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Engenharia do Porto



Interim Report
European Project Semester 2013

PET TRACKER

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European Project Semester
Instituto Superior de Engenharia do Porto
14 de April de 2013

Abstract

Ten million pets are lost every year. A lot of these animals could have been found if they would wear some kind of tracking device. We believe that our product is a solution to this common problem and that it would reduce the number of lost animals.

We have analysed existing products and looked for opportunities to stand out among them. Most of the already existing products only provide tracking features. Therefore we decided to add extra features to stand out among others. This report describes the development process of an activity and tracking system for pets.

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Acronyms





| | | |
|---------|---|--|
| ASK | - | Amplitude Shift Keying |
| CPU | - | Central Processing Unit |
| DSI | - | Display Serial Interface |
| FSK | - | Frequency Shift Keying |
| GLONASS | - | <i>Globalnaya Navigatsionnaya Sputnikovaya Sistema</i> |
| GNSS | - | Global Navigation Satellite System |
| GPRS | - | General Packet Radio Service |
| GSM | - | Global System for Mobile Communications |
| HDMI | - | High Definition Multimedia Interface |
| IEEE | - | Institute of Electrical and Electronics Engineers |
| Li-ion | - | Lithium ion |
| Li- Po | - | Lithium Polymer |
| MCU | - | Microcontroller unit |
| NiCd | - | Nickel–Cadmium |
| NiMH | - | Nickel–Metal Hydride |
| ODM | - | Original Design Manufacturer |
| OEM | - | Original Equipment Manufacturer |
| OOK | - | On/Off Keying |
| PCB | - | Printed Circuit Board |
| Radar | - | Radio Detection And Ranging |
| RAM | - | Random Access Memory |
| RCA | - | Radio Corporation of America |
| RF | - | Radio Frequency |
| RISC | - | Reduced instruction set computing |
| SRAM | - | Static Random Access Memory |
| SWOT | - | Strengths, Weaknesses, Opportunities, and Threats |
| USB | - | Universal Serial Bus |
| USD | - | United States Dollar |

1. INTRODUCTION

Product development and innovation benefit from interdisciplinary educational backgrounds. We are a multidisciplinary project team that can use our different ways of approaching problems to ensure success in our project. Multi-cultural cooperation leads to productivity, “team morale” and a generally good working atmosphere. The European Project Semester will help us improve our engineering and social skills further during this product development.

Our group consists of four students from different countries (Tab. 1):

Table 1 - Team members

| | |
|---|---|
|  | <p>Aleksandra Borzecka</p> <ul style="list-style-type: none">• Poland• Lodz University of Technology• Biotechnology |
|  | <p>Artur Costa</p> <ul style="list-style-type: none">• Portugal• ISEP• Electrical and Computers Engineering |
|  | <p>Anton Fagerström</p> <ul style="list-style-type: none">• Finland• Novia University of Applied Science• Industrial Engineering and Management |
|  | <p>Marti Domenech Gasull</p> <ul style="list-style-type: none">• Spain• Escola Politècnica Superior d'Enginyeria de Vilanova i la Geltrú• Computer Engineering |

1.1 PROBLEM

Develop and design a pet tracking device that complies with the following requirements:

1. Web interface;
2. Display track using Google Maps/Google Earth;
3. On board data storage;
4. Data download Interface;
5. Light, small, portable, wearable device;
6. At least 48 h Power autonomy;
7. Use open source technologies;
8. Comply with the following EU Directives:
 - a. Machine Directive (2006/42/CE 2006-05-17);
 - b. Electrical Safety: Low Level Voltage Directive (2006/95/CE 2006-12-12);
 - c. Restriction of Hazardous Substances (ROHS) in Electrical and Electronic Equipment Directive (2002/95/EC 2003-01-27);
9. Mandatory adoption and use of the International System of Units (The NIST International Guide for the use of the International System of Units)

We wanted to offer something extra in addition to normal GNSS tracking. Since a wide range of products that offer this feature are already available, an additional feature will be included: activity tracking, to ensure that your animal gets enough exercise.

1.2 MOTIVATION

We are pet owners and we would never want our own pets to go missing. This motivates us through the project. We are young engineers who want to put our knowledge into something useful for the world.

1.3 OBJECTIVES

The main objective is to design and develop a pet tracking system, which follows set requirements. Once the main objective is fulfilled, to create a unique environment for the pet owner where functionalities meets the needs, and every user finds whatever he is looking for.

1.4 EXPECTED RESULTS

The product needs to meet the original requirements to satisfy our client, José Barros Oliveira. In addition to these basic features, we intend to offer activity monitoring. The following features will be available:

- Locate your pet with Google maps.
- See the trail of where your pet has gone during the day.
- Monitor your pet's activity to ensure that they get enough exercise to stay healthy.
- Share your pet's activities on social media.

1.5 WORK PLAN

A Gantt chart (Fig. 1) was created to give us a good overview of our project. We also created a task list (Tab. 2) to assign specific tasks to specific team members depending on what they preferred and their previous knowledge.

