rEvolution

Process Report

MSc.4-ID18 May 2012
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Synopsis

rEvolution concerns improvement of the indoor cycling concept and experience of today.

Indoor cycling has developed very little since its origin in the 1980's when Johnny G merged his road cycling bike with an exercise bike.
This report will explain how indoor cycling can be brought into the technological era of the 2010's implementing monitoring systems, online logging and easy access by smart devices for nursing motivation and commitment to reach certain goals.

The project takes offset in developing a retro-fit upgrade and styling kit for BODY BIKE Classic Supreme.

The indoor cycling activity will be referred to as "spinning", not to confuse with the brand Spinning®.

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Danish Summary

Denne rapport er en del af specialet fra Arkitektur & Design på Aalborg Universitet.

Projektet og denne rapport handler om forbedring af fitness begrebet spinning.
Projektet startede i samarbejde med indoor cycle producenten BODY BIKE, som ligger i Frederikshavn. BODY BIKE startede ud ved at give et projekt oplæg, som forklarer de ønskede et produkt, som ville give spinning deltagerne indtryk fra lyd, lys og videoer.

I undersøgelses fasen af projektet var det klart, vil denne type produkt ikke give deltagerne en bedre træning. Deltagerne forklarede alt for mange indtryk vil kun forvirre i stedet for at optimere, de bedste træning vilkår er være et rum med høj musik og nedtones lys. Dette resulterede i projektet ville tage en retning, som BODY BIKE var ikke tilfreds med, og det blev besluttet, at projektet ville gå videre uden dem.

Det blev undersøgt, hvilken slags spinning koncepter var på markedet, og det blev opdaget at de fleste af de indendørs cykler ikke havde udviklet sig siden den første indendørs cykel blev designet. I en elektronisk tid alder er der kun få som laver en indendørs cykel med en gadget til at holde styr på træningen, men i de fleste spinning koncepter kører deltagerne med skyklapper. Deltagerne har ingen mulighed for at overvåge deres træning og ingen mulighed for at vide hvor meget de bliver bedre med tiden, fordi de ikke ved, hvor mange kalorier de har forbrændt i spinning timen.
Det blev undersøgt hvad der motiverer atleter og folk i almindelighed, som viste, at sætte træningen i system bidrager til at motivere udøverne.

Det blev besluttet at udvikle et produkt, der understøttes af et system, der vil holde styr på træningen både i træningssituationen og efter træningen, med en online log til at overse forbedringen. Produktet vil være et add-on produkt til at installere på indendørs cykler, som allerede står i fitnesscentrene. Produktet vil have oprindelse i de indendørs cykler som Body Bike producere. I en forstand virker alle indendørs cykler på samme måde med en skrue, som driver en bremse ned til svinghjulet, så produktet vil kunne tilpasses til cykler fremstillet af andre producenter end BODY BIKE.

Produktet er et automatiseret bremsesystem, der styres af et program som spinning instruktøren har lavet før spinning timen begynder. Bremsesystemet justerer derefter belastning på svinghjulet i henhold til programmet, så deltageren ikke behøver at justere belastningen af skruen. Årsagen til at justeringen er taget væk fra deltageren, er usikkerheden i at justere belastningen selv, nogle af deltagerne kan skrue op for belastningen for meget i starten og løber tør for energi før timen er ovre. Systemet sikre at deltageren vil få den rigtige udfordring i forhold til hans fysiske formåen af handicapsystemet.

Handicap systemet vil give hver deltager et individuelt handikap genereret fra en fitness test udført i introduktions timen. Som deltageren gennemfører spinning timer vil handicappet langsomt falde, hvorved intensiteten øges, og udvikle sig med deltageren, som han forbedrer sin udholdenhed.
Deltageren vil være i stand til at justere belastningen med +/- 5%, så hvis han har en dårlig dag kan han skrue ned, eller hvis han føler sig meget selvsikker og energisk kan han skrue op.

Deltageren kan følge træning under spinning timen via en display konsol på styret.
Konsollen giver en køreplan for intensiteten af det aktuelle program, ved at vise en graf, så deltageren kan se, hvor langt han er nået, og hvornår den næste stigning i intensiteten vil komme.
På samme skærm som grafen er også en kadence måler, der på en simpel måde illustrerer, om deltageren kører med den rette kadence i henhold til programmet, eller hvis det er for hurtigt eller for langsomt.
Den sidste måler på skærmen viser det aktuelle producerede watt-antal, som deltageren kører med i spinning timen.

Efter at spinning timen er ovre kan deltageren logge ind på sin profil og se alle de timer han har gennemført, individuelt listet. Deltageren kan også se en oversigt over alle timer, og hvordan han har forbedret sig over tid.

Project Focus

Project Statement

Indoor cycling of today is carried out as an 'individual group workout', but also a 'blind' workout. The load adjustment knob of BODY BIKEs does not have any dials, so it can be hard to apply the right amount of resistance to the bike during a session. This also means that the users cannot read any direct improvement by comparing load levels from different sessions.

For recreational athletes, who compose the majority of the spinning class, it is an important motivational factor to be able to see and experience progress. The improvement over time can be used for both insight to own workouts and as a means for social acknowledgement. Last mentioned tendency is currently used by the fitness app Endomondo, which automatically uploads e.g. run paths, time and distance to Facebook to let your friends know you are active.

The objective of this project is to give the participants the best possible workout by enabling them to exercise at the correct resistance load on the bike and to ensure progress of performance capabilities. Furthermore it is desirable to enable the user to overview the ongoing workout programme, during the session, for orientation.

"How to enable the individual spinning athlete to exercise with the correct resistance load in order to provide the most advantageous workout, avoid defeat and the feeling of physical insufficiency and through this being able to guarantee improvement in physical capacity"

Target Group

In the project there are two target groups - the user of the equipment and the provider of the equipment.
The product will need to meet both target groups in order for the providers to offer the users a better experience.

User
Recreational spinning athletes
– novices as well as experienced.

Client
Providers of spinning programmes and facilities.

Project Scope

The project will be focused on development of the technical aspects of the solution and how to use the man/machine interface in a motivational manner.

ill. 1 BODY BIKE Connect

Project Initiation

BODY BIKE's Project Pitch

The initial project pitch from BODY BIKE International A/S was centred around the environment in which their products are situated. They wanted to be able to control the surroundings of the bikes to create a full experience of their bikes as a part of a rooms interior and not just as an exercise bike in some basement.

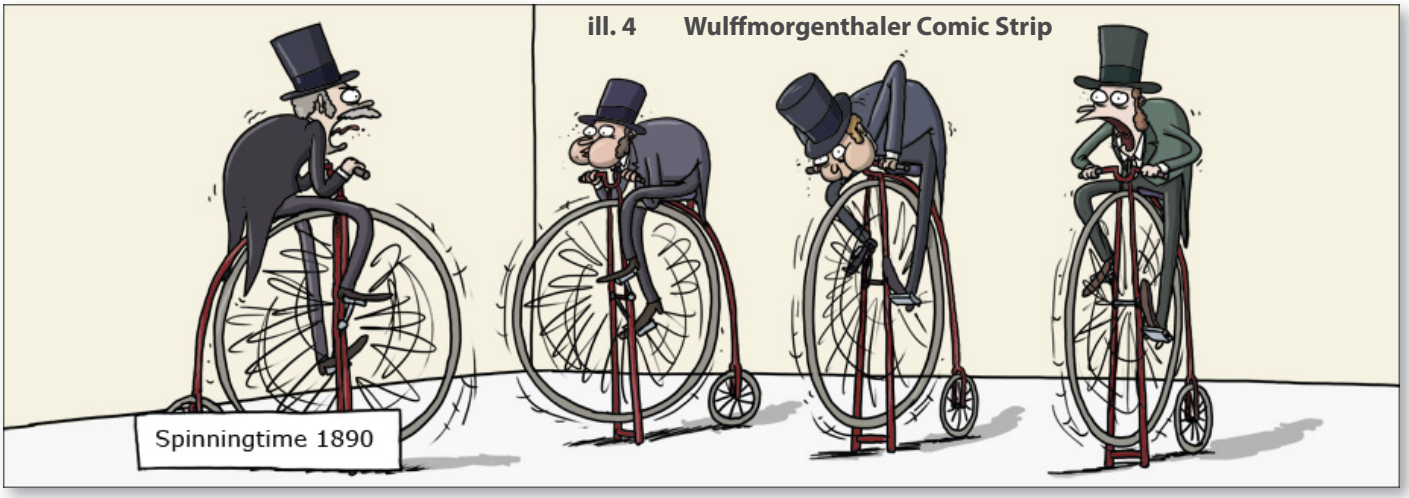
To achieve this, they wanted to fill up the room with impressions such as wall projections, variation in temperature and ventilation, etc.
Along with the bikes and other interior it should be shipped as a full package, tailored to the individual gym's requirements, in a container.

After the initial meeting with BODY BIKE a quick and dirty questionnaire concluded that most spinning athletes did not want any distractions during a session and some needed a motivational factor in the form of data of the session.
This issue was found more relevant and interesting than a '4D spinning cinema' and thus began the development of a box to measure energy and performance.
At the next meeting this concept was presented to BODY BIKE, who then informed that they had used the past 1½ years to develop such a device and the launch was due in April 2012.

Back at status quo and after own spinning experiences had been gathered the 'Follow the Leader' concept, described in Concept Description, page 21, emerged and was presented to BODY BIKE. Since BODY BIKE was not enthusiastic about the concept at all, it was decided to cancel the colaboration and continue the project without BODY BIKE.

ill. 2 Cooperational illustration

Phase 1 - Research



ill. 4 Wulffmorgenthaler Comic Strip

The origin of Indoor Cycling

Indoor cycling (in this report referred to as "spinning") had its origin in the late 1980's when Johnny Goldberg, a Race Across America athlete came up with the concept of indoor team cycling. In the early 90's the concept was successfully adopted by fitness centers in Los Angeles and New York and was presented to the public on conferences in 1995 by Mad Dogg Athletics, founded by Johhny G. and John Baudhuin. Since the spinning has gained a tremendous amount of interest and is an exercise service that most fitness centers must meet to satisfy their customers. (Salminen 2005)

ill. 3 Johnny G on the original bike

Spinning - A Blind Workout

Today in fitness centers the typical indoor cycling scenario is a gym equipped with 30-50 spinning bikes facing towards an elevated plateau for the instructor's bike and music controls. The music's beat is the foundation of the workout session. It dictates the cadence in which everybody is cycling. The resistance control, on the other hand, is operated by you and you alone. Through a spinning session of 50 minutes the load is continuously applied and released according to the programme. Aditionally BODY BIKE's load adjustment knob is placed in a rather inconvenient location on the bike frame.

In some gyms the workout intensity is defined by a percentage of the individual participant's maximum pulse. In Fitness World the instructor refers to 5 intensity levels which are vaguely described on a laminated paper card attached to the bottle rack of the bike.
Here the intensity levels are described from physiological reactions to the intensity level such as:

"Level 4 – Slightly staggering speech, in short sentences or separate words. Continuous duration at this level - 5 minutes."

This means that the user has no tangible target to aim for when applying resistance load.

The outcome of faulty resistance settings can be either:
1. The user applies to little load and does not get the expected workout.
2. The user applies to great a load and cannot last the whole session at this intensity level. Also this situation results in an insufficient workout.

ill. 5 **BODY BIKE Classic "Signal"**

ill. 6 **BODY BIKE Time line**

BODY BIKE's History

BODY BIKE International A/S was founded in the mid 1990's and is located in Frederikshavn, Denmark. In 1998 the first production bike was finished and today BODY BIKE produces more than 10,000 bikes per year, which are sold to about 34 countries (Web 1)

Since BODY BIKE Classic a redesigned Classic Supreme has been launched; same bike essentials in styled packaging. Also a down scaled version of Classic Supreme, the BODY BIKE Magic, has been launched for children. This version was equipped with a simple rpm display for easier use by children.

Just recently BODY BIKE has announced the introduction of BODY BIKE Connect.
This product is actually the Classic Supreme fitted with sensors, gauges and a display which is able to inform about time, cadence, heart rate, calories and watts.

ill. 8 BODY BIKE Braking system

ill. 7 BODY BIKE Basic, Classic, Classic Supreme and Connect - Same frame

BODY BIKE Product Profile

The common BODY BIKE indoor cycle of today is essentially the same product since BODY BIKE Classic of year 2000. Same frame, drive train and brake.

The Bike frame is made from durable 40mm square profiles, some from stainless steel to avoid corrosion. The 20 kg cast iron flywheel is directly driven by a belt by the patented drive train. Resistance load is added to the flywheel by bolt with a knob that pushes the Kevlar brake pad onto the periphery of the flywheel. The square bass nut, in which the bolt runs, is only constrained in upwards direction, so emergency braking can be managed by pushing down on the knob.

The fore mentioned moving parts are enclosed in a plastic cover in a variety of colours. The seat and handlebar are both horizontally and vertically adjustable.
This makes a very sturdy and stabile construction which needs very little maintenance. The only elements to wear out are the braking pad and belt drive.

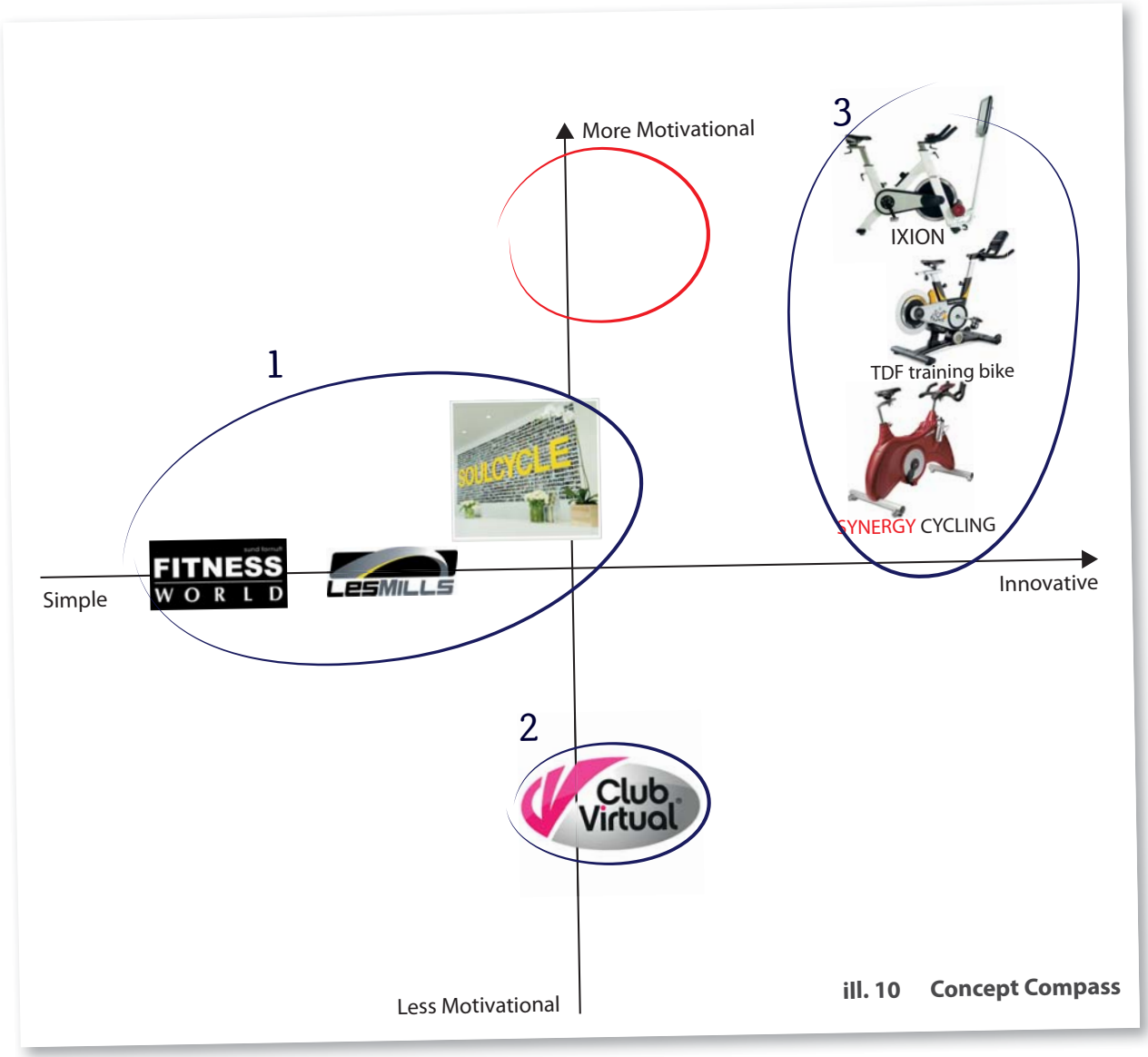
Some of BODY BIKE's competitors use magnetic brakes that does not wear out as this mechanical system does. Described in Appendix ??.

ill. 9 **Main design strokes of BODY BIKE Classic Supreme**

BODY BIKE Aesthetic Analysis

The exterior design of BODY BIKE Classic Supreme is very simple and clean. Basically it consists of three main strokes with an add-on for embracing the seat post. On the side wall of the black shell, the drive train and flywheel are emphasised by using their contours and adding translucent regions to reveal the flywheel.

