Lympha bike

The meaning of light in sport

Design & Engineering A.Y. 2021-22
Supervisor Innocenzo Rifino
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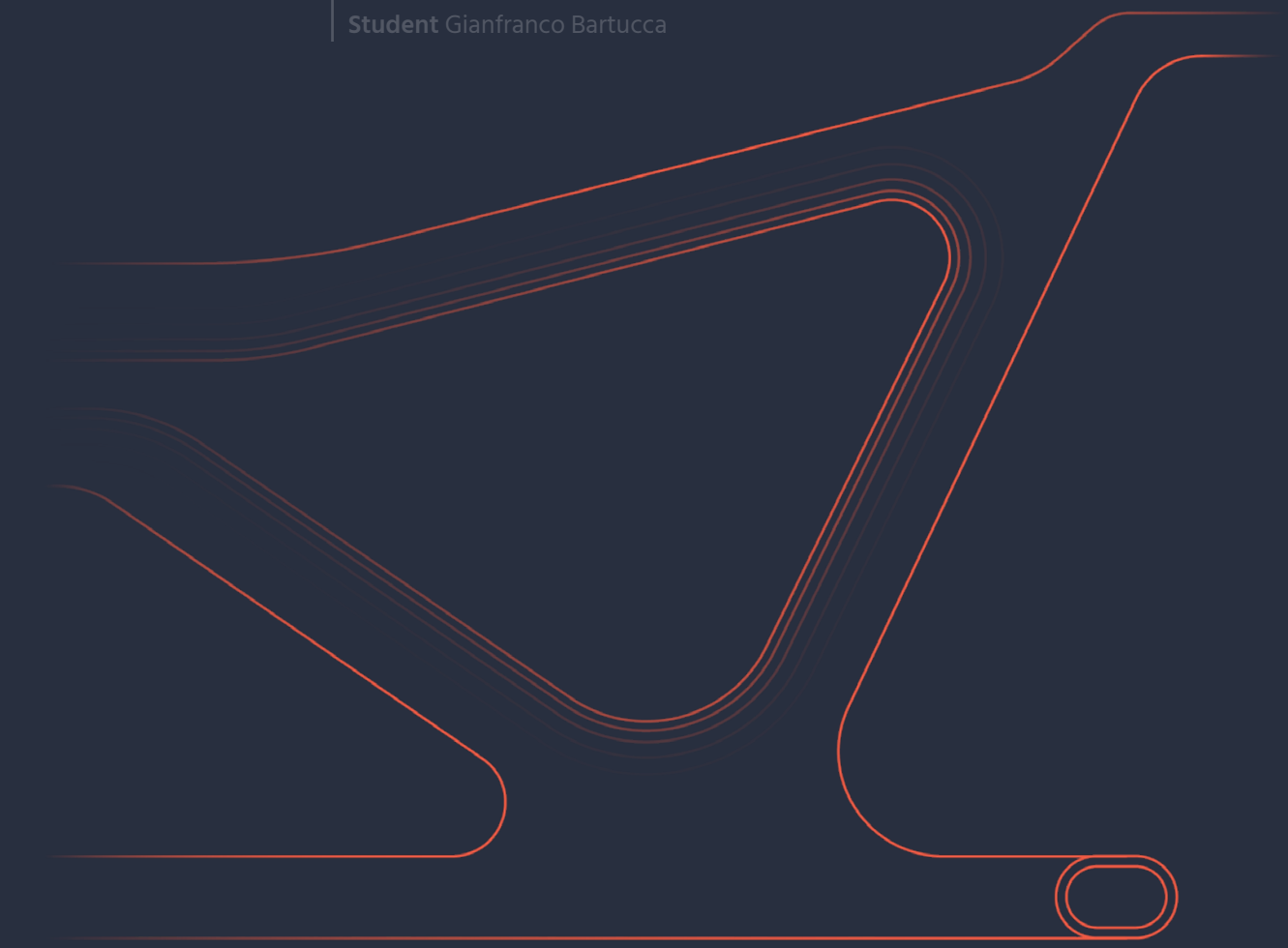

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Master's Degree | Design & Engineering
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Contents

Abstract

English

The way we approach sport and exercise in general has always evolved over time, adapting to changing habits, emerging technologies and a future of training that is becoming more and more hybrid year by year. This thesis aims to investigate a slice of this market, focusing on what the gym will look like in the future and the products within it. It does so by means of a project in the world of indoor cycling, a mainstay among the fitness disciplines, which over the years has seen a rapid increase in the number of practitioners, gaining a reputation as an effective and above all fun sport. The project in particular explores light as a potential means of communication and interactivity, exploiting the influence it has on the mood of the users and the possibility of creating special visual effects, which adapt to the dynamism of group indoor cycling, blending perfectly with other peculiarities of the context, such as music. This interactive indoor bike is therefore an example in what could be a new type of intelligent product capable of guiding us during training, supporting trainers and making our experience in the gym more meaningful, not only through data aimed at increasing efficiency, but also through other means such as light, capable of providing a more complete and symbiotic experience between the fitness equipment and the user himself.

Italiano

Il nostro modo di approcciare lo sport e più in generale l'esercizio fisico si è sempre evoluto nel tempo, adattandosi al cambiamento delle abitudini, alle tecnologie emergenti e a un futuro dell'allenamento che di anno in anno sta diventando sempre più ibrido. Questa tesi vuole indagare una fetta di questo mercato, concentrandosi su come sarà la palestra nel futuro e i prodotti all'interno di essa. Lo fa attraverso un progetto che si colloca nel mondo del'Indoor cycling, pilastro portante tra le discipline del fitness, che nel corso degli anni ha avuto un rapido incremento nel numero di praticanti, guadagnandosi la fama di sport efficace e soprattutto divertente. Il progetto in particolare, esplora la luce come potenziale mezzo di comunicazione e interattività, sfruttando l'influenza che quest'ultima ha sull'umore degli utenti e la possibilità di creare particolari effetti visivi, che si adattano alla dinamicità dell'indoor cycling di gruppo, sposandosi perfettamente con altre peculiarità del contesto, come ad esempio la musica. Questa indoor bike interattiva si pone dunque da esempio in quella che potrebbe essere una nuova tipologia di prodotti intelligenti in grado di guidarci durante l'allenamento, supportando i preparatori e rendendo la nostra esperienza in palestra più significativa, non solo attraverso i dati volti a incrementare l'efficienza, ma anche attraverso altri mezzi come appunto la luce, in grado di restituire un'esperienza più completa e di simbiosi tra l'attrezzatura fitness e l'utente stesso.

Introduction

Chapter 1

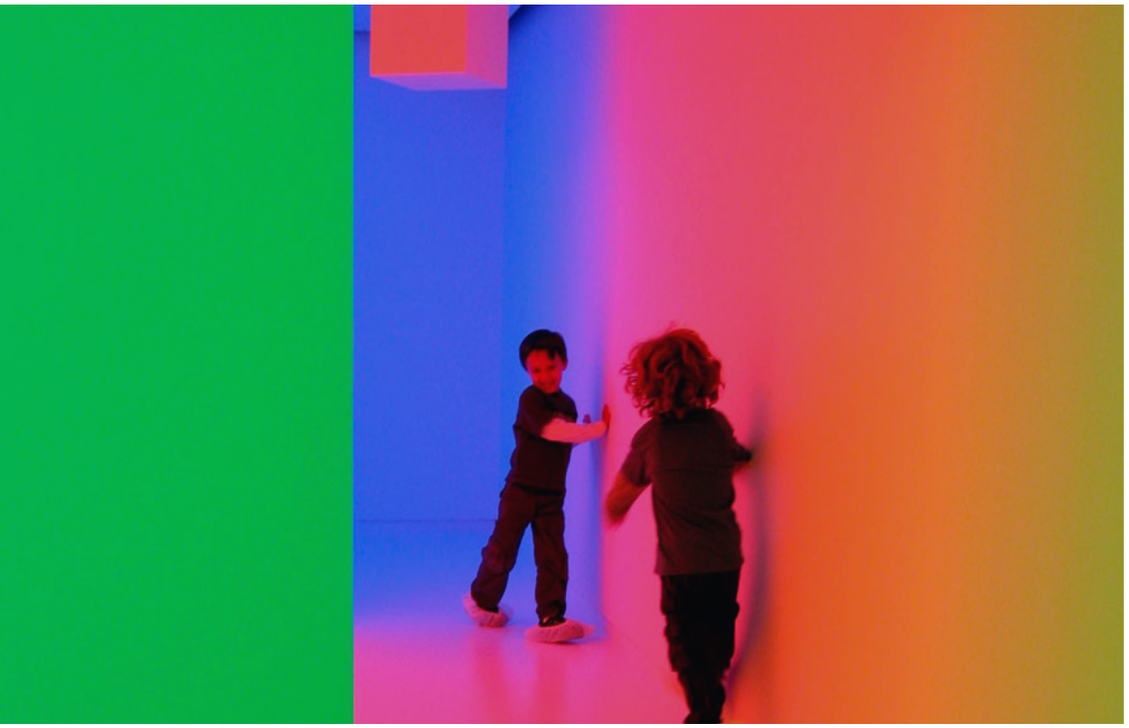


Fig. 1:
Light show, Museum of Contemporary Art Australia

As a child I was always fascinated observing light moving through objects, disappearing and then appearing again, giving a shape and claiming attention on an object that until the apparition of the first glow, seemed lifeless. I have been dealing with design for a few years, continuously exploring objects in their functional and technical aspects, and despite that, my astonishment about the effect light can have on objects did not change too much (and probably neither for people). Indeed, even if the light is now widely used in several forms and modalities, thanks to a very fast evolution of different technologies and an established (and even still growing) market, light can still create a great surprise effect on the user in several cases. For this reason, it is not unexpected today to see its integration not just for its primary function, i.e. to illuminate, with an emergency role or to indicate the state of an activity, but also with an entertainment purpose, or with the aim to create an immersive experience and change the perception we have about something. It remains one of the most effective ways through which a product can communicate and convey something to a user, and the exploration of light in this sense, considering functions, relationship with materials, colors, and much more, can be very wide and still in the middle of his path.

1.1 Interactive indoor cycling through light

And it is the main objective of this thesis exploring and investigate the role light can have matching a field like sport, another strong passion I always tasted in its different forms and expressions. In particular, this is the case of Indoor Cycling, one of the most practiced sports in fitness gyms for years and still gaining a lot of practitioners thanks to its nature of sport both effective, since it is one of the best sports allowing to lose weight and develop leg strength very fast, and from the other side also fun: it is a group activity where the music leads the user through the whole training. So the thesis will have two main directions: from one side it will deeply analyze the fitness and Indoor Cycling world, understanding the state of the art and all the related opportunities. The whole fitness world, also the discipline of Indoor Cycling is changing, and becoming fertile soil for new discoveries and experimentations from a product design perspective, especially about user experience. With a gym evolving continuously, increasingly integrating technology in the training routine, and the shift of the market in business model proposing more fitness equipment for at-home work-out, there is the necessity to be a more competitive player through a new type of involving and immersive offer and to resettle in an ecosystem where training is more a “hybrid” business[1].

On the other side, this thesis will investigate a parallel component: light. Light has been largely a topic in the design field, so this research will skip a common technical description of it, and rather it proposes a different point of view, where the light capacity to be a communication mean between the user and the object becomes the main project driver, creating an interactive machine capable to make training more fun and effective. For the same reason, these two directions will meet at some point, creating a new question: how light can turn into a meaningful means in sport? This question highlights an opportunity that, as will be demonstrated later, is still latent in the market, and not completely explored. Light is a possible solution to imagine a more interactive and immersive way to work out even in the gym, and not just at home: is the “how” discovered through research on the way the fitness world is facing the growing necessity of achieving first an effective performance, through data-driven and technological approach to our daily businesses, and then a more entertaining experience. Indeed, the research will

1. “Hybrid” defines a blended offer where the gym and at-home workout broaden training possibilities: a deeper definition will be provided in the next chapters.

also show a clear misuse of technologies, and also for this light can gain importance that until now was underrated, seeing it more in an older and primary function to enlighten instead of exploiting its effects on human psychobiology.
The result is innovative equipment for Indoor Cycling using light to lead user training, and at the same time helping the trainer to manage the work-out itself, creating at the same time a connected system with software, a fully engineered product, and a complete user experience in the context of an already existing gym, enhancing the training itself and solving several problems present in this fast-growing sport.

1.2 Research method and structure

In order to cover every aspect of both the two claimed directions the following scheme was followed. After a first approach consulting general literature and trends in the fitness world, the first main topic was understanding how the gym is changing and evolving: this was the real starting point to understand from horizontal research, what is the market direction, what gym owners are trying to do to overcome post-pandemic difficulties and which sports are growing really fast despite the at-home training phenomena. As for the whole research, the main important tool for this investigation was the collection of inherent case studies: these cases allow a deep understanding of topics that are less immediate and those can be just included through concrete examples. They regard real gyms, temporary solutions, and the launch of innovative products and services. Additionally, case studies help in creating more practical questions that are useful in a design-driven approach, as well as giving a much quicker and more quantitative understanding of the real world offer.
The resulting considerations of this first wide research lead us to consider Indoor Cycling among the potential fields on which to make a vertical and in-depth study: there are several reasons for this choice, those will be described in a specific and dedicated chapter. Here the intention is to switch the approach from quantitative research about the fitness world, with the analysis of several case studies describing how the gym is trying to become a more immersive and entertaining context, to more qualitative research, allowing an accurate understanding of a specific discipline not just through desk research, but even though on-field research. This concerns direct observation in several gyms,

Fig. 2: Indoor Cycling embracing innovation for an entertaining approach to fitness (Les Mills, The Trip).

especially big fitness chains, but also in specialized studios where Indoor Cycling is practiced in smaller classes based on a more customized experience. Here I had the possibility to meet several trainers and managers, but also Indoor Cycling enthusiasts: all these dialogues helped me in building a valuable journey for the analysis of trainer and user need and problems. Additionally, it was through this "shadowing" operation[2], that was possible to create all the maps explaining this huge and complex training in a more easy and direct way to the reader: these maps were then used even to make clear the intervention areas of the project. Other case studies focused on involving immersive spaces and services were presented, this time considering the Indoor Cycling world only. Additional reverse engineering and benchmark analysis were fundamental to getting information on the equipment itself (main components, functionalities, market opportunities, etc.), identifying the typology of the product to design for the project, and knowing which features are specifically important for both users and experts of this field. From this analysis were obtained the most important considerations to formulate a starting list of pain and opportunities related to the current way of training (also here for both trainer and user), and so a starting brief.

These two huge phases lead to consider light as a potential solution and project driver, especially after the case studies review. The idea is to investigate every light component functional to the product, understanding how it is actually used in products and equipment for sports activities: some case studies were collected again to get some inspiration and insight, as well as to evaluate light integration and purpose in this typology of products. In this way, it is possible to enrich the started brief and start the description of the resulting project directions concepts and so on the product development phases.

2. The term "shadowing" means the direct observation of the user in the analyzed context, with the purpose to get a more objective observation of his behavior.

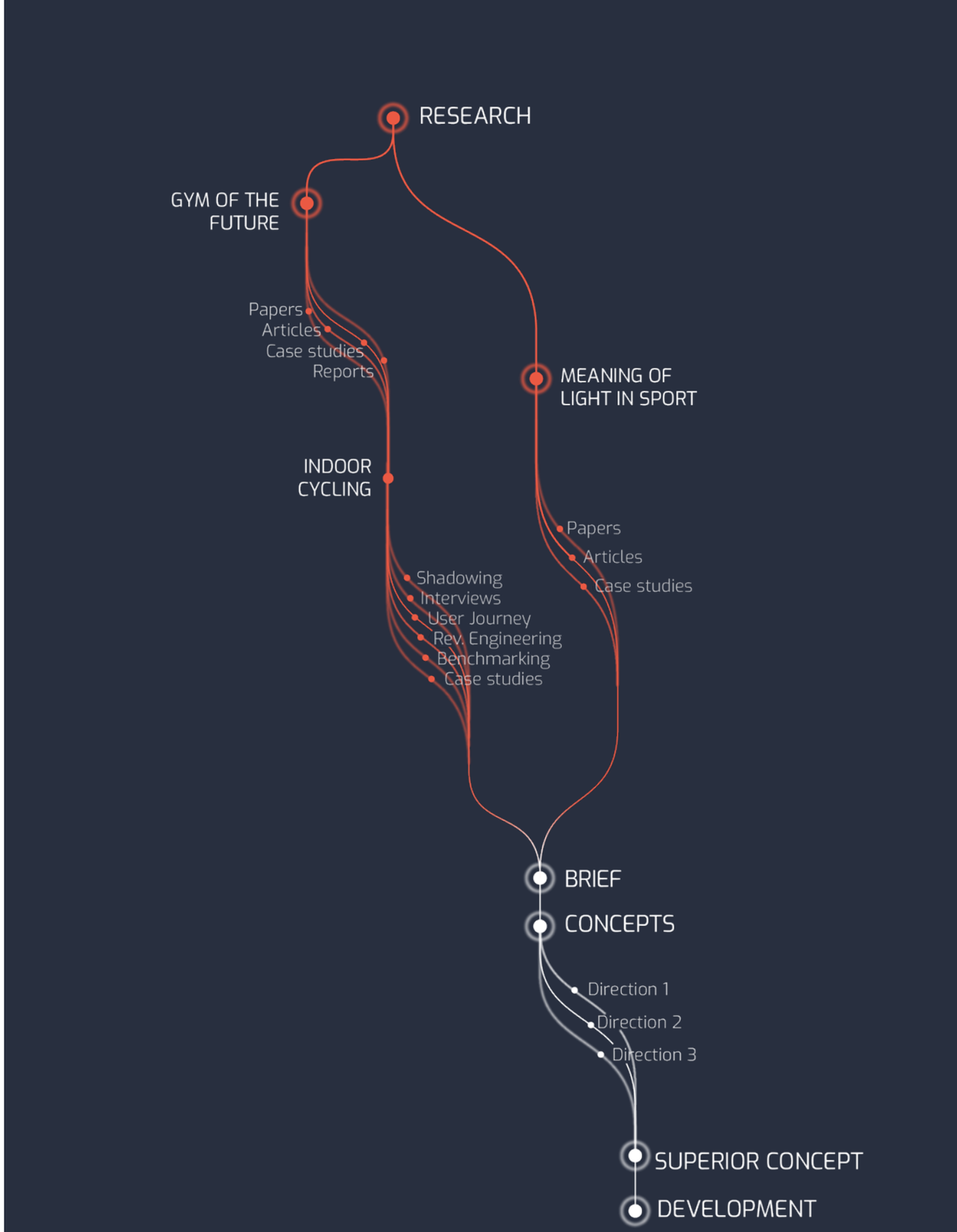


Fig. 3: Evolution and development of the research phase

Gym of the future

Chapter 2

Fig. 4:
Virtual reality, AI, digital content in the gym of the future (Les Mills)

Despite the fact that a pandemic has affected the way we work out, making it increasingly easy to train at home, several reports show that the majority of users are determined to return to the gym on a permanent basis, for social and, above all, functional reasons: the most plausible direction in which we are heading is towards an increasingly hybrid experience. The trend towards a hybrid offer is driving several gyms (from the smallest and most specialized to the largest international chains) to adopt digital tools integrated with products and/or spaces that are increasingly interactive, with the aim of attracting the user to the gym and appealing to entertainment. A collection of case studies of interactive spaces in the fitness world is provided, helping us to have an idea about what gym owners can currently offer.

2.1 Why gym is changing: an hybrid routine

The gym, as we have it in mind over the last decades, has been almost the same for many years: a place including a wide target of users, practicing several different types of sports, and above all joining beginners with most professional ones. This kind of place, collecting several types of training machines according to the presence of different users, was the result of a process during the 20th century where the increasing awareness of the benefit of body workout, due to social and economic changes, like better conditions in the working class, made fitness environment more accessible and consequently a fast-growing phenomenon (Andreasson & Johansson, 2014). At the same time including fitness activities in the ones in schools, and curricula represented a fundamental step for the beginning of the long story of fitness and the achievement of its strong social component, making it a priority in a lifestyle pursuing good health and well-being. Crowning of it was the first apparition of health clubs chains, like the one of the Tanny brothers in 1947, a symptom of a huge market seeing its success in a business model joining good quality guide and work-out experience whit low-cost and long-term subscriptions (where a pioneering and emblematic case was McFit in Germany), by sanctioning fitness as an established market that cannot be easily culled (Les Mills, n.d.).

Despite this strong position, as in many areas of our modern lives, also the fitness world was challenged by the Covid-19 pandemic, becoming one of the most affected sectors since gyms were among the first places to be closed for safety reasons related to the infection risk. Starting in 2019, an uncertain situation characterized this market, causing heavy money losses, not just for missed subscriptions and lower people capacity, but also for the attempt to conform gyms to new sanitization standards defined by governments even if the opening were not a certainty. For instance, according to a report by the International Fitness Observatory (IFO) about the covid impact on the fitness market during 2020 in Italy, after the first five months of the year, there have been losses of a total of one billion euros, with about 200.000 jobs at risk (IFO, 2021): not ordinary numbers if we considered what has been said about fitness industry so far. However, even in such a context, the fitness industry follows the traced path of several activities, starting first to leverage social channels to push people to train at home, and, in a second moment, gradual-

ly building digital platforms for work-out at home (with first dedicated products emerging). One of the first emblematic examples was Forme, a product by Yves Behar specifically designed for at-home training, hiding beyond an elegant mirror a small gym studio for weight training, cardio, barre, but also yoga and dance: a case followed by several big and small or new players, for sure an innovative and strong direction: if we now look to the fitness market, most of the main products of sport equipment companies are dedicated to the home context. Even if the possibility to train at home is a distinctive factor, a characteristic to consider and these products have in common is a high price range, not making them accessible for all. Moreover, not everyone has the needed space for an at-home gym: it is clear that there are products intended to help people in difficult times, but as with every product that is in the starting phase of its launch, they are targeted for a specific type of consumer. But where hardware cannot solve the problem, several times software occurs: digital platforms for personalized and dedicated training sessions were provided, starting from the case of Technogym with MyWellness, which provided a user-driven experience allowing the customer to get a

Fig. 5:
Forme, designed by Fuseproject studio

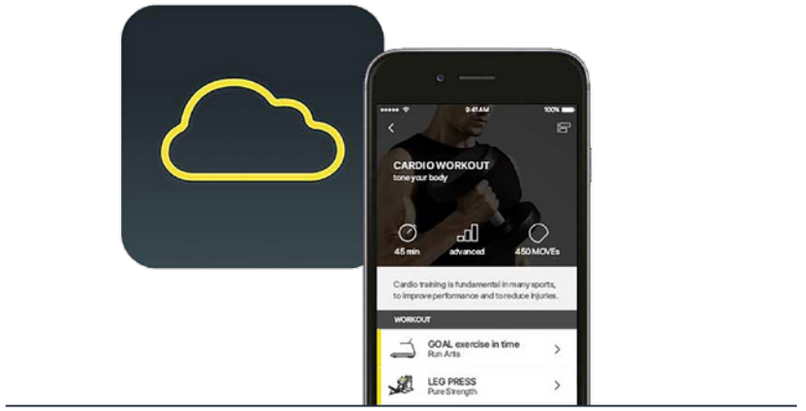


Fig. 6:
MyWellness (Technogym), digital platform for custom workout

dedicated program from the trainer based on its specific attributes and goals. It was also the case of Peloton, among the big players who get an important boost in this context: all companies trying to integrate digital assets in a well-established offer of physical products, something that, depending on the addresser, can complete the experience or just make it possible. It should be highlighted how in this case the topic is about platforms, and not just applications (Nike was already providing it for a long time), a wider concept if considered in the covid context, since initially was thought for it and not just driven by the digital trend.
But the intention of this thesis is not to analyze just the fitness state of the art during the pandemic period, but furthermore in the post-pandemic era: considering the period in which this paper is written the pandemic is still not completely over (and must be considered for a long time to come), analyzing deeply the future perspective of this world after Covid-19 is more interesting and challenging, since nothing can be given for granted.
Particularly after the above-mentioned solutions, most of us would expect people will not come back again to the gym: this tough period has shown how often it can be easier to train at home. Sometimes it could seem even more convenient: first, you can train whenever you prefer; second, it is not necessary to move from home, gaining time in commuting or waiting moments queuing for a specific training machine (a common practice in our time); last but not least, the workout can be specifically designed according to your needs, so it sounds like having a personal trainer avoiding terrible situations at the gym, like feeling un-

comfortable in training in a public space (sometimes it can be the most difficult step in starting to do it). But the situation is more complex than this: there are several factors affecting the reason why we prefer to train at the gym instead of at home. They could be social reasons, motivations related to the training itself, or just something based on the way we face our training process and habits.
Surely our way to approach training has changed, and this has been proved by several reports: a report from the IHRSA (the International Health, Racquet & Sportsclub Association) titled "The Covid Era fitness consumer", analyzing in particular gym-goers habits in the U.S., shows that 94% of them plan to return to their previous-Covid routine (IHRSA, 2020). But other interesting data are provided in the same report, explaining someway the reasons pushing people to come back to the gym or worrying them about this idea: for instance, almost half of them, (between 53-54%), confirm their exercise routine during the pandemic period is less consistent and challenging, indeed a 10% even stopped training. Even if the "motivation factor" could be declassified to a simple justification, because not considered functional, keeping the motivation to train is one of the key aspect boosting people to go to the gym: as we shall see later on, this reflects on the choice of the place, of the workout or sport and so on. Being motivated is extremely important for gym-goers, and probably nothing will change this aspect.
This data may be approximated since they refer to a specific target of users (gym-goers with a subscription plan), but they demonstrated how contrary to our first assumptions, people need to return to the gym. Our tendency to see a polarized approach to the situation can lead us to think

Fig. 7: IHRSA data about "The Covid era fitness consumer"

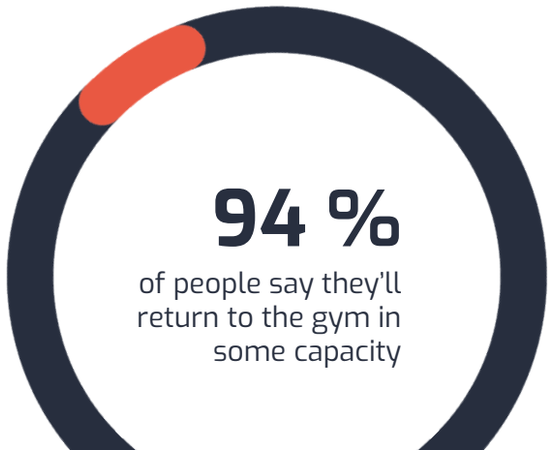
Why 50% of gym goers are **dissatisfied** with their new fitness routine?

*pandemic period data

the results of this analysis are quite contradictory. But with a deep look at the problem, we can see how this new routine drives people to a third direction, a new possible option as a result of the pandemic: a hybrid choice. A blended routine includes a moment where people prefer to train at home and other moments where people favor the fitness environment, and a lot of trainers or chains, realizing that, are starting to keep their offer updated.

2.2 An increasingly interactive & entertaining experience

As we have seen in the previous paragraph, the new daily routine of normal gym-goers foresees the possibility to decide if training at home is the best choice or if planning some days at the gym is convenient. This is the result of a process leading to what several fitness and sports articles call the "hybridization" of fitness routines, a phenomenon that is becoming increasingly popular. As we have seen it is a new reality emerging on one side as a result of the routine changing process due to the pandemic period, but most importantly, on the other side, consumers started to like it for the opportunities and comforts this system offers, bringing advantages for everyone. This is confirmed by several reports, like one of the largest studies about fitness consumer habits and needs in the post-pandemic period, the Global Fitness Report (Les Mills, 2021): this work, collecting information about a target of 12,157 fitness consumers worldwide, shows how 80% of them would like in the future to continue in the integration of a digital offer into their current training routine, in particular with a 60:40 split of on-site training and home workout. In mentioning the digital offer, we should imagine to include in it several components like all the digital platform functions and use of applications to track and prepare a workout, but in this case, the report refers speci-



fically to live stream and on-demand classes, since their large use during the pandemic period. Despite these numbers, the same report highlights the fundamental role of the so-called "human factor": 67% of the gym members confirm it is important to attend a group live class, demonstrating how the possibility to train with familiar faces after two years of training is important to increase exerciser motivation. Other secondary aspects boost this factor, like for instance the relationship between the chosen class and the assigned instructor. Adam Zeitsiff, former CEO of Intelivideo, in an article for the blog Club Industry, synthesizes perfectly the concept of hybrid training in a few words: "Digital fitness isn't making gym workouts obsolete; rather, it's helping to highlight just how ubiquitous fitness offerings can be" (Club Industry, 2021).

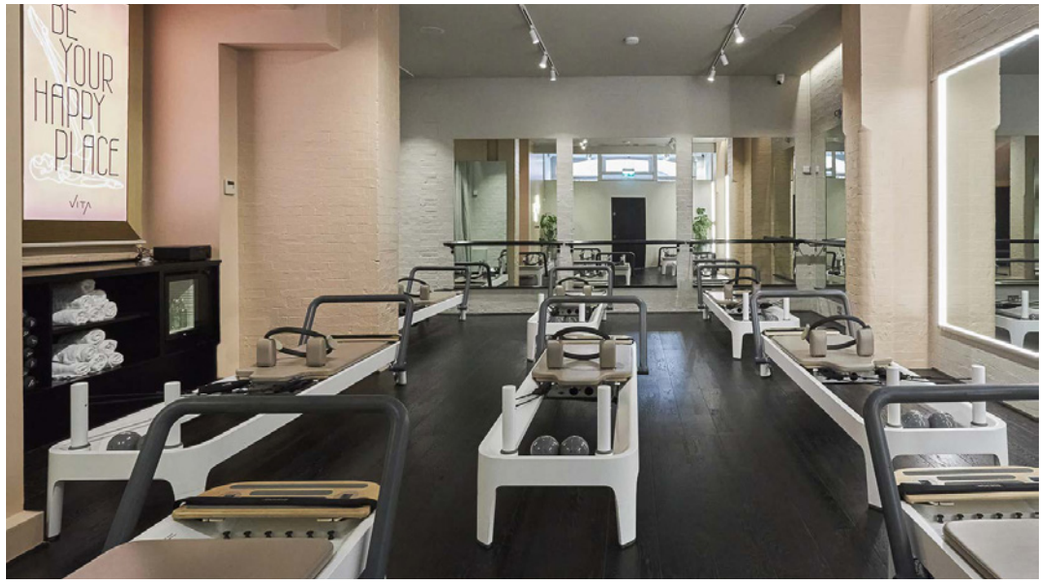
Once the future gym direction has been consolidated, there is an important aspect to analyze, which is strongly dependent on this new trend. Even if the return to the gym by previous gym-goers was partly a result of several needs manifested during the pandemic, being mostly consequences, these consumers (and even those who will find it more difficult to return) developed a more sophisticated expectation about how the on-gym experience should be. Of course given the several problems that occurred in the last years and a strongly competitive market on the other side, for gym owners is extremely important to meet these expectations, investing to equip adequately their spaces: in some way the hybrid experience regarding the gym (where also a physical gym with the on-demand class model are emerging). This topic was highlighted as well by Les Mills report, showing how 62% of people choosing brand classes choose them evaluating quality factors, that means music, type of equipment, use, and preparation of choreography. The post-pandemic attitude by consumers is just reinforcing this quality demand, increasing a grade of expectation that was for sure lower in the previous years, but that has been always present, especially in group fitness sports. The importance of all these aspects is increasingly growing to enhance the user experience and leading them to be motivated in doing the class and, above all, willing to pay (from a gym owner perspective).

When we specifically refer to a space like a gym, the main intervention in this sense is made considering two main possible alternatives: light and sound. Whenever their use occurs, they are extremely related and interdependent: sound allows to bring the user an additional dimension beyond the space itself, and for this reason, it affects a lot the way people perceive it and generates a further immersive experience. On the

Fig. 8: The fitness trend of an "hybrid" workout routine, combining advantages by both sides

other side, as it will be better explained in the following chapters, light is more used to follow the sound (enhancing the perception of the rhythmic sound) or to just make the experience more entertaining, creating particular effects in dark spaces where the training station is essentially fixed. This type of combination is in someway an application that can be seen in advanced design and big spaces, and it is the most common one, especially among the big fitness chains, leading to the opportunity to have not just an engaging environment, but even a space that can boost and improve the exerciser performance, as it has been proved by some studies about HIHR (High-Intensity Heart Rate) training in Cycling Studios (Gottschall, Jinger, Hastings & Bryce, 2017).
But the possibility to increase the entertainment in training spaces does not exhaust with the use of sound and light but can be even something more complex. Indeed, among the several trends bringing gym owners to create an engaging space for their customers, it can be also common to find gyms implementing digital solutions communicating with training equipment present inside the studio. These types of solutions can be of two types: the first one can create a virtual experience with real-time projections, as it was a competitive game, or just a way to create, in parallel with the activity, an involving way to get out from the physical workstation.
For this reason, are not any more isolated cases the ones seeing a

Fig. 9:
Boutique Fitness, a growing business in the world (Vita Boutique Fitness, London & Milan).