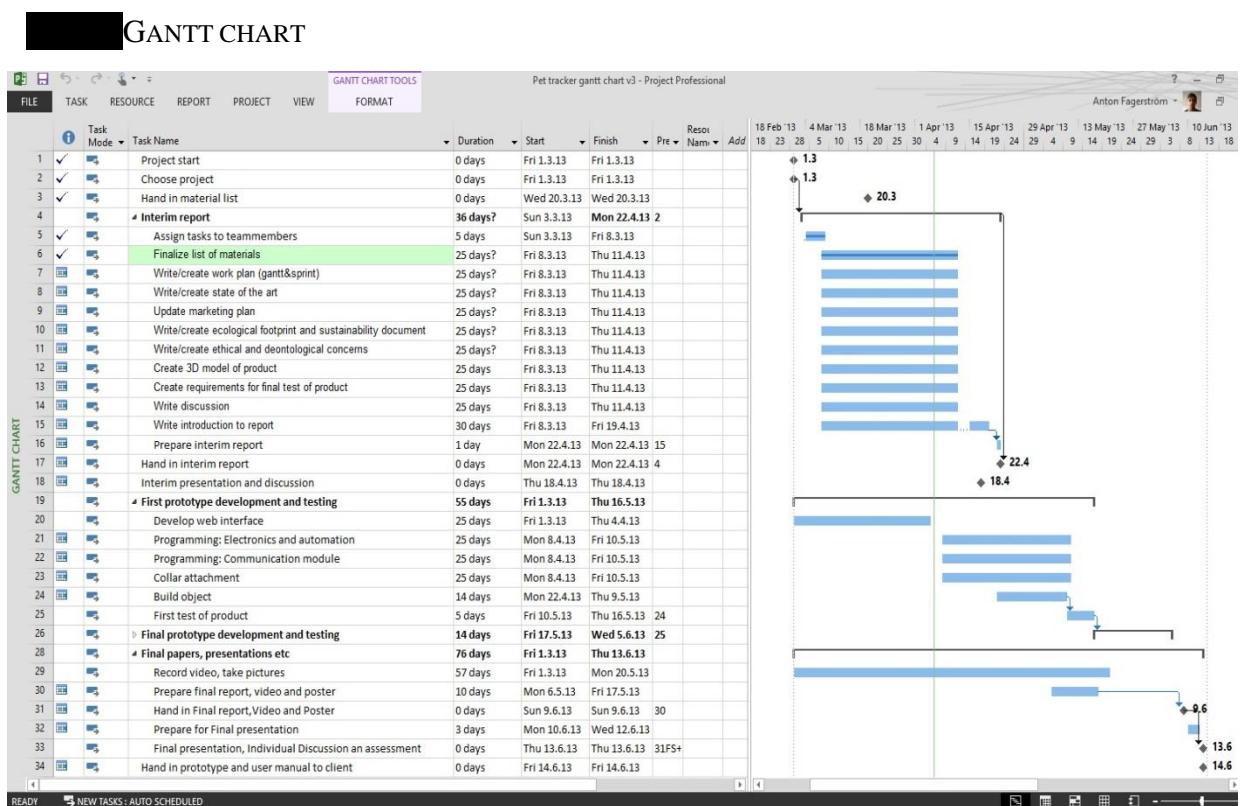


Figure 1 - Gantt chart

Table 2 - Table of tasks

| Task | Responsible |
|------------------------------------|--------------------|
| Search components and materials | All |
| Marketing Plan | Anton |
| Design | Anton and Ola |
| Web interface | Marti |
| Electronics and automation | Artur |
| Communication | Artur and Marti |
| Eco- Footprint and Sustainability | Ola |
| Ethical and Deontological Concerns | Anton and Ola |
| Final presentation | All |
| Final tests | All |
| Video, Paper Poster | Ola |

1.6 STRUCTURE OF THE REPORT

This report is structured in eight chapters.

The first chapter is the Introduction and presents the problem, the motivation, the objectives, the expected results.

The second chapter is the State of The Art and presents a general view of present technologies we use to create our product.

The third chapter is the Marketing Plan and presents market environment analysis, SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis, market segmentation, marketing targeting and positioning, and marketing mix.

The fourth chapter is the Eco-efficiency Measures for Sustainability and presents what is a sustainable product, what kind of materials we are going to use and how they influence the environmental, social and economic life.

The fifth chapter presents our Ethical and Deontological Concerns for the project.

The sixth chapter is the Project Development. It presents the materials used, the system architecture, modules used, functionalities and the final test requirements.

The seventh chapter includes our conclusion of the project as well as suggestions for future developments.

The eighth chapter is the Bibliography and presents the references we have used.

2. STATE OF THE ART

Nowadays it is possible to find products for almost anything, and a pet tracker is not an exception. A pet tracker is a device used to monitor and track one's pet location, and it can be used for different purposes, either hunting or just to know your pet is safe at home.

In the process of designing this product there are many things to take in consideration. The major aspects are the location system, a mean of communication, power supply and something that controls the system.

This section will present some of the most relevant systems and technologies found in our days that can be used to build a pet tracker.

2.1 RELATED PROJECTS AND PRODUCTS

Tagg – Based on the GSM location system, this product allows the owner to track his pet for about 100 USD and a monthly fee of 7.95 USD. This product allows the user to define a secure area for the pet, to monitor its activity and has a tracking mode that can be activated once the pet is lost. This device weighs 34 g and its use is recommended for dogs that weigh 4.5 kg or more.

Garmin Astro – Dedicated to hunters, this device can be bought for 600 USD and offers a collar and a handheld device used to track your pet. It displays the pet's current location as well as the previous ones. This hunter oriented product allows the owner to track up to 10 dogs with one handheld device. It has a 14.5 km range and provides sun and moon information as well as the hunt/fish calendar.

TECHNOLOGIES

2.1.1.1 WIRELESS COMMUNICATION

With a strong presence in our society, wireless systems allow us to transfer information, communicate, between two or more points that are not connected by an electrical conductor [1]. There are many ways to communicate without any wires, and there are some who have a growing impact in our lives.

- **WiFi** – Very popular technology that allows an electronic device to exchange data wirelessly (using radio waves) over a computer network. This technology refers to the IEEE 802.11 standard. A device that is able to connect to a WiFi network can make use of the internet and use it to communicate with other devices [2]. This connection can be established using the correct hardware: a wireless adapter (ZigBee, USB Adaptor, WiFi module, ...) and an access point to connect to. This technology is limited to the access point range, which may vary from 20 meters indoors to greater outdoors range like 100 meters, and the adapter's characteristics.
- **RF Modules**– These modules consist of small electronic circuits used to transmit/receive information [3]. The RF signals are commonly modulated in amplitude (ASK), frequency (FSK) and On-Off (OOK). To be able to communicate it is necessary to use one transmitter and one receiver, and there are limitations when it comes to distance.
- **Bluetooth Modules** – With a physical range varying from 1-100 meters, this wireless technology is a standard for exchanging data over small distances. Useful in low-bandwidth situations, Bluetooth is commonly used to transfer sound data with telephones (i.e., with a Bluetooth headset) or byte data with hand-held computers (transferring files) [4].
- **GSM/GPRS Modules** – These modules are used in the mobile phone industry as the main communication device. The range of these devices is restricted by the presence of telecommunication antennas, but there is world coverage for these network. The GSM standard was developed as a replacement for first generation analog cellular networks, and originally described a digital, circuit switched network optimized for full duplex voice telephony. This was expanded over time to include data communications, first by circuit switched transport and then packet data transport via GPRS [5], [6].

Table 3 - Wireless communication technologies comparison

| Technology | Range | Limitations | Cost |
|-------------------|--------------|---|-------------|
| WiFi | Up to 100 m | Range of the access points | Low |
| RF modules | Up to 20 km | The need for a transmitter and a receiver | Low |

| | | | |
|-------------------|-------------|---|--------|
| Bluetooth Modules | Up to 100 m | The need for a transmitter and a receiver | Medium |
| GSM/GPRS Modules | World wide | Operation expenses | Medium |

2.1.1.2 LOCATION SYSTEM

There are many approaches when it comes to location, one can think of a street, a room or a remote spot on the desert. In this project, location refers to geographic coordinates (latitude, longitude and altitude). There are many ways to determine location using navigation tools, being the most commonly divulged the Global Navigation Satellite System, GNSS. It is also possible to determine one's position using radar (RADio Detection And Ranging), GSM (Global System for Mobile Communications), Wi-Fi and other radio tools.

- **GNSS** – This system make use of artificial satellites that transmit time signals and allow electronic receivers to determine latitude, longitude and altitude [7]. There are operational GNSSs in the United States(Global Positioning System - GPS) and Russia (Globalnaya Navigatsionnaya Sputnikovaya Sistema - GLONASS). Some other systems are being developed in China (Compass) and Europe (Galileu). These systems are typically used in tracking and navigation and are becoming more established in our society every day. This is an accurate and reliable location system when used outdoors.
- **Radar** – Mainly focused in object detection by means of radio waves, it is typically used in aerial, maritime and terrestrial navigation. It is more commonly used for military, astronomic and meteorological purposes [8]. Although it is a reliable system, it implies a great investment in the antennas and the range is proportionally limited to that same investment.
- **GSM** – Even though this is not directly a location system, the mobile device industry has turned it into one. This technology makes use of the nearby telecommunication antennas to determine the GSM module's location – using multilateration. This technology does not present considerable limitations when it comes to indoors use, but its accuracy relies on the number of telecommunication antennas nearby.

