.
Inside the casing small tubes are positioned to mount the PCB.
Technical drawings can be found in the appendix chapter 3.2.1.

3.1.2. Production

For production and materials an expert on injection moulding[2] has been consulted. Ideas about the material, constructions and production are discussed (in appendix 3.2.1.). So eventually a concept is made that is producible and realistic.

Material casing

The production method that is preferred for the MicroRouter is injection moulding. Injection moulding is suitable for a large number of complex products.
The material for the casing has to be injection mouldable. In this case a thermoplastic material will be used. The plastic needs to be up against harsh environments. Weather and temperature influences may not destroy the casing. At the moment ABS (Acrylonitrile butadiene styrene) is used for the SmartPoint. This product is also has to withstand the influences of harsh environments.

[2] Richard van Ringen, Manager Engineering, Reobijn plastic products, Haaksbergen

The material chosen for the MicroRouter is ABS. It is suitable for the harsh environments, temperature influences and can survive a rough trip. Previous research [1] suggested HDPE (high density polyethylene). HDPE is used for plastic bags and crates. These applications do not need a high quality appearance. The look and feel of the material is different than the look and feel of ABS. Therefore to achieve the right look and feel for the MicroRouter, ABS is used.
Other options for material use are discussed in appendix chapter 3.2.1.

A lens of a different material is chosen to ensure good visibility of the LEDs. The material is polycarbonate (PC), which is suitable for LED applications. A PC variant which is semi transparent (diffusive) is used. Light will come out but the components at the inside of the box cannot be seen. This part will be separately injection moulded (lens see Figure 3-5).
Other options have been considered and cost calculations were made. All concluded that this lens is a good option. Other options and the calculations described in appendix chapter 3.2.2.

An advantage of the separate part is that the colour of the ABS can be changed. At the moment this is already a possibility for the SmartPoint. Now it also could be an option for the MicroRouter.
Both parts of the casing can be made in one mould, when there is chosen for a separate lens. This reduces the costs.

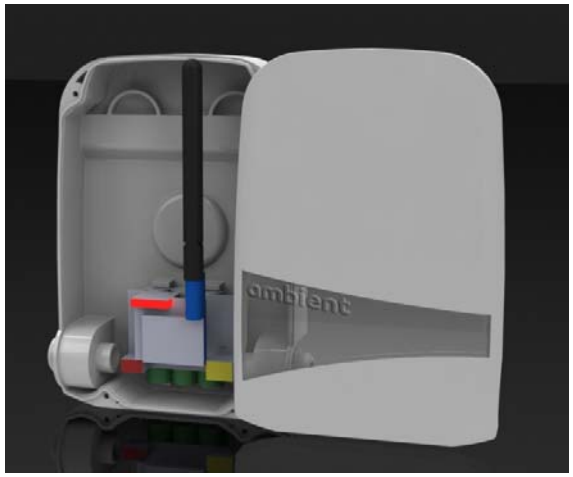


Figure 3-4 Inside of the final concept

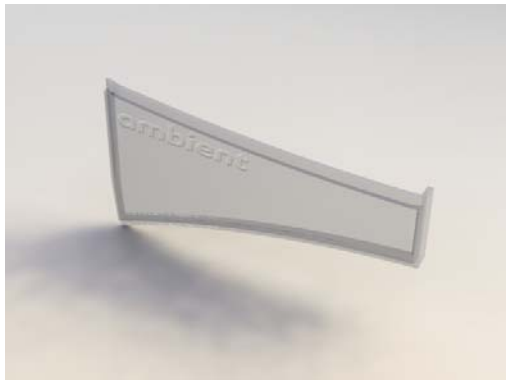


Figure 3-5 Lens

Finishing and Assembly

After the injection moulding finishing the product is needed. A hole needs to be drilled for the power cable, and then all parts need to be mounted. Screw-treat needs to be inserted. Metal inserts are chosen so it will be no problem if the casing will be opened and closed many times (see Figure 3-6).
The lens will be mounted in with glue. It must be perfectly sealed.
For sealing the casing, a rubber ring has to be put in the slot. A ring 2 mm is needed with a length of 585mm.

Figure 3-6 Metal insert

The gland is mounted into the casing. The next step is mounting the batteries and PCB on top. The batteries will be clamped in the casing. The finished PCB will be screwed in the casing and the wires/cables can be attached. When everything is in place the top can be screwed on and the label can be put on the casing. On the bottom an area for the label is reserved (Figure 3-7). This way a quick look is enough to identify the product. Nevertheless it will not disturb the clean look of the casing (more on the label can be found in appendix chapter 3.2.3.).
The power supply of the MicroRouter is not changed. Therefore the current adaptor is used in the new concept.

Figure 3-7 Label at the bottom of the router

3.1.3. Colour

The colour of the MicroRouter is off white. This is the outcome of considerations concerning use, environments and the company's colours. In Figure 3-8 the colours of Ambient Systems are presented, orange, white and blue.
The environment in which the MicroRouter is used in also has an influence on the colour choice. The MicroRouter can be used outdoors, in industrial and hospital surroundings, but also in supermarkets and offices.
The colour has to fit in each of these environments.
When the MicroRouter is used in hospitals or nearby food it is necessary to have a clean and hygienic device. Therefore the surface of the MicroRouter is smooth so it can be easily cleaned.
In all cases the device can get dirty. With the white colour makes it easy to detect this, compared to the use of dark colours. This way it is easier to detect whether the product needs to be cleaned in order to value the hygiene.
The material used for the lens is white too. This will give a clean and professional look.

Figure 3-8 Colours of Ambient

3.1.4. Costs

A mould needs to be made the casing, and therefore an investment is needed. The costs of a mould are high, but during the years the mould is used many product can be produced. With good maintenance the mould will have a life of 10 years (estimated).
Ambient predicts that they will sell three thousand MicroRouters. This is quite small amount of products for injection moulding. But it can be done. Although not all injection moulding companies are willing to make such small amounts.
Below the price per product is calculated and an estimation of the investment is made.

Mould costs: estimated on
±6000 euro for the lens,
and ±22.000 for the casing
(both parts of the casing in one mould).

Material costs: the material prices per kilo [3].
ABS: €1.80, and PC (diffusive): €3,00.

It is difficult to make an estimation for assembly costs and additional components. Therefore the current costs for the whole minus the casing itself is calculated.
This is sixty-five euro's minus nine euro's for the casing (see chapter 1.3.6.).
Than the costs are fifty-six euro's (€56,-) per casing.

Part cost:

Casing :

€5,30

Lens:

€3,02

Parts, finishing and assembly:

€56,00

Total price per product:

€ 64,32

This is with a depreciation allowance of 2 years. When a depreciation allowance time of 5 years is chosen the product will cost: €58,42. These calculations can be found in appendix chapter 3.2.3.

3.2. Final concept 2-2

Concept 2-2 is chosen for the new future design of the MicroRouter.

The concept is rectangular shaped like the other final concept (Figure 3-9). This may form a line in the future line of MicroRouters.
In this concept the same principal is used for the LED visibility. A lens will be separately made and later on placed in the Router.

The material choices are the same as concept 1-1. The router will be of ABS and the lens will be made of PC. Due the two separate parts there is an option to change the colour of the casing. The standard colour will be off white.

There is only one PCB used in this case. On one side the components, LEDs and antenna will be placed. On the other side there is room for different size batteries. The batteries can be mounted with clips on the PCB. This gives the opportunity to make the device wireless in the future.
The exact positioning of the components on the PCB is not made yet and requires further development.

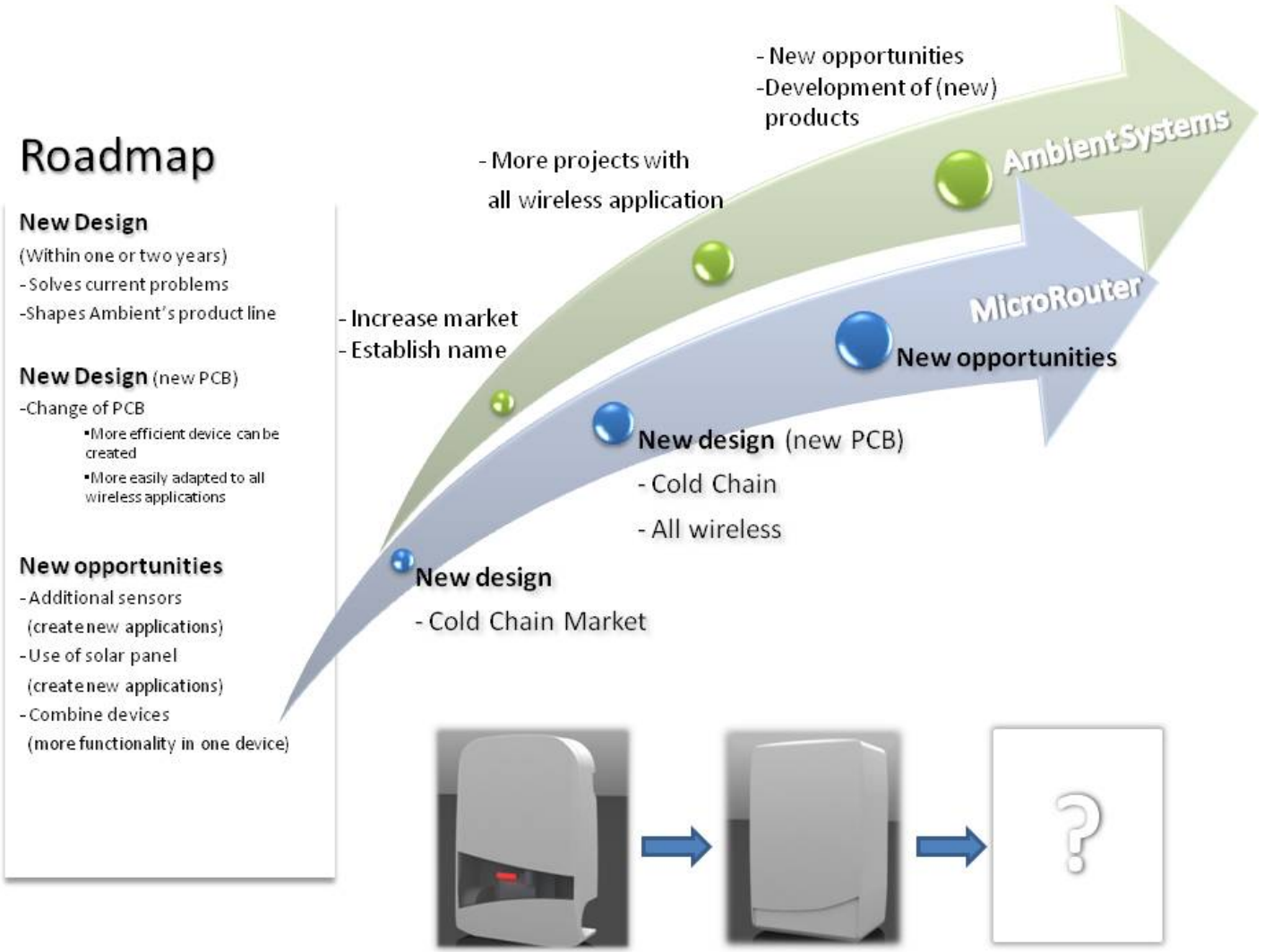
If there is chosen for a power connection an output can be made at the bottom of the device. For the sealing of the cable a 'Klikseal' is used. This is a simple, quick and nice looking solution. When the seal is in the same colour as the casing will blend in even better.

The mounting option used in concept 2-2 is not a good option. According to the expert this solution will be difficult to injection mould. It would make the mould unnecessarily complicated. Therefore the mounting option used in final concept of 1-1 is a more practical solution. An extra mounting option is added on the back. A magnet can be placed at the embossing in the back.

Dimensions and other images can be found in appendix chapter 3.3.1. and 3.3.2.
The costs for this concept are estimated on €5,95.
This is a rough estimation based on the casing and a lens. The cost estimation of the lens of final concept 1-1 is used. This is because these lenses are comparable. Calculations can be found in appendix chapter 3.3.3.

Figure 3-9 Final concept 2-2

3.3. Roadmap


Roadmap
New Design
(Within one or two years)
- Solves current problems
-Shapes Ambient's product line
New Design (new PCB)
-Change of PCB
•More efficient device can be created
•More easily adapted to all wireless applications
New opportunities
- Additional sensors
(create new applications)
-Use of solar panel
(create new applications)
- Combine devices
(more functionality in one device)
- Increase market
- Establish name
- More projects with
all wireless application
- New opportunities
-Development of (new)
products
New design
- Cold Chain Market
New design (new PCB)
- Cold Chain
- All wireless
New opportunities
MicroRouter
Ambient Systems
?

4. Conclusion

The aim of this report is giving recommendations and example designs for two concepts for Ambient's Systems MicroRouter. The different chapters worked towards that goal. In the previous chapter the final two concepts were presented. In this chapter a conclusion is made about the report and the concepts. Furthermore recommendations are given in the second paragraph in this chapter.

4.1. Conclusion

Giving recommendations and make an example design for an industrial design of Ambient Systems MicroRouter is the aim of this assignment. This goal is achieved as can be seen in chapter 3.

During the development the focus on the pragmatically aspects was important. Research helped achieving this. Current problems as watertightness and producibility are solved in the new design. By injection moulding the casing the company's wishes can be achieved. Environmental influences were analyzed and led to a choice of materials.

The alignment with other products and the corporate image were also important issues. More insight was gained by research where also the Ambient employees were involved. It showed how the company wants to present itself and its products.

Most of the requirements are met with this new design. For some aspects of the MicroRouter it is not clear if the requirements are met. This can only be checked by testing these aspects with prototyping or with a 0-series.

The second design concept is an example for a future design. This design shows the possible changes for the layout and look of the MicroRouter. The material and mounting aspects are the same as the first concept., this because of the requirements and producibility of the concept.

4.2. Recommendations

What needs to be done before the product can be produced.

- For a better picture of the final concept a rapid prototype needs to be made. This is a relative cheap way of making a model for checking the look and the functional aspects. There can be chosen for a prototype of ABS or gypsum. The gypsum model will be fragile but cheaper than the ABS.
- Different analyses can be performed on the CAD model. For example a mould flow analysis.
- Consult a specialized company. These people have more knowledge on further actions regarding the production of the product. For ambient is it not possible to have their own mould flow machines and they need to put out under contract.
- Then the first 0-series needs to be made to check the functioning of the product in the actual environment. After that the product will be ready for final production and marketing.

- Overall it is important for the company to set their goals and image of the company. This has to be quite strict in order to develop the right products for the right market. A new design for the casing of the MicroRouter will be in use for a couple of years to gain profit.
- Because the design cannot be changed instantly the electronics need to stay quite the same.
- An improvement can already be done by replacing the current antenna for a smaller one. This solves many current issues like the watertight connection and reliability of the device.

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Conversations with:
Ir. Mark J.J. Bijl, Ambient Systems, Technical Pre-sales Consultant.
Richard van Ringen, Manager Engineering, Reobijn plastic products, Haaksbergen.
Msc. E.E. Eugen Moldovan, product development Ambient Systems.