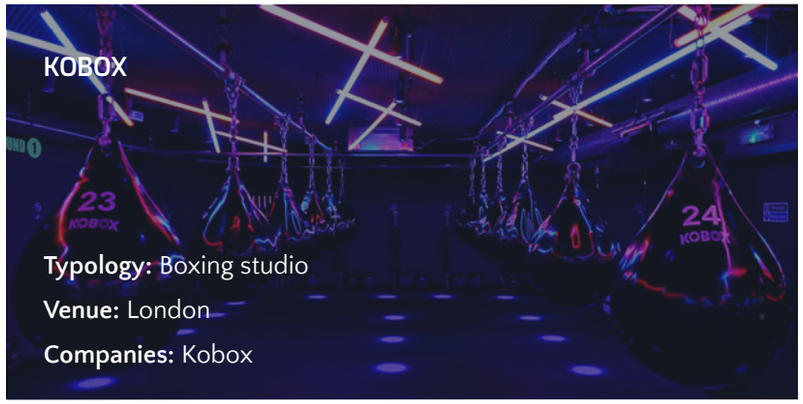
growing trend in the gamification of this type of activity: this is one of the best options to motivate users and works better especially in group class training (where the collective factor is functional to it). The second "digital" option simply concerns using technology to track data (in real-time as well) during the training, making them visible to the users with the aim to guide them during the workout and improve their execution or performance. In this sense, also the implementation of wearable products and smart equipment (that means simply training machines that can record workouts, and track data about them, so to get feedback to improve) should be considered, even if this direction leads more to another context, the at-home workout. In fact, this type of equipment was initially boosting the trend to bring several people to train at home, riding the wave of the pandemic situation: a growing market that over time has slightly deviated forward the integration of this equipment in the already arranged gym spaces, proposing them also as a premium service for enthusiastic and more professional customers. It is an aspect that should not be underrated, since in some way even if addressed to different targets (at-home exercisers and gym-goers), these products are in practice the same typology, justifying, even more, the above-mentioned hybridization phenomenon. All these examples will be deeply analyzed in the following paragraphs with the proposal of some case studies.
A last phenomenon that should be taken into consideration in this perspective is the one of "boutique studios", an emerging type of space increasingly growing, especially in big cities. A boutique studio essentially differs from a normal gym because it provides a single type of training for a niche: so you basically will train in smaller groups than the ones in the normal gym classes, and you will do it in an environment with premium services (of course at a premium price). Even if it is a specialized market, it is interesting to see this example since they were born to address a high-quality demand that the gym cannot provide at all for several reasons. In any case, they represent an emblematic example of specializing the service to improve the quality, integrating more experiential solutions, and creating interactive training. Boutique studios, if we want, are similar to what will be probably the gym of the future: a more interactive experience allowing for personalization, but with the difference to keep offering variety. So some case studies about boutique studios will be considered during the case studies analysis, to help us figure out better the direction towards which we are moving.

2.3 Interactive and immersive fitness: case studies

Until now we have seen several possibilities for gym owners to improve their space for a boosting and immersive experience, with the idea to enhance the quality of the training and increase the number of people willing to come back to the gym. It could be interesting to make a deep description of some case studies that somehow show us what can be considered an interactive environment. For this analysis we will take into consideration that some solutions are space-designed: they are provided with an intervention in the space where people train, with lights, sound, or even virtual reality. In other cases the review considers instead equipment: a training machine (that can be integrated with other accessories) capable to influence and guide the user through the work-out experience, being helpful in several ways: showing "how to do" it, giving feedback or simply making it easy as a game. The purpose of this review will be to get some insights for a starting direction in designing what we considered the gym of the future.

As we have seen until now, the shift toward an immersive experience was not a direct proposal coming by gyms: before being an accepted model, big sports and fitness companies have proposed it being pioneers of that idea of the "gym of the future". Already in 2016, Nike was thinking about the potential of this idea, realizing it in a physical space and as a temporary experience in London, called Nike's Unlimited You. Basically, it was a multi-sensory space for high-intensity training available for a short period of three days, where people can follow a workout made by professionals through a path with flashing lights animations boosting training sessions, and a specific soundtrack performed by a live orchestra. Even if we are describing an exasperation of what can be defined "immersive work-out space", and considering this as a consequence of a promotional context, this space was really emblematic in showing the potential of light and sound combination during training, In fact, at a first sight, we can consider it just as a concept integrating a good lighting design project into a fitness environment, just making it more appealing; but making a deeper consideration, it was one of the first project in the fitness world challenging the passive idea of a gym and using light and sound not just with an entertaining role, but above all for functional reasons. In Artisan's words, the studio that designed the space, "Rather than directly influencing how the body responds, the light installation guides participants through their workout with instructions and generates different landscapes and backdrops as they progress". This is the crucial aspect: the "spectacle" elements are a way to guide the user through their experience to do it better, both as execution and performance.

Highlighting this kind of case study, being mainly an installation (even if accessible), was not just important to make a gradual start in this world, but also for the partners involved: among them, there was Barry's Bootcamp brand and the boxing studio Kobox. In particular the last one, they are among the list of popular names in the premium and high-quality experience training brands, proposing today spaces, like the one above described, in the biggest cities around Europe and the world. Even if can be classified as a sort of boutique, Kobox was an interesting environment joining a classic boxing studio with the space design of a nightclub: the purpose was to exploit light effects in the dark (comple-



Interactive factors:
Light and sound combination in HIIT training, night club environment

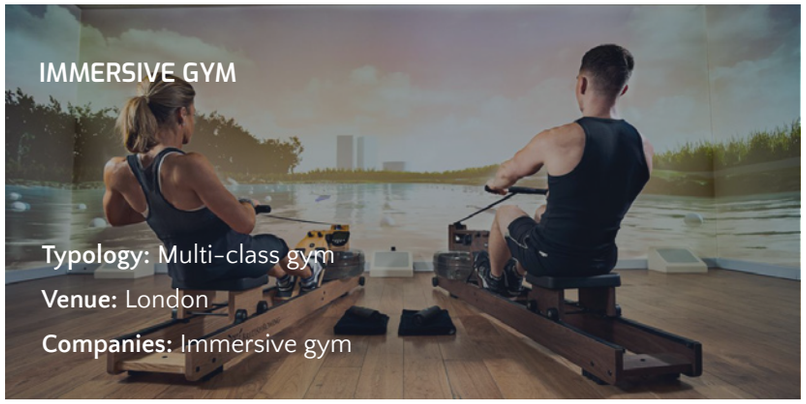
Interactive factors:
Ceiling modular lighting, programmable, reacting to real live music customizable animations by trainers

mentary element with respect to light, but equally important) and the beat of the music to encourage users in performing better and at a higher intensity. This type of model will be over the years the most common one: probably the simpler, but as highlighted previously, the effect of such a space can be very impactful.
As we are seeing the light element will be the most common: it is suitable for the integration in the space, being clearly visible and perfectly following the training rhythm proposed by the trainer, and even indirectly, use it to guide the workout. Sometimes this element can be even extremism: Rise Nation, a cardio climb gym operator, involved the design studio Cactus in the realization of two studios, where programmable LEDs are embedded in modular units of the ceiling, helping to keep motivated users in a suggestive atmosphere. The modular composition allows a trainer to create even a customizable light animation, that can adapt itself depending on the training made day by day or can respond in real-time to the music. A recurring aspect of these solutions is that they are well fitted, especially in High-Intensity Interval Training (HIIT): this can be explained considering that this type of training requires a particular intensity and motivation for the exerciser, with a process that is cadenced by intervals where intensity changes continuously and this aspect should be somehow "immediately" communicated to the user. In these moments, light fulfills its function.

Interactive factors:
Cinematic display walls and synchronised light and sound, re-creating the suitable environment depending on the in class training

Another interesting case is the one of Studio Society, which allocates itself to the "immersive gym" market, so recognizing an established niche in the market. This gym proposes several group classes, including Yoga, HIIT, Boxing, Spin, Bodypump, and so on, all realized in immersive spaces where 4 walls re-create the most suitable background based on the type of training: the immersive factors are still lights, sounds (and in some cases even smell), but the typology of solution (like in the case of ceiling for Rise Nation) is different, aiming more too create a particularly comfortable and well-defined environment also with the use of images and animations, instead that with the direct use of lights like in the other cases. Even if there is still missing a new interactive component (perceptions elements are still used to motivate the user), we are here starting to consider the element of simulation, which until now has never been made so explicit. Studio Society can be considered among the first ones, but particularly in these years is very common to find cases of multi-sensory rooms used in a very different context: so it can be expected that solution also is in the fitness world. In fact, the model behind Immersive Gym is quite similar to the one of Studio Society, proposing an immersive room through the use of displays showing a POV animation/video related to the workout user is making. Additional use of cameras for instantaneous feedback about the training is provided in the room, enriching the experience with a functional advantage as well: it is

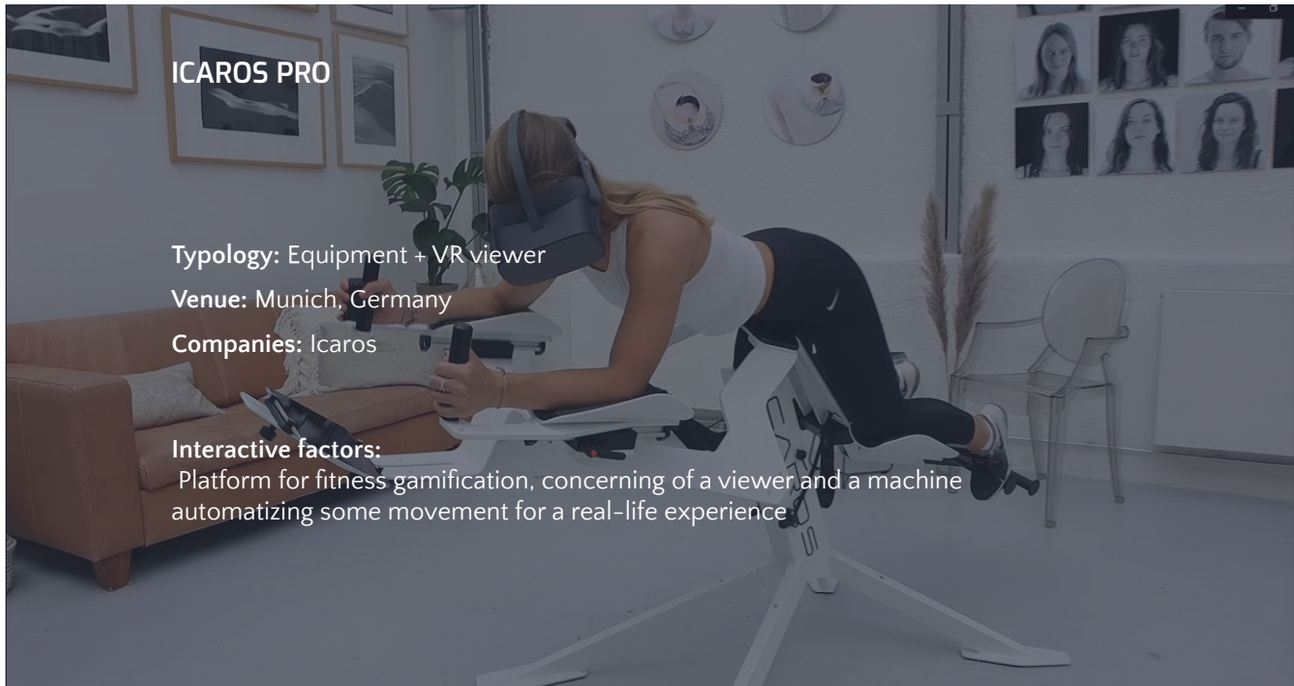
more intended as a "platform", considering the strong digital footprint of the model proposed (also thought for a limited number class, if not only individual). Another difference with respect to the previous case is the willingness to completely create a simulation of a space that can create consequently a sense of calm or motivation, according to the workout purpose. Therefore, this kind of solution is increasingly leading to a realistic representation, detaching from the path we follow until now, where somehow the abstract elements were involved to create a proper training environment. The last example introduces us to another solution, often adopted to create immersive spaces and at the same time a performative and more interactive environment: it is the use of virtual reality, As a proposal, is not so uncommon to find it integrated not just in a space, but even in some products. For instance, the company Icaros, designed and realized a line of products specifically intended for gamification purposes. They are training machines where through the integration of a viewer, people can experience almost a real perception of belonging to a gamified world, thanks to the automatized movements following the expected gesture in the visual world and so in the real training. Even if this type of product can be implicitly targeted for at the home gym, considering the cost of such a machine and their use in a probably still unprepared environment, are more and more growing the number of specialized studios using this type of equipment in a sort of boutique studio business model. Gamification is one of the key elements to keep motivated users: it is not a surprise to find also some gyms proposing specific programs where the training itself is a game and a workout challenge, not necessarily between each other. For instance, in Singapore, the gym Ascend Fitness is proposing Exergame 4D an interactive platform that guides the user in an entertaining training through the peculiar use of motion sensing and projection mapping, giving even real-time data to the user. The possibilities are really a lot, especially thanks to the growing opportunities in the technology field, well fitted in a sector like the one of sport activities and gym fitness in particular: here we found a massive use of these tools and here the market offers a huge set of solution that moves toward an high-technology experience.



Interactive factors:
Large display walls simulating realistic training outdoor environment, real time feedback response through the use of cameras.

2.4 The entertaining factor: indoor cycling case

It is quite easy to note that the entertainment factor is somehow multiplied in fitness activities involving group classes. Indeed, group classes have the advantage to increase individual motivation in training for a number of reasons. Among the main ones and apart from the feeling of being part of a team, they constitute the social component of the fitness world, leading people to be encouraged by the presence of other users and by the opportunity to meet new people having a chat with each other, improving through feedback also by other people. Therefore, from a functional perspective, having more people in one space increases the possibility to play with the immersive and interactive dimensions of a workout. For instance, in a lot of cases the interactive or immersive factor of a gym, in an individual training session is achieved mainly through the implementation of virtual reality: it is easier to scale this model for more individuals and there are not many ways to get a different interaction being alone (in a typical gym scenario, trainers do not follow



continually exerciser, so also in that sense the interaction with another person during the exercise is strongly weakened). As Lucas Werthein, co-founder of the Cactus studio and designer of the above-mentioned Rise Nation studio, says explaining its light project concept "The lighting modules promote individuality and unity at the same time": promotion of the individuality with feeling the relationship with the rest of the group has a key role in achieving an involving experience through these activities.
Among several activities, one of them never stops growing for attendant's numbers and better followed a path evolving in one of the funniest fitness sports ever: indoor cycling. The indoor cycling sector is currently one of the strongest in the fitness world and its long-standing success lies in a variety of reasons: among them its ability to be effective in the short term, easy and at the same time fun for a very wide target group of gym-goers. This thesis will explore the role of fitness in the context of a gym: it is a key difference since it can be also done individually and at home. But individually (if it is not the at-home case) is usually an option for a more professional target, typically training outside and deciding to shift to indoors in the rainy periods. The main purpose here is instead to achieve a wider segment of the user, a middle-prepared one or even completely new to this activity, understanding how the opportunity of entertainment and interaction can be captured in this sport, and discovering how a product can change the way we do training activities in a "gym of the future".

Interactive factors:
Motion sensing and projection mapping can combine 100 workout movement with different purposes, gamification

What the gym of the future will look like?

case study review

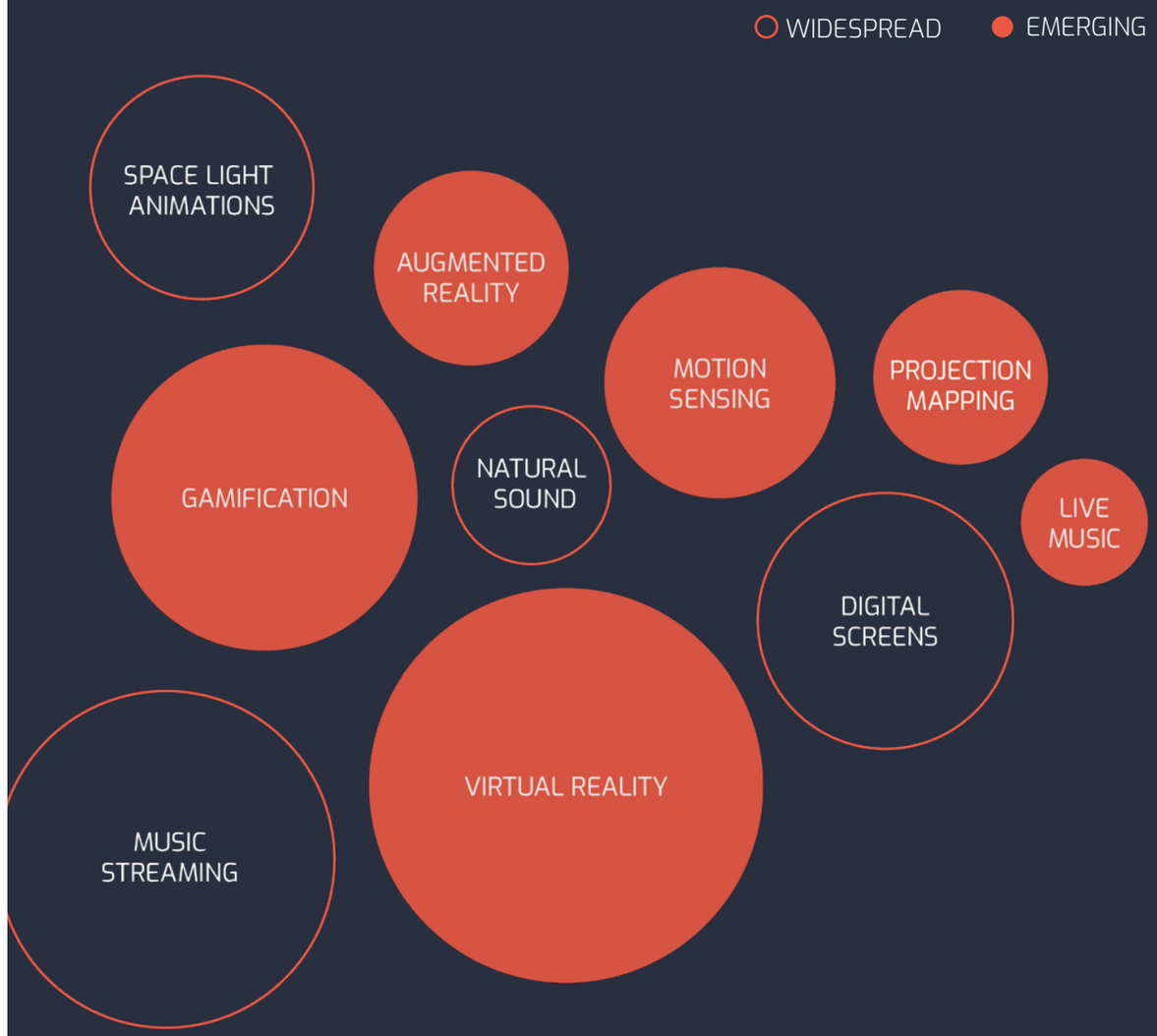


Fig. 10: Summary representing growing trends in the gym of the future: high-tech solutions are the most common.

Indoor Cycling

Chapter 3

Fig. 11:
Indoor cycling is one of the disciplines that evolved the most in the last decades

This chapter will explore deeply each aspect of the indoor cycling, actually a very wide field involving people of very different targets and just started as alternative to outdoor cycling. In fact, when we talk about indoor cycling we mean every activity in which the user practice cycling in an indoor context: it can be a gym, home, a cycling studio and so on. But more specifically, this thesis will investigate a particular declination of this sport that cannot be identified anymore with the common and previous expression of Spinning, being a licensed mark since 2000 by the company Mad Dogg Athletics, applicable for some activities, equipments and multimedia contents. Despite it is commonly used in general spoken, several brands required the licensed mark decay, that so far has not been accepted. So all these aspects, even if characterized by some peculiarities, are now embedded in the general expression of indoor cycling (as well as in this thesis). The chapter content have been not just written after desk research, articles and scientific consultation, but it is the result of activities including even face-to-face interviews with on-field people meetings, of both sides, but in particular expert trainers in many years of practice.

3.1 The evolution of a huge sport

One of the most interesting aspects to analyze is the reason behind the success of such a discipline: to discover it, this part will follow the evolution timeline of this sport over the years, trying to understand how it adapted to the user need, adding even more value to a simple training experience.
At the start of this timeline, is well known even among long-standing practitioners, the role of Johnny Goldberg, a popular South African cyclist in the 80s. Indeed, it was during a training period for the Race Across America, one of the toughest and long races, crossing the United States from East Coast to the West, that the cyclist thought of an alternative way of training in every condition, where cycling outdoor could be dangerous or simply impossible (like for weather conditions or in the dark by night). The legend tells that the event pushing him to imagine a different context was related to a road accident in which he has been involved during one of his workouts, almost risking his life: is not difficult believing to this story since still today death on the road cycling represents a huge issue. Regardless of the story, these necessities lead the cyclist to design and develop dedicated equipment first, with the creation of the Johnny G Spinning Center in 1989, whit the bikes he built. After this shy beginning, Johnny started a business successful path with another cycling enthusiast, John Baudhuin, creating the first Spinning Program, offered in New York, in 1993 and improving the bike over the years, with the commercial distribution of it with the program. In a short time, this activity leads to Mad Dogg Athletics' creation, still, a Spinning trademark holder (as well as for related programs and equipment) and the main player in the Indoor Cycling market for a long time to come, starting even to partner with other brands in this field and to create a Certification program for a professional instructor around the world. What these events should remember, especially for the ones who never directly meet the Indoor Cycling world, is that this sport emerged as training for professionals, and not immediately as an entertaining practice (the way probably every outsider sees it). Additionally, even if the origins of this discipline can be traced back to previous events, we should consider that some technological attempts at indoor cycling activity (even intended as "at home") were made even before, as witnessed by an article of 1897, where a draw shows the use of the ancestors of today's bike

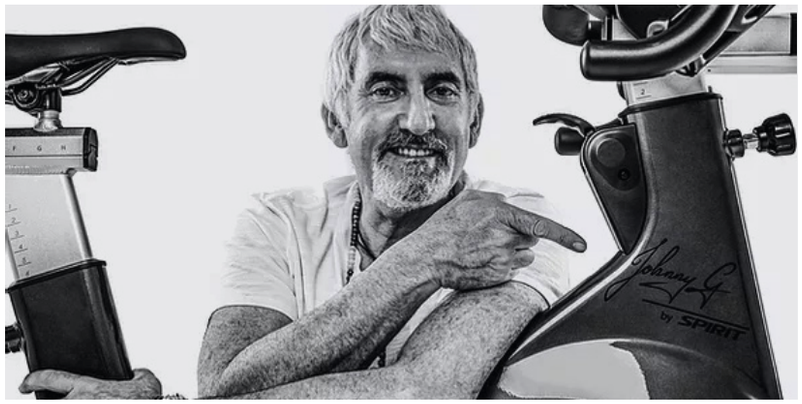
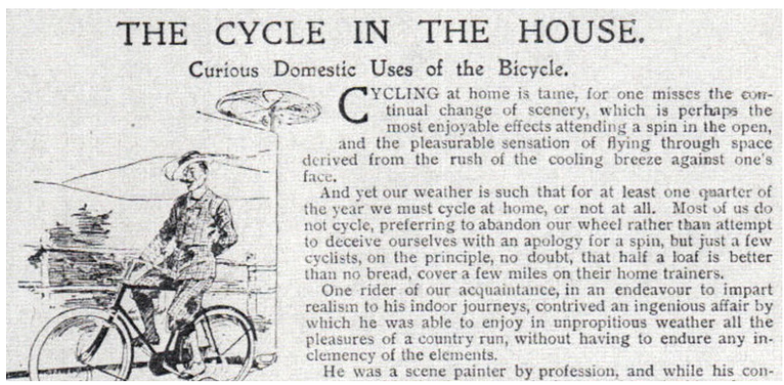


Fig. 12:
Johnny G with the Spirit bike model

rollers. In fact, bike rollers have been technically developed as an alternative mean for indoor cycling, probably becoming even a better choice for professionals over the years, but being a business based more on technical improvement, their market success was not comparable whit the huge wave created by Indoor Cycling as we know it today.
This story could appear a quite fast simplification about how relatively things went, but it is out of the question the incredible fast rising of something that even in this start seems to be more a "movement" than an effective sport discipline. Indeed, one of the main boosting factors since its origins was the media curiosity gained by the sport, described in a 1994 article title (that means just 28 years ago) by the Rolling Stones magazines as the "hot exercise you need to try". Starting from this period, indoor cycling was becoming a kind of phenomenon, involving an ever-increasing number of practitioners attracted by group classes accompanied by music. It was music the first main factor to be involved to make classes more entertaining, strengthening the idea of training (rather an experience) designed to make people sweat but have the most fun, and not seeing it through the lens of a stressful fitness goal to be in shape. Mainly for this reason, people look at this type of fitness differently: easier, more motivating, effective. These last aspects should not be underrated, since the second step, after gaining the practitioner's attention, is to convince him of indoor cycling effectiveness: indeed, this kind of discipline is considered in that set of sports activities included in HIIT training, quickly alternating high-intensity interval to less expensive in terms of physical energy expense. Nevertheless, the equipment allows a lower load on a joint like one of the knees and is particularly used also for injury recovery: this aspect being more technical will be treated in depth in the next chapters. What matters now, is the number of aspects

that suddenly make Indoor Cycling a "popular"[4] discipline: from the first moment it emerged, it does not try to appear exclusive, rather the opposite, and still today is gaining people in this perspective. People, and in general communities, are one of the most important aspects in this field: most of the people involved continue and keep motivated to work out through the help of the group, having not just an important influence on the training itself, but even before and after it, building a healthier context as better explained in the next paragraph.
But also the popularity of this sport can lead to unexpected effects: the already mentioned dispute about trademarks is an emblematic example, convincing increasingly people that all Indoor Cycling can be viewed as Spinning and vice versa, but the apparently unsolved problem makes the second one more common even in people's vocabulary, by making difficult an already confused topic.
Of course on a business level, popularity means also the market is growing and will continue to do so, as the many models of indoor bikes and players moving toward that direction on the market are proving. Just to cite again one of the main player in this field, Les Mills, through a 2019 survey (Les Mills, 2019) highlights that at least 20% of the fitness market provide indoor cycling classes in their offer, being a leading activity for the business as confirmed in Active Leisure Trends 2018 report, released by the UK Active Research Institute, that shows how the 13% of the total group exercise participants in the considered year are involved in indoor cycling classes (UK Research Institute, 2018). Despite the already several factors mentioned, the future has still a lot to discover, especially with the increasing involvement of data-driven training or virtual reality (partially already seen in the introductive chapter "The gym of the future"). The project in this thesis tries to ride this wave, hoping to exploit the latent potential of technology in this field.



THE CYCLE IN THE HOUSE.

Curious Domestic Uses of the Bicycle.

CYCLING at home is tame, for one misses the continual change of scenery, which is perhaps the most enjoyable effects attending a spin in the open, and the pleasurable sensation of flying through space derived from the rush of the cooling breeze against one's face.

And yet our weather is such that for at least one quarter of the year we must cycle at home, or not at all. Most of us do not cycle, preferring to abandon our wheel rather than attempt to deceive ourselves with an apology for a spin, but just a few cyclists, on the principle, no doubt, that half a loaf is better than no bread, cover a few miles on their home trainers.

One rider of our acquaintance, in an endeavour to impart realism to his indoor journeys, contrived an ingenious affair by which he was able to enjoy in unpropitious weather all the pleasures of a country run, without having to endure any inclemency of the elements.

He was a scene painter by profession, and while his con-

Fig. 13:
"The cycle in the house", article of 1897.

3.2 Indoor Cycling context

After an initial look at the timeline of Indoor Cycling, the following paragraphs focus will be on the current state of the art of the discipline, with the aim to describe what happens during an Indoor Cycling class, the context, specific problems, and requirements of both training and equipment. The first step of analysis will be the context, which means not only the specific physical location where practitioners meet but even the side factors that in some way influence the training and the moment right before and after it. Actually, thanks to the market offer, Indoor Cycling can have different physical contexts; the first one is the eldest and most common: a fitness gym.
Fitness gym was also our starting point in this thesis since the project's purpose is also to affect the "gym of the future". As we already saw, during gym history, different specific places were thought to introduce several disciplines and embrace a wider catchment area, and Indoor Cycling was one among these. What makes the dedicated space interesting is the fact that Indoor Cycling classes are group ones, and so over years, the space has been arranged to fulfill and improve the group experience with the main goal of a motivating scenario. Our references for this thesis will be fitness gyms visited (so mainly big fitness chains like Virgin Fitness or GetFit), but basically, every gym included in this target is designed for a class of about 25-30 users (probably a larger one can be difficult to manage for just one trainer). On one side of the room, there are users' bikes, spaced about 1 meter between each other, both on the side and on the front: as we can see in some pictures, even if there is space, this type of arrangement leads the trainer to not just guide the session riding his bike, but maybe requiring sometimes to get off the bike to give instant feedback to the users. For the same reason, some gyms have an overpass workstation for the trainer, allowing a better view for the trainer and the users as well. The trainer workstation includes his bike and a small console to manage music and visual contents: technology, given the training requirements, increasingly became part of these rooms. Indeed, being music a fundamental part of this kind of training, it is possible to find a dedicated tool in every gym, almost the less equipped. Year by year, especially in the last ones, the importance to entertain users have become crucial, leading gym owners to design them with particular attention to the space. As can be shown in the next paragraphs, the entertainment factor is not exhausted in the use of music, but some gyms started exploiting even Virtual Reality or more advanced digital content, shifting even more the sport toward the field of gamification. Since this approach is still the prerogative of a few gyms, it will be described through the use of some case studies in the paragraph "Indoor cycling as interactive experience": for now we will limit to the current common situation and context, making the analysis and so the project as much as faithful to the "real" world.
A second factor that actually occurs with music is the attention to the studio lighting conditions: usually, they are designed to have a very dark environment with the start of the real workout (so lights on during the warm-up phase and during the stretching exercises at the end of the training), combined with the use of some colorful lights, fixed or more dynamic (depends on the gym considered) that create a dynamic look to the room and quite a spectacular effect. It is quite rare to find gyms with dynamic lights since designing them can be a very high-cost activity, but in the last years the number of gyms with this type of lights is quickly growing, showing how light can eventually become a crucial factor for hiring new practitioners, even used in a different way. For this reason, the use of light, even in the case studies that later will be analyzed specifically for Indoor Cycling, as well as the ones described in the chapter "Gym of the future", was the first insight into how to get a more involving experience in this type of classes. Right next to the console, in some gyms, we found a screen where visuals contents are projected for the user: the content is different for every gym, and this could be seen as interesting, since every gym uses the tool for different purposes,

Fig. 14:
Spinning class room in the Virgin Active centre (Kennedy)

Fig. 15: Console for VR cycling in the Procycle Studio in Milan

depending on the preferred target. Some gyms use them for projecting abstract visual content, that in the dark environment creates a nice effect and a fun atmosphere for the user, allowing him to be focused on the training without being bored by the continuous cycling: in some way they have the same function as music. In other gyms, the screen is used for more technical reasons: during on-field research in a Virgin Active center, the trainer used it to project some bubbles containing each user's rpm values, making possible a real-time comparison in the whole class among each bike, and making it available for the trainer in a first look to ensure every user is riding with the correct intensity. Of course, this type of use can have some collateral effects: as a trainer highlighted in an interview[3], people sometimes feel quite uncomfortable in being compared to the rest of the class, and even if this can be extremely important for trainers and to give instant feedback for correct training during the workout, most of the users dropped classes for the same reason, leading to important subscription losses for the gym.

A last fundamental aspect to consider is the dimension of a group class. This aspect is something that strongly influences the context itself since several surveys proved to be a crucial factor motivating people to train (ISPO, 2022). The presence of other people, probably struggling with some difficulties and problems, or capable to help newcomers to start the path with advice, is very important in the perception of a welcoming place, the perception that for the gym owners is very important to gain new people. Being uncomfortable in a context already requiring physical stress would be just a new obstacle for the user to reach the consistency needed in this sport: fun in indoor cycling has always been a particular priority. Even if not properly in the interest of this thesis, it is important to consider in the research also the existence of different spaces from the fitness gym: these spaces can be described as professionals studios, mostly attended by expert users, and where the training is totally thought to improve the performance for competitive races. So it is difficult to find music or light and dark games in these kinds of spaces, but maybe equipment for better monitoring of the training and particular attention to technical aspects of it. For instance, one of the gyms visited, the Procycle Studio in Milan, uses software allowing the different bikes of the studio to compete in a simulation, engaging, even more, the users and at the same time making easy and quick access to the information about the race.

These studios are also often attended by people needing to recover from injuries or as the owners explained, by people who like to train but without the "chaos" of music and screams of fitness gyms. When this experience becomes something elitist and strongly customizable in terms of experience, they are better described as "boutique fitness": basically a space with a limited number of people allowing for a more controlled and careful experience (with of course high price range related to comfort with respect to a normal gym). The last alternative is home: as has been already highlighted, home is an established context even for workouts like indoor cycling, since the presence of Covid pandemic restrictions starting in 2020, lead people to consider training at home. The context itself will be not treated in this case, but it is important to remember it since the evolution of the equipment has been affected by this context shift for some companies: of course, there will be bikes dedicated to gym or studio, and other ones specifically design for home, but in the middle, there are also bikes designed for both (as a strategic decision of some companies), and this has technical implications on the training itself.

3. See in the interviews section the meeting with Pietro, Virgin Active trainer in Milan.

3.3 Equipment: reverse engineering

The first step to be done is a process of reverse engineering: we imagine the disassembly of the whole bike understanding which are the main components, how they are organized, and why. Additionally, this allows us to get preliminary information particularly important about materials and manufacturing processes, considering also the integration of the needed electronics. This analysis will be conducted using a particular bike as a reference, the model M3 (fig. 16) of the German brand Keiser. The reasons behind this choice are many: firstly is actually one of the most spread models not just in the fitness gym around the world, but also in other sports structures where Indoor cycling is part of the training; secondly, the reasons for its success reside in the accurate technical development, that required years in this field, of the bike itself, since in this sense the Keiser M3 is one of the most advanced indoor bike model (the one capable to provide high performances with incredible design simplicity). It can be evident how this level of technical development is the most suggested for this type of analysis, allowing us to already take into consideration the constraints in designing such a complex product. Lastly, given the first two motivations, it is easy to find as much information as possible about this bike: as it will be shown during this thesis a lot of information has been got not only through online research and catalog consultations but above all through the physical survey on the model and discussion with professionals in this field.
Looking at every indoor bike on the market it is possible to see a main assembly built always starting from the frame, supporting other important sub-assemblies like:

1. The **drive system** with a resistance mechanism allows the stationary ride;
2. The **handlebar**, becoming increasingly complex with the addition of monitors;
3. The **seat** is usually adjustable and sometimes equipped with weight holders.

The following sections will deeply analyze each subassembly, helping us to understand key technical aspects and to easily move among the several models on the market in the following benchmark analysis.

