Triathlon training room

Development of a conceptual space for swimming, cycling and running

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Human needs are the driving forces which guide and inspire industrial design. Design is the method used to satisfy those needs, keeping in mind that there are needs that survive along the time and also will be others that arise due to the constant evolution of the society in which we live.

Designers play a fundamental role within this process, discovering the needs present in the existing market and creating adequate products that provide satisfaction to human needs.

Attending this master thesis, one of the needs that came out was being able to practice a sport like triathlon in a reduced space, without needing three different sports installations. Detecting this present in the market need was the starting point of an idea of the company TriRoom Innovation AB. Throughout the years, they have been working on and refining this concept that step by step has become a real project, looking for diverse collaborations to get to create what it is now the Triathlon Training Room. Besides having different companies by their side, they make have invited us as master thesis students to participate in this project.

This master thesis describes the project from the beginning, following the process of a need turning into something tangible.

As an acknowledgment, we would like to thank to the company TriRoom Innovation AB for letting us be part of this project, specially to Alessandro Cozzani for his huge enthusiasm deposited inside the Triathlon Training Room and his trust and help within the project.

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The company TriRoom Innovation AB had the idea of creating a new sport training system, the Triathlon Training Room. During the development they wanted to involve some students who contribute with ideas to the project and to look at it with an open-mind. The need of involving students is the base of this Master Thesis project, that is the last step of the Degree at Industrial Design Engineering and Product Development at Zaragoza University, developed at Luleå University of Technology during an Erasmus program.

In this thesis the product has been analysed from the required open-minded view, finding different problems and designing valid solutions to each problem, paying particular attention to the details.

Much of the work consists of analysing the product that the company provided to the students and criticized it in a constructive way in order to improve the product. The design has followed the human-centred design process to create the most comfortable product and in order to maximize the use.

The first step was to ask people about what they want and need while they play sports to have a good knowledge of the user. Taking the users as the design critical point, the given design was analysed and some problems were found. Creative methods were applied in order to generate creative ideas to solve those problems; brainstorming and sketching were used for fulfilling that objective. To further develop and visualize the concept, a model was made using CAD software, and finally, photo realistic images were generated as well as a 3D printed prototype to complete the whole design process.

The result is a more completed and refined product, in which exist the perfect solutions for each design challenge that have been appearing during the project. The Triathlon Training Room has a powerful aesthetic style that matches perfectly with the TriRoom Innovation AB needs, and its design will inspire people to try a new sport training system.
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Introduction
1 Introduction

The focus of this master thesis is the Triathlon Training Room, conducted at the request of the company TriRoom Innovation AB with the aim of developing a new concept of training system. The master thesis is the final part of the degree at Industrial Design and Product Development Engineering at Zaragoza University, developed at Luleå University of Technology during an Erasmus program, in the spring semester of 2013.

1.1 Background and Issues

The Triathlon Training Room is a project developed by TriRoom Innovation AB involving several design aspects. The training room conceived by the company includes three sport stations, for cycling, running and swimming; these cockpits are connected by a transition room which gives access to a swimming station. The aesthetic style of the Triathlon Training Room has to be the same although each cockpit has to be designed by itself, with its own needs and features. The main issue remains; in these different zones for training have to be considered together while designing individually, in order to have a common design style that currently does not exist in the present Triathlon Training Room proposal.

Our project was focused on the design of the interior of the transition room and the cockpits for cycling and running.

1.2 Aim and objectives

The purpose of this master thesis is to design the interior of the transition room and the cockpits for cycling and running. In this project the objective was not only to develop a common aesthetic between these spaces, but also to diverse aspects such as ergonomics, safety, user, usability, quality and functionality.

The master thesis includes different objectives that are summarized into three main goals:

1. Apply our own design process to develop the final product, which is a combination of previously learned methods in the way that we can obtain the most suitable one for each step of the project. The mentioned methods were learned along our university years.
2. Improve the existing product, analysing it from an outside point of view, detecting problems and giving design solutions to them.
3. Continue with the aesthetic style of the company, but attending to an holistic view and taking care of aspects such as ergonomics, safety, usage, environment, functionality, etcetera.

1.3 Boundaries

Our work is limited to concept development, for example creating blue prints to define the measures, but not detailed construction plans. The structural calculations are not included in our task.
Current Situation
2 Current Situation

2.1 Triathlon Training Room Components

The Triathlon Training Room (see figure 1) devised by TriRoom is composed of four different zones that together make possible to complete a full training. These spaces are the three sport cockpits for swimming, cycling and running and the transition room which gives access to the swimming pool and can be used as a changing room [43]. In this chapter these different parts will be investigated, knowing the training machines and the characteristics of each zone.

Training machines

Swimming cockpit
The zone made for swimming is a swimming pool (see the pool in figure 2) with measures of 4000x1500x1200 mm, its sink is moulded in one piece to guaranty maximum efficiency in water retention. The structure walls are a combination of panel assembly that increases the design flexibility, allowing changes in colours or an easy replacement of each part.

This way of assembly also is made to avoid water infiltration between the pool and the side walls, achieving diverse benefits as lower humidity levels and maintenance or stable water levels.

For the construction of this swimming pool TriRoom will count on Piscine Laghetto®, company experienced in swimming pools since 1974. [20,43]
2 Current Situation

Running cockpit.

To carry out the running practice, the Triathlon Training Room will include a WOODWAY® product [50], the Curve treadmill (see figure 3).

The major benefit achieved with this treadmill resides in that Curve is a motor-less treadmill, a training tool for improving speed and metabolism. The fact that has no motor, there are no buttons and it is entirely manual, leads on saving all electrical expenditures and reducing the cost of maintenance because there are not electrical components that never need to be replaced. [48]

Other advantage of using Curve is that the user is able to control its pace, take more control of its position and gravity doing its training in a major level, not just a muscles exercise.

The functioning of this non-electrical treadmill is possible due to the running belt is made of individual slats comprised of two materials: a rubber based surface and an aluminium T-shaped frame mounted on a continuous set of tooth belts. The tooth belts mesh with the front pulley assembly, which meshes with the drive motor. This grouping is supported by two bearing rail assemblies that hold the individual slats together and avoid tracking the running belt to right or left. The bearing rail assemblies are mounted above an endless steel wire reinforced lateral belt, and 17 cm diameter toothed roller drums that allows the dissemination of the cyclical movement. All this belt engagement system results in very little friction and heat and no slippage which increases the longevity of the running surface and treadmill itself. [49]

The idea of TriRoom is using only the lower part of the treadmill, including the running surface with its structure and excluding the handlebars to have it in a more integrated way within the whole room. [43]

The technical characteristics of the Curve, in the way of are required by TriRoom, are:

Width x Length x Height (see figure 4): [48]
79 x 173 x 40,6 cm

Its weight capacity is 227 kg while running and 363 kg while walking. [49]
Cycling cockpit.
The aim of TriRoom is to provide a real triathlon training system, that is why the method used to feel this reality in the cycling cockpit is to use the motor-less rollers manufactured by Elite (see figure 5).

Above these rollers a real bike can be ridden in the same way that it could be done in the road, making a complete natural and intuitive training due to one part of the training is keeping the bike balanced without any external help.

These rollers provide a lot of advantages. They are adjustable to adapt to different bike sizes, the intensity of the training also can be regulated due to a roller resistance unit is integrated which through three different resistance levels can simulate both flat terrain and slopes, to enable a power or an agility training. [7]

The frame of the Elite Rollers is made of aluminium alloy and plastic materials, and the rollers are made of an anti-static plastic material that reduces noise and tyre wear. The rollers also have a parabolic shape being smaller in the middle, to make it easy to keep balance on the bike. [7,8]

Like the same way than the Curve in the running cockpit, the Elite rollers will be integrated inside the cycling cockpit (see figure 6) to maintain one common style in the room.

The dimension of the E-motion rollers by Elite is: 1700x656x110 mm. [7]
2 Current Situation

Transition room.
The fourth main zone in the Triathlon Training Room is the transition room (see figure 7). [43] This space is thought to give access to the swimming cockpit by a ladder; inside it the user can dry himself after swimming, and also is thought as a space in which the personal belongings of the user can be left.

In the way it is the concept of this room nowadays it has a polymer panel assembly structure that makes the walls of the room, an aluminium ladder that gives access to the pool and also acts as a structural factor in the cabin.

Another part of the cabin is the floor, done with small holes which allows to evacuate the water when exiting the swimming pool.

The main problems identified in this zone are the ladder and the door, that is why in this chapter we will look after information about these critical parts.

Figure 7. Transition room

2.2 Usage of the Triathlon Training Room

Practising sports not only requires the proper machines to do it but also there are some essential objects than could not be possible or would be harder to train without them.

In the Triathlon Training Room three different sports are practiced, and for each one will be some complementary objects that have to be kept in mind because there are part of the experience of training.

Swimming maybe be the most demanding sport of the three performed in the Triathlon Training Room when speaking of necessary objects to practising it.

Due to the Trathlon Training Room is going to be placed commonly in a public space, personal hygiene is an important factor that the user will have to attend to maintain the cleaning and the quality of the pool. That is why it will be recommendable to wear a bathing cap while swimming. The bathing cap is also an object that is wore for avoiding wetting the hair or to have a better performance while practising the sport.

Another indispensable objects for swimming are bathing goggles that will allow the users to see through the water or a towel to dry after exiting the swimming pool.

One optional complement that can be wore during swimming is a neoprene bathing suit, commonly used in triathlon competitions due to an increase of the performance in the water [33]. However the training practised in the triathlon room is a HIIT (High Intensity Interval Training) and wont be compulsory to wear it.
2 Current Situation

It is important to have these objects under consideration because it will be necessary to have an space to place them when they are not going to be used that is when practising another of the sports in the room or having the towel in the transition room for drying when exiting the pool. Some examples of objects can be seen in figure 8.

Similarly when practising swimming, while cycling and running some objects are used. Some of them are not compulsory but will ease the training or will help to simulate a triathlon competition.

Doing cycling and running there are common objects used in both sports as a bottle to avoid dehydration, some energetic bars, running shoes that will be used also in the bike or a towel to remove the possible sweat of the user.

As a complement of the cycling training, a bicycle helmet may be wore to feel the same than in a real triathlon, where these objects are used because of security reasons.

When designing the cockpits alike the objects for swimming will be important to have them under consideration and make a complete real simulation of training. See some examples of cycling and running objects in figure 9.
2.3 Target group

To know the target group is important in order to design according to their preferences and needs. The target group of this product is given by the company TriRoom Innovation AB[18] and it contains the people that the company wants to attract with the product. This section is an analysis of this target group and some examples of people that could belong to this target are shown in figures 10, 11 and 12.

The target group is formed by men and women who have a healthy lifestyle; people who enjoy sports and train frequently, but who would like to have more time to exercise during the week. This group is why they are very busy during the week due to a heavy workload.

They are competitive and ambitious in their working-lives, but also in their everyday lives. They want to be on the top in many aspects and love personal challenges specially related to sports.

They are individualistic people who are more confident with themselves than with other people, focused on their goals, so they follow a method in order to achieve these goals. They use training methods like HIIT (High Intensity Interval Training) that focuses on correct exercise and that has got a good body impact. They also look for training methods that are time saving and “efficient”.

They are the people of the new century so are interested in technology and use social networks.

We consider that there are two big different target groups inside the general target group:

1. People who has professional aspirations and want to train like a professional, having the same lifestyle.

2. People who need adrenaline and enjoy sports, but they are very busy with their works.
3 Theory
The following chapter is about what we have taken into consideration in order to understand completely the task and in order to have all the information that we will need to develop the final product. We have used different methods to achieve the objectives such as benchmarking, surveys, talks with experts and users and internet researches.

We found interesting to know about high intensity interval training, its benefits and method. It is because high intensity interval training is the way of training that the product is thought to use, according to the company TriRoom Innovation AB.

As important as knowing about the training system is to understand the different sports present in the product. The sport discipline selected by TriRoom Innovation AB was the triathlon. We consider good to know about this sport discipline and the needs of the user while practising triathlon.

While designing a product that has to be in contact with human it is essential to have knowledge about ergonomics. That is why we found important to investigate and understand ergonomics and anthropometry in order to design the best product for the future users.

We also have been investigating about possible materials and manufacturing processes that we could use for the final product such as non-skidding materials, carbon fibre and vacuum molding process. Those materials and manufacturing processes could not be the selected ones at the end of the design, but they were the materials and processes in which the company TriRoom Innovation AB was thinking and wanted at the beginning of the master thesis.

Finally, we found important to know in which Placements the product could be placed according to the company needs and also according to possible new Placements that we found interesting.
3 Theory

3.1 HIIT: high-intensity interval training

Health and physical concern is important for everybody, at the same time as people are busier and busier everyday. People want to keep fit but, they may not have time to go to the gym for a couple of hours everyday or they are bored with the traditional concept of exercise. During the last years, a new conception of training has been developed, which has got the properties that people are demanding: the high intensity interval training.

What is HIIT?

The High-Intensity Interval Training, called HIIT and also called High-Intensity Intermittent Exercise (HIIE) or Sprint Interval Training, is a type of cardiovascular exercise that was popularized in the 1970s by Arthur Jones, the founder of Nautilus (fitness equipment manufacturer). HIIT has become more popular since 2010. [21,34,42]

HIIT is an enhanced form of interval training, an exercise strategy alternating periods of short intense anaerobic exercise with less-intense recovery periods. Usual HIIT sessions may vary from 7–20 minutes [21,34,42]. These short, intense workouts provide improved athletic capacity and condition, improved glucose metabolism, and improved fat burning. Also, HIIT is a good way of taking care of the heart, see figure 13.

Characteristics

The High-Intensity Interval Training has different characteristics [29] such as:

- HIIT is an anaerobic exercise, it is a short but intense activity developed without oxygen interchange inside the human body.
- Its intensity level must be over the 85% of the Maximum Heart Rate (HRmax).
- The number of mitochondria in the muscles increases and this metabolic change produces a huge fat burn.
- The organism is rusting fat during 24 hour after the training, it is because the glucose is the main power resource in this kind of exercise.
- The person who is training with HIIT will keep its muscle mass.
- The training time is around 20 minutes.
- Usually the training sessions are 2 or 3 times per week.
3 Theory

Benefits

- **Efficient**: HIIT is the ideal workout for a busy schedule. Research shows one person can achieve more progress in a mere 15 minutes of interval training (done three times a week) than a person who is jogging on the treadmill for an hour. According to a 2011 study presented at the American College of Sports Medicine Annual Meeting, just 2 weeks of high-intensity intervals improves the aerobic capacity as much as 6 to 8 weeks of endurance training [3].

- **Burn More Fat**: the human body burns more calories during HIIT workout, the human organism is burning fat after 24 hour. [3]

- **Healthier Heart**: HIIT is an anaerobic exercise. This means that when somebody pushes its body into the anaerobic zone it is difficult to breathe and the heart runs very fast, but this extreme training produces extreme results. [3] See figure 14.