6. Glossary

RFID	Radio Frequency Identification
ABS	Acrylonitrile butadiene styrene
GW	Gateway
SP	SmartPoint
MR	MicroRouter
LED	Light Emitting Diodes
HACCP	Hazard Analysis and Critical Control Points
PC	Polycarbonate
CAD	Computer Aided Design

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1. Research

1.1 Parts of the MicroRouter

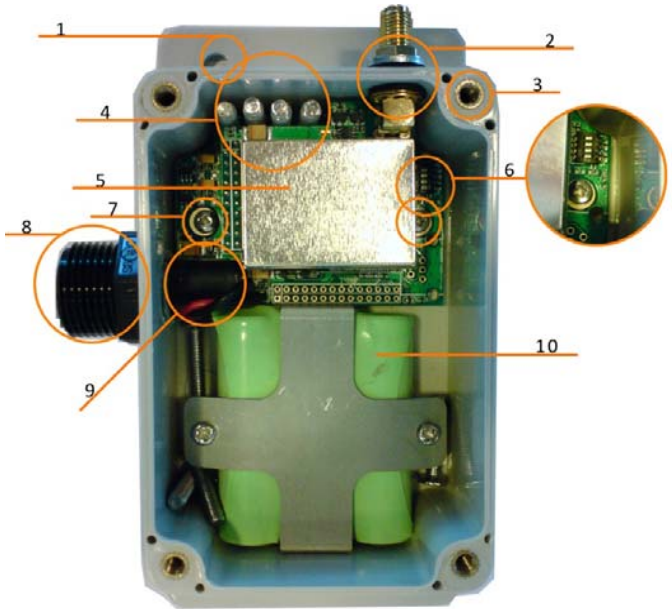


Figure 1-1 Parts of the MicroRouter

1	Mounting hole	6	Dip switch
2	SMA connector	7	Mounting PCB
3	Mounting top	8	DC gland
4	LEDs	9	Power connector
5	Metal plate	10	Batteries

Table 1-1 Parts inside the MicroRouter

1.1.1. Antenna

The antenna is an important component of the MicroRouter. The antenna is responsible for sending radio waves to connect with the GateWay, the SmartPoints and other MicroRouters. It is important to optimize the connectivity and prevent blocking of the signal.

The orientation of the antenna is important to guarantee good connectivity. At the moment the antenna is placed on the outside of the MicroRouter and can be bent in the right direction to optimize the connectivity. In most cases the antenna will be orientated vertically for optimal connectivity.

The optimization of the connectivity is also done by using an antenna of a certain length.
At the moment the antenna is about 110 mm in length (Figure 1-2). This length is necessary for the range and strength of the signal. If another antenna will be used in the future the signal strength and the range may not decrease.

The antenna mounted on the SMA connector on the PCB and is also connected to the casing (Figure 1-3). This makes a strong junction and provides more stability to the antenna. Still the antenna is very fragile, it sticks out and it has no outer protection. During transportation and production the antenna is taken off. Before use the antenna has to be mounted (screwed) on the MicroRouter. For the placing of the antenna at the moment see Figure 1-1 number 2.

* Enclosure may not influence the connectivity of the antenna
* The antenna needs to be placed vertically in or on the enclosure, for best connectivity
* The range and strength of the signal should be maintained.
* The antenna should be protected from external influences
* The antenna should be stabilized/ supported

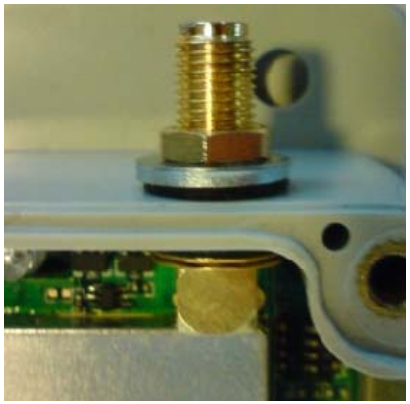


Figure 1-3 SMA connector

Figure 1-2 swivel antenna

1.1.2. The power connector

The MicroRouter can run on batteries if necessary, but it will generally be connected to an external power source. This power source will be connected by a Power Jack on the PCB (Figure 1-1, no. 9). To make the connection watertight and to give it more strength the wire is sealed by a gland (Figure 1-1, no. 8). This gland is now glued in the casing. The power cable is not plugged in during transportation and it has to be connected before use. To illustrate this see Figure 1-4.

This part of the MicroRouter should be tight and have enough strength to handle some pulling on the cord. It has to be tight because external influences, like water, may not come into the product. At the moment the output is orientated at the side of the MicroRouter (figure 1-6, no. 8 and9). Because the MicroRouter is always hanging high and most electric points will be lower than that, it will be more suitable to orientate the output at the bottom of the device. It can also improve the look of the MicroRouter.

* The connection should be water tight, IP65
* The connection should have enough strength, pulling
* Logical orientation of the power connector, at the bottom

1.1.3. Batteries

As backup power the MicroRouter has a battery pack. The battery pack consists of three rechargeable Nickel Metal Hybrid (AA) batteries. For the placing of the batteries at the moment see Figure 1-1 number 10.
Because the battery pack is big, compared with the PCB's, it has a great influence on the positioning of the components inside the MicroRouter. At the moment the batteries are attached to the casing by a little metal plate, which fasten them firmly (Figure 1-5). This way the batteries in the MicroRouter can cope with vibrations and shocks.

*There should be room for the battery pack of 3 AA batteries
(3 x 13.5 - 14.5mm (diameter) x 50.5mm (height))
* The battery pack should be stuck or stabile in the casing, cope with vibration
* The battery pack and housing should meet the safety requirements.

Figure 1-4 DC Gland and Power Connector

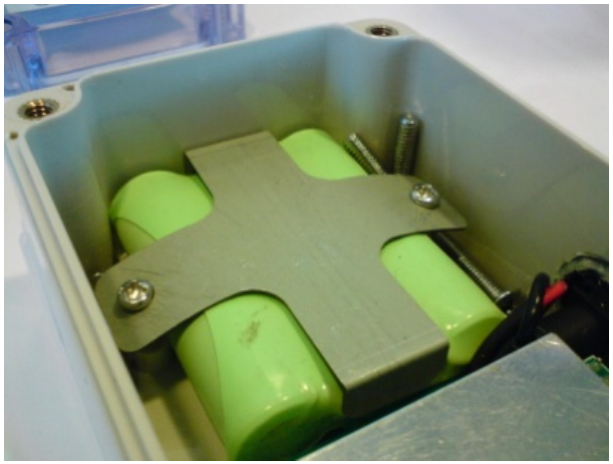


Figure 1-5 Batteries inside the MicroRouter

1.1.4. LEDS

The MicroRouter has four different coloured LEDs (Figure 1-6).
The LEDs indicate the status of the MicroRouter. For example if the MicroRouter is on, if it is connected to the network and if it has low battery. Because the LEDs are an indication for the user in what state the MicroRouter currently is, the LEDs should be visible all times.
So when it hangs on the wall, the user has to see instantly if the device is working properly. In some cases the device will be hung on a high sealing, for instance in a factory hall. Even then the user requires good visibility of the LEDs.

To ensure this, bright LEDs are needed and the casing must facilitate optimal visibility of all LEDs. This is also needed in case of bright surrounding light. Because the light in the environment makes it is harder to see the light of the LED.
Another thing that may block the light of the LEDs, and make them less visible is the dirt in the environment. This should all be taken in account to guarantee a user-friendly product and a successful operation of LED visibility.

* Four different coloured LEDs, blue, green, orange and red.
* Visible at all times, not blocked by anything (e.g. casing)
* Visible at all times, even from a height and in a dirty environment
* Visible when it hangs in a room full of lights
* The LEDs should be IP65
* The LEDs should be protected from damage
* A cost effective solution

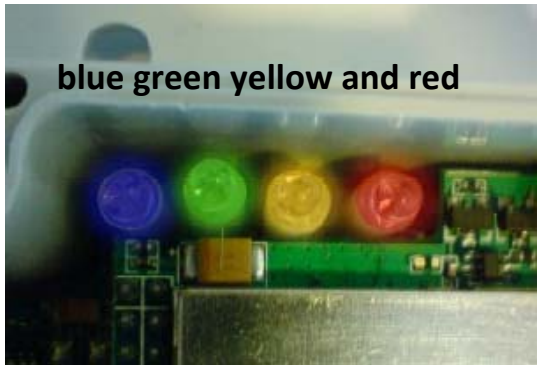


Figure 1-6 The LED colours

1.1.5. PCB

The PCB on which all components are placed is on of the mayor parts in the MicroRouter. At the moment there is a fragile PCB structure inside the MicroRouter. At the bottom the carrier board is placed and on top of that board a radio board, see Figure 1-7. This very fragile construction should be protected by the casing.
The off-the-shelf casing at the moment is not ideal because a standard size PCB does not fit in. Before placing the board in the casing, corners have to be removed. This requires an additional operation that raises the costs. It is rather convenient using a standard shaped PCB or even a standard size. The standard European Eurocard size is 100mm x 160mm. Components on the board are licensed. When changing the orientation or place the license has to be renewed.

The PCB is now attached to the casing, by screwing it to the casing. The screw mounting holes are already in the body of the casing (Figure 1-1, no. 7). The dip switch (a small component with switches) which is placed on the PCB is an component that should be reachable. It does not have to be reached at any time. It should be reachable by for example removing the cap of the device.

* PCB needs to be supported
* Protection of the PCB
* A standard PCB should fit in (in a future redesign)
* The PCB should be reachable, related to the dip switch
* The assembly of the PCB in the casing should be convenient
* A standard sized PCB is a Eurocard (160 (mm) x 100 (mm))

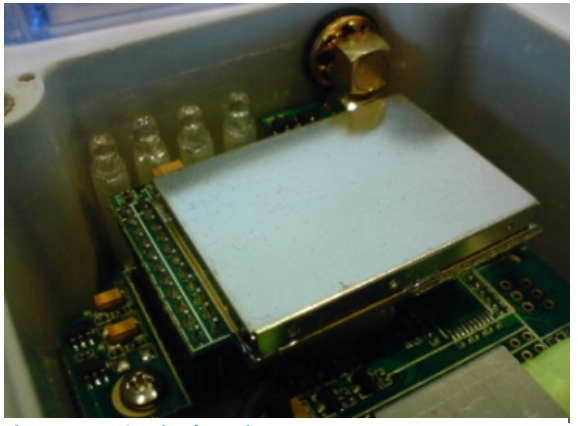


Figure 1-7 PCBs in the MicroRouter

1.1.6. Casing

The parts just mentioned are important for the design of the casing. They have to fit and be protected.
There is a request to have some space around the components. This is to make small adjustments to the components in the future.

Another requirement of the MicroRouter is that at all times one should get to the inside of the device. This is necessary because adjustments should be made, even after the assembling of the MicroRouter. This requires a proper resealing method of the enclosure.

The environment the device is used in has also influence on the design. The consequence is that the enclosure should be properly sealed.
The cap on the casing is now sealed with a rubber and screwed on (screw holes Figure 1-1, no. 3).

The MicroRouter is always used up in the air, and often hung on a wall. The current casing can be mounted by four screws (screw hole, Figure 1-1, no. 1).
In a new design there must be the possibility to mount the MicroRouter on for instance a wall.
The outside of the MicroRouter should be recognisable for the user. The Ambient logo should be applied on the casing, or another logo for private labelling. A flat surface with the right size is needed to place the label.
The colour of the casing has to be adaptable for any consumer.

* A standard shape PCB should fit in
* The casing should be properly (re-)sealed, IP65 (and IP 67 is preferred)
* The inside of the device should be reachable
* The casing should have possibilities for mounting
* The ambient logo should be visible or private labelling
* The casing should have a flat surface of a appropriate size for the label
* The colour of the casing should be adaptable

Figure 1-8 MicroRouter

1.1.7. Labelling

On the outside of the MicroRouter a label should be placed. At the moment this is a thermal label. Because it is thermal it can cope with the wide range of temperatures. The casing of the MicroRouter is too small for the label and it does not fit perfectly.

The label is for the identification and certification of the device. On the label relevant and obligated information is placed. The CE-marking (Conformité Européenne) certifies that a product has met the EU consumer safety, health or environmental requirements. This mark is only used in the European Economic Area (EEA).
The electronics in the MicroRouter contain chemicals which need to be separated by discard at the end of the product's life. Therefore the product will get special treatment compared with the normal waist. To clarify this, a small sign should be put on the label. The RoHS (restriction of hazardous substances) sign indicates this.

There needs to be an indication where the power input (/output) and the antenna are positioned. This can also be put directly on the casing.
The IP65 code will also be printed on the label.

It is important for the company and the customer to know the differences between the devices, therefore a barcode, serial- and model number have to be on the label. These barcode and numbers have to be visible and easily read at all times for identification of the device. The company's name is also printed on the label.

* CE mark, Conformité Européenne
* RoHS mark
* Power en antenna input/output, if not put on the casing itself
* IP 65
* Barcode
* Serial number
* Model number
* The label should be easy to read
* A thermal label should be used

Figure 1-9 Label on MicroRouter

1.2. Collages

1.2.1. I Collage Ambient

This collage shows Ambient the company. Ambient is a technical company developing new technologies. Ambient is doing business all over the world. To do this they have different business partnerships. It is a small but growing company, located in the Netherlands.

Figure 1-10 Collage Ambient

1.2.2. II Collage Environments

In this collage different environments are shown. These are the environments were the MicroRouter operates. In the cold chain the MicroRouter is used near medication and hospitals but also food, food storage and transportation. It will also be used in the environment of heavy cargo and nature with all its changes.

Figure 1-11 Collage environment

1.2.3. III Collage Competitors

Figure 1-13 Collage competitors

In this collage the major competitors with their key products are shown. Not all competitors have exactly the same devices, but they operate in the same area as Ambient Systems.

1.2.4. IV Collage Routers

This collage shows different routers. These routers are mainly internet routers for home use. There can be seen that most routers don't differ that much. Most routers are boxes with or without antennas on top. On the left routers with one antenna are shown, in the middle routers without any antenna and on the right routers with more than one antenna. Some are very shiny and have a smooth surface. Others are more robust and industrial looking.

Figure 1-12 Collage Routers

1.3. Brainstorm session

To gain more information about the look and feel of Ambient a brainstorm session was planned. At the moment Ambient has not got one line in their products. There is also no predetermined vision on how their product should look. Clear is that no one of the company likes the current of the shelf box. The question arises than what would the company like?
The brainstorm session was held with a few employees from Ambient. The people who joined are aware of the concerns and are experts on different disciplines.
The participants were:

- Eelco de Jong
- Eugen Moldovan
- Jose de Rooij
- Mark Bijl

The session was divided into different steps. The first step was to encourage creative thinking. After that the questions were more focused on Ambient and the MicroRouter. These steps will answer the following questions:

- *What is the look and feel of Ambient and their product? What is the appearance of the company? How should the Ambient products look according to the employees? (step 1-3)*
- *Why is a new design needed? What are the issues at the moment? Are there different requirements in case of an ideal MicroRouter?*

Before the session different images were printed, because this was in black and white also a PowerPoint presentation was made. All steps were prepared.
At the beginning it was not necessary to explain my assignment extensively, because all participants were well posted earlier.