Table 4 - Location system comparison

| Technology | Accuracy | Limitations | Cost |
|-------------------|-----------------|--------------------|-------------|
| GNSS | 1 m – 10 m | Indoors | Low |

| | | | |
|-------|------------|----------------------------|--------|
| Radar | 3 m – 5 m | Infrastructures | High |
| GSM | Up to 1 km | Telecommunication antennas | Medium |

2.1.1.3 MICROCONTROLLER

A microcontroller is a computer built in an integrated circuit and it is used to control and automate electronic and electro-mechanic systems. Due to future references on single-board microcontroller (or development board), the present exposition will refer to such products. A single-board microcontroller is a microcontroller built onto a single printed circuit board [9], PCB. We can find a wide quantity of such products in the market but they all have the same common aspects: microprocessor, Input/Output circuits, clock generator, RAM – Random-Access Memory and stored program memory. These devices are typically low-cost and very effective, offering an easy way to evaluate microcontroller chips.

- **STM32F4 Discovery** – Produced by STMicroelectronics, this board is very powerful and versatile. It contains a STM32F407VGT6 microcontroller, based on the Cortex M4 processor, at 168 MHz with 1Mbyte flash and 192kbyte SRAM, Static RAM [10]. This board also includes an accelerometer, a microphone and a great amount of pins to interface.
- **Arduino Pro Mini** – Based on the ATmega168, it has 14 digital input/output pins, 6 analog inputs, an on-board resonator, a reset button, and holes for mounting pin headers [11]. This board is intended for semi-permanent installation in objects or exhibitions, and it is suitable for small projects that do not require large processing capabilities.
- **MSP430 LaunchPad** – Based on the MSP430G2x Value Line MCUs (Microcontroller Unit), this 10 USD board offers an ultra-low power consumption, 16 kbyte flash, a 512 bytes SRAM and 20 pins. The device features a powerful 16-bit RISC (Reduced Instruction Set Computer) central processing unit (CPU), 16-bit registers, and constant generators that contribute to maximum code efficiency [12],[13].
- **Raspberry Pi(Model A)** – Developed in the United Kingdom by the Raspberry Pi Foundation, aims to promote teaching basic computer science in schools. With the ability to run a Linux based operating system, this device is loaded with a 700 MHz ARM1176JZF-S core (ARM11 family), 256 Mbyte SRAM, HDMI/RCA/DSI (High-Definition Multimedia Interface/Radio Corporation of America/Display Serial

Interface)video outputs and power ratings at 300 mA(1.5 W) [14][15].

Table 5 - Single-board microcontroller comparison

| Board | Frequency | Input Voltage | Flash | Dimensions |
|------------------|----------------|---------------|----------|--------------|
| STM32F4 | 168 MHz | 3.3 V - 5.0 V | 1 Mbyte | 9.7 x 6.6 cm |
| Arduino Pro Mini | 8 MHz - 16 MHz | 3.3 V - 5.0 V | 16 kbyte | 3.3 x 1.8 cm |
| MSP430 LaunchPad | 16 MHz | 1.8 V - 3.6 V | 16 kbyte | 6.8 x 5.1 cm |
| Raspberry Pi | 700 MHz | 5.0 V | - | 8.6 x 5.4 cm |

2.1.1.4 BATTERY

A battery is a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy [16] and vice versa. This device can either be rechargeable or not, and this project has in consideration the ecological footprint, the mid/long term economic and maintenance concerns as well as the consumer's comfort, hence the use of rechargeable batteries. This narrows the types of batteries and battery chemistries to study.

- **NiCd** – using nickel oxide hydroxide and metallic cadmium as electrodes, the NiCd is used in applications that require long life, high discharge rate and low price. Main applications are two-way radios, biomedical equipment, professional video cameras and power tools. The NiCd contains toxic metals and is not environmentally friendly.
- **NiMH** – this type of rechargeable battery uses positive electrodes of nickel oxyhydroxide (NiOOH) and the negative electrodes use a hydrogen-absorbing alloy [17]. NiMH batteries will not perform well in high rate discharge applications, typically providing only a small fraction of the rated capacity in these instances. NiMH batteries have higher energy than NiCd battery, but they have higher self-discharging rate and shorter shelf life.
- **NiZn** - this batteries have a charge/discharge curve similar to 1.2 V NiCd or NiMH cells, but are able to provide a higher 1.6 V nominal voltage. Low cost, high power output, the absence of toxic material and good temperature operating range make this chemistry attractive [18].
- **Lead-acid** - oldest type of rechargeable battery, are suitable for larger power applications where weight is not a concern [19]. Despite having a very low energy-to-weight ratio and a low energy-to-volume ratio, their ability to supply high surge

currents means that the cells maintain a relatively large power-to-weight ratio. Some lead compounds are extremely toxic and long-term exposure to even tiny amounts of these compounds can cause brain and kidney damage, hearing impairment, and learning problems in children [20].

- **Li-ion** – Emerged in the early 90’s, it has a high energy density, a relatively low self-discharge rate, no need for maintenance as well as the ability to provide high current to a system. This type of battery has some limitations, mainly in its maturity and the requirement of a protection circuit in order to maintain the voltage and current within the safe limits [19]. The Lithium ion chemistry is lightweight, does not contain toxic metals like the lead acid batteries and lasts long enough to span the typical life of the product.
- **Li-Po** – Similar to the Li-ion batteries has its main advantages by being lightweight, very low profile, resistance to overcharge and the low chance for electrolyte leakage. On the other side of the scope it may become more expensive than the Li-ion as far as the cost-to-energy ratio may concern [19].

Table 6 - Battery Comparison

| Battery type | Cell Voltage (V) | Specific Energy (MJ/kg) | Self-discharge/Month¹ | Maintenance Requirement | Cycle Life ² |
|---------------------|-------------------------|--------------------------------|---|--------------------------------|--------------------------------|
| NiCd | 1.2 | 0.14 | 20% | 30-60 days | 1500 |
| NiMH | 1.2 | 0.36 | 30% | 60-90 days | 300-500 |
| NiZn | 1.6 | 0.36 | 8% | Not required | 400-1000 |
| Lead-acid | 2 | 0.14 | 5% | 3-6 months | 200-300 |
| Li-ion | 3.6 | 0.46 | 10% | Not required | 500-1000 |
| Li-Po | 3.6 | 0.48 | 10% | Not required | 300-500 |

¹room temperature

²80% of initial capacity

CONCLUSIONS

Based on the previous comparisons, we decided to design a quality product that is reliable and accurate as well as economical and practical. To make this possible we selected a GPS module, a GSM/GPRS module, an Arduino single-board microcontroller and a Li-ion battery to power everything up.

The GPS's choice is related to its accuracy and cost. To balance its limitations we are also using a GSM module to cover the indoor location and to provide an independent communication mean.