In the beginning the top shell was only available in the red version, see BODY BIKE Classic Supreme ill. 11, but is now available in a wide range of colours.



ill. 10 Concept Compass

Market Research - Exsisting Spinning Concepts

The concept compass maps selected spinning concepts by level of innovation and motivation.

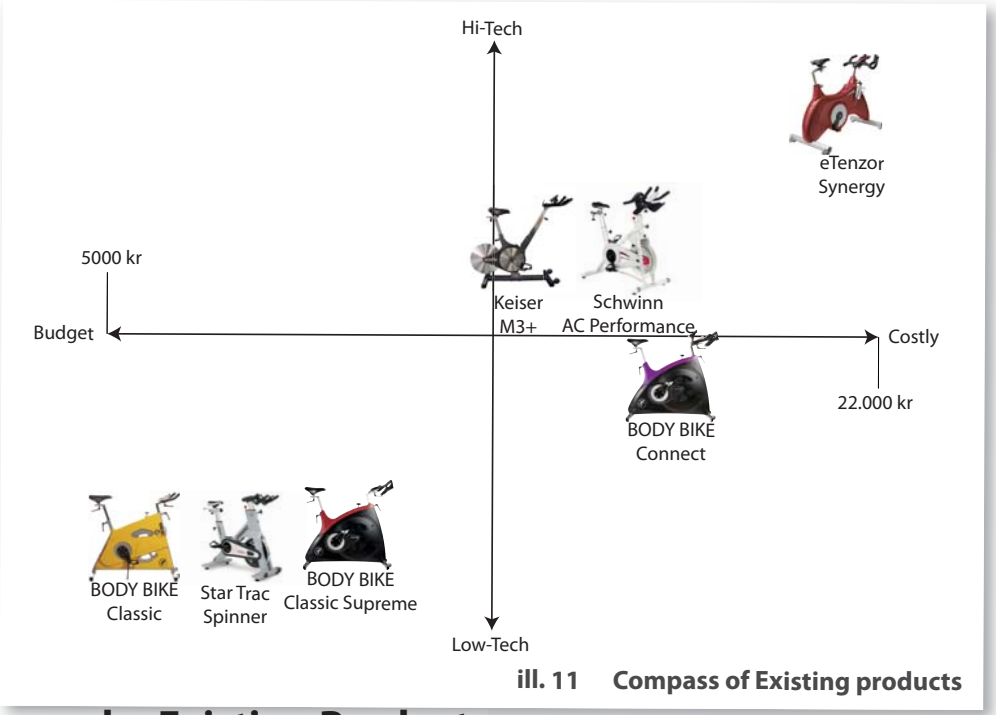
Fitness World is used as a benchmark concept, on the motivational level because there is one instructor and a soundtrack which makes up the motivation factor. At the same time the spinning in Fitness World is a basic spinning concept so it is neutral on the innovation axis.

The three concepts in group 1 have a connection because they are all a slightly further developed model of the already existing spinning concept. It is one instructor, one soundtrack and that is the only outside motivational factor for the participants. Soul cycle, however, differentiate with "excluding" the participants from the outside world while working out. They do this by lowering the lights and setting up rules for how to behave in the center.

Group 2 only have one concept, because it falls outside of the others. Club Virtual is a concept marketed at the private market. It has a innovation height greater than group 1, because it takes spinning out of the usual environment and takes the instructor into the participants living room. Though the instructor is excited and upbeat it all becomes a bit comedic looking at the screen and not greatly motivational.

The group 3 concepts are dependents on the right equipment for the workout will be as good as the concept intends. The Synergy Cycling concept gives the participant an individual staged bike, with a handicap set specific for the individual, so everybody regardless of physical capability can ride together. The Tour de France training bike from Proform is not a spinning bike in the classical sense, but the technology is exciting. On the display of the bike the participant will select a route of the Tour de France, which is encoded in the bike, with length and height profiles so the resistance will switch accordingly. The Amada Sports IXION bike is a combination of the TDF training bike and the Club Virtual concepts. Amada has an extra feature so the participant can draw his own course and then he will see a virtual generated road instead of the real thing.

The concept developed in this project aims at the area between group 1 and group 3. It needs have a high motivational level but it does not need to be as innovative as the group 3 concepts.



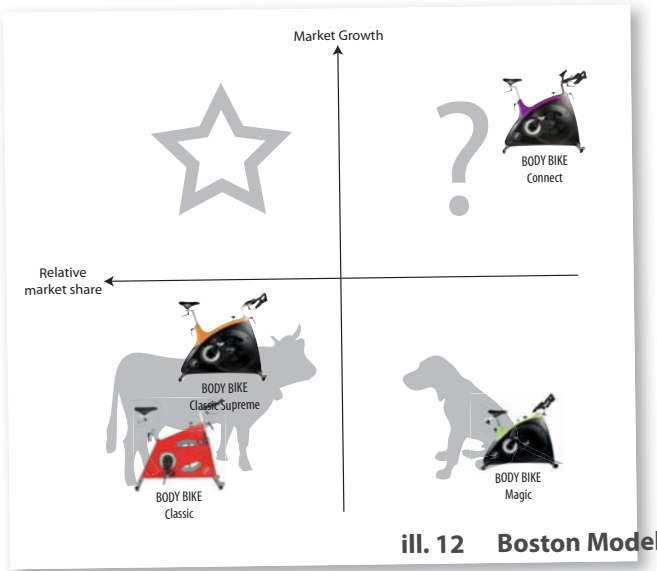
ill. 11 Compass of Existing products

Market Research - Existing Products

The market for professional indoor cycles repetitive, there are not many manufactures of professional indoor cycles, most of them in the price range of BODY BIKE work in similar ways. In the category DKK 5,000 - 9,000 are BODY BIKE Classic, BODY BIKE Classic Supreme and the original Star Trac Spinner, which started the concept of spinning.
The two types of BODY BIKEs are virtually the same, the Classic Cupreme has an updated cover, but the mechanics are exactly the same. The Star trac spinner is the first spinning bike which was launched and is still the best selling, however, it has not evolved since it first was launched in the technology department. Both BODY BIKE and Star Trac use mechanical brakes (see section 'Brake System' on page??)

In the next price range from DKK 9,000 to 12,000 the indoor cycles are more complex. The BODY BIKE Connect has a display connected to a load cell and trip meter(tachometer) in the bike which gives some information about the ride. The Keiser M3 and the Schwinn AC Performance are indoor cycles with magnetic brakes, the Keiser M3 also have a display to give information to the participant.

In the very expensive end of the scale there is one product, the eTenzor Synergy bike is a bike which have a large system/ service around it. eTenzor is a high-tech spinning bike, with a special "metabolic gearing system" which adapt to the individual participant. The eTenzor bike costs DKK 21,000 which is a heavy price tag and no common fitness center have these bikes.



ill. 12 Boston Model

Market Research - Bonston model of BODY BIKE

BODY BIKE has three products which comes in different editions. Two of the products is on the market and doing well, though the evolution of the products is minimal. The third product is a bike for children and has been a failure from the beginning because children under the age of 15 are not allowed in fitness centers.
The BODY BIKE Classic and the BODY BIKE Classic Supreme are Cash Cows and are in imminent danger of becoming Dogs if a competitor should launch a product with a higher level of technology which offers more than the bikes on the market.
There is, however, one more recently added bike in the product portfolio BODY BIKE Connect which was launched in April and is therefore placed as a question mark.

H

Market Research - BODY BIKE and Poter's 5 forces

New Entrants
The market of spinning bikes is saturated with products which all do the same thing. To penetrate this market with "just another" spinning bike will be almost impossible, however, if a manufacture wants to come into the market with a product which stand out with a higher level of technology there is a large opening on this market.

Suppliers
The suppliers used by BODY BIKE has no bargaining power because they make steel profiles and weld them together, and many companies can do that. However, BODY BIKE buy most of their supplies locally in Frederikshavn which is a politic of the company and that expands the suppliers bargaining power

Industry rivalry
In the market of spinning bikes the biggest competitive parameter is the price of the products and the quality of the products.

Buyers
The buyers have a huge bargaining power because of the big selection of spinning bikes on the market from different manufactures in several price levels.

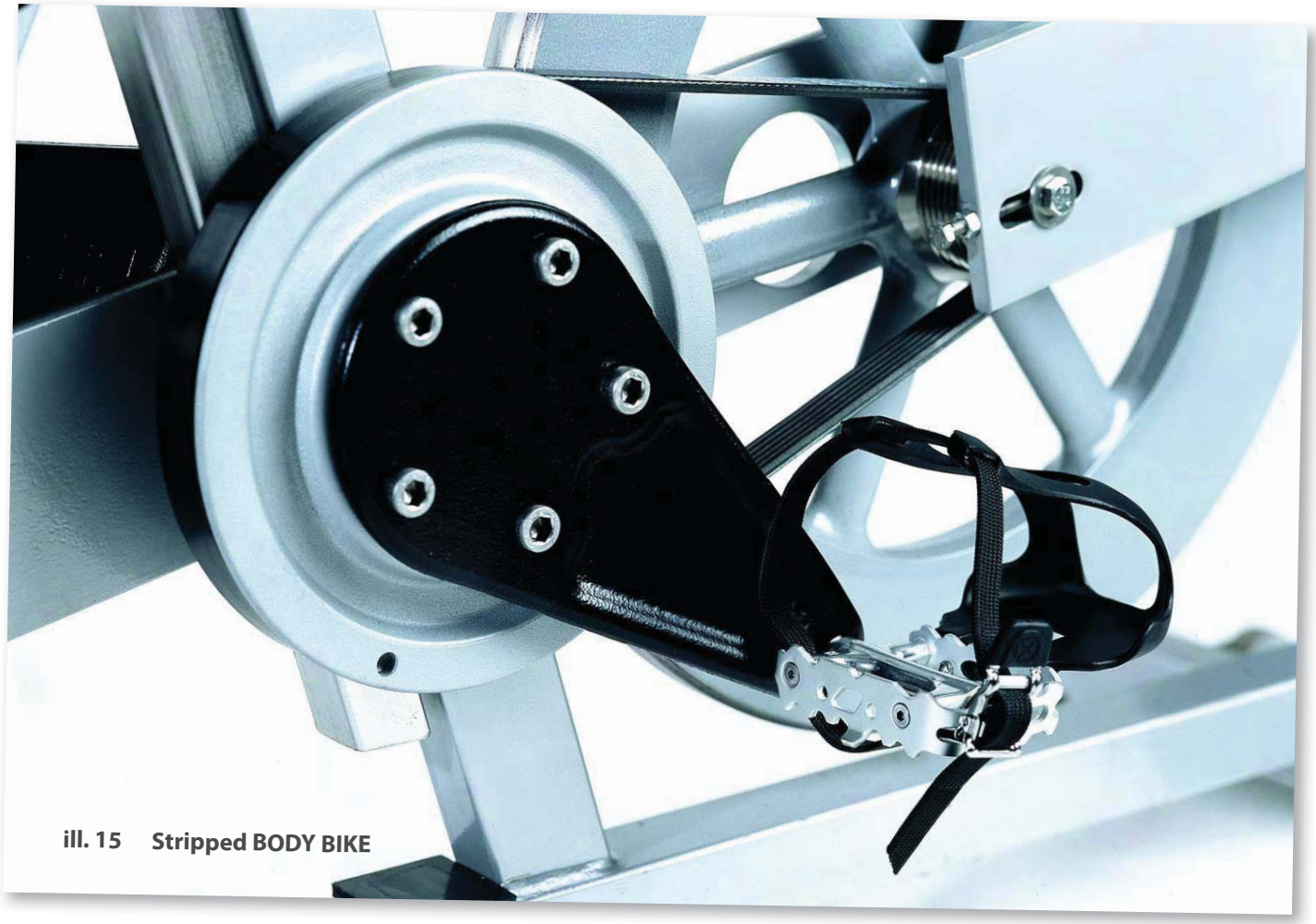
Substitutes
There is a large number of manufactures of spinning bikes. It is not difficult to find a product which can do exactly the same as a BODY BIKE, and also cheaper. What is hard is to find a product which does 10% more than the standard at the same price

ill. 13 Porter's 5 Forces

ill. 14 Red Ocean

Conclusion of BODY BIKE analysis

BODY BIKE has a good and durable product, which is similar to almost all the competitors, but more expensive. From the analysis made it is clear BODY BIKE needs a new strategy or a new series of innovative products or maybe both. If BODY BIKE wants to keep making bikes they need to cut down on expenses and optimize the bikes to useable for a limited time period so they can sell more bikes. Another and better possibility is to be in front of the competition and design a product which will elevate BODY BIKE compared to the rest. The product could be a new better bike or be an add-on product which can be used on several bikes, to steal market from the competitors.



ill. 15 Stripped BODY BIKE

User Research - Questionnaire

To gain a little perspective of people's spinning habits a quick questionnaire was created and distributed through Facebook.
These questions concerned both the spinning and non-spinning segments.

The non-spinning segment was asked why they do not exercise spinning and what might have them consider spinning in the future.

The already spinning segment was asked for how long and how often they have been doing this particular exercise, if they use any kind of electronic device to display their performance and to which degree they were affected by the surroundings, instructor and co-spinners. Full questionnaire in Appendix 1.

Questionnaire Conclusion
From this questionnaire it is clear that spinning is a quite common activity amongst young people of 20-35 years of age. Some use it to get rid of those few extra kilos they are carrying and an equivalent quantity is using it to keep fit.
The instructor is a very big motivational part of the workout, but anyway a third of the spinning respondents use an electronic device to monitor their pulse to try to force an, as accurate as possible, intensity of the workout. This is necessary because of the lag of monitors and gauges to display a given load or performance level, and the fact the resistance adjustment is without markings. The spinning participants are not able to perform their optimal because they do not know the course of the program and thereby not push themselves to the limit.
The respondents who do not use a pulse monitor believe that it is a strong motivational factor to be able to read their progress and improvement through a history of recorded workouts.

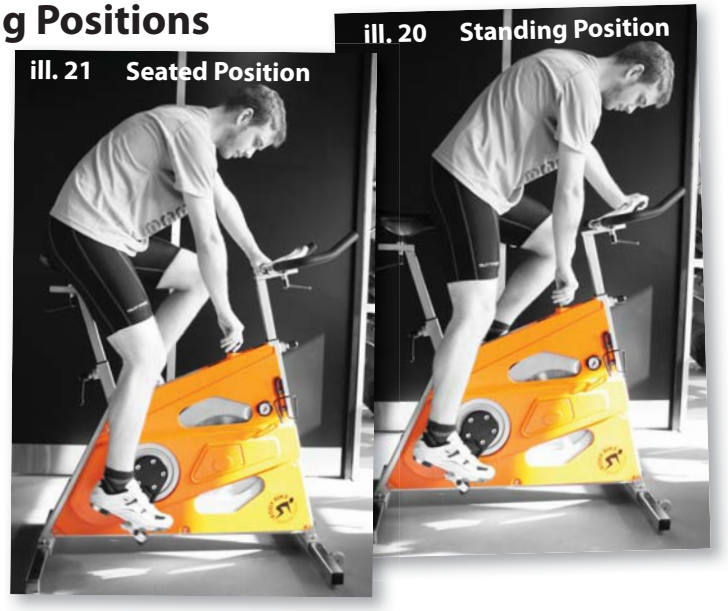
There is a conflict between the possible motivation of working out with a partner and being free and independent to work out whenever it suits the respondent. This leaves spinning in a peculiar gap as an 'independent team experience' and a 'blind workout' with no reference to your level or improvement.