1.3.1. Implementation

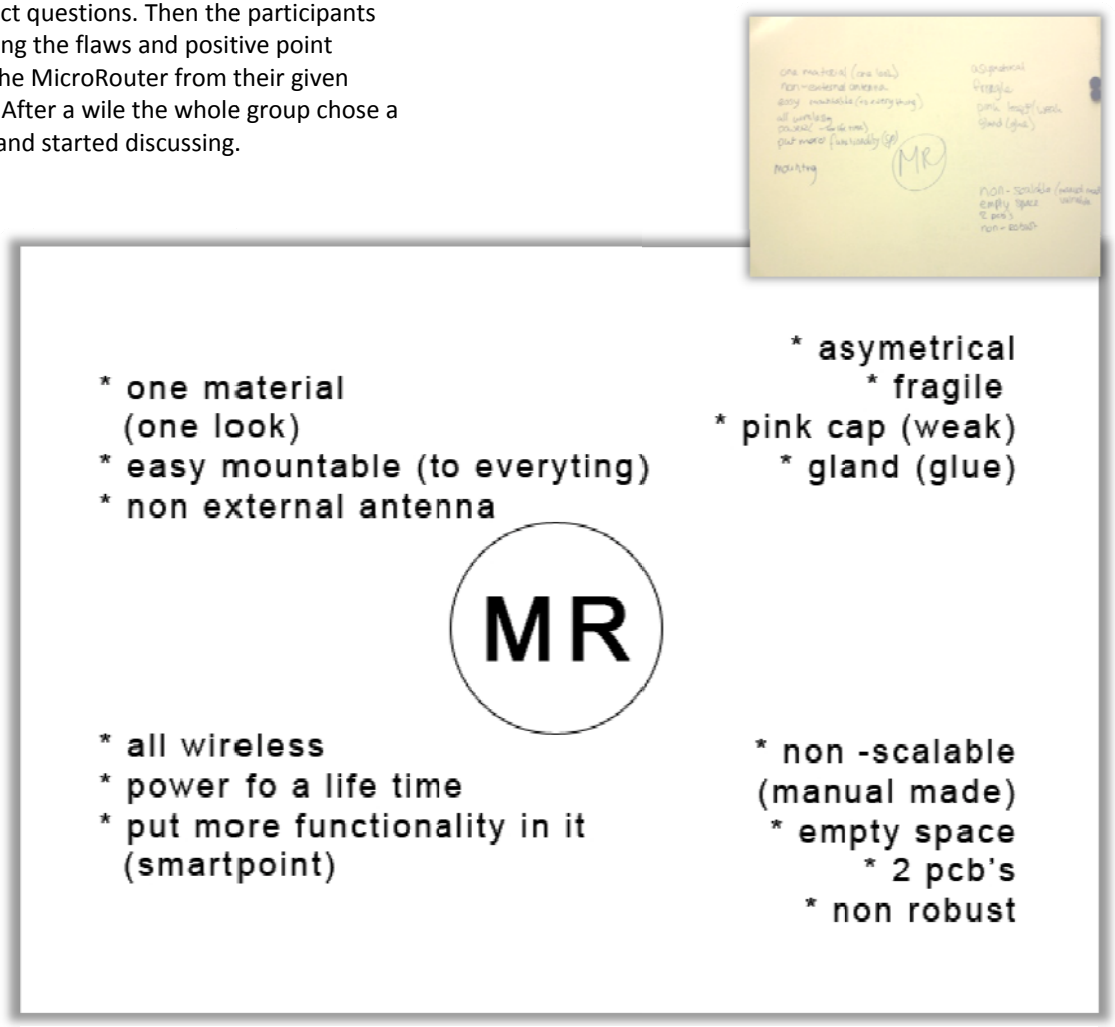
The first step
The first task was placing the images which I brought into an axis. On the vertical axes the words ugly (unattractive) and beautiful were placed. On the horizontally axes the words functional and non functional were used. The participants had to mention why they placed the image on a specific place in axis. When they disagreed with each other they had to mention it too.

ırm step 1, 2 and 3.

One by one they placed an image in the axis, and most of the time placing the image was discussed with each other. At the end of this step the axis was well filled.

Second and third step
The goal of the second step was to place Ambient and their current products in the axis. Why would you place there in the axis? Are there differences between the current Ambient products.
A discussion started about the non designed MicroRouter and about the products which do not make one unified product line. After that the participants started mentioning the positive and negative points about the SmartPoint. They picked the SmartPoint because this is the only designed device of Ambient. They also came up with ideas for a possible product line for Ambient.
By discussing the third step was already answered. The third step was about where, in an ideal situation, Ambient and their products would be placed. Why and what are the features of the products? And what needs to be changed to match this product category?

The fourth (and last) step
Starting with a future scenario, there was looked forward at a next new generation of Ambient products. In the future Ambient will focus on the cold chain and all wireless market. The Goal is creating a ideal vision for the MicroRouter. What functions should an ideal MicroRouter have? What are the flaws at the moment and what is needed to solve this? To view this from another perspective every participant is given another role than they usually have. So the marketing person gets an engineering role, the engineer gets a marketing role, and the others had a visionary and pessimistic perspective. The words that were mentioned were put down on a whiteboard.
It was hard to start this last step, because there were no direct questions. Then the participants started naming the flaws and positive point concerning the MicroRouter from their given perspective. After a wile the whole group chose a perspective and started discussing.



1.3.2. Results

The conclusion from the first step is that something can be said about the design of products. In the end the participants could manage axis which they mainly agreed on. Main conclusion read from the filled axis is that simple, clean designs are generally liked. When the product looks simple the focus is more on the functionality. This is often preferred. Organic shapes are also in the category beautiful, but when exaggerated this quickly shifts more to the ugly less functional side. Products which are designed are called more often beautiful. The designed products are smooth shapes.
Points that were mentioned during the discussion about the SmartPoint were:
No optimal use of the SmartPoint features.
A glossier product looks more professional.
Making the Ambient logo more visible
The products should be unified in one product line. The SmartPoint is an already designed product and the other products have to go in line with this device. When the products are unified it will give a more professional look.

Also about the MicroRouter was a discussion. The critical points that were mentioned:

- Fragile antenna and PCB's
- The glued gland and watertight connections
- Hand mounted and thus not scalable
- Non robust
- Transparent cap and different materials
- Mounting the device to any surface
- Future perspective adding more functions
- Everything internal (incl. antenna)

The conclusion is that the MicroRouter needs to be designed. Most critical points are related to the off the shelf box. This casing is causing many problems for the different users of the MicroRouter, from the production up to the end-user. So with a new enclosure all users should be taken in account. The appearance will be important for the customer and the marketing of the product.
For the use the connections should be watertight. The antenna is fragile and needs to be supported. In the future perspective there is thought of several changes. For instance changing the two PCB's to one PCB and using larger batteries to make the network wireless.

Reviewing the brainstorm session

Overall the brainstorm was received positively. The participants thought it was interesting and had a good set up. But there were also things to improve. The first step in the brainstorm took too much time. There was a lot of discussion by placing the images. It was useful letting the participants think about what is beautiful/ ugly and functional /non-functional, but it could have been shorter. In the future with less discussion the axis can be filled more. Placing ambient in the axis was hard because only the SmartPoint is designed. The discussion developed what caused that the set up of the brainstorm was not followed. Here the session leader could have stepped in to take control and lead the brainstorm session. What could have helped were more specific questions. The last step of the session was also not that organized. Direct questions could have helped here too.

2. Concepts

2.2. Antenna Specifications

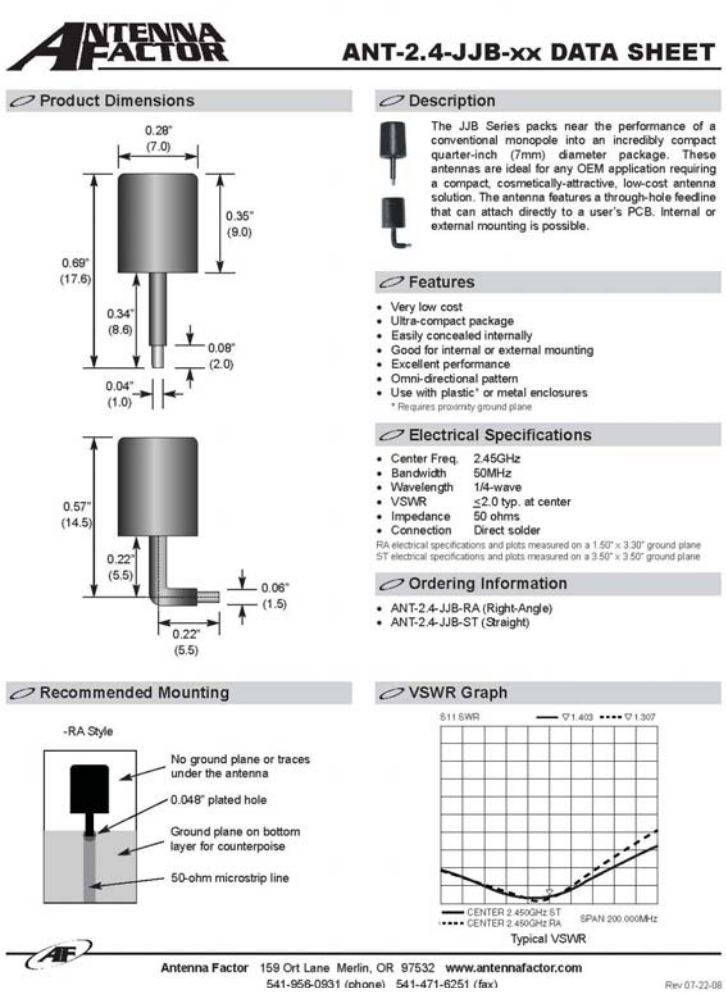


Figure 2-2 Cylindrical Antenna specifications

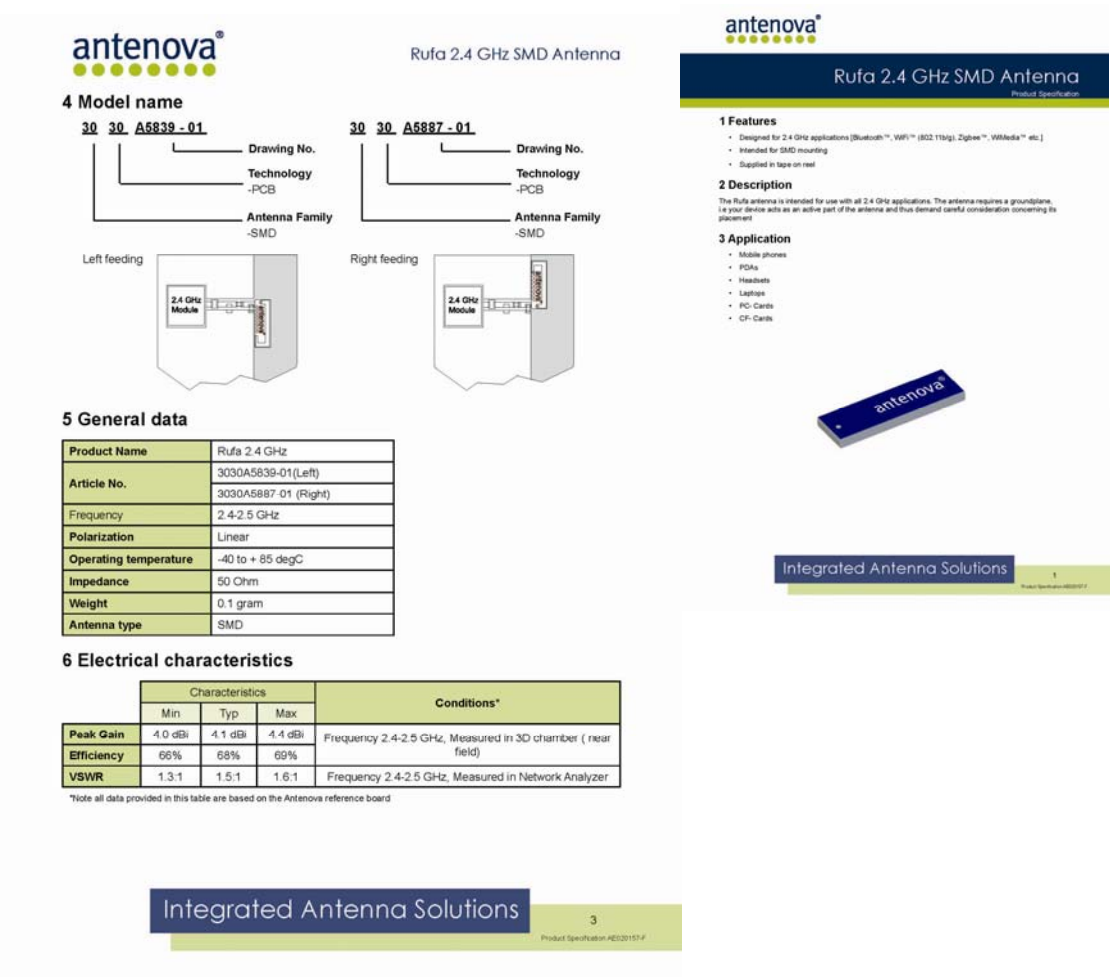
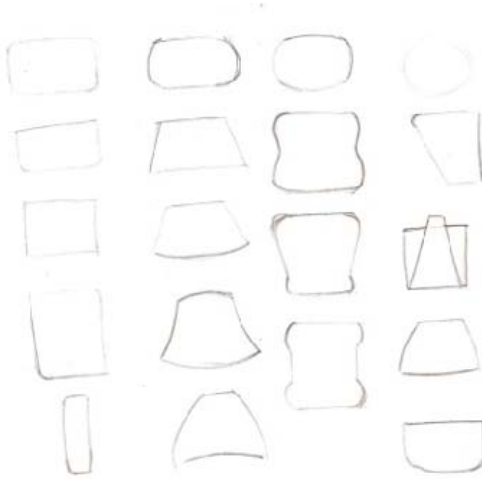
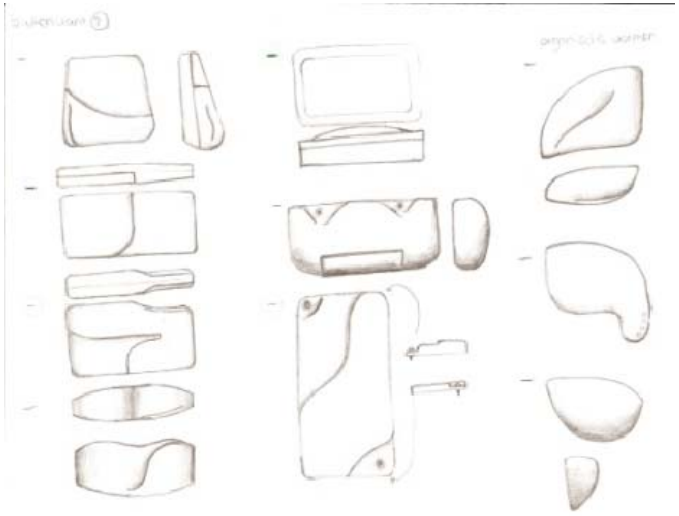