To control the system we decided to use the Arduino Pro Mini at 8 MHz because we are not looking for extreme frequency processors and it is small enough to fit in a pet collar. The lower frequency also reflects in the power consumption of the controller. To power up the system we chose a Li-ion battery due to its specific energy, cell voltage and cycle life characteristics.

3. MARKETING PLAN

3.1 MARKET ANALYSIS

■ CURRENT MARKET SITUATION

Our product will be the first of its' kind produced in Europe. There are other GPS trackers in Europe but none of them offers activity tracking. This is the thing that will make our product unique for the European market. There is only one company that offers the same kind of features in their product and they are located in the United States. We need to be prepared to compete with other big companies who might enter the market after us if our product is successful.

Gadgets tend to have a short life cycle, they 'mature' very quickly. To counter this problem we will have to continuously develop the system further with new features after the first product has been released.

A product that creates a need to use it will be a successful one e.g. Facebook, Twitter. Since our tracker can be used to secure that your loved ones are okay, pets or humans, it finds a place in Maslow's hierarchy of needs (Fig. 2) as something that affects you. A need to know that they are safe.

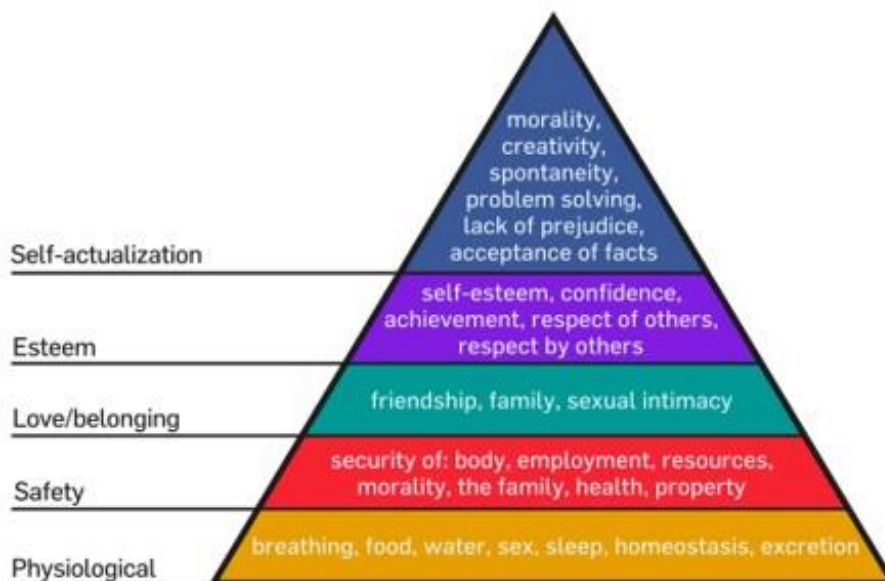


Figure 2 - Maslow's hierarchy of needs

3.1.1.1 MARKET DIMENSION

We are aiming for the Finnish market. The Finnish monthly gross income median is set at 2776€ [21]. This means that Finns might have some extra money to spend on their pet. There is approximately 600,000 registered dogs in Finland at the moment of which about 450,000 are purebred. [22]. Purebred dogs are more expensive and an owner of a purebred dog might be willing to spend a little extra to make sure that these dogs are not lost. For many Finns, their dog is not only a member of their family, but a whole lifestyle which includes shows, training, sports trials and being involved in canine clubs. Agility, hunting and obedience training are among the most popular activities besides attending dog shows. There are about 300 dog shows in Finland with a total amount of dogs attending of 195,000 every year. [21]

3.1.1.2 PEST ANALYSIS

The PEST analysis (Political, Economic, Social and Technological analysis) can be used to identify macro-environmental factors that might have an impact on your company in a country. These factors have to be taken in consideration when you launch a new product to a market.

Political/ Economical As a rule, Sales of goods to customers in the EU internal market are taxed in the country of sale. Distance selling from one Member State to another is an exception to this rule. Distance selling takes place when a supplier from one member state supplies goods and is responsible for their delivery to a private individual or a non-VAT-registered person in another Member State. If our sales to Finland would exceed 35,000 EUR per year, we'll have to register our company for VAT in Finland. If we exceed 35,000 EUR we will have to pay 24% instead of 23% in valued added taxes. In Finland, most online consumers prefer to pay via their Internet bank. Therefore, it would be a good idea to include direct payment functionality in our web shop. Sales to customers in Finland are subject to the provisions of the Finnish Consumer Protection Act, which states, for example, that it is the seller who is to pay the return freight if the customer wishes to cancel the purchase and return the product.

Social/ Technological A social-cultural trend right now is that people compete in showing on social media that their life is more exciting than other's. We can add another component to this "race". The added component would be that: "I take care of my dog better than you". Social comparison is a remarkably ubiquitous process which influences how people think about themselves, how they feel, what they are motivated to do, and how they behave [23].

3.1.1.3 MAIN COMPETITORS

Our main competitors are Garmin and Snaptracs (a Qualcomm company).

3.1.1.3.1 GARMIN

Garmin is a well-known navigation company from Switzerland. They provide navigation systems for all kinds of vehicles and activities as well as equipment specialized for hunters. In their animal department, Garmin offers dog tracking and pet obedience products. The quality of their products is of high standard but a high price follows. Their cheapest complete dog tracking system is set at 500€ (handheld device 300€+collar 200€). This product is a collar with a built-in module and antenna. Their products can handle 10-20 dogs simultaneously depending on model of handheld device. Garmin's dog tracking products are mainly used by hunters. Our product will offer basic GPS tracking of animals at a much lower price than Garmin, provided that you already have a smartphone and/or computer.

3.1.1.3.2 SNAPTRACS

Snaptracs is a Qualcomm company. Qualcomm is an American semiconductor company that specializes in wireless telecommunication. They have one product called “Tagg”. Snaptrack's “Tagg” is not aimed for hunters but for regular dog owners that wish to keep track of their dogs. The product is small with a sleek design. Tagg is currently priced at 100€. This price includes a 3 month GSM service. After 3 months you have to pay 7€ (+1€ per additional pet) per month. The Tagg product will be our main competitor since they are in the same market as we are aiming for (regular pet owners) with a competitive price.

3.2 SWOT-ANALYSIS

SWOT-analysis for our product and the Finnish market:

Table 7 - SWOT analysis

| Strengths | Weaknesses |
|-----------------------------------|--|
| New product on a untouched market | Lack of experience in product development |
| Uses new technology | Lack of position on the market |
| Open source technologies | Limited financial resources |
| Easy to use | Limited amount of time to develop product. |

| | |
|--|--|
| Young adaptive development team | |
| Main competitor does not have a strong position in the European market | |
| Patronage of ISEP | |
| Opportunities | Threats |
| Create demand for such products | Product acceptance |
| 600 000 registered dogs in Finland | Easy for big companies to copy/improve |
| EU | Main competitor drop their prices |
| Median monthly gross income in Finland is 2776€ | |

The SWOT-analysis shows that our product has more strengths than weaknesses. We can become leaders of the market if the product is accepted and the demand is big. There are both pros and cons when you introduce a product to an untouched market.