User Research - Body Storming Riding Positions

To gain more knowledge about spinning, both group members have been spinning on a regular basis to experience the challenges and difficulties at first hand.

Basically there are two riding positions; seated and standing and two cadences; single and double beat.
In up-hill simulation the cadence is single beat and downhill or sprinting is usually double beat or faster. Both simulations can have intervals in both riding positions.

Load adjustment is carried out continously through a session, how many times depends on the instructors programme and spinning style. During one session the number of adjustments was counted to more than 30 times.
The workout intensity comes from combining cadence and resistance force.



User Research - Body Storming Display Location

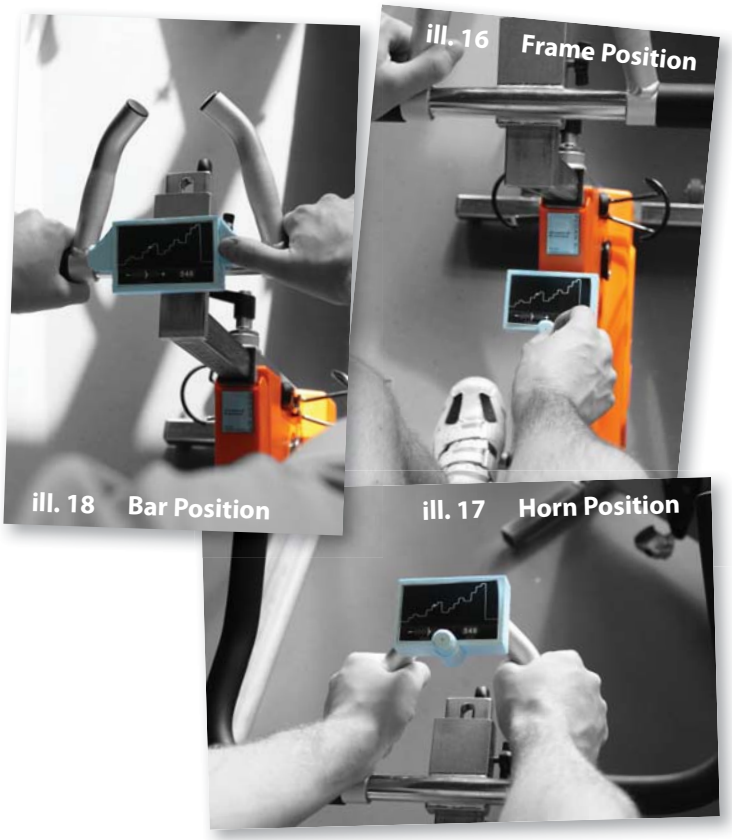
To try out different positions where to locate the display on the bike, a set of display unit mock-ups was made from foam. In this way the pros and cons for each location was easy to experience. It is decided to integrate monitor, card reader and interaction buttons in one unit to avoid external wiring. Initially it was also an aim to keep it out of the 'sweat zone', but this would require an extensive arm or mounting on the back of the bike in front. See Bike Layout - page 27 and 28.

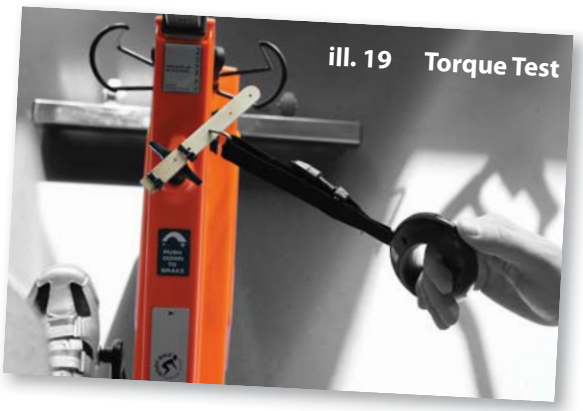
Placed on the frame, ill. 16, where the adjustment knob is located today, the display was very distant and in standing position it was partly blocked by the handlebar stem. Also load adjustment was just as inconvenient as the current solution.

The best viewing position was on the end of the small horns on the handlebar, ill. 17. This resulted in narrow space for hand placement and troublesome adjustment access, though. Furthermore the horns are not mounted exactly the same from bike to bike, so making a mounting bracket for it would not be desireble.

On center handlebar, ill. 18, the viewing angle of the display was almost as good as the horn position, but offered easier access to service operation and was not in the way for hand placement. Though, it cannot extend too far to the rear due to collision with the ever moving knees.

Through the body storming it is decided to choose last mentioned location for the display unit.





Torque Test

As a quick benchmarking of the torque requirements of the motor and gear assembly a test was conducted with a luggage weight and an arm attached to the load knob of the bike. Here one person cycled while the other applied pressure. When the cycling person was no longer able to spin the flywheel the load adjustment force was read. Because non of the group members are elite athletes, an extra 30 % was added resulting in a benchmarked torque requirement of 1816 mNm. See 'Torque Requirements Calculations, page 31.

Motivational Factors in Fitness World

Today in Fitness World the typical indoor cycling scenario is a gym equipped with several spinning bikes facing towards an elevated plateau for the instructor's bike and music controls.

When spinning the cadence is set by the beat of the music and the resistance control is operated by you and you alone. During the spinning session the instructor refers to 5 intensity levels, which are vaguely described, on a laminated paper card attached to the bottle rack of the bike, see ill 22.

Here the intensity levels are described from physiological reactions of the intensity level such as:

"4 – Staggering respiration and very hard to speak".

With this kind of benchmarking the user has no tangible target to aim for, when adjusting resistance load continuously according to the programme. In addition the load adjustment knob is placed in a rather inconvenient location on the front of the bike's frame.

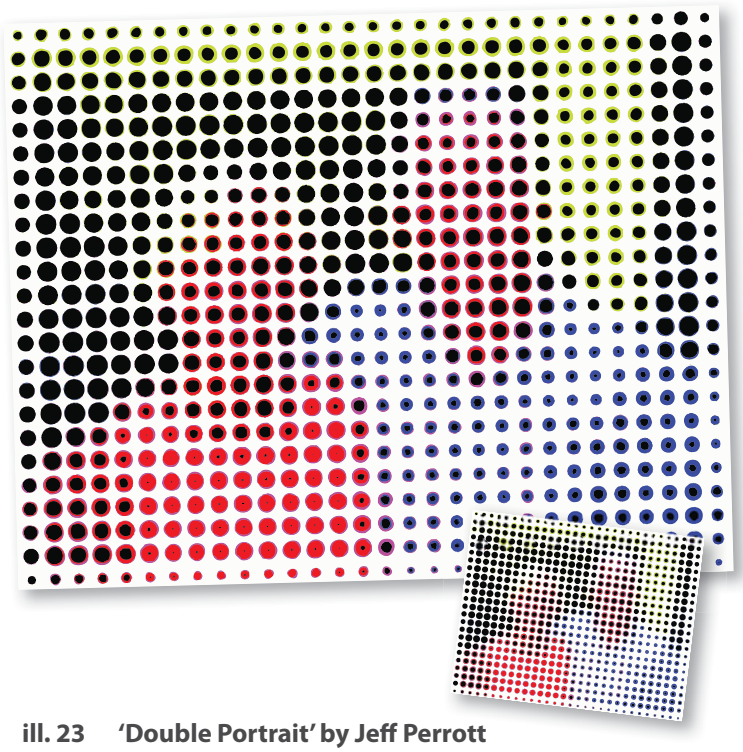
ill. 22 Fitness World Intensity levels

FITNESS WORLD

Intensity Scale

Level	Description	Feeling	Zone
1	Relatively easy to moderate work	• You warm up without any strain • Conversation on a normal level	1-3 hours
2	Slightly strenuous to strenuous work	• The work load increases and you start to sweat • Conversation still on a relatively normal level	45-60 min.
3	Strenuous to hard work	• Demanding work load • Slightly starting burning sensation in your legs • Respiration increases and you are only able to conversate in short sentences	20-40 min.
4	Hard to very hard work	• Highly demanding work load • Burning sensation in your legs • Staggering respiration and very hard to conversate • Short sentences to separate words	5-10 min.
5	Extremely hard work	• Maximum physical work load • Conversation impossible and gasping respiration • Work load almost unbearable	30-60 sec.
Zone: Possible duration of workout without no break			

Perseption Psychology



ill. 23 'Double Portrait' by Jeff Perrott

Simple Perception Psychology suggest the person who wants to e.g. start a spinning class needs to fit the task of working out into a context to understand what needs to be done. This is a part of the "Gestalt-psychology" which says the human mind can easier understand a whole than the whole as the sum of its elements. This allows humans to perceive information completely without unnecessary repetition analysis.

Humans tend to group similar objects together accordingly to four things, to avoid having to consider each object individually, because it takes up too much time in the mind.

Considering how many spinning instructors a chain such as Fitness World (in Aalborg alone counting 36 BikeFit instructors) have, who all have composed their own specific session programmes, the participant does not know what to expect if attending a new instructor's class.

It is highly desirable to make the spinning activity easier to perceive and hereby more tangible for the athelete.
By mapping out the full workout session for the participants to overview, instead of only giving seperate verbal instructions before each exercise, it is easier to prepare for the upcoming challenges. (Web 2)

Motivation Psychology in Sports

In the following it is described how human behaviour acts as a drive to make an extra effort to reach certain goals in competitive environments.

According to Robert J. Vallerand there are three types of motivation

Intrinsic motivation (Inner motivation)
The joy and satisfaction of performing the activity. The hard work and effort is the reward itself.

Extrinsic motivation (Outside motivation)
The motivation is an external reward such as prices, rankings, medals, acknowledgement etc.

Amotivation (Negative motivation)
Amotivation can be caused by insufficient capability and capacity to do a satisfactory performance. This is the most common source of amotivation.
Also a predetermined belief of non-achievement, an expectation of too demanding an effort or the experience of not being in control of the situation, can lead to amotivation.

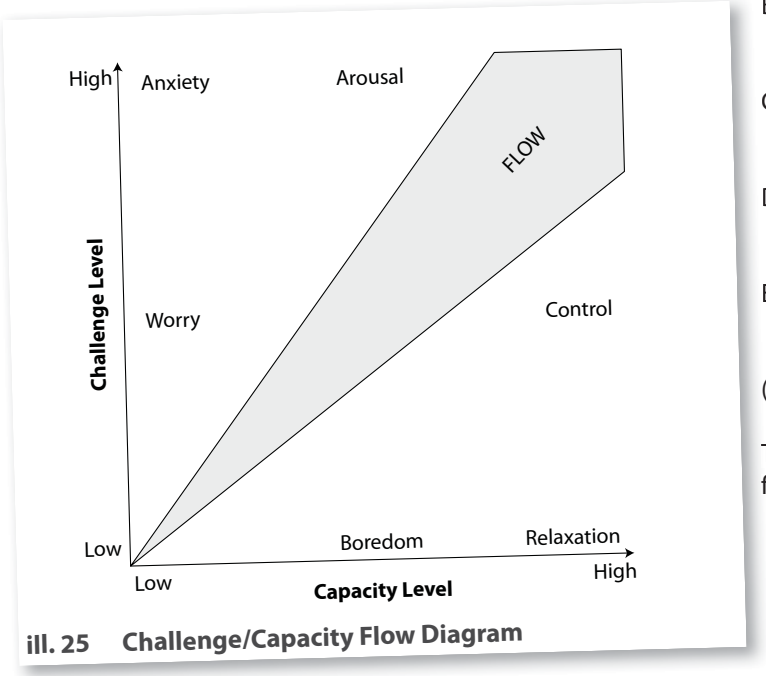
Goal Orientation and Motivational Environment
Task goal orientation focuses on the belief that improvement is achieved by performing the task and performing it right. This approach refers mainly to athletes with a high level of intrinsic motivation and leads to increased interest in and satisfaction of the performance.

Ego goal orientation on the other hand focuses on the outcome of the performed task. Here the result of the performance is rated and compared to competitor's results in order to define success or failure. Ego goal oriented athletes are therefore mainly driven by extrinsic motivational factors.
The athlete is not necessarily either task or ego goal oriented but can have different levels of both orientations, which results in different attitudes, conceptions and behaviours amongst athletes.
Also the motivational environment has a great impact on the athlete. A result oriented environment is eg. a parent asking the child if they won the match. A process oriented environment would ask the question if the child had fun at the match today or if it learned something new.
The result oriented environment can give the impression that anything but victory is failure and nothing less is tolerable. This might contribute to a fear of defeat, performance anxiety and low self esteem of the athlete, while the process oriented environment nurtures a higher level of competence, joy and satisfaction of performing the activity. Furthermore the process oriented environment is prone to enable the athlete to handle and overcome adversity in a better way.
(Hassmén 2005)

ill. 24 Keep On

Flow Psychology

Mihaly Csikzentmihalyi, former psychology professor at University of Chicago, describes 'flow' as a state of concentration or complete absorption with an activity and situation.
This flow state is an optimal state of intrinsic motivation, where the person is fully immersed in what he or she is doing.



ill. 25 Challenge/Capacity Flow Diagram

To create a flow nurturing environment a series of steps are crucial:

A. To set a main goal and an appropriate amount of realistic sub goals.

B. To find a method to measure progress, according to these fore mentioned goals.

C. To concentrate on the activity itself and continuously extend the challenges of the activity.

D. To develop the necessary skills to meet the available possibilities.

E. To keep increasing the performance if the activity becomes boring.

(Csikzentmihalyi 2005)

Through this project the goal is to embrace these steps to facilitate flow and motivation.

Conclusion
To improve the experience of spinning and keep the participant motivated it is important to make the whole experience lucid and easy perceivable. Therefore it is a goal to 'take the blindfold off the participants' to let them know the path to follow in advance.

Through motivation psychology in sports and flow psychology a series of do's and don'ts to navigate from have emerged.

To nurture the intrinsic motivation and flow it is important to set realistic and achievable sub goals for the workout and avoid defeat during a session. Especially the last part can be tricky because of the tipping point of maximal performance workout and feeling insufficient.

Extrensic motivation can be helped along by linking the performances to a social environment as the Endomondo fitness app does it today. This creates a breeding ground for competition and comparison amongst friends or like-minded athletes. Here, ofcorse, it is important to keep in mind the task goal oriented environment so it all does not focus on the achievement in itself but also consider own improvement progress of performance and capability.

ill. 26 Motivational Carrot

Concept Description - 'Follow the Leader'

The baseline of the concept is that the participant in spinning workout cannot easily adjust the load for the optimum workout throughout the whole spinning session. The load adjustment screw of today's BODY BIKE does not have any scales or dials, so the instructor cannot tell the user to set the dial on '3'.

The system can be used in several ways:

Controlled by the instructor
The instructor will adjust the resistance on his bike/console and this will adjust the resistance on all the other bikes in the spinning room. The instructor will act in the same way as he does in regular spinning classes, explaining when to "go uphill" and when to "sprint" and the instructor will then turn the load up or down for the entire class.

Controlled by Les Mills
Les Mills develops new spinning programs every three month. It is plausible they could put another level into the programme so the bikes in the fitness center would be controlled by the Les Mills programme.

Controlled by DVD
Similar to the Les Mills solution it is also a possibility to do an all virtual workout, like Club Virtual, where a DVD movie of a workout session on a big screen contains an extra data track with a preset programme, which controls the workload.

In all instances the instructor's bike acts as 'Master' and the participants bikes act as 'Slaves'.

Handicap System
To enable everybody to have a suitable workout regardless of physical condition a handicap system is introduced.
The individual athlete's handicap is calculated from a fitness test that each participant will have to undergo before being able to start the first spinning class. This could be a part of the already existing introduction classes, where the users learn how to set up the bike properly. The instructor as well will have to do the fitness test to benchmark according to the system.

Braking System
The mechanical braking system takes offset in BODY BIKE's design of the brake, which is standard on BODY BIKE Basic, Classic and Classic Supreme, but instead of the participant manually adjusting the load on the flywheel, the load is controlled by the automated braking system.
The brake pad is operated by an actuator which forces the brake pad onto the flywheel to increase resistance and draws it away to decrease the resistance.

System Interface
To allow the user to interact with the bike, it is equipped with a display unit for several purposes.
For the bike to know data and handicap the user have to log onto the bike. Here the display should provide the instructions of how to log in.
During a spinning session the display enables the athlete to monitor the preset programme, which enables the user to prepare for the upcoming challenges and read some key performance data of the workout.
To interact with the system a simple and intuitive controller/button system should be easy accessible in riding position.