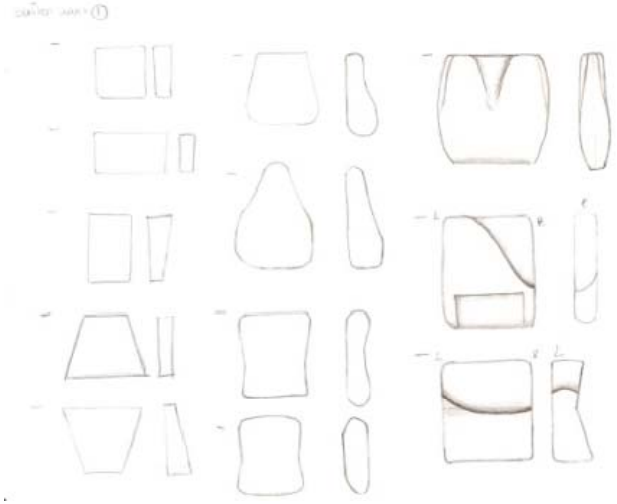
Figure 2-1 Block Antenna Specifications

2.3. Sketches

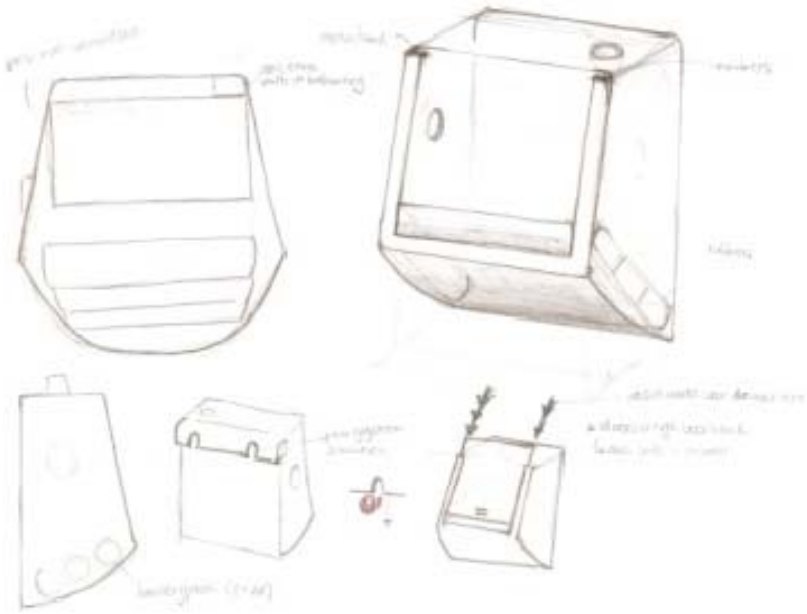
2.3.1. Shape sketches

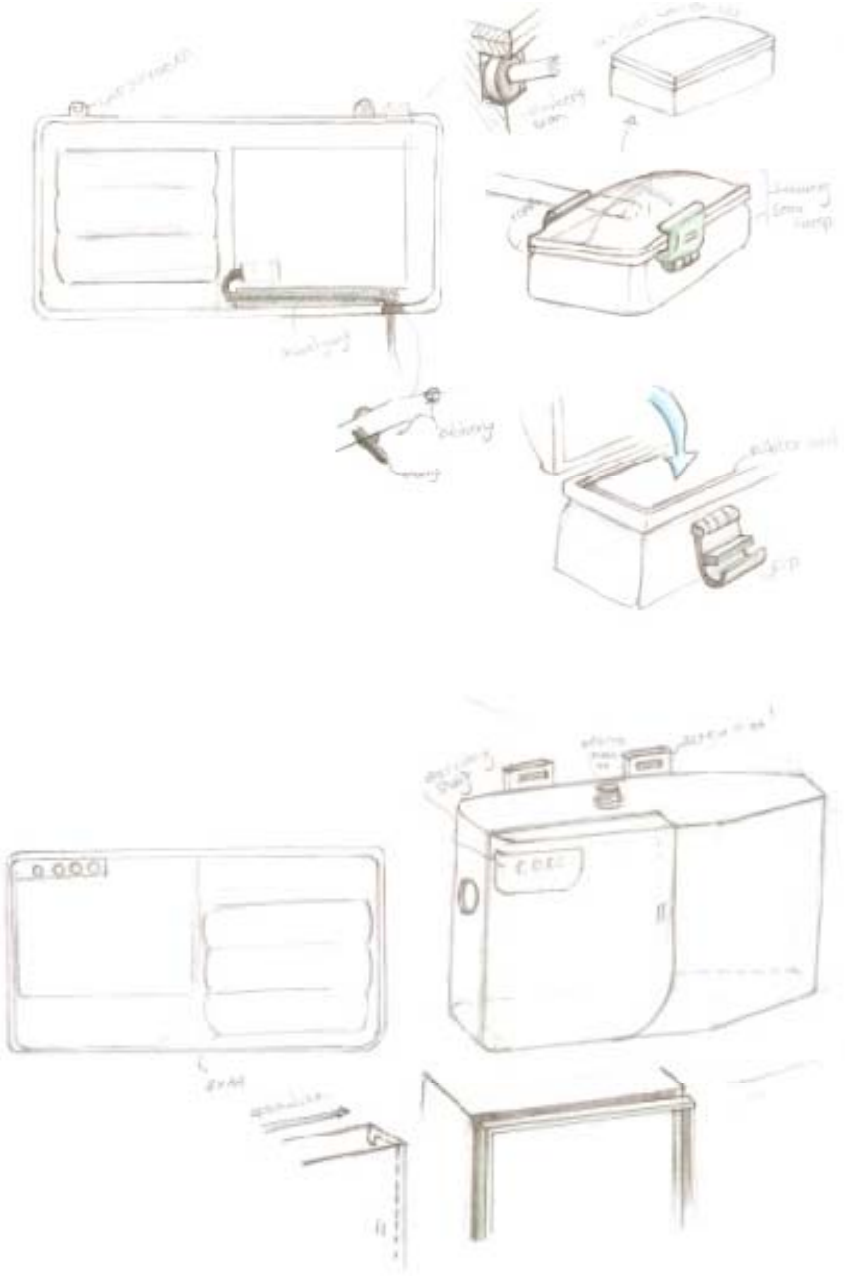






2.3.2. Concept ideas





2.4. Survey

Concepts were created by combining the different ideas and sketches. In a survey the opinion of the employees of Ambient Systems was asked. The opinion of the employees resulted in a better view on the ambient look. All expertise in the company was used. After a short presentation I asked their opinion. Five concepts were hung in the hallway for several days to give the employees the chance to take a look. There was asked to rate and give their opinion about the concepts on paper.

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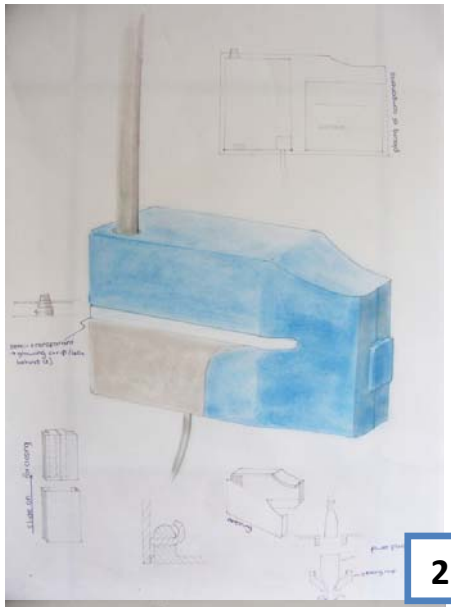

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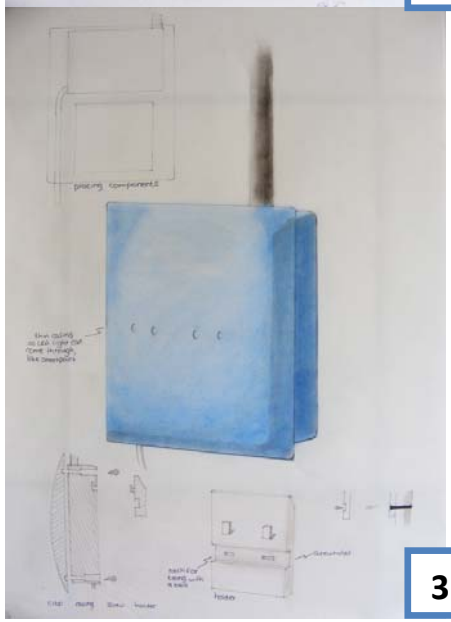

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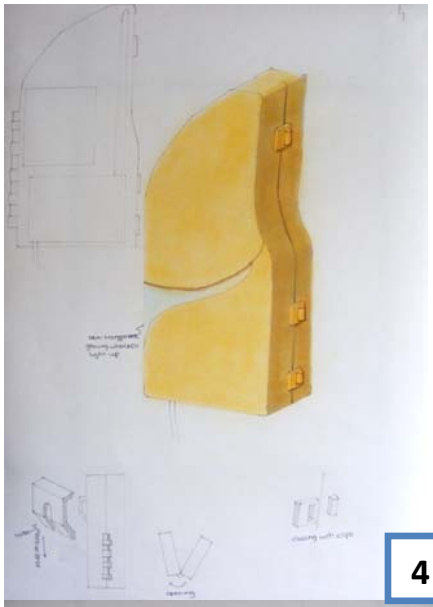

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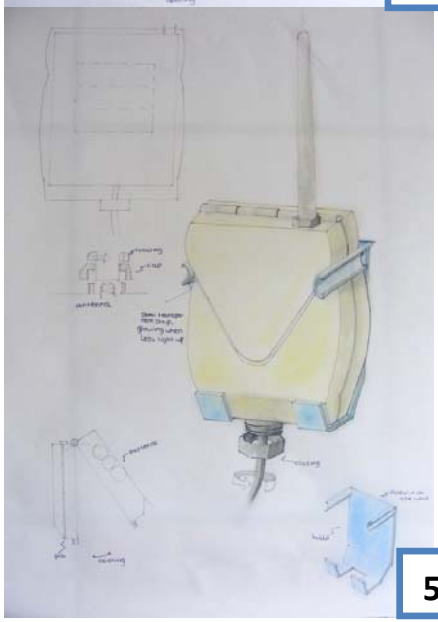


5

The response were ten reactions on the concepts. The reactions differed from an elaborated one page report up to a rating for all MicroRouters.
The responses pointed out positive and negative things on the MicroRouter concepts. In the table below the most common and most notable responses are put down.

+		-	
No 2	Also usable as Gateway (shape)	**No 1**	To little mounting casing not tight
No 3	Producibility and simple	**No 1**	Rotating closing system
No 4	Antenna inside	**No 3**	Enough light trough casing?
No 5	Cap on antenna	**No 3**	Mounting system (an extra part and not sturdy enough)
No 2/4/5	LED strip	**No 3/4**	Space behind MicroRouter attracting dust and dirt
No 2/3	The blue colour	**No 4**	Latches (watertight?)
		No 4	Placing batteries nearby antenna and PCB
		No 5	Swivel for closing (watertight?)
		No 5	Hinges (dislike the look)
			MicroRouter doesn't need to be opened much
		No4/5	Yellowish colour

Ideas	
	Bring back shape of SmartPoint in MR
	Instead of the two colours, one colour with on the bottom a silver label

Table 2-1 Survey results

2.5. Concepts ideas

2.5.1. Foam shapes

2-1 concept 1-1 (2x)

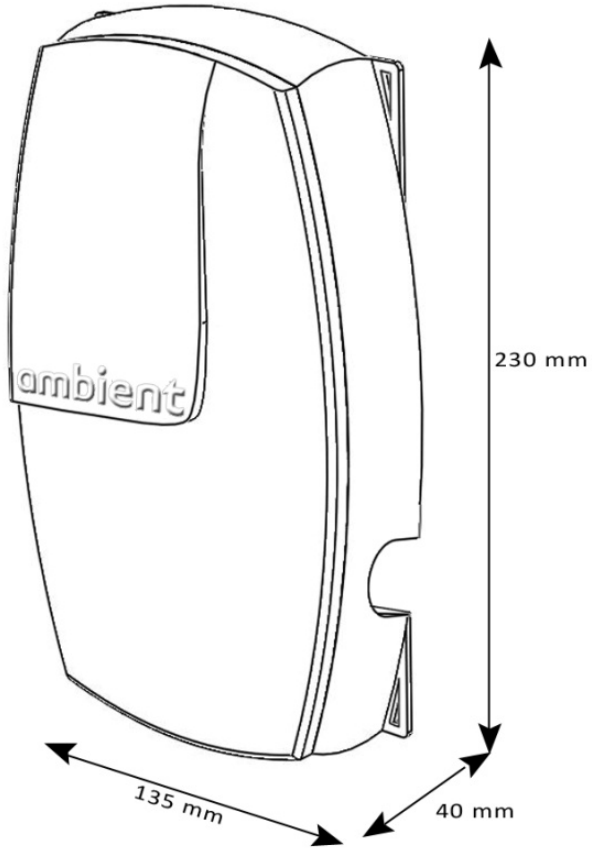
1-2 concept 1-2

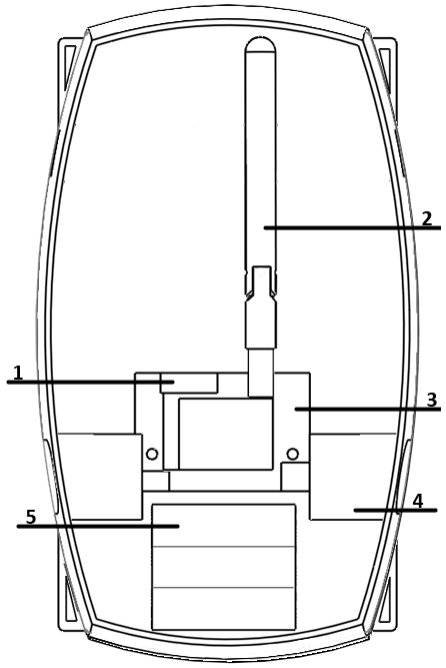
1-3 concept 2-1 (3x)

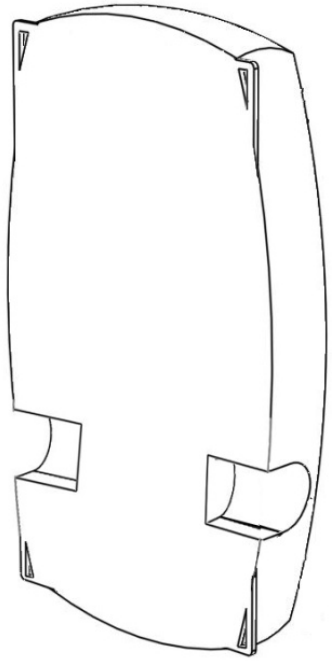
1-4 concept 2-1 (2x)

1-5 concept 2-2 (3x)