3.3 MARKET SEGMENTATION AND TARGETING

To divide properly a broad market into small segments comprising of individuals who have similar needs, requirements and interests the process called Market Segmentation has to be done. Concerning our product three main categories are taken into considerations:

- Geographic segmentation
- Demographic segmentation
- Psychographic segmentation

■ GEOGRAPHIC SEGMENTATION

The target market for the Pet Tracker is North Europe, more precisely –Finland. This decision was made due to the fact that the citizens are great animal lovers and at the same time there is a huge possibility that the average person could afford a product offered by us. The rest of Europe is also included in a plan although countries like Spain, Poland or Portugal cannot ensure such a big success as Finland.

■ DEMOGRAPHIC SEGMENTATION

The main factors affecting this part are:

- Income – the citizens whose average month salaries are at least at the satisfactory level (not less than national average) and actually who live in the countries not affected by the crisis, are our most target group
- Occupation – we assume that the clients whose professions in everyday life are connected with animals (e.g. veterinarians, breeders, farmers) are more likely to buy a Pet Tracker due to their specific job than other consumers
- Education – the type and level of education may affect the attitude towards the animals and result in willingness to buy such a product in emergency case (loss of pet)
- Variables such as age, gender, religion or race are not included in demographic segmentation process due to the fact they do not influence the demand for our product.

PSYCHOGRAPHIC SEGMENTATION

Clients may be divided into different groups based on:

- Social class – consumers from the middle and higher class are assumed to be much more interested in potential purchase of Pet Tracker
- Lifestyle and personality – clients whose job and lifestyle are already strictly connected with animals as well as regular pet owners are more receptive to innovations appearing at the market

SEGMENTATION CRITERIA ON BUSINESS MARKET

3.3.4.1 NEEDS APPROACH

We are getting out in front of the customer expectations which are related to obtain a good quality product for a reasonable price. The main advantages of Pet Tracker are:

- General accessibility - basing on client opinion survey we decided to introduce a product for online shopping as well as to the usual, local pet shops and supermarkets. The animal health centres are also taken into consideration
- Ease of everyday use - user-friendly web interface is available for all internet compatible devices on the market. Besides, the Smart Clip-on fits a wide range of collar sizes and can also be attached to belts or other human clothing which gives a

huge flexibility

- Durable and lightweight module – the animal should not be burdened by a heavy and bulky module with pointy antennas. The durable exterior of our product is made to withstand all possible weather conditions while not limiting the features

From the engineering point of view our main goal is to provide the clients with a product of highest quality for the lowest price. Due to the fact that currently we are

3.3.4.2 PURCHASING APPROACH

Limited by the budget, we are searching for the best possible options. The next aim is to acquire new customers who were not familiar with such a product before as well as try to convince already existing clients to purchase our Pet Tracker (we can do it easily by comparing it with other companies offering similar ones and pointing out our main strengths)

Results of the survey created by our team (answers collected from 56 respondents from different countries) are presented below:

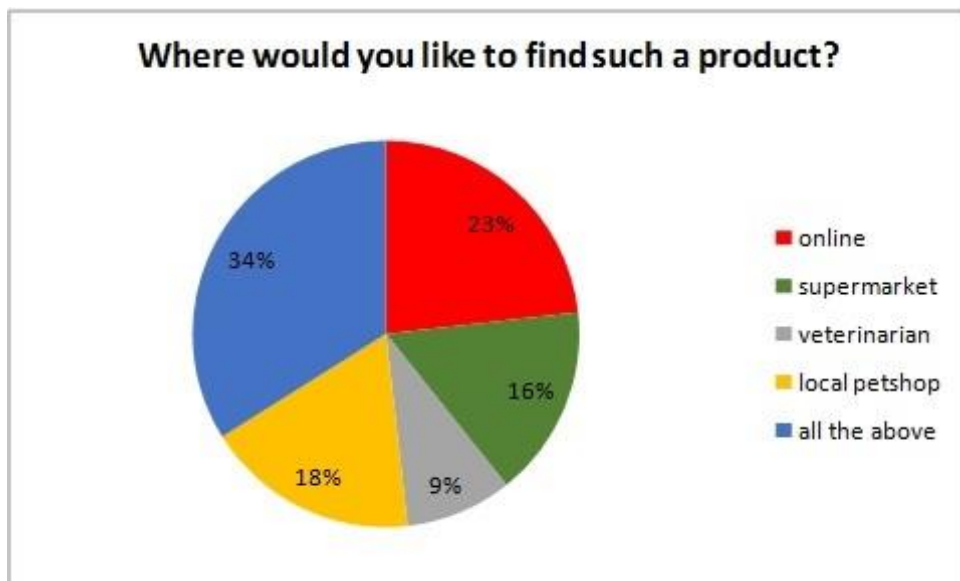


Figure 3 - Collected answers part 1

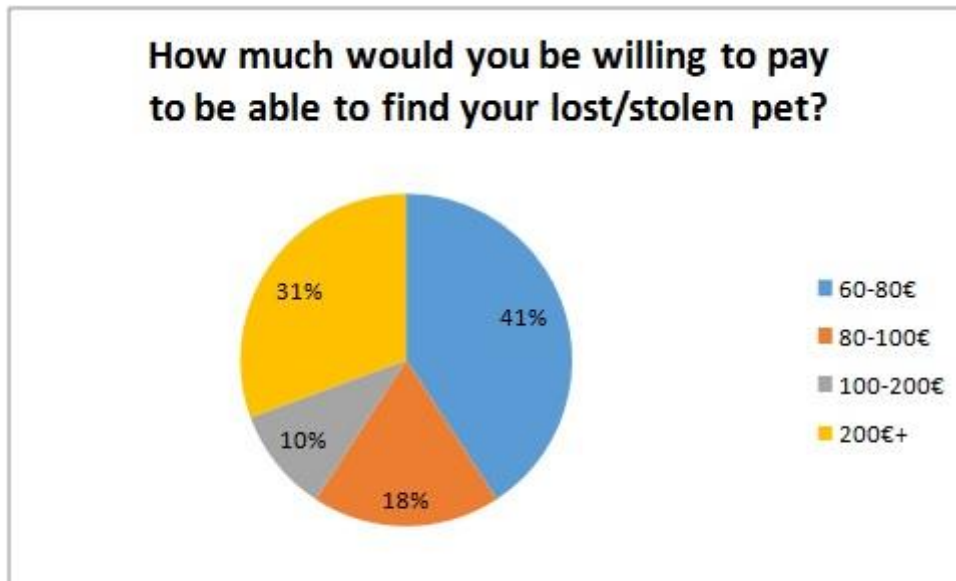


Figure 4 - Collected answers part 2

3.4 MARKET POSITIONING

Our product can satisfy all the user criteria mentioned above. No other European company offers the same kind of product. The marketing plan focuses a lot on the fact that we have a unique product.

Our company is small which is of advantage at the start. A small company can more easily adapt quickly to changes in market and the communication within the company is better.

3.5 MARKETING MIX

The marketing mix is a business tool used in marketing products. The marketing mix is often crucial when determining a product or brand's unique selling point. The four P's are the following:

- Product
- Price
- Promotion
- Place

PRODUCT

Our product is a tracking and activity monitoring device. It uses a GPS module in combination with a GSM/GPRS module to accurately localize your pet and show where it is on a website with Google maps. The website is accessible with both mobiles and computers. The built-in triple axis accelerometer stores data about how active your dog has been during the day. Everything is controlled by an Arduino Pro Mini board and powered by a Li-Ion battery.