- **Lose Weight, Not Muscle**: the weight loss with HIIT comes from body fats and not from the muscles. [3]

- **Increase Metabolism**: In addition to increased fat burning and more muscle preservation, HIIT stimulates production of human growth hormone (HGH) by up to 450 percent during 24 hours after the workout is finished. This is good for human health since HGH not only is responsible for increasing caloric burn but, also slows down the ageing process, making someone younger both inside and out. [29]

- **Challenging**: This is not a workout that can be done while reading a magazine or chatting with some friends. Because it is so short, the person who is training will be working hard the whole time. The trade-off is that this format offers seasoned exercisers, a new challenge and new exercisers, a quick way to see results. [3]
3 Theory

3.2 Triathlon

Triathlon is a three-sport athletic competition, which combines both swimming, cycling and running in consecutive order. Since its beginning in France in the 1920s, the triathlon has become an Olympic sport designed to test the endurance of its participants due to the long distances that are covered between the three sports.

Athletes who practice triathlon maintain a severe training schedule in order to meet the stringent test conditions, both physical and psychological. These test conditions may variate in the diverse race distances that currently exist for triathlon: Sprint, Intermediate, Long or Ultra distance, this last one more known as Ironman. [46]

Triathletes as the ones seen in figure 15 are competitive, successful and role models for people interested in sports that want to carry a healthy and sportive lifestyle. Triathletes represent toughness, resistance and a way of pushing the body to the limit, because they usually work harder and longer than athletes of many other sports.

They also push their body to the limit having a complete training in at least three sports disciplines. With each sport being an endurance event, training for a triathlon provides cardiovascular exercise benefits sports performance and aerobic capacity among some benefits.

Triathlon in the Triathlon Training Room

The aim of doing a triathlon training room is not for training this specific sport but thought to be a complementary high intensity training that completes a normal workout. In that way, a HIIT training, previously explained in this chapter, will be applied at the triathlon training room, practising about five minutes swimming, cycling and running and assigning around two or three minutes for doing the transitions between them. Combining HIIT and triathlon it is maximize the efficiency of a single training in a short period of time.

The objective of the triathlon training room conceived by TriRoom is not to provide training for triathlon sport so a same user is not going to simulate a real race in it, not spending long training hours time. The real vision of the TTR is that a short periodic training in each one of the three disciplines will allow the user to enjoy a combination of workouts and general strength conditions which will prepare his body for a more efficient training.

Another important issue concerning triathlon is the necessary objects that are used to practice it, regarding bathing caps, goggles, neoprene suits, bikes, etcetera. This objects are tackled in the previous section 2. Current Situation.
3 Theory

3.3 Ergonomics

Ergonomics is the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theoretical principles, data and methods to design in order to optimize human well being and overall system performance. [13]

Ergonomics is a decisive factor for determining the measurements of objects because in that way the products will be properly designed for the users. Thinking in the typology of users that will interact with a product, will make a good design of it, but for calculating its measurements, exits a specific branch of ergonomics, the anthropometry.

Anthropometry

Anthropometry is the scientific discipline which attends the human beings measurements (see figure 16) study with medical, anthropological, sportive or user interaction systems objectives. As it has been said before, we will have to attend the users that are going to use the product to adapt it in order to be easy to use it, at the same time that contributes to safety.

In achieving this aim, it becomes necessary to understand and design for the variability represented in the population, spanning such attributes as age, size, strength, cognitive ability, prior experience, cultural expectations and goals. Those aspects will be the ones that affect the differences in the anthropometric measures of the people. [12,36]

For applying anthropometry to a product design it is important to follow three stages, the first one in which a preliminary study will determine the relevant measures, the second, where depending on the users characteristics an anthropometric table will be chosen and the last one, in which the dimensions of the product will be calculated. When it becomes to apply this third phase and a designer wants to calculate a dimension there are diverse principles of application: Design for extremes, for averages and for adjustable ranges.

The most common method for calculate dimensions used by companies is to apply the design for extremes, which is the most suitable one when fixed measures are going to be calculated. In this case, the first thing to do is to determine which is the extreme that provokes less problems to the group of population, that is determining the restrictive extreme.

When design for the extremes does not provide a satisfactory solution for the product, sometimes it is used design for averages, having as a example of user the one that has a 50 percentile. Applying this principle the problems come out with the extreme users.

Another principle of applying anthropometry is to design for adjustable ranges, and it is used for defining variable measures of a product in order to be able to be used by the largest range of population. [36]

At the time of designing the final product, it will be a decision of the designer which anthropometric data will be used as well as which is the most suitable principle of application for each measurement.
3 Theory

3.4 Materials

Carbon fibre

A carbon fibre is a long, thin strand of material about 0.0002-0.0004 in diameter and composed mostly of carbon atoms. The carbon atoms are bonded together in microscopic crystals that are more or less aligned parallel to the long axis of the fibre. The crystal alignment makes the fibre incredibly strong for its size. Several thousand carbon fibres are twisted together to form a yarn, which may be used by itself or woven into a fabric. The yarn or fabric is combined with epoxy and wound or moulded into shape to form various composite materials. In figure 17 it shown a carbon fibre sheet.

Carbon fibres were developed in the 1950s as a reinforcement for high-temperature moulded plastic components on missiles. The first fibres were manufactured by heating strands of rayon until they carbonized. This process proved to be inefficient, as the resulting fibres contained only about 20% carbon and had low strength and stiffness properties. In the early 1960s, a process was developed using polyacrylonitrile as a raw material. This produced a carbon fibre that contained about 55% carbon and had much better properties. The polyacrylonitrile conversion process quickly became the primary method for producing carbon fibres. During the 1970s, experimental work to find alternative raw materials led to the introduction of carbon fibres made from a petroleum pitch derived from oil processing. These fibres contained about 85% carbon and had excellent flexural strength. Unfortunately, they had only limited compression strength and were not widely accepted. Today, carbon fibres are an important part of many products, and new applications are being developed every year. The United States, Japan, and Western Europe are the leading producers of carbon fibres. [2]

The most common expression of the carbon fibre nowadays is the carbon fibre reinforced polymers that is an extremely strong and light fibre-reinforced polymer which contains carbon fibres. The polymer is most often epoxy, but other polymers, such as polyester, vinyl ester or nylon, are sometimes used. The composite may contain other fibres, such as aramid e.g. Kevlar, Twaron, aluminium, or glass fibres, as well as carbon fibre. [23]

Speaking about how to manufacture carbon fibre reinforced materials it would depend on the requirement needed [23]. It also depends on the piece being created, the finish required, and how many of this particular piece are going to be produced. In addition, the choice of matrix can have a profound effect on the properties of the finished composite. But the most popular manufacturing processes for carbon fibre materials are:

- Molding
- Vacuum Bagging
- Compression Molding
- Filament Winding
Carbon fibre is used mainly in aerospace engineering, automobile industry, sport equipment, civil engineering applications, military equipment, medical equipment and aircraft industry [2,15,19]. In figures 18, 19, 20, 21 and 22 are shown some current examples of carbon fibre applications.

Figure 18. Automobile Industry
Figure 19. Apple Laptop
Figure 20. Boeing X32
Figure 21. Bicycle
Figure 22. Motorbike Helmet
No Skidding Materials

The Triathlon Training Room requires to use a no skidding material in some parts, for example around the sport machines or inside the transition room. It must be a no skidding material because the user could be wet after training at the swimming pool or because the user could be sweated while he or she changes of sport. Safety must be one of the most important characteristics of the product so it is needed to have several knowledge about what kind of materials could be used in order to assure the user security.

There are different kinds of no skidding material such as plastic materials, no skidding tapes, vinyl coverings and some sort of paintings.

- **High Density Polyethylene (HDPE):** or polyethylene high density (PEHD) is a type of plastic prepared from ethylene by a catalytic process. Since this material can be remoulded by subsequent melting and shaping, it is classified as a polyethylene thermoplastic. It can also be joined in segments when welded or machined. However, it does not accept adhesives very well. High density polyethylene is denser than most other polymer plastics due to its crystallization structure occurring in a linear fashion rather than branching out to form long chains of polyethylene. Instead, the lack of branching results in its carbon molecules bonding with more hydrogen molecules. This allows the final product to possess greater tensile strength, even though it is lighter than water. It also makes high-density polyethylene highly resistant to acids and solvents. [24]

Since high density polyethylene is so durable and chemically non-reactive, it has numerous applications in various industries. It is used in many different types of packaging containers, such as milk and laundry detergent bottles, as well as plastic grocery bags. It is also found in storage systems designed to store chemicals and fuels. In fact, high density polyethylene is used to produce materials to act as chemical barriers, such as liners that are placed under landfills to help prevent soil and groundwater contamination. One of the most common uses of this material is in the manufacturing of wood plastic composites to make furniture, flooring, fencing, and landscaping materials [24].

In terms of environmental impact, products made of high density polyethylene are not easily biodegradable in landfills. Such products can be recycled, albeit at the risk of losing some of its original tensile strength [24]. Since this material is constructed of hydrogen and carbon, being subjected to high heat merely results in the release of water and carbon dioxide. In figure 23 it is shown the resin identification code of this material.

![Figure 23. Resin Identification Code](image-url)
3 Theory

- **Teflon (PTFE):** polytetrafluoroethylene is a synthetic material. PTFE is a fluorocarbon solid, as it is a high-molecular-weight compound consisting wholly of carbon and fluorine [25]. Its molecular structure is shown in figure 24.

PTFE is a thermoplastic polymer, which has got the lowest coefficient of friction of all kind of plastics [25]. Owing to its low friction, it is used for applications where sliding action of parts are needed [25]: plain bearings, gears, slide plates, etc. In these applications, it performs significantly better than nylon and acetal; it is comparable to ultra-high-molecular weight polyethylene (UHMWPE), although UHMWPE is more resistant to wear than PTFE.

Others characteristics of PTFE are the high chemical resistance, it means that almost none chemical product could attack and wear out the PTFE. It is a non-stick and waterproof material due to it is used in the production of Gore-Tex fabric. PTFE is also good where high or low temperature resistance is required. The worst problem of PTFE is its price, is an expensive material compared to other sorts of plastics. [25]

- **No Skidding Safety Tapes:** anti slip tapes are an excellent and economical choice for most general purpose indoor and outdoor requirements for slip resistant tape. The no skidding tapes are usually made by a polymer [1], which contains some kind of abrasive material such as the grit aluminium oxide or silicon carbide.

The no skidding tapes can be produced in different colours, in figure 25 is shown some examples of these colours. This colour choice possibility makes the tape a flexible material, talking in design terms.

There are different kinds of no skidding tapes, which they have different properties depending of the requirements that are needed. For example, there are waterproof tapes, high traction safety tapes or tapes for heavy foot traffic and work environments.

Current applications [1,30] of no skidding tapes are playgrounds apparatus, pool areas, boat decks, ramps, walkways, aquatic equipment, locker rooms, showers, bathtubs stairs treads, power lawn machines entryways, snowmobiles, scooters, construction machinery, vehicles, machine shops, hazardous floors, industrial equipment, work areas, dock areas, stairwells, therapy rooms, exercise equipment, trucks and trailers.
2 Theory

- **Ethylene Vinyl Acetate (EVA):** it is commonly called EVA or foamy, which is its commercial name. It is a thermoplastic copolymer manufactured through the free radical polymerization of ethylene and vinyl acetate in the presence of initiating agents using the high pressure bulk polymerization process [40]. Structurally speaking, the weight percent vinyl acetate usually varies from 10% to 40%, with the remainder of being ethylene. [47]

EVA's properties vary dramatically from one product to another depending on the content of vinyl acetate in the macromolecule [6]. EVAs with different properties are used for different purposes. But all sorts of EVAs have some characteristics in common, all ethylene vinyl acetates are polymers that approaches elastomer materials in softness and flexibility, yet can be processed like other thermoplastics and its recyclability is as good as other thermoplastic. In figure 26 are shown some examples of the most common expression of EVA material, the foamy.

EVA has several properties such as good clarity and gloss, barrier properties, low-temperature toughness, stress-crack resistance, hot-melt adhesive, water proof properties, and resistance to UV radiation. EVA also has little or no odour. EVA can be processed by many different methods, such as injection molding, extrusion molding, blow molding, calendering and foaming. It is principally used in the production of packaging material, agricultural film, injection-moulded products, cable materials, foamed plastics materials, foamed plastics, master batch carriers, blending toughening material and damping soundproof material. It can also be used in the production of hot melt adhesive, carpet backing, wax-based coatings and shoe soles. Through hollow molding, EVA can be used for making expandable hoses, micro-irrigation tubes and other types of flexible hoses. [6,40,47]

Ethylene vinyl acetate does not only have industrial applications, EVA foamy is sold at toy and handicrafts shops. Due to its cutting, molding and glueing properties, EVA foamy is used in elderly therapy and childhood education. And because of its waterproof and non-porosity properties EVA is used in martial arts floors and parks where security is one of the most important characteristic. [47]

![Figure 26. EVA Foamy](image-url)
• *Anti-Slip Floor Paint Coating:* some kinds of paintings have non-skidding properties and they could be used as a finished treatment for covering floors. [27] Nowadays this paint coating is commonly used in diverse ways such as pleasure boat decks coating, sport courts coating and highways and cycle lanes coating. See these examples in figures 27, 28, 29 and 30.

The anti-slip paintings can be made of several kinds of additives but the most normal additive that is used for get no-skidding properties is the epoxy resin. Epoxy resins are created by transforming liquid polyethers into infusible solids through a special curing process. In most cases, resins are the result of a chemical reaction between epichlorohydrin and bisphenol-A. Epoxy resins have thousands of applications, they could be used like adhesive, foam, construction material, pipe, composite material component, in the aerospace application or in the electric industry. But the coatings industry is the biggest consumer of epoxy resins, these resins are used mostly as chemical and special purpose coatings. Epoxy resins provide thin-layer durable coatings having mechanical strength and good adhesion to a variety of substrates. They are resistant to chemicals, corrosion, and solutions. They find applications in washing machines and appliances, ships and bridges, pipelines and chemical plants, automobiles, farm implements, containers, and floor coatings. Epoxy coating formulations are available as liquid resins, solid resins, high molecular weight thermoplastic resins, multifunctional resins, radiation curable resins, and special purpose resins. Epoxy baking finishes are obtained by high molecular weight epoxy resins crosslinked by phenolic or amino resins. High-solid coating solution formulations attain maximum film properties. These are based on liquid epoxy resin acrylic adducts with epoxy resins. [10]
3 Theory

3.5 Manufacturing Process

Vacuum Forming

Vacuum molding has been considered by TriRoom Innovation AB as the manufacturing process which is going to be used in order to manufacture the final product and the chosen company for that task is called Jaxal AB. In this chapter the vacuum molding process and the company will be explained.

Jaxal AB (see logotype in figure 31) was founded in 1992. Originally the company manufactured passenger car trailers in aluminium and hoods for those in plastic. Roofboxes were also products that were included in the former range. Trailer Production ceased in 1998 and developments and efforts were made solely on plastic products. [14]

Their vacuum-forming machines are some of the largest in Europe. Their forming capacities are 4900x2400x1300mm. At the moment, they have two vacuum-forming machines. The first one was put into operation in 2008, and the latest one in 2011. [14]

Their market areas include the Nordic countries, Estonia, the Netherlands, Germany and Austria, being the company located in Övertorneå, Sweden, in the Torne Valley region near the Arctic Circle. [14]

About the process, vacuum forming is a simplified version of thermoforming, whereby a sheet of plastic is heated to a forming temperature, stretched onto or into a single-surface mould, and held against the mould by applying a vacuum between the mould surface and the sheet [30].