2.5.2. Concept 1-1

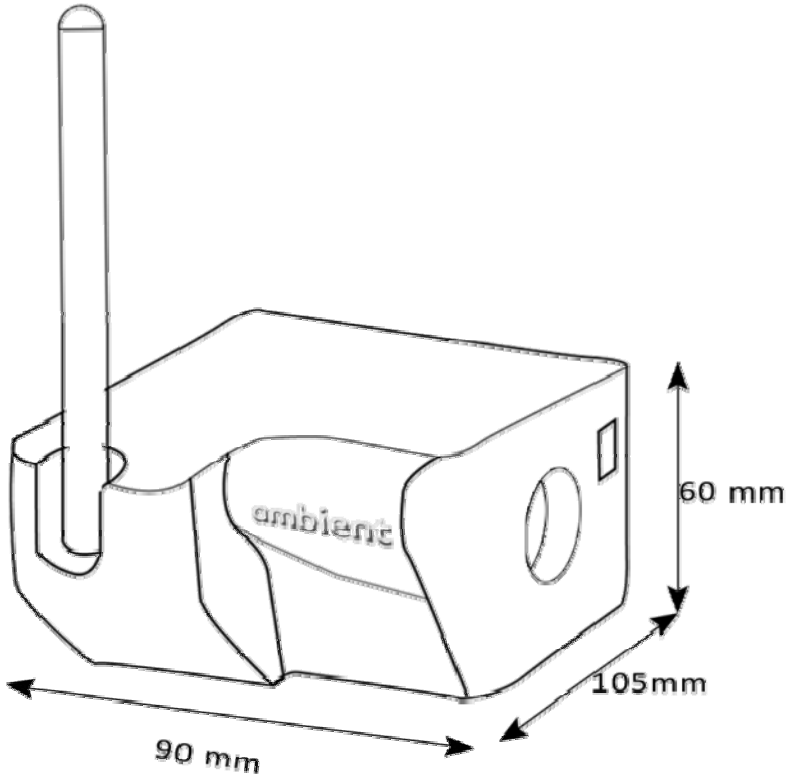


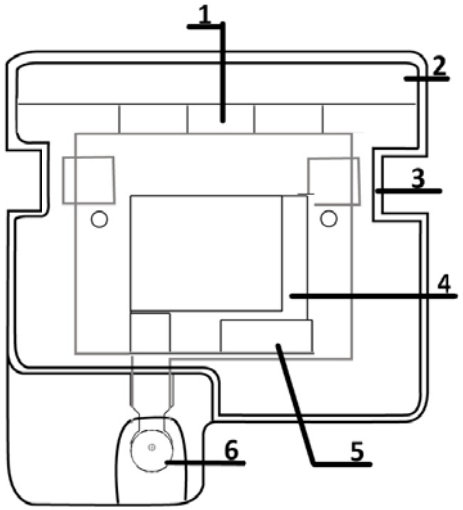


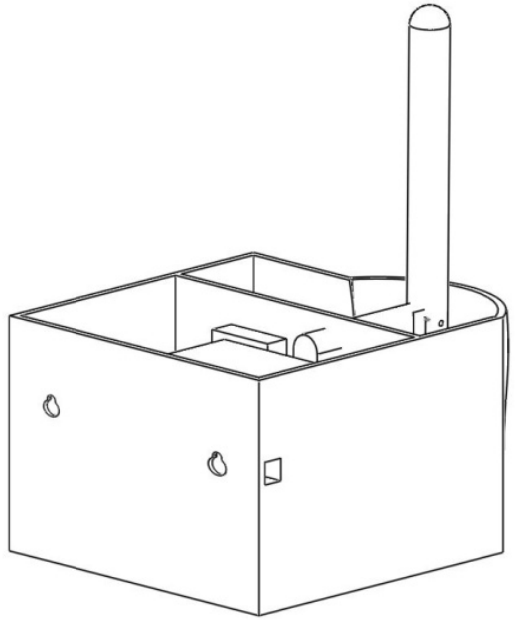


Numbers	Parts
1	LEDs
2	Antenna
3	PCB
4	Tube
5	Batteries

2.5.3. Concept 1-2

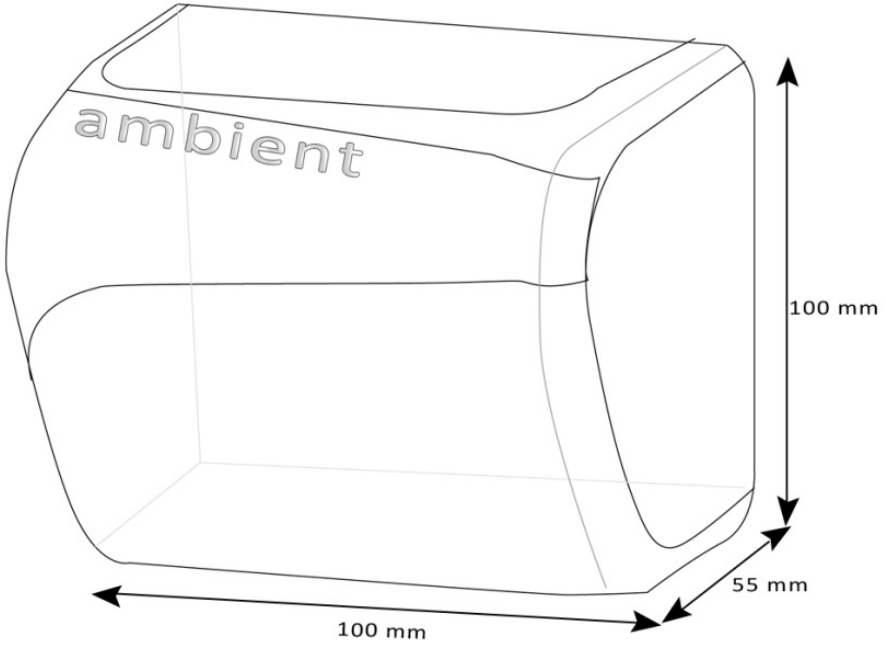


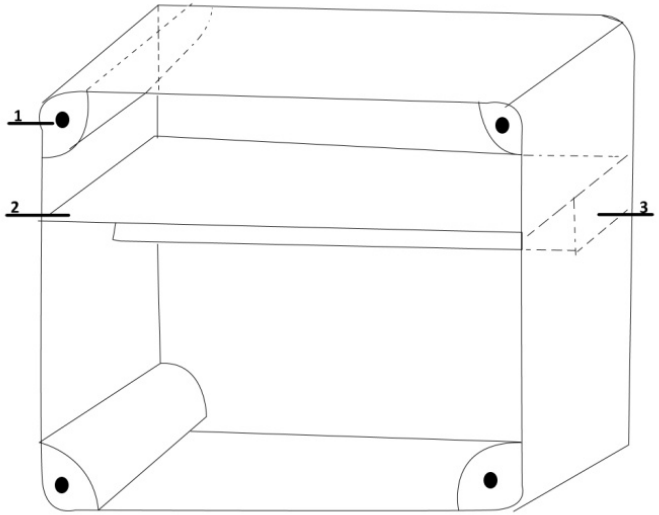


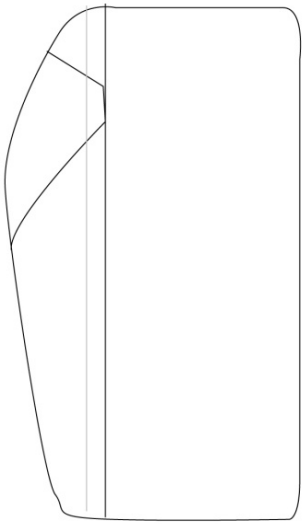


Numbers	Parts
1	Batteries
2	Mounting tube
3	Tube
4	PCB
5	LEDs
6	Antenna

2.5.4. Concept 2-1

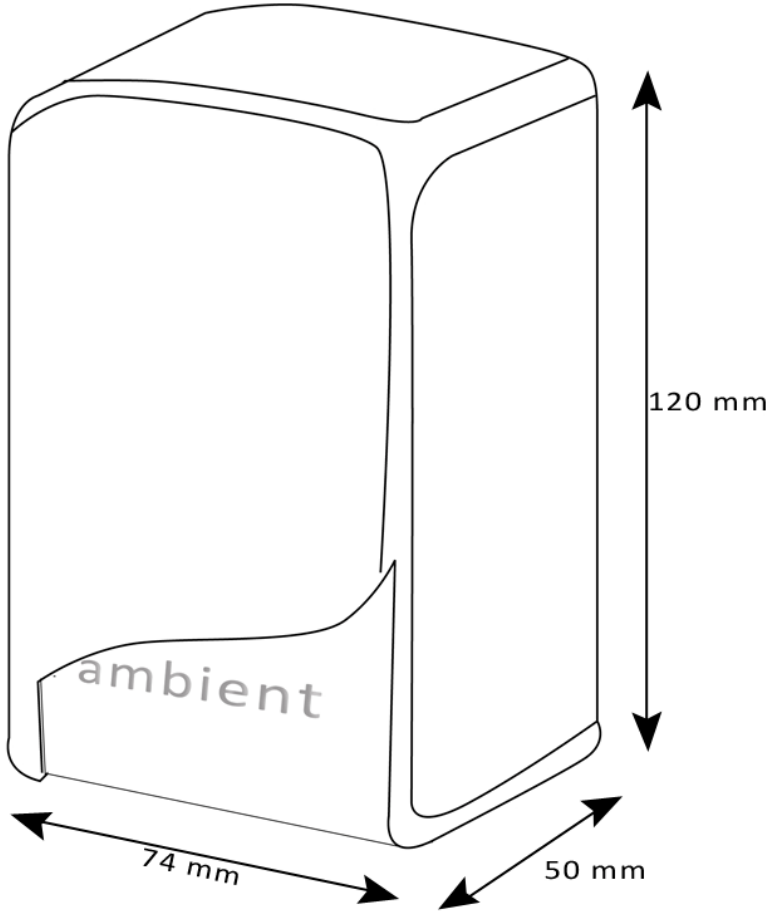


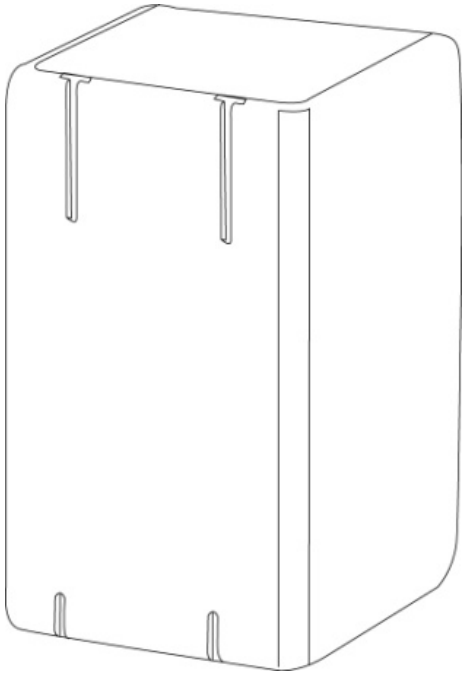


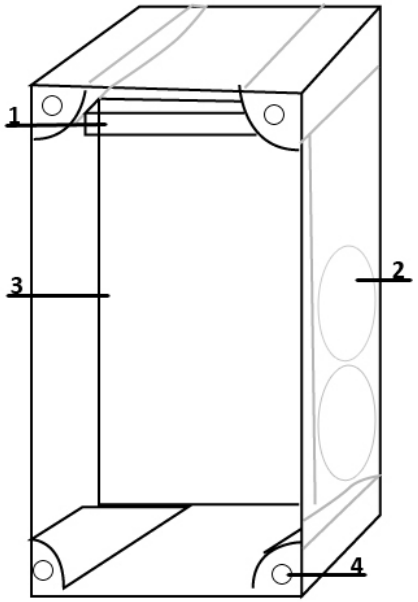


Numbers	Parts
1	Screw hole
2	PCB
3	Mounting tube

2.5.5. Concept 2-2







Numbers	Parts
1	Antenna
2	Batteries
3	PCB
4	Screw hole

2.5.6. Concept review

In this section the made concepts are reviewed. This will show how well the concepts meet the requirements. The requirements (chapter 2.1.1. in the report) are numbered. These numbers can be found in the first row of the table. In the following columns concepts 1-1, 1-2, 2-1 and 2-2 are listed.
For each requirement the concept is rated. This is done with a + (good), +- (less good) and – (bad). In the first row a '*' indicates the most important requirements.
When 'NA' (Not Applicable) is written down, the requirement does not apply on the concept.

Requirements

Antenna:

1 * Enclosure may not influence the connectivity of the antenna
2 * The antenna needs to be placed vertically in or on the enclosure, for best connectivity
3 * The range and strength of the signal should be maintained.
4 * The antenna should be protected from external influences
5 * The antenna should be stabilized/ supported
6 * Should not be blocked, should be able to transmit radio signals

req	1-1	1-2	2-1	2-2
1	+	+	+	+
2	+	+	NA	NA
3	+	+	+	+
*4	+	-(+)	+	+
5	+	-(+)	+	+
6	+	+	+	+

Comment: the connectivity may be influenced by de casing. Three concepts have the antenna at the inside of the casing. In theory this should not be a problem. But t can be proven with prototyping. Concept 1-2 has the antenna extern. It will be supported but is more vulnerable for influences.

Power connector:

1 * The connection should be water tight
2 * The connection should have enough strength, pulling
3 * Logical orientation of the power connector, at the bottom

req	1-1	1-2	2-1	2-2
*1	+	+	+	+
2	+	+	+	+
3	NA	NA	+	+

Batteries:

1 * There should be room for the battery pack
2 * The battery pack should be stuck or stabile in the casing, cope with vibration
3 * Preferable are bigger batteries

req	1-1	1-2	2-1	2-2
*1	+	+	++	++
2	+	+	++	++
3	-	-	+	+

Comment: bigger batteries can only be put in the new concepts. When the PCB would change also bigger batteries should fit in concept 1-1.

LEDs:

1 * Four LEDs
2 * Visible at all times, not blocked by anything (e.g. casing)
3 * Visible at all times, even from a height and in a dirty environment
4 * Visible when it hangs in a room full of lights

req	1-1	1-2	2-1	2-2
1	+	+	+	+
*2	+	+	+	+
3	+	+	+	+
4	+	+	+	+

Comment: requirement 2 will depend on the material chosen. Requirements 3 and 4 need to be tested to make sure the casing meets the requirement.

PCB:

1 * PCB needs to be supported
2 * Protection of the PCB
3 * A standard PCB should fit in (in a future redesign)
5 * The PCB should be reachable, related to the dip switch

req	1-1	1-2	2-1	2-2
*1	+	+	+	+
2	+	+	+	+
3	NA	NA	+	+
*4	+	+	+	+

Labelling:

1 * A flat surface, were the label should be put on
2 * A standard size label should be used, thermal label
3 * A mark should be placed to locate the power connection and antenna (on casing or label)
4 * Should be visible at all times, regard the serial- and model number

req	1-1	1-2	2-1	2-2
1	+	+	+	+
2	+	+	+	+
3	+	+	+	+
4	+	+	+	+

Comment: all concepts have a surface suitable for a label.

Design:

1 * All current components should fit in
2 * Extra space for adjustments, e.g. the PCB
3 * It should be easily mounted
4 * It should be opened and properly reclosed/ resealed
5 * Ambient logo should be visible, or a private label
6 * Fit in with the other devices in the product series 3000
7 * Not being inferior to products from others
8 * Look and being reliable
9 * The colour should be adaptable for private labelling

req	1-1	1-2	2-1	2-2
*1	+	+	+	+
2	+	+	+	+
3	+-	+	+	+
*4	+	+	+	+
5	+	+	+	+
6	+	+	+	+
7	+	+	+	+
8	+	+	+	+
9	+	+	+	+

Comment: the space for adjustment on the PCB is not extended by concept 1-1 and 1-2. In this case the basis is the current PCB. Adapting the colour will depend on the production and material.

Conditions:

1* Various temperatures, -40˚C to +85˚C
2* Humidity (0 – 100 % RH) and dust, IP65
3* Preferable IP67
4* Easy to clean
5* Sturdy, should survive a rough trip

req	1-1	1-2	2-1	2-2
*4	+	+-	+	+
*5	+	+-	+	+

Comment: Requirement 1 depends mainly on the materials. This will be determined later. Requirements 2 and 3 cannot be checked at the moment. This should be done with prototyping.

3. Final concepts

3.1. Interview with injection moulding expert

Date: 11 march
Time: 9 o'clock
Interview with: Richard van Ringen
(chief engineer)
Company: Reobijn, plastic products, Haaksbergen.

Reobijn is a injection moulding company. This company is specialized in developing and producing plastic products. They supply plastic semi-manufactures and end products to a broad range of customers in business sectors like the car manufacturing and food industry, packaging branches, as well as the sanitary and heating sector for very diverse applications.
Richard van Ringen is.

Questions were prepared and Richard already viewed these before the interview. In a conversation with Richard the questions were answered.
The topics of the questions I had were material, production and specific questions on the ideas I had made. The answers are in the texts on materials and production in this report.

Material

Q:Two materials were suggested, ABS and HDPE, but are these materials suitable in this case? which material is best applicable? And what are the costs, is than one more preferable than the other?
A: Richard said ABS will be preferable. This material is more suitable in this case, because it has a better appearance than HPDE. HDPE is more used for crates and things like that. The price will not be a problem because of the amount of products.

Q: is there a semi-transparent variant of ABS? Maybe with a sertain thickness or colour? Or is another material more suitable?
A: Abs can be semi-transparent so some light will come through. But this needs to be experimentally determined. A good option for this is a Polycarbonate. This material is often used for light purposes. There are some variants which are clear or semi-transparent. Some materials for light purposes have added materials (flakes in this case) which improve and guide the light emission. The PC with flakes is more expensive but for small parts affordable.

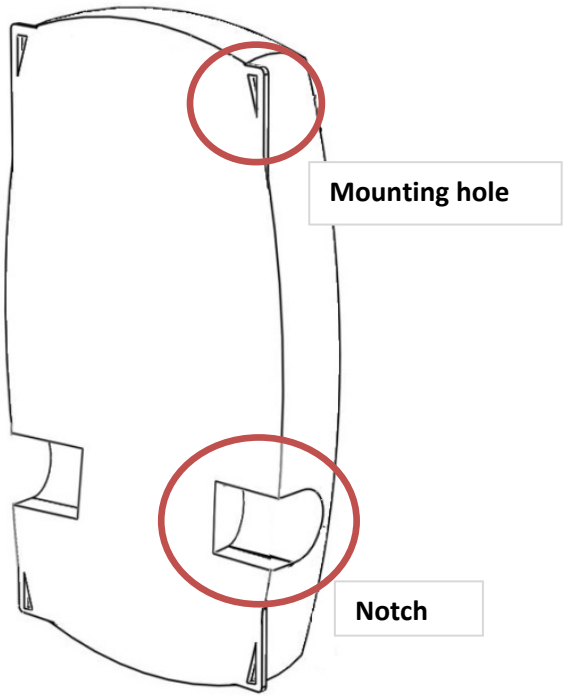
Q: How can a semi-transparent component can be added to the casing? Is 2-k moulding an option? And if it is a loose part how can this be mounted?
A: When the same materials are used ultrasonic welding is possible. If there are two different materials used it can be glued in. In this case 2-k moulding is a too expensive option. The amount of products is too small to have benefit from it. The lens can also be put in during the injection moulding process, this will increase the leap-time.

Production

With developing ideas the injection moulding process is been taken in account. Though I have some questions about the production.