PRICE

Setting price for the product is not easy. The final price will cover:

- Material
- Advertising
- Packaging
- Profit
- Distribution of product
- Labour
- Building

The material costs will be higher for our prototype than a mass produced product since we are limited to buying components that can be found in Porto and the price for a single component is higher than when bought in bulk. The price could be lower if these restrictions did not exist because then we could buy cheaper components from China and in bulk mass. As for the price for the prototype, we can only give the price that covers the material cost which is 279.55€. Payment methods available for customers will be:

- Bank transfer
- Credit card
- PayPal

PROMOTION

We will use different types of promotions. Since dog shows are very popular in Finland, this will be the best place to have a product demonstration and get in contact with our first potential buyers. Product demonstrations at veterinary conferences might also be beneficial.

Posters and leaflets can be handed out at veterinarian offices, dog shows and fairs. We can also send products to different product review websites, known bloggers and other relevant websites that might help us spread the word. The following dog journals are the biggest ones in Finland and a review of our product in one of these might give good publicity:

- Koiramme (<http://www.kennelliitto.fi/fi/kennelliitto/koiramme/>)
- Meidän koira (<http://www.karprint.fi/meidankoira/>)

████████ PLACE

The product will be available for purchase on our website during the launch of our product. To keep the shop online is cheap, it can reach a big market and a customer can do his/her shopping 24/7 without leaving his/her home. Distribution will be outsourced as it is a cheaper for us than creating our own department, at least at this stage. Products will also be sold when visiting dog shows and fairs. When the product becomes more popular and we get more potential customers we can start distributing to retailers.

3.6 CONCLUSIONS

The marketing plan describes our market segments and strategies that will be used to reach the market. When analyzing the microenvironment, we found that there is only one company that offer the same kind of product and they are based in the United States. Since we are aiming for the european market, more specifically northern Europe, we think that the competition will not be that huge. There are other tracking systems as well but they do not offer activity monitoring. The product is targeted at anyone who want to make sure that their animal does not get lost or that it receives enough exercise to stay healthy.

4. ECO-EFFICIENCY MEASURES FOR SUSTAINABILITY

While working on the project, the eco-efficiency as well as sustainability have to be taken into consideration. It is necessary for us to imply a strategy to fulfil the task and create the best product possible according to the rule - “doing more with less”. Eco-efficiency offers a number of practical benefits for our business such as:

- increase of product value
- reduction of contaminants level and waste
- reduction of energy and materials
- reduction of costs
- enhancement of brand image

Considering the sustainable development, the life-cycle of Pet Tracker needs to be taken into account. The reduction in ecological impacts may influence the increase in resource productivity, which in turn might create competitive advantage. Not only the environmental aspect is our main concern, also social and economic point of view has to be considered in future mass production.

The greatest challenge for us was to find a solution responding to every aspect of eco-efficiency and maintenance of sustainability, not only through production step to marketing and distribution but mainly in applying it in the same time to real life use. This particular issue still has to be discussed and improved in the nearest future. Comparing to other similar products available right now in the market, our main concern is lack of previous experience in this matter. However, we strongly believe we are able to provide our customers with competitively priced good which satisfy their needs and increase the quality of life.



Figure 5 - Life cycle of the product

4.1 MATERIAL EXTRACTION AND PRODUCT DESIGN

First of all we want to use as less materials as possible. We can divide our product into two categories: internal and external. Considering inside of the Pet Tracker we think mainly about the electronic components. It is quite hard to assess in this moment the exact source of raw materials for this part of device, though the box – a container will be made of renewable material, mainly of plastic which allows a device to be light, durable and resistant to different weather conditions.

4.2 MANUFACTURING PROCESS AND TRANSPORTATION

According to the fact we are the first company in Europe offering such a product which includes also activity tracking mode, we are mainly focused on this particular continent – more precisely, Finland is the target market for the Pet Tracker. Taking into account costs of the whole production and transportation, our company should be settled down also in Europe to be closer to the potential customers and available in case of any problem.

At the beginning another place for the mass production was considered (e.g. China) but we cannot be sure about the real lower costs of this investment. Besides, we want our future company and logistics partners to obey the environmental regulations and human rights. Not limited by the budget, we would like in the future to produce the Pet Tracker even smaller than prototype in order to avoid wasting materials and energy. We are aware of the fact that better components exist on the electronic market so far, that is why we have the possibility to improve the product. In case of prototype, we would support local stores through buying all necessary materials in Portugal. Concerning the transportation, the Pet Tracker will be sold in the supermarkets, local pet shops, veterinary health centres as well as it will be

available online to buy. That is why the reliable logistic company is needed, responsible for supplying all places mentioned above in our product.

4.3 USAGE AND RECYCLING

When our device becomes useless there are few options: either we can exchange the used component of the Pet Tracker (e.g. battery) in the service point, or we can separate the product into parts and take all of them to the appropriate recycling storage for electronic devices. Lithium-ion batteries cannot be thrown away as usual waste because there is a risk of exploding when incinerated. The external part – a container can be easily recycled again and replaced. Battery recycling is considered to be energy-intensive and it takes more energy to reclaim metals from recycled batteries as it does to produce the materials through other means. Lithium can also be recycled an unlimited number of times; 20 tons of spent Li-ion batteries yield one ton of lithium, but recycling could be more expensive than harvesting new supply through mining [25]. One of the highest recycling fees apply to this particular battery, because it contains little in retrievable metal. The recycled lithium is contaminated and has a quality similar to raw material that needs much processing [26]. The true cost to manufacture a modern battery is not only in raw materials alone but in preparation, purification and processing into micro and nano structures. Anyway, the European Union has a battery recycling law that will require vendors to reclaim for recycling a minimum of 25% of the batteries they manufacture and sell so we are obliged to obey it.

The main concerns and suggested solutions for the Pet Tracker are presented below:

- **Usage of materials and costs** – we avoid searching for additional components which are not that essential for our product. The main objective for us it to create a product as simple and small as possible, using exclusively necessary parts. The only distinctive component of the Pet Tracker is an accelerometer which allows us to control the activity of the pet but also in this case, we chose the most suitable one to maintain the sustainability. Our accelerometer can be configured to generate inertial wake-up interrupt signals from any combination of the configurable embedded functions allowing to monitoring events and remaining in a low power mode during periods of inactivity [27]. Another important aspect is connected with open source web application. The user-friendly web interface is available for all internet compatible devices on the market. By not developing

different mobile applications for different operating systems, we reduce the development costs as well as the final cost of the product.