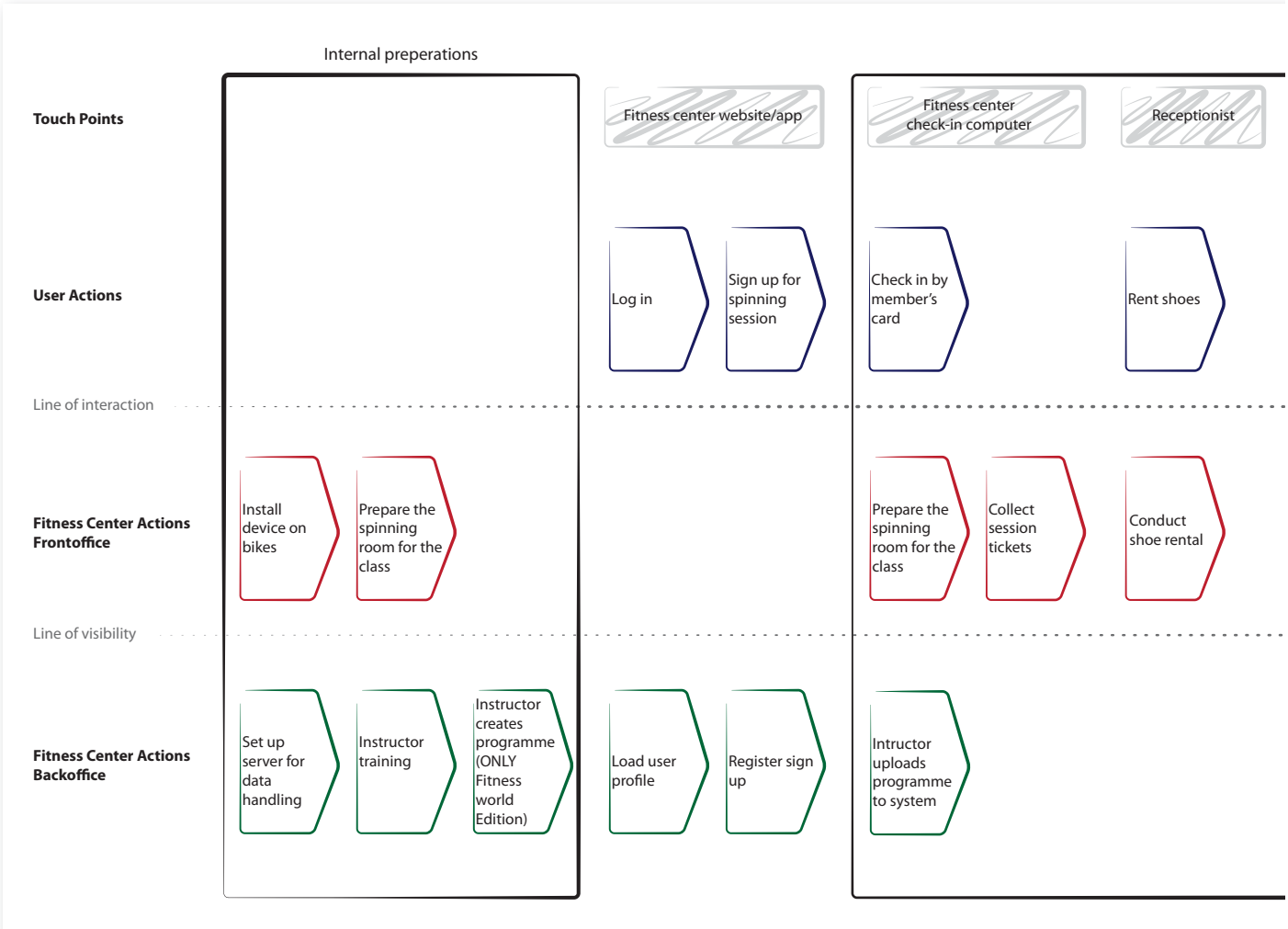
ill. 27 Birds in V formation

Phase 2 - Concept Development

Main Plan

To be able to provide the main concept 'Follow the Leader' it was first decided to make an add-on product for the new BODY BIKE Connect, but since this model is the most expensive bike in their product range it does not seem feasible to make a retrofit product which makes a light upgrade to a new expensive bike. Instead forcus changed to upgrading an older model, Classic or Classic Supreme, to exeed the functions of the Connect within the budget of the price difference between a new BODY BIKE Classic Supreme and Connect: DKK 3,200 excl. VAT. See Appendix 3 'Bike Prices'.

To derive workout intensity it is essential to be able to measure force and RPMs. A simple magnet-on-spoke induction setup, as for cycling computers, can provide the revolution speed and an easy force measuring solution was to use Look and Polar's KeO Power pedal. The only obstacle was the price tag of $ 2,500 for the KeO pedal. As a result a load cell or strain gauge is to be implemented to the final concept solution.



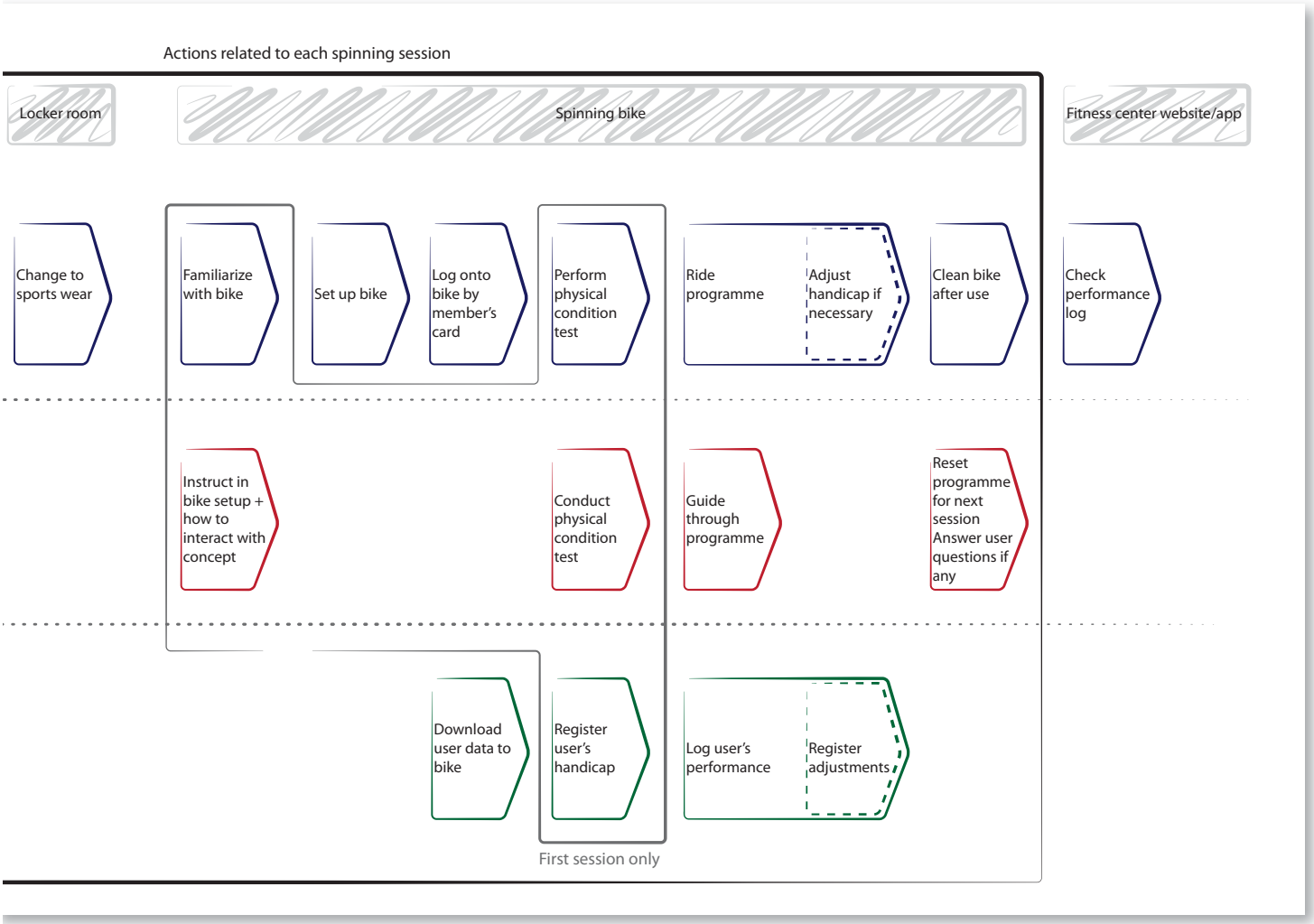
ill. 28 Service Blueprint - Overview of actors and actions involved in the service

Service Senarios

To the primary purchaser of rEvolution there are two main scenarios to consider; The 'Les Mills Edition' and 'Fitness World Edition'.

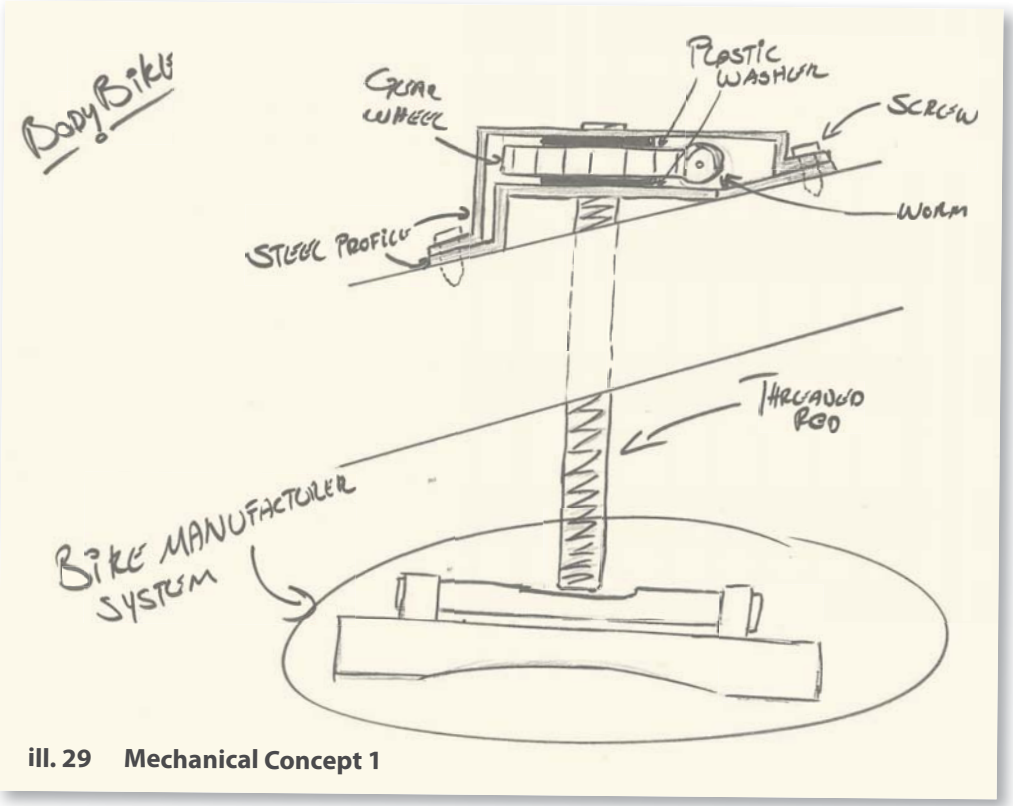
Les Mills workout programmes, with dedicated soundtrack, are planned by the headquarter and distributed to the individual Les Mills certified instructors on DVDs. Here the instructors only need education in concept handling - loading the correct programme and assisting the participants in interacting with the new concept.

In fitness centers employing freelance instructors it is, as well as the fore mentioned aspects, required to teach the instructors how to write a programme, mix the desired music tracks and test it to make sure it works when hosting a session.



Mechanical Solution Concepts

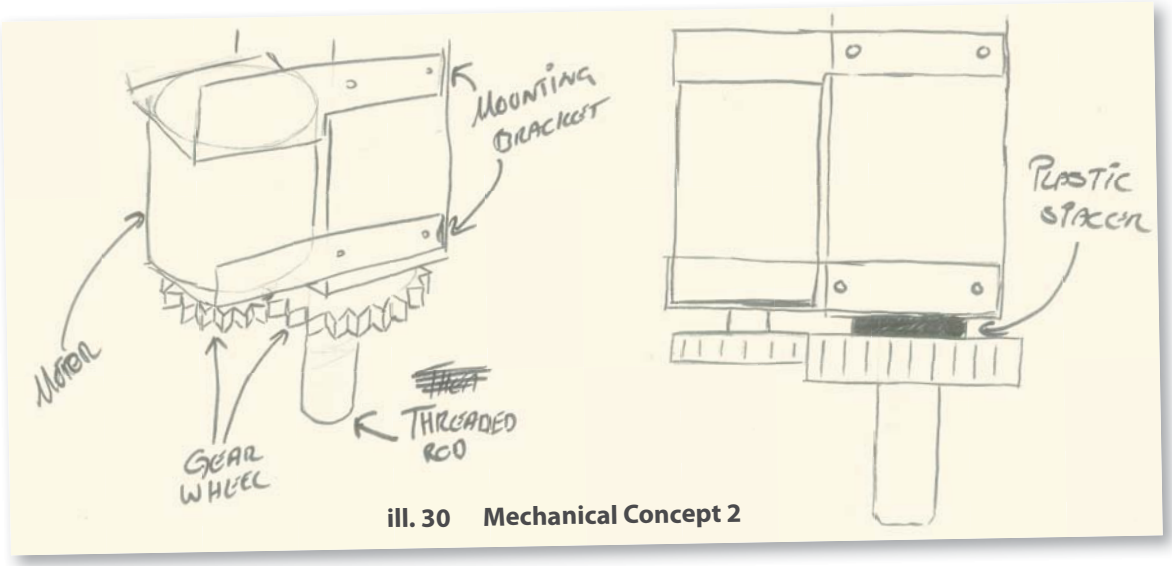
To ease installation on BODY BIKE Classic Supreme the goal is to replace the manual load applying mechanism with a similar automated mechanism. The intension is that no major modifications are necessary to perform the installation.



ill. 29 Mechanical Concept 1

By using a worm shaft on a cog wheel to move the rod up and down a fairly small electrical engine can apply a relatively great amount of pressure to the brake through a low ratio, high torque gearing.

The worm shaft produces less noise than two intersecting cog wheels and uses no power to keep the tension.



ill. 30 Mechanical Concept 2

Cog-on-cog gear drive with an appropriate gear ration makes a minimal space requiring and very simple solution for inside body installation. Here the threads in the vertical rod works as the worm shaft and prevents the brake from pushing the motor backwards when it is not active. Hereby the motor only uses power when adjusting the load and does not consume power in its passive states.

Power Supply Concepts

In order to provide the system with electrical power different solutions to power sources has been compared and discussed.

Since the product is fitted on an exercise bike that is driven by muscle power and has a rotating flywheel it would only be natural to adapt technologies from bicicle ligts to transform the rotating motion into electrical energy and make it selfsufficient.
Of course regular 230 volt power outlets are available at the given location but this solution raises an issue of up to 50 single power cables running along the floor to connect the bikes to the power grid.

Batteries are as well an easily implementet electrical source but how often will they have to be replaced - how energy efficient is it possible to make the solution?

ill. 31 Reelights

ill. 32 Bicycle Dynamo

Induction

Pros
Low maintenance
Does not affect the ride
No external cables

Cons
Uncertainty about power output
Might interfere with magnetic brakes
Toolless fitting on flywheel
Flywheel balance

Dynamo

Pros
Low maintenance
No external cables

Cons
Uncertainty about power output
Affects the ride
Difficult to fit on a bike with magnetic brakes


ill. 33 Batteries


ill. 34 Power Chord

Battery

Pros
Easy to fit
No external cables
Does not affect the ride

Cons
Continous battery replacement

Power Chord

Pros
Unlimited power
Easy to fit

Cons
Cable connection to every bike

Interface Screen Concepts

The aim of the display is for the user to have a 'spinning-GPS'. Its purpose is to enable the user to know, and navigate according to, where in the programme he or she currently is and what to expect further on.