Vacuum forming is usually restricted to forming plastic parts that are rather shallow in depth. Thin sheets are formed into rigid cavities for unit doses of pharmaceuticals and for loose objects that are carded or presented as point of purchase items. Thick sheet is formed into permanent objects such as turnpike signs and protective covers. [37]

Suitable materials for use in vacuum forming are conventionally thermoplastics. The most common and easiest to use thermoplastic is the high impact polystyrene sheeting (HIPS). It is moulded around a wood, structural foam or cast or machined aluminium mould, and can be formed in almost any shape. Vacuum forming is also appropriate for transparent materials such as acrylic, which are widely used in applications for aerospace such as passenger cabin window canopies for military fixed wing aircraft and compartments for rotary wing aircraft. [37]

Original equipment manufacturers (OEMs) utilize heavy gauge vacuum formed components for production quantities in the range of 250–3000 units per year. Vacuum-formed components can be used in place of complex fabricated sheet metal, fiberglass, or plastic injection molding. Typical industry examples include kiosks and automated teller machines, enclosures for medical imaging and diagnostic equipment such as magnetic resonance imaging (MRI) machines, engine covers in a truck cab, and railcar interior trim and seat components. [37,38]
3 Theory

3.6 Usage environment

When developing a product, it is important to study its environment. In this section diverse usage environments will be studied in order to know more about possible placements of the Triathlon Training Room (TTR), to know its characteristics, requirements and needs.

When referring to usage environment, we mean everything that affects the product being placed into a certain context. That is the reason for this section includes information about possible placements, formal and functional studies of objects that have a similar context.

Placements

Originally the TTR was considered to be placed in gyms or fitness centres, but due to the target group in which is focused, its placement can be extended to hotels, airports, private spaces...

The only requirement that demands the Triathlon Training Room is an open space of 30 m².

_Gyms/Fitness Centres_

After the investigation of diverse gyms and fitness centres style (see an example in figure 32) we consider that in general all gyms are composed by several open rooms in which the training machines are placed, or empty rooms with the purpose of being multidisciplinary spaces in which one can practice diverse activities.

Fitness centres are places where people can get athletic aspirations, achieve fitness goals or accomplish having a good health following a certain lifestyle.

That is why a gym or fitness centre is the perfect emplacement for the Triathlon Training Room.

_Private spaces_

Another possible placement could be a private space, thinking about people a little bit outside the target group, making the Triathlon Training Room their own gym at home.

_Waiting rooms_

Attending the general characteristics of the target group of the Triathlon Training Room, they want to follow a certain lifestyle, taking care of their health, having a high interest into sports but due to their professional daily life they do not have too much time to practice it.

With these characteristics, there are diverse places in which the target group could make the most of free time to practice HIIT. Because of that, Placements like hotels, airports or offices were additionally analysed, see one example of this analysis in figure 33.
4 Method
4 Method

The design process includes any action carried out in order to achieve a design objective. Through the design activity is necessary to know different methods and design tools for applying the most suitable one in each situation. A method is the way of achieving a goal previously proposed, following a group of rules. [5]

This project is carried out using our own process that is the result of our last university years, based on our own work experience and self-knowledge. The process has several steps in which each one of them different methods are used, the steps of our process can be seen below and the methods used in each step are explained in detail along this chapter.

1. Briefing and Planning
2. Gathering information and Information analysis
3. Problem and Needfinding
4. Creative Phase: Idea generation and concept generation
5. Concept development and Concept choice
6. Modelling: 3D Visualization and Prototyping
7. Reporting: Presentation and Report

4.1 Briefing

The briefing is the first step in any design process. Inside the brief is shown the information and requirements that the designer needs to start with the project. For this project the brief is given by the company, TriRoom Innovation AB, and the objectives are focused during a meeting with them. The brief and our situation analysis is presented in more detail in Chapter 2, Current situation.

4.2 Project Plan

A project plan is required to accomplish certain objectives along a specific time period. The project is structured in different phases and a period of time is assigned to each phase in order to be finished according to the settled deadline. A Gantt Chart is created following this time planning. Our project plan and Gantt Chart can be seen in Appendix 3: project plan.

4.2.1 Gantt Chart

This method is a graphical representation of the time planning for the project. The chart has a horizontal timeline on one axis and a vertical list of tasks in chronological order on the other axis. Every task is presented with a bar, where the length corresponds to the duration of the task. [39]

To use a Gantt Chart along the project was useful for us in order to know our deadlines and what part of the master thesis should be done for each deadline. The Gantt Chart is also a good way of dividing the work into several steps and small objectives that can be achieved day by day.
4 Method

4.3 Data Collecting

Gathering data is made at the first stages of design to have all the information necessary for developing a product. In this chapter diverse methods are applied to get useful data about the fields which are important for the product that is going to be designed.

4.3.1 Concept mapping

To organize a successful compiling of the information is needed to know which are the areas that need to be covered in the project. To structure the project is applied the Concept mapping method, through concepts related to the product enclosed in circles or boxes, and relationships between them indicated by a connecting line that results in linking the concepts. All the fields that need to be studied are graphically represented in a segmented way thereby. [31]

This method helped us at the beginning in order to structure the information that we will need for knowing the product and designing the best solution.

4.3.2 Benchmarking

Benchmarking is a comparison of solutions on competitor’s products against the problems or requirements that are tackled in the project. [26]

Benchmarking is used to know how relevant design problems are solved nowadays and in order to inspire us during the creative phase. This method was applied mainly attending to the formal study of the product and the way of take the most of small spaces.

Formal study

When designing a product, its formal appearance may be decisive for being a success inside the market, and if groups of objects with the same characteristics are looked at, it is common that they are designed under the same design patterns.

Approaching different environments that have similar attributes as the idea of the Triathlon Training Room, it will be possible to identify some possible design outlines and formal appearances.

Products

Sports vehicles and complements can be placed in the same context than the TTR, because they are used by people who like competition and sports, and usually people who practice these hobbies also share a common lifestyle.

If a formal study is made, some important design factors can be pin-pointed, for example all the vehicles have an aggressive appearance without resting elegance achieved by full colours or steady lines which emphasize the shape of the product. Examples of this style can be see in figure 34.

Figure 34. Group of images with examples
4 Method

Architecture
Another important field of study that can give inspiration about a common design style that fits the environment of the Triathlon Training Room is architecture. Thus, attending to F1 motorhomes, football stadiums or museums it can be observed futuristic styles, but no-ornamental resources, using glass and concrete as main materials, recurring to organic shapes and using no-colours (black and white). Some example of this style can be seen in figure 35.

![Figure 35. Group of images that illustrates this style applied to architecture](image)

Interior design
In the same way, exterior design is used as inspiration as was architecture. It is also found important in a formal study to be attending to the interior design of the Placements in which the Triathlon Training Room could be placed. Some examples are gyms, VIP waiting rooms or clear and open rooms (see figure 36).

![Figure 36. Group of images that illustrates this style applied to interior design](image)

Similar Functionality
One of the present problems with the TTR, and something we will analyse in the creative phase is to have some spaces to keep the necessary equipment for the different sports.

In figure 37, some examples of solutions to storage in small spaces can be seen, these solutions go from using objects as storage furniture (doors, chairs..) or reducing the space to the minimum.
Some examples of actual solutions for ladders and doors that are built for small spaces are shown in figures 38, 39 and 40 to be able to analyse them later.
4 Method

Figure 39. Examples of ladders for reduced spaces

Figure 40. Examples of door for reduced spaces
Figure 10. Examples of door for reduced spaces
4.3.3 Personas

Making personas is an useful method to approach the target group defined for using the product. This technique enables the designer to build up detailed profiles of the personas themselves, their relationship to the product, and the context in which they use the product. [32]

We have made two “personas” who illustrate the target group, they are Daniela and Hans. With both of them the objective was to understand the target group in detail.

**Daniela Aguirre**

Age: 26

Lives in Buenos Aires (Argentina), but she comes from Mar del Plata (Argentina)

Languages: speaks Spanish, English and Portuguese.

Education Level: Higher education.

Daniela (see her in figure 41) works as a nurse in a public hospital, she is single and lives alone with her dog in a small apartment near her workplace. She wants to live in the outskirts in order to have time to go for a walk with her dog, but her work shifts do not allow her to live there.

She is a person who has been taking care of her health since she was a child, that is why she decided to study nursing at the university. During her university studies she discovered the athletic and decided to be inside the athletic team, before the university she usually did jogging and other sports but not in an organized way. Daniela enjoys more doing sprints than running long distances and she wants to be a sprinter, she realizes that she is good at it because she has won several university competitions. When Daniela finished her studies she wants to be in a semi-professional athletic team, but she have not been able to find the right one. She could not combine her working hours and the athletic team, so she has made her-own training plan adjusted to her schedule.

She is not really keen on technology and informatics trends, but she uses social networks in order to be in touch with her European friends who she met at international athletic competitions. Also she uses internet to be informed about semi-professional competitions and new training methods. She has a blog, where she gives some advices about sport and health.

Daniela likes classical music and she use it to relax after playing sports. She loves outdoors activities like camping, where she can be in contact with the nature. That reminds her of childhood when she spend the whole summers in her grandparents village. Whenever she has time, she goes running with her dog.

Daniela is an organized and persevering person, she is cheerful and she takes care of her physical appearance, because she is working with people and in relation to health and knows that this aspect is very important.
Hans Van Dijken

Age: 50
Lives in Rotterdam, Holland
Languages: speaks Dutch, German, English and a bit of Spanish.
Education Level: Higher education (in Economics)

Hans (see him in figure 42) works as a managing director in an international exports company, based in Rotterdam. This city has the biggest port in Europe. His job position makes Hans having an economically good position that allows him to own a sailboat, which he enjoys in his spare time with his family.

Hans is married with Ursula, 45 years-old, and they have two sons aged 20 and 15 and a daughter who is 5.

His job is very time consuming, because being managing director of an international company involves traveling a lot. In these business trips he usually has some waiting time in airports or while waiting for visiting clients, time that he uses to check national and international news about economics, politics and sports. Hans consults all these information in his iPad or iPhone, so he is update in technology, since he also uses them to work.

Hans is a friendly person in his personal environment but when speaking with his professional “face” he is strict, ambitious and quite tough.

He has always been very keen on sports and had a healthy lifestyle. When he was a teenager he was really passionate about cycling, a sport that he trained hard until he was getting a bit older. Having more professional obligations his time to dedicate to cycling was decreasing, but now when he wants to exercise he is going out with his mountain bike.

He spends his summers in Mallorca Island, Spain, where he goes sailing and cycling.

4.3.4 Mood Boarding

A mood board is a type of collage that may consist of images, text, and samples of objects in a composition. This method is done to know better the target and get insights about the likes of this group, also is a convenient visual tool to have an overall ‘feel’ about the users of a product.

[51]

4.3.5 Research

Diverse researches, mainly internet ones are made to get all the information that is needed to know about the project.
These investigations are carried out researching in segmented fields that are concerning to the product, is the case of HIIT, materials, manufacturing processes or the components of the Triathlon Training Room.

The research is made in order to compile relevant information for the product design.

4.3.6 Digital Surveys

A short questionnaire is spread through social networks to European population with diverse characteristics in age, studies, gender and etcetera to have an heterogeneous group of results. The surveys are made to know the opinion of the population concerning diverse aspects regarding the product and its environment, so a feedback with external persons to the project can be obtained.

4.4 Information Analysis

As important as collecting all the data that must be known during a project, is the analysis of that information. The information must be analysed in a detailed way because it is the base for several conclusions that will be taken into consideration while designing.

4.4.1 Survey Analysis

An empiric analysis is required in order to understand the information that the digital survey gives. The first step for compiling statistics information was to made a descriptive analysis, it provides a general vision of all the data and it also controls the possible errors and the values that are out of the study range [44]. After this, the questions are divided into two groups, one is for the closed questions and the other one is for the opened questions, where the surveyed can write their opinions. Distribution charts are made to represent graphically the closed questions and the opened questions are analysed one by one. [45]

4.4.2 Theory Analysis

The analysis of the theory chapter is realized through a deeply reading. While this reading is being done, notes must be taken and the important factors must be identified. After this reading, several conclusions are obtained.

4.4.3 Problem Definition

The conclusions obtained after the theory analysis and the survey analysis are used to define the main problems that exists in the products. The further idea generation is based in how to solve these problems.

4.4.4 Design Specifications

A product design specification (PDS) is a statement of what a not-yet-designed product is intended to do. Its aim is to ensure that the subsequent design and development of a product meets the needs of the user. [17]
4 Method

4.5 Idea Generation

The idea generation is the creative process of generating, developing and communicating new ideas, where an idea is understood as a basic element of thought that can be either visual, concrete, or abstract. The idea generation is all stages of a thought cycle, from innovation, to development, to actualization [9]. It is an essential part of the design process.

4.5.1 Brainstorming

Brainstorming is a technique for generating creative ideas and solutions through intensive and free wheeling group discussion. Every participant is encouraged to think aloud and suggest as many ideas as possible, no matter seemingly how outlandish or bizarre. Analysis, discussion, or criticism of the aired ideas is allowed only when the brainstorming session is over and evaluation session begins. The term was popularized by Alex Osborn in the 1953 book Applied Imagination. [4] Along the brainstorming session, the generated ideas are represented by both sketches and written ideas.

The brainstorming session was carried out in order to get the maximum number of ideas about all the design challenges that appeared during the need finding and problem definition step.

4.5.2 SCAMPER method

SCAMPER is a technique used to spark the creativity and help to overcome any design challenge. In essence, SCAMPER is a general-purpose checklist with idea-spurring questions. It was created by Bob Eberle in the early 70s. [22]

SCAMPER is based on the notion that everything new is a modification of something that already exists. Each letter in the acronym represents a different way that can be used to trigger new ideas:

- Substitute
- Combine
- Adapt
- Magnify
- Put to Other Uses
- Eliminate
- Rearrange

The SCAMPER method is applied in order to generate ideas that solve concrete problems, which are previously defined by analysing the data collection as it is explained in the sub-section called problem definition.

4.5.3 PMI: Plus, Minus, Interesting

PMI is a lateral and creativity thinking technique developed by Edward De Bono. It is used to evaluate different ideas, it is designed to deliberately direct your attention to the positive, negative and interesting aspects of a particular idea, subject or decision. [11]

PMI helps to make decisions quickly by weighing the pros and cons of a decision. It is also useful for widening your perception of a problem or decision, and for uncovering issues that might be not ordinarily have considered. [28]

4.5.4 Idea Classification

After the evaluation of each ideas, they are classified into several groups: ideas that are interesting but out of the project objective, ideas concerning to the transition room, ideas related to the cockpits, ideas about the ladder and ideas for the storage spaces.
4 Method

The idea classification is done in order to know which ideas are more interesting to go deeply in the next step.