- **Power consumption** – lithium-ion battery chosen by our team has a high energy density as well as relatively low self-discharge rate of approximately 10% per month, comparing to other batteries available in the market. The next important feature is high open circuit voltage which is beneficial because it increases the amount of power that can be transferred at a lower current. Lithium-ion does not require maintenance battery, an advantage that most other chemistries cannot claim. There is no memory effect and no scheduled cycling is required to prolong the battery's life [19]. All this information helped us to make the final decision about choosing this particular battery for the project.
- **Size and comfort** – considering the fact that our device will be used by the animal almost every day for a long time, dimensions of the product are extremely relevant. That is why we want our product to be light, small, portable and without bulky module with pointy antennas. There is a wide variety of shapes and sizes of the lithium-ion batteries efficiently fitting to our product. The whole weight of the Pet Tracker in the end of the project should be less than 100 g and the exact dimensions of our device (based on the sketch) are following: 6.5 x 5.5 x 2.5 cm. Because we are limited by the budget and time, the prototype may not be suitable for very small dogs but this feature will be improved. Regarding comfort, the Smart Clip-on would fit a wide range of collar sizes so that it may be easily attached with no risk of being uncomfortable to wear for dogs.
- **Durability** - the durable exterior of our product is made to withstand all possible weather conditions while not limiting the features. Considering the battery, the chosen one can work in wide range of temperature (from -10 °C even up to 50 °C) which should be sufficient to survive in different atmospheric conditions. The container (a box) for the components will be plastic and water resistant as well to ensure the longer endurance of our device. The main concern in this case is the usage type of the battery which is still not well known issue. Some capacity deterioration is noticeable after one year, whether the battery is in use or not. The battery frequently fails after two or three years. On the other hand, the rest of chemistries also have age-related degenerative effects. Subject to ageing, even if not in use - storage in a cool place at 40% charge reduces the ageing effect. Manufacturers are constantly

improving lithium-ion. New and enhanced chemical combinations are still introduced [19].

- **Safety and ecology** - Li-ion batteries have some limitations, mainly in its requirement of a protection circuit in order to maintain the voltage and current within the safe limits. But on the other hand, it does not contain toxic metals like the lead acid batteries and lasts long enough to span the typical life of the product. Components are environmentally safe as there is no free lithium metal. If we want to make the battery last longer, there are few things to consider and keep in mind. First of all, an extreme heat (above 50 °C) should be avoided as well as taking the battery all the way down to zero. Considering the risk of eventual explosion of battery, lithium-ion cells contain a separator sheet that keeps the positive and negative electrodes apart. If that sheet gets punctured and the electrodes touch, the battery heats up very quickly [28].

4.4 CONCLUSIONS

Eco-efficiency and sustainability are important in every business aspect and we need to implement it also in our project. From the social point of view, we are making the whole process of activity monitoring and tracking much easier than before because of including pets in social networks. We believe it helps in better protection of lost animals and contributes to greater awareness of this common problem. Moreover, we hope for the best considering the enhancement of our brand image and achieving the positive feedback from our potential customers.

5. ETHICAL AND DEONTOLOGICAL CONCERNS

We may encounter different problems not only in everyday life but also in almost every business aspect. Some of them may be strictly connected with ethics and morality. In such a case the following questions have to be answered:

- Are we able to find the most convenient solution, taking into consideration the “common good”?
- How can we implement the best strategy in our project?
- How exactly do we understand the meaning of ethics in engineering?
- Is it possible to reach success without abusing anybody or anything from ethical point of view?
- What are our main concerns?

Ethics allows us to follow some obligatory rules and make right choices in order to maintain the good brand image in the future – we want our company to be reliable and well known in the market. That is why the appropriate attitude has to be presented: if we respect our potential employee's and customer's needs, we will achieve our goals as well as become more recognizable and trustworthy. In our case ethics handles with a problem of the whole process of use and disposal of the product, with no harm for anybody in every single step.

First of all, we cannot promise our clients things which we are not sure about. It has to be taken into consideration while promotion and marketing strategy. If we ensure about ease of everyday use of the Pet Tracker and its general accessibility, we have to make it as simple as possible to reach every kind of client and do not use any sophisticated system in our device. Also the way of working (activity monitoring and tracking system) has to be exactly presented to public.

Secondly, any kind of doubts (e.g. the real-time life of the battery) has to be excluded but if it is not possible – should be disclosed and explained. The next concern is connected with

recycling – in that moment, we may offer a service points to receive dead batteries from the clients in order to send them later to collection storages for recycling. We know that there exist companies dealing with this problem but on the other hand we are also aware that this ecological sector is not as cost-effective as it is generally thought to be (especially concerning lithium-ion batteries). Nonetheless, the European Union has a battery recycling law which we are obliged to obey and respect.

Considering the comfort of animals, we need to make sure that our device will not affect the pet's behaviour and health in any way. Our product is designed to be small, light and not bulky, to avoid risk of irritation of the animal. Also from medical point of view, the container for electronic components has to be made of plastic so that it will not cause any allergic reactions. Moreover, the whole product has to comply with EU Directives which are mentioned in the introduction part.

Before process of manufacturing and sale, the research concerning patents has to be done – information about availability of the brand name and trademark are necessary to avoid law problems connected with intellectual property regarding other companies which offer similar products.

The next concern is about the place for mass production – because our main target market is Finland, it would be reasonable to assemble the product in Europe. But the following question appears: would it be cheaper to do it somewhere else, but knowing that there exist a risk of abusing employees and not obeying the basic environmental issues? If we want to be a friendly, respected and transparent company, we cannot allow to do that.

5.1 CONCLUSIONS

The ethical approach has to be implemented in the project. Some of the concerns and suggestions were presented above. It may still be the matter for deeper analysis but in this point we believe we are able to assess what kind of decisions and choices are the best for the Pet Tracker development in the future. Thinking about the “common good” is the key issue for us as well as improvement of the quality of both people and pets' life.

6. PROJECT DEVELOPMENT

6.1 MATERIALS

Table 8 - List of products

| Product | Link | Description | Quantity |
|-------------------|---|------------------------------------|-----------------|
| GPS | https://www.sparkfun.com/products/8234 | EM-408 with Antenna/MMCX | 1 |
| Arduino | https://www.sparkfun.com/products/11114 | Arduino Pro Mini 328 - 3.3V/8MHz | 1 |
| Battery | http://pt.rs-online.com/web/p/paquetes-de-baterias-de-litio-recargables/5306325/ | ENIX 3,7V 1840mAh | 1 |
| GPRS/GSM | https://www.sparkfun.com/products/10138 | ADH8066 | 1 |
| GPRS/GSM Board | https://www.sparkfun.com/products/10497 | ADH8066 Breakout | 1 |
| Charger | https://www.sparkfun.com/products/10401 | LiPo Charger Basic - Mini-USB | 1 |
| Antenna(GSM) | http://pt.rs-online.com/web/p/antenas-gsm-y-gprs/7043417/ | GSMMQB - Mini Quad Band Antenna | 1 |
| Accelerometer | https://www.sparkfun.com/products/10955 | Triple Axis Accelerometer Breakout | 1 |
| Memory | http://pt.rs-online.com/web/p/chips-de-memoria-eeeprom/0454145/ | I2C EEPROM - 1Mbit | 1 |
| Total cost | | | 279.55 € |

6.2 ARCHITECTURE

Our system will follow a star topology, being the microcontroller the central structure that controls the peripheral modules.