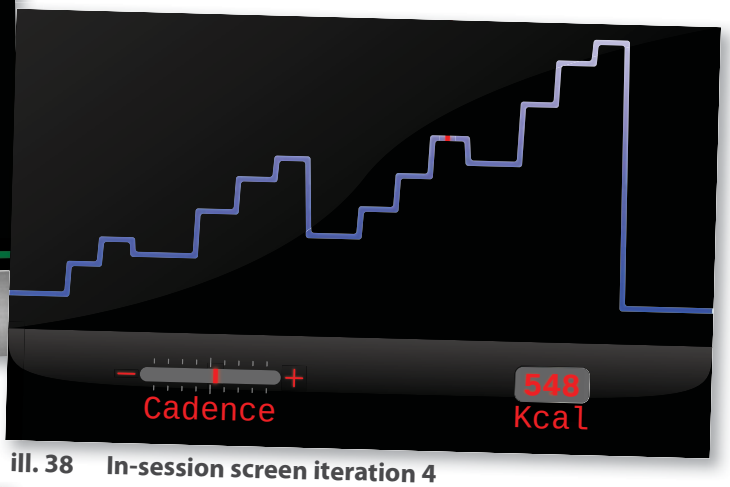
For the display a 3.7 inch monitor is chosen because of its small, but still readable size. This choice is proofed acceptable in comparing the different interface screens on different smart phones, such as HTC Desire S (3.7"), Sony Ericsson Xperia Mini (3"), Iphone 4 (3.5") and Samsung Galaxy S2 (4.3"), amongst fellow students.

During session only the most important information should be displayed to avoid taking focus from the workout; the session map, the given cadence and the resistance load.

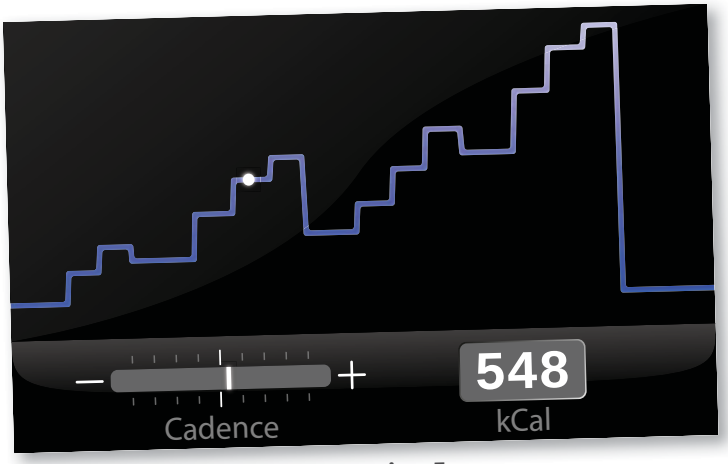
ill. 35 In-session screen iteration 1

ill. 36 In-session screen iteration 2

ill. 37 In-session screen iteration 3



ill. 38 In-session screen iteration 4



ill. 39 In-session screen iteration 5

The first iterations of in-session screens displayed time and heart rate, which through the project turned out to be less important. First iterations also took into consideration the current five intensity levels, but since the full session is mapped out and the intensity control is not longer up to the participant there is no reason to retain the intensity level division.

For some participants it can be hard to follow the beat of the soundtrack to maintain the right cadence. Therefore the display is equipped with a 'cadence-meter' which shows the participant's cadence relative to the instructor's. The bar will move to the '+' side if the participant's cadence is too high and towards '-' if too low. The correct cadence is in center of the meter.

Component Layout Concepts

ill. 40 **Bike layout sketch 1**

ill. 41 **Bike layout sketch 2**

ill. 42 **Bike layout sketch 3**

For the spinning concept to work several main components are cruzial to apply to the bike:

User interface	**Mechanics**
Display	Mechanical braking system
Controllers	Control box for braking system
Log in terminal	Power supply

These components are connected to the existing measuring and wireless communication systems on BODY BIKE Connect.

Through sketching on the Connect bike, and body storming, see Body Storming, page 15, a list of pros and cons is generated and taken into consideration.

Display
The best location for the display would be out of the 'sweat zone' and right in the user's eye sight. The only two locations out of the sweat zone are on the middle top part of the bottle rack or on the back of the saddle of the bike in front. Though, these positions are not optimal because of non linear bike arrangements in the gym and the bottle rack is very loosely mounted on the handlebars.

Controls
The controls should be more accessible than it is today. Inspiration on sketch 2 comes from Formula 1 car's paddle shifts for gear selection. Placed on the handlebar they are very accessible but leave a wiring issue for connection to the rest of the system.

Mechanics
It is desired to use as much of the existing braking mechanism as possible in order not to modify the bike frame and body excessively. Inside the body of the bike there is plenty of room for control box and power supply. Considering the braking system there might be a space problem if mounting the system inside the body in the current location. Therefore there is an opportunity for mounting the mechanism on top of the plastic body (here the green part) where the load knob is situated.

Cleaning
After every spinning session the bike are sprayed with a cleaning solution and wiped down from sweat. Therefore any external add-on should be easy to clean and not be sensitive to liquids.

ill. 43 **Final bike layout sketch**

Final Bike Layout

The final positioning of the components are as following.

The mechanical and electronic components for brake adjustment, such as motor, gear etc. are mounted inside the plastic body of the bike thus isolating it from the sweat and while protecting the user from moving parts.

The display, control buttons and card reader for log in are all located in one integrated unit in center of the handlebar.

The power supply consists of batteries charged by an induction principle. The batteries are placed in the top cover along with the mechanics.

Design Concepts - Body

Since rEvolution is an add-on to BODY BIKE Classic Supreme the design aesthetics has taken its offset in the existing body panels of the bike. The only body part to be replaced is the coloured top shell, which accommodates the electromechanics of rEvolution and shields it from dust, sweat and cleaning solutions while shielding the user from the moving parts inside.

rEvolution is about performance thoroughness and precision. Values which are represented in high performance sports and grand prix motorcycles as well. In the mood board, ill. ??, there is a clear tendency to gather the mass in front and make it significantly more slender towards the rear end in and aerodynamic streamlined shape.
Predefined design constraints to take into consideration are the body's side panels, the handlebar and seat post and adjustment screws, the electronic mechanical brake components and of course the user's limbs. Furthermore the profiles of the frame, in which the handlebar and seat posts are mounted, are made from powder coated stainless steel, so they are not vulnerable if exposed like on BODY BIKE Classic.

The geometry which mounts on top of the side panels are given by the existing top design, which has been purchased to measure and inspect. It is desired to blend the existing with the new design in the transition to make it an integrated part of the current bike. Still the new top part, along with the display console, is the visual recognition and signature of rEvolution.

ill. 44 Mood Board

ill. 45 Sketch 2.2

ill. 46 Sketch 2.3

ill. 48 Sketch 2.5

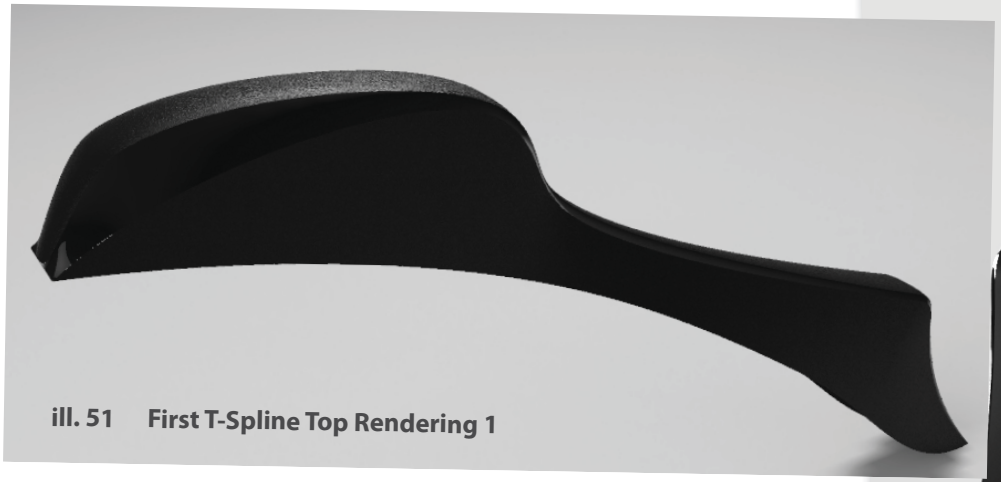
ill. 47 Sketch 2.6

ill. 50 Sketch 2.8

ill. 49 Sketch 2.9

As a quick tool for sketching and visualising new designs is used a pen tablet in Photoshop for rendering on top of the original design.

Further through the process T-Splines, a plug-in for Rhino, has been used to mock up models.



ill. 51 First T-Spline Top Rendering 1

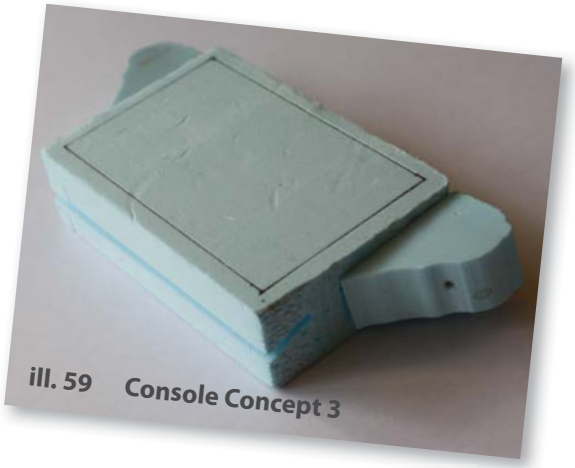
ill. 52 First T-Spline Top Rendering 2

Design Concepts - Display Unit

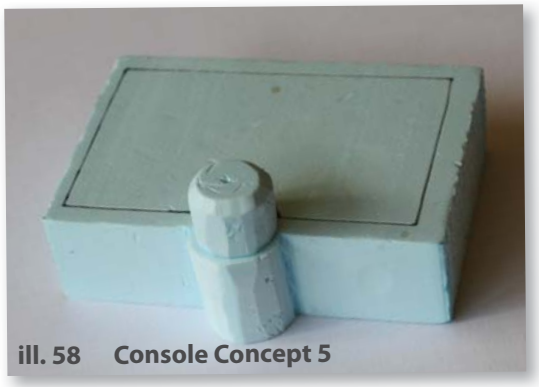
For display unit concepts a variety of models have been made. Touch screen has been overruled due to the moist environment and wet fingers when operating.

It has been taken into consideration to have buttons on the side of the console and track wheel and touch pad-like scroll functions as well. Even eye tracking has been discussed but has not been considered due to the fact that when in use the head is always moving.

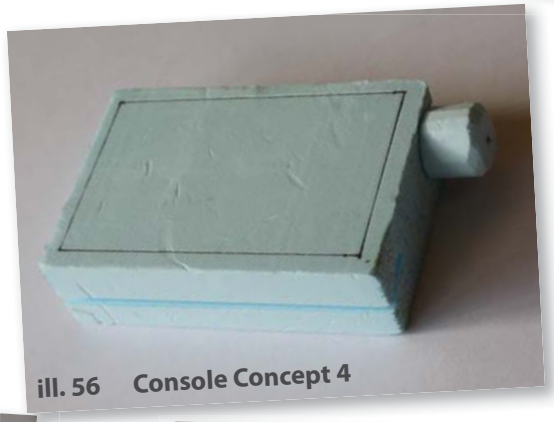
The different concepts are tested in 'Body Storming', page 15.



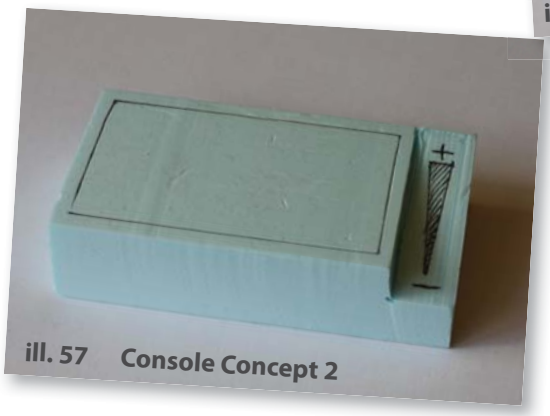
ill. 59 Console Concept 3



ill. 58 Console Concept 5



ill. 56 Console Concept 4



ill. 57 Console Concept 2

ill. 55 Console Concept 1

ill. 54 Sony PSP

ill. 53 TOMTOM GPS

ill. 60 Display Console Concept 1

ill. 62 Display Console Concept 3

ill. 61 Display Console Concept 2

Phase 3 - Concept Detailing

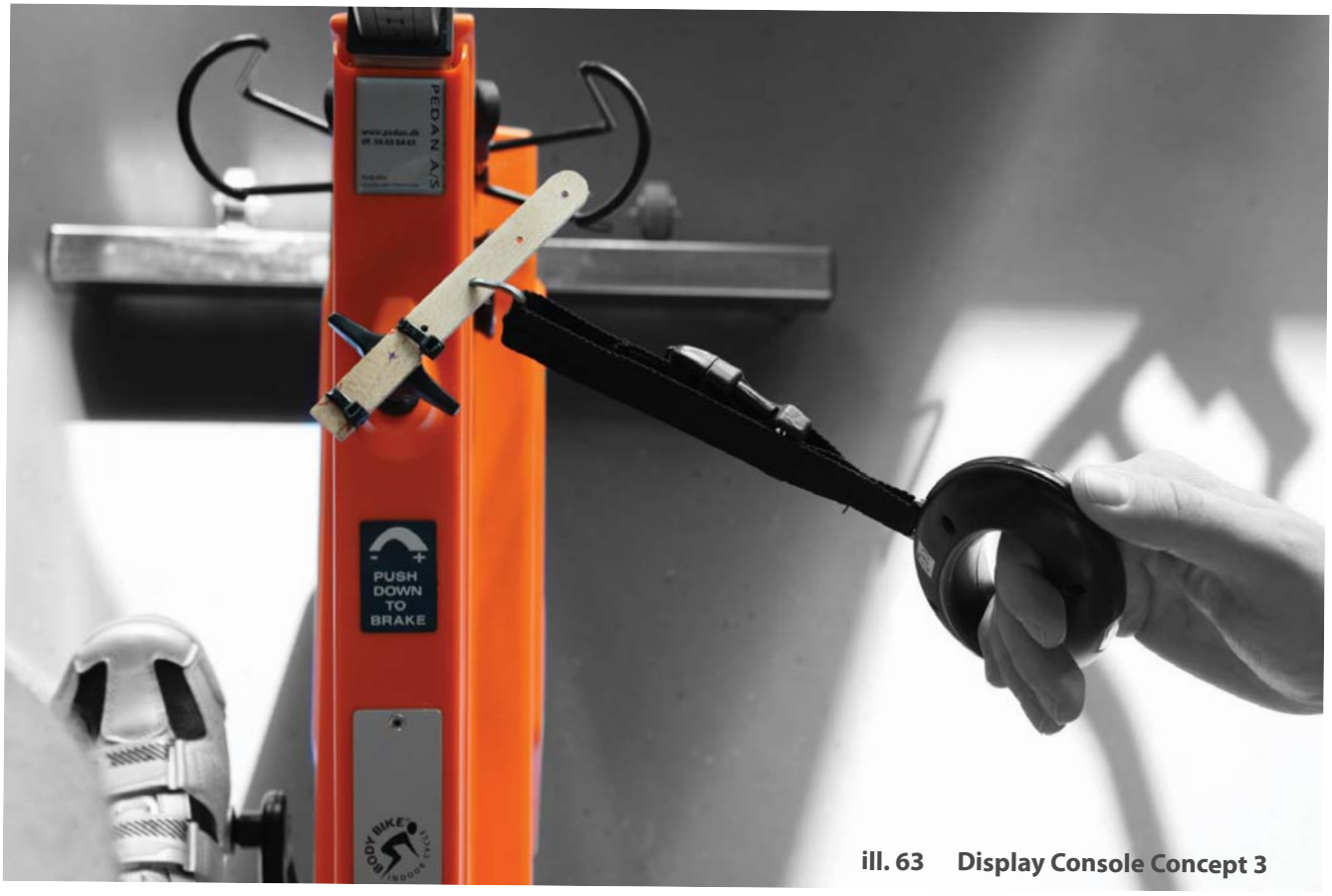
In phase 3 the specific components of the Concept phase are defined by the individual requirements.