Drive system

The drive system can usually be of two different types: a chain-drive system or, as almost the majority of bikes on the market a belt-drive one. As easily understandable by the name, a chain-drive system is like one of the normal road bikes, where a chain transmits the motion to the back wheel. Even if the ride feeling can be more similar to one of the normal bikes, a negligible factor penalizing this system is the more noise produced during the ride and the additional susceptibility to be broken, requiring repair with high frequency (something not for sure so manageable, especially in a context like a gym). The belt-drive system concerns a rubber belt transferring power from a drive-pulley to a smaller driven one, attached to the flywheel: the presence of a tensioning device makes sure to have enough tense the belt to transmit the motion. This one is now a more established system thanks to its quietness during the ride and a lower necessity for maintenance over time (almost zero). Being a proven solution also in other industry sectors requiring transmission (especially for motors), the cost of this design is now low: for this reason is very difficult seeing a chain-driven system, since for all these aspects is extremely inconvenient. In the specific case of the Keiser M3 (but even of models like the ones made by Technogym), the belt used is a Poly-V one, as can be visible from the V-shaped grooves keeping in position the belt.
One of the main components to consider in this sub-assembly is the flywheel, very important for a smooth ride for the user: its purpose is to store the kinetic energy generated by the user cycling, and for this rea-

Fig. 16:
The model M3 developed by the the german brand Keiser

Fig. 17:
The Keiser M3 was one among the first models with a lighter Flywheel

son, usually, it was an intentional heavy component. The kinetic energy generated is affected by mass and velocity, so making a heavier component increases the energy stored for a more controlled movement. However, some of the last models, like in the case of the Keiser M3, adopted a different approach: using a lighter flywheel allows one to get more power from the training, lowering the risk to hurt knees (fig. 17). Additionally this solution requires fewer maintenance operations, since the load on bearings and axles is lower, with a whole lighter product to move around (since the most of the weight usually depends on the flywheel). As the benchmark will show, most of the models on the market have a front-positioned flywheel, which makes it easier to move the bike. But there is an important problem related to this negligible aspect: indoor cycling is a sport where the user sweats a lot because of the training intensity, for this reason as explained by an interviewed professional "sweat represents one of the main threats for the flywheel, causing corrosion of the transmission and so implying a frequent flywheel maintenance or in any case requiring more attention by the user". This is the reason because the analyzed model and the last alternative ones as well (mainly launched in the last few years) have a rear-positioned flywheel, avoiding this problem. A last distinction that can be done is between a fixed wheel and a freewheel: basically, the second one allows one to take the feet off without continuing to rotate, something that instead happens in the first case. Fixed flywheels are the most common for cost reasons (inconvenient for product purposes), but at the same time can have other advantages, like pushing the user to continue cycling until the end of the workout. Moreover, this problem is overcome by integrating a brake system in another important sub-assembly that we are now going to approach: the resistance mechanism.

The resistance is a key feature of an indoor bike: it allows to increase or decrease the power needed to cycle by the user, hindering the flywheel rotation. This is an important aspect by one side for professionals who like to train in a context that is as similar to a real ride as possible: in fact, they use this type of bike to prepare themself for competitions. But in a case like the one of the gym with group classes, the resistance mechanics is accountable for the intensity of the training, becoming the main feature to make such an efficient training: the whole activity depends on it. For this reason, the choice of type of resistance is fundamental. Two main types of resistance solutions are now available in the market: magnetic resistance and friction one. The friction mechanism is the older type, and as the name explains, leads to an increase in the difficulty in cycling through mechanical friction (so touching directly the flywheel) through the use of a felt or leather pad. Being a mechanical solution makes it susceptible to all mechanical obstacles and phenomena, like dust, sweat, and wearing, so requiring high maintenance to clean or repair it. For this problem, in the last years, almost every indoor bike shifted to a magnetic solution, where a magnetic field generated by a clip with integrated magnets interferes with the flywheel itself, making cycling harder (fig. 18). The importance to choose a mechanism like this affects also other components of the bike: in fact, based on what has been said until now about the flywheel, magnetic resistance is more indicated for a lighter one, being careful also to keep it out of the so-called "sweat zone". Like in the case of the Keiser M3, the resistance mechanism can be managed through a physical lever, that is connected to the clip by a metal cable that can bring the clip closer or push it further away from the flywheel, managing the resistance level (fig. 5). Even if on the market are present also semi-automatic systems like electromagnetic resistance, that in addition use an electric charge for increasing or decreasing the effect of the magnet, the manual adjustable magnetic one is the best compromise about efficiency/cost ratio. Instead, the only disadvantage concerning the friction mechanism is that provides less control over the resistance, but at the same time, it lets get a better understanding for the user of the correspondent level of resistance (something not achievable in friction systems). Noise also, as we already saw in the belt case, could be a determinant factor for the choice of a magnetic solution instead of a mechanical one.

A last aspect related to the drive system to consider is the so-called

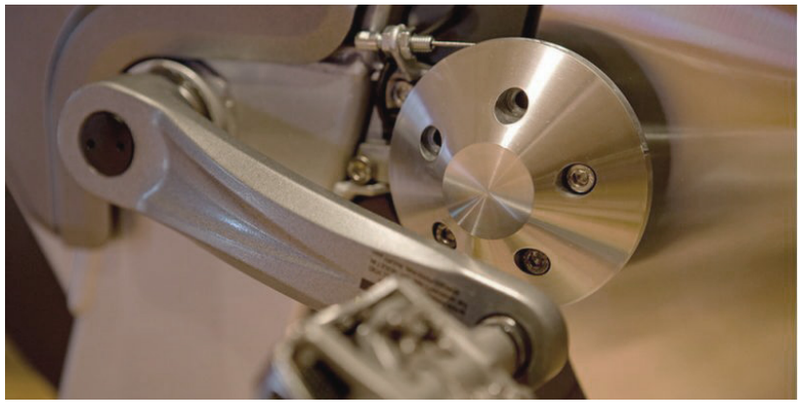


Fig. 18:
Using a steel cable the disk can rotate and regulate magnets position

Q-factor, already known also in the road cycling field. Indeed, as largely described also in buying reviews on the web (Your Exercise Bike, 2019), the Q-factor is technically defined as the distance between the outside of the two crank arms. This distance is quite important since if narrow, and so correctly designed, allows for a more efficient and comfortable riding of the bike: a reasonable value of this distance is about 170 mm, enough to not have legs too close between each other and to the bike frame, but also not too much wide leading to an uncomfortable leg inclination (Fig. 20).

Handlebar & seat subassemblies

The handlebar and the seat are considered two different subassemblies but are closely interlinked since their adjustment affects user training. Indeed, one of the most important constraints of an indoor bike is its adaptability to the user who will ride it, who probably will be different day by day, and for this reason, having an adjustable system for them is fundamental. In the last years, one of the main solutions going behind the classical vertical and horizontal adjustment mechanism is the design of the called “V-shape” frame, as can be seen in the Keiser M3 (fig. 16): having the tube of the seat and of the handlebar inclined creating the outline of a V, allows for a divergent movement of the two tubes, enlarging (or reducing in the opposite case) the space between them. Set up of the bike is always underrated, although the correct height of both the handlebar and seat are fundamental to have an effective ride and most of all to avoid undesired injuries. There are different ways they can be adjusted, but a general suggestion is to have them both at the same height: this condition can change, based on the type of training done. For instance, in the case of a more intense class, having a higher handlebar on the seat is better for posture, on the contrary, a lower seat can be perfect in a relaxed position. Both usually can be further adjusted, through an unlocking system that changes depending on the model: for sure a model thought for the gym needs to be quickly adjustable, due to continuous changes of the user during the same day, and in this sense, some mechanisms are better than others.
Regardless of the adjustment mechanism itself, another interesting aspect is the evolution of a tool like a handlebar over years. An increasing number of models in last years changed a simple tubular grasp adding larger and larger screens: starting from a simple display self alimented by the bike itself, today screens are an important part of the training, thanks to the integration of on-demand class and more accurate data on the training. The market shift toward the home context additionally leads to the availability of applications usually used on a smartphone or smart tv even during training. These models are now available also in some gyms, where to diversify their market several brands are adding a testing spot for the particular type of user, going ever more towards the hybrid experience described in paragraph 2.1, ”Why gym is changing”. About the shape, several attempts have been made to achieve more comfort during the training or grip similar to the road bike experience. This design approach leads to the adoption of curved aerodynamic handlebars, despite the real benefit they can have for the purpose. It is difficult describing how the perfect handlebars should be, and for the same reason, we found a lot of shapes on the market: surely a good design

Fig. 19:
Handlebar of the Technogym Ride model (electromagnetic resistance)

should take into consideration the different phases during the workout, and so the need to have some recovery moments in which user need to restore without losing energy in an uncomfortable position. Some latest models' shapes are even affected by the presence of the resistance change levers directly on the handlebar, see for instance the Technogym Ride model (fig. 20)

3.4 Benchmark analysis

Another important step is analyzing what the market actually offers: a benchmark analysis conducted through different indoor bike brands, among the most famous and specialized, brings us to take into consideration several limitations and opportunities related to this field. Before showing the analysis some premises should be done: the first one is that the set of bikes considered will be included also indoor bikes for different contexts from the gym, like home. As the analysis carried out in this paragraph shows, our target is different, since the gym context is the one interested, but the shift made by this market leads many brands to add features that basically add the possibility for the user to train remotely, but at the same time do not affect the mechanical arrangement of the product, being something interesting more the interface of the product and the service provided with it.
A substantial alteration of the product architecture is verified only in rare exceptions, that in any case can be interesting to consider as alternatives in the design of some components.
As far as analysis is concerned, all the price ranges were considered: in the analysis for reasons of synthesis will be considered just some models for each category, even if the research took into consideration more than the ten models shown. Along the benchmark scheme will be considered some technical data that can be helpful for our purposes and that will help to define the main constraints, related to mechanical aspects or to user experience, to consider in the development phase of the project.

	Schwinn 700IC	**Yosuda** YB001	**Proform** Carbon CX
DIMENSIONS	114,3 × 58,4 × 124,5 cm	101,6 × 55,8 × 114,3 cm	133,3 × 55,6 × 129,5 cm
RESISTANCE	Friction, felt pad	Friction, felt pad	Magnetic
FLYWHEEL	Front, 18.1 Kg	Front, 15.8 Kg	Front, 12.7 Kg
AD. FEATURES	LCD Console	LCD Monitor	iFit with automatic resistance
PRICE	550 €	355 €	576 €

LOW RANGE

Technogym Group Cycle

Nordictrack S22i

Peloton Bike

Kettler HOI

Keiser M3i

Wahoo Kickr Bike

113,8 × 58,9 × 114 cm	154,9 × 55,8 × 147,3 cm	121,9 × 61 × 152,4 cm	138 × 55 × 105 cm	124,5 × 66,1 × 129,6 cm	121 × 76 × 119 cm	**DIMENSIONS**
Magnetic, manual	Magnetic, electronic	Magnetic, manual	Magnetic, manual	Magnetic, manual	Electromagnetic, automatic	**RESISTANCE**
Front, 17.8 Kg	Front, 14.5 Kg	Front, 18 Kg	Rear, 8.5 Kg	Rear, 3.6 Kg	Rear, 5.8 Kg + motor	**FLYWHEEL**
Self-powered LCD screen	Incline/Decline function	Monitor for on-demand classes	Touchscreen e connettività wearable	LCD Display and very light	Automatic resistance and inclination adjustament	**AD. FEATURES**
1.953 €	1.920 €	1.387 €	2.899 €	2.000 €	3.999 €	**PRICE**

MEDIUM RANGE HIGH RANGE

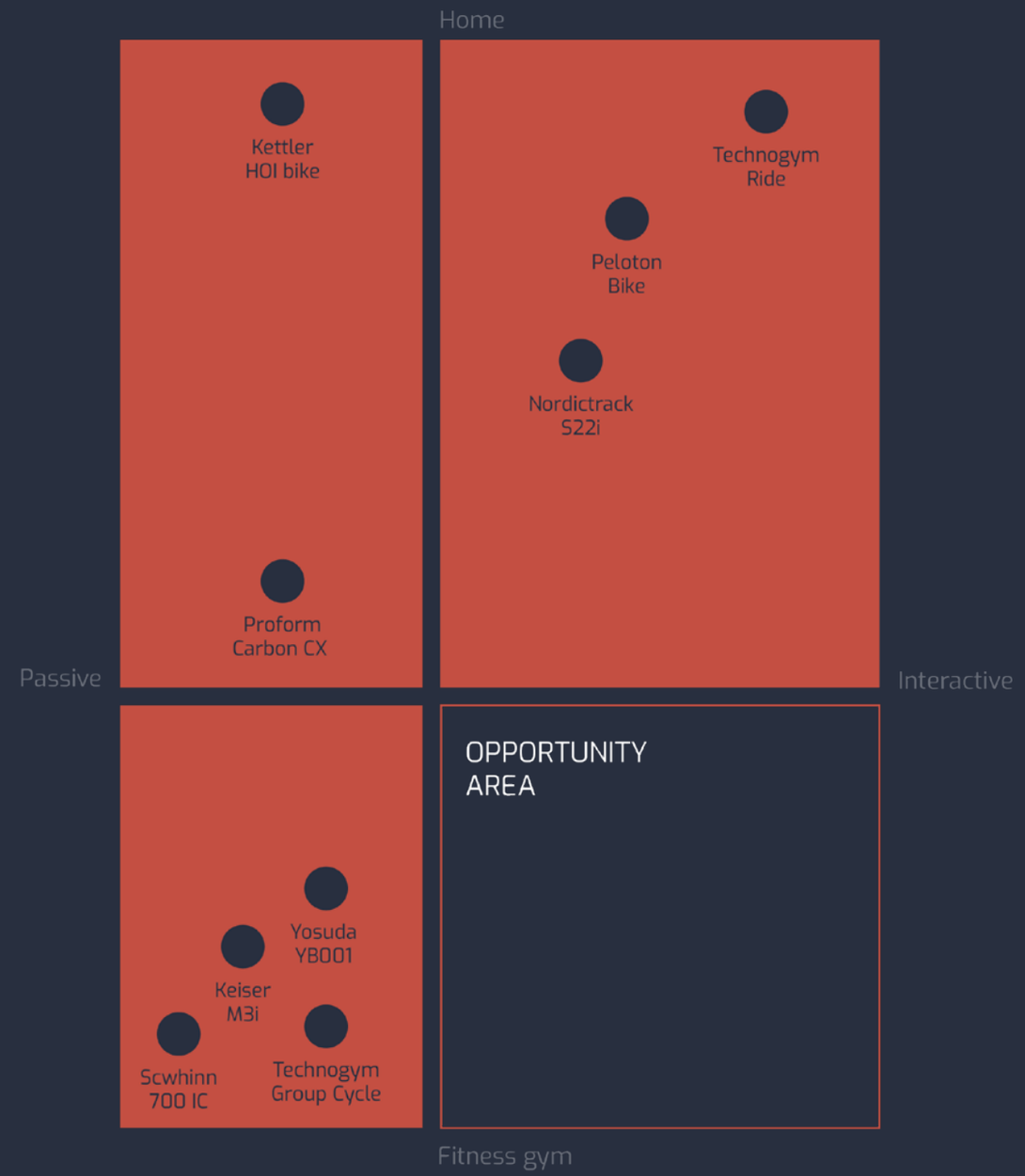


Fig. 20: Bikes proposed (in the last years) by the market are mid-interactive and mainly for home

3.5 User research: interviews

In the following lines are collected three of the most important interviews made during the research phase. They collects all the needed informations for the project purpose and also common considerations made also by other trainers in other interviews. The choice to specifically involve trainer was related to their capacity to provide key information (technical and not) about the practitioner common experience.

Oscar

Role: Indoor Cycling trainer **Gym:** Getfit

Other: manager of a multinational company

"Even among the less experienced, it is well known that it all started with Johnny Goldberg and his training for the Race Cross America, which became an indoor sport at that time: for this reason he built the first spin bike in his garage and then went on to create a programme called Spinning, which however does not differ too much from indoor cycling per se; the intensity is almost always the same, and the variations between one programme and another are nothing more than the result of market logic used by the company that owns the brand. Consequently, there are a series of patents through which the first Spin bike was designed, which then evolved thanks to incremental improvements over time, including through the intervention of other brands."

"In Italy, the ICCF was founded as a spin-off created by the Italian Spinning Federation, later creating a series of bikes through a collaboration with Technogym. Mainly there are two macro-schools: those who started with J. Goldberg and others who now follow other types of programmes aimed at effective but more fun and engaging workouts"

"In fact, everything now takes place through the use of music, music that many believe is chosen at random, but which is actually specially arranged by the trainer, or whoever is in charge of the gym anyway: in this sense the role of music is crucial. There is musical research, which is also fun and perhaps the most beautiful part of our work, even if it is demanding. We use technical and instrumental music alternating with commercial music. The choice is obviously influenced by the training target: today, for example, there are users who will not do an extreme type of training without music it becomes a pedalling on the exercise

bike that you can do anywhere, without knowing the logic that trains you: then the trainer can vary every single aspect, but in any case there is a study."

"In fact, all classes are divided by type: you have interval training, strength training, aerobic building and so on. There are so-called training profiles created with specific logics: the one I'm giving today will be an interval, where we alternate intervals of different intensities in a workout lasting a total of 45 minutes. I tend to divide it into three moments: warm-up of about 7 minutes and bring it up to a frequency that is useful for training as well as avoiding injury, especially at the beginning; then there are the actual work-outs, where, for example, in the case of this workout you go to recover a third of the total work time. There will be, for example, a total of 9 minutes of work in one phase, so the recovery will be about 3 minutes: during the whole workout the duration of the intervals changes, but I always apply the rule of 3 work and 1 recovery. The recovery phase obviously does not have to be so relaxing that the frequency required for the workout is lost, but rather to make it recover while maintaining it, between 65% minimum frequency and rising"

"Obviously within the workout there are different techniques, which respond to the specific variables one wants to achieve. So I have the outline of the lesson, with the different pieces of music, the number of revolutions per minute, i.e. the cadence (rpm), and finally the cardiac intensity. All this with the various techniques integrated: sitting, standing up, so as to simulate the different efforts that flat and uphill would require in reality: in this sense, although different, it does not vary much in terms of fatigue from a road race, there is no downhill by definition, because it would make no sense. I tend never to do training in which following a flat stretch I immediately require the effort of a very steep climb. You have to consider one aspect, the people who come are people who, once they have started, become passionate about this type of training. So you have to make those who come straight away understand that you have to adapt to the bike, not being a normal bike, and understand how to use the resistance."

"One of the aspects that motivates many people to train here is precisely the presence of other people, who, although of different ages, form a group that will also stop and talk before and after training (as you can see even now), and this in the long run helps especially those who start training not to give up immediately. What makes this sport interesting is the ability to combine a number of motivating factors to deal with physical exertion and almost not even perceive it as such: for me as a trainer this is a fundamental thing. In fact, the age variety of the group also leads to the need for a different type of communication per user: there will be the more stubborn one, who already knows what he wants and therefore risks doing it on his own, as well as the inexperienced type who is frightened by the use of methods that are too technical and which he is unable to follow. It has to be a communication that can be applied to everyone. It is important to make it clear that it is their training, and not a competition, so not everyone will have the same fatigue as a reference, but rather the percentage of heart rate to be reached."

"Injuries? Very few, in my case almost never. Generally the training is adapted, so you just have to follow the trainer's instructions correctly. For the rest, all you have to do is wear the classic cycling outfit, maybe some comfortable shorts that alleviate the pain of having to sit on the saddle for a long time. Then I always ask them to start getting familiar with the equipment, so that I can be sure that they don't hurt themselves by following not-so-good examples."

"Taking a large section of the public as well, the interest in data changes from one user to another: in this gym there is a tendency to favour fun over performance, but there is no shortage of those with an almost maniacal focus on monitoring, generally experts who come to train when they cannot do it outdoors (as you see, it always goes back to basics)."

Oscar
Getfit trainer

"One of the aspects leading people to train here is precisely the presence of other people."

Pietro

Role: Multi-class trainer **Gym:** Virgin Active Kennedy

Other: disc jockey, producer

"In my experience the type of user I follow has changed a lot: whereas in the beginning, even up to six years ago, it might have been the cyclist looking for an alternative, now indoor cycling has become totally a fitness business. We have moved from vertical training to a more horizontal one, certainly for market reasons, but also to get more people involved. I myself am one of those who has made this change in contrast to what many professional cyclists still think of indoor cycling done in the fitness business, there is a bit of snobbery."

"I like to follow the training not on the bike but standing around the room, maybe I'm the only one: firstly because I can't do both well, so pedalling and giving directions at the same time. Then secondly I'm not sure I can see everyone well throughout the lesson, especially those at the back, and as you can imagine this doesn't help the user, especially those who are hiding at the back because their training suffers. This very much reflects the earlier reflection on the transformation of indoor cycling into a full-fledged fitness activity. Then you also have to consider that the user after the first few lessons."

"Considering that this is one of the best bikes on the market, as well as one of the simplest, we usually communicate with the user on two levels: rpm and levels. There is one detail that can create some problems initially, and that is that for the same rpm and levels, two bikes can 'unleash' two different forces. Surely after a few lessons these are the two values that create the least margin for error and which it is therefore important to keep an eye on at all times. And then they are values on which the user can hardly make mistakes in understanding the training indications. In any case I pay a lot of attention to communication regardless of the instrument: it is something that is strictly important and related to the fact that it takes place in a fitness gym. The operation is very trivial: the better you communicate, the more people like to stay in the gym and come back. This is something I invest time and energy in, and I say this as an instructor who runs courses for other instructors here at Virgin and all over the world, including abroad."

"I have also worked in other places in the world to give courses to other instructors, they have more of a concept of music linked to a background theme, unlike here in Europe where music dictates movement times: the bpm of the music, give me the rpm of the cycling. Elsewhere it doesn't, it prevails more as entertainment. Everything is much easier for me, even working professionally with music."

"Les Mills was the first company internationally to create a product, I think I call it rpm cinema, where depending on the cardiac target the room would change colour: green, blue, yellow and red. Another product (software) was Intelligence Cycling, where we instructors, depending on the physical stress we wanted the user to achieve, associated a colour. Consequently, I can assure you as a first-time user of these tools, that there is a possibility of offering the market something that works with light and colour."

Fig. 21:
The console used by the trainer in one of the visited gym

Stefano

Role: Indoor Cycling trainer **Gym:** ProCycle studio

Other: certified trainer instructor and studio owner

"In Italy it arrived in 96, as stationary bicycles where one went to the beat of the music without following any scientific notions, and over the years it evolved in this sense, with the growth of many brands. From there they started to have a computer inside, more or less important, and the performance part became more and more important. There is now a lot of talk about watts, rpms and other data that are crucial in this sport, even at the professional level. The type of bikes you see here are high-end bikes designed mostly for professionals who prefer or need to train indoors."

"Everyone has their own characteristics: for example, there are bikes with heavier flywheels because they help to have a smoother ride with more mechanical resistance, as opposed to those with, say, a 3 kg flywheel where you have to put the force into pedaling. So the former is for a more inexperienced target group, while the latter is mainly designed for cyclists."

"In all the screens you see, rpm, watts energy you produce as resistance increases, muscle calories you consume as you go along (muscular, not cardiac). Resistance, on the other hand, is managed by a knob, which usually uses felt pads, with all that this entails. It is better than consequences to opt for something more precise, i.e. magnetic type resistances, which allow you, for example, to have data as comparable as possible with outdoor training."

"Mostly cyclists come to this studio, who are interested in this kind of data we are talking about. On the contrary, the slightly older target group, who need to lose weight, is not really interested in reading all this data, so this type of user gets demoralized and would go to the classic virgin gym, where I also worked out. However, in recent years, the gym has become more of a socially active environment as well as functional fitness, so I don't just find the indoor cyclist who trains 6 months a year. Consequently I also offer training for some of these people who don't like the chaos of gyms or the presence of too many people (and of course many users choose us for. this). It is therefore important for me to diversify my offer primarily as a matter of survival of my studio, so I also have these types of clients."

Pietro
Virgin trainer

"There is a possibility to propose to the market something that works with light and colors."

"As you can see there is also a separate workstation with a console where I can choose a programme and start it, here is the graph where depending on the colour you can see whether it's uphill or downhill, at the top I can see all the bikes that are in the room with their names and relative data, as if it were a sort of pedaling with my group or a real race. I usually draw up the necessary tables, where you work by asking for example to go to 30 % of the maximum frequency, which is an easier reference, plus it gives you two lines within which you have to keep yourself as a user. I am therefore forced to follow each user so that each of them actually goes through a training part that is functional to the type of physique or sportsman I am dealing with (professional or amateur or inexperienced). Once this training is over, the software generates a summary of the final data, and sends this report to your mobile phone, where it takes into account power ì, cadence and frequency, and then saves the data. Many also decide to share them (20,000 speedy brand, taking other brands such as Keiser and Scwhinn) allowing then to go and mount motion sensors that with bluetooth connect to the control unit and then go to work on this type of system. It is fundamental because it has allowed you to take a further step especially in terms of the evolution of your data (from yesterday to today)."

"The Technogym ones are the ones that don't connect to these console times because they have their own separate ecosystem, which they resell to you with the bike itself, so they're real competitors. Here it works that I prepare a type of workout, going to set the values that interest me, then the graph comes out on the monitor of the prepared workout, where it tells you the speed to go, and in the next phase I should go at a faster speed but you can change the resistance, exactly how. You do when it comes out you could change ratio depending on whether it's uphill or flat (or even downhill). So even this type of bike that knows gender, age and other information goes to set you the right training. So it goes to in-

clude a broader target that is not specific to cyclist or inexperienced, and that is increasingly the direction that many brands are taking, especially post-pandemic. It also reports like the console, you just can't do a group session (also because the single bike is very expensive) as well as specialized, and it is also often difficult to train instructors who know how to use them. Gyms are looking for people who know a little bit about everything, so they are cheaper than experienced and therefore more skilled professionals who have left that more mainstream environment, so these bikes won't be in the big chains. Now more and more specialized studios are springing up, with 5-6 people, perhaps higher prices. Many come because being so little besides having better tools they can be followed and a single specific training is created that takes about 3 or 4 hours of work."

"As I told you, I create the music myself and use software that changes the bpm of the chosen song by increasing it (of course you have to choose songs that fit, overlap, etc., so as not to make the workout lose the correct rhythm). This helps users a lot, although there are a few cases of people who have trouble keeping up anyway. But if you feel the rhythm, it helps and it is much more immediate and comprehensive than the single piece of data to be read on the monitor, and obviously more fun too."

Fig. 22:
Abstract animations projected during an indoor cycling class

Fig. 23:
RPM, Kcal and time are always informations in the foreground

"Among the characteristics that I recommend paying attention to are magnetic resistance, handlebar and saddle adjustment (for which I also prepare cards based on a test that helps me understand what height the various components must be in order to be able to train correctly for both comfort and effectiveness), and the rear flywheel so as not to sweat on it. Other secondary but nevertheless important aspects can be having prosthetic saddles, which usually have saddles in this sense that are not proportionate to the bike and not even comfortable for the user because they are probably not even designed. Finally, the heart rate monitor, which is often underestimated but is always needed in any case, or the training could be critical."

"The final training consideration is to always make them work according to their physical condition: so give them the right pace, the correct posture at all times, and convince them to use a heart rate monitor. Then make them train for the full 45 minutes. Gradually then integrate the explanation of all this data."

3.6 Indoor cycling training: shadowing and user journey map

One of the most fundamental step for the project (and in general the research), was the direct observation of indoor cycling classes: being a very popular and spread discipline lead to a distorted view in the collective imagination, resulting in a set of biases who can betray the value behind it and the potential opportunities hidden from a design perspective. The following journey will collect and synthesise all the informations gained not only during the shadowing session, but also in the interviews and meetings with trainers and users, trying to discover which are the most common problem and needs not just for the exerciser, but also for the trainer. The observation interested more fitness gyms, so to verify what happens and to have a wider view in the analysis: this was even a way for the understanding of how each class has common touchpoints with other ones, or in which factors can differ.
Each training has usually a time of 50-60 minutes: the training time, with the characteristics of the workout, can change depending on the type of class provided. Indeed, most of the gym offer in their catalogue three type of workout: there are training thought for a less expert target, where usually user entertainment with the basics are the priorities; then there are training for people whose intention is improving their force and power in cycling; last but not least, and also among the most common classes, there are interval classes for HIIT (High Intensity Interval Training), that basically means programs where moments of intense workout (over 80% of max heart rate) are interrupted by short recovery periods, and still considered after years among the increasingly spread fitness trends by many articles and papers (Thompson, 2023). The last one described is also the typology considered as references for the journey, being among the most frequent cases. Regardless from the type of lesson, each trainer has the task to organize the class drafting the so called "profile" (fig. 11): for each training phase and so step, the trainer notes time, technique, sound track to be used (being associated with bpm needed), cadence (rpm), percentage of max heart rate and other notes helping to give as accurate as possible information to the user during the work out. An aspect that should not be underrated is the encoding of training music, made always by the trainer, and fundamental aspect of the training itself, since in each moment, sound track bpm guide cycling cadence of the user, helping him to correctly distribute effort and intensity over the whole training.
Everything is managed thanks to the presence of a specific console, set by the trainer before the start of the lesson, and a projector that when used create abstract visuals for context atmosphere (fig. 12-13). It can be also used as already saw in the interviews, for functional purposes, but during the on-field research this happened just one time (even considering more classes in a gym of the same brand). In the user journey are then specified activities, timings and factors involved for each step, tracking the state of both trainer and exerciser, collecting some insights useful for a starting brief definition. Particular attention should be also given to two different phases: the moment before and after the training, when class preparation, recovery and stretching occur, and short interval used by the trainer for instant feedback to users.

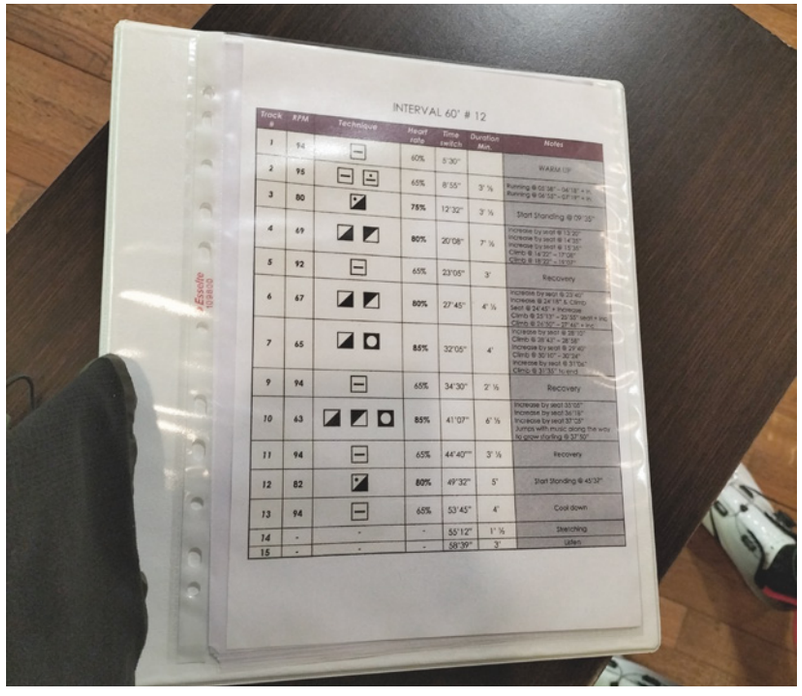
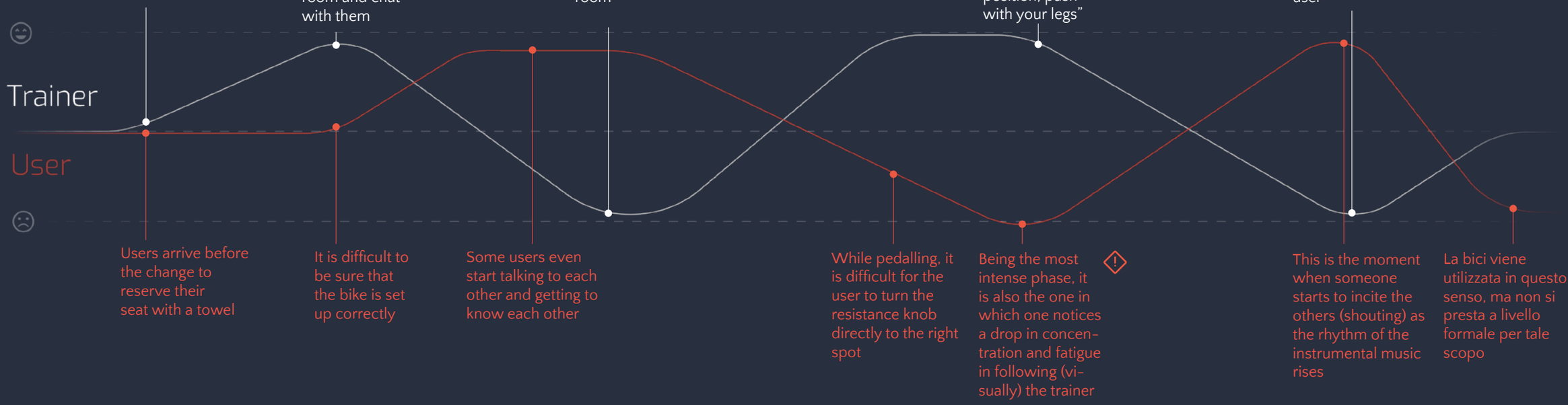


Fig. 24:
The training program prepared by the trainer at Getfit

Step	PHASE 0	PHASE 1			PHASE 2			PHASE 3	
	Set-up	Check-up	Stretching	Start	Soft climb (R)	Hard climb (R)	Last steps	Fun	End
	The trainer prepares equipment for music management and the profile of the lesson in the program **TOOLS** bike , console, microphone, projector	Everyone enters in the room and there is an initial check of the bike setting for each user **TOOLS** bike, microphone	A stretching phase is carried out directly in the saddle to avoid abrupt efforts	A low-key start, with a normal cadence driven by commercial music **DATA** Levels, RPM, Watt, % of heart rate	The real start of the work-out: the trainer calls for increasing resistance level and in recover moment (R) starts the countdown	The most intense phase of the work-out with users switch to intervals with climbing technique **TOOLS** bike , console, microphone, projector	Users must not stop but use the phase for recovery without losing the right cadence for the next step	The trainer gives the last directions to end the training, giving fewer directions to leave room for fun **TOOLS** bike , console, microphone, projector	At this point they stop cycling to begin a final stretching session involving the neck and especially the legs



INSIGHT						
	Knowing students level	Having information on everyone at a glance	Giving an idea of cadence/resistance at a glance		Indicating also a training progress	Making clear the tecnique for the user visually

3.7 Indoor cycling as interactive & entertaining experience: case studies

At this point of the research it can be interesting a step back to how currently gym owners provide an entertaining, immersive and interactive experience in their spaces, but with a specific focus on Indoor Cycling. In fact until now we had a wider look to fitness world, and narrowing the field is necessary to understand how this aspect can be exploited for the specific project purposes.
When we talk about interaction, different specific factors can be involved and so mentioned in the term description, but in Hornbæk, Kasper e Oulasvirta words we can basically define it as the situation where "two entities determine each other's behavior over time" (Hornbæk, Kasper & Oulasvirta; 2017). If we though to the several cases presented and reviewed, there is an intrinsic interactive component, and an entertainment one as well, in Indoor Cycling, built on different layers. The first one is the human-human one: a trainer providing constantly feedback to the user, showing what to do and how to do it (since in the most of the cases the trainer is riding on the bike too). On the other side, we can consider a space-human interaction, where the sound cover a fundamental role in guiding through rhythm (or better through bpm) the user, helping it to keep the right cadence while living an arguing but enjoyable experience. But as shown in the chapter "Gym of the future", as in the general fitness environment, also in the indoor cycling class there is a slight and slow evolution of the space and of the equipment used.
In a lot of cases the direction is the one going toward virtual reality: the concept behind this activity is to recreate a realistic or totally invented space through the use of projections on large screens. It is the case for instance of **Immersive Fitness**, a project created by Les Mills (one of the most active and known player in indoor cycling and fitness field in general) and Reebok, where specific rooms are designed to host 270 degree screens projecting high definition animations and video. Specifically **"The trip"** was the most interesting and dedicated itinerary for Indoor Cycling classes, where projections show a run across the street of a city in the far future: it is actually sold as a course for gym-owners intended to create an immersive space. However even if at first sight it can be seen only as an entertaining tool, it implies the interaction as well, requiring with a response by the user depending on the video, like increasing the cadence in a downhill or increasing the resistance level in a climb and so on. The perception of a changing space around him, boost the user through a less annoying and static journey, and this is one of the first strengths to take in consideration in a new user experience of the class. On the other side the VR solution seems to be one of the most common, almost the only one: this is probably related to the effectiveness of the tool compared to the required costs to embody it in an existing space (or a new one as well). Additionally, the advantage about every digital outcome allows a particular flexibility, becoming something easily accessible on different platforms and provided through different means. Looking for instance to the home context, **Peloton** was one of the main fitness brand to provide a bike equipped with a digital offer, with virtual contents included as well. So you may just jump on your bike and start a ride in every part of the world, every time choosing a different path and maybe even challenging some friends. This type of offer was also provided by **Technogym**, another company pioneering digital offer and virtual reality starting from Indoor Cycling. In general the topic of gamification, strongly related to the virtual content trend, is another different

Fig. 25:
Les Mills The Trip:
a huge screen
projecting futuristic
ride videos

step toward the interactive and entertaining gym class: the challenging mood, joined to an accurate and accessible data collection, help the user to behave accordingly, keeping the right effort and easily following instructions for a correct training (and have fun of course). Some specific boutique fitness for indoor cycling are also equipped with platforms where multiple bikes can connect simultaneously and compete, like the **Procycle Studio**, one among the several analyzed during the user research. In this case the brand provide just a console, and then it is possible to connect every bike with bluetooth or wi-fi connection. Therefore most of this studio provide a kind of training specifically designed for people riding professionally.
Making a step back to the gym environment, one of the most important chain providing a quality experience is the famous **Virgin Active**: in the last years it is very common to find studios with the use of large screens where to project real-time data feedback about the ride. In one of the visited class for instance, a ball with the main information of each rider was projected, in this case more with the intention to allow the trainer a constant monitoring of each user (that as we know can be very difficult in a full room for at least 25 people) and give quick feedback to enhance their experience; on the other side a challenging factor remains, also if indirectly. But using the competitive factor of a game can be a double-edged weapon as sometimes will emerge: projecting data can go beyond the willingness of the users, putting them in an uncomfortable situation where they do not prefer to make visible data about their training. This type of inconvenience should be considered having always in mind the user as a priority, and showing also that an easy access to such specific data is not always good for the user: if from one side can be functional to the performance, the experience can be not so enjoyable as it should be, with for example an implicit interface which stands out important information for the user without creating a negative comparing.
Trying to follow the digital path is not easy: it is an easy, effective and also sometimes fun choice. Despite all these positive aspects, it is important for user experience purposes to find a balance in designing the experience: digital tools should support the experience, and not totally overwhelm it.