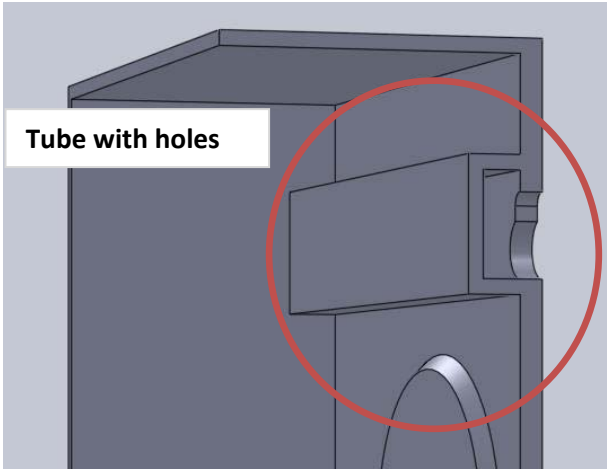
Q: The casing is build up from two parts which will be mounted together. A slot for a rubber sealing is needed to make it watertight. What kind of rubber can be used?
A: There are different materials used for this purpose, silicon and rubbers. It can both be used in this case. There are also applications made of these materials. A o-ring or another profile can be used. A profile can also be punched out a rubber or silicone mat. The profile matches the profile of the slot. For larger productions a flexible rubber or silicone can be injected into the slot where it hardens.

Q: In figure 2 an idea for the casing is presented. The notches at the bottom of the casing, are they injection mouldable?
On the four corners holes for mounting are visible. Can these be injection moulded? Or has is need to be drilled in after injection moulding?
A: The notches can be injection moulding, using sliding cores.
The holes in the four corners are too small for injection moulding. There is a big change that a membrane remains after the injection moulding. Then extra works needs to be done. The best way will be drilling it in afterwards. The thickness of the material cannot be made too thin, otherwise it will break easily.

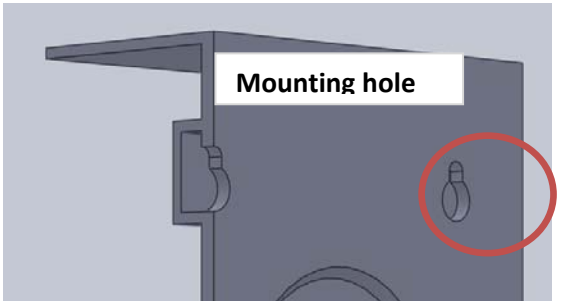


3-1 Back of the casing with notches and mounting holes

Q: in figure 3 and 4 and idea is presented for mounting. In the back a tube is placed with holes for screws. The casing will rest on the screws and can be taken of easily.
Can this be injection moulded with for example a sliding core? Can these holes be injection moulded?
A: It is more easy to make the tube open at the back. This way it is more easy to injection mould it. Also the holes should be opened. This makes the mould less complicated.



3-2 Tube inside the casing



3-3 Back of casing

Q: Another idea is to make four slots at the back of the casing, see figure 5. The screws fit in the T profiled slots.
Can this be injection moulded? Are there problems that you need to be aware of?
A: This not a good mounting option. To injection mould this sliding cores are needed, but because these slots are so small it is hard to injection mould. It is likely that problems will occur.

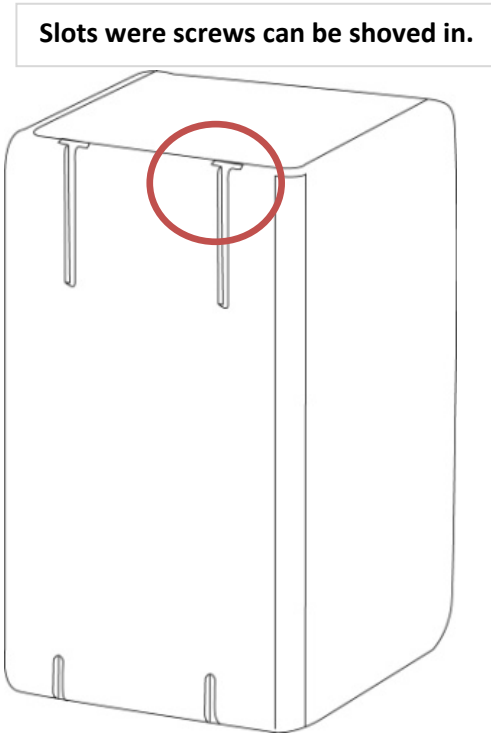
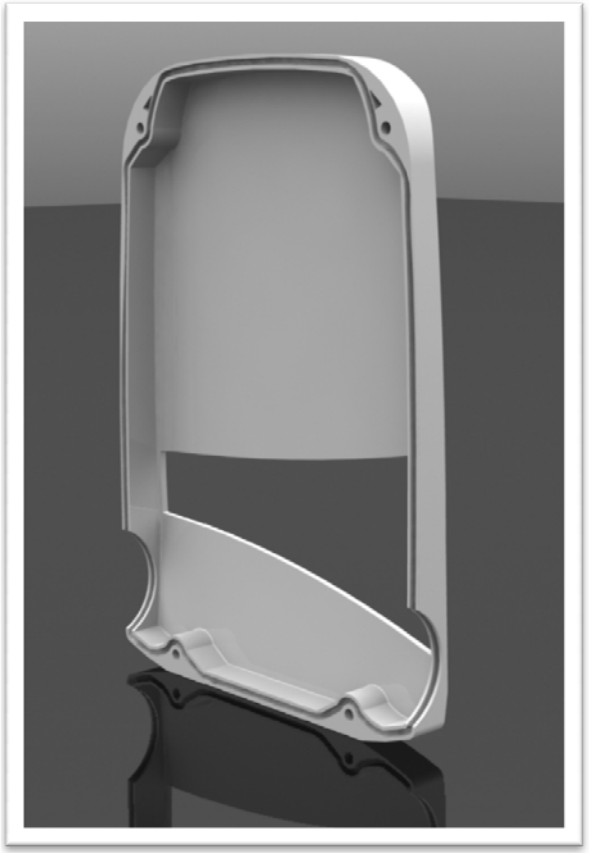
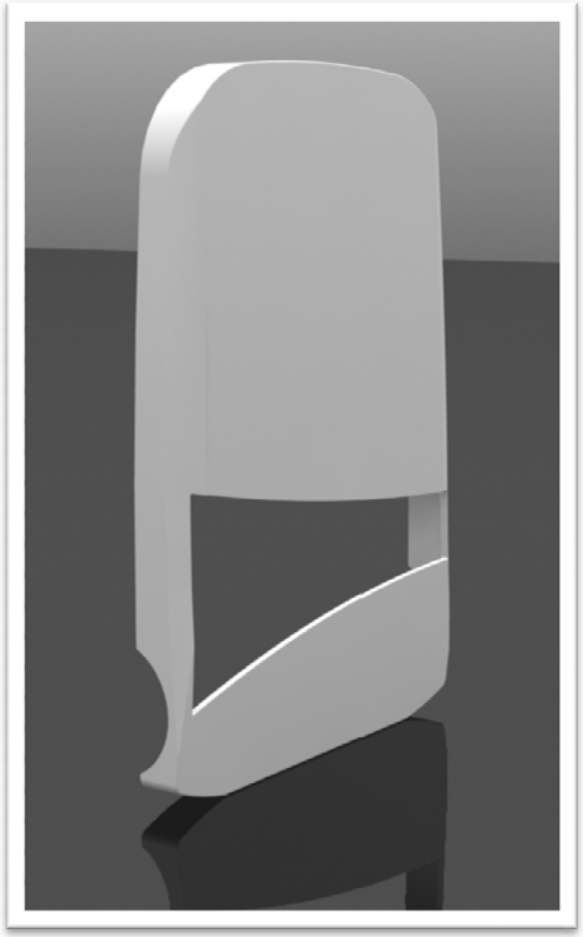
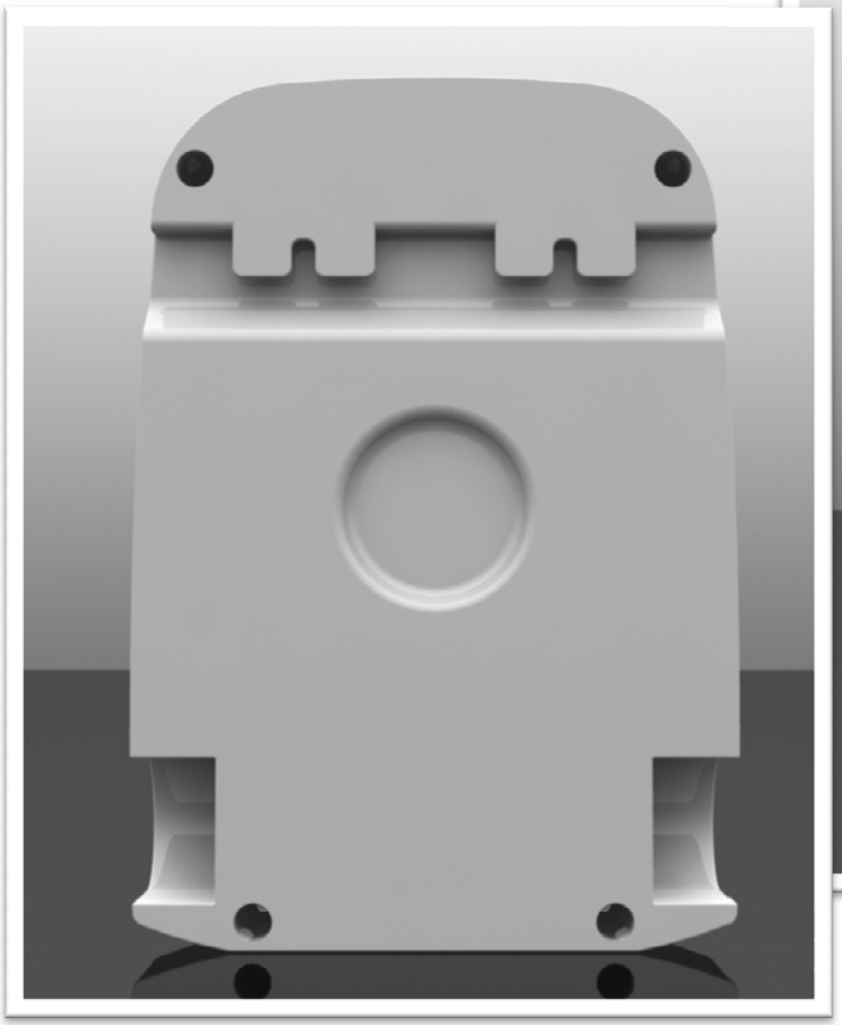


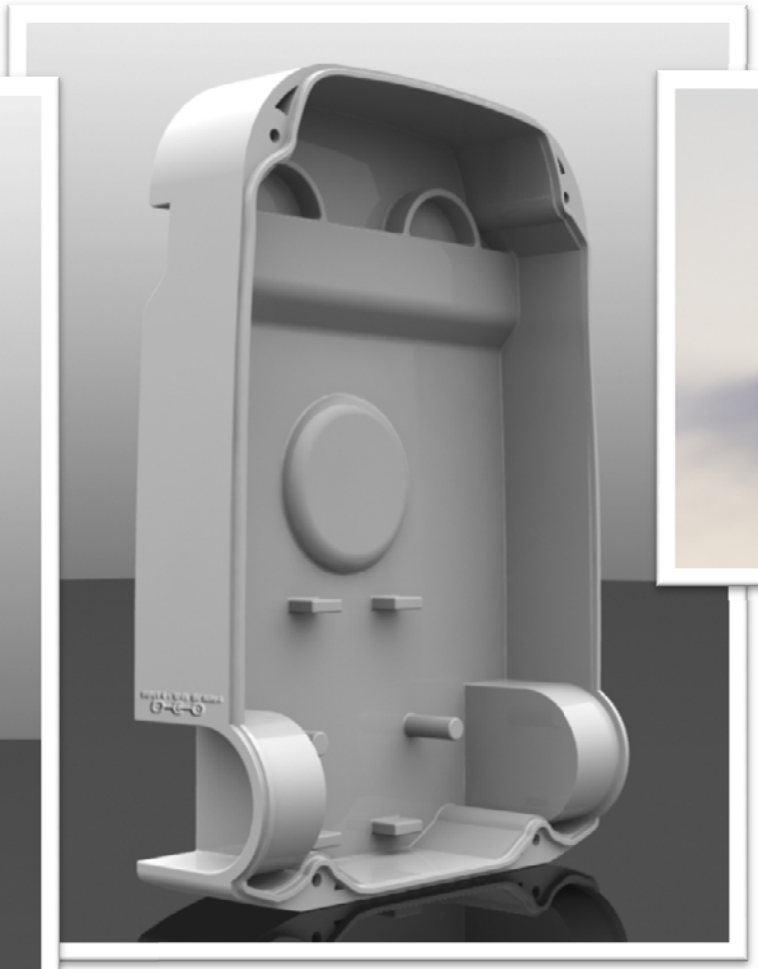
Figure 3-4 Slots on the back of a casing