Torque Requirement Estimation

To determine the amount of torque needed to drive the brake pad to brake an experiment has been executed.
The test setup is made up of a wooden rectangular rod, with holes drilled through at a spacing of 25 mm to slip a hook into and pull on it with at baggage weight. In this way it is possible to measure the kilograms at a given length and thereby calculate the torque which is needed to make the screw turn.
At a length of 40 mm from the centre of the screw the readings were somewhat coincident, the maximum load reading was 3,56 kg.

Max load	43,92 N
Torque arm	40 mm
Torque	1394,96 mNm
+30%	1816,03 mNm

The torque needed to drive the screw is 1816,03 mNm and it is unlikely a motor which can produce this amount of torque can fit on the frame of the bike. This means a gearing will be needed to increase the torque and decrease the speed.



ill. 63 **Display Console Concept 3**

Motor and Gear Requirements

For the mechanical concept to work a motor is needed to drive the brake pad onto the flywheel to give resistance to the rider. The motor needs to be a small electrical motor with a cross-section of on more than 40x40 mm. The motor need to be precise to secure it will stop exactly when it is needed so the load will be the same every time the same programme is run on the bike.

The demands for the motor:

- Needs to start/stop precisely
- Cross section cannot exceed 40mm x 40mm
- Have the lowest possible profile
- High torque

For this concept the most important demand is the precision of the motor. That is why a stepper motor has been chosen. The stepper motor is produced by Anaheim Automation and is called 15Y203S-LW4 the most important facts of the motor is listed below. See Data Sheet Appendix 4.

Motor Length	38,10	mm
Shaft Length	23,88	mm
Width	39,12	mm
Height	39,12	mm
Torque output speed	282,462	mNm
Step Angle	1,8	deg.
Voltage	5,6	V
Current	0,85	A
Weight	394	g

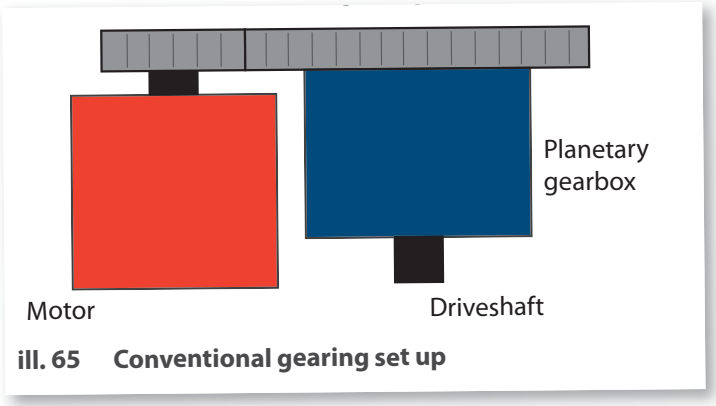
As seen in the scheme the motor has 282,462 mNm of torque which is not enough to power the brake system. It is considered a gearing of reasonably size which will fit on the bike frame can increase the torque.

$$\text{Gear Ratio} \quad \frac{\text{Needed Torque}}{\text{Motor Torque}} \Rightarrow \frac{1816{,}03\ \text{mNm}}{282{,}462\ \text{mNm}} = 6{,}43$$

The gearbox needs to increase the motor torque 6,43 times, and this is considered possible.

The stepper motor needs a controller to manage when to turn and how much to turn. It will be a controller which is manufactured by schmalzhaus.com which can control any stepper motor, with a 7V to 30V power supply. The controller is called EasyDriver v.4.4.

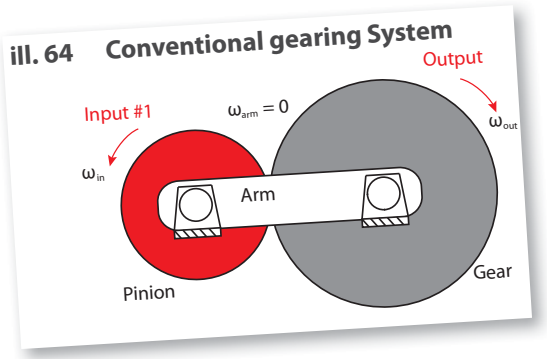
A gearing is needed in the mechanical system which controls the brake, to ensure enough torque and the right amount of revolutions per minute.



ill. 65 Conventional gearing set up

To tighten the load screw on the spinning bike a force of 1816,03mNm is required. To get this force from the desired motor size a gearing is needed. The gearing is going to increase the torque the motor produce and reduce the speed. The smallest pinion able to fit on the motor is 6mm in radius. With a normal gearing with a pinion wheel and a gear wheel the gearing will be as follows:

ill. 64 Conventional gearing System



Motor power	282,642	mNm
Desired power	1816,03	mNm
Pinion radius rP	6	mm
Gear radius rG	?	mm

$$rG = rP \times \text{Gear Ratio} \Rightarrow rP \times \frac{\text{Needed Torque}}{\text{Motor Torque}}$$

$$rG = 6\ \text{mm} \times \frac{1816{,}03\ \text{mNm}}{282{,}642\ \text{mNm}}$$

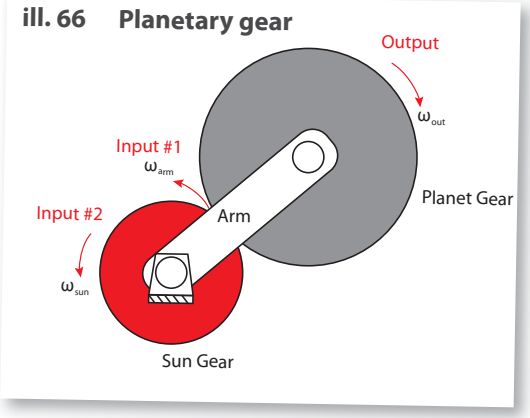
$$\underline{\underline{rG = 38{,}58\ \text{mm}}}$$

With a radius of 38,58mm the gear wheel will be too big to fit on the bike frame which is 40mm wide. Due to this, another gearing is considered. The gearing type known as Planet- or Epicyclic gearing is a gearing with two degrees of freedom instead of one in a normal gearing, can achieve the same gear ratio in smaller spaces than conventional gearing.

It is important the brakeing system does not expand beyond the width of the frame of the bike, because that would involve a risk of the participant bumping his knees into it while riding.

With a planetary gear consisting of standard gear components a sun gear, planet gear, arm and ring gear the gearing will be as follows. The ring is stationary the arm is input with a ω_{arm} of 1rpm, the last gear in the train ω_L is the ring which has no velocity and ω_F is the unknown.

ill. 66 Planetary gear



SUN	10
PLANET	20
RING	45
ω_F	?
ω_L	0
ω_{arm}	1

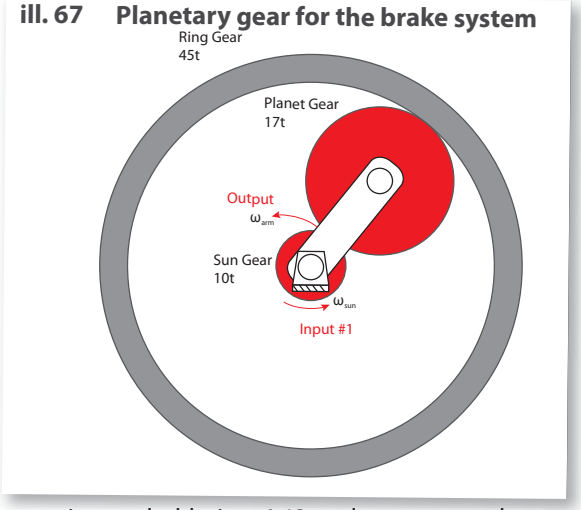
$$m_v = \left(-\frac{SUN}{PLANET}\right) X \left(\frac{PLANET}{RING}\right) = \frac{\omega_L - \omega_{arm}}{\omega_F - \omega_{arm}} =>$$

$$m_v = \omega_F X \frac{PLANET}{RING} + 1 => \underline{m_v = 5{,}5}$$

ill. 68 Planetary Gear Drill

This calculation determines the angular velocity ratio when the arm is the input in the train and the sun is the output. However in the train for the brake system the sun is the input and the arm is the output, this results in the brake system having a torque ratio equal to the angular velocity ratio in this calculations.

ill. 67 Planetary gear for the brake system



With the Gear ratio needed being 6,43 a planetary gearbox with more than one gear train is needed, if the size of the gears matches the ones in the calculation.
To create the lowest profile of the motor and gear combination the two parts will be mounted next to each other. To transfer the power from the motor to the gearbox a "transfer gearing" of pinion and a gear wheel which can be of the same size.

The gearbox chosen for the brake system is a planetary Portescap gear size 11, the full specifications for the gearbox is found inAppendix 5. The most important specifiacations are:

Gear Ratio	7
Max torque output	2.600 mNm
Efficiency	90-95 %
Rotation output	Same as input

(Norton2006)

Power Supply

Main electro-mechanics

The power supply needed to drive the motor, have to work in small intervals over a period of 50min a spinning class lasts.
The dynamo generator will apply extra resistance to the flywheel making it extra tough to participate in a spinning class. The idea to use normal power output and transfer the power to the system with a cable will is undesirable because it will be much harder to clean the floor and people may trip and fall in the cables. Batteries would work well, but have a big disadvantage that they will need to be replaced once in a while and because not all bikes are used equally it will be at different times and this would require more maintenance with the bikes. The induction is a maintenance free technology but it does not develop the desired power to drive the motor.
It is chosen to combine the induction and batteries concept into one, so the batteries will give the power the motor needs and the batteries will recharge throughout the spinning class with the induction.
In a spinning class with an instructor who like to drive short distances before adjusting the load, a participant will adjust the load 30 times over the course of 50 min. It is estimated the motor will need to run for 2 seconds to make the adjustment needed. The motor needs to be active a total of 60 seconds throughout a spinning class of 50min. If a fitness center offers 27 spinning classes a week the motor will be active 27min a week.

Motor		ANT Transciver		Motor controller	
V	mA	V	mA	V	mA
8,4	700	3,0	0,24	8	70

Ib is Battery Capacity
Id is Current Consumption

$$\text{Battery life} = \frac{Ib}{Id} \times 0{,}7 \Rightarrow \frac{300\ mAh}{700\ mA + 0{,}24\ mA + 70\ mA} \times 0{,}7 = 0{,}27\ hours$$

$$0{,}27\ hours \times 60 = 16{,}36\ min$$

On a standard 9V battery the motor and ANT transceiver will be able to run for 16 classes. When two standard Relight induction system which deliver 4,8V and 54mAh is mounted in series on the bike it will charge with 9,6V and 54mAh, see ill. 67 and ill. 68.

Cc is Charge Capacity

$$\text{Charge time} = \frac{Ib}{Cc - 20\%} \Rightarrow \frac{300\ mAh}{54\ mA \times 0{,}8} = 6{,}9\ hours$$

With this setup the 9V battery will be fully charged in the course of 9 spinning classes.
With this setup the battery will in theory not be completely discharged, however, it is possible the battery will be worn over time and not have the same capacity, so a replacement might be necessary.

Display Console

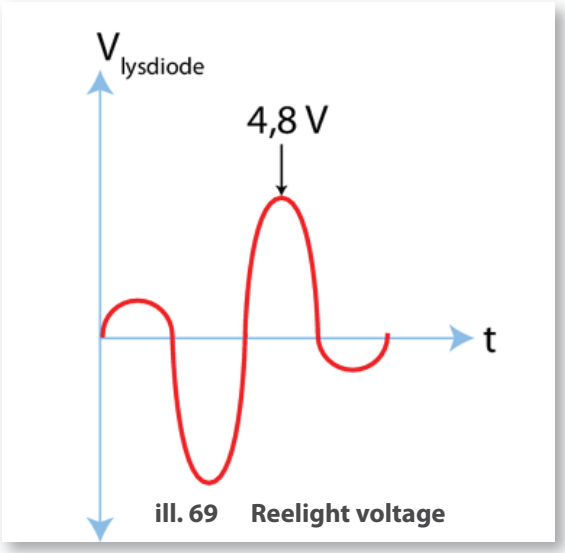
The display is not connected to the power source described above because it is not desirable to have cables running up to the handlebars due to the adjustment which happens every time a new participant comes to the bike.

The display need 3,3V and 2,3mA and the display driver need 0,4mA and an ANT transceiver need 0,24mA. With two AAA alkaline battery of 1,5V and 1200mAh the battery life is cal-

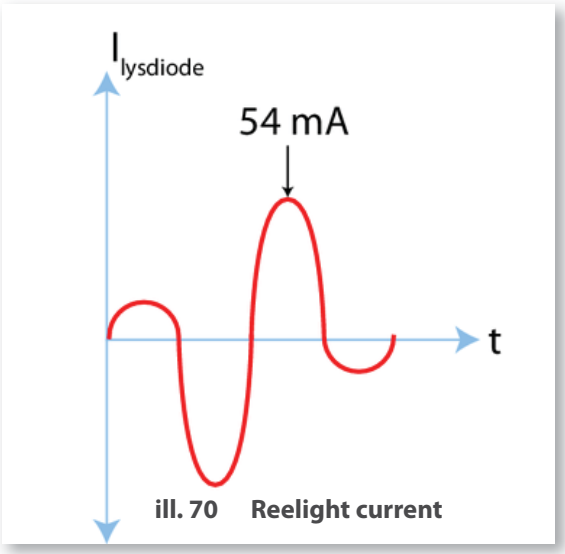
$$\text{Battery life} = \frac{Ib}{Id} \times 0{,}7 \Rightarrow \frac{1200\ mAh}{2{,}3mA + 0{,}4\ mA + 0{,}24\ mA} \times 0{,}7 = 285{,}7\ hours$$

$$\frac{285{,}7\ hours}{50\ min}\ 342{,}9\ classes \Rightarrow \frac{342{,}9\ classes}{27\ \frac{hours}{week}} = 12{,}7\ weeks$$

The fitness center can run the bikes for 12,7weeks before they will need to change the batteries.



ill. 69 Reelight voltage



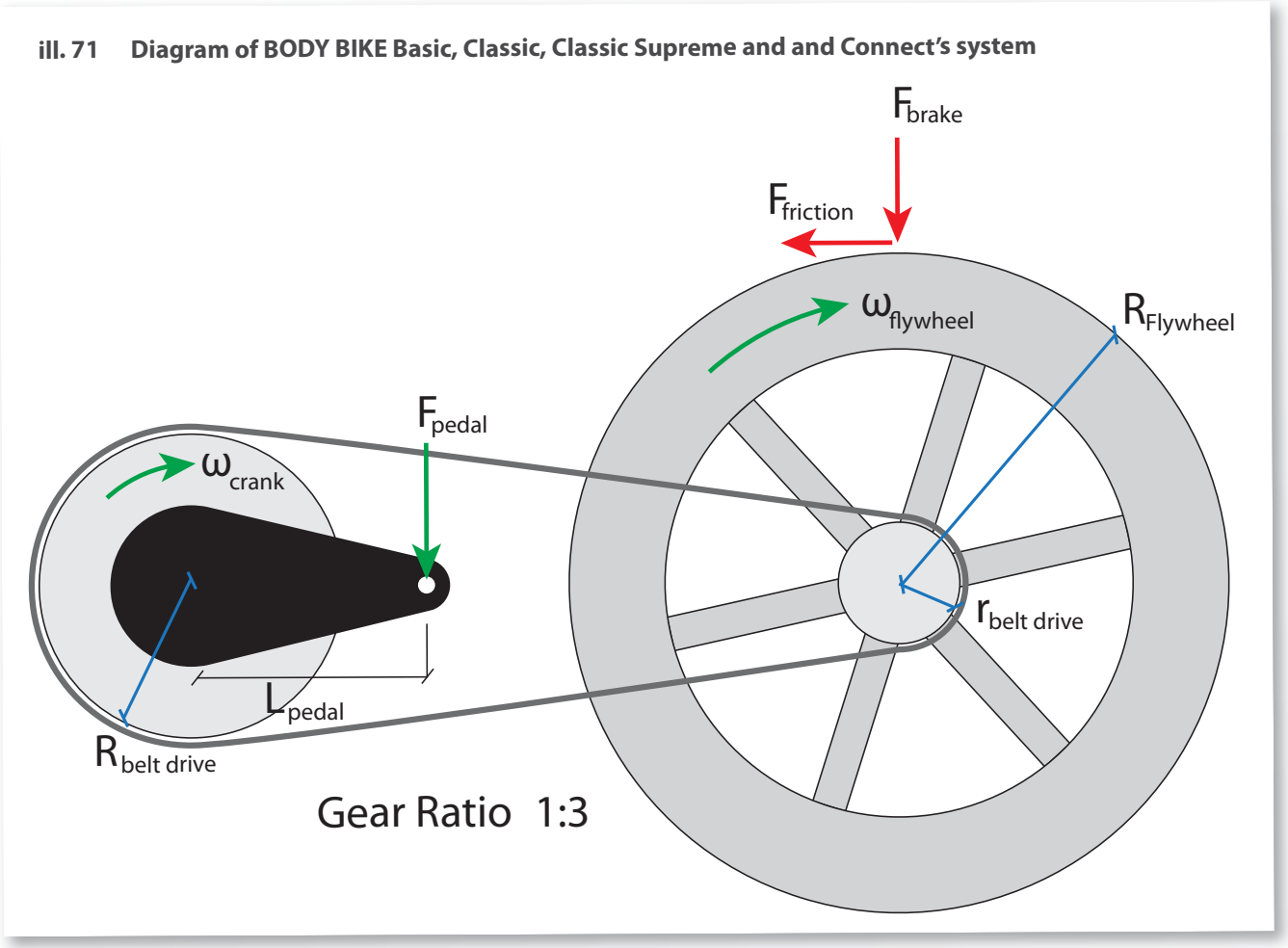
ill. 70 Reelight current

Performance Energy Calculations

To calculate the energy consumption of the bike the working forces of the system, the cadence and the systems geometry is required.