Fig. 26:
Real-time data comparation during a Virgin Active session

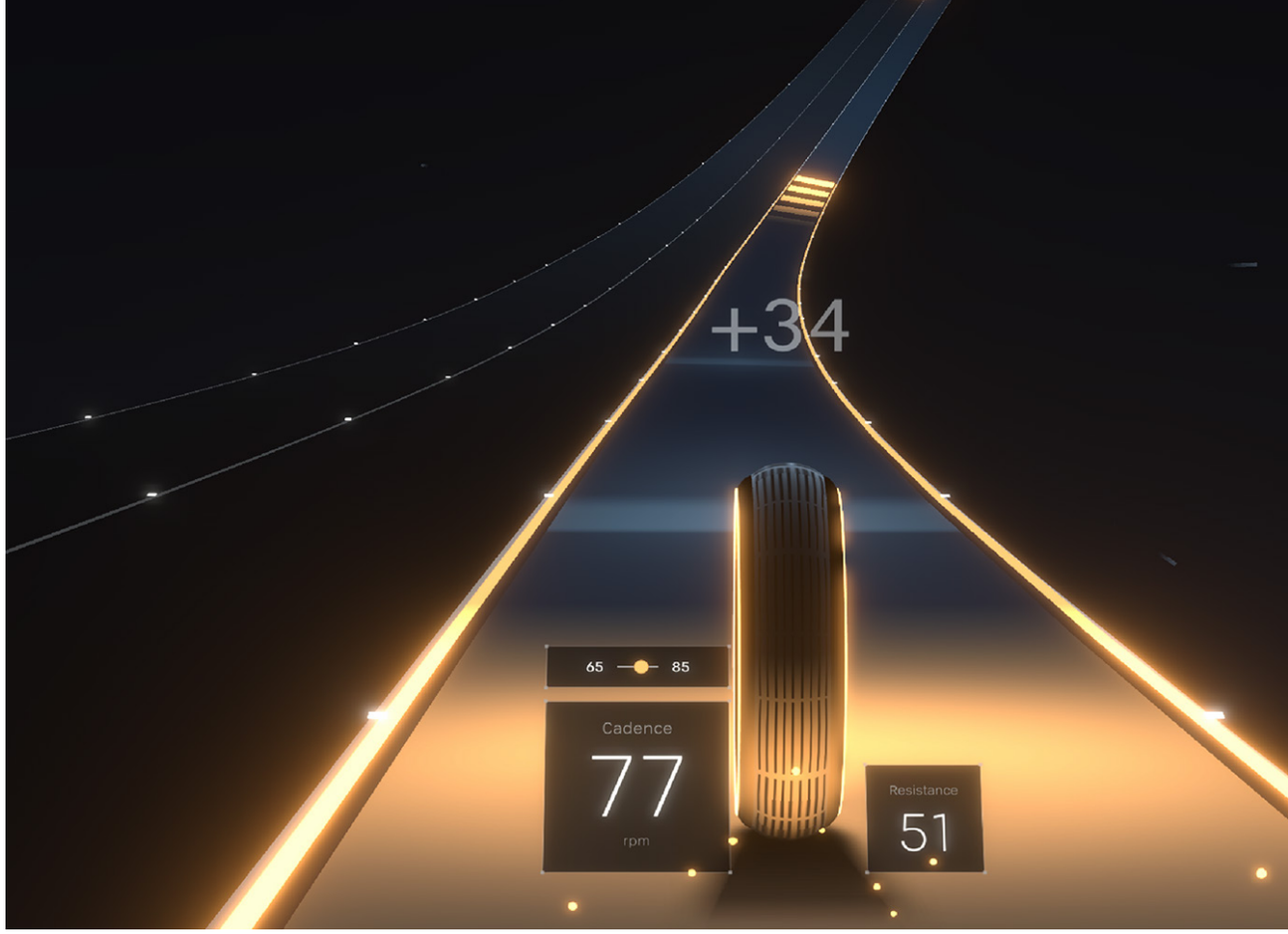


Fig. 27:
A frame of the Peloton Lanebrake gamified training

Brief

Chapter 4

Fig. 28:
ICG Connect, a digital platform for data-visualisation

The following chapter will define the starting brief of the project collecting all the requirements based on the defined problems through the user research and the on-field observation, trying to set a starting direction for the concept. Specifically, the archetype of the project will be an indoor bike, and as a consequence, several technical constraints must be respected in order to achieve the performance capable to make this bike competitive enough on the market.
But mostly important will be the purpose of the bike: this project aims to create a new type of equipment on the market, a product able to guide directly the user in the training session, and in the meanwhile to support the trainer in the work-out, providing an immediate feedback on users performance and creating enjoyable and clearer indication on what to do and how to do it, lightening the trainer intervention. It will be important even the aesthetic and the atmosphere the bike will be able to provide: for this reason, a potential tool that could combine functionality and a meaningful experience is light, allowing to reconceive the user interface of a product that actually provide only digital screens as alternative. The use of the light try to bring the experience a step further, exploiting the presence of several bikes in a single dark room and so to boost the journey and the mood of the exerciser. But before to explain a potential way to do things, it is fundamental defining a starting point: in this case we will list each user pain highlighted in the customer journey and after that, as a consequence, the opportunities to which they led.

4.1 Project target & context

As already explained, the context of the project is the classical indoor cycling class or studio: to be clear, we intend a gym space where indoor cycling classes are attended, with the presence of more than 25 users which are supported by a single trainer. This target helps us to include the smallest cycling studios as well as the big fitness chains equipped with a dedicated space for indoor cycling training. The choice to address this product in a gym context instead of an at-home workout is a strategic one: in fact, as we have seen, contrary to what several fitness (and not) extreme articles declared, the future of the gym is not only our house. We are shifting toward a routine where people are no more constrained to work entirely at home or in the gym, whit several gym owners intended for sure to provide an on-demand offer for the user who is not able to go to the gym, but also to improve and enhance the current system to attract more and more users in the studios. Indeed, as suggested by our starting review about users' habits and the gym of the future, users will always prefer the gym context, keeping at-home workouts more as an alternative: every sports activity has a social component that we cannot ignore and which is fundamental both on the effectiveness of training and the attractiveness of the gym itself. Furthermore, the at-home market seems already filled, proposing now almost similar products that try to solve just functional problems, pushing the product performances instead of finding the key for an entire meaningful and enjoyable experience. Especially when we talk about indoor cycling, there is an entertainment factor that cannot be underrated, since the common user chooses this activity not just to be in shape, but also because it can have fun in doing it.
To be instead more specific in defining the user we should keep in mind that the common indoor cycling class involves two characters: the user and the trainer. During the whole activity, they interact continuously since each user should follow the trainer's instructions. For the same reason, the project addresses both the user and the trainer, trying to fulfill the needs of each one. When we talk of a trainer, we should remember that the one typically involved in a fitness gym is a person for sure prepared, but that does not do that as a primary job. In most cases, we are talking of people who do professionally something else, and who started their path as certified trainers only out of passion for indoor cycling itself.

This led to a key difference: even if every trainer should follow guidelines given by the gym, he or she always has the possibility to prepare the training differently in order to achieve a given intensity base on the program type. On the other side, the common user attending a fitness gym indoor cycling class covers a very diversified range of people: young or older, starter or more expert, every user could decide to do it for several reasons and with different objectives, and this is one of the peculiarities of the big gym fitness chain. So it is difficult to keep in consideration a specific profile, but for sure we should consider that is not a professional rider (it is almost impossible to meet someone doing it for this, if not for injuries reasons), and that even the more expert can face some common problems in every training session.

4.2 Pain & opportunities

In the previous chapter, it is possible to notice that the current journey gives a wide but complete picture of the most common problems that each user, as well as each trainer, has to deal with during a class. In the following table, it is possible to see the main pains related to the trainer and the ones related to the users. They refer to a specific aspect of the training but are mostly related to the main problem of communication and feedback between the trainer and the users.
The main problem regarding the trainer is usually related to the presence of several exercisers in the same room, usually, a number including between 25 and 30 people. This creates a certain difficulty in following the progress of each person in the room, even considering the bike arrangement inside the room. As a result, during the workout, several trainers stop their ride and get off the bike to have a look around the room, and consequently to share some advice almost “randomly”, depending on the most worried users. This can happen from three to four times in a class, in some cases to manage more easily the training; there is some trainer that neither rides a bike: nor just stand up walking around the room the whole time to give indications. Of course, the problem is mutual: if from one side the trainer cannot have enough information, visibility, and time to follow every user in the room, on the other side there are a series of related problems from the user side. For instance, the first one is the difficulty of understanding each user of the cadence to have (a problem that is partially solved by the music bpm) and of the level of resistance. So in most cases happens is that each user can turn

the knob of resistance increasing it too much or not doing it enough. This can bring injuries, additional useless effort, or incorrect management of it, compromising training effectiveness. This is a typical situation that can even degenerate into the total distraction of the user when the training becomes harder: for instance, a common situation is a user who stands up when should be seated or vice versa. In general, we can confirm the complex interaction given by collecting a lot of data e showing them in a small display: the lack of persistent and more instantaneous understandable feedback being helpful for the user in indicating what to do, makes even useless all the related data about kilocalories or heart rate and so on.
On the other side, there are both opportunities highlighted by all these problems, but even related to the entertainment factor influencing indoor cycling activities. Among this one for example, the possibility to create a specific fun factor integrated into the equipment, which can involve increasing the user and boosting his mood during the training while helping the user to be guided for the whole session and overcome the communication problems between user and trainer. The previous research about gm of the future and what the market is currently proposing to engage more the user-led us on considering the possibility to use light in addition to sound, to create a more spectacular environment and involving mood. Indeed, light has several characteristics that could help, as seen in some of the previous case studies, to completely redesign the user experience, both from a functional and entertainment perspective. For this reason, an additional and quick case studies review about the potential role of light in sports activities and interfaces will follow this chapter, helping us to define some potential direction for solutions in the concept generation.

Trainer

PAINS

1. Lack of **control** on every person
2. He/She cannot give specific instantaneous **feedback** on resistance level and cadence
3. Sometimes cannot be clearly **heard** by everyone in profile change

OPPORTUNITIES

1. He/She would like to have an immediate feedback on user **performances**
2. He/She would like to manage an additional **"fun factor"** to the sound during the training

Practitioners

PAINS

1. No feedback about right resistance level
2. Interface data not easily and quickly understandable
3. No information about training progress
4. Difficult setting of the correct resistance level
5. Distractions due to the workout effort

OPPORTUNITIES

1. They like to be in touch between each other during the training session
2. They would like a specific fun moment for attention catching
3. They need constant motivation/remind during the whole session

4.3 Brief: requirements & constraints

In the following pages are so synthesized all the requirements and constraints the final solution must have. Indeed, the purpose of the project will be the design of an interactive and innovative indoor bike for group sessions inside the gym, able to guide the user in the main steps of the training and to support the work of the trainer throughout the whole session. Specifically, the bike should provide a persistent and continuous way to make easily accessible and understandable the cadence to keep, the resistance level to achieve, and at the same time be able to create an interesting scenic effect exploiting the coexistence of more equal products in the same room. The main aspect to consider in the success of this project is the design of a kind of shape-integrated interface, simplifying performance understanding for the trainer, and as a consequence creating a more enjoyable experience for the practitioner.
As anticipated **light** can be a key element of its flexibility and the advantages in using it: to anticipate some of them for example, there is the possibility to create several scenic effects and to use it simultaneously as a functional element to make understandable the right movement and position of the user with respect to the product itself. On the other side, light has several strengths if correctly embedded in the product interface, affecting especially the feedback immediacy and noise in the user experience.

COLOR CODE FOR LIGHT

Designing an **interactive indoor bike**, for group sessions in fitness gym, which **guides** the user's workout and **assists** the trainer's activity through **light**.

- RESISTANCE FEEDBACK
  Instantaneous and persistent feedback for user on resistance level & cycling cadence
- VISIBILITY
  Information for trainer about the user training at glance
- PROFILE FEEDBACK
  Constant feedback about training profile ("up" or "seat")
- STEPS TOUCHPOINTS
  Notifying the passage between different steps
- SCENIC
  Fun and scenic effect involving all the users in the class
- REAR FLYWHEEL
  Flywheel on the back of the bike (out of the sweat-zone)
- MAGNETIC RESISTANCE
  Flywheel on the back of the bike (out of the sweat-zone)
- DATA
  Clearly visibility of rpm, cadence, Kcal, time and heart rate.
- ADJUSTABILITY
  Adjustable seat and handlebar

Light meaning in sport

Chapter 5

Fig. 29:
Interactive LED wall installation for Nike+ shoes (Los Angeles)

Among the main revolutionary changes in our society over decades, the introduction of light in our cities, roads, and houses, was one of the most radical factors that impacted our lives, helping us to enlighten spaces for activities in the dark or during the night. It was surely a change that leads to negative effects on our natural rhythms, extending our days at the expense, for instance, of our sleep. But at the same time, a very fast evolution of light emission technologies gave us several opportunities to overcome these problems and to outline a wide range of applications in new different fields. In this sense, product designers made a very broad use in the last years of LED technology, exploring light potential function not only as a means to enlighten but even to communicate something through interfaces or the object itself, to create a surprising and fascinating effect, sometimes even for wellness reasons. The purpose of this thesis, and in particular of this chapter, is to investigate this parallel and unconventional use in sports activities and equipment. As we already saw, in several fitness contexts is already applied as an added value, and this directs the research toward a potential use in the indoor cycling world, going beyond the common use in this field and market and discovering something that can affect a positive way our idea of training.

5.1 Light: a powerful meaning

As previously explained, nowadays light achieved several contexts of use, a use that does not exhaust space enlightenment, but that is capable to add new values, latent until further development of new light emission phenomena and technologies.
Indeed, to understand that, we should make a long step back to the first years of the 20th century, when the electroluminescence discovery of the English engineer H. J. Round led to the creation of the light-emitting diode in 1927, by the hand of Oleg Losev. But as frequently happened during history, each invention requires a long period of refinement before expressing its potential in the real world, and so before achieving the market. That was what happened with N. Holonyak's invention of the first LED emitting visible light, turning this technology into a lighting source useful for a wide range of activities: then a further step in the 1990s was achieved with the invention of the blue-light LED, that years later awarded I. Akasaki, H. Amano, S. Nakamura with the Nobel Prize.
From this moment on, the efficiency of LEDs combined with their very small size, made them particularly suitable for several applications, since they can be now integrated even into the smallest appliance: a new functionality concept was rising around the light, with the scientific world starting to talk about "Human Centric Lighting". The meaning of this expression was very vague for several years until a growing number of implementations in real life lead to the definition of it as "Evidence-based lighting solutions optimized for vision, performance, concentration, alertness, mood, and general human health and well-being." (Houser, 2018: 213-214). The effect that light can have on human physiology and psychology is now definitely and widely recognized, thanks also to several studies about circadian rhythms, which explored the influence of both natural and artificial light along our daily journey. For instance, some articles investigated how the light color in a given environment can affect people's humor, demonstrating how even in a working context each color is associated with a common response. Light is converted and processed by our brain, specifically by our hypothalamus (involved in our biological clock as well), and generates as a consequence a specific emotion (Cupkova, Kajati, Mocnej, Papcun, Koziorek, & Zolotova, 2019).
The culmination of this research is the wide use of light made nowadays in consumer electronics: the unexpressed potential of lighting was brought out by the union with electronics, which provided the light of intelligence and, most importantly, of meaning. If we continue on the path

Fig. 30:
Sincronia, motion-responsive luminous arena designed by Habits Design Studio

strictly related to functionality, the first integration outside of lighting was the realization of new user interfaces: as nicely explained by EE Times, there are two main types of how electronics can drive LEDs, a direct control, where microcontroller and resistors directly manage LEDs activity, and an external one, where a dedicated device is involved in the communication with the microcontroller (EE Times, 2011). Of course, the last one is less cheap with respect to the first one, but these are the two main approaches through which the majority of products we interact with on a daily basis work, and how they lead to do what we do.
This combination quickly raised the investigation of light in products even in a wider sense of "meaning", thanks to constant cooperation and involvement by big tech companies of innovation-driving design studios. Habits Design Studio, in Milan, was one among these: through their work and their multidisciplinary approach to the project, light gained increasing importance bringing the user interfaces (and the user experience as well) to a further step. Driver principles of this approach are that light can be involved in an easy and more direct communication process with the user, through an "analog sensory perception" and adding value to the experience itself, even in a metaphorical way. This, they highlight, can have several advantages, like its flexibility in the behavior, a "low noise" communication, and a kind of "background" activity, without the risk to overwhelm the user. Additionally, light can add that sign of "vitality" to products not tangible until the last few years, changing our perspective and approach with respect to an industrial object (Luce & Design, 2019).
It was the case for instance of **Sincronia**, a motion-responsive luminous arena, where the light follows the body's movement creating a performance joining light, movement, and sound: the project was displayed in Milan Design Week 2022.
These elements give an additional level of perception to light and imagining a synthetic view of how light itself affects our behavior we can define mainly three poles: the first one with the one we intended always as a primary role, i.e. to enlighten: here we can take a lot of examples, since the lighting market can provide a huge number of devices for every type of illumination, where light interacts with several materials in different shapes; the second one intended as the light capability to directly communicate a message, acquiring a more active role: think for example to **directional lights** used in car design to indicate if the driver is going to the right or to the left; last, but not less important, light effect on our mood, especially if we consider a further factor like the color of the light: an example are all the lamps changing their intensity and color in order to wake up us in the morning and relax us in the evening, like **Clova** mood lamp. If we join each of these factors, light gains a more complete activity, canceling every distance between functionality and feeling, to create a new harmonic value in its use and application. This is the value and the goal this thesis project aims to achieve, proposing this as an example for a future project in the sports field.

Fig. 31:
Audi A7 Sportback rear directional lights

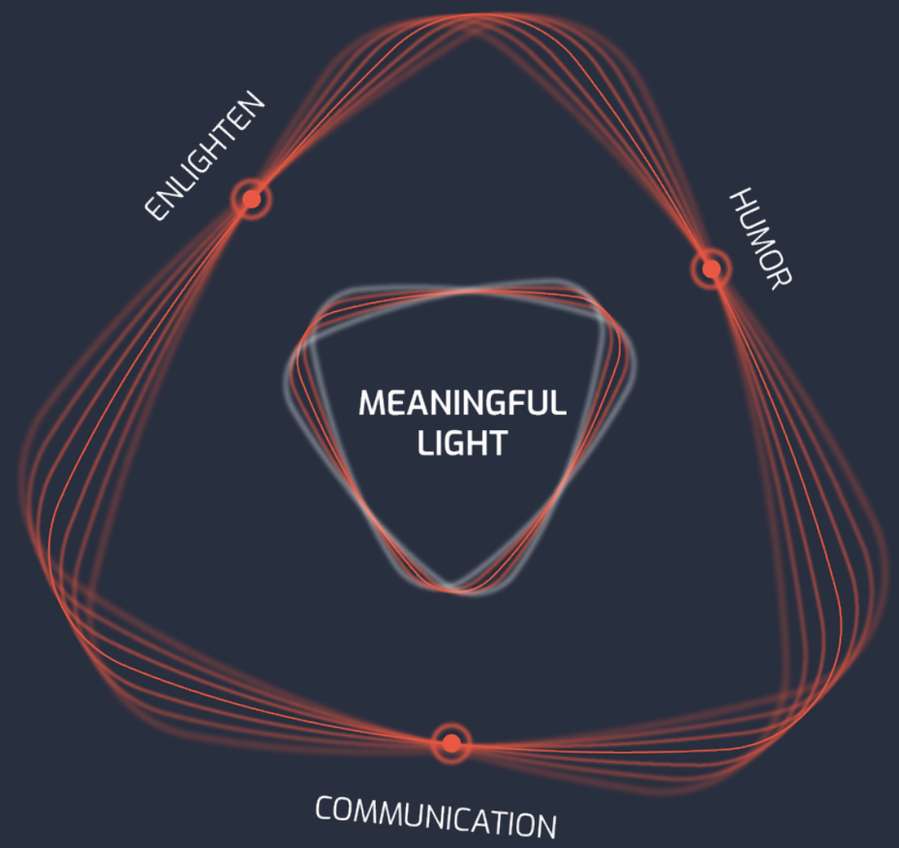
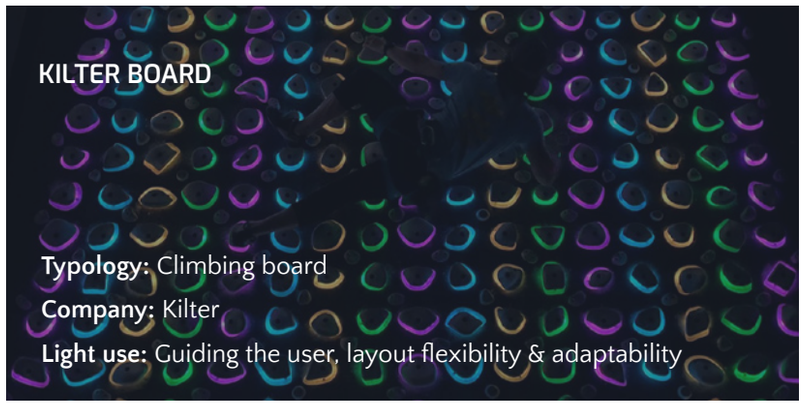


Fig. 32: Three poles making light meaningful: enlighten, communicating and affecting human mood.

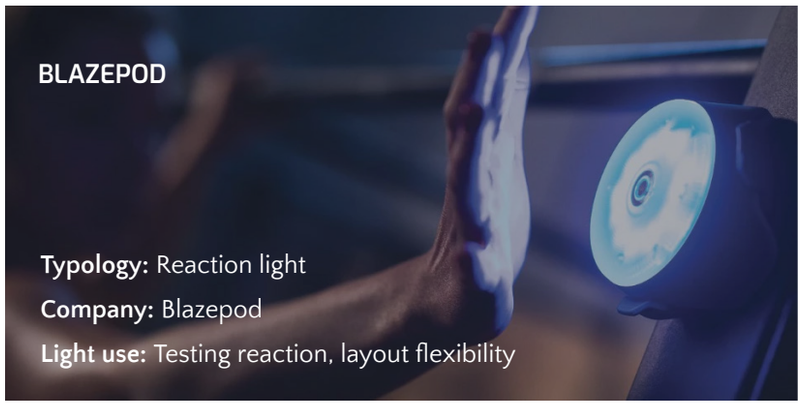
5.2 Sport equipment using light: case studies

The topic of light was considered the most interesting factor in the case study analyzed until now, where the use of it allowed the user the achievement of an experiential context where to train, generating an involvement process still in progress. Indeed, what we have seen at this point of the research is an interesting integration of light in the spaces, but that can be considered a very shy attempt at using it and mostly with the purpose of creating a "nice" gym where to work out: as we explained in the previous scheme, the potential of light is very huge and despite this, the cases of gym exploiting it is very exiguous (inter alia, are also examples who belong to an elitist use).
And this topic still remains true if we add a further level of complexity, shifting the research also to the product instead of the space. Of course, if we through quick research would try to define the range of activities in the meaningful value of the light scheme with respect to what the market offers, we would note that the one of interior design is bigger than the one of product design. This can be explained considering the necessity of large manufacturing scale, and so a higher complexity to intervene on a product scale than the one of a scale. Despite this argument, it is possible to find on the market sports products that make interesting use of the light: the integration of it is more or less interesting, but useful for us in the research of insights to understand how our brief can be completed and enriched by this aspect. Even if less interesting, this quick analysis should be mentioned also those products classified as "gadgets": just think of all the products used to enlighten our outdoor running work-out

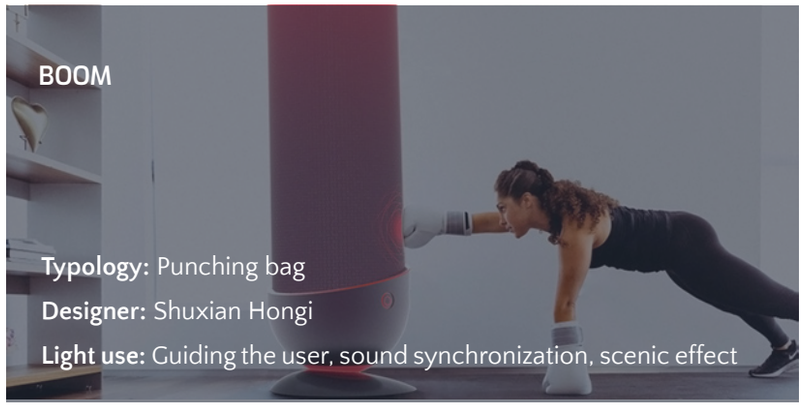
Fig. 33:
Clova mood lamp, changing intensity and color based on the moment of the day



during the night, or the several products sell as glowing, probably to see more as toys for a young target than really useful objects. They can be someway skipped, since the use and study of the light in them are almost null and void, aiming to satisfy a very primary level.
The really first interesting use in the sports field was made in the climbing market: for the ones who usually start this fantastic discipline, a fundamental step is to focus on the path to follow while climbing. If they should do that with the luck to train alone in a private space it can be easier. But for the others who start in a public and huge space it is not easy at all to approach the problem, being involved in many problematic factors: a lot of people in the same tiny space, a lot of holds with different colors, the pressure to not be good enough. They are not insurmountable problems, but the task can be easier: the **Kilter board** should be seen from this perspective. Presented in 2018, the board is concerned with several holds that can brighten in different colors, thanks to the integrations of LEDs backlighting the holds through the use of software allowing them to control them. The object is interesting in several aspects: first using a low disturbing factor like light can guide the user through the climbing path; secondly, it creates a very nice scenographic aesthetic and mood; lastly, the use of light makes very sense also considering a logistic aspect: it is possible to use all the holds to create different training layout with specific difficulties, without being constrained by the already embedded color of a normal climbing hold.
The second case study is related probably to one of the first use of light made by sports professionals, i.e. light to train reflexes. Launched in 2018, **Blazepod** is one of the most interesting reaction lights among the



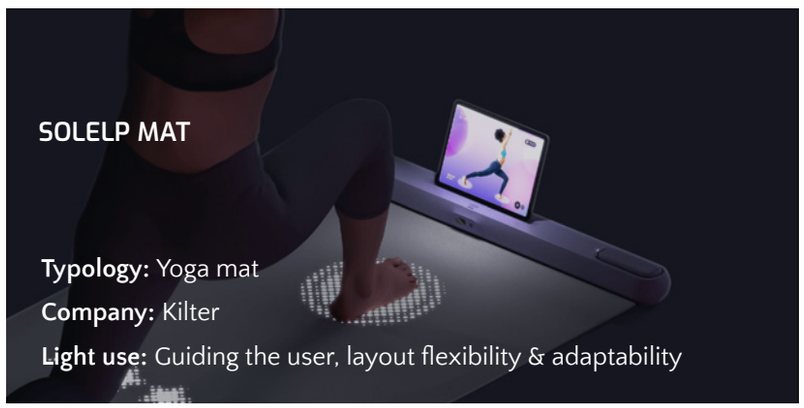
several ones provided by years on the market. Reaction lights are indeed employed to train reflexes in a lot of sports (think for instance football, tennis, racing, etc.), and one of their key factors is to be very unpredictable: the use also here of really easy and fast visible light is perfectly suitable for this purpose, making this pads flexible and adjustable for a wide number of context (since they can be placed in different ways, i.,e. on the wall or on the floor, even attached to a punching bag). It is probably an unbalanced case study toward the function, but surely an interesting one, since also this one is a product directing us toward a light that can define and guide our training: this is the first big potential opportunity related to light use in a sports field, and in particular for this thesis in the Indoor Cycling context.
A similar use of light is proposed by the **Boom** concept, made by the designer Shuxian Hong, awarded the Core77 Design Award in 2022. This concept proposes an interactive boxing bag for training at home, working on different modalities: there is a modality for just visual effects following music; another one to guide the user as in the previously presented case of reaction light, leading the user to punch when the bag lights up at specific points; other modalities are less interactive but still interesting, like for instance the one in which the bag is used as a tracing project for training using a light response feedback for every punch. Even if we are talking of a concept, that probably requires a very complex product development phase, it is one of the few cases where light, got with the integration of a LED lighting matrix, is a very driver in the design process of sports equipment. Light fulfills several goals, achieving a completely meaningful value since it is functional to the workout itself,

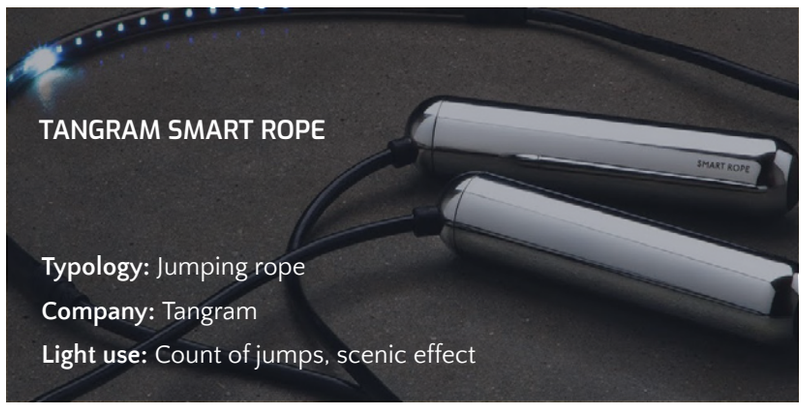


capable of clearly communicating to the user what to do, and empowering his mood during the training. In the field of boxing (and extending it even to mixed martial arts, since the similar training equipment), this type of equipment is slowly growing, one side for the need to design more appealing products for having fun during work-out, by the other side to give a "smart" appearance to this typology of products, increasingly becoming capable to measure and trace everything about our training. Another emblematic case study is the **Liteboxer** shield, with a clear and easy interface: on the shield are present six symmetric pads that the user should punch following led movement across the network joining these six punching points. The idea behind it is of course very similar to one of the reaction lights, but the way the user interface is designed is still different, adding to the previous pulsing behavior a more dynamic movement leaving the user the necessary amount of time to prepare the punch and to know where to direct it. An added value, in this case, is the possibility to create a training program starting from the selected music playlist: this means light movement and behavior will follow music beats. In fact, music and light are often two aspects always working together, since capable to complete the sensorial experience for the user (sight and sound) and are easy to coordinate with each other.
Always considering the previous cases, is interesting noticing how the use of light is still constrained in individual training: this is an important point since Indoor Cycling is a discipline done in a group class, so it can be a further appealing factor considering how light can be also integrated during a context attended by a group of people, and not just individually.
The idea of guiding the user in the process is still the main goal pursued by light use, like in the case of the **Solelp** mat, designed by the Korean studio Minjco. Through the use of a LIDAR sensor, a camera, and a LEDs matrix embedded in the mat, it guides the user on the correct movement for stretching and yoga exercises, providing real-time feedback to the user on the correct way to do it (with an additional supporting video). Also in this case, like in the previous ones, light is the element of physical contact between the user and the object, and this aspect is extremely fundamental in turning a static exercise like yoga into a complete sensorial experience through the equipment itself. The capability to create this physical connection and the correlation between the user's body and light movement is very important for the user experience since allows to guide the user without an effort that for example, a normal interface could overwhelm the user's thinking: this is an example of the "low noise" factor just mentioned in the paragraph "Light: a powerful meaning".
A last interesting example is more atypical with respect to the ones seen so far: we are talking about the **Tangram** smart rope. Also, in this case, the "smartness" of the objects is proved by the presence of an interface realized by a row of 23 small LEDs, integrated into the rope itself: for each jump, these LEDs light up creating a floating display for jump counting during the workout. It is a totally different use and a more shy approach than the cases previously analyzed since the light is not so dominant in the object design. What by the way remain interesting is the capability to use light to innovate even a classic like the jumping rope: the simplicity of a LEDs strip allows to increase the product functionality (even in a so simple object) without affecting the training itself and the equipment size or weight (that in a sports context are of course very determinant).
It is quite difficult to find case studies capable to go beyond the enlightening level and providing added value to sports equipment through light, but even just these example, providing a wider vision of light lead to make some consideration on the possible light integration in a product like an indoor bike.