4.6 Concept Development

Developing concepts is a decisive stage in the design process due to the ideas generated in the previous phase are the starting point to get suitable concepts which give solutions to the project requirements. During this phase, the concepts are submitted to a constant process of refinement and evaluation until the final design.

4.6.1 Sketching

Sketching is made during the idea generation phase along with the concept development stage, in order to visually represent ideas and concepts. This method is not only used for represent ideas but also to generate and explore diverse alternatives quickly. The sketches are first drafts made with pencils over whiteboards or sheets of paper, sometimes adding colours to differentiate zones and with small annotations that shows details that help the idea to be communicated. This technique is carried out individually and later on is shared within the design team.

4.6.2 Real Measurements Visualization

In order to have knowledge about the real measurements that the whole product have, some simple models are built. Those models are made of sticky tape or soft materials such as clay or foam. They are built basically for knowing the real space that can be used for designing. In figures 43 and 44 is shown some examples of these simple models.

4.6.3 Exploratory CAD Models

The virtual models are three-dimensional models generated using computer design software, they are very useful to verify measurements, knowing properties such as the volume or the weight and to visualize different kinds of materials and colours quickly. SolidWorks software is used to generate those CAD models.

The first CAD models are made in order to visualize the concepts in a real way.
4 Method

4.6.4 Concept Evaluation and Selection

Diverse concepts for different components of the product are generated during the idea generation. In order to chose the best solution for each component, we have applied the Pros and Cons method. This method works looking at the best and worst aspects of each design concept, these aspects are focused on the goal of the project, and then choosing the concept that has got more “pros” than “cons”.

4.7 Final Concept Definition

After choosing the best concept for each component, it is needed to continue developing the first concepts in order to achieve the final design for each component and for the whole product. Some important aspects of the design must be taken into consideration, such as the shape, the measurements and the final materials.

4.7.1 Shape Definition

The final shape of each parts must follow the same aesthetic style in order to be observed as one complete product, to avoid putting together some components with nothing in common. For the final shape design of each component it is needed to take care of this requirement and developing at the same time the different parts to give them aesthetic harmony. The triangular shape is the base for giving to the design this harmony.

4.7.2 Measurement Definition

The measurement definition for each component must be done following ergonomic rules in order to make the design comfortable for the maximum range of users.

Ergonomics is a multi-disciplinary science about understanding the relations between humans and machines and also the environment that is around them, in order to adjust the product to the user. To design for the maximum range of user, the design for the extremes method is used. Designing for the extreme users means taking as restrictive measurements the extreme population measurements and adjusting the measurement of the product to allow the whole user range between the extreme users to use the product with comfort.

4.7.3 Materials Definition

The right materials must be selected for each component of the Triathlon Training Room. The materials should be chosen attending to the specific requirement that each parts have, talking in terms of properties such as strength, translucent characteristics, manufacturing capabilities and so on.

4.8 Modelling and Visualization

When the final design is done, with all the right measurements and materials, the complete design must be visualized in a realistic way in order to make an approach to how the real product would look like.
4 Method

4.8.1 CAD Modelling

The virtual models are three-dimensional models generated using computer design software, they are used in order to create realistic models that can be used for the manufacturing. SolidWorks software is used to generate the final 3D CAD model.

4.8.2 Rendering

Making renders with photographic quality is the best way to illustrate how the real product would look like when it is manufactured. The tool used for generating these render is a design software called Key Shot.

4.8.3 3D Prototyping

Making a scaled model of the whole product helps to visualize and understand the final design. The technique carried out is using a powder 3D Printer (ZPrinter 650) to build the product.
5 Results
5 Results

5.1 Analysis

Survey Analysis

In order to have more information about how are the people who practise sports to use real data and opinions as a design tool to discover needs, habits... A survey has been done to gather the most common behaviours while doing sports as well as more focused opinions about this project, such as questions about triathlon and HIIT. The survey answered by those polled it can be found in the Appendix 1: Survey questions at the end of this report.

Doing this survey, the opinion of 292 persons with diverse job occupations, gender, age, habits... has been gathered.

Among these 292 persons, almost 70% of them (See Chart 1) usually practise sports more than 1 hour a week.

From now on, the charts and percentages shown are referred to these 69% of those polled who usually play sports because they are the people in which the interest is kept to our product which is a Triathlon Training Room.

In the charts below it can be seen that the survey respondents are gender-equalled due to a 51% of them are men and a 49% are women (see Chart 2).

The age majority of those polled is young people between 20 and 30 years-old (See Chart 3) but this percentage is not so big to distrust the results because results of people from 15 to 60 years-old have been analysed, contemplating a big age range that allows knowing different opinions from diverse points of view.
5 Results

As it can be seen by the results of the following charts (see charts 4-5) people who play sports are people with education (98%), who are active either working (42%) or studying (49%), being only a 9% of those polled unemployed. This working condition may be the reason why further on, there are some complaints about the lack of time for training.

Another important information about people who usually play sports is the weekly time that they dedicate to train. Here the opinions can be split in two groups, the majority of people (70%) play sports between 1 and 5 hours a week (see chart 6), and a 30% train more than 5 hours, being a 12% of those polled, people who dedicate more than 7 hours a week which gives us a profile of really sporty people of those which answered the survey.

One of the most important things about the Triathlon Training Room is that TriRoom wants to transmit a training lifestyle while using it, that is why it has gone deeply about the reasons why people play sports (see chart 7), being the three main causes health (85%), fun (76%) and physical appearance (69%).

Contrary to what it is commonly thought, the main reason is not the physical aspect of oneself for playing sports, in fact, people usually train to feel good with themselves and have a good health and lifestyle.
5 Results

Knowing the amount of sports and also which ones are the most played between people who usually do sport is also important in our project. So as, it is seen in the bar chart (see chart 8) the majority of people play between 1 and 3 different sports (87%), and only a 13% dedicate weekly hours to more than 4 sports.

Among the most common sports played, cycling, jogging and swimming are found, sports which will be trained at the triathlon room. The list with the most popular sports along with the number of people which practise the sport is completed in the table shown below, see also figure:

<table>
<thead>
<tr>
<th>Sports</th>
<th>Number of Practisers</th>
</tr>
</thead>
<tbody>
<tr>
<td>+50</td>
<td>Jogging, Gym (Bodybuilding and Cardio), Cycling</td>
</tr>
<tr>
<td>20-50</td>
<td>Football, Collective classes in the gym, Swimming</td>
</tr>
<tr>
<td>10-20</td>
<td>Basket, Ski, Walking, Paddle, Hiking</td>
</tr>
</tbody>
</table>

The rest of the sports played by the survey respondents were: skating, athletics, tennis, motocross, marcial arts, hockey, mountainbike, trail running, climbing, mountaineering, yoga, pilates, snowboard, golf, dance, tai-chi, table tennis, badminton, cross country skiing, diving, rugby, kayak, volley and archery.

The usual place in which people play sports is also important to take it into consideration to see which locations would be suitable for the TTR.

The place preferred for those polled to play sports is outside (65%) followed by the gym (50%), (see figures 46 and 47) leaving places as home or sport halls as secondary. (Note that most of the times one person plays sports in more than one place).
Despite the diversity of sports played, only 10 persons, a 5% of those polled who do sports have participate in a triathlon at least once in their lives. See triathlon Olympic pictogram in figure 48.

Although this percentage would increase if people which have played the three sports separately (swimming, jogging and cycling) are considered.

Even if a person has never tried triathlon, if he or she is used to playing sports, he has to have a concreted opinion about this olympic sport. The following list of words shows the most common opinions shared by the survey respondents to the question *What do you think about triathlon?*, this list provides the general idea of people about this sport.

- Discipline
- Perseverance
- Time
- Rough
- Endurance
- Demanding
- Strength
- Continuous dedication
- Competitive
- Tough
- Big Training
- Physical requirement
- Complete
- Intense
- Willpower
- 3 sports in 1

Most of the comments gathered with the survey shows that people think that triathlon is a very demanding, complete and tough sport, that requires a lot of hard training but it can be funny at a time, due to the variety, the combination of three sports in only one. Tough because it demands a lot of training but it is compensated by exercising the muscles of the whole body and leads a great physical and mental strength and resistance, making it a complete sport.
Some other comments were not so positive and reveal some complaints about the lack of time to practise triathlon because it is necessary to train several hours weekly and in a very intense way. Among the different opinions was also believed that it is necessary to have a previous good physical fitness, impossible to reach if you have not played sports since you were very young. Another of the most common objection is the need of installations for training the swimming part (see figure 49). Some interesting quotes from the survey are the following:

“Very complete sport in which the muscles works in different way. You must control the water with the swimming, dominate the ground by running and have influence over the wind with the speed of your bike. Only controlling the Earth elements you will be able to be an Ironman.”

“It is a considerably hard challenge and you have to be in shape both physically and mentally”.

“The variety of sports included in a triathlon makes this sport very attractive and funnier than practicing only one sport.”

When doing triathlon or any other sport, the most common thing is having the need of carrying some extra objects that help while training. That is why people were asked about what kind of gadgets they use when they play sports and about where they keep those objects. This question provides us an idea about people needs and likes during the exercise, and it will be very useful in order to know what people want while they train.

The question, asked “Do you use any extra object when you play sport?”, shows that more than the 70% of those polled use some extra object while they play sports. The most common objects which are used are media players and bottles of water, and they are used for almost everyone who had said “yes” to this question (see examples in figures 50, 51, 52, 53 and 55). In less amount of use, towels for the sweat and smartphones are found, the last one is used as a music player on most occasions. Another objects that had been mentioned are stopwatches, gloves and tools for bikes, some food and training planning.

About the place where people keep the objects (see figures 54 and 56), the most common places are their own hands while they go running, the pockets of their clothes, a small bag and a special armband for the smartphone. Other places were mentioned such as the floor, the gym machines, the bike and the tights. Some of the people say that they never know where they can put those objects while doing sports.
5 Results

TriRoom pointed out that they wanted to use a new technology that allows to share all your training results in social networks, so using apps to control your performance and efficiency, that is why we have included a question in the survey to know which percentage of people use technology while training.

The results shows (see charts 9-10) that almost the half of those polled (40%) use apps to control their results, being Endomondo, Sport tracker and Runtastic Pro the most used. But only a 25% of these 40% share their results in social networks being Twitter (40%) and Facebook (60%) the only ones used for sharing.

The last purpose of the survey is to discover if people know about the HIIT (High Intensity Interval Training) model and knowing which percentage of people have ever practised it.

As it can be seen in the Chart 11 a high percentage of people who do sports do not know what HIIT is (80%), this big amount of sporty people that is unaware of the HIIT model supposes a problem due to the ideal way of interacting with the TTR, that would be using it during a short period of time but at high intensity.

Other of the questions is referred to the practise of HIIT, revealing that only a 7% of those polled have trained using this model and a 9% would like to apply it in their training (see chart 12).

One of the reasons of why there is a low percentage of people who have practised HIIT may be the ignorance of this method and the advantages that involves such as burning more calories practising only 15 minutes (three times a week) or the hard work during the whole time to be more efficient.
5 Results

Theory Analysis

In this chapter it is shown an analysis of all the theory, current situation and method chapters, reviewing the information that it has been considered essential to the future design process. Some parts of the chapter are not analysed deeply because there were for our own information and knowledge, but they are not relevant for the design phase.

The main characteristics of the target group are a healthy lifestyle, the lack of spare time due their working lives and that they share an interest in sports. They would like to follow a semi-professional and efficient training.

Another characteristic of the target group is that they usually use technology devices such as smartphones, laptops and e-books. For helping with the analysis a mood board has been done which can be seen in next page, figure 57.

The high intensity interval training has a lot of benefits both for the health and for the body shape, but it is a very unknown training model, so people could be afraid of its use. People could feel reticent to believe that 20 minutes of HIIT exercise are more efficient that 2 or 3 hours of traditional exercise like running or weightlifting.

As it can be seen in the chapter 4. Method, the formal appearance of the TTR has to resemble to environments that have similar attributes for the target, among these formal quality it can be found:

- Aggressive appearance without resting elegance achieved by full colours or steady lines which emphasize the shape of the product.

- Futuristic and minimal style but using no-ornamental resources, using glass and concrete as main materials, recurring to organic shapes, endless lines and using no-colours (black and white).

Along the same chapter, materials and manufacturing processes have been investigated paying special attention to the non-skidding material. That is because having an anti-slipped surface is a desired property within the transition room, there are several options in order to achieve this characteristic, so using this material is not a restrictive feature.

The majority of the people surveyed believed that for training in a semi-professional level or if you want to participate in a big competition like triathlon, you have to invest a lot of time that they do not have due to their working lives, this is a problem that could be easily solved with a bit more of information about the HIIT training model.

There are people who are more reticent to practise triathlon due to the lack of sports facilities for swimming during the winter or for skiing (referred to White Triathlon) during the summer.

Thanks to the information gathered within the surveys, it is known that people are used to dedicate a fixed time for doing sports and they train in the same places, being the most used the gym and outdoors.
5 Results

Mood board

Figure 57. Group of images that illustrates the target group preferences.
5 Results

Problem Definition

After the revision of all the information analysis diverse problems that require solutions have been found, the following is a more detailed explanation of those problems.

- High intensity interval training is a very unknown sport, and normally people are afraid of changes. It can be seen in the survey analysis that the 80% of people who play sports do not know what HIIT is. It happens the same with the percentage of people who have ever practised HIIT, they are just the 7% of those polled. And finally, the 9% of those polled answered that they would like to try high intensity training. People could be afraid of trying the Triathlon Training Room because it is a completely different way of training from their current sport habits.

- There are three different objects that people use while they play sports, these objects are smartphones/music media players, bottles of water and towels for the sweat. People normally use their body to keep these objects, they use their arms, hands or the pockets of their clothes. While people use the Triathlon Training Room they will not use those spaces to keep the objects so it is needed to design the perfect solution for keeping those objects with safety.

- The high intensity training is a very demanding sport both for the heart and for the body so it is need an experienced person who advises the users. It must be necessary a previous health check-up in order to know that the user can go through its limit without having health risk. For example, the intensity of the first training session cannot be as hard as the fifth training session, even if the user is a skilled sport person, and somebody has to control that the user is doing its best.

- Since there are three different sports there are different tools, that are needed while playing each sport. At the swimming pool the user needs a bathing cap and diving goggles. While the user uses the treadmill and the bike he needs to wear sport shoes, so it is important to think where these objects could be placed inside the Triathlon Training Room.

- If the users will use their own smartphone, laptop or iPad the three sport stations need a support for these objects. Each kind of devices has its owns measures and it could be not possible to get a general solution for all kind of devices in which they will be used in safety conditions.

- Using a motor-less treadmill as the Curve from Woodway is, supposes that the machine does not count with a quick stop security button in case of falls.

- As the way they are now, exits a design problem in the transition room, specifically with the ladder and the door, that they are not defined yet.

- The cockpits for cycling and running are in their first phase of designing and need a more detailed design.