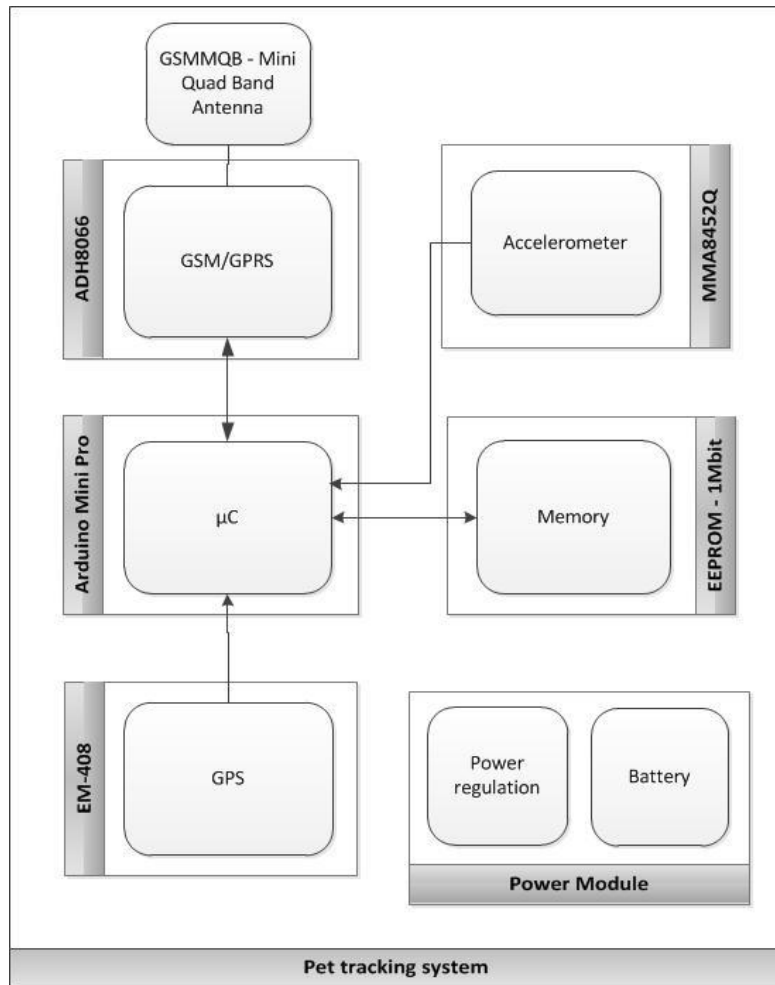


Figure 6 - Basic system architecture

It is also necessary to regulate the power supply in order to fulfil the needs of all components.

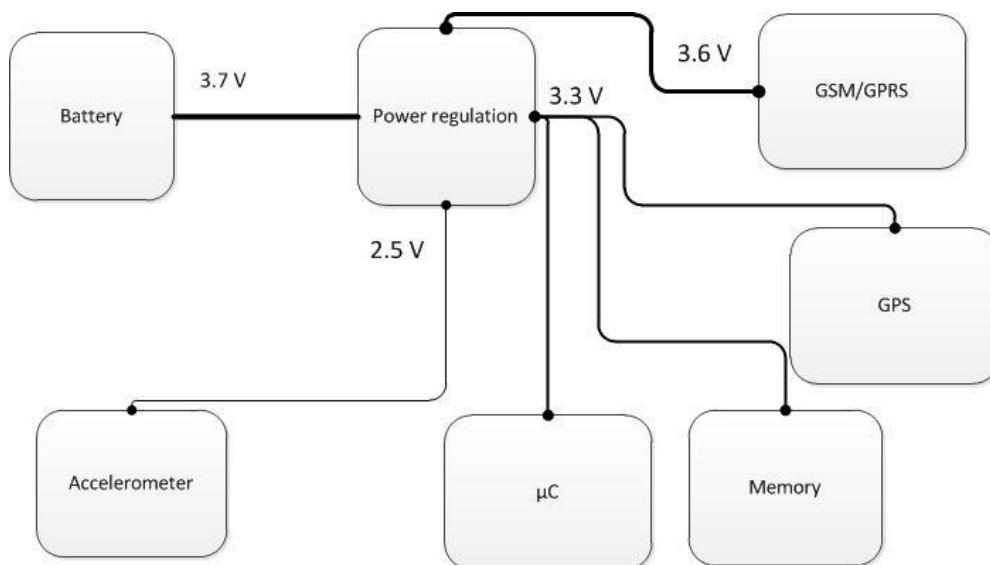


Figure 7 - Power regulation

6.3 MODULES

The pet tracker makes use of two fundamental modules, one used to communicate and one to locate with precision. These modules are the GSM/GPRS, the ADH8066 and the EM-408 GPS module.

ADH8066 – This is a quad band GSM/GPRS communication module. It supports standard AT commands and enhanced AT commands which provide rich voice and data communication functions. It's an ideal solution for various communication applications [29]. With its dimensions at 33mm×36mm×5.4mm, and the weight of 8 g, this device will allow our pet tracker to communicate with the user and make it small and light enough to be used by the pet.



Figure 8 - ADH8066 GSM/GPRS module

EM-408 – This engine board is low cost but maintains high reliability and accuracy making it an ideal choice for integration with OEM/ODM (Original Equipment Manufacturer/original design manufacturer) systems. The EM-408 features an integrated patch antenna for complete implementation [30]. This module will allow locating the pet with precision.

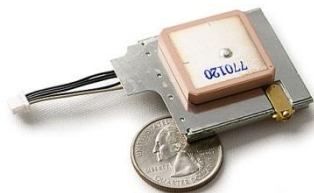


Figure 9 - EM-408 GPS module

6.4 FUNCTIONALITIES

In the end, our product should be able to:

- Locate the pet
- Monitor the pet's activity
- Display the pet's location and activity in a website
- Enable a Safe mode (when the pet is home or somewhere the owner considers secure), and a Tracking mode (when the owner wants to pursuit the pet)
- Enable a low power consumption mode
- Send a text message to the owner when the pet leaves the secure are to witch the device is confined

6.5 TESTS

MECHANICAL AND ELECTRICAL

- The product must comply with the following EU Directives:
 - Machine Directive (2006/42/CE 2006-05-17)
 - Electrical Safety: Low Level Voltage Directive (2006/95/CE 2006-12-12)
 - Restriction of Hazardous Substances (ROHS) in Electrical and Electronic Equipment Directive (2002/95/EC 2003-01-27)
- The product must adopt and use the International System of Units (The NIST International Guide for the use of the International System of Units).
- The module must be light, small and portable. Maximum size: 6.5 cm x 6.5 cm
- The modules battery must have at least 48h power autonomy.
- The module must have a user friendly charging system.
- The module mustn't contain extremely toxic materials like heavy metals.

SOFTWARE

- The software must be made using open source technologies.
- The web interface must be responsive(Responsive Web Design).

- The software must be able to define a secure area for every pet/product.
- The software must be able to store all pet/product information by client.
- The software must be able to show all pet/product information by client.
- The software must be able to display the pet location with an acceptable margin of error.
- The software must be able to display track using Google Maps/Google Earth.

7. CONCLUSIONS

At this moment it is not possible for us to draw any conclusions regarding the project. We can only assure we will continue to do our best.

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