It is considered simplified as a system at constant velocity with energy consistency - resistance in bearings and wind resistance inside the bike's shell are neglected, so input power is equal to the brake's power consumption.

ill. 71 Diagram of BODY BIKE Basic, Classic, Classic Supreme and and Connect's system



First requirement is momentum equilibrium for center crank and center flywheel.

$$M_{c,flywheel} = F_{friction} \cdot R_{flywheel}$$

$$F_{friction} = F_{brake} \cdot \mu_{kevlar/metal}$$

$$M_{c,crank} = F_{pedal} \cdot L_{pedal}$$

$$R_{flywheel} = 0{,}25\ m$$

Friction coefficient is not currently available
– estimated equal to wood on machined metal

$$\mu_{kevlar/metal} = 0{,}35$$

$$L_{pedal} = 0{,}2\ m$$

Power [W] is the product of momentum and angular velocity.

$$P_{input} = P_{output}$$

$$P = M \cdot \omega$$

The gear ratio from belt drive is as following

$$R_{belt\ drive} = 0{,}12\ m$$

$$r_{belt\ drive} = 0{,}04\ m$$

$$Ratio = \frac{r_{belt\ drive}}{R_{belt\ drive}} = \frac{0{,}04\ m}{0{,}12\ m} = 3 => 1:3$$

Hence

$$M_{c,crank} \cdot \omega_{crank} = M_{c,flywheel} \cdot \omega_{flywheel} = M_{c,flywheel} \cdot 3 \cdot \omega_{crank} =>$$

$$M_{c,crank} = 3 \cdot M_{c,flywheel}$$

and

$$\omega_{crank} = \frac{1}{3} \cdot \omega_{flywheel}$$

So

$$P_{input} = M_{c,crank} \cdot \omega_{crank} = M_{c,flywheel} \cdot \omega_{flywheel} = M_{c,crank} \cdot 3 \cdot \omega_{crank}$$
$$= F_{brake} \cdot \mu_{kevlar/metal} \cdot R_{flywheel} \cdot 3 \cdot \omega_{crank}$$

To dictate a required power input level, at a constant cadence, the stepper motor controller unit needs to calculate how much braking force to apply by following formula, where F_{brake} is isolated.

$$F_{brake} = \frac{P_{input}}{(R_{flywheel} \cdot \mu_{kevlar/metal} \cdot 3 \cdot \omega_{crank})}$$

For calculations RPM needs to be converted into angular velocity ω[rad/s]

$$\omega[rad/s] = \frac{x\ RPM}{60\ s} \cdot 2\pi$$

Example
Calculation of required braking force F_{brake} to set the input performance to 200 W at 100 RPM.

$$\omega_{flywheel} = 3 \cdot \frac{100\ RPM}{60\ s} \cdot 2\pi = 31{,}42\ rad/s$$

$$F_{brake} = \frac{200\ W}{(0{,}25\ m \cdot 0{,}4 \cdot 31{,}42\ rad/s)} = 72.76\ N$$

Top Shell Design

The reason for the shape of the shell, is it must cover up the mechanics, form follows function. Furthermore the shape of the shell gives the bike a more dynamic look, by imitating the gas tank of a motorcycle, see 'Design Concepts - Body', page 27.

The original top shell enclosed the part of the frame in which the seat post was mounted. This part is now stripped to make it 'lighter' in the rear end, emphasizes the forward direction of the bike and reveals the rough and rigid expression of the frame.
This part of the frame is made from powder coated stainless steel, black or metallic silver, and is not vulnerable to corrosion in any way - on BODY BIKE Classic it is exposed as standard.

ill. 72 BODY BIKE Classic Supreme - rEvolution

ill. 73 rEvolution Top Shell Ribs

Inside the shell are ridges to secure the shell rests on the top of the frame, stabilize the walls and create the necessary space between the frame and the shell to house the mechanics. In the front of the shell, under the 'hump' the mechanics are mounted.

ill. 74 rEvolution Top Screw Towers

To hold the shell in place, and make the entire assembly more rigid the shell is mounted to the top of the mechanics with six screws.

Display Console Design

The display console is designed in relation to the top shell, taking offset in the TOMTOM GPS and Sony PSP, ill. 51 and ill. 52 in Concept Development.

ill. 75 Display Console 1.1

Mounting

The monitor is mounted on center handlebar to provide a good viewing angle and easy access to adjustment buttons. Due to screen glare it is necessary to coat the display surface with an anti-reflection treatment. The display console is mounted in the middle of the naked piece of the handlebars. So when the spinning participant have his hands on the straight area of the handlebars the buttons will be at the thumbs of the participant.

Card Reader

The card reader slot is placed on the lower edge closest to the user. Mounted on the handlebar it is slanting slightly downwards so liquids will not interfere with the reader head.

ill. 77 Display Console Mounting Bracket and Card Reader Slot

Control Buttons

The system on the bike is in the ultimate calibrated scenario meant to run all by itself, and the system will, as long as the participant are steady at the same handicap. When the participants physical condition alters, due to the workout and he improves his stamina or in another case after being absent from the gym over a longer period of time e.g. due to holiday or other. When the participant improves his stamina to an extend where the handicap given by the intro-class no longer challenges him, he will as the challenge diminishes increase the handicap over the course of a class, by the buttons on the side of the display unit.

ill. 76 Display Console Mounted

Material Details

Besides a new and improved top shell to cover up the mechanics, another three components will secure the motor and the gearbox. The material chosen for the shell, the motor-gear shell-mount and the motor/gear top- and bottom mount will be defined in this chaptor.
The forementioned components are designed to be manufactured from injection molded plastic.

To cope with the stress from the pressure generated by the motor and gearbox and forces of impact from body parts or shoes, the material needs to be strong and tough so it will not have plastic deformation if exposed to these forces.

The material for the four components need to be resistant to sweat and light detergents.
Sweat is a salty and acidic liquid which is why the material need to be resistant to week acids and salt water. At the same time the cleaning detergent, used after the spinning class to wipe down the bikes, is a week alkali, to which the material also need to be tolerant.
The required characteristics of the plastic used for the three components are:

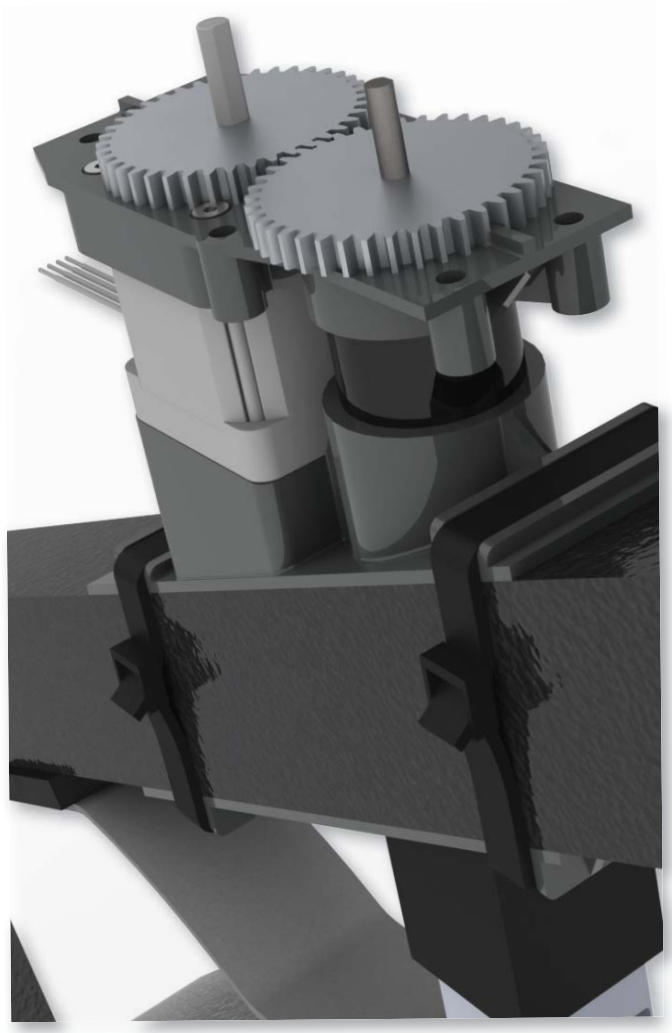
Yield Strength	10 MPa
Price	10-15 DKK/kg
Resistances	
Salt water	Very Good
Weak acids	Good
Weak alkalis	Good

The material chosen for the four components is ABS, it is within the price range, have a high yield strength and is resistant to all the critical substances it will be exposed to.

Shell
The top shell which shields the mechanics from the surroundings is the largest visible part of the project and it will need to be resistant to kicks and scrapes from fixed-pedal shoes. The surface will be semi-rough to avoid the scratches will be seen in the surface. Though to give the shell a direction, making it more masculine the top of the shell will be in a smoother surface finish.

The top shell will have a surface finish of Mold-Tech MT11540 which have a depth of 46µ.

Display
The display is constructed of two shapes, a semi-organic top part facing the spinning participant and a back part which is screwed on the front, with a rubber sealing in-between. Both parts of the display will be moulded from same type of ABS as the Shell. The buttons on the console have a flexible membrane from ?? moulded as a second component.

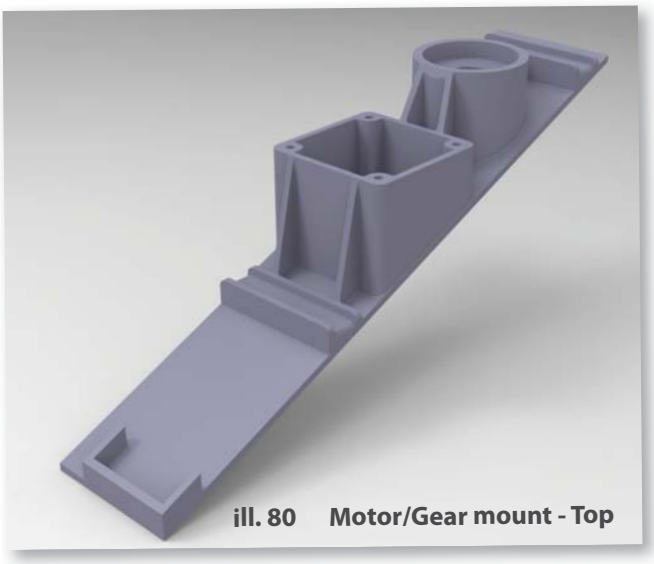


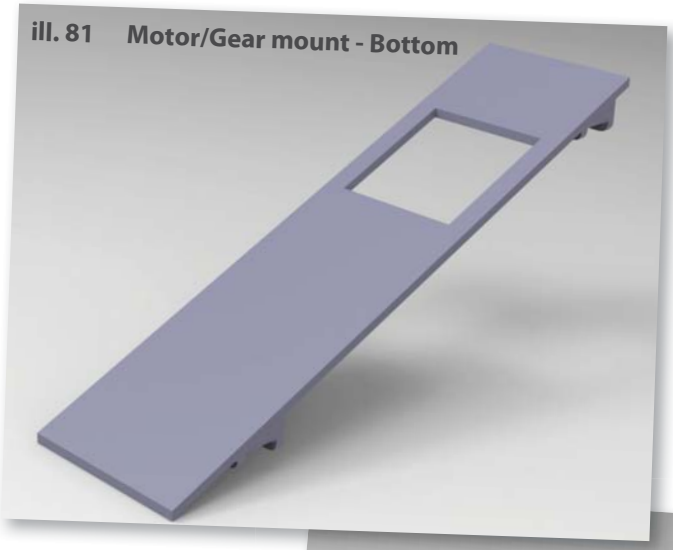
ill. 78 Motor and Gear Mount

ill. 79 Console Bottons 2 Component Molded

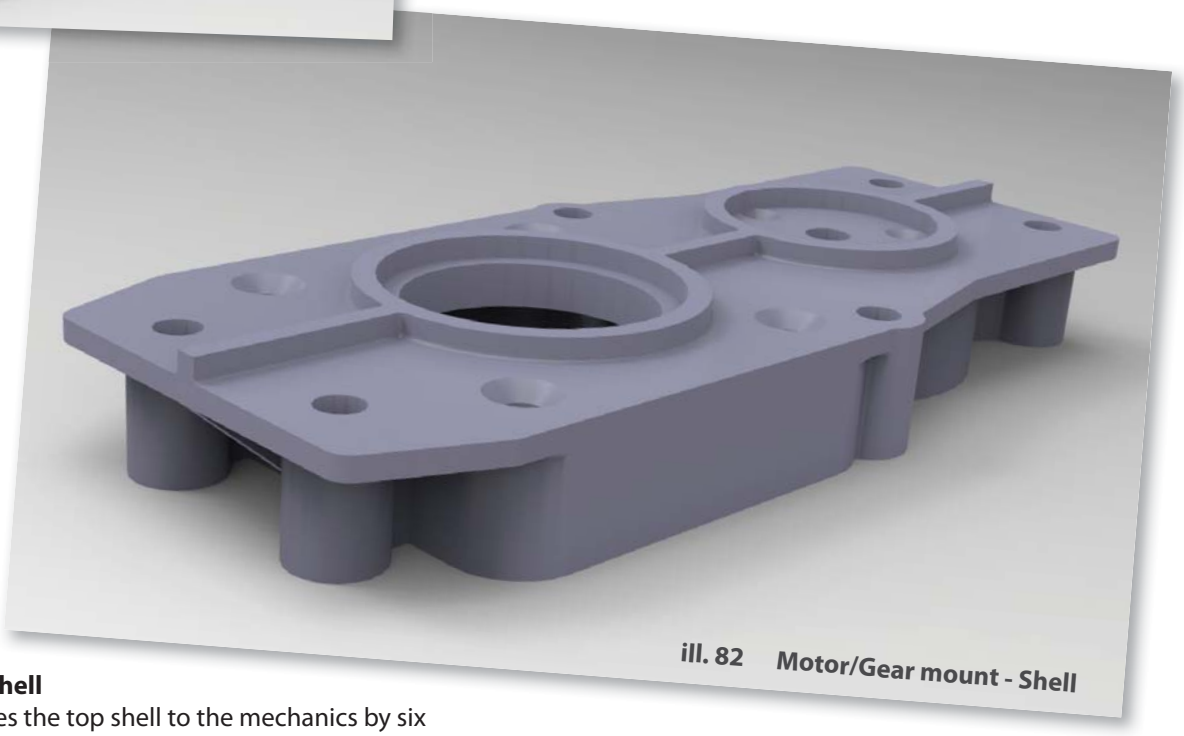
Mounting Component

Motor/Gear mount - top
The part holds the motor and gearbox in place on the bike frame. The gearbox is press fitted down into the part and the motor will be fitted with bolts from the top through the 'Motor/Gear mount - shell'.
Working drawing Appendix 11


ill. 80 Motor/Gear mount - Top


ill. 81 Motor/Gear mount - Bottom

Motor/Gear mount - bottom
This part has one purpose which is to secure the 'Motor/Gear mount - top' on the frame by being slid over the part which holds the screw, brass nut and brake block. The top and bottom 'Motor/Gear mount' is held in place by cable ties, because it is easy, everyone knows how they work and it avoids making destructive steps to mount the rEvolution product.
Working drawing Appendix 12


ill. 82 Motor/Gear mount - Shell

Motor/Gear mount - shell
The 'shell mount' secures the top shell to the mechanics by six bolts which also works as decorative objects.
Working drawing in Appendix 13