5.3 Light as project driver

As seen in the previous review, light use and application can cover a huge number of tasks, but most importantly, light provides a range of characteristics capable to expand the experience which users can have of the product. One of the first interesting aspects was the possibility to "animate" the product: light moving physically through the object, exploiting for example its shape, or between several modules (think for instance the lighting climbing holds), defines the interactions point between the machine and the human side. This interaction allows for example to give instructions to the user about the execution of the exercise, like the velocity of the movement, the power to do it, the path of the movement itself, and so on. We can define this feature as a sort of "synchronization", able to drive the workout without overwhelming the user with precise data not easily readable and with a high risk to distract him from the primary activities, which in this case is cycling in a certain way.
Another outstanding project aspect related to the movement of the light is its "flexibility": the combination of LEDs and electronics creates a wide range of dynamic behaviors, that enables the simulation of most of the real training movement. This is one of the main factors expanding light potential in sports equipment since makes it relevant for a large number of activities and, as a consequence, of movements. In particular, there are three main manageable aspects of the light: the path and the direction of the movement; the timing, related both to the movement itself or to the switching of the light (allowing for example to simulate beats); and lastly the intensity of the brightness, capable to provide a different perception of a product function. The control of these three elements usually is all you need to create a great variety of effects.
The third advantage can be defined as "modularity": it occurs only with the presence of more modules of the same product, or simply more than one product. Modularity helps to manage through light all the products that need for example to be arranged in more layouts, with the purpose to recreate the different types of training and layout, or maybe with the aim to recreate different light effects if combined with a certain behavior. In the case of indoor cycling can be a crucial aspect, being a group activity and requiring the involvement of more than one piece of equipment doing the same workout.
The fourth dimension of light will be color: light can assume different colors based on the intensity or the purpose of its message. This affects how we react to it and how we behave in our response: color and perception are strongly related, and even if the use of color in a lot of case studies seems to be not so much "designed", it is a determining factor on how light is received and processed in our understanding of a product and its interface.





The main focus of the project will be finding a solution to embody the light in the bike, allowing it to guide the user through the whole training and at the same time providing an enjoyable experience through the light itself. Synchronization, flexibility, modularity, and colors will be the starting point to enrich our brief and give a meaningful value to the product designed. These four aspects will be integrated into three starting directions, to create as many concepts for a new interactive indoor bike. More specifically, synchronization, flexibility, and colors will be involved in the functional sphere: they will help the user and the trainer to manage different levels of power and cadence during the training, guiding the effort of the exerciser. Modularity instead, combined of course with these two first elements, will act in the sphere of the immersive and entertaining function. But the design will not start completely from zero: one of the main constraints, considering the user experience and so the interface, will be the color. As we saw in the previous lines, there is an already established color code for the training, not so difficult to understand, and that is for the same reason we will use it as a strength of the project. Indeed, the timeline of every indoor cycling training provides a curve with five colors, blue, green, yellow, orange, and red: each color is associated with a different level of power, and to be more technical and referring to the bike, a different level of resistance. These levels are usually indicated with a number, so the change between every level provides helpful feedback, neither for the user nor for the trainer. The color instead can help to modify the user interface, deleting the number code and simplifying the interface itself, making it something naturally fitted in the product shape and not just limited by the use of a digital screen. The interface will change the perception of other bikes in the room, will provide constant and immediate feedback about training progress, and most importantly will also help the trainer to monitor more people in a single room with more ease and precision.

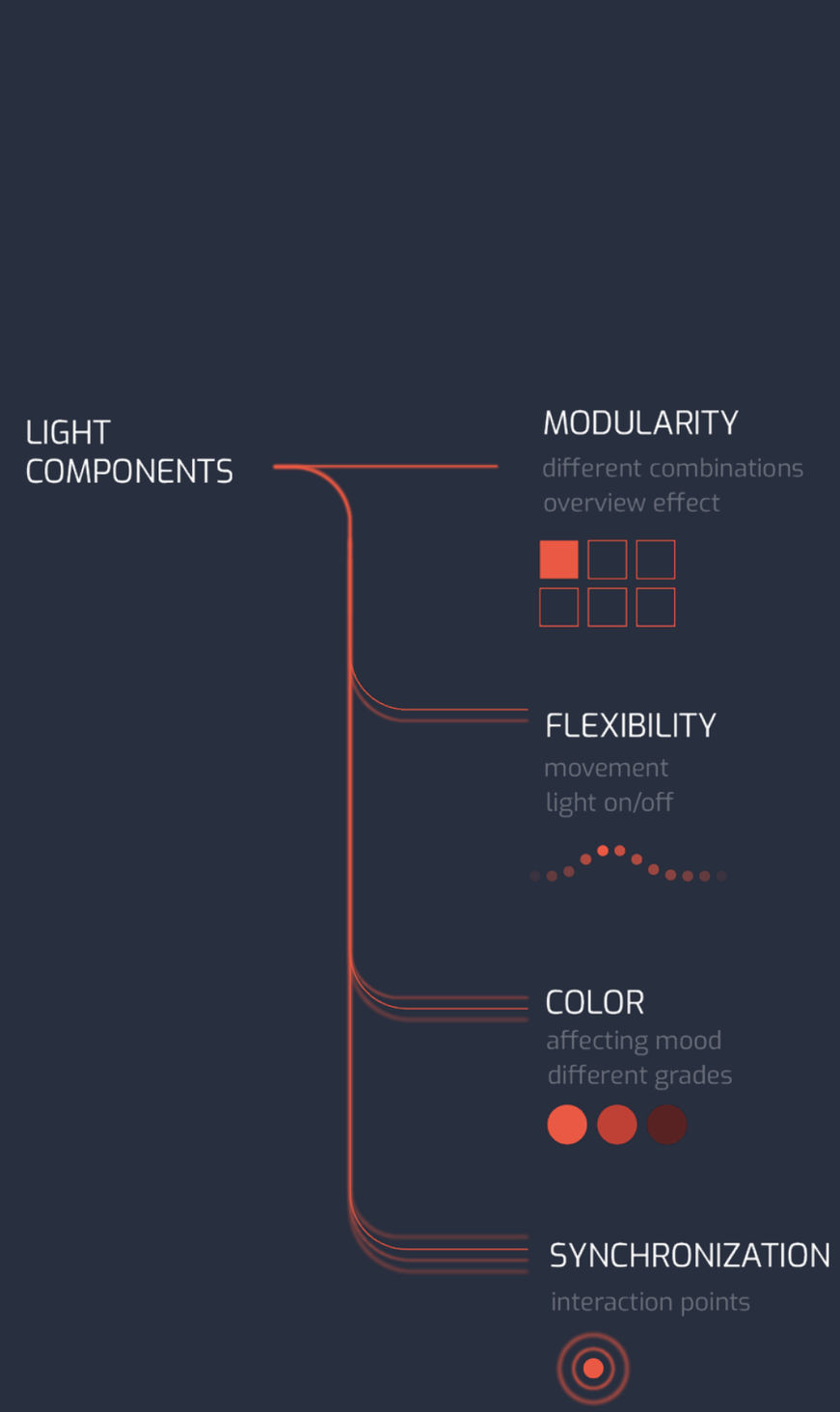


Fig. 34: The four components of light to create a meaningful application (from case study analisis)

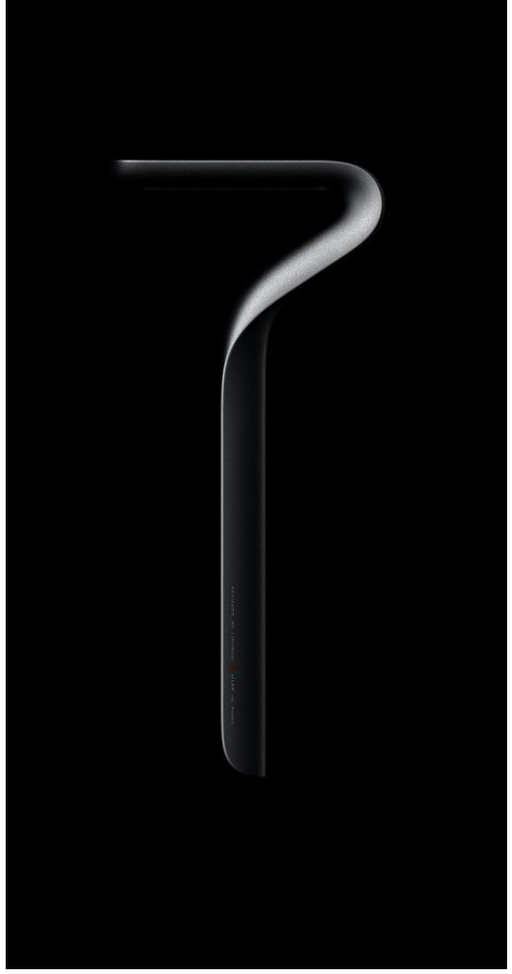
Concept design

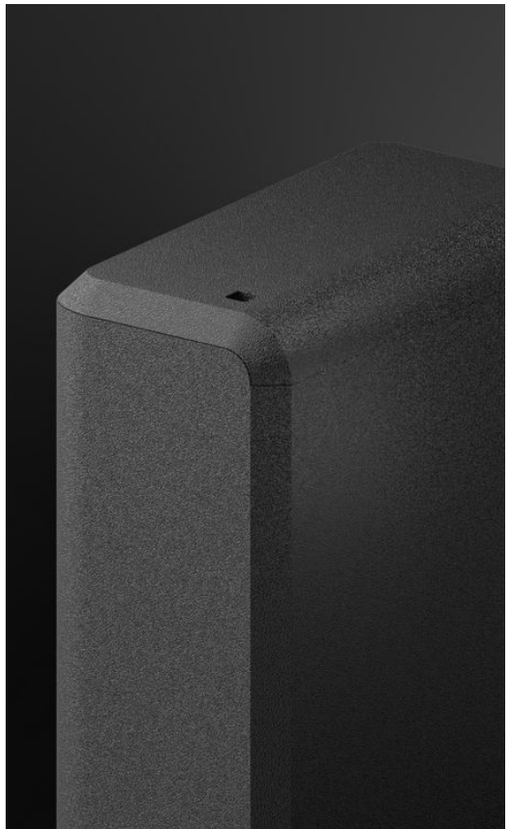
Chapter 6

We went through a huge research combining two main directions: from one side we followed the path of the **gym of the future**, trying to understand how the future sports facilities, and equipment as well, will evolve in order to face the hybrid training routine and at the same time how they will attract new users, exploiting products those will become **smarter** year after year. This first point of view was fundamental in the understanding of the sports equipment design potential and how this will change also the way we train in a gym. **Indoor cycling** will be for sure one of the sports affected: as its story has shown, it is a sport in a continued upgrading, due to its nature of a mainstream discipline, that everyone can practice, and for the same reason, with the need to adopt interactive and entertaining solution capable to ride the wave of training supported by innovative equipment. We identified in the **light** a bridge capable to join this aim by the indoor cycling sector on one side and by the other side a new potential way to use and associate a more **active role** to the product, in this case, the equipment itself. But how this can happen? How the three main components concerning the meaningful action of light can be adopted and applied in order to fulfill this purpose? We will now see three main directions that guided the generative phase of the project in which the main approach was finding a possible configuration where light is not just an additional element, but something perfectly and naturally fitted in the starting archetype of an indoor cycling bike. This step was very important in order to differentiate our solution from the current market offer and to provide a key role of the light during the whole experience, going beyond the functional constraint seen so far.

6.1 Moodboard

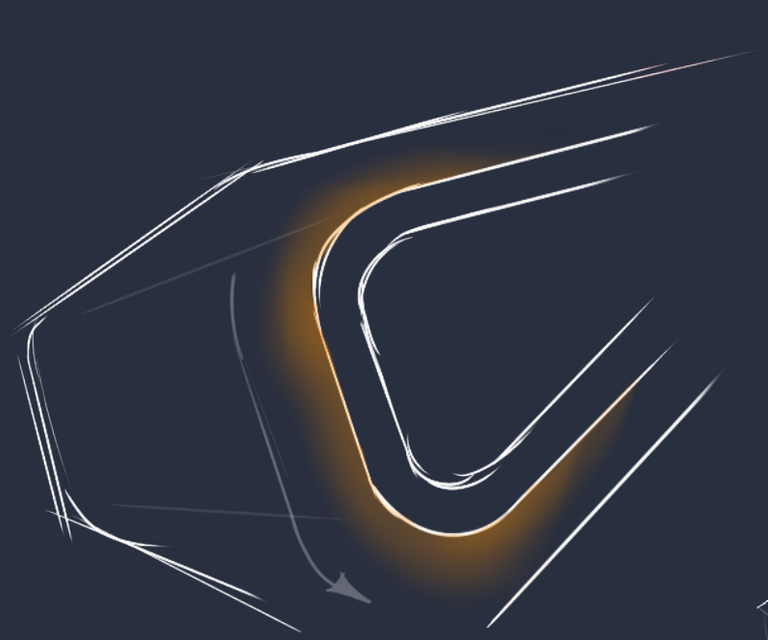
The moodboard role was fundamental in order to guide the project on the type of perception and experience the product must provide, while considering the target involved and, most of all, the context of use. The main idea was finding a way to emphasize the **light** presence and **movement** through a simple volume shape and the use of moderate and dark colors. This provides an interesting contrast in order to make more visible the light movement in a darker room, while giving also an idea of **strength** and an high performance and smarter product. Additionally the lines of the product should give an idea of a moving and **dynamic** object, since we are talking of a static product during the use: this is perfectly in line with the communication of a sport products. Finally it is important to consider the presence of several bikes in the same room, allowing us to exploit the presence of more product in a sort of modular solution capable to give an interesting overall effect in the room: the result of this effect will depend on how the light will applied and in which part of the bike will be embodied.

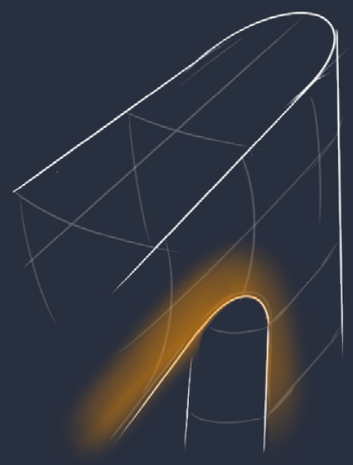


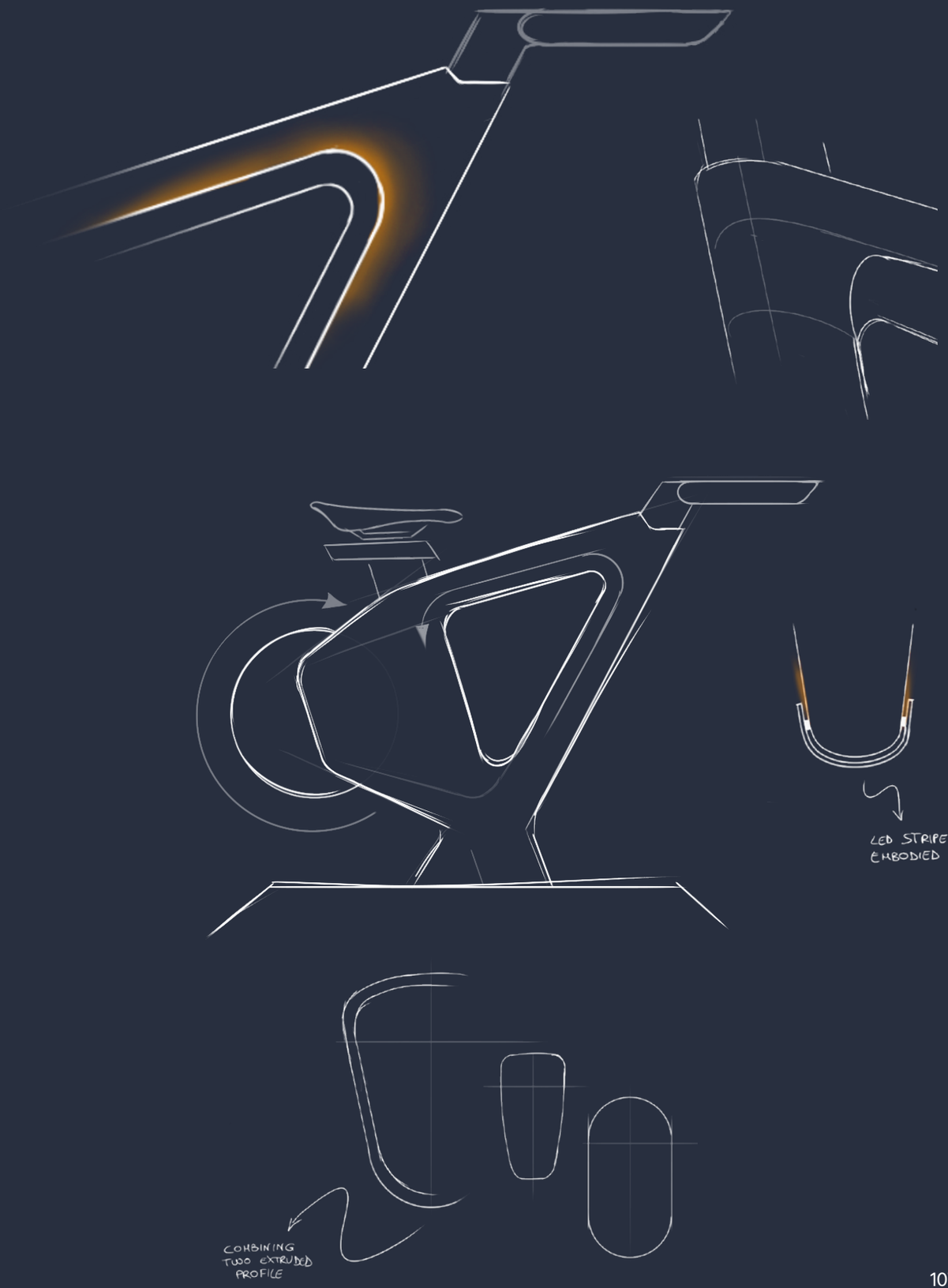


6.2 First direction: joining shape and light

The first idea was to exploit the body of the bike in order to draw a **path** where the light can move, defining a specific **shape** in order to indicate the position the user should have in a certain moment and the profile adopted (for example if he/she should stay up or seat). The path should be closed to provide also the possibility of a rhythmic movement along the same line: in this way it is easy for the user to associate to the light velocity the **cadence** he/she must have during the training, helping the user to keep the right effort during the workout with a continuous and persistent feedback.

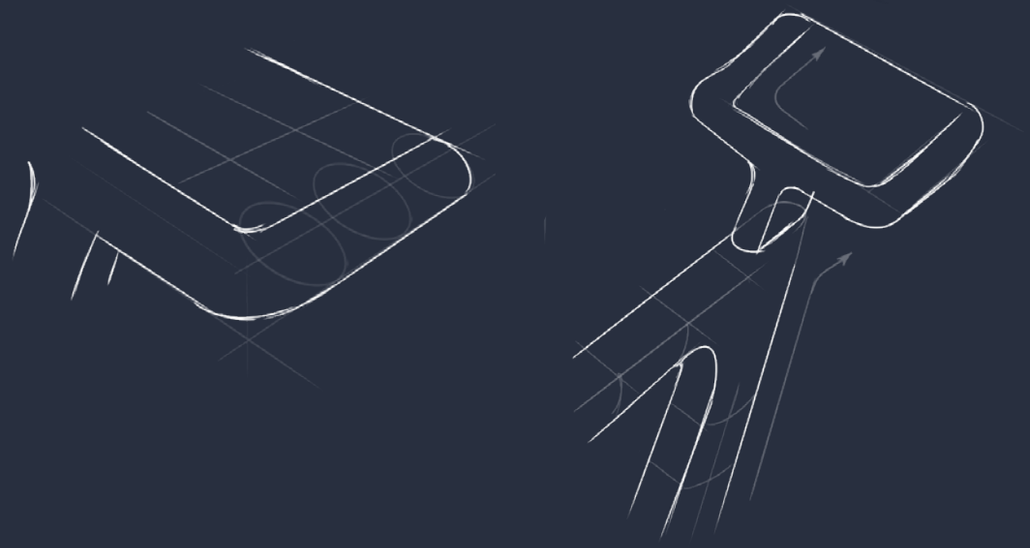


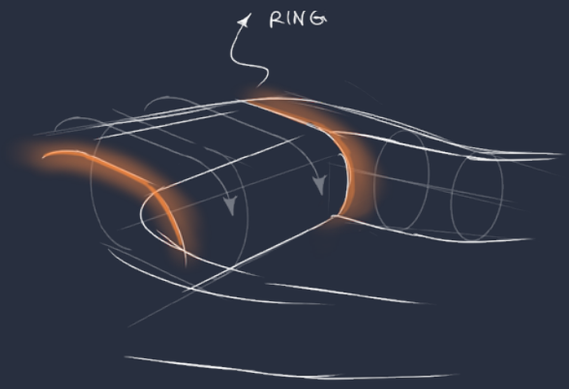


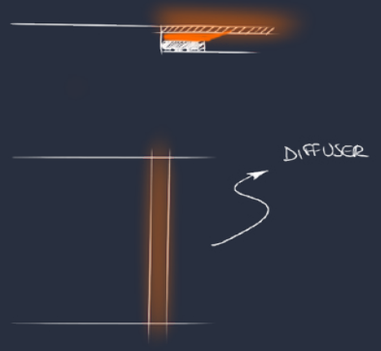


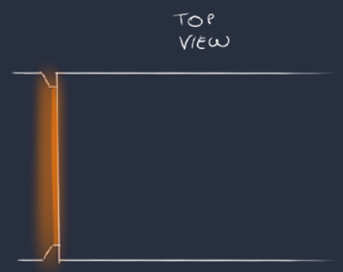
6.3 Second direction: light driven

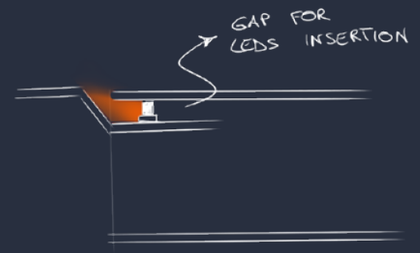
In the second concept the idea was to give a key role to the **handlebar**: the main advantage about it is the visibility of this component for the user, who stands right in front of it for the whole training and so can be clearly visible in every moment, without requiring a user particular attention. In this case the idea was to exploit the potential changing **color** of the light as communication tool between the trainer and the user (as in the other concepts), but with the intention to exploit the color change in order to create a **gradient** effect that was interesting to make immediately clear the shift over different grade of resistance and so different state of training effort. The **cadence** to keep would be defined by the linear movement on a translucent pad integrated in the handlebar, backlighting a screen with less and most import data about training: this configuration helps to keep all the important feedback about the training at glance. Another possibility for this second direction is the creation of two or more light stripes following the handlebar shape profile: exploiting the circular movement of this light, it is possible to simulate the cycling act and can become an interesting declination of the whole product interfaces.

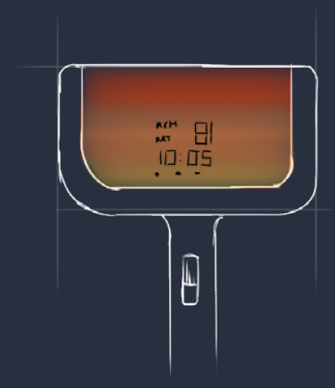






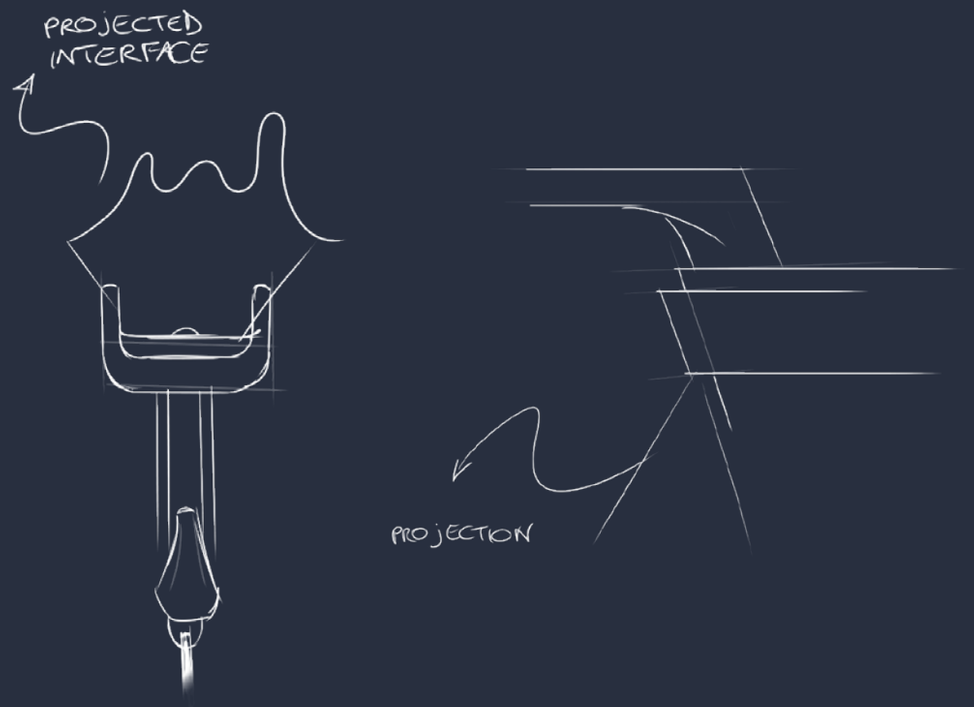


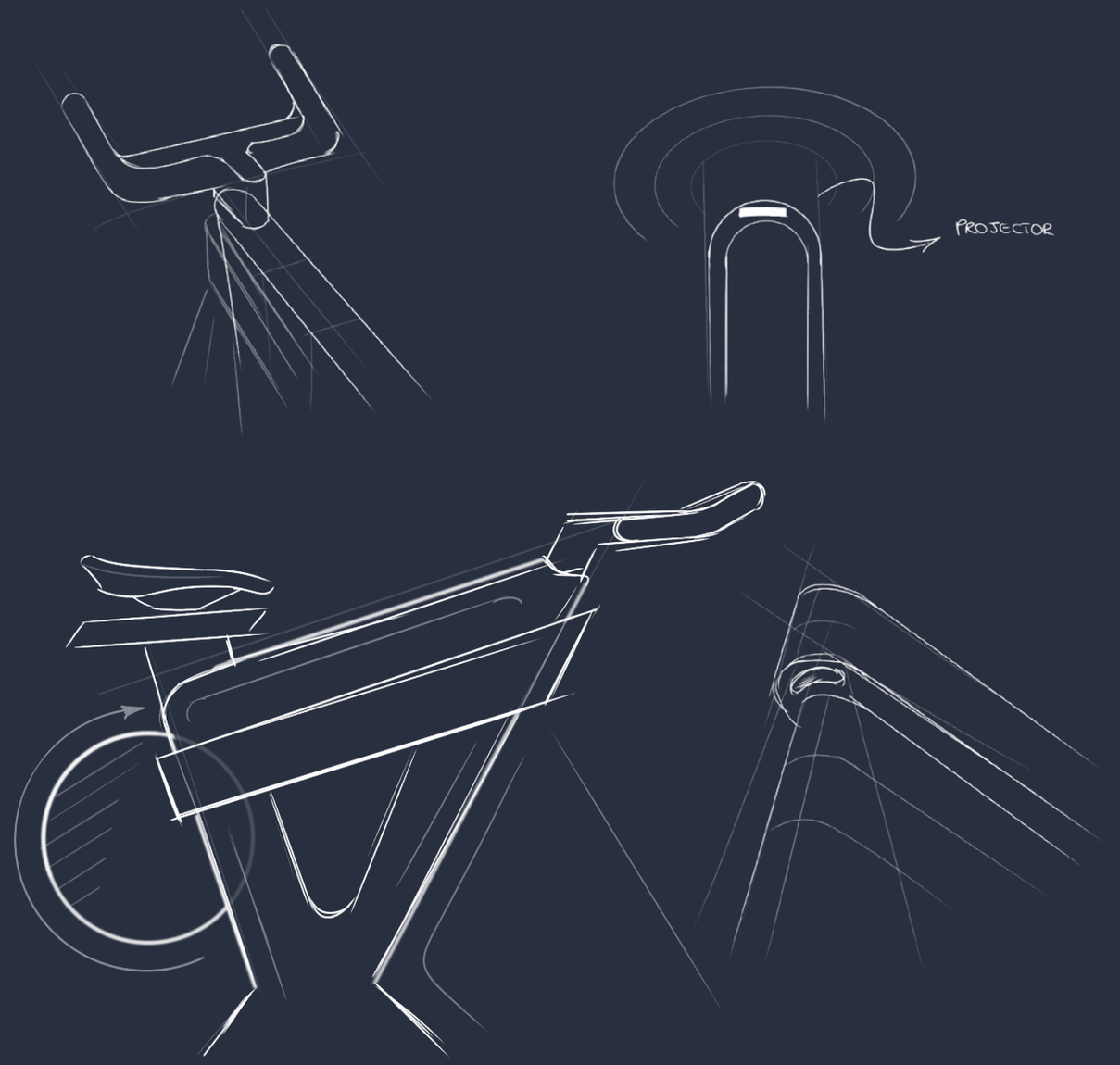




6.4 Third direction: light ptojection

The third and last direction was a different approach to the problem: instead of considering a possible embodiment like in the first two concepts, here the idea was to exploit the space around the bike, projecting the like on the floor area right near the bike and helping in this way to understand the position the user should have, to have always the passage of light marking the cadence and the possibility to create several effects, visible both by the user on its own but always by the others. In this way, the scenic effect made by every bike allows even the enrichment of the space, giving added value to the bike feature and creating a connection between the training equipment and the room, even if they are completely unrelated from a design point of view. Additionally, the use of the projection could give the possibility to project not just a certain colored light but even, in alternating intervals, a more specific and technical interface, covering all the information needed even for a more expert user. This concept has a slightly higher flexibility in terms of interface.





6.5 Final choice

The idea to define wider directions instead of three defined concepts was crucial in understanding the possible involvement of light through different modalities, without excluding many of them. There are cases in which applying more than one among these ideas in the same concept could lead to discovering a specific use of the light for a single feature of the bike and on the other side another one for a different purpose, considering a better association between the light behavior and peculiarities, and the specifically related feature of the product: this was the case. the last direction was the first one to be excluded for two main reasons: the first one was the low effectiveness to communicate to the user the needed information, since projecting, considering multiple bikes in the room, could be not really visible; the second, as a consequence, is the constrain to project every information, since the required hardware can be enough expensive to exclude other technologies for the defined purposes, limiting a huge potential in light use. The first two ideas were so joined in a kind of new concept: in particular, these two directions were interesting since they join an interesting correspondence between light and body movement (the first one for the body position, and the second one for the cycling act) and an awesome scenic effect using light on surfaces instead of using it as a direct light source: indeed, the use of a direct source can be even harmful and boring, making excessive use of this mean and not creating a balanced effect, as declared in the first stage of the generative phase (the reason that leads to excluding one of the ideas in the second direction). So in the end the bike will use a moving light on the body, that will create a scenic effect and at the same time give constant feedback on the profile to keep, and a more functional light on the handlebar for cycling, leading to a total new re-design of this last component and at the same time the same use of the light movement for different purposes, involving the whole product like as if it came to life.