- Having three users inside the TTR at the same time implies that they have to begin training at once, otherwise they might have diverse training rhythms, it would be possible making them waiting to start one of the sports and they may feel observed and pushed to finish by other user while doing the sport. Gathering these issues gives an unprofessional point of view of the product.
5.2 Design Specifications

In this section the design specification that TTR would have to have are shown as a list, noting that some of them are requirements and other ones are desirable features.

- Having a security system or protection in case of fallen due to none of the machines count with a security stop button because they are motor-less and they stop completely because of the friction or the lack of action over them.

- Proposing suitable designs for the door and the ladder of the transition room that satisfy the needs of space and functionality without decreasing the aesthetic factor.

- The measurements of the Triathlon Training Room are defined by TriRoom and they are a critical specification being not recommendable to overcome that limit of 22 sqm. The sport machines measures are going to be considered too.

- Having some space to keep the necessary objects which are needed to practice the different sports.

- To have space for placing the second bike that is used in the cycling cockpit for having more variety of sizes and being more adaptable to a wider range of users.

- Considering the different zones for training together while designing individually, in order to have a common design style within the whole TTR.

- Taking into consideration the materials used in the machines for cycling and running so as in the pool for trying to maintain a design according to them, giving importance to diverse polymers due to that is the main option considered by TriRoom.

- The aesthetic must be simple and elegant without using garishly colours, the Triathlon Training Room will be preferably designed in white and black.

- The Triathlon Training Room must be a differentiated product.

- The product must be adapted to the majority of users and their needs.

- The Triathlon Training Room will be integrated in its environment, having in mind that this environment is not always the same. That is why the room could be customizable.

- The maintenance and the repairing facility will be taking into consideration while designing.

- The product will be human-centred, focused in the target group described in chapter 2, but not being this restrictive.

- The transition room is a space in contact with water so it is needed security measures to avoid accidents. Security factors must be considered in the whole product to avoid injuries.

- Intuitive cockpits design are needed, in which the user does not need to think, that is because the transitions between the three different stations should be fast (just a few minutes). It is a characteristic of the HIIT training method.

- The use of the room it is thought to have three users at the same time.

- The space is reduced so it has to be saved to the maximum, taking advantage of its possibilities.
5 Results

5.3 Idea Generation

A creative phase where ideas grow up is a need in order to develop useful concepts. Different creative methods have been applied such as brainstorming and SCAMPER (in figure 58 are shown some examples), but the previous analysis and the problem definition have been taken into consideration too. The union of creative methods and rational analysis have generated a list of ideas, those ideas are general ideas about the Triathlon Training Room and specific ideas about the transition room and the cockpits.

**General Ideas**

High Intensity Interval Training is a very unknown training method, the list of ideas below is about how to solve this problem:

- The creation of a strong advertising campaign about HIIT which includes a sport celebrity, for example a Formula 1 or Moto GP driver.
- To make the difference inside the gym using a different entrances, gym-card and etcetera. It is the same in the automobile industry with MINI and BMW, they are the same manufacturer but different brand, and people think that they are different cars.
- To create a new social network where TTR users could share advices, throw challenges and meet each others or create big events for common training sessions.

While the users are playing sports they generate energy, this energy could be stored and used for supplying the electricity system or the water cleaning system.

Everything is controlled by an informatics application, so there are the needs of some electronic devices. If each one uses its own smartphone, it could be stolen, it could suffer damages or it could be wet. So the best solution is not having your own electronic device inside the TTR and use just one device which is included in the TTR. The users will have access to their own information by logging on the application (which is personal and customizable).

TTR must be an effective way of training, so:

- The training system must be adjusted to the user and not on the contrary.
- The users could use their idle times to go there and play some sports.

*Figure 58. Some examples of the creative methods applied.*
5 Results

The HIIT training method is a very demanding sport, specially for the heart.

- A professional advise is needed, before using the TTR and while someone is using it. In order to have a professional control.
- A check-up must be done before using the TTR, in order to know what is the maximum training rhythm that the user can reach.
- It is needed a heart rate control while using the TTR. The user could have a heart rate monitor during the use and if something is not correct the heart rate monitor could send a signal to the informatics application and stop the training session or decrease the rhythm.

Since it could be three users at the same time:

- Theft must be considered, that is why a security system should be included.
- The user needs privacy.
- The objects must be identified, it could be by means of name, colour or number identification.

Since there are three different sports, some objects must be used:

- The survey has shown that almost everyone needs three objects while they play sports. Those objects are music, towels and a bottle of water. The music could be integrated inside the TTR by the use of electronic equipment but some space is needed in order to keep safe and dry the towels and the bottles of water.
- At the bike and run cockpits the user needs to wear sport shoes, so a place for keeping them is required.
- At the swimming pool, everyone needs bathing cap and diving goggles and maybe someone may wear earplugs.
- Those objects could be used during the transition time (while people change of sport), so it is important to put them where do not disturb and where they could be used with fluency.

Transition Room Ideas

The starting point to generate ideas about the transition room was the analysis of the current situation, in figure 59 there is a graphical analysis of it. It has been included the current functions and problems of the transition room, but also are mentioned some issues that must be considered.

Then those problems have been focused one by one and creative methods have been applied in each part, in order to achieve ideas that could solve the problems.

The next list of ideas has been generated after applying creative methods to each focused problem.

- Since three results must be controlled at the same time, it is needed to unify the control and to have a main device control and one screen in each cockpit.
- Is the door needed? If the user is not going to use the transition room as a changing room, the answer to this question is no, so the door could be deleted.
• The solution of having electrical control and the existence of water may be the voice control. The best way of control the TTR (your results, the app, the climate system and so on) is by the voice, it cancels some risks such as touching the screen with wet fingers or the chance of an electrocution accident.

• It is a problem that the ladder has structural function, talking about the aesthetic part, so it must be changed. Without this structural function the shape of the ladder can be changed and so, gain freedom for the conceptual design part. Also it has been considered that the aesthetic should be sportive and it must be used the black and white colours, but also is considered the possibility of making the TTR customizable.

• The measures are restrictive, but the triangle shape maybe is not the best shape to optimize the space and it could be changed to a circle. With a circular revolving door that give access to each cockpit and not only to the swimming pool.

• The current conception of the transition room creates a stress feeling. We can solve it by deleting the door or by changing the material (from one opaque plastic to a translucent one like poly-methyl methacrylate or polyvinyl chloride).

• A ladder is required and some space for storage is required too, so we can use the ladder as a storage space. We can put three steps for three boxes used by three users.

• The user has to wear sport shoes for cycling and running so a seat to put them would be advisable, it could be a fold-down seat like the ones existing in motor-homes.

• About the water evacuation it has been thought about changing the floor grid to an absorbent material that filters water, avoiding injuries on the feet.

Figure 59. Current situation and Issues to consider.
Cycling and Running Cockpits Ideas

The method implemented for ideas about the transition room has been used for cockpits as well. In the process, the starting point is an analysis of the current situation of the sport stations. This analysis, made in a graphical way, can be seen in figure 60. The figure includes problems and functions existing in the cockpits and also issues that will have to be kept in mind during later stages of design.

Once the previous analysis is made, we have been focusing on the different parts of the analysis to get ideas by diverse creative methods, which lead to the starting point of concept generation. The list shown below are the ideas extracted from the process mentioned above.

- The current surface which give access to the cockpits should preferably not be curved, making it more ergonomic compared to the one that exists currently in the product, including a non-skidding material as texture which proper friction.
- The cockpits have to include a safety element which allows the user to avoid accidents and that acts as a support element, for being in constant contact with the user will have to be designed including an anti-slipped and soft material to make a grip texture. The less edges the better.
- The safety element along with the surface which gives access to the cockpit has to have the same aesthetic design, having a formal relation in the whole cockpit.

Figure 60. Current situation and Issues to consider.
• Taking advantage of useless spaces to keep objects, as the walls or the back floor surface.

• User experience has to be made during training and the external walls of the transition room could have integrated screens in which the user could see the necessary information controlled by a central unified system.

• Thinking in the user experience it could be done in one direction giving information to the user. This data could be provided by colour lighting to start/stop the training.

• Combining the last two ideas, integrated screens and information communication, with the fact that the user should want to improve its training, a new concept of mirror could be included in the wall, in which the movements can be seen and also the requested useful data given by the unified system in the same mirror.

• Including a real triathlon simulator which include a micro-clime system raining or wind mood which can provide diverse clime situations.

• Are the walls necessary? Maybe they can be removed from the first proposal, saving construction costs and giving another aesthetic approach.

• The transitions between sports will have to be fast, that is why the design will be intuitive and will ease the access to the cockpits.

The Woodway Treadmill does not have a security stop button like the electric treadmills, and it is impossible to add one, the list below is about how to make it safer and prevent accidents:

• The floor of the cockpit could be made of rubber. If someone falls, is not going to be injured.
• A security handlebar is needed along the cockpit in order to make the chance of holding on to them and not fall.

As a conclusion of this analysis, there are some points where we will be focused while developing the previous ideas:
5 Results

5.4 Idea Evaluation

Gathering all the ideas mentioned in the previous section, it is necessary to make an evaluation to determine which ones that would be good bases for the concept generation phase. The method chosen for this idea evaluation is P.M.I (Plus, Minus, Interesting) [28]. Ideas are classified in three big groups including general, transition room and cockpits ideas. Inside each one of these groups there is a list of diverse ideas evaluated by the method mentioned above, using our own evaluation.

General Ideas

1. Theft must be considered, creating a security system.
   - **P** Increases users trust.
   - **P** The users do not have concerns about the possibility of theft.
   - **M** Adds some external elements (keys, codes...)
   - **M** Difficulty to implement for so many users.
   - **M** There are limited spaces to have safes, lockers...
   - **I** The process of doing sport is slower having to do all the security steps.
   - **I** Using security cameras reduces the negative points.
   - **I** If you do not enter the TTR with personal belongings it is not necessary.

2. The users need privacy.
   - **P** Depending on the users, they will not feel observed and under pressure.
   - **M** If the room is closed they might get the feeling of anxiety and lack of space.
   - **M** Some users go to a gym for their own exhibition, and this aspect would be decreased if the privacy is increased.
   - **M** Decreases the social factor.
   - **I** If the cockpits are opened is difficult to get privacy for three users.
   - **I** If the transition room is not used as a changing room, the privacy needed is not so high.
   - **I** The user would be the one who decides if their results want to be seen.
   - **I** Along with idea 1. together, the TTR could be placed in the streets.

3. Identify the users objects.
   - **P** Confusions are avoided.
   - **P** There is more fluency at the transitions.
   - **M** Adds more information to the user to remember.
   - **M** It might be repeated names for identifications.
   - **M** If there is storage in every cockpit it would be hard to remember what do you have in each cockpit.
   - **I** Make difference between identifying the objects or de spaces in which you place them.
   - **I** The identification method used could be used for more data, like own social network, apps...
5 Results

4. Integrate music in the Triathlon Training Room.
   \textit{P} • Most of the users listen to music while playing sports.
   \textit{P} • One device and its connector is eliminated for placing it.
   \textit{M} • If there are three users at the same time it is hard to isolate the zones.
   \textit{I} • If the same music is playing in the whole TTR users might have diverse likes.
   \textit{I} • Users could sync their list to an unified control of the TTR for playing them.

5. Using energy generated by the user when is doing sport.
   \textit{P} • It could be used for lighting, electrical supply...
   \textit{M} • There would be to do some studies to see if it could be profitable.

Transition Room

1. Unify the control having a main device control and the same screen in each cockpit.
   \textit{P} • Aesthetic unity.
   \textit{P} • Avoids the theft of personal smartphones, due to they are not kept inside the Triathlon Training Room.
   \textit{P} • Saves time in transitions because is not necessary to change from one cockpit to another.
   \textit{P} • There is no need to have multiples connectors to adapt each users device.
   \textit{M} • Being the same screen used for every user it is faster worn.
   \textit{M} • Need to have electrical supply 24 h. (Plugs, wires...)
   \textit{I} • Possibility of connecting the user device via wifi/bluetooth to the unified control.

2. Having voice control to administer the room.
   \textit{P} • Avoids the short-circuit possibility.
   \textit{P} • It could be used as a security system to identify objects.
   \textit{M} • It would be counterproductive if there is music integrated.
   \textit{I} • Is not a 100% developed technology, it may be the possibility of mistakes, misunderstandings or the non recognition.
   \textit{I} • The water contact could be avoided touching the screens with a pointer.

3. Removing the structural factor of the ladder.
   \textit{P} • Avoids the short-circuit possibility.
   \textit{M} • It is not sure to be able to suppress it.

4. Give circular shape to the transition room, having a revolving door.
   \textit{P} • It is a good solution for the door.
   \textit{P} • Eliminates the feeling of narrowness.
   \textit{P} • Gives access to the three cockpits.
   \textit{M} • Reduces the possibility of structural feasibility.
   \textit{M} • Three users could rotate the door at the same time.
   \textit{I} • More shapes could be considered.
   \textit{I} • With a revolving door you have to enter through the cockpits.
   \textit{I} • It could ban the entrance to the occupied cockpits.
5. Delete the door.
   P • Reduces the anxiety in the user.
   • Eliminates material, reducing costs and weight.
   • It would make the transitions faster.
   M • The privacy is lost.
   • It could be water splashes outside the transition room.
   • It would be to study the structural feasibility.
   I • Why not also eliminate the transition room walls.

6. To have non-opaque material at the transition walls.
   P • It decreases the stress feeling.
   • It creates a more open space, talking in visualization terms.
   M • The price of the product will be increased because it is used one extra material.
   • It could be not possible to create aesthetic coherence in the whole the product.
   I • Translucent materials, like PMMA plastic, create more privacy than transparent materials, like glass.

7. Using the ladder as a storage space.
   P • It is a combination of two needs or functions.
   • It saves space.
   M • The first step is very close to the floor, it could be an ergonomics problem.
   • It does not work well for all the objects that the user needs, some of these could not be placed there.
   I • Ergonomics must be taken into account.
   • It could be three boxes, one for each user, but they will have different measures.

8. Fold-down seat.
   P • It saves space.
   • It is solution that could be integrated easily, in visualization terms.
   • The need of putting on the training shoes is solved.
   M • The panels, where the seats will be placed, will not be modular.
   I • If the seat is placed inside the transition room the hygiene will decrease.
   • There is the possibility of having a different kind of seat, not only fold-down seats are considered.

9. Having an absorbent material instead of a grid in the floor.
   P • The safety of the personal objects will increase.
   • It decreases the chance of suffering foot injuries.
   M • This material will be a membrane, so it needs another layer of material in order to be more tough.
   • This kind of filter will need a periodic change.
   • If the user is without shoes, this material is not hygienic.
   I • It could be used in other elements such as the walls or the ladder.
   • Maybe it is enough with a small grid.

Cockpits Ideas
1. To not have curved surface in the cockpits floor.
   P • It increases the stability.
   M • Maybe it is not possible to change this shapes owing to assembly requirements.
   I • It could be just a very thin curve.
5 Results

2. Floor made of rubber.
   P • The safety is increased because this material is non-skidding and it is also a soft material, that does not cause injuries if the user fall out the machines.
   I • The material change must be taken into consideration because it is important to take care of the aesthetics of the whole product.
   • It could be possible not to apply this material to the whole surface.