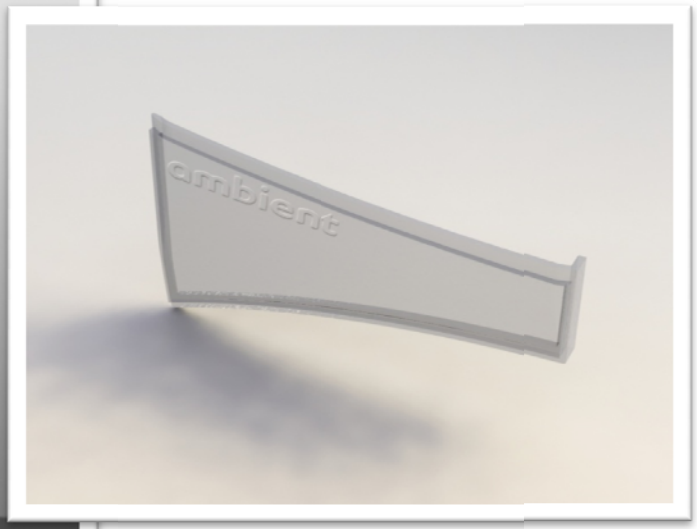
3.2. Final Concept 1-1



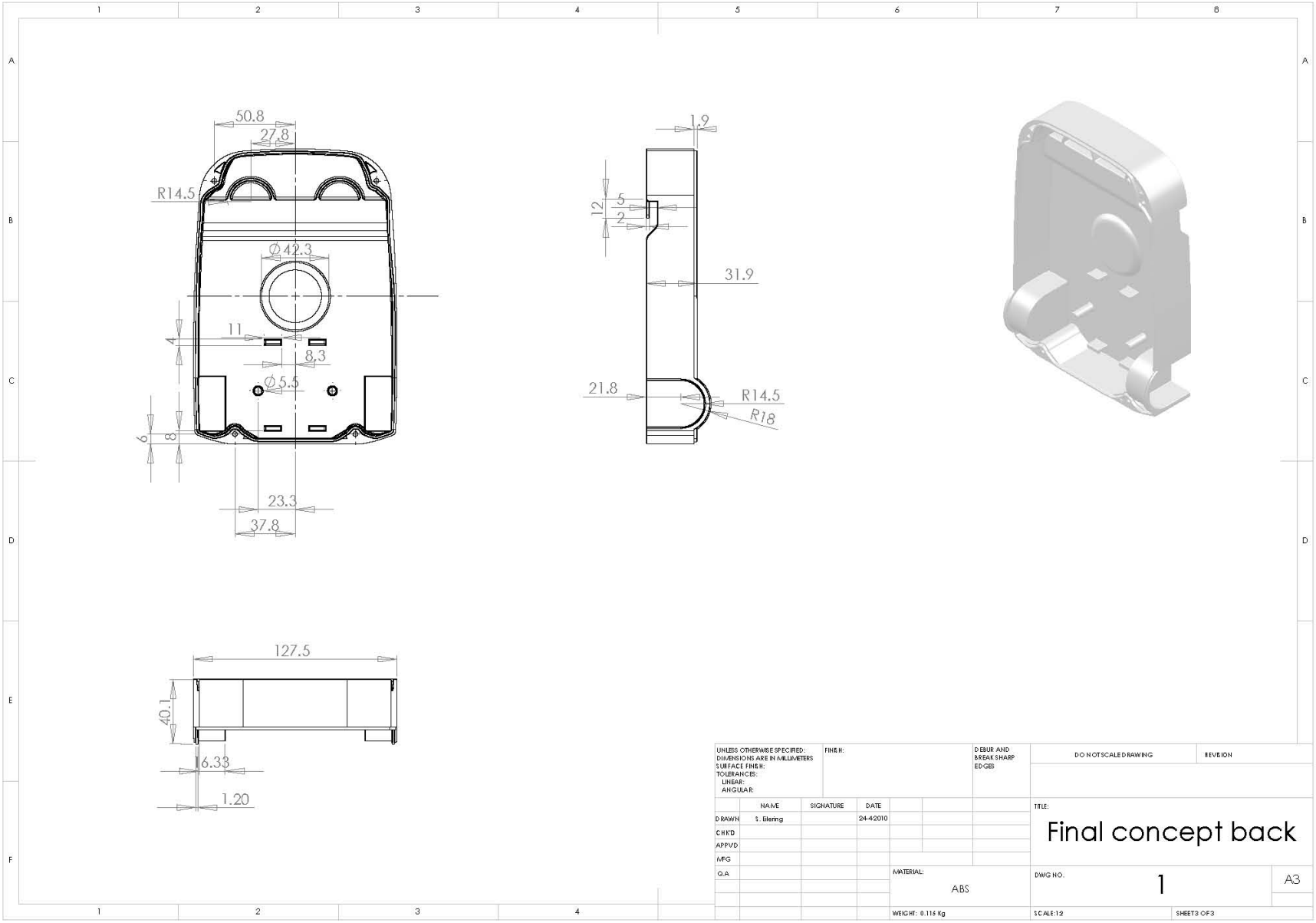


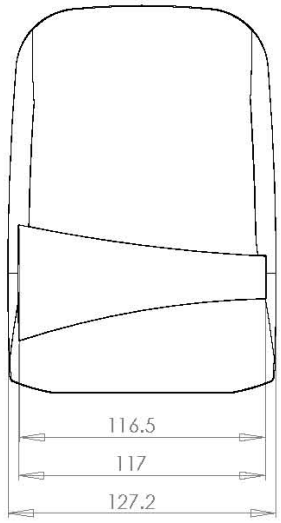


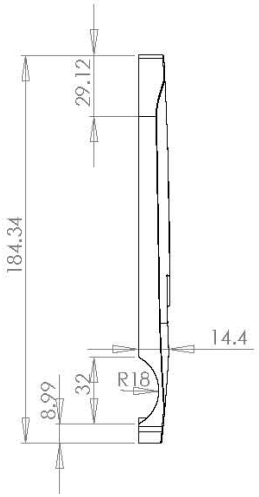


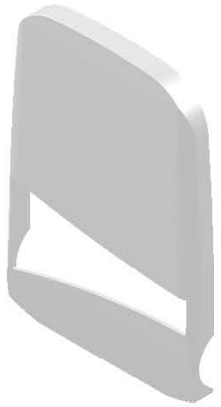

ambient

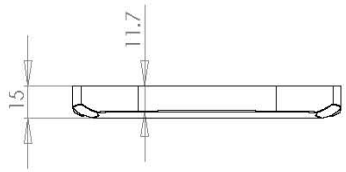
3.2.1. Technical drawings



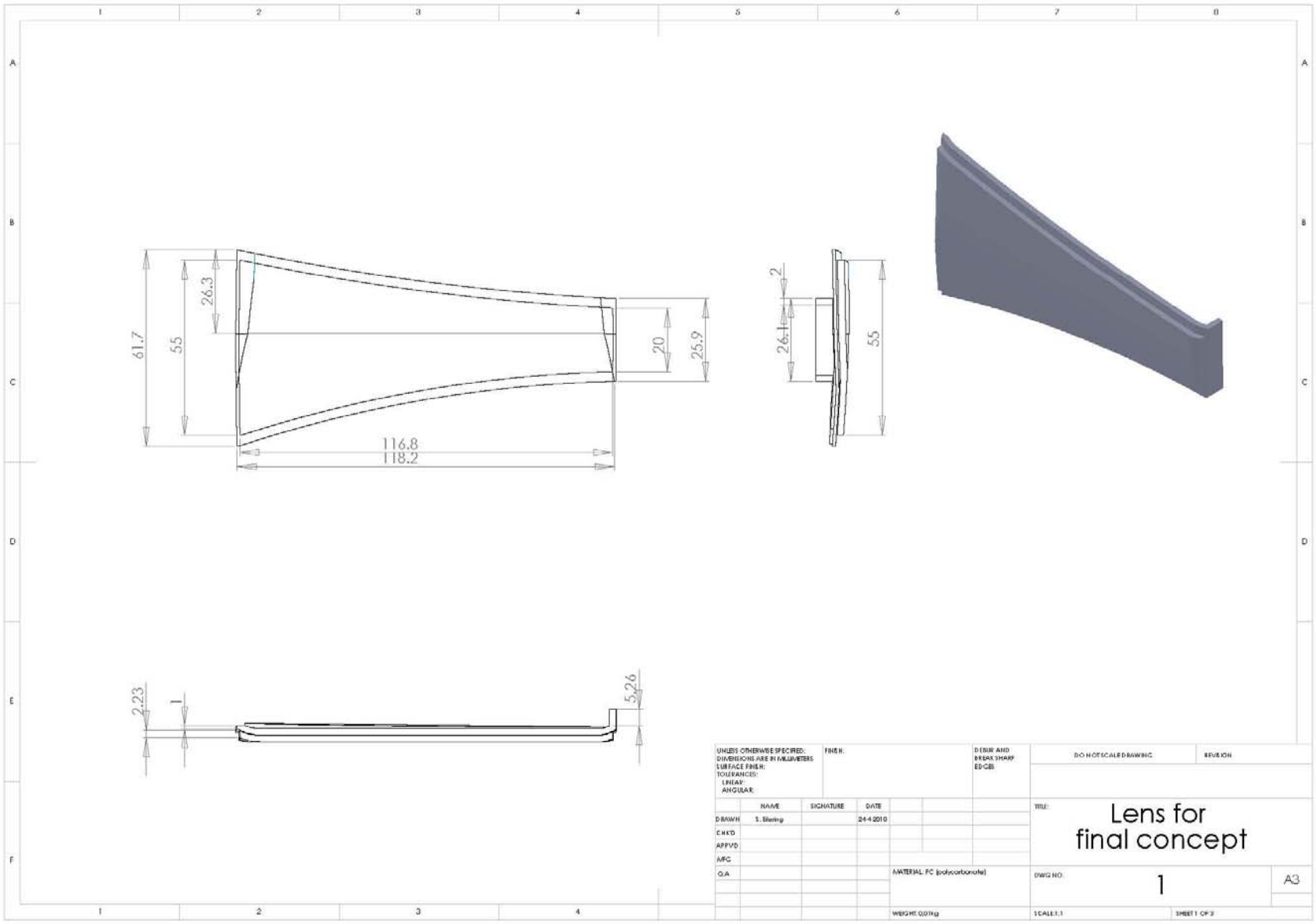








UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:		FINISH:		DEBUR AND BREAK SHARP EDGES		DO NOT SCALE DRAWING	REVISION
	NAME	SIGNATURE	DATE			TITLE:	
DRAWN	S. Ellering		24-4-2010			Final concept top	
CHK'D							
APP'VD							
MFG							
Q.A				MATERIAL: ABS		DWG NO. 1	A3
				WEIGHT: 0.061 Kg		SCALE:1:2	SHEET 2 OF 3


61.7
55
26.3
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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBUR AND
BREAK SHARP
EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
DRAWN
S. Blering
24-4-2010
CHKD
APPVD
MFG
Q.A
MATERIAL: PC (polycarbonate)
WEIGHT: 0,01kg
TITLE:
Lens for
final concept
DWG NO.
1
A3
SCALE:1:1
SHEET 1 OF 3

3.2.2. Material

In all designs the LED lightning will shine through the casing. To achieve this semi-transparent material is needed. Entirely transparent material is not preferred because then the inside and so the electronics can be seen. There are several options to achieve this. This is discussed with an expert.
A thinner part in the material could be a solution. In this case also the material is very important. Not all materials are suitable for showing LED light. The colour will influence brightness of the light. With a dark colour the light will be blocked more than with a light one.
The material properties of ABS cause that the material is never clear. It will always be a milky white. When ABS will be used there can not be said in advance how thick the material should be and whether enough light will come through the material. This should be experimentally determined.

To make sure light will come through the casing another material can be used for the top. There are materials that are often used for LED light purposes. A good material for this application is PC, polycarbonate.
A variant of this material is clear and has flakes which focus and guide the light of the LEDs. It is a strong material which can be used outside and can resist various influences. This material is more expensive than abs. The impact of this material on the costs of this product will not be extremely high. This is because of the small amounts and the relatively small product part. When the top will be made of another material than the rest of the casing it is necessary to have two separate moulds. This will be an investment.

There can also be chosen for an additional part of a different material. The first option is adding an additional part into the design. The advantage is that that part can be made of another material than the casing itself. Therefore a polycarbonate can be used. This material is ideal for LED applications, because it can be clear. In this case a diffusive PC can be used. A name for this material is diffusive PC, Lexan FXD121 (this is the material from a specific brand). This additional part will not be standard and needs to be designed as well. It needs to be separately injection moulded and mounted in the casing later on. For small amounts it is most likely to mount in the part afterwards. This can be done by welding, when the material types are the same if not it can be glued. A more expensive way is to place the part in the mould and mount it by injection moulding. With this small amount of products it is a too expensive method for this application.

Another option is two component injection moulding. In this case two different materials will be injection moulded at the same time. The advantage here is that the connection between the two materials is watertight and strong. Also for the look of the casing is it a pro, because a smooth overlap can be made. This method is more expensive and will not be preferable in this case. Because of the small amount of products and the high cost for this method, it is no interesting option.

3.2.3. Cost calculations

To weigh the options calculations are made. It could be an option to make the whole casing of abs with a thinner part for the LEDs. For now it is no option because there can not be said if it will work. Therefore the options with a front in PC and a front in abs with a lens or small part of PC are compared. In this calculation several cost and numbers are estimated. It results in a preliminary cost estimation (see next page). This result is used to further develop the final concept.

kostprijs matrijzen (onder voorbehoud; volgens methode Maillard)

complexiteit matrijs:	niet-gecompliceerd			complexiteit matrijs:	gecompliceerd			complexiteit matrijs:	zeer gecompliceerd		
	kosten (€)				kosten (€)				kosten (€)		
voudigheid:	1-voudig	2-voudig	4-voudig	voudigheid:	1-voudig	2-voudig	4-voudig	voudigheid:	1-voudig	2-voudig	4-voudig
opp. vl. cm*2				opp. vl. cm*2				opp. vl. cm*2			
0-10	4,860	8,748	14,580	0-10	10,680	19,224	32,040	0-10	27,540	49,572	82,620
0-16	5,160	9,288	15,480	0-16	11,340	20,412	34,020	0-16	30,660	55,188	91,980
16-25	5,400	9,720	16,200	16-25	12,600	22,680	37,800	16-25	34,380	61,884	103,140
25-40	5,760	10,368	17,280	25-40	13,380	24,084	40,140	25-40	40,020	72,036	120,060
40-60	6,240	11,232	18,720	40-60	14,820	26,676	44,460	40-60	45,180	81,324	135,540
60-100	6,780	12,204	20,340	60-100	16,500	29,700	49,500	60-100	47,640	85,752	142,920
100-160	7,560	13,608	22,680	100-160	18,120	32,616	54,360	100-160	54,660	98,388	163,980
160-225	8,340	15,012	25,020	160-225	20,400	36,720	61,200	160-225	61,800	111,240	185,400
225-400	10,380	18,684	31,140	225-400	25,380	45,684	76,140	225-400	76,620	137,916	229,860
400-625	12,660	22,788	37,980	400-625	30,180	54,324	90,540	400-625	92,040	165,672	276,120
625-900	15,180	27,324	45,540	625-900	34,680	62,424	104,040	625-900	107,760	193,968	323,280
900-1225	17,820	32,076	53,460	900-1225	40,980	73,764	122,940	900-1225	123,060	221,508	369,180
1225-1600	20,520	36,936	61,560	1225-1600	47,220	84,996	141,660	1225-1600	138,720	249,696	416,160
1600-2025	22,860	41,148	68,580	1600-2025	52,500	94,500	157,500	1600-2025	153,900	277,020	461,700
2025-2500	25,080	45,144	75,240	2025-2500	57,360	103,248	172,080	2025-2500	168,300	302,940	504,900

kostprijsschatting matrijzen (op basis van io 82A: construeren in kunststoffen)

Gebruik tabel:

1 Bepaal het geprojecteerde oppervlak (loodrecht op openlopen v/d matrijs) van het product in cm2.
2 Zoek de bijbehorende rij in de tabel.
3 Schat de mate van complexiteit van de matrijs(toleranties, oppervlaktestructuren, schuiven e.d..)
4 Kies de benodigde voudigheid (aantal producten per matrijs).
5 Zoek nu de bijbehorende kolom.
6 Op het kruispunt van rij en kolom staat de schatting van de matrijskosten.

matrijs-euro(1).xls

Table 3-1 Mould cost estimation

KOSTPRIJSBEREKENING per 100 stuks | **SAXION HOGESCHOOL ENSCHEDE** INDUSTRIEEL PRODUCT ONTWERPEN (GvH) | 3/19/2010

Product: | Student: | gele velden invullen

onderdeel			materiaal per 100					bewerking per 100				investering per 100							totaal
nr	naam onderdeel	aantal per produkt	kilogram per 100 stuks	€/kg	subtotaal C=A*B	met uitval en afval D= C*(1+%)	met materiaal toeslag E=D*(1+%)	cyclustijd in seconden	man/machinekosten per uur	aantal stuks per cyclus	bewerkingskosten J=F*G/ 36/H	gereedschapskosten	producten /jaar	over ... jaar	afschrijving N=K/(T* L *M)*100	rente O=((K/2*%)/L * T)*100	onderhoud P=((K*%)/L * T)*100	investerings kosten Q= N+O+P	totaal kosten per 100 T* (E+J+Q)
						6%	9%									6%	8%		
		T	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	
	voorbeeld	2	0.57	1.20	0.68	0.73	0.79	8	14.50	4	0.81	10,000	200,000	3	0.83	0.08	0.20	1.11	5.41
1	bovenkant	1	5.90	3.50	20.65	21.89	23.86	10	75.00	2	10.42	18,000	3,000	2	300.00	18.00	48.00	366.00	400.28
2	bovenkant_gat	1	4.80	1.75	8.40	8.90	9.71	10	75.00	2	10.42	18,000	3,000	2	300.00	18.00	48.00	366.00	386.12
3	onderkant	1	10.50	1.75	18.38	19.48	21.23	15	75.00	2	15.63	18,000	3,000	2	300.00	18.00	48.00	366.00	402.86
4	glaasje	1	1.20	3.50	4.20	4.45	4.85	10	75.00	2	10.42	10,500	3,000	2	175.00	10.50	28.00	213.50	228.77
5	bovenkant	1	5.90	3.50	20.65	21.89	23.86	10	75.00	1	20.83	10,000	3,000	2	166.67	10.00	26.67	203.33	248.03
6	bovenkant_gat	1	4.80	1.75	8.40	8.90	9.71	10	75.00	1	20.83	10,000	3,000	2	166.67	10.00	26.67	203.33	233.87
7	onderkant	1	10.50	1.75	18.38	19.48	21.23	15	75.00	1	31.25	10,000	3,000	2	166.67	10.00	26.67	203.33	255.81
8	glaasje	1	1.20	3.50	4.20	4.45	4.85	10	75.00	1	20.83	6,000	3,000	2	100.00	6.00	16.00	122.00	147.69
9	boven_onder	1	16.40	1.75	28.70	30.42	33.16	15	75.00	1	31.25	12,000	3,000	2	200.00	12.00	32.00	244.00	308.41
10	boven_onder_gat	1	15.30	1.75	26.78	28.38	30.94	15	75.00	1	31.25	12,000	3,000	2	200.00	12.00	32.00	244.00	306.19
11	boven_onder	1	16.40	1.75	28.70	30.42	33.16	15	75.00	2	15.63	22,000	3,000	2	366.67	22.00	58.67	447.33	496.12
12	boven_onder_gat	1	15.30	1.75	26.78	28.38	30.94	15	75.00	2	15.63	22,000	3,000	2	366.67	22.00	58.67	447.33	493.89
13	boven_onder_gat	1	15.30	1.75	26.78	28.38	30.94	15	75.00	1	31.25	22,000	3,000	5	146.67	22.00	58.67	227.33	289.52
14	glaasje	1	1.20	3.50	4.20	4.45	4.85	10	75.00	1	20.83	6,000	3,000	5	40.00	6.00	16.00	62.00	87.69
15		1			-	-	-			1	-				-	-	-	-	-
16		1			-	-	-			1	-				-	-	-	-	-
	montage	1			-	-	-			1	-				-	-	-	-	-
	verpakking	1			-	-	-								-	-	-	-	-
	ontwikkeling	1			-	-	-					-			-	-	-	-	-
	TOTAAL																		######