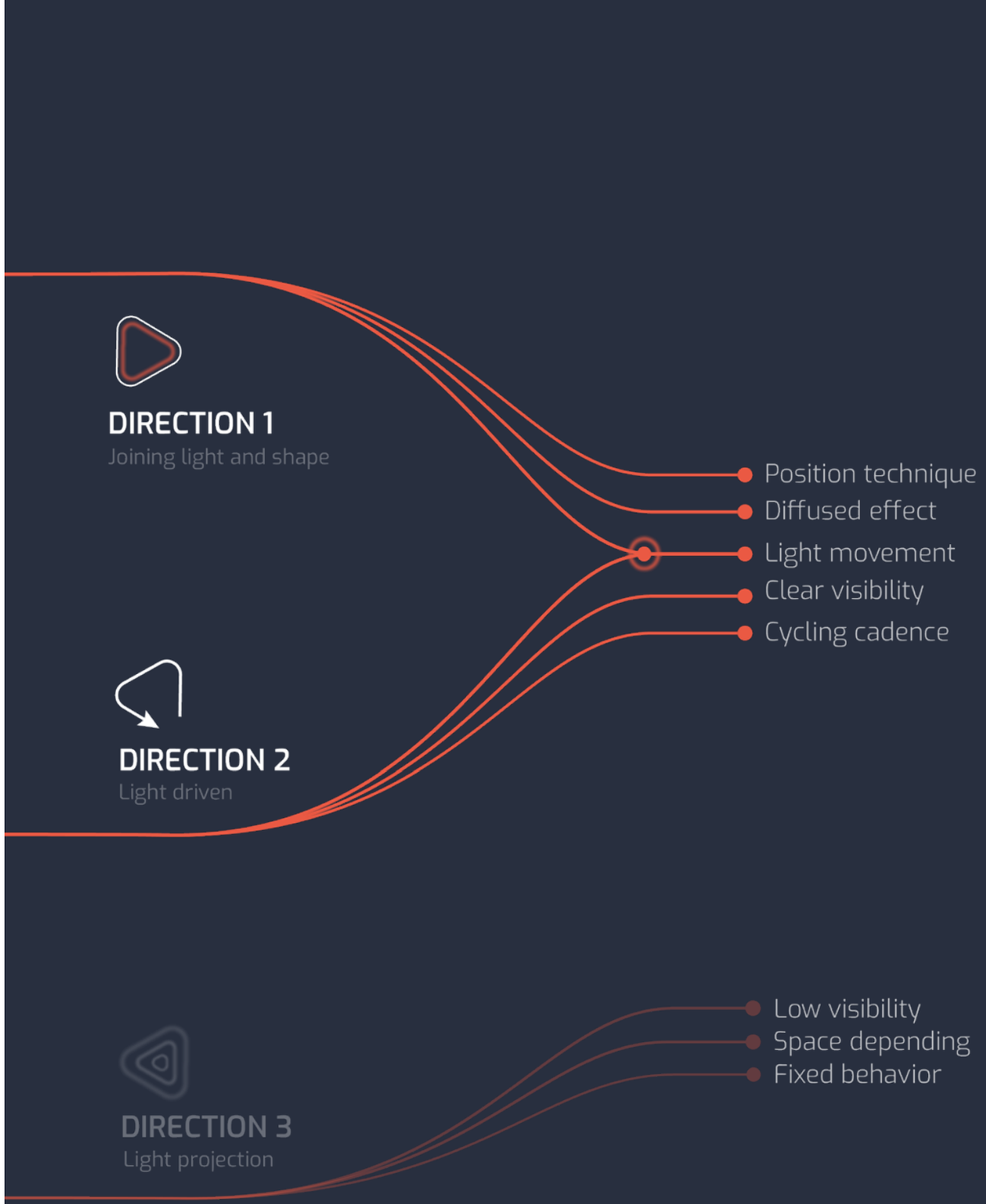


Fig. 35: Strenghts and weaknesses considered in concept choice

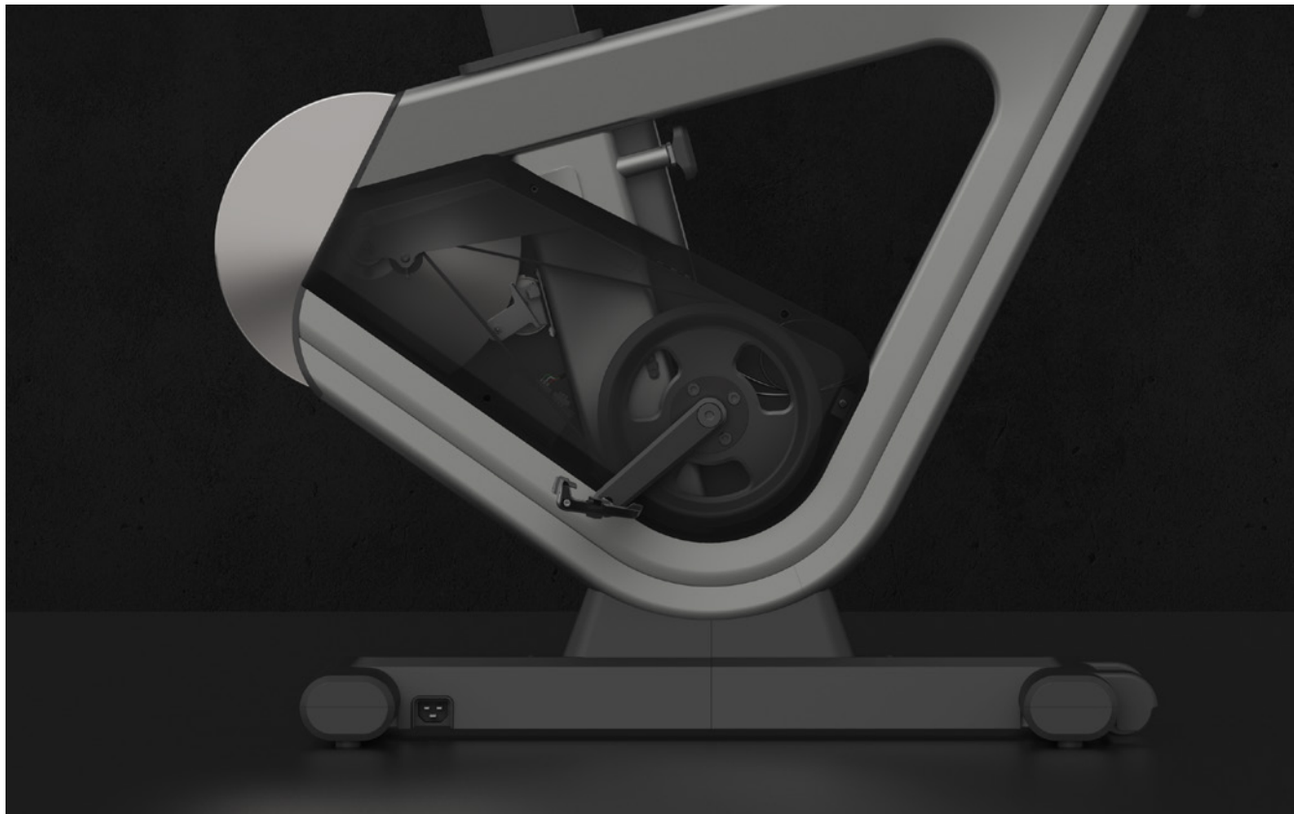
Lympha indoor bike

Chapter 7

Lympha is an indoor bike with an embedded lighting system able to guide users through the training and at the same time support trainers in accurately monitoring and advising every practicer in the class. The project was born as an innovative proposal in using light during fitness indoor cycling class and at the same time proposing this type of equipment as a leading product for the gym of the future, trying to valorize a mean like the light not just in a functional perspective but adding a scenographic and experiential value to the whole experience. Indeed, the name Lympha joins the capacity of the light to “animate” products and the design vision of a more involving and interactive object, almost coming to life. Life of what we consider inanimate starts with the user interaction, so giving a primary role to the interaction in a passive object thought for an active behavior was the primary objective of the project.
More specifically the product is designed for a fitness gym context and for use during a group class, clearly detaching the market from the at-home fitness trend but not denying it: the product emphasizes a spread experience and an alternative in the hybrid future of gyms. Part of its functions is designed considering the use of more models of the same product in a single space and especially to empower the group factor since it was one of the main important aspects of indoor cycling training. Of course, some design choices make the product targetable for a gym already having this type of attention to indoor cycling and in general to group workouts, providing maybe digital supporting services too, but the product is designed for every type of level of knowledge about the sport, and in a certain way it is also better to the ones who never practiced it before.
Another interesting aspect of Lympha is to transform what was proposed on the market as an individual product, into a mediator between the trainer and the practitioner, and at the same time between each practitioner. It was a key goal to design a bike intended to co-work with the trainer, and not to substitute it: the second option was not a valuable one for several reasons, like the importance to have a human figure (in terms of an emphatic experience and perception) guiding the user through the process. Smart objects became really smart if they are not drastically and forcedly inserted in the experience, but if they are actively and gradually inserted in user activity. Lympha does not aim as a lot of products to boost just performances but considers the whole picture to provide a meaningful experience.

7.1 Product architecture

This paragraph will introduce the whole assembly to indicate part of the design choices and have an idea of the whole product: each subassembly will be then deeply analyzed in the “Product Development” chapter, in order to widely explain also how some engineering and manufacturing decisions affected the design of some components and of the product in general. The product concerns mainly three sub-assemblies: the frame, supporting the other ones, and for this reason having a fundamental role in the whole assembly; a belt drive transmission system, including other small subassemblies like the magnetic resistance mechanism, able to manage the cycling toughness, the lever to move it and the belt idler. All these mechanical components are hidden by the use of a plastic carter in order to give a clean and rigorous aesthetic able to emphasize the dynamic frame, the real main character in the design of the product, and at the same type whit a chamfered shape capable to hide the not symmetric disposition of the transmission components. The choice to not completely hide every mechanical component was intended in order to recall the attention of the observer on the inner complexity of the product, but without overwhelming the whole aesthetic: it is a stimulus for observer curiosity, respecting the compromise of a simple product feeling. The base is the structural main component, hidden as well by a series of plastic components in order to make it less visible and intrusive, but giving the low part of the product a solid and strong appeal. The two last subassemblies are the seat and the handlebar, designed in order to provide wide adjustability of the product for the user. In particular, the handlebar covers a crucial role in the whole project design, since is one of the main involved in the user experience and also a completely redesigned part with respect to the ones on the market.
The main interesting aspect of the product is the integration of the light, that as anticipated, affected the assembly of the product, leading to a new disposition of some components and at the same time to a re-design (and consequent development) of other parts and sub-assemblies. In particular, following the first two concept directions, the final design includes three sources of light: the handlebar, part of the frame, and part of the carter. The handlebar, as already specified, is the most consistent and important subassembly, considering the interaction with the product and the innovation from a development perspective: here four addressable RGB LEDs stripes were fitted to emit a dynamic light from



four gaps, following the handlebar section shape. Here the main information regarding the training will be provided: the role of this source of light is completely functional. The second light source is another gap, but this time following the bike frame: this light was inserted in order to create an interesting effect with the frame shape and at the same time to emphasize it. The choice to have gap emitting points instead of a direct lighting approach is related to two main reasons: the first one was functional since the user should not be disturbed and overwhelmed by the direct light presence (considering the darker conditions of the room as well); the second one was aesthetic since the idea from the starting phase was to have controlled and well-fitted use of the light, creating a balance with other features of the product itself and giving a perception of elegance, even in a sports field where usually an aggressive effect is preferred. The light following the frame will be used partially for functional purposes and partially for scenic ones: the idea was to propose a path where light can move, this time not a circular and closed one but a linear one. The last emitting point, having the same purposes as the second (but for different features), is the translucent part of the carter: being this component a high diffusing (and the only point with a direct diffusion of light) one it could allow for an interesting matching between light and the material, enhancing its properties and creating a pleasant effect to the sight.

Being a sports equipment targeted for a huge user pool, Lympha is accurately designed for bodies with very different peculiarities, being always comfortable guaranteeing a vertical and horizontal regulation of the two contact points with the user body, the handlebar, and the seat. This regulation is allowed thanks to the frame shape and the adjusting mechanism in both subassemblies. Additional considerations have been made for the dimensions, in order to respect the current space disposition and capacities in fitness gyms since the product should allow an integration also in spaces not specifically designed for the purpose and that can be at least adapted, enlarging the potential customers and not excluding a fast arrangement in current facilities.

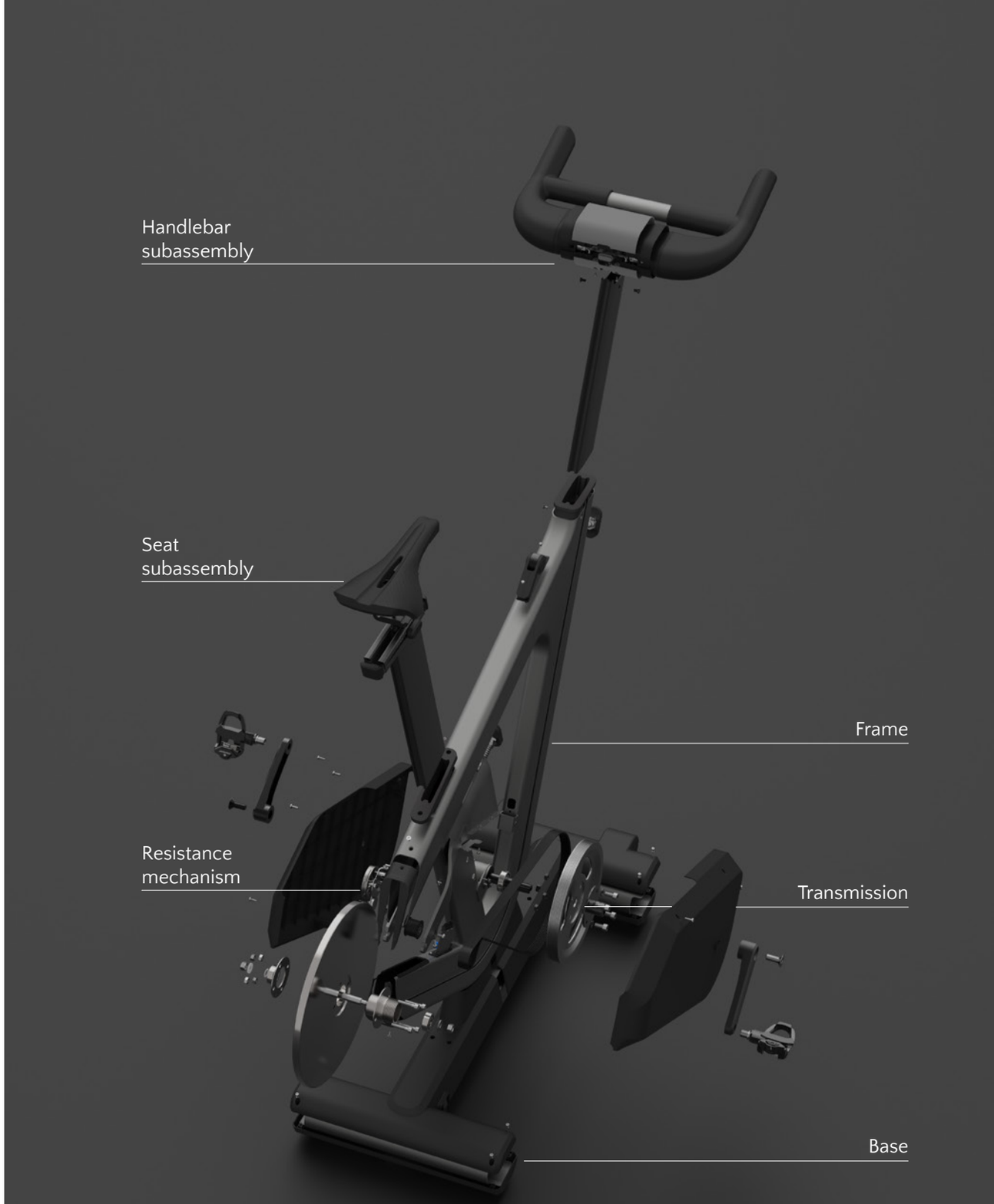
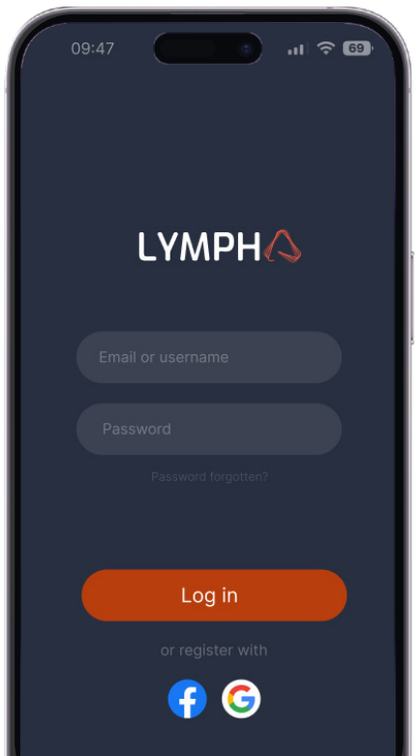


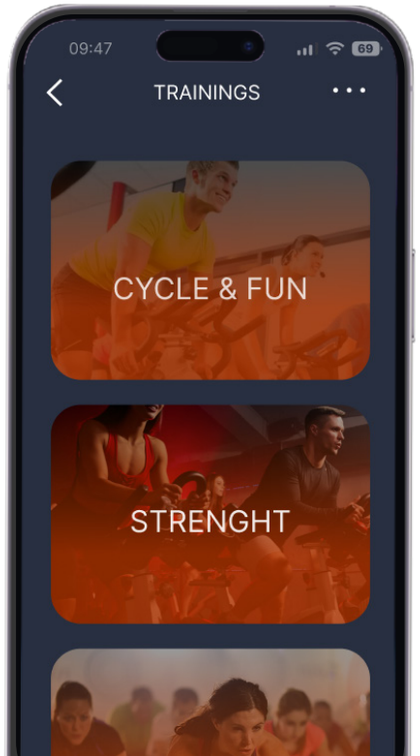
Fig. 36: Exploded view with main subassemblies

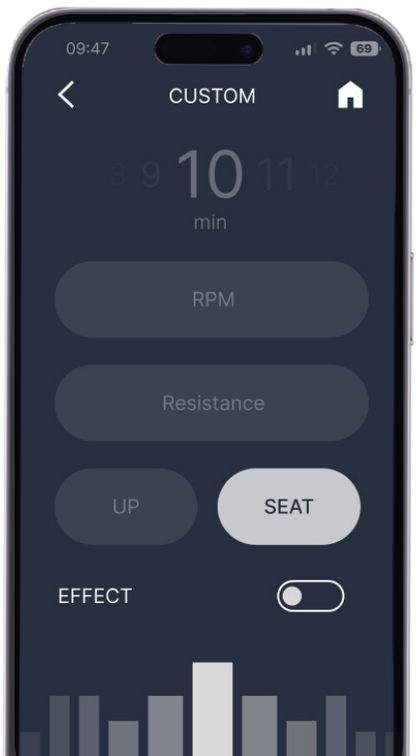
7.2 The machine guiding the user

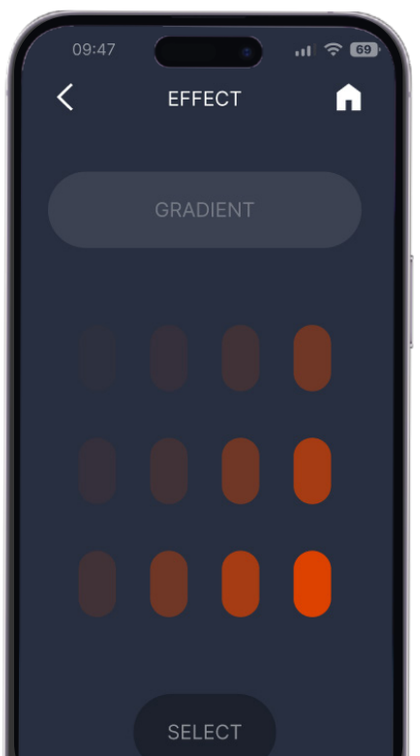
It is in the interaction and uses that the real value of the product emerged since Lympha is a product designed to guide through the process the user, fulfilling not just the primary function of cycling but also supporting the user in doing it, like an additional trainer.
To do so, the idea is to exploit the already existing digital platforms and tools that, as seen in the user research phase, are currently widespread in the gym market, especially in the case of big chains. Through these digital tools, it is possible to prepare all the information and characteristics needed for the workout itinerary, a process controlled completely by the trainer, who decides how to structure the training in terms of time for each step, the intensity of the workout, profile, and sounds. More specifically the itinerary is represented as a curve whit higher peaks indicating intervals with maximum intensity (so increasing the cadence and resistance level) and valleys which, on the contrary, will show an interval with lower training intensity. The specific colors of the curve in that section will reflect the related level of resistance as well, showing a color among blue, green, yellow, orange, and red. The trainer will be in charge of timing settings not just for the whole session, but even for every single phase (creating milestones that will be visible to the users), and simultaneously he/she can insert a specific value of rpm and resistance (managed with the color), deciding the position the user should have and for how much time he/she must keep it: a classical approach is based on defining a specific percentage of rest and recovery position, for a time of real work for each phase. Additionally, there is the possibility to create an automatic setting based on the choice of the music: what the trainer actually do is decide the specific soundtrack for each part of the training, modifying it in advance in order to achieve a higher or lower value of bpm (and so an associated value of bpm). Finally, several presets for scenic effect are provided: specifically in the final phases, a series of the particular behavior of the light will be proposed, and the trainer can choose one of them or personalizing these effects aiming to increase the scenographic and empowering effect of the light during the training.
The handlebar has a backlighted surface where a concise and detailed summary of the main needed information are shown: two values, showing time (always on), and an alternated lighting number that can indicate Kcal, RPM value or heart rate. The user can switch from one value, deciding which value to see in an easy e faster way and without being

overwhelmed by tons of data on an expensive and large screen. The drastic UI design choice to not included a specific value among these for the resistance level, was the normal consequence to simplify the whole interface and lower the data exposure for the user, exploiting instead the presence of the dynamic light.
Combined to this display, there is the key part of the interface and somehow of the whole product: four slot shape gaps (following the natural shape of the handlebar) emitting a circular moving light. The velocity of the light rotation, and the emitted color, will reflect the ones set by the trainer, clearly indicating to the user how fast to cycle and which color (and resistance to achieve, slightly moving the frontal lever). An adding feature was assigned to these slot rings, those are four for a specific design choice: two of them (inner ones) follow the effective cycling cadence of the practicioner, the other ones (other rings) will instead follow the the suggested cycling cadence (that usually is the one setter by the trainer). The final goal of the user is cycling to synchronize the four rings, that will bright white for two rounds as instant feedback to indicate the correct value of rpm and resistance level as achieved, like in a game. Keeping them with the same velocity and the same color as well, will be the unique and most important action of the user.
On the other side, as previously explained, two additional light sources will occur. What happens during normal training is that between each phase, users continue to move in a different position, up or seat, simulating a resting position in a real ride and a climbing one, increasing or decreasing the needed effort. The light path of the body will exactly follow this movement, recreating both a particular effect, and keeping the user focused (looking also at other bikes) on the position to keep: as demonstrated in the user journey, it can seem simple, till the user starts to feel tired and lost the focus very quickly. The low diffuser will indicate instead the shift between different phases, lighting up and blinking to follow the countdown of the trainer.
The last function will be related to the possibility of choosing and creating interesting fun and scenic effect exploiting all the bikes in the room and the wireless connection among them: following the trainer preset, the carter diffusers of all the bikes will light up creating a peculiar movement, based also on the type of training phase or soundtrack set in it. It can be a wave, a sort of sprinkling and random behavior, or a linear specific movement like in a sort of domino effect. The huge potential in the use of these lights, lies in the wide possibilities of custom lighting layout, exploiting the bike disposition in the room as well. A machine that trains and guide the user, not overwhelming the user with unnecessary precise data and not forgetting one of the most important aspects of indoor cycling: having fun while training.









SEAT

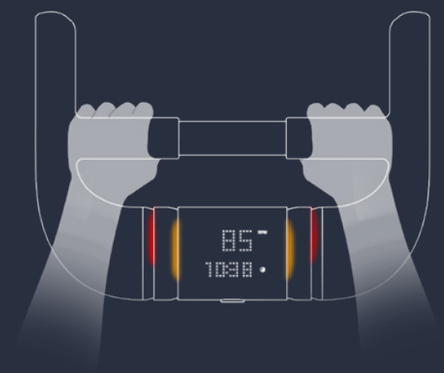
The integrated light of the frame can guide the user position in order to be visible by others

UP

When the profile to keep is “up”, light moves to the front of the bike

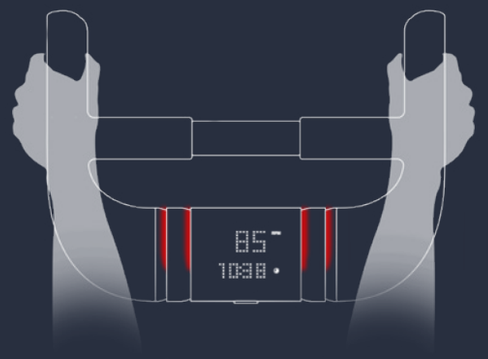
COUNTDOWN or SCENIC MODE

A blinker signal inside the diffuser follows the countdown between each step, while can be used in a group scenic mode at the end



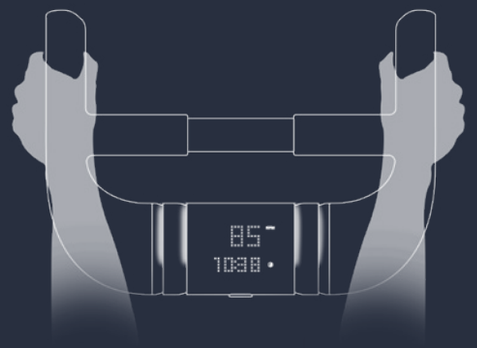
RESTORE

The middle grasps can be used during the re-store phase (the user is sitting during it)



INCREASE

With the cadence and resistance growth the user should start to follow external rings in order to synchronize all of them



SYNCHRONIZE

Once at the maximum of the resistance (red) is achieved light turns into white for two rounds

Product development

Chapter 8

8.1 Frame

The frame is, of course, the most important component, since it is the structure that must be able to support all the other several assemblies, and for this reason, it was the starting component to consider by designing every other part and subassembly. The frame itself concerns two different parts: the body, to which the handlebar subassembly, the seat one, and the transmission system are attached, and the base, assembled through reversible joining techniques to favor a possible disassembly for component substitution by the manufacturer. By the way, it will be a rare case, related just to manufacturing problems that can occur in the starting phases of the chain.
In particular, the design choice of the body was a V-shape structure, since this type of choice presents an advantage in terms of usability. Indeed, due to the need for the adjustable seat and handlebar, the V-shaped frame allows movement in two opposite directions, not only rising the position of the two components but enlarging the space between them, to have a comfortable seat for users with different heights. To dimension it, and considering the wide range of typical users of this type of product, a minimum percentile for women (1st percentile) and a maximum one for a man (99th percentile) have been considered to guarantee enough flexibility and comfort in the use of the bike, even if it must be always considered possible variation from anthropometric data (Federal Aviation Administration, 2003). More specifically, for a comfortable ride, it has been considered the distance between the rotation center of the pedal (point A in the figure) and the seat contact point with the user's back (point B): this distance is technically defined as inseam height or crotch height.
From a manufacturing perspective the material choice for the frame, and the other components as well, was made firstly through benchmarking to understand which materials are already used, and starting from here they were filtered with the definition of its functions, constraints, and goals (considering, of course, the manufacturing and joining leading to the final component). When more than one material resulted suitable to these attributes, a further comparative analysis was conducted, based on the design priorities. A starting premise about indoor bike frame is that it does not differ too much in requirements and functions from the frame of a normal outdoor bike, since it is less externally stressed, due to its use in a static condition. Bike frames are surely one of the most advanced and complex components to design, considering their need

to join an appealing aesthetic by fulfilling high functional requirements. One of the most challenging aspects, in the case of this frame, was the need to join more manufacturing processes capable to guarantee the peculiar curvature joining the upper tube, the front one, and the handlebar. For this reason, the final decision was to build a frame going through three main processes: the hot metal extrusion for the upper and lower tubes, the roll bending, exploiting three adjustable rollers which can curve also complex profiles, and joining them through casted components becoming the head tube of the bike. The same approach was already used in bike manufacturing, for example in the case of the Evo utility bike, where the particular shape hosts a locking mechanism for the bike itself: joining this casted component to another stock tube of 4130 chromoly steel, they obtained a nice final product shape. After a review of the bikes we considered for instance in the benchmarking table in chapter 3, the most commonly used material remains steel, and in particular the most one (considering also the normal bike frame manufacturing) is the high-tensile carbon steel, a low-carbon one (that means it has a 0.05-0.30% carbon content for weight) including alloying ingredients (like chromium, molybdenum, nickel, manganese, etc.) able to provide a specific tensile strength to the material. For this reason, among the frequent applications for structural tubing, we found the 4130 and 4145 steels (SAE designation). After the definition of the main constraints,

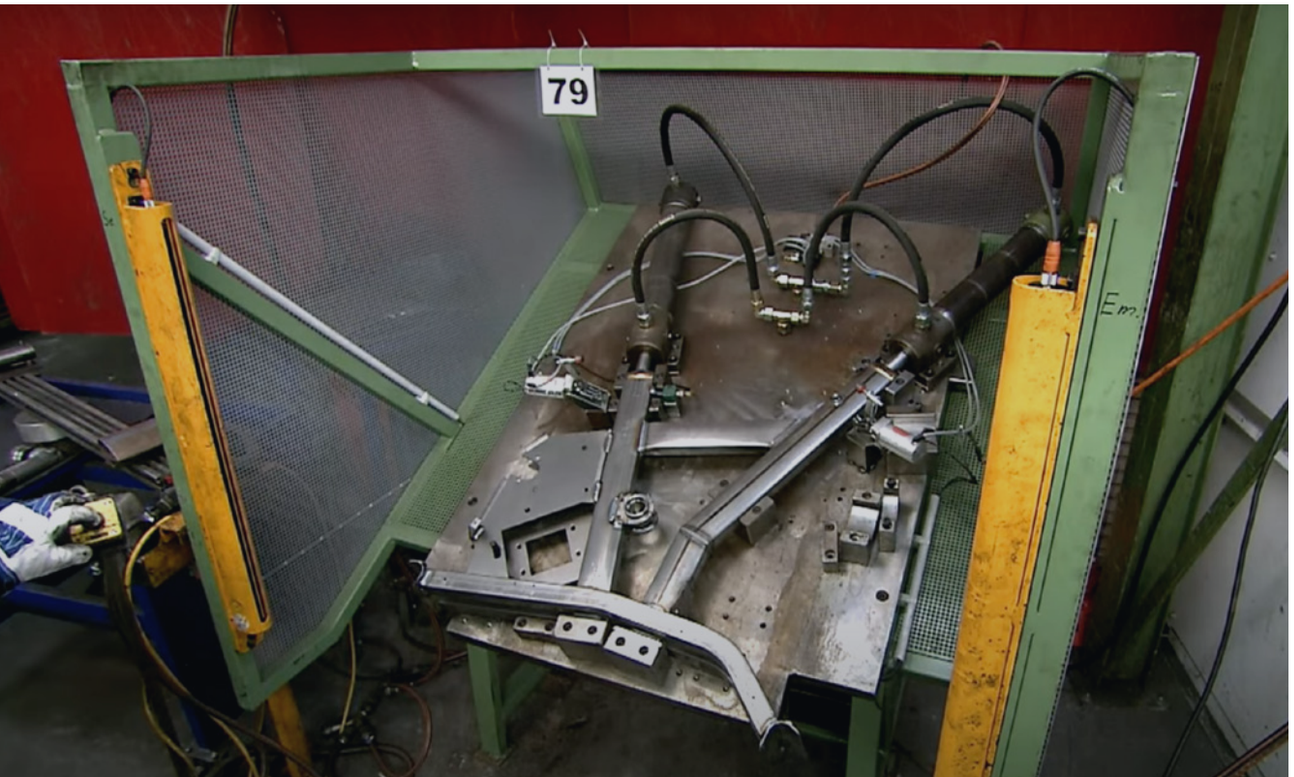


Fig. 37:
The moving fixture used for computerized welding of the frame

considering the peculiarities of each alloy the SAE 4130 resulted as the most suitable material: indeed, even if in terms of durability the advantages of the two type of steels are quite similar, the 4130 alloy has higher mechanical pros, like the tensile yield strength, fundamental considering that it is a structural frame, and the elongation at break, here considered since the necessity to bend some components. The last comparison was among the different casting processes for the head tube, and considering a high batch size (over 10.000 to also 100.000), the shell mold casting was the definitive choice, also considering the complexity of the product. This process is an expendable mold casting one (suitable for both ferrous and non-ferrous alloys), where the final component is the result of pouring the liquid hot metal into a mold made by two thin shells of sand held together by thermosetting resin, whit the use of a core if needed to create hollow parts. The main advantages concerning other casting processes like sand casting are the possibility to get a better finish, with good dimensional accuracy of the product and without the need to be further machined (to create for instance holes for assembly), but the most important aspect is that can be mechanized for mass production, getting more expensive metal pattern which costs, however, are covered by a potential higher production rate. After the TIG welding of each part of the frame, which usually happens through the help of a computerized system (Fig. 37) that requires just the manual insertion

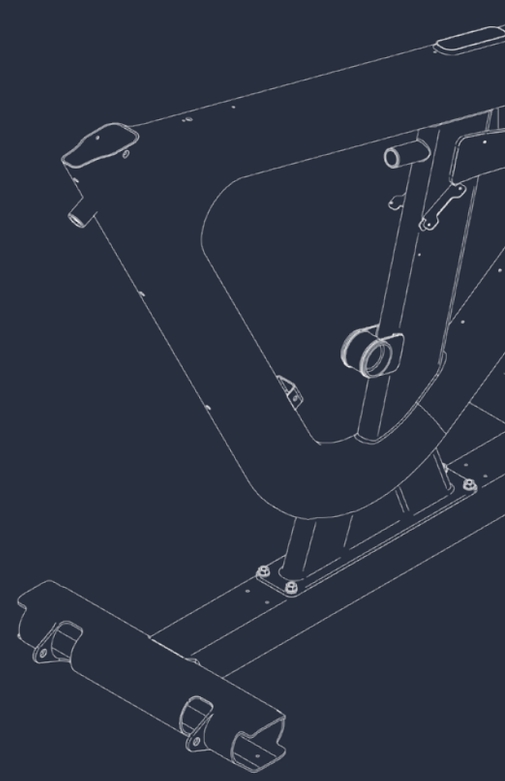
of each part to be welded on a moving fixture, the whole frame can be sand-blasted and painted through powder coating, getting the desired color with an elegant satin effect.
The same processes, without the need for casting parts, are used for the supporting cover of the red stripes, divided into two components: the extruded profile can be bent and laser cut where needed, and subsequently joined to the frame through the use of screws, to allow the disassembly for the LEDs maintenance when needed.