   P • Some kind of security element, for example a handlebar is a critical requirement, it is need in order to avoid accident and to create stability.
   M • It could be an obstacle for entering in the cockpits.
   • These security element must increase the safety not create accidents (for example if they are made in a hard material and the user collides with them).
   I • It must be made of non-skidding material, because the user could touch it with sweated hands.
   • It could have double function, the security elements could be used as storage space.

4. To use the walls and the floor as storage spaces.
   P • It takes the most of the space that exists inside the product.
   • It is the perfect solution for training shoes, personal belongings...
   M • It is not that perfect for bottles of water and sweat towels.
   • The modular assembly will be lost.
   I • These spaces inside the walls or the floor must be “invisibles” while they are not being used, they must be integrated.

5. Integrated screens.
   P • It is more safety for the screen, because it is more difficult to break it and they also do not disturb.
   M • The modular assembly is not possible.
   • If the screens are far away from the user the interaction between each others will be difficult.
   I • Another way of putting the screens could be considered.

6. Having information in just one direction (Room-User).
   P • It avoids the chance of pressing the start button while the user has already started the training.
   • The users are more focused on the training because they are not thinking about doing other things.
   M • It must be some pre-defined times or it must be specify at the beginning.
   • The user could forget that there are screens that show information and the user will not pay attention to them.
   I • The written information could come with a sound.
   • What kind of information is needed?
   • The device needs to know where the user is going to start.
7. To have a mirror in which is shown information.
   - It combines two necessary functions, a mirror where the users could see their movements and the need of showing information.
   - The price of production will decrease because there are less technology, avoiding the use of Kinect system or video cameras.
   - The user could be overload because too much information is shown at the same place.
   - There is the possibility of having a video camera recording behind the wall, if the user wants to see its training after.

8. Micro-clime system.
   - There is the chance of training under different weather conditions.
   - It three users are training at the same time it must be three different climates at the same time, and it is a big technical problem.
   - The micro-clime system will use a lot of energy and it is very difficult to apply.
     - If there is the possibility of simulating rain, where does the rain go after?

9. To remove the walls of the cockpits.
   - More freedom feeling.
   - Less money expenses.
   - The visual impact will be lost.
     - It will have less structural tough.
     - It does not permit the possibility of storage things.

5.5 Idea Selection

After applying the P.M.I. method, there are some interesting ideas that are out of the objectives of this master thesis, that is why the list of ideas below are not going to be developed. The ideas in which the concepts are based will be described along the next chapter.

1. High Intensity Interval Training is a very unknown training method, the list of ideas below is about how to solve this problem:
   - Make a difference inside the gym using a different entrances, gym-card, etcetera. It is the same in the automobile industry with MINI and BMW, they are the same manufacturer but they are different brand, and people think that they are different cars.
   - Create a new social network where Triathlon Training Room users could share advices, throw and meet each others or create big events for common training sessions.

2. Triathlon Training Room must be an effective way of training, so:
   - The training system must be adjusted to the user and not on the contrary.
   - The user could use her or his idle times to go there and play some sports.

3. The High Intensity Interval Training method is a very demanding sport, specially for the heart.
   - A professional advise is needed, before using the Triathlon Training Room and while someone is using it. In order to have a professional control.
   - A check-up should be done before using the Triathlon Training Room, in order to know what is the maximum training rhythm that the user could get.
   - It is needed a heart rate control while using of Triathlon Training Room. The user could have a heart rate monitor during the use and if something is not correct the heart rate monitor could send a signal to the informatics application and stop the training session or decrease the rhythm.
5 Results

4. While the users are playing sports they generate energy, this energy could be stored and used for supplying the electricity system or the water cleaning system.

5. The music and the micro-climate system could be integrated inside the whole Triathlon Training Room, but we cannot design the electronic circuit or the best system to do that, because we have not got enough technical knowledge to do it. We can design the external sound and micro-climate exits, it means that we can design the speaker shapes, where the speakers and the micro-climate system should be put or the amount of the decibels we can use, talking in ergonomics terms.

6. We think that the best way of controlling the Triathlon Training Room is using a unified control, it means to use just one main device instead of use the user’s smartphone. It could be made through the informatics application but we have not knowledge enough about informatics to design this kind of technology. It can be designed the interface of the application but not how it will work.

7. Thinking about the unified control and taking into consideration that the TTR contains water (electronic devices and water is not a good combination), it is thought that one way of control the whole application could be using the voice. But analysing the voice control system we realized that it has got more negative aspects than positives, that is why this kind of technology is not enough developed yet.

5.6 Conceptual Design

Our concepts are based on the next list of main ideas and requirements:

- Unify the control of the TTR (informatics application, results, times...), using one screen in each cockpit and not the user’s device.
- The ladder is not a structural factor, giving more freedom.
- Change the transition room shape (circular, rectangular...)
- Delete the door, because we have considered that it is not useful for the users to change their clothes inside.
- Different materials: floor made of rubber, translucent material for the transition room walls, absorbent material in the transition room floor...
- Using the ladder, the walls and the floor as storage spaces.
- Place a fold-down seat which saves space.
- Not curved surface in the cockpits floor which is not safe.
- Including a security element such as handlebars.
- Communication in one direction, the user does not have to interact while training.
- To have a mirror with the information instead of a screen.
- Removing cockpits or transition room walls.

In the following pages are shown the concepts developed based in the previous list of ideas. To be focused, the solutions have been segmented according to diverse zones of the room.
Transition Room: Walls, Shape & Door

At the beginning the transition room was thought to have a triangular shape and to give access only to the swimming pool. But, why is this shape the best solution? And, why the transition room is not the main access to the three sport stations?

Thinking about those questions, is desirable to develop a concept in which the users could enter to each cockpit directly through the transition room interior and it has been considered that the best solution is to have a revolving door, as the ones that are normally at the shopping centres. But there is a big constructional problem that grows up with this idea: a perfect circle is needed in order to allow the rotate movement. This perfect circle cannot be made in the product because the swimming pool wall has to be flat to make possible the access to the pool. In drawing 1 is shown the idea of the revolving door and the mechanism that is needed.

Since this revolving door cannot be applied to the product, but continuing with the idea of changing the transition room shape, it is thought about making the transition room with a circular shape but making a non perfect circle. Also, we considered that the door should be changed from a normal door to an “invisible” door which could be hidden when is not need, see this idea in drawing 2.
Thinking about the transition room shape and its door another question came out, is it the door required? If the user is not going to change its clothes in the transition room, the door is not needed and it is a waste of money, talking in manufacturing terms. So, a concept in which there is no door in the transition room has been developed and this idea could be applied to the traditional rectangular shape or to the circular one, as it is shown in drawing 3.

If the door is not needed because there is no clothes change, why do we need walls in the transition room? Thinking about the way of using less plastic material, which decreases the manufacturing costs, we considered that the transition room could be made without walls, just having a solid structure that support the whole product. But also, we thought that if we want to put some walls (because is more aesthetic, there is more privacy, etcetera), that walls could be made of some fabric or glass, or by roller blinds or folding screens. Those examples are shown in drawing 4.
Storage Spaces

As it is explained earlier in this chapter we made a survey, and one of the most interesting and useful result was that people need several objects while playing sports. Since those objects are needed, the product has to have some storage space where the objects could be placed.

We have considered that there is not too much space inside the product, because the whole Triathlon Training Room must be placed in a 22sqm room, so those storage spaces must take the most of the free space.

One solution is using the ladder that gives access to the pool as a storage space, as it is shown in drawing 5. With this concept three requirements are solved, one is the need of giving access to the pool, another is that there is some space to keep objects and the last one is that with this kind of ladder there is a place where the user could put on his or her training shoes.

Another solution for keeping objects could be using the walls as storage space, these walls could be the transition room walls and the cockpit walls. We thought that this storage could be developed by making small pockets. Those pockets could be made of Velcro or fabric, to make the pockets invisible by folding them when they are not in use. Inside the transition room we can put two different pockets in order to have spaces, one dry and one wet to storage the swimming pool stuffs. See those concepts about the wall storage in drawing 6.

People need some extra objects while they play sports as towels, bottles of water or music players. But they also need to use some objects because without them they cannot play some sport, one example of this is the training shoes. It is a need to have a space where the training shoes can be placed while the user is swimming. One solution for this storage could be using the free space between the cockpit wall and the machine (the treadmill or the bike rollers) as it is shown in the drawing 7.
Bikes storage

The Triathlon Training Room is thought to include two bicycles in it. That is because if there are two bikes, one of them can be adjusted by one user that enters in the room, while other user is using the second bike in the cycling cockpit.

All possibilities of usage have being considered so the concepts are thought to keep two bikes stored when there are no users at the TTR. It is also kept in mind that transitions between sports have to be easy and fast.

Regarding those issues the solutions proposed are to keep the bikes handled while they are not used, but having a space in the floor for the bike that is adjusted by the user. For keeping this concept explained, a common sequence of normal usage is explained below.

- User 1 takes the bike 1, adjust the bike and place it on the marked zone of the floor. Then enters in the pool. (See drawing 8)

- User 2 enters in the room when user 1 has already taken the bike 1 from the floor and is using it in the cockpit. User 2 takes bike 2, adjusts it and places it on the marked zone of the floor. Then enters in the pool.

- When user 1 finishes cycling, places the bike 1 on the holder and goes running. Then user 2 can use the bike 2, previously adjusted in the cockpit for cycling.

- User 3 enters in the room and has bike 1 handled ready to take it and being adjusted.

- With this solution always will be one bike adjusted on the floor and another one handled that may be adjusted by the next user.

The problem resides in the zones that the bike might be placed due to the reduced space that the Triathlon Training Room has.

Below there are shown different formal solutions of handlers that can be placed in diverse areas of the room:

- Having the bikes placed in a vertical way (see drawings 9, 10) handled by one wheel.

This solution could be applied in the door of the transition room (see drawing 9) and also in the front side of the pool (see drawing 10), using space that is no used otherwise.

Having the bikes in the door is a good solution for saving space but could complicate the access to the transit room or may appear the problem of falls of the bikes due to the continuous use of the door.
Another space that can be used is a small area of the floor of the TTR that exists between the cockpit and the pool (see drawing 11). This area would have a small fissure on the floor with the width of the bike wheels for keeping the bikes in a stable position.

This place is also a good space for keeping the bike that have been adjusted by one user while he is swimming in the pool.

Another suitable area to place both bikes is using the walls of the cycling cockpit (see Drawing 12), either the external or the internal one. This zone provides a lot of freedom regarding to the formal development of the handlers (see Drawing 13), being possible to place each bike in one handler or both in the same one.

These handlers also could be used for store a bag with the personal belongings of the user having in this way a place for storing the necessary items without adding other extra handler for only that specific use.
Continuing the idea of handling both bikes and also the handler could be used to store the bag of the user the next concept is created, including both handlers (bikes and bag) in the same piece (see drawing 14). This piece could be placed in the areas previously mentioned or in the lateral side of the pool (see drawing 15) which is another space that could be taken advantage of.

![Drawing 14. Handler.](image1)

![Drawing 15. Bikes on the side of the pool.](image2)

**Seat**

One idea was to have a seat inside the transition room to make more ergonomic the process of putting the shoes on. This process is carried out when the user enters in the transition room and has to take his or her shoes off for entering the pool or when the user make the transition between swimming and cycling and has to put its trainers on.

The main idea is to have a folding seat, thinking always on saving space due to the area of the transit room is very reduced. Diverse solutions are shown in the drawings below, considering that the seat can be placed on the door or in one of the walls of the transition room.

The first concept is based in a polyester folding seat (see drawing 16), similar to the ones used for fishing or camping. The seat would be made of polyester or some fabric and two of the legs could be integrated on the wall, making the other two foldings, in order to free them when the user wants to use the seat.

![Drawing 16. Polyester seat.](image3)
The next idea is to have a folding seat that is attached to two vertical guides (see drawing 17) and make possible to adjust the height of the seat.

Another possibility is to have the same kind of seat but removing the guides (see drawing 17) due to the transition between sports is fast and the fact of adjusting the height of the seat could slow the rhythm of training.

Security Handlebars

The last field in which is focused the concept development is the security bars that can be found in each cockpit. This element is not only required due to a safety issue, also is thought to include an informative screen which provides sport information to the user, places to keep the necessary objects for doing exercise and additional support while cycling or running.

The first concept considered was thought simplifying the material to the minimum, having some simple bars to provide support to the user that also can be used as a place for having a water bottle or a towel as it can be seen in drawing 18.

Another option that is seen in drawing 19 is having some simple bars attached to fictitious walls that can be act as a separating element in case that there is no walls in the transition room. This element could have some pockets for water bottle or towel.
The third possible solution to this problem (see drawing 20) is two parallel curved bars that start in the wall or the floor of the cockpit and have another curved bars in the opposite direction for providing support while running and cycling.

As the previous concepts, the bars should have attached a support element for the objects that are used while playing sports.

In the middle of the parallel bars an iPad holder is included attached to adjustable guides which make possible to modify the position of the iPad. This adjustable element is included for having module bars that can be used both at the cycling and the running cockpit being adapted to ergonomic criteria in each case.

The last two concepts of bars are continuous bars that come out whether of the walls (see drawing 21) or of the floor (see drawing 22). Both solutions have an integrated screen in which the users are able to see the proper information that they require when they are practicing.
Final Design
Once the conceptual design is finished, each concept is analysed and the best solution for each problem is selected. After this selection of concepts, the design process continues developing the final design.

Each component of the Triathlon Training Room is explained in detail along this chapter and then the whole product is explained as one unique machine.

6.1 Transition Room

The interior part of the transition room is one of the most important problems that has to be solved in order to achieve the goal of this master thesis project. The transition room has several components, as it can be seen in figure 61, those components are explained in full detail below.

The transition room structure is made of welded steel tubes with squared section. These tubes are covered by two different kinds of fabric, one straight and waterproof such as Gore Tex, nylon or kevlar for the interior of the transition room and a reinforced fabric, such as carbon or aramid fibres, for the external part of the transition room.

The transition room also has a sheet of aluminium as floor. This sheet of aluminium is manufactured by laser cutting and it has a small grille that allows the water drainage. The grille should not be made by more than 5mm circular holes. If the diameter of the holes is bigger, people could be injured in their little toes or their personal belongings could be lost.

But the transition room should be more than a simple part of the product, it must be the Triathlon Training Room heart because it is the place where the training starts and where the user must be the centre of the design. That is why the transition room should has some space where the users can sit and put on their training shoes, some places for keeping objects (personal belongings, wet and dry stuffs) and for hanging their towels, but also it has to be big enough to allows people movement.

Since the transition room gives access to the swimming pool, some ladder must be placed in order to allow the entrance.
6 Final Design

Seat

The seat is a fold-down seat inspired by the current camping chairs that can be found in the sport equipment shops.

The seat is a folding seat to take the most of the space that the transition room has, in that way, when the seat is not used it could be folded and would be more space for the users movements.

The structure is made of powder coating steel tubes and the seat is made of vinyl coated polyester (polyester fabric with PVC coating). The seat is welded to the floor of the transition room.