Finite Element analysis

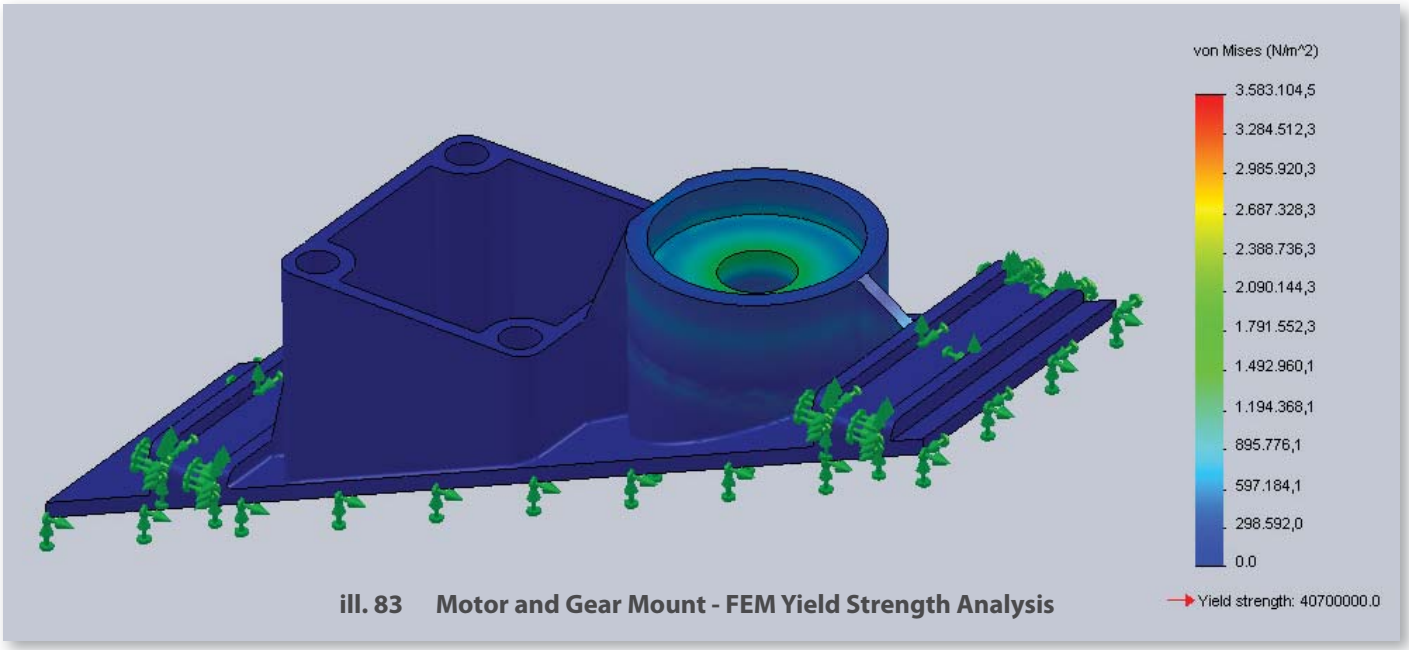
In the construction of the braking system are three different parts. One part to screw the motor and the gear box onto the inside of the shell, and two parts which will act as guidance for the motor and gear box on the frame of the bike, of which the upper part is the most critical.

It is estimated that a load of 30 kg, 300 N, pushing down on the flywheel will stop the rotation, no matter how much the athlete works the pedals. With this force pushed down on the flywheel a resultant force will work the opposite direction and apply force on the mounting fixture which holds the gearbox in place.

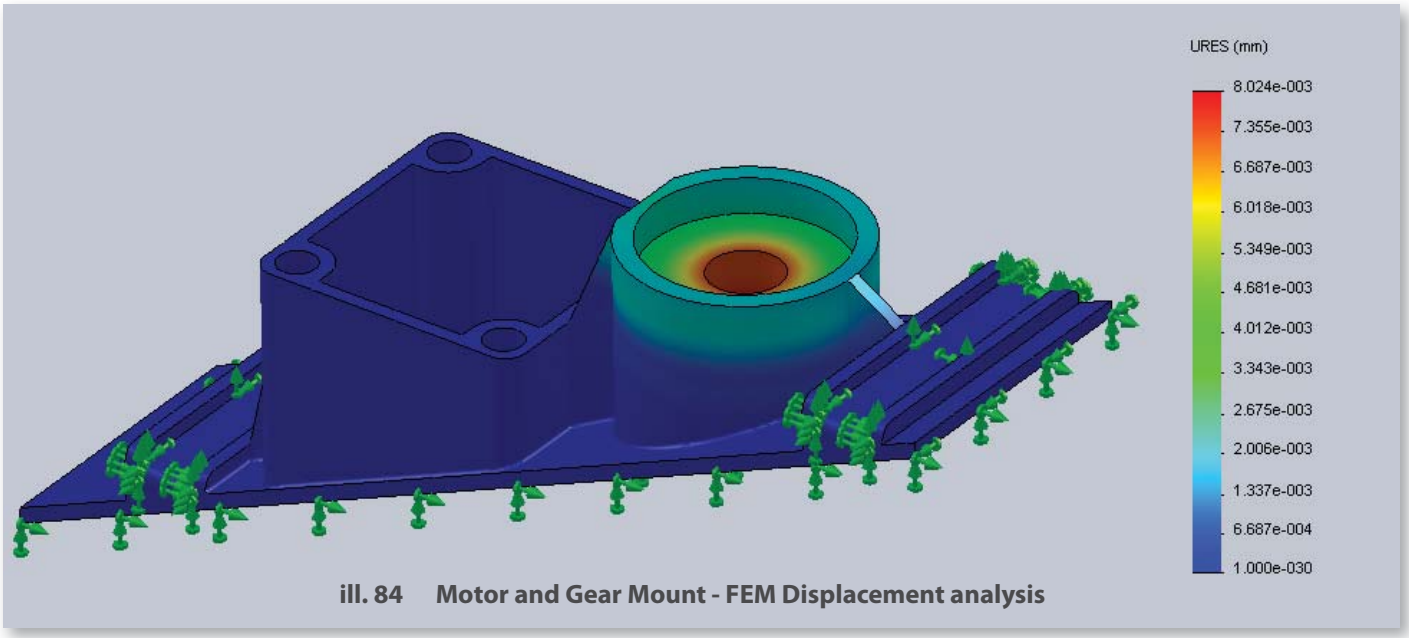
The illustrations show the design of the part which secures motor and gearbox to the frame, which is exposed to this resultant force.

A Finite Element Analysis has been executed on the part as seen in ill. 83 and 84, the same part as ill. 80.
The resulting stress (Von Mises yield criteria) is 3,6MPa and the unfilled ABS has a tensile strength of 40,7MPa, thus the construction can easily absorb the force.

With the stress, being as low as it is, the displacement of the model is 0,008 mm which is highly acceptable.



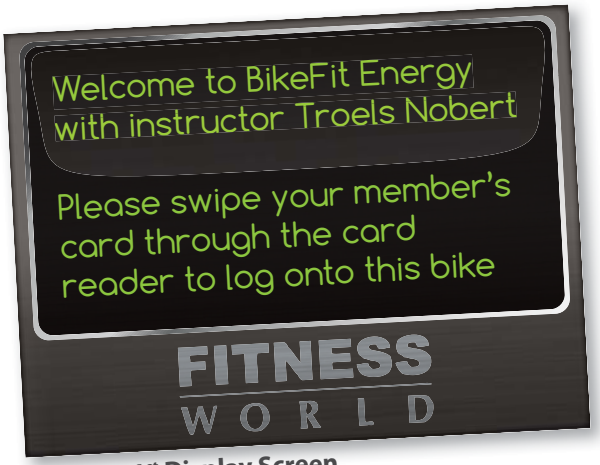
ill. 83 Motor and Gear Mount - FEM Yield Strength Analysis



ill. 84 Motor and Gear Mount - FEM Displacement analysis

Display screens

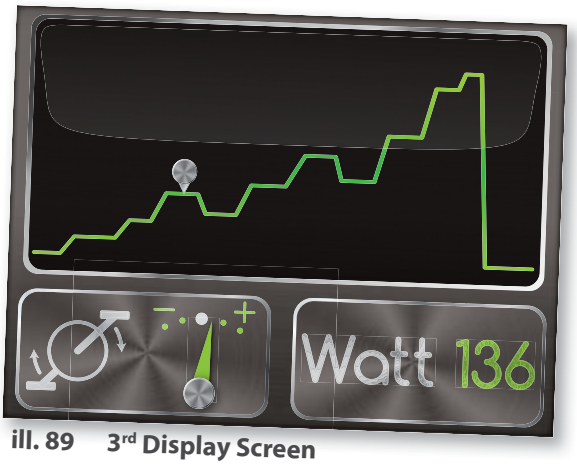
The final layout of the display screens feature a text screen communicating how to log in, and where to find the log of your performance. Also there is an in-session navigator screen which displays a map of the current workout, a cadence meter and the resistance load in Watts and a post-session log screen with the same session map and a slider, so the user can review the performance at any given time through the session. Additionally the total calorie burn, average wattage and handicap value are listed. All displays are illustrated in real size, except the app screen which depends on the screen size of the user's smartphone.



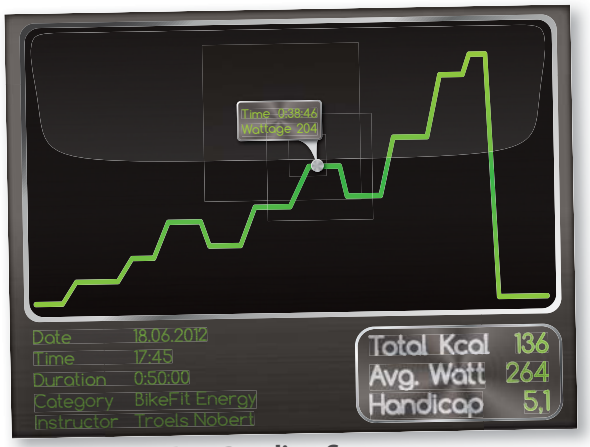
ill. 85 1st Display Screen

ill. 86 2nd Display Screen

ill. 87 4th Display Screen



ill. 89 3rd Display Screen



ill. 88 App Log Reading Screen

Price Estimate

Cost price

To determine a cost price it is necessary to determine a sales price for the product to know how much money is able to use to build the product. The basis for this is the BODY BIKE indoor cycles, the Connect cost 11.500DKK and the standard BODY BIKE Classic Supreme cost 8.299DKK, the difference is 3.201DKK. This product should be able to compete with the BODY BIKE Connect when bought with a BODY BIKE Classic supreme, but because the product offers more than the Connect bike 3.500DKK is set as final sales price.

Target cost price

Sales price to fitness center	3.500 DKK
Retailer sales price	3.500 DKK
Retailer turnover (100%)	1.750 DKK
Sales price to retailer	1.750 DKK
Company contribution margin (100%)	875 DKK
Company cost price	875 DKK

the list above shows a cost price of 875DKK which is the desired cost price for the product.
To determine the exact cost price of the product a Bill Of Materials/processes(BOM) is made with the purchased and manufactured components, together with the processes made in the manufacturing and assembly.

Cost price

Purchasing	918,20 DKK
Production	17,71 DKK
Manufacturing	8,04 DKK
Assembly	36,83 DKK
Total price	980,79 DKK

The exact cost price is higher than the desired cost price by 105,79DKK however, it is considered the project will still make profit despite of this.

To determine how much money will need to be invested in this project to make it reality a development budget is made, considering further development, expenses to models, tools and marketing.

Development budget

Salary for further development	187.500 DKK
Models	60.000 DKK
Tools for production	382.840 DKK
Marketing	15.000.000 DKK
Total cost	15.630.340 DKK
Unforeseen expenses 10%	1.563.340 DKK
Total	17.193.374 DKK

17+ millions is a large development budget, however, the biggest post being marketing is not used all at once, it is spread over the years the product is on the market, with most of the money used in the beginning.

From knowing the sales of the largest suppliers of indoor cycles with mechanical brakes, together with a PLC curve it can be determined how many products will be sold as an upgrade to new indoor cycles. However, many bikes are in use in fitness centers, and they can all be upgraded with this product, this makes it difficult to determine exactly how many products can be sold. The basis of the sales calculation is the new indoor cycles from the three largest manufactures, Star Trac, Tomahawk and BODY BIKE.

Sales of new indoor cycles

Star Trac	60.000	psc
Tomahawk	25.000	psc
Bodybike	12.000	psc
Total	97.000	psc

It is estimated this product will be on the market for 10 years, before an update of the product is needed to make it competitive again.
To get a perspective on the product life on the market a calculation on the turnover is made.

Profit calculation

Year 0	- 693.374,00 DKK
Year 1	- 2.653.255,75 DKK
Year 2	- 3.229.128,76 DKK
Year 3	- 2.091.178,63 DKK
Year 4	1.603.124,82 DKK
Year 5	8.773.765,49 DKK
Year 6	18.234.856,96 DKK
Year 7	26.461.893,02 DKK
Year 8	31.176.705,65 DKK
Year 9	32.729.164,97 DKK
Year 10	33.156.962,58 DKK

From the calculations it is seen the break even point is somewhere during the fourth year, this is considered to be a bit too late. Though a profit of +33 million DKK is considered a good profit having in mind this only is the market of the new indoor cycles.

Conclusion

The biggest post in the cost price is the purchases, which is possible to reduce by establishing connections to the OEM's and bargain with them to obtain better prices for the subcomponents.

Conclusion

Through the project it has been proven possible to remote control the bikes of a spinning class. For motivational value the bike is now equipped with a monitor for the user to navigate from.

Mechanics
The mechanical system has been defined and tested through simulations, of the finite element method, at the most critical points of the construction.
Financials
The financial estimates on return of investments are not completely satisfactory. This due to the combination of a relatively tight development budget grounded in the aim of sales price and inaccurate price gatherings online. The immediately available prices of components are generally too high considering bulk purchase discount agreements with the manufacturer.

Design
The final aesthetic outcome of the top shell for the Classic Supreme model can be considered a bit too true to the original design. The limited time for external designing has not quite permitted enough iteration to exactly express the innovation and conceptual progress lying 'under the hood'. That said, the rEvolution top shell is a visually integrated part of the original bike design, adding a bit more edge and direction to the expression.
The display console is a better example of the desired motorcycle inspired direction of aesthetics; curvy and organic but still defined.

Concept Validation
The workout concept, though, is only supported theoretically. Since it has not been possible to manufacture functioning test models, and a BODY BIKE has not been at hand, it has not been possible to carry out practical tests to validate the concept. A wide variety of opinions has been met on the subject – some positive, some negative and some just enthusiastic about new developments to a trivial exercise form. Although, it is still the conviction of the project group that, this new concept will add significant value to the experience of spinning as of today.


ill. 90 Pencil Sharpener

Discussion

The collaboration with BODY BIKE did not work out quite as we had hoped to. In a business with products so hopelessly outdated compared to the standards of exercise equipment today, BODY BIKE was very unwilling to update their product and expand their market. Because of the unwillingness to expand product portfolio and market the collaboration termination with BODY BIKE came as a relief, because it was starting to weigh heavily on us, and created a bad mood in the project work.

'Spinning' is a peculiar concept. It is an individual sport pushed into the boundaries of a team sport, but there is no interaction within the 'team' in session. In a typical individual sport like jogging you might meet other joggers while training, but they will be on their own way the second after you meet them. You do not know which distance they have covered so far and you do not know how far they have left. In spinning the 'distance' is clear from the start, it is 50 min(in a normal spinning class) and though all your 'team mates' are right besides you, you do not know how much energy they have left and you have no way of helping them as you would in road cycling by letting them be draught. Spinning needs a competition aspect, because it is well known if you have someone in front of you, it will drive you to perform on a higher level.