MATERIAL SELECTION
Frame

Functions	Support its own weight and the maximum static loads of the drive system, handlebars and the pedalling user, without breaking or plastically deforming.	
Constraints	· Yield strength · Process compatibility · Resistance to humid environments · Resistance to detergents and solvents	· Elastic limit · Durability in wet environments · Ductility
Goals	Finding the right compromise: · Minimising cost and density · Maximising stiffness	· Price per unit volume · Density · Young's modulus · Percent elongation at break

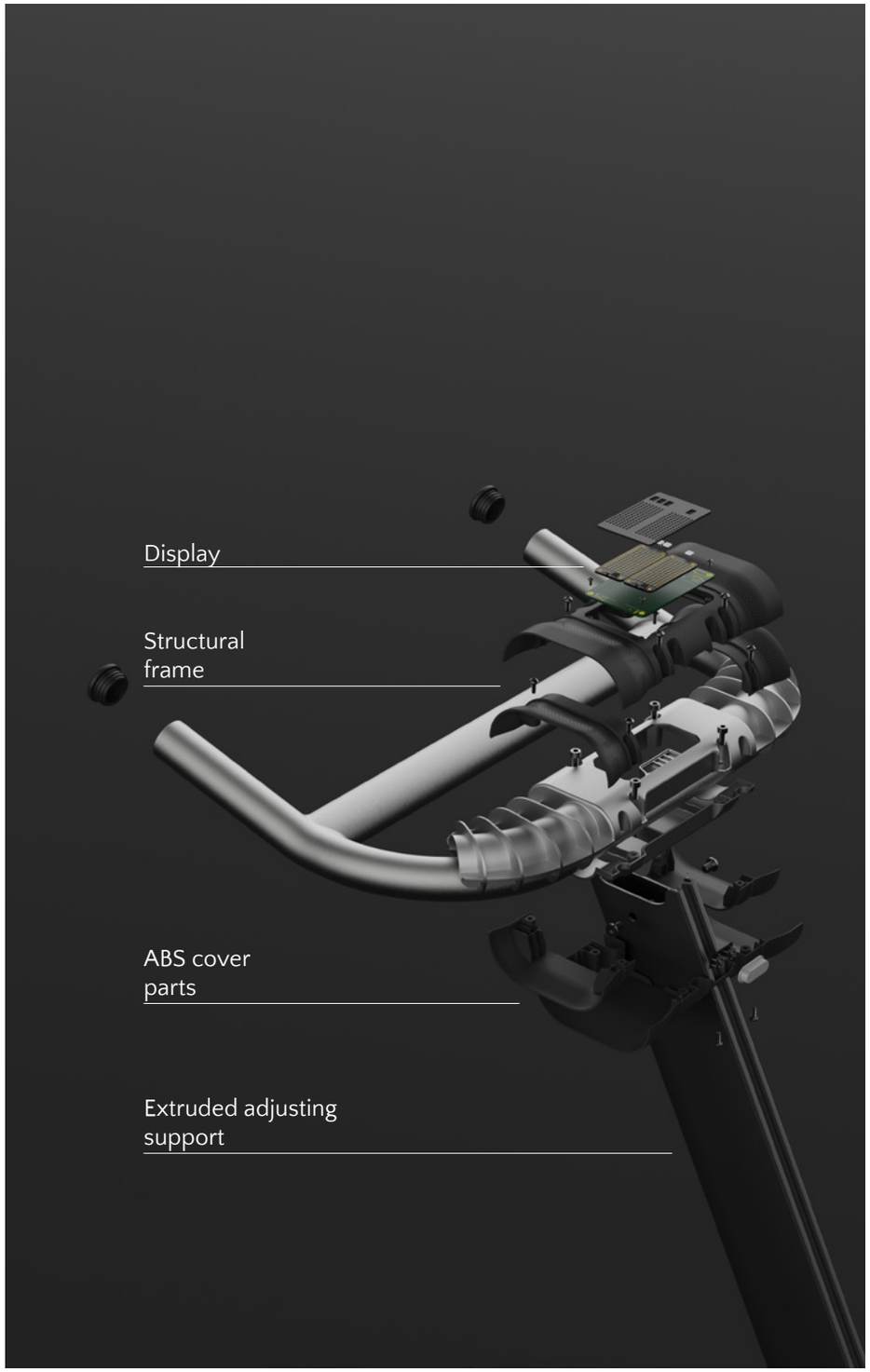
Comparison	SAE-AISI 4130	SAE-AISI 4145
Price	**5.700 €/m³**	7.254 €/m3
Density	7,8 g/cm³	7,8 g/cm³
Young's Module	**205 Gpa**	190 Gpa
Tensile yield strength	**635 Mpa**	360 Mpa
Elongation at break	**21,5%**	16 %
H_2O durability	Acceptable	Acceptable
Durability to detergents and solvents	Excellent	Excellent

Choice	SAE-AISI 4130
Forming process	Hot extrusion and roll bending for tubular parts, shell mold casting for the headtube
Cutting process	Laser cutting
Joining process	TIG Welding
Finishing process	Sandblasting and powder coating with electrolytic deposition process
Massa	18,3 Kg
Material cost	13,4 €
Colors	RAL 9023, satin finish
End-of-life perspective	Recyclable

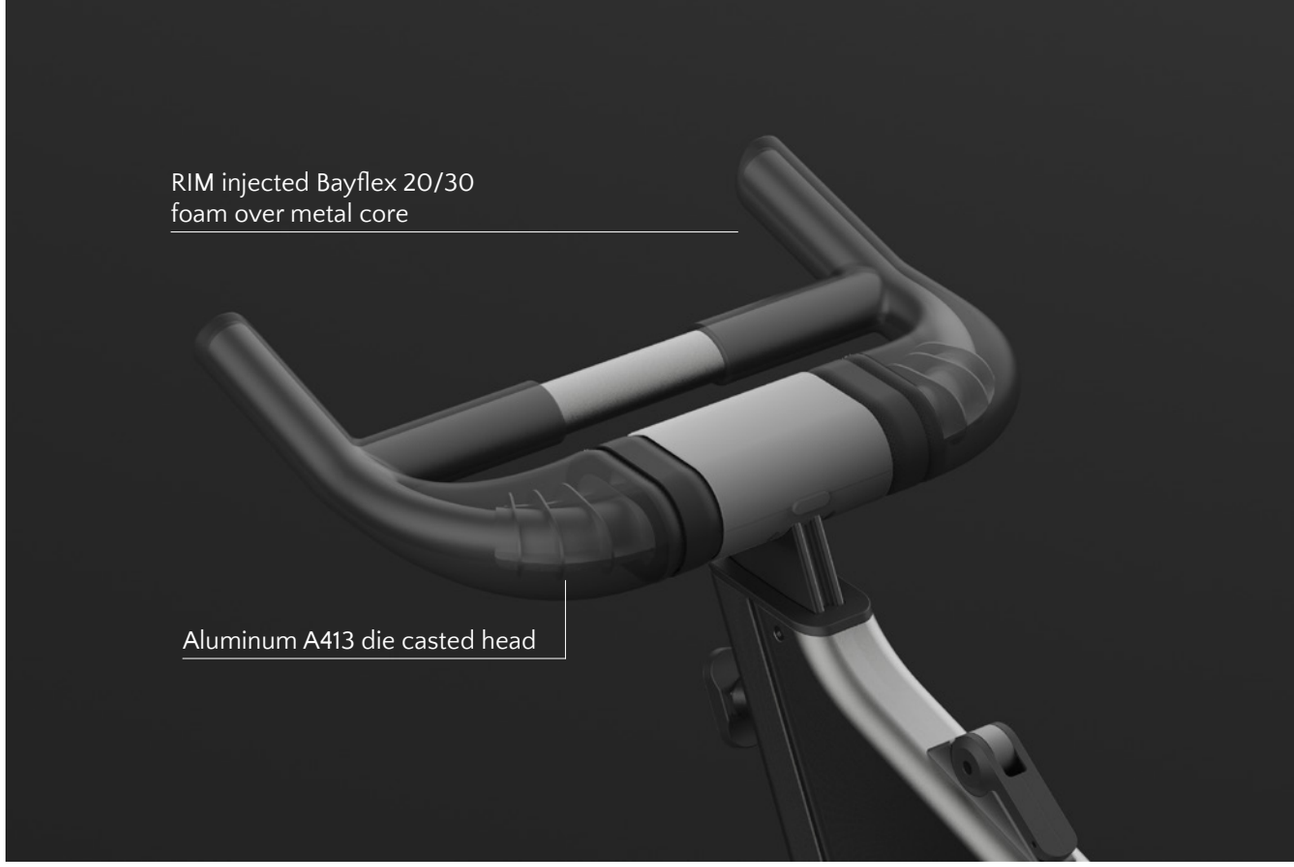


8.2 Handlebar

The handlebar is one of the most complex components since being a key assembly for product use and interaction, several other components have been integrated, and as a consequence the part have been redesigned with respect to a normal indoor bike handlebar.
The structural part concerns of an inner metal core, where a steel tube is clamped in two die-casted half. The choice of die-casting was a consequence of creating un upper complex component with several ribs allowing to get the allowed thickness variation and material grip for the injected molded grasp. In fact, the metal assembly can be inserted in a mold where, after two liquids (isocyanate and polyol) have been injected in a mixed chamber, chemically reacts creating a Polyurethane foam. The process is a variation of Injection moulding and it is called Reaction injection moulding (RIM), widely used for instance in the creation of steering wheel grasps. It allows to get components with highly variable thickness, good mechanical properties minimizing the weight, and rigid or flexible components with a chosen finish: in this case a specific material was defined, the Bayflex® 20/30, guaranteeing an excellent processability with good mechanical properties and a soft touch feeling.



The remaining components of the subassembly will be assembled after joining the head to the tubular component that will feet and slide in the frame. An inner main ABS plastic body will be realized in two injected moulded halves, which one of them supporting the handlebar PCB, and a slot for the addressable RGB LEDs stripes attachment. Same approach will be used for the other components, creating through the fitting design some gaps where LEDs light will be emitted. Additionally, to add an aesthetic value to the light emitted surfaces, will be created an in-mold finishing matching a matte background with a polish pattern, so creating an interesting effect when the surface is hit by light.
Lastly, particular attention should be paid to the creation of the interface: a PCB with two LED matrix 15 x 7 mounted on was used, covered by a plastic mask helping to create focus spots for each single led. Additionally, in the upper injected mould component, was lowered the thickness in order to make more visible the light passing through it. The approach used is inspired by several product using LED matrix for interface and clear components masking them in order to not making visible

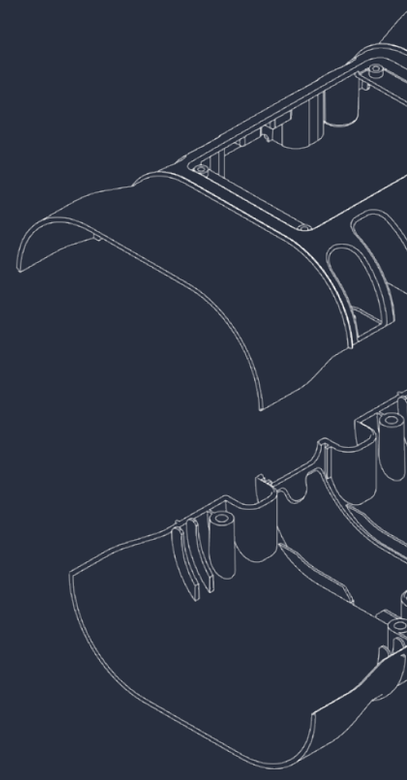


Head	Aluminum 413
Density	2,650 g/cm^3
Tensile yield strenght	140 Mpa
Young's module	74 Gpa
Price	4531,5 €/m^3
Forming process	Die Casting, machining for details and threaded holes
Mass	225 g (top part), 95 g bottom
Material cost	0,55 €
End-of-life perspective	Recyclable

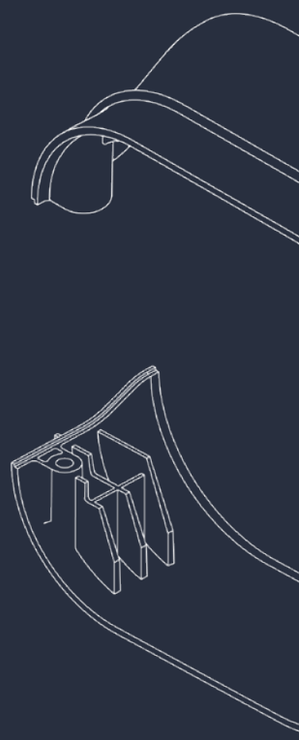
Grasps	Bayflex® 20/30 (PU foam)
Density	0,500 g/cm^3
Forming process	Reaction Injection Moulding
Finishing process	In-mold finishing
Color and finish	Black, soft touch
Mass	20 g
Material cost	0,05 €
H_2O durability	Acceptable
End-of-life perspective	Not recyclable, combust for energy recovery

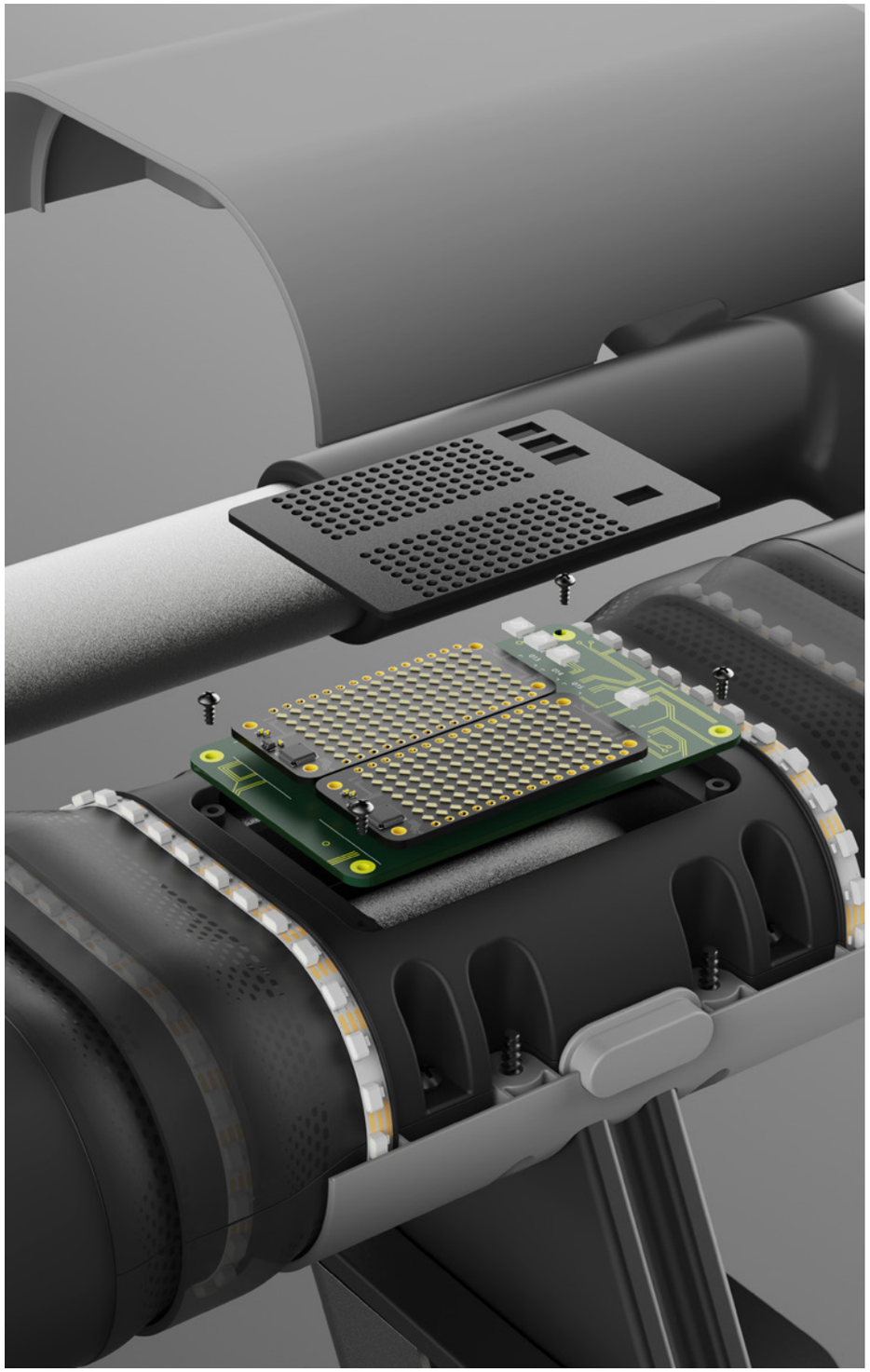
the display when switched off: in this case the reference was the smart thermometer created by Withings.
In general a final consideration should be made on ABS choice: the material in fact, provides a series of mechanical advantages with respect its moderate cost and it has key properties in terms of durability, considering the humidity in the fitness space and the possible contact with sweat or detergents for cleanings. Additionally it is useless to highlights the compatibility with injection moulding, that makes it one among the most used materials in the consumer electronics field.

Middle body	ABS
Forming process	Injection moulding
Finishing process	In-mold finish
Color and finish	PANTONE BLACK C, SPI C-3 (back with normal matte) and polished pattern
Mass	32 g (top part), 35.7 g (bottom)
Material cost	0,10 €
End-of-life perspective	Recyclable

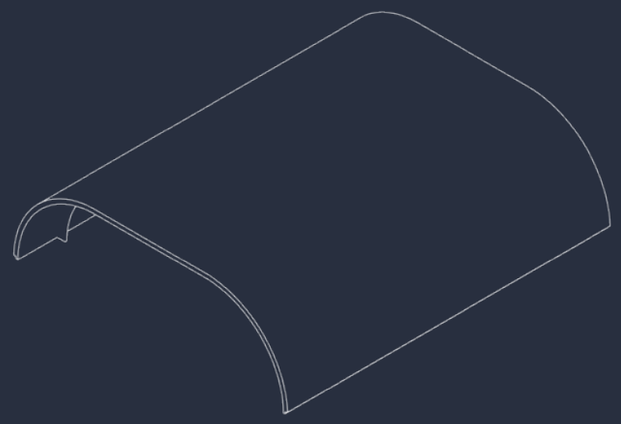


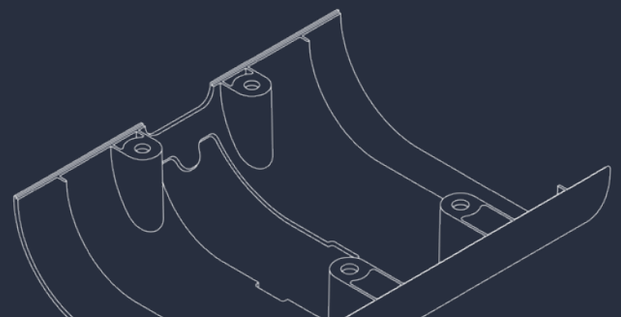
Outer parts	ABS
Forming process	Injection moulding
Finishing process	In-mold finish
Color and finish	PANTONE BLACK C, SPI C-3 (back with normal matte) and polished pattern
Mass	10,2 g (each one)
Material cost	0,07 €
End-of-life perspective	Recyclable





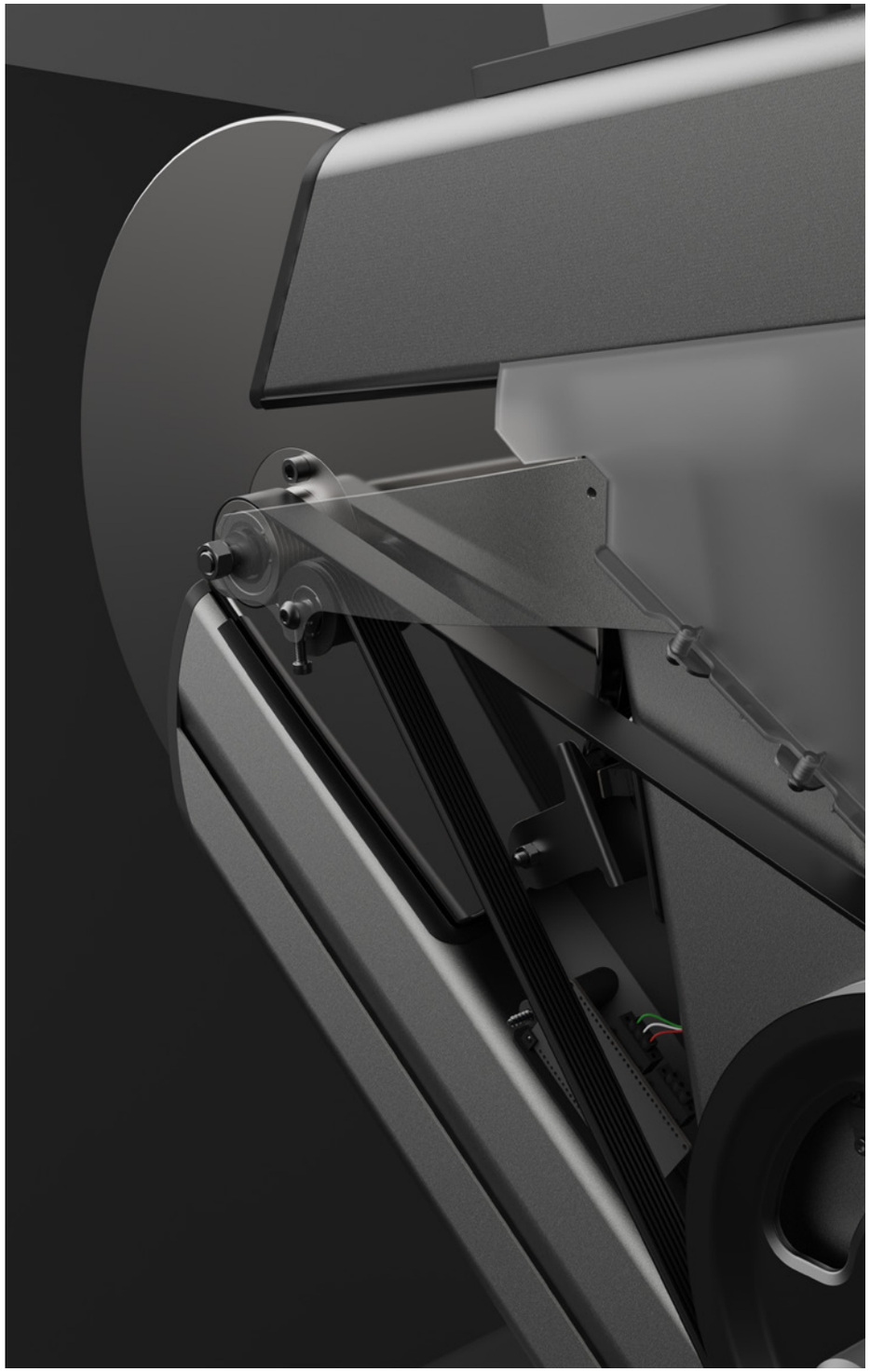
External body	ABS
Density	0,899 g/cm³
Price	880 €/m³
Forming process	Injection moulding
Finishing process	In-mold finish
Color and finish	Clear grey, SPI D-1 (satin)
Mass	36 g (top part), 33 g (bottom)
Material cost	0,11 €
End-of-life perspective	Recyclable
Notes	To allow light to pass through the workpiece, a plastic mask was created and in some point of the molded component the thickness was lowered





8.3 Transmission system

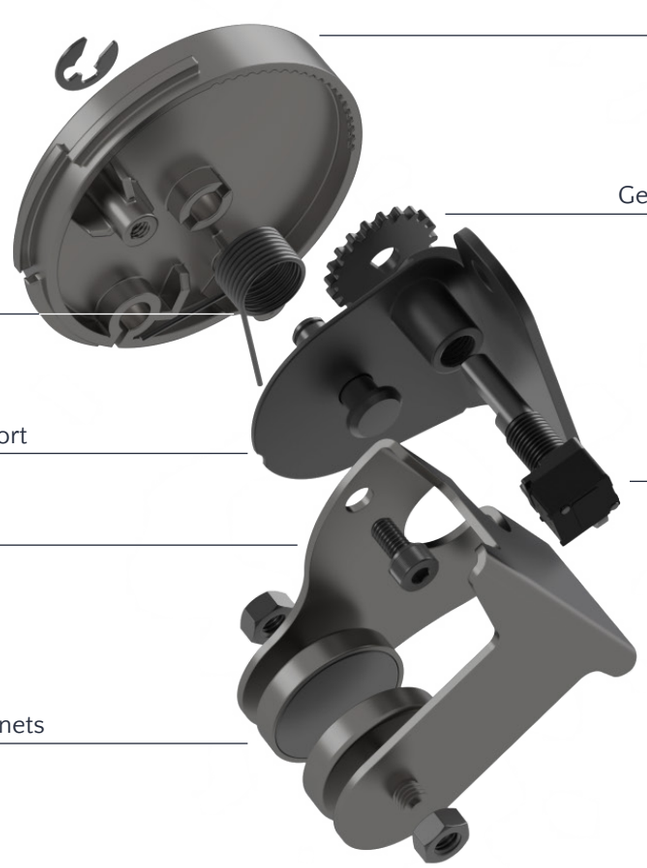
The transmission system is another fundamental subassembly from a functional perspective, since it is the subassembly responsible for the primary working function of the bike itself, affecting the cycling experience of the user. For Lympha, the choice was to adopt a mechanism exploiting a Poly-V rubber belt: in the last years, this belt became the most spread on the market, for a series of strengths like making the cycling noiseless (fewer vibrations in the free section of the belt), reducing the overall dimensions of the mechanism, since they can wrap also very small pulleys, and their efficiency, allowing to save costs for other components of the transmission as well.
The main design choice in the case of the transmission concerns the position of the Flywheel. As previously explained the flywheel is responsible for storing the cycling kinetic energy, making the ride smoother. It is one of the main components to be subjected to maintenance, since most bike position the flywheel in the front half of the bike, where user sweat can create durability concerns. For this reason, it was fundamental to locate it on the rear, affecting as a consequence all the other smaller subassemblies (and the design of the bike). Indeed, the bike was thought in order to have a dynamic shape, not really closed (in order to give a feeling of movement), but ending with the flywheel itself and the frame closed by two plastic caps: this disposition, creates both an effective aesthetic for the bike and an arrangement allowing to easily disassembly the flywheel subassembly for maintenance. Other final considerations are about the material: considering the use of a magnetic resistance mechanism, the flywheel should be particularly light, and for this reason, the choice was the Aluminum 1050 (EN AW-1050). In fact, among the strengths of all the Aluminum of the 1000 series, there are compatibility with casting processes, excellent corrosion resistance, and very good workability as well, in order to be easily machined in the last stages of manufacturing, getting, as a result, a high polish finishing: these are all the peculiarities making them suitable for transmission components, like in this case.
Not having the weight as a particular constraint for the driving pulley, the choice of the material falls on ASTM A27 Cast Carbon Steel, being one of the most used alloys for the casting process and with the possibility to be machined as well.

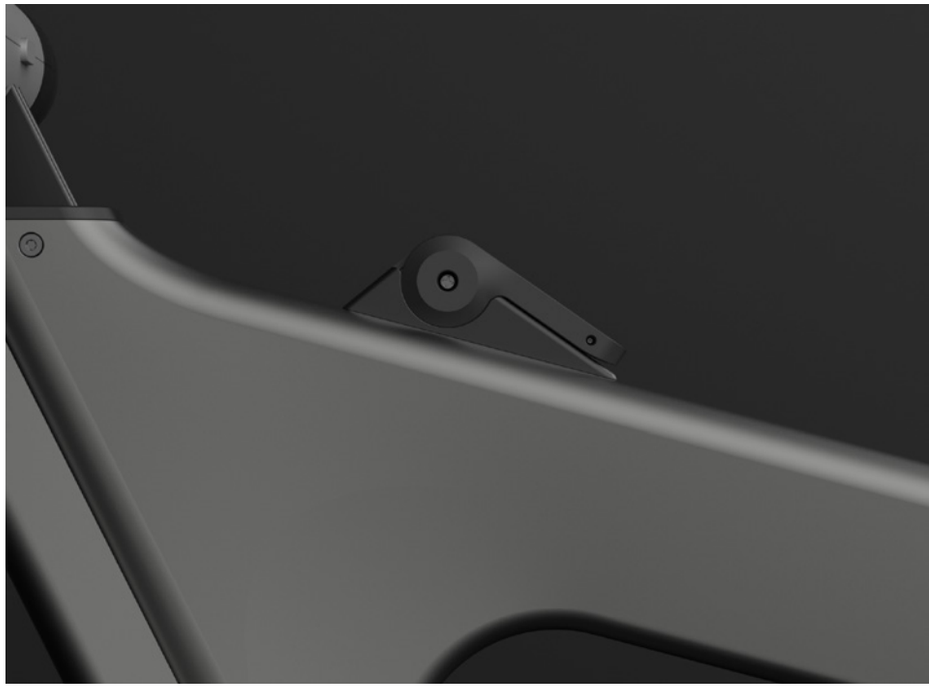


One of the main concerns regarding the transmission system was about the resistance mechanism to adopt: the magnetic ones are increasingly growing thanks to their several advantages, like the possibility to act on the flywheel without contact and so preserving the flywheel itself, being as a consequence noiseless, and becoming also less expensive over years if the efficiency of the mechanism is considered. This type of mechanism is suitable for every type of flywheel location, since (like in this case), can be controlled using a common metal cable (also spread for instance in the bike market for breaks). Raising and lowering the lever on the front of the bike, the user can regulate how much resistance wants on the flywheel: the cable will rotate an aluminum disk, moving closer or far away two magnets acting on the flywheel and creating so more resistance if close to the flywheel, less resistance if further away. In this way the resistance can be regulated on several preset levels, which entity will be transferred to the processor thanks to the action of a small gear and a potentiometer, exploiting the rotation of the disk. This value, combined with the rpm sensing, helps the bike to understand the level of resistance, and so the color the LEDs should emit.

Drive pulley	ASTM A27 Cast Carbon Steel
Density	7,8 g/cm^3
Price	≈5000 €/m^3
Tensile yield strenght	270 Mpa
Young's module	190 Gpa
Forming process	Sand casting, machining for details and threaded holes
Finishing process	Sand-blasting
Color and finish	Dark grey, matte finish
Mass	2.881 g
Material cost	1,84 €
End-of-life perspective	Recyclable

Flywheel	Aluminum 1050
Density	2,7 g/cm^3
Price	4.531 €/m^3
Tensile yield strenght	140 Mpa
Young's module	72,5 Gpa
Forming process	Sand casting, machining for details and threaded holes
Finishing process	Polishing
Color and finish	Grey, polished
Mass	3.700 g
Material cost	6,21 €
End-of-life perspective	Recyclable


Rotating disk
Gear potentiometer
Torsion spring
Sheet steel
mechanism support
Potentiometer
Sheet steel
magnet support
Neodymium magnets



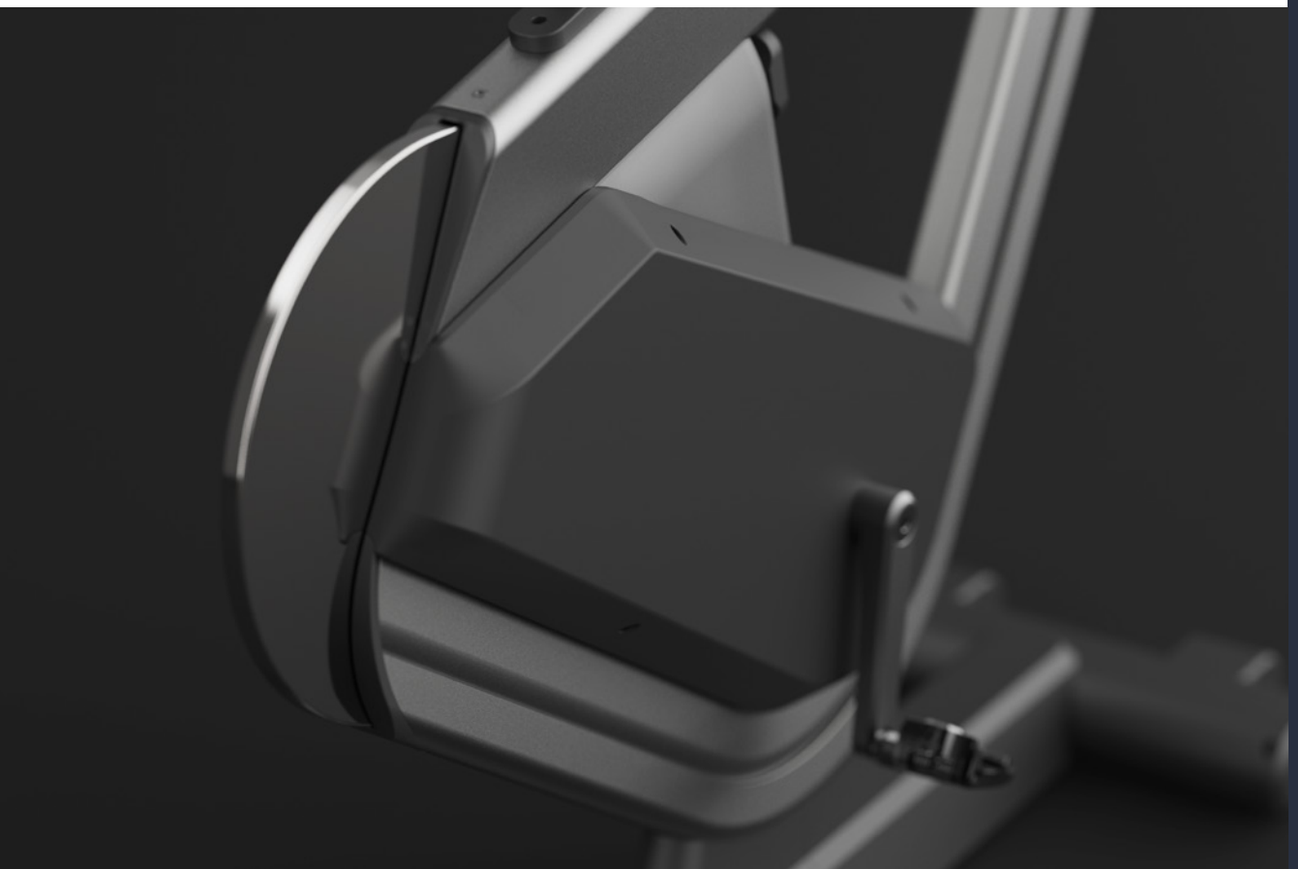
8.4 Carter

The true protagonist in the whole Lympha design, together with the frame, is the Carter. Its main function is to cover the whole mechanics inside the bike, giving the product an appealing aspect and protecting the internal electronic components. To hide the asymmetrical disposition of the inner mechanical parts, the shape was chamfered, creating the illusion of less overall dimension and the idea of an identical offset on both sides of the bike, even if it is not. The two halves are of course injected molded, and considering the environmental conditions of a fitness space, like high humidity, and the necessity for cleaning and maintenance of these products, a comparison between Polypropylene and ABS was made. Both the materials have excellent compatibility with the process, giving the possibility to get the same colors and finishes: having slight differences in terms of density and cost (considering always the objective to minimize cost and weight), the final choice lead to the ABS, since it has consistent higher values in terms of mechanical properties. The final

MATERIAL SELECTION
Carter body

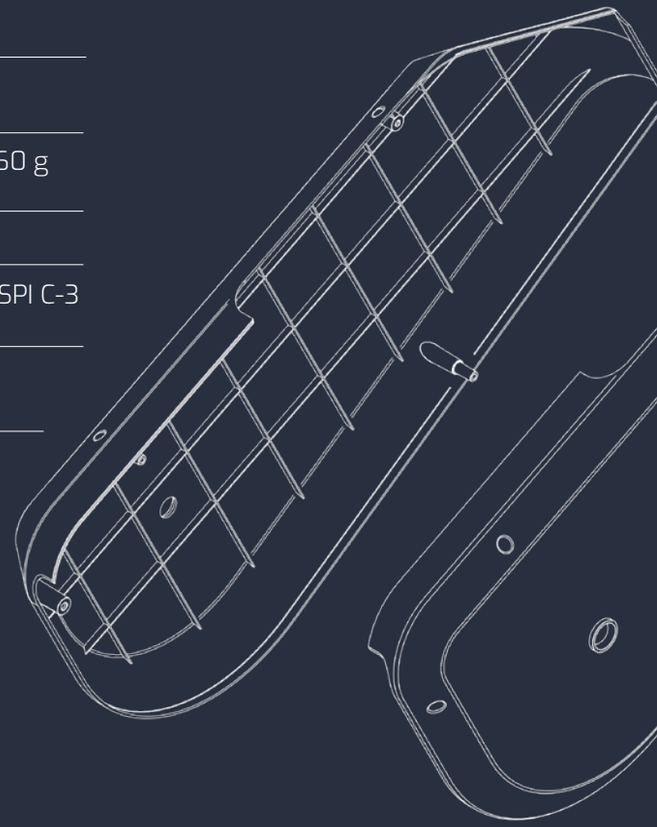
Functions	Supporting its own weight, protecting internal electronic components from shocks, resistance to detergents, solvents and sweat	
Constraints	· Process compatibility · Resistance to humid environments · Resistance to detergents and solvents	· Compatibility with injection moulding · Durability in wet environments · Durability to detergents and solvents
Goals	Finding the right compromise: · Minimising cost and density · Maximising stiffness	· Price per unit volume · Density · Young's modulus

finish will be a normal matte surface, with a PANTONE black C color. From an assembly perspective, the two halves are screwed to the frame and between each other, to allow the possibility to remove just one half in case of maintenance for the transmission component (which usually is more interesting in this sense).
Even if the intention was to hide most of the inner mechanics, from a design and aesthetic point of view, can be interesting giving a glimpse of the internal components for the observer, exploiting both the complexity of such a huge product and both the intention to have an additional light emitting source that can create scenic light effects with other bikes. By matching these two requirements, the idea of a diffuser on the Carter body was born, mounted on the frame itself and closed between the two black halves of the Carter. Here the material selection was not so different from the other two components, but with a consistent difference: here the priority was looking for a material ensuring the same properties in terms of durability and mechanical resistance, but being translucent. This effect allows both the slight transparent effect, almost



Comparison	Polypropylene	ABS
Price	**938,08 €/m³**	1518 €/m³
Density	**0,902 g/cm³**	1,04 g/cm³
Young's Module	0,922 Gpa	**2,42 Gpa**
Tensile yield strength	26,25 Mpa	**42,05 Mpa**
Injection moulding compatibility	Excellent	Excellent
H_2O durability	Excellent	Excellent
Durability to detergents and solvents	**Excellent**	Acceptable

Choice	ABS
Forming process	Injection moulding
Finishing process	In mold finishing
Massa	320 g (carter sx), 360 g (carter dx)
Material cost	0,99 €
Color and finish	PANTONE BLACK C, SPI C-3 (normal matte)
End-of-life perspective	Recyclable



frosted, but diffusing also better the light emitted by LEDs on the PCB right under the saddle. The two compared materials in this case where PMMA and PP: both compatible with injection molding, have particular advantages looking at their optical properties. In this case, the main property analyzed was the transmittance, defined as the amount of light able to pass through a material, without light reflection or absorption. Looking at the percentage range, both of them provide interesting and possible values for the design of this part of the Carter. Polypropylene provides more advantages in terms of price and density, being also easier to mold: said that PMMA has a large range of use for optical effects, probably wider than PP, but for the component aesthetic expectation, the second one can be considered more suitable.