The measurements of the seat are defined following ergonomic criteria, they can be seen in the Appendix 2: ergonomic explanation of the measurement. The measurements are 350x450x420 mm (Length x Width x Height). In figure 62 is shown a photo-realistic image of the seat.

Object Storage

In order to keep personal belongings of the users while they are swimming, and the pool stuffs when they are wet and when they are dry, some shelves are needed.

These shelves are shown in figure 63, the aesthetic follows the triangular shape that the company logotype has. The shelves are made of steel powder coating tubes as structure and vinyl coated polyester.

The measurement of the shelves are 345x185x188 mm (Length x Width x Height) the central shelve, and 195x125x175 mm, the others. The height where they are placed is explained in Appendix 2: ergonomic explanation of the measurement.
Towel Holder

A multifunctional hook is designed for hanging the towel inside the transition room and in the cockpit, but also it is used for storage the bikes when they are not in use.

The multifunctional hook can be seen in figure 64. It is made of polypropylene and it measurements are 45x130x31.5 mm. (Length x Width x Height)

The place where is placed inside the transition room is designed using ergonomic rules and it is explained in Appendix 2: ergonomic explanation of the measurements.

Swimming Pool Ladder

The transition room is the only access to the swimming cockpit, it is a requirement to have a ladder inside the transition room that allows the entrance, but also it is compulsory to have some system to come out of the pool after the swimming training is finished.

The solution to this problem is having two ladders, one inside the transition room and one inside the swimming pool. These ladders are made of polished stainless steel tubular structure for both of them and the steps are made of polished stainless steel with a non-skidding coating, the transition room ladder has two steps and the swimming pool ladder has three steps. This different steps number is because the level of the floor inside the transition room is 400 mm higher than inside the swimming pool, and the extra step is needed to save that difference.

The measurement of each step is 600x100x50 mm (Length x Width x Height) and the gap between them is 250 mm. In order to permit the user to be hold while entering the pool there is a security handlebar added to the window that acts as the pool door. This handlebar is made of stainless steel and it has a diameter of 50 mm. In figure 65 is shown the transition room ladder and in figure 66, the swimming pool ladder.
6 Final Design

Door

The transition room must have a door because it is the place where the user change his or her clothes, from swimming to cycling and running. But also because it is the place where the users keep their personal belongings, that is why this door should be able to be locked from the interior of the transition room.

This problem can have two solutions, one is a folding door and the other one is a saloon door, but in both situations the door is made of painted PMMA with a stainless steel knob. The folding door option permits to have bigger transition room area than the permitted by the saloon door. But also with the saloon door the transition room area could be a little bit bigger than the first one, because in the first design the transition room door was almost one meter width and according to ergonomics it is not needed that much space, as it is explained in Appendix 2: ergonomic explanation of the measurement. The saloon door gives a transition room area of 1.57 square meters and the folding door, a 1.63 square meters area.

In figure 67 can be seen the saloon door option and in figure 68 the folding door option.
6.2 Cockpits

The two cockpits present in the triathlon training room are the same, talking in manufacturing and design terms, but they are used for playing two different sports. Both cockpits need to have a security handlebar, an Ipad holder and some space for keeping object such as personal belongings of the user, a sweat towel or a bottle of water.

The cockpit and it components can be seen in figure 69, those components are explained in full detail below.

The cockpit structure is made of welded steel tubes and the structure is covered with aluminium, manufactured by laser cutting. The roof, that joins the cockpits and the transition room roof, is made of a carbon fibre tubular structure and tight fabric such as polyester or nylon for covering the structure.

As it was said before, inside the cockpits, the users need to keep some objects such as the sweat towel, their personal belonging, the stuffs for playing the other sports or the bottle of water. Different solutions are designed for keeping each object.

Object Storage

For keeping the personal belongings and the stuffs for playing other sports it is used the same triangular shelves that are placed inside the transition room, they are already explained in detail early in this chapter. The use of the same shelves is because it gives aesthetic harmony and it makes the production easier.

Towel Holder

For hanging the towel, it is used the same multifunctional hook than it is used for hanging the towel inside the transition room but it is placed close to the handlebar. The material and measures of this hook are previously explained.
6 Final Design

Security Handlebars

Both cockpits, the running and the cycling one, need to incorporate a security handlebar that does not allow the users to fall. But also the handlebars are used in order to support the users while they are running, if they want to hold on to them, and they are used for gather momentum while cycling.

The handlebars are made of polypropylene tubes (with a diameter of 50mm) and polyester fabric. The handlebars are 1340mm height and 790mm width, the with measure is big enough to allow the users to be hanged while running and it is also big enough to permits some bike movement along the rollers while cycling. The measurement of the handlebars are explained in Appendix 2: ergonomic explanation of the measurement.

The handlebar has added a small pocket for keeping the water of bottle, this pocket is made using the same materials than the handlebars and they are placed on the right side of the bike cockpit and on the left side of the treadmill cockpit, that is because in this way the pocket is always close to the open space for making the transitions faster. This pocket is also thought to be folding in order to be more integrated with all the design.

In the middle of each handlebar there is an iPad, this iPad is held with a holder designed for being placed in this handlebar. The holder is made of an aluminium base, that match perfectly with the diameter of the security handlebar, and a polycarbonate holder where the iPad is placed.

In figure 70, it can be seen the whole security handlebar and figure 71 and figure 72 are detailed images of the iPad holder and the place for the bottle of water.

Figure 70. Security Handlebar.
Figure 71. Place for the bottle of water.
Figure 72. iPad Holder.
6 Final Design

6.3 Bikes

The product is thought for having two bikes at the same time, one used by one user and other one adjusted for other user. That is why some space for store the bikes is required.

Bike Storage

The multifunctional hook that was explained early in this chapter is used in order to store the bikes while they are not in use.

The maximum height for this holders is 1600mm, according to ergonomics, as it is explained in Appendix 2: ergonomic explanation of the measurement. And the gap between them is 800mm in height and 400mm in width, those measures match perfectly with the bikes frame size.

In figure 73 it can be seen two bikes stored.

Adjusted Bike Space

There are two valid solution for keeping the adjusted bike while it is waiting to be used. One is putting the bike next to the pool and the other one is putting it close to the cockpit, in the same direction of each one. But in both of them the system for holding the bike is the same, there are two holes in the floor with the perfect measure for keeping the wheels and for holding the back wheel safer there is a steel tube that supports the wheel by the axle box.

Both options are correct for solving the problem, although putting the bike next to the pool gives a more freedom feeling than putting the bike close to the cockpit, that creates a felling of a closed space. Both solutions are shown in figure 74 and figure 75.
6.4 Final Product

In figures 76 and 77 the whole Triathlon Training Room as one unique product can be seen.

*Figure 76. Front side of the Triathlon Training Room.*

*Figure 77. Another view of the whole product.*
6.5 User’s Journey

To clarify how the product should be used, a short explanation of one typical user’s journey is described below. In this use sequence it is seen which actions has to do each user and how it is managed to be three users at the same time for a proper functionality of the room.

*Figure 78. User’s journey 1*

At the beginning of the training, user 1 (blue shirt) enters in the TTR. User 1 takes bike 1 down and places it in the bike holder. User 1 adjusts bike 1 and enters in the pool through the transition room.

*Figure 79. User’s journey 2*

User 1 finishes to swimming, he or she enters in the transition room and change his or her clothes and put on the training shoes. User 1 takes the adjusted bike and starts cycling.

User 2 (green shirt) enters in the room.

*Figure 80. User’s journey 3*

While user 1 is riding bike 1 in the cockpit user 2 adjusts bike 2 and places it in the bike holder.

User 2 starts to swim.

*Figure 81. User’s journey 4*

User 1 finishes to ride the bike and place the bike 1 in the multifunctional hook that is in the cockpit wall. User 1 starts to run.

User 2 finishes to swim and takes the bike 2, that is pre-adjusted, and starts cycling.

User 3 (red shirt) enters in the room.
6 Final Design

Figure 82. User’s journey 5

While user 1 starts running and user 2 starts cycling, user 3 enters in the room and takes the bike 1 down (which is held in the multifunctional hook) and user 3 adjusts it in the floor holder.

User 3 goes swimming after the bike 1 adjustment.

Figure 83. User’s journey 6

User 1 finishes running and he or she finishes the training session.

User 2 finishes cycling and places the bike 2 in the multifunctional hook that is in the cockpit wall. User 2 starts to run.

User 3 finishes to swim, takes the adjusted bike and starts cycling.

Figure 84. User’s journey 7

User 2 finishes with the running and the training session is done for him or her.

User 3 place bike 1 in the multifunctional hook in the cockpit wall and starts running.

Figure 85. User’s journey 8

User 3 finishes to run and the training is done for him or her.
Reflection
7 Reflection

In this section some questions that can be object of discussion are further reflected upon. The questions addressed below are the result of our own analysis seen from an external and critical point of view.

7.1 Theory

The information gathered in the chapter 3. Theory is information that we considered to be needed to confront the project, those fields were considered essential to carry on the next phases of the product design.

The first insights (referring to target, materials, etcetera) given by the client company, TriRoom, were the base of the information which appears in this chapter and the previous one, 2. Current Situation, later on in this project it is seen that some of the information is not used for the final design but was absolutely necessary at the beginning of the project.

7.2 Method

When the project that this thesis is grounded in was planned, we decided to carry it out using our own design process following diverse methods applied in each step, considering which one was the most suitable one for each situation. The fact of using our own process and not applying a previous established one might be risky, but we thought is better to have a personalised process that is the result of our own work experience and self-knowledge.

The fact that there are both rational and creative methods implemented in diverse phases of the project often means a better output in the results. Having this mixture makes each method perfectly adapted to get the desired solution within the phases of the project.

7.3 Results

The first part of the results, in which the analysis of the survey is made, gathers the answers of certain people in a concreted lapse of time. That means that the conclusions obtained from the survey are only data for the period of time in which the survey is done and therefore the results could vary with time.

Ideas came out during the results phase that may be interesting for the product, but they were out of the fixed boundaries that the work had. That is why they are presented as recommendations in chapter 9. Recommendations.

Some of the ideas that are turned down initially are recovered in later stages due to the constant feedback that was got from the company, thus according with the ideas of what they would like for the Triathlon Training Room.

During the final stages of the results, when the concept development was carried out and continually modified thanks to the feedback provided by the client company, there was a point in which was decided to not implement more modifications due to the time issue and hence for meeting the project deadline.

7.4 Final Design

Before this thesis was done, the room was functional, but being only functional it is not enough for a product. With the final design, a room that besides functional has been adapted to the user looking at issues like usage, security, ergonomics, etcetera. Having this refinement we provide the user a easier and comfortable use of the Triathlon Training Room without lacking the functionality.
The aesthetics created for the TTR is based in the company actual logo due to they do not have their brand identity yet. So the style of the room and their components is triangular based (as so it is the logo) and keeping minimalism using black and white and modularity as well as common materials in diverse elements. This style could change once the company will develop a brand identity for the Triathlon Training Room and so the aesthetic of it should be adapted to the look and feel that they want to transmit with that identity.

This design style is completed with the modularity of the components placed in the TTR, making the sport practice as an intuitive training for the user.

Ergonomic was a key factor when speaking of getting the final measurements of the different components of the room due to all the project is followed on a human-centred design being a restrictive factor for the design of some sections of the project.

7.5 Objectives

In the beginning was hard to focus the project because the input obtained from the company was already a developed product and the fields in which they wanted us to work at were not clear. Getting more information we detected that a refinement was required in some areas of their project as well as paying attention to some fields as security or ergonomics.

In the way of getting the goal of the fixed objectives at the beginning also some problems were detected that were not directly concerning the objectives but may be considered also part of our work, that is why the solutions given to them are included in the report and therefore part of the reached objectives.
Conclusion
The assignment Triathlon Training Room looked like a completely finished product when we first looked at it. But when we started to analyse the project in depth, we realized that there were some work remaining, because several aspects and details had not be taken into consideration.

In this way, our starting point was to look at the project with "new eyes" and "open-mind" in order to find new needs and problems in the current design. The fact that we were two students without any previous knowledge of the product, its components and functions, was a very important point, because we could be free to criticize the product, but also, to discover new strengths. We think that it was necessary to involve someone new in the project, in that step of the development.

We have analysed the whole product, we have found problems that no-one has discovered before and we have created valid solution for each problem. However, we have not only solved problems, we have found so many new ideas that can be useful for further developments. We have not constricted our design to the limits of the master thesis objectives, we have been thinking further and we have come up with fresh ideas for the product and for the company too.

We have completed the Triathlon Training Room design with our concepts, now the product is more complex, more defined and easier to use, because the user has been the centre of our design process. We think that our solutions match users needs and preferences. Also, we have followed the aesthetic style that TriRoom has initiated.

Although, we have not designed a lot of new products or components for the Triathlon Training Room, we have reached the objectives that we had at the project start. We have developed an exhausted analysis of the product, discovering new aspects and needs and we have given to TriRoom Innovation AB many new things to think about.

At the end, the product designed with an holistic view, in which terms of safety, ergonomics, experience, functionality, etcetera has been covered, achieves the fulfilment of a problem’s solution, giving the users an adequate product for covering its needs. If this product is appropriate for the users it will mean an increment in the use of it, and hence it will be a benefit for the sales and standing of the company.

The company also will be beneficiary of our work because it has relevance in all the aspects that we have tackled, being the user the centre of our thoughts, and having a better design for them therefore.
Recommendations
There are some ideas that are not covered in this report due to time or knowledge limitation or because they are outside the main objective of the project. However, we think that those ideas would be interesting for the TriRoom future plans. The list below is a short explanation of our recommendations:

- We consider that a market plan is a very important point for attracting the maximum range of users, and to make the most of the product. The best thing would be making a strong advertising campaign explaining what is high intensity interval training and its benefits, and also, publicize the triathlon. We recommend to use a famous sportsman or sportswoman, such as e.g. a Formula 1 driver.

- The differentiation of the product is also important. The Triathlon Training Room is a new conception of training and this differentiation must be its mayor strength. We recommend to make the differentiation using a different gym card or entrance.

- We suggest to create a new social network where users could challenge each others and share their results and advises.

- Users should wear special clothes for using the TTR, we advise to create special swimming suits, diving goggles, towels, training shoes and etcetera, which have the TriRoom logotype and a customized design. The creation of this “corporative products” would make the experience better.

- In order to emphasize the fact that the TTR is a luxury product we think that the user can have a “welcome pack” at the beginning. This welcome pack could include the corporative products that we discussed before and, also, information about the way of training the HIIT. It could be given to the user when he or she buys the gym card.

- We have designed two different solutions for the transition door, one is a folding door and the other one is a saloon door, we recommend to use the folding door. Because if the transition room has that kind of door, the transition room area is bigger than the saloon door area. And also, it is more comfortable to open it because the user is not going to disturb the other user, who is in the running cockpit.

- We suggest to put a lock system in the door. That is because if the user wants to change clothes, the user may want to have more privacy.