Table 3-2 Preliminary cost calculation

The results show that a casing from abs with a loose lens/part is most preferable. This idea has the lowest costs per product. It also shows that one mould with both casing parts is the easiest and cheapest way.

mogelijkheden	product prijs bij 5 jaar	product prijs bij 2 jaar en 75
1. bovenkant_pc onderkant_abs 1x	2.86	
2. bovenkant_pc onderkant_abs 2x	4.35	
3. bovenkant gat_abs onderkant_abs glaasje_pc 1x	3.35	
4. bovenkant gat_abs onderkant_abs glaasje_pc 2x	5.02	
5. bovenkant onderkant_abs glaasje_pc 1x	2.57	4.54
6. bovenkant onderkant_abs glaasje_pc 2x	3.89	

Final Concept Costs:

Total costs for the product by injection moulding is:

€ 8,32 (in two years)

€ 2.42 (in five years)

Mogelijkheden	product prijs (Euro's)
1.boven en onderkant 1 matrijs (afschrijving 2 jaar)	5.30
2. bovenkant en onderkant (afschrijving 5 jaar)	1.52
3. glaasje (afschrijving 2 jaar)	3.02
4. glaasje (afschrijving 5 jaar)	0.90
5. bovenkant onderkant + abs glaasje_pc (2jaar)	8.32
6. bovenkant onderkant + abs glaasje_pc (5jaar)	2.42

KOSTPRIJSBEREKENING per 100 stuks								SAXION HOGESCHOOL ENSCHEDE INDUSTRIEEL PRODUCT ONTWERPEN (GvH)									4/26/2010			
Product:								Student:									gele velden invullen				
onderdeel			materiaal per 100					bewerking per 100				investering per 100						totaal			
nr	naam onderdeel	aantal per produkt	kilogram per 100 stuks	€/kg	subtotaal C=A*B	met uitval en afval D= C*(1+%)	met materiaal toeslag E=D*(1+%)	cyclustijd in seconden	man/machinekosten per uur	aantal stuks per cyclus	bewerkingskosten J=F*G/ 36/H	gereedschapskosten	producten /jaar	over ... jaar	afschrijving N=K/(T* L *M)*100	rente O=((K/2*%)/L * T)*100	onderhoud P=((K*%)/L * T)*100	investerings kosten Q= N+O+P	totaal kosten per 100 T* (E+J+Q)	materiaal	prijs per stuk
						6%	9%									6%	8%				
		T	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q			
	voorbeeld	2	0.57	1.20	0.68	0.73	0.79	8	14.50	4	0.81	10,000	#####	3	0.83	0.08	0.20	1.11	5.41		
1	bovenkant_onder	1	17.62	1.80	31.72	33.62	36.64	15	75.00	1	31.25	22,788	3,000	2	379.80	22.79	60.77	463.36	531.25	abs	5.31
2	glaasje	1	1.05	3.00	3.15	3.34	3.64	10	75.00	1	20.83	6,240	3,000	2	104.00	6.24	16.64	126.88	151.35	pc	1.51
3	boven en onder	1	17.62	1.80	31.72	33.62	36.64	15	75.00	1	31.25	22,788	3,000	5	151.92	22.79	60.77	235.48	303.37	abs	3.03
4	glaasje	1	1.05	3.00	3.15	3.34	3.64	10	75.00	1	20.83	6,240	3,000	5	41.60	6.24	16.64	64.48	88.95	pc	0.89

3.2.4. Finishing and Assembly

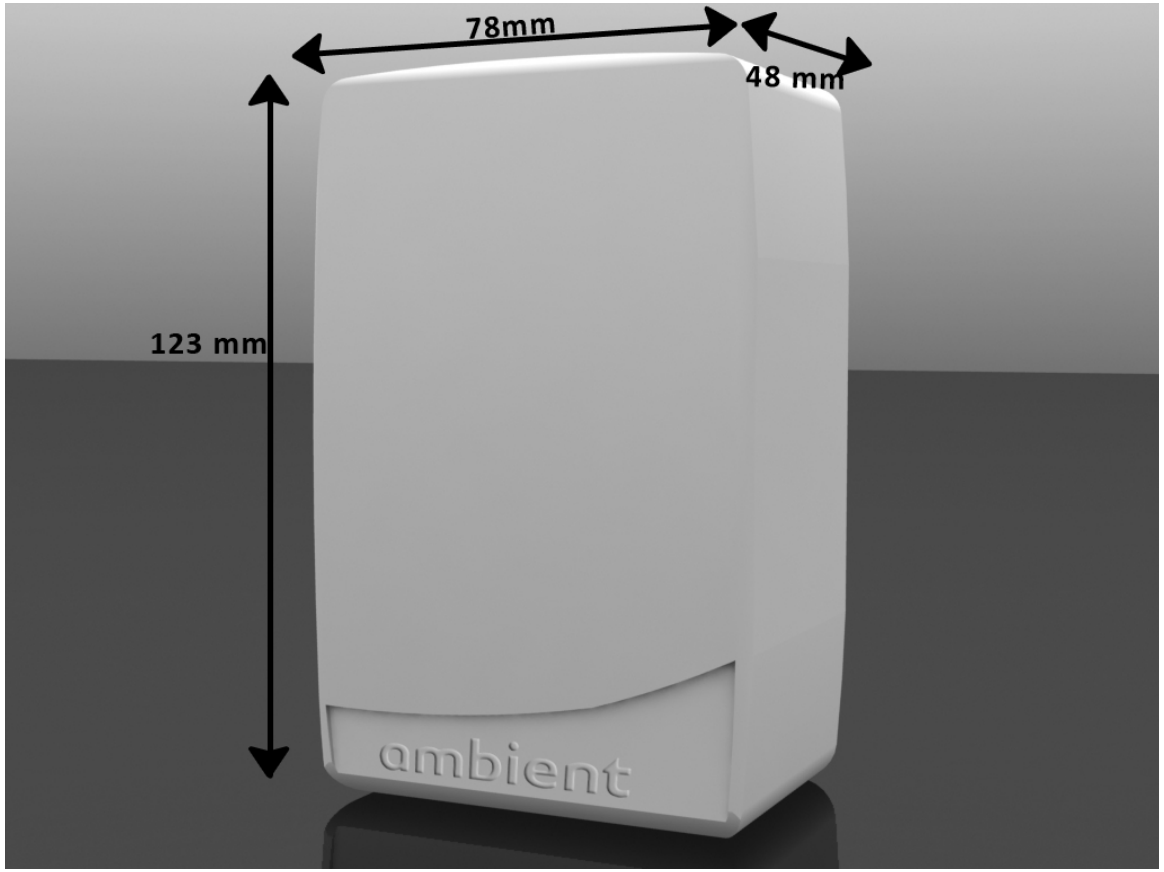
The injection moulding finishing of the casing is needed. Holes need to be drilled in at the sides. By drilling in holes afterwards per casing can be determined if a hole is needed. For the gateway two holes will be needed and only one for the MicroRouter. The size this hole is … so that the current gland fits in.
The lens/loose part has to be mounted in.
The attachment of the top of the casing will be done by screws. Therefore screw threat is needed. This can be done during the injection moulding. But this is very fragile and can not be used too many times.
Therefore an insert need to be placed after injection moulding. This screw threat will last longer and is sturdier. There is also the possibility to place it during the injection moulding. This will lengthen the time needed for injection moulding. For this small amount of casings putting this in by hand is most easy and cheaper. This can be done by tucking it in or screw it in. The insert will hold standard screws. The same screws as in the current model can be used (Ø3.5 mm).
The watertight connection between the top and the rest of the casing will be made with an additional material. There are several material options and shapes. It is smart to use a standard shaped rubber in this case. An O-ring is a standard shaped rubber that can be bought in large amounts. The advantage is that no additional production is needed, it is always available and it can be cut at the right size. Another option is buying a standard O-ring with the right size. The o-ring will be put in by hand after the injection moulding.

Gland size: Tyco electronics anti-vibration nylon locking gland, M16.
Label: Brady thermal transfer printable label, colour white, dimensions: 25.4 mm x 50.8 mm, product number: 236719.

A suggestion for the label is made:

3.3. Final concept 2-2

3.3.1. Dimensions final concept 2-2



3.3.2. Images final concept 2-2

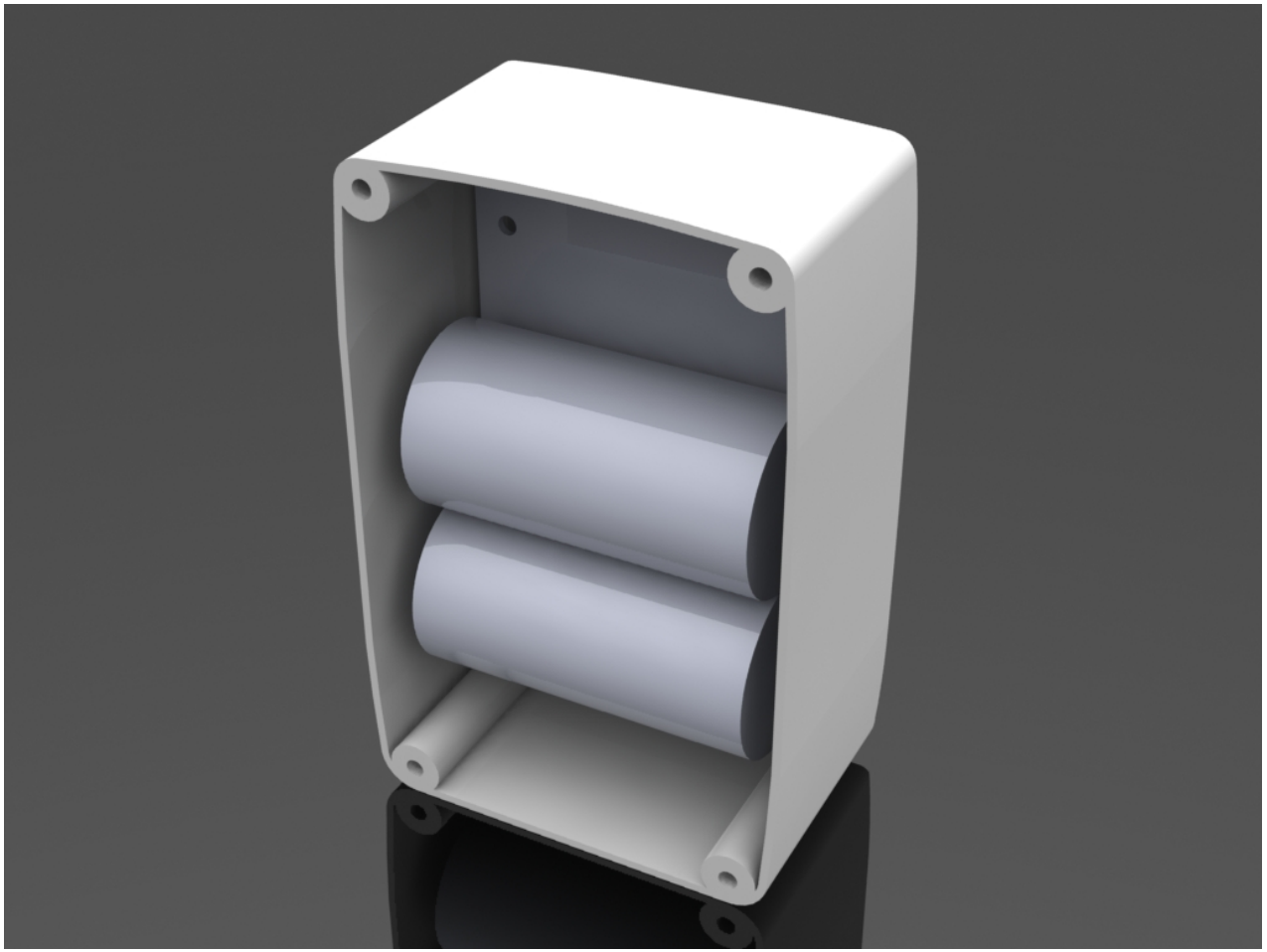


Figure 3-5 Back of final concept 2-2

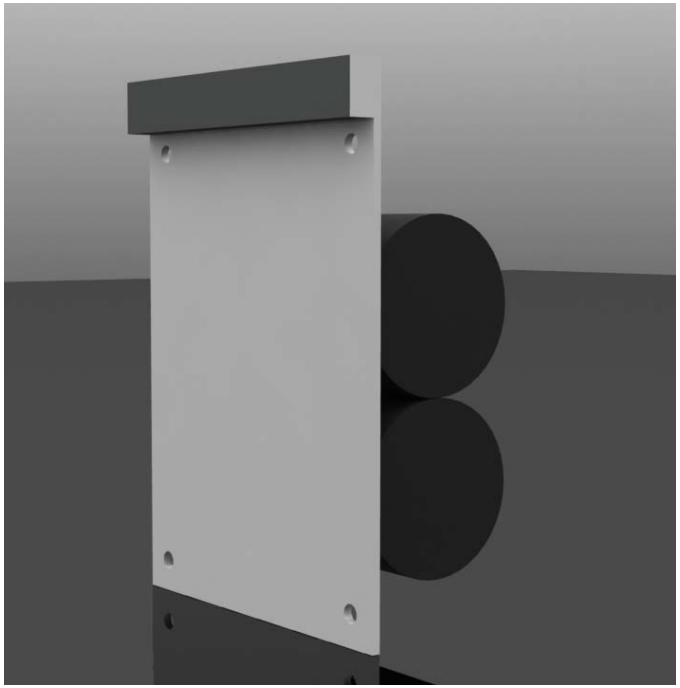


Figure 3-6 PCB and batteries final concept 2-2

3.3.3. Cost estimation final concept 2-2:

Mogelijkheden	product prijs (Euro's)
1.boven en onderkant 1 matrijs (afschrijving 2 jaar)	2.93
2. boverkant en onderkant (afschrijving 5 jaar)	1.71
3. glaasje (afschrijving 2 jaar)	3.02
4. glaasje (afschrijving 5 jaar)	0.90
5. boverkant onderkant + abs glaasje_pc (2jaar)	5.95
6. boverkant onderkant + abs glaasje_pc (5jaar)	2.61

onderdeel			materiaal per 100					bewerking per 100				investering per 100							totaal		
nr	naam onderdeel	aantal per produkt	kilogram per 100 stuks	€/kg	subtotaal C=A*B	met uitval en afval D= C*(1+%)	met materiaal toeslag E=D*(1+%)	cyclustijd in seconden	man/machinekosten per uur	aantal stuks per cyclus	bewerkingskosten J=F*G/ 36/H	gereedschapskosten	producten /jaar	over ..jaar	afschrijving N=</(T* L *M)*100	rente O=((</2*%)/L * T)*100	onderhoud P=((K*%)/L * T)*100	investerings kosten Q= N+O+P	totaal kosten per 100 T* (E+J+Q)	materiaal	prijs per stuk
						6%	9%									6%	8%				
		T	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q			
	voorbeeld	2	0.57	1.20	0.68	0.73	0.79	8	14.50	4	0.81	10,000	200,000	3	0.83	0.08	0.20	1.11	5.41		
1	Future concept	1	6.50	1.80	11.70	12.40	13.52	15	75.00	1	31.25	12,204	3,000	2	203.40	12.20	32.54	248.15	292.92	abs	2.93
2	glaasje	1	6.50	1.80	11.70	12.40	13.52	15	75.00	1	31.25	12,204	3,000	5	81.36	12.20	32.54	126.11	170.88	pc	1.71