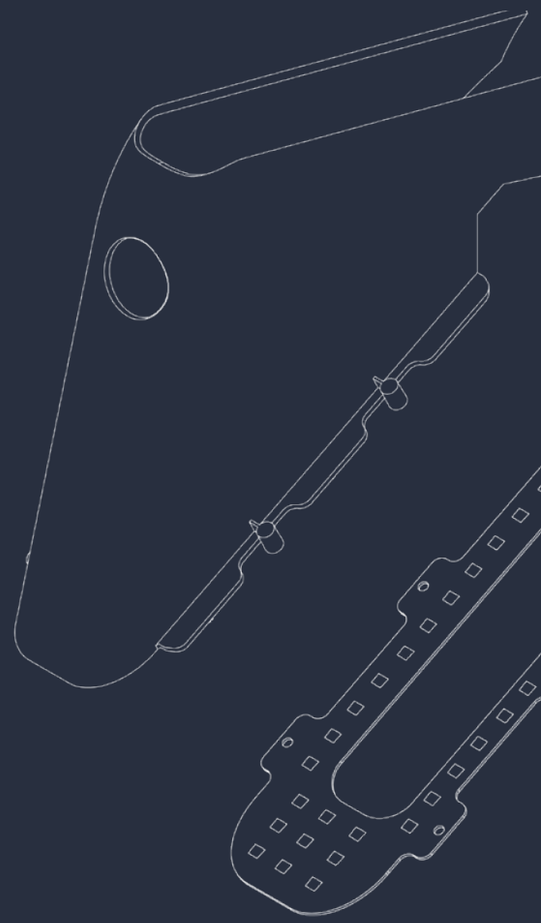
MATERIAL SELECTION

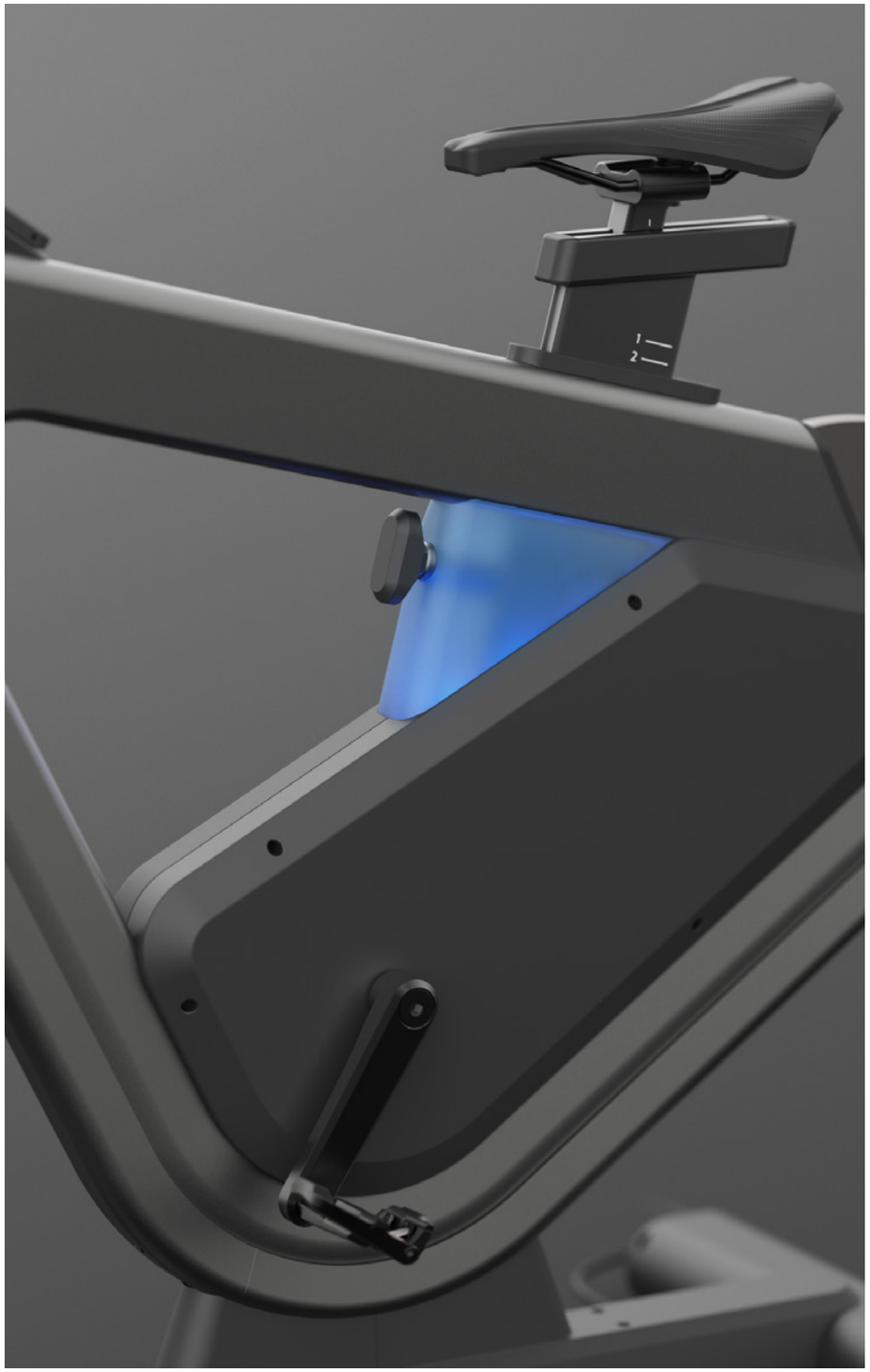
Carter diffuser

Functions	Supporting its own weight, protecting internal electronic and allowing a uniform light diffusion allowing a partial visibility of inner components	
Constraints	· Process compatibility · Traslucency	· Compatibility with injection moulding · Traslucent
Goals	Finding the right compromise: · Minimising cost and density · Maximising stiffness	· Price per unit volume · Density · Young's modulus

Comparison	Polypropylene	PMMA
Price	**938,08 €/m³**	1790 €/m³
Density	**0,902 g/cm³**	1,17 g/cm³
Young's Module	0,922 Gpa	**2,24 Gpa**
Tensile yield strength	26,25 Mpa	**63 Mpa**
Trasmittancy (min-max %)	85-90 %	80-93 %
Injection moulding compatibility	**Excellent**	Acceptable

Choice	Polypropylene
Density	0,899 g/cm³
Price	80 €/m³
Forming process	Injection moulding
Finishing process	In mold finishing
Massa	76 g
Material cost	0,08 €
Color and finish	Traslucent
End-of-life perspective	Recyclable

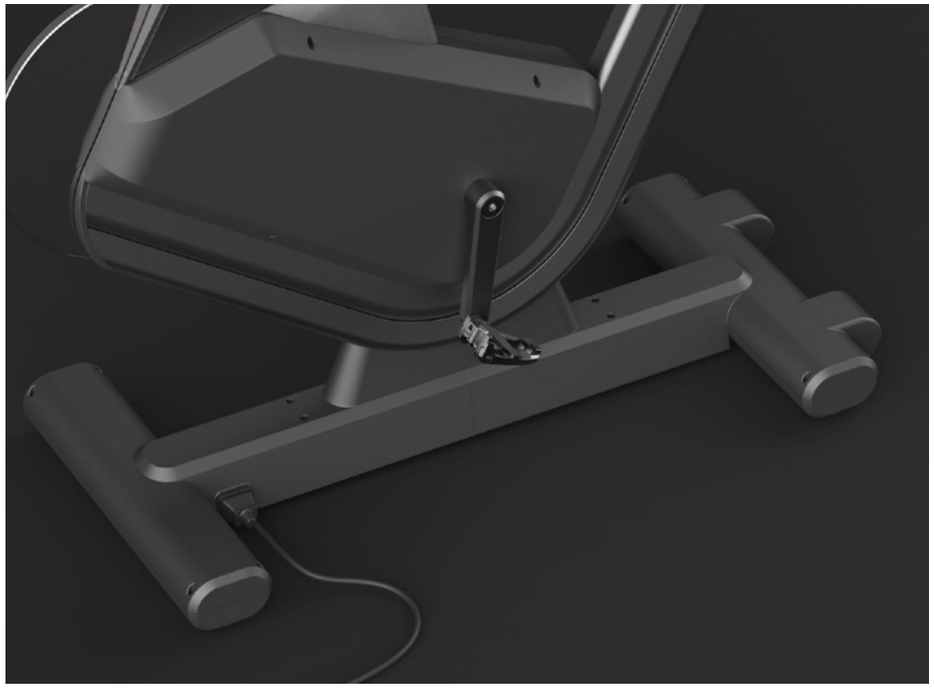


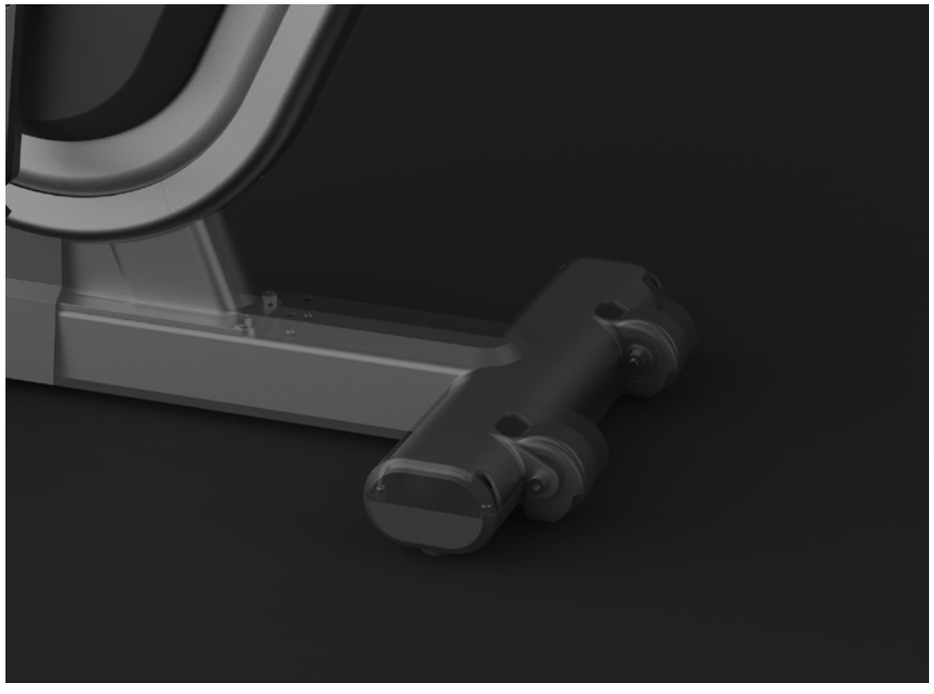


8.5 Base & seat subassemblies

The last subassemblies considered are the base and the seat, considered less important since the number of the component involved in their design is significantly lower. The base, specifically, is covered by four ABS parts, obtained through injection molding and joined with screws directly to the frame base steel part. Their function is only aesthetic since they are designed in order to cover the small component integrated into the frame using the less amount of material possible, and as a consequence with fewer components. The main constrain in this case was applying the same black used for the Carter, with the purpose to give a sense of stability, since it is the "basement" of the whole product, and at the same time to have less impact in the whole design as well, since usually, the base is an important component for its dimension, overwhelming and disturbing the appealing of the rest of the bike. Two technical considerations should be made here: the first one is the need for the current power supply, and the second one is the addition of wheels for product displacement. Even if the use of a battery can seem the most suitable choice, it should be considered two factors influencing the choice of this system: the first one is related to the design of the space where the product is located, and the second to the maintenance of the product possible battery. Indeed, in the last year (and as confirmed also in some talks with gym owners), several gyms are considering the option for a system where the energy gained by the equipment can be converted into power supply for other equipment, or in any case, the implementation of a facility with the direct current supply by renewable sources; this possibility, implies the direct supply by floor, and since the indoor cycling class is usually a specifically designed space, this kind of infrastructure is for sure the future. Batteries instead will create an important maintenance cost, since they should be charged in any case, requiring someone doing it and in general an additional product to do it. It is surely a possibility, but the choice made is more related to the idea of a future gym. Wheels are of course constraints: all the current bikes have them in order to be easily moved in the space, especially if targeted for the gym, a space where the equipment and the rooms in general, are cleaned every day.

For instance many times, during the field visit, there were bikes set aside to be repaired.
The seat as well needs to be quickly described. As we have seen, the V-shaped frame, combined with the presence of the vertical adjustability mechanism for both the handlebar and the seat, allows a comfortable seat and ride for every type of body. However, a horizontal adjusting mechanism can be required, for a wider possibility to adjust the seat more precisely: to do it a rubber lock mechanism was adopted. Tightening the screw, and so rotating the specific knob, it is possible to lock the seat in the preferred position.

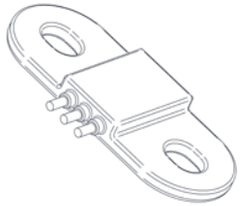




8.6 Buy components

Hall effect sensor

Combined with a magnet attached on the drive pulley, this hall effect sensor is capable to provide the number of round per minute, fundamental data in the indoor cycling. Additionally the rpm value given by this sensor will be used to get other informations, like for instance the resistance value of the bike in a specific moment.

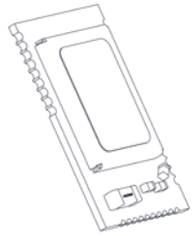


55100 Hall Sensor

Typology	Miniature Flange Mounting Proximity
Manufacturer	Littlefuse
Dimensions	25,0 x 11,0 x 3,0 mm
Mounting	Screws or adhesive
Product number	5052567
Sensing range	Max 19 mm
Supply voltage	2.7 - 24 V
Output voltage	400 mV
Price	6,26 €

Wi-fi module

This module is one of the two components allowing wireless connection, very important in every product nowadays, especially in the ones connecting with other digital devices in order to works.
In this case, for instance, it allows the connection for training program share, directly from the trainer device.

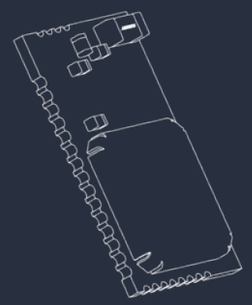


WF111-A module

Supported protocol	802.11 b/g/n
Manufacturer	Silicon Labs
Dimensions	19 x 12 x 2.1 mm
Mounting	Screws or adhesive
Product number	1774871
Max. operating temperature	+85 C°
Min. operating temperature	-40 C°
Supply voltage	1.8 - 3.3 V
Price	10,20 €

Bluetooth module

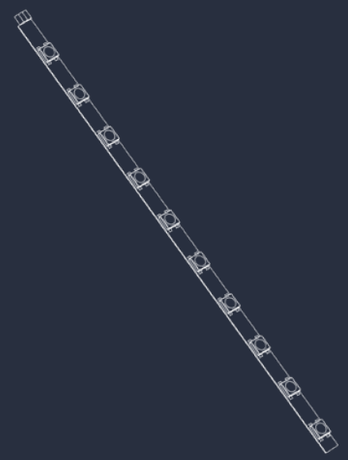
It is the second wireless communication channel, useful for a series of features: the Bluetooth module in fact allows the connection between multiple products (needed for instance in the case of synchronized features), as well as being useful for personal smart wearables identification and heart rate frequency, considered as a very important data during the training, even if one of the most underrated.



ATWINC3400-MR210UA143	
Version	Bluetooth 5.0
Manufacturer	Microchip
Dimensions	22,0 x 14,0 x 2,0 mm
Product number	249-9718
Receiver sensitivity	-92.5 dBm
Price	12,35 €

RGB addressable LEDs

This LED strip is integrated in the cover led metal component, directly attached to the frame through screws. They are quite cheap, providing a good quality light that can be managed through a microcontroller, both for color choice and LEDs behavior.



RGB addressable LEDs strip	
Typology	Narrow LEDs Strip
Distributor	Superlightingled
Dimensions	5 mm width
Mounting	Adhesive
Product number	VL3030
LED number	120 leds/meter
Input voltage	DC 12 V
Power	12 W / m

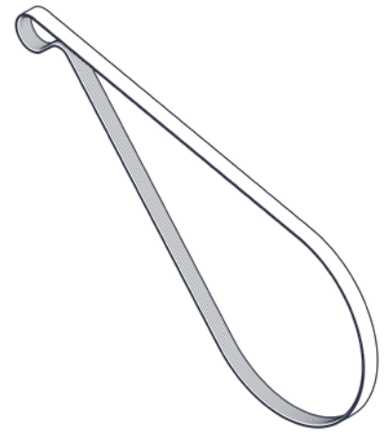
Side LEDs strip

The peculiarity of these LEDs is related to their emitting surface, on the side. Thanks to this, they can be embodied also in the narrowest spaces of a product and subsequently attached through adhesive. In the Lympha bike they are integrated between each plastic component of the handlebar.

Side RGB addressable LEDs strip	
Typology	Side LEDs
Distributor	Superlightingled
Dimensions	25,0 x 11,0 x 3,0 mm
Mounting	Adhesive
Product number	SK6812
LED number	120 leds/meter
Input voltage	DC 5 V
Power	24 W / meter

V-belt

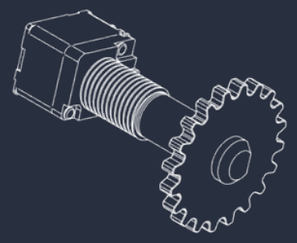
The peculiarity of these LEDs is related to their emitting surface, on the side. Thanks to this, they can be embodied also in the narrowest spaces of a product and subsequently attached through adhesive. In the Lympha bike they are integrated between each plastic component of the handlebar.



Poly V-belt	
Typology	Poly-V
Manufacturer	SIT
Dimensions	19 mm width
Material	Polyester and chloroprene rubber
Product number	SK6812
Grooves	120 leds/meter
Operating temperature	-20 / +80 C°

Potentiometer

Integrated into the resistance subassembly, this component, with an attached gear, provides an accurate value of resistance level (regulating it through different angle rotation) and a combined action with an rpm sensor: through a certain position of the magnets and a defined rpm number, it can provide Watt consumed and Kcal as well thanks to a previous set-up.



Alps potentiometer RK097 series	
Version	Bluetooth 5.0
Manufacturer	Alps
Dimensions	35,0 x 10,0 mm
Product number	7293498
Power	0,05 W
Shaft diameter	Ø 6 mm

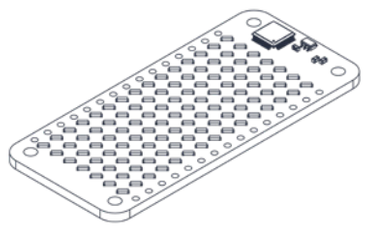
Magnets

Neodymium magnets are among the most spread on the market for two reasons: their cost accessibility and their longevity, a crucial feature especially in sports equipment (think to maintenance). They are provided with a very wide range of dimensions, depending of course on the applied force needed.

Magnets	
Typology	Neodynium
Manufacturer	Eclipse
Dimensions	Ø 25 mm
Mounting	M4 Screw
Product number	8735004
Tensile force	16 Kg
Price	23,85 €

LED Display matrix

Two display matrices are used to create the handlebar interface: joined with a specifically designed mask in order to create defined light spots, they backlight the external grey ABS part, additionally thinning the part in the required points.

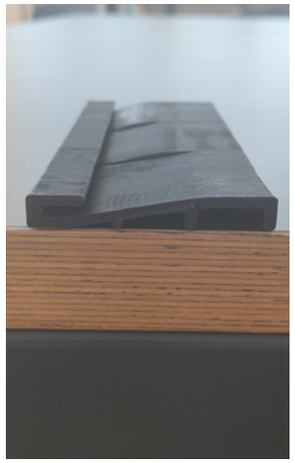
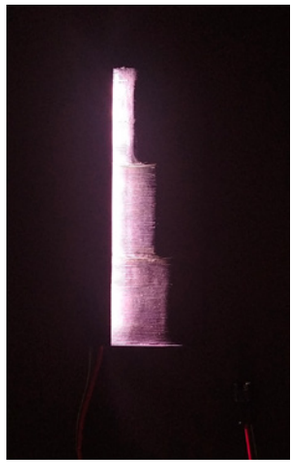
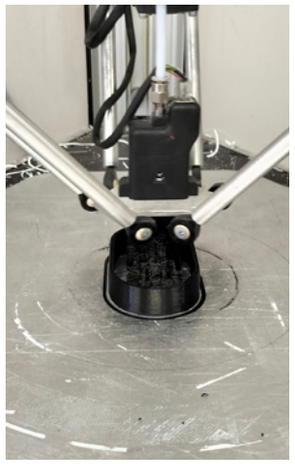
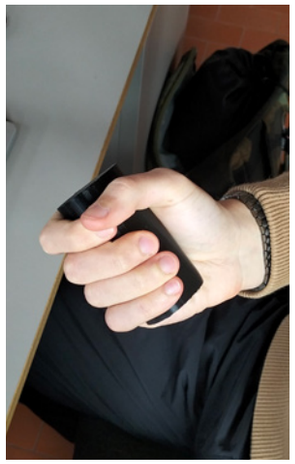


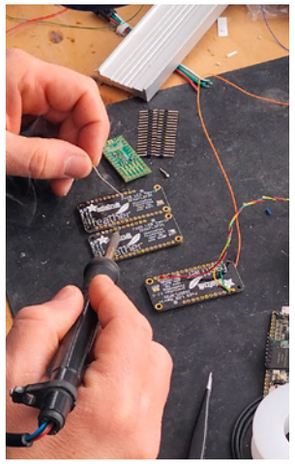
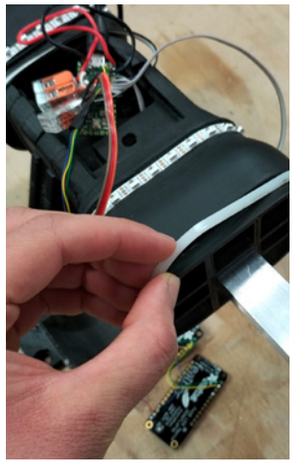
Adafruit CharliePlex LED Matrix	
Typology	LED matrix
Manufacturer	Adafruit
Dimensions	43,0 x 28,0 x 2,4 mm
Light color	White
Product number	3135
LED number	15 x 7
Input voltage	2.7 V
Price	15,30 €

8.7 Prototyping phase

The realisation of the prototype was a fundamental part of the design process, making it possible to evaluate various aspects related to both the proportions of the handlebar, realised in full scale, and the functionality and aesthetics of the interface.
In fact, in a first step, a component was realised in order to evaluate the desired light effect: to do this, a guide was realised by means of 3D printing, which could contain the side LEDs chosen and to be integrated in the handlebar, realising in the same component three gaps with three different spaces and at the same time three different inclinations relative to the surface affected by the light. One can immediately understand how these two dimensions are interrelated and at the same time, as a consequence, the variation of the gap dependent on these two factors allows a greater or lesser passage of light. In this case, the more inclined surface allows for a greater dispersion of light, however, a smaller distance relative to the passage of light allows for more defined and consequently more visible rings. For this reason, considering the quality of the scattered light as well as the resulting effect, the best option is the one that creates less wide lines of light.

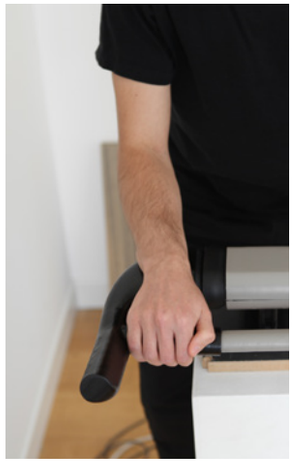


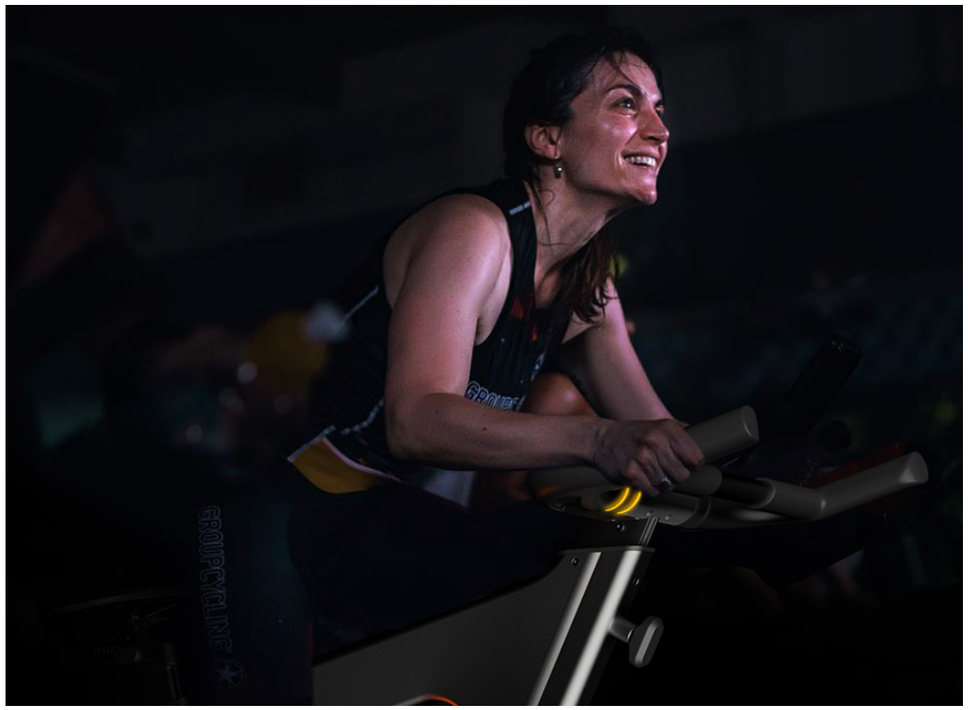
This was the starting point for the realisation by 3D printing also of a section of the handlebar, useful to understand the ergonomics of the grip of the handle: starting from a mass dimensioning, after testing with several users, it was noted that the diameter of the grasped section was quite comfortable, but its orientation quite uncomfortable. In fact, the section has a narrowing towards the inside, which is useful to accommodate the fingers and still make it easy to close the hand around the handle. For this reason, the narrowing section was oriented downwards instead of remaining central, in line with a more natural grip by the user. The last step was the creation of the finished full-scale model of the handlebar, with two main objectives: to confirm the comfort of the grips and at the same time to recreate it in working order in order to verify the effect of light and its behaviour. To do this, a combined support structure was created from 3D filament prints and aluminium profiles. As a result, the individual components with housing for the electronics were manufactured. The construction of the prototype is in fact almost similar to the configuration of the real handlebar, with the wiring of four different LED side strips around each printed part. The only difference in this case

lies in the realisation of two mirrored halves following a vertical axis instead of a horizontal one (as would be the case with the real bodywork). Finally, the LED matrixes were connected, placed immediately under a shell partially made from a sheet of plexiglass: lightly painted, this latter allows the matrixes to be hidden on the outside, and once the interface vinyl mask is attached, it is possible to recreate the backlit effect of the real handlebar. Unlike the components made in the preliminary phase, it was also possible to test the comfort of the handle in the eventual rest position (perhaps even more important than the normal grip). In fact, the elliptical section, as well as the enlarged flat surface joining the central part of the handlebar and the side grips, makes it possible to lighten the pressure exerted on the wrists and provide greater relief during the recovery phase, leaving the central part available to hang towels or other aftermarket components used in these contexts, such as the bottle holder.



Conclusions

The exploration of the design potential related to the use of light to create meaningful experiences has experienced great growth in recent years, thanks to a change in both the type of experience sought by the user and the evolution in the visions of several medium and large companies in the industrial product sector, integrating an increasingly design-oriented approach into their product launches. Extending this possibility to the sports sector, and more specifically to indoor cycling, was the primary objective of this thesis, proposing an advanced solution but at the same time tracing the beginning of an as yet unexplored path.
Lympha in fact, is part of a still early context for the enhancement of experience in terms of perception and meaning, which has mostly launched products rightly aimed at increasing performance and training effectiveness. However, and this is especially true in the field of Indoor Cycling, many of these sports are aimed at a non-professional audience, and a work in an experiential as well as functional perspective on the products used, can only increase not only the appealing of the product to the market, but also our relationship with sports equipment, as well as our idea of training.
By means of this thesis, we wanted to emphasise in particular how the 'life' of a product begins with the interaction with the user, who should for this reason always be central in the study of a new product and the consequent design, becoming pillars of the process that leads to the final solution, in an iterative circle that is always questioning itself. Hence also the name Lympha, a Latin term that gave rise to the word 'lymph', which besides having a scientific meaning indicates a component of something living, animated. Light is the lymph that makes this product alive, also changing the user's perception of it and everything that goes with it, from training to the end of its use.
Obviously, the proposed solution, although in an advanced state of development, is still a modest example for the use of light in sport. There are several improvements that can be proposed, as well as further developments in this thesis. For example, it could be investigated how the integration of such a product influences the role not only of those who practice, but also of those who have a sport practised, i.e. the trainers. It could also broaden the concept of the gymnasium, making it an even more pleasant space to live in, and thus also have consequences in the context of the application considered. Finally, as it is a very specific application, it could lead to a new series of products in the field of sports disciplines: in fact, each activity has peculiarities that can be closely related to a component of light, and used accordingly. This was the case with indoor cycling and will probably be the case with other sports, where products can be rethought from this perspective and perhaps discover other meanings that light can take on as a consequence. It should also not be forgotten that light is to be regarded as a medium that is constantly evolving technologically: this thesis has already shown how its current application would not be possible without such rapid advancement as has occurred in recent decades. For this reason, it is also possible to pave the way for other applications, equally specific and perhaps also using other technologies, taking full advantage of the great functional, scenic and experiential potential of light.



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