- For the real production of the Triathlon Training Room, the vibrations that will be generated because of the use must be taken into consideration. We advise to make a vibrations study before production.
9 Recommendations

- We have generated two valid solutions for placing the adjusted bike, one is on the floor close to the bike cockpit and the other one is next to the swimming pool wall. We suggest to use the second option because it creates a more open space than the first one. To place the adjusted bike close to the cockpit could make the space more closed, and the user could hence feel locked in the cycling cockpit.

- The safety is a must in all designs that involves peoples use, specially when there is water around. Since there is a swimming pool inside the product some emergency system must be included in order to make a rescue if needed. It should be a different access than the transition room in order to have a fast access to the swimming pool or a water evacuation system that does not permit the possibility of being drowned.

- We think that the product should be customizable for each customer, it could be done by using more colours than black and white. For example; if a gym buys the Triathlon Training Room, the gym logo could be placed somewhere in the product, or it could be painted with the corporative colours of the gym.

- The product is a very demanding way of training, so we consider that some medical advice is a good idea. We recommend that each user has a check out before starting the training for the first time and also during the training sessions, for example once a month. We also suggest that the users must wear a heart monitor that controls the heart rate while training.

- The HIIT training and the triathlon sport are very unknown for the general customer, so a professional advise is needed. We suggest to have a qualified person, very experienced in HIIT and triathlon, who can supervise the training sessions of the users and give some advices to them.


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- **Figure 59**: Current situation and Issues to consider
- **Figure 60**: Current situation and Issues to consider
- **Figure 61**: The transition room and its components
- **Figure 62**: Fold-Down seat
- **Figure 63**: Object Storage
- **Figure 64**: Multifunctional Hook
- **Figure 65**: Ladder in the transition room side
- **Figure 66**: Ladder in the swimming pool side
- **Figure 67**: Saloon door
- **Figure 68**: Folding door
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- **Figure 70**: Security Handlebar
- **Figure 71**: Place for the bottle of water
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- **Figure 73**: Two bikes stored
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- **Figure 76**: Front side of the Triathlon Training Room
- **Figure 77**: Another view of the whole product
- **Figure 78**: User’s journey 1
- **Figure 79**: User’s journey 2
- **Figure 80**: User’s journey 3
- **Figure 81**: User’s journey 4
- **Figure 82**: User’s journey 5
- **Figure 83**: User’s journey 6
- **Figure 84**: User’s journey 7
- **Figure 85**: User’s journey 8
- **Figure 86**: Seat measurement
- **Figure 87**: Shelves height

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- **Figure 89**: Grip zone height
- **Figure 90**: Door width
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- **Drawing 3.** No door concepts, circular and triangular shapes
- **Drawing 4.** Transition Room without walls or using fabric, blinds and screens
- **Drawing 5.** Ladder as storage space
- **Drawing 6.** Wall storage
- **Drawing 7.** Cockpit floor storage
- **Drawing 8.** Bikes Storage
- **Drawing 9.** Bikes in the transit room door.
- **Drawing 10.** Bike in the front side of the pool.
- **Drawing 11.** Bike placed on the floor.
- **Drawing 12.** Bikes on the wall.
- **Drawing 13.** Formal possibilities.
- **Drawing 14.** Handler.
- **Drawing 15.** Bikes on the side of the pool.
- **Drawing 16.** Polyester seat.
- **Drawing 17.** Adjustable seat and normal one.
- **Drawing 18.** Simple concept for bars.
- **Drawing 19.** Fictitious walls for bars.
- **Drawing 20.** Parallel bars.
- **Drawing 21.** Bar coming out of the wall.
- **Drawing 22.** Bar coming out of the cockpit floor.

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- **Chart 2.** Gender.
- **Chart 3.** Age.
- **Chart 4.** Level of education.
- **Chart 5.** Job occupation.
- **Chart 6.** Weekly hours dedicated to sports.
- **Chart 7.** Reasons for training.
- **Chart 8.** Number of practised sports per person.
- **Chart 9.** Use of sports apps.
- **Chart 10.** Sharing results on social networks.
- **Chart 11.** Knowing what HIIT is.
- **Chart 12.** Have practiced HIIT.
Appendix
Survey questions

This survey was made in order to know more about people sport habits. The goal is to get relevant information about what kind of sports people play, what people think about triathlon or how many people knows what is high intensity interval training. The questions made are shown in the following chapter.

Personal Information

Age

Gender
- Male
- Female

What is your job occupation?
- i.e. student, teacher, unemployed...

Education Level (finished or currently doing)
- Without education
- Secondary education
- Higher education

Survey

Do you play sports?
- Yes
- No

*If the person said no to this question the survey finished for him or her, that is because the target group for TriRoom Triathlon Training Room is people who play sport regularly. The opinion of people who do not play sports is not relevant for the goal of the project.*

If the person said yes, the are asked the next questions about sport routines.

How many ours per week do you do exercise?
- 1-3 h.
- 3-5 h.
- 5-7 h.
- More than 7 h.

Where do you do it?
- It can be multiple choice
  - Gym
  - Outside
  - I play team sports
  - Other

What kind of sport do you do?

i.e. jogging, soccer, fitness...

Why do you play sport?

Grade with 1 the less important and 3 the most important for you

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<thead>
<tr>
<th></th>
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<th>3</th>
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</tr>
<tr>
<td>Fun</td>
<td>o</td>
<td>o</td>
<td>o</td>
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<tr>
<td>Physcal Appearance</td>
<td>o</td>
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</table>

Do you use any extra object when you do exercise? Where do you carry it/them?

i.e: iPod, sweat towel that you carry on your shoulders...

Do you use sport apps when you practice sports?

i.e: Endomondo sports tracker, Runtastic Timer...

○ Yes
○ No

If you have choose YES, which ones? Do you share your results in any social network?

Please list in which social networks in case you share your results.

Have you ever play triathlon?

○ Yes
○ No

What do you think about triathlon?

You must answer although you have said no in the last question.
Do you know what HIIT (High Intensity Interval Training) is?
HIIT examples: Tabata, Gibala, Timmons
○ Yes
○ No

Have you ever practiced HIIT?
○ Yes
○ No
○ No, but I would like to
Ergonomic explanation of the measurements

Ergonomic is a decisive factor for determining the measurements of objects because in that way the objects are properly designed for human beings. In this appendix a deep explanation of which measures have been restrictive for designing the diverse parts of the Triathlon Training Room can be found.

To determine all the measurements it has been used the document International Anthropometric Data for Work-Place and Machinery Design [16] using data from European Population aged 18-60.

Folding seat

The folding seat has three dimensions that have been defined according to ergonomic criteria, see figure 86. To define the height of the seat, is considered the lower leg length (no. 20 on the table), having the restriction between the percentile 5 and 50 of the population, being the final height 420 mm. The width depends on the breadth of the hips of the user (no. 19), considering the extreme is the percentile 95, due to this percentage of the population will have the widest hips, also we give some margin being 450mm the width of the seat. For deciding the measure that sets the depth of the seat, the critical user is the biggest one, taking into consideration its abdominal depth (no. 21) as the final measure.

<table>
<thead>
<tr>
<th></th>
<th>P5</th>
<th>P50</th>
<th>P95</th>
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<tbody>
<tr>
<td>19. Hip Breadth</td>
<td>333</td>
<td>368</td>
<td>440</td>
</tr>
<tr>
<td>20. Popliteal Height</td>
<td>380</td>
<td>444</td>
<td>495</td>
</tr>
<tr>
<td>21. Abdominal Depth</td>
<td>195</td>
<td>237</td>
<td>350</td>
</tr>
</tbody>
</table>

Figure 86. Seat measurement
Appendix 2: Ergonomics

Height of the shelves

The shelves are regulated according to ergonomic criteria due to the lateral ones may keep small objects that need to be seen by the smallest possible user (percentile 5), that is why its eye height (no. 2) has been used.

The shelf placed in the middle only will keep a sport bag with the personal belongings of the user, so its in a height that is inside the reach of the smallest person, being its maximum height 1750 mm. See figure 87.

![Figure 87. Shelves height.](image)

<table>
<thead>
<tr>
<th>2. Eye Height</th>
<th>P5</th>
<th>P50</th>
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<tbody>
<tr>
<td>1420</td>
<td>1603</td>
<td>1750</td>
<td></td>
</tr>
</tbody>
</table>

Handlebars

The security handlebars, that are found inside each cockpit, are elements designed in a restrictive way taking ergonomic criteria and sports positions into consideration. The main problem resides in these bars are used both for cycling and running, being the position of the two sports really diverse.

The lowest point in the bars (Min. H) will be defined by the height of the handlebar the bike which is the point in which the elbow of the user will be, according to a triathlon posture (see figure 88). This depth's point will be the addition of the elbow-wrist length (no. 15) plus the hand length (no. 23) of the percentile 95 user and adding some margin counting with the bike wheel diameter (571 mm). This measure that will be 600 mm also is checked when running with the forward reach (no. 34).

![Figure 88. Cycling posture.](image)

<table>
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<th>15. Elbow wrist Length</th>
<th>P5</th>
<th>P50</th>
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<td>279</td>
<td>318</td>
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<table>
<thead>
<tr>
<th>23. Hand Length</th>
<th>P5</th>
<th>P50</th>
<th>P95</th>
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<tbody>
<tr>
<td>164</td>
<td>182</td>
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<table>
<thead>
<tr>
<th>34. Forward Reach</th>
<th>P5</th>
<th>P50</th>
<th>P95</th>
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<tbody>
<tr>
<td>640</td>
<td>728</td>
<td>820</td>
<td></td>
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</tbody>
</table>
For deciding the height of the screen, the restrictive measure is the eye height of the cycling user, that would be the addition of the bike handlebar height (previously seen) and the shoulder-elbow length (no. 12). To cover the posture difference between cycling and running, the screen will have adjustable inclination.

The last restrictive measure is the maximum height of the grip zone, which is obtained in the running position with the percentile 95 user, adopting a comfortable position stretching its arm at a medium height between its shoulder and elbow. See figure 89.

<table>
<thead>
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<td>12. Shoulder Elbow Length</td>
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<td>3. Shoulder Height</td>
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<td>23. Elbow Height</td>
<td>960</td>
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</table>

**Figure 89. Grip zone height.**

Multifunctional Hook

One of the uses of this element is to hold the bikes in the cockpit wall. The bikes are placed at two different heights, and both have been checked (with a scaled mannequin and graph paper) that are inside the reach of the percentile 5 user, so the highest height which the bike is placed (1600mm) is within the reach of most of the users. Likewise, this piece is also used for holding the user towels inside the transition room and the height in which is placed (1650mm) also it is found within the reach range of the percentile 5 user.
Door width

As it is explained in the report, the width of the door has been modified, being 700 mm width for the narrowest solution. This breadth has been check to have enough space for the biggest person (percentile 95) to enter through the door. This measure is solved with the widest distance in the human body that is from elbow to elbow (no. 16). See figure 90.

<table>
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*Figure 90. Door width.*
Appendix 3: Project Plan

Background

The Master thesis Triathlon Training Room, 30,0 ECTS, is conducted at the request of TRiROOM INNOVATION AB. It is the final part of the Degree at Industrial Design Engineering and Product Development, 240,0 ECTS at Zaragoza University, developed at Luleå University of Technology during an Erasmus program.

Background of TRiROOM INNOVATION AB

TRiROOM INNOVATION AB is a new company, located in Luleå, created 6 years ago with the aim of developing a new concept of training system. In fact their idea is not only training the body, they want to create a whole lifestyle in which is important to feel good with yourself and have a good health. This idea has been forming during years coming up with a whole training room reduced in 22 sqm which can be placed in different places such us gyms, hotels, airports...

The project is still in continuous development, counting with diverse companies and universities that take care of different parts of it. For TRiROOM is important working with students due to they are open-minded and have no fear to dream. For TRiROOM is important counting with LTU students because the first prototype is going to be produced in Norrbottens province. That is why they want us to be part of the project.

Problem Description

The triathlon training room that is being developed by TRiROOM INNOVATION AB is a project that involves several design aspects. The training room conceived by TRiROOM, includes three sport stations, for biking, running and swimming; these cockpits are connected together by a transition room which give access to the swimming station. The aesthetic style of the triathlon training room has to be the same but logically each cockpit has to be designed apart to have under consideration its own needs and features. The problem remains in these different zones for training that have to be considered together while designing individually, in order to have a common design style that currently does not exist in the present triathlon training room proposal.

Our project will be focused in the design of the inside of the transition room and the cockpits for biking and running.

Delimitations

We are going to create scale plans to define the measures, but not the construction plans.

The structural calculations are not included in our task.
Methods

The project will be carried out using our own process that is specified in the chapter work plan of this document. This process is the result of our last university years, based on our own work experience and self-knowledge.

The process has several steps in which each one different methods will be used:

1. Briefing and Planning.
   1.1. Gantt Chart

2. Gathering information and Information analysis
   2.1. Benchmarking
   2.2. Interviews with the target group
   2.3. Interviews with the company
   2.4. Interviews in the sport environment
   2.5. Highlight important aspects

3. Problem and Needfinding
   3.1. Define problems
   3.2. Function list with hierarchy
   3.3. Function breakdown

4. Creative Phase
   4.1. Brainstorming
   4.2. SCAMPER
   4.3. Apply/Potential Chart
   4.4. Weighing Evaluation

5. Concept development and Concept choice
   5.1. Sketches
   5.2. Formal evaluation
   5.3. Functional evaluation
   5.4. Feedback from the company and the supervisor

6. Modelling
   6.1. CAD modelling in the suitable software
   6.2. Rendering
   6.3. 3D animation
   6.4. Scale Prototyping with 3D printer

7. Reporting
   7.1. A digital presentation will be made
   7.2. A written report will be handed in
Purpose

The purpose of this master thesis is to design the inside of the transition room and the cockpits for biking and running for the triathlon training room of TRiROOM. In this project we will not only develop a common aesthetic between these spaces but also we will have under consideration diverse aspects such as ergonomics, safety, user, usability, quality and functionality.

On the other hand, if during the third phase (Problem and Needfinding) we came up with interesting problems that need to be solved regarding other aspects of the product we will suggest solutions.

Documentation

Documentation will be made continuously during the project, given as a result a written report, CAD models, an scaled mock-up and an oral presentation at Luleå University of Technology.

Work plan

The work will be carried out following our own working process.

1. Briefing and Planning
2. Gathering information and Information analysis
3. Problem and Needfinding
4. Creative Phase: Idea generation and concept generation
5. Concept development and Concept choice
6. Modelling: 3D Visualization and Prototyping
7. Reporting: Presentation and Report

Organisation

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TriRoom representative:
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Supervisor:
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Email: anders.hakansson@ltu.se
Phone: 092 - 049 19 20

Examiner:
Åsa Wikberg-Nilsson, LTU
Email: Asa.Wikberg-Nilsson@ltu.se
Phone: 092 - 049 13 42

Meeting and Reports

Face-to-face meetings with the supervisors will be held when needed. Reports will be sent by e-mail to Anders regularly.

Skype meetings with the company will be held when required. Periodic informs will be sent by e-mail to the company to keep in constant contact.

Timeplan

The timeplan is attached in the next page of the document with a Gantt chart to see the time organisation in a more visual way.

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## Appendix 3: Project Plan

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Legend: W18 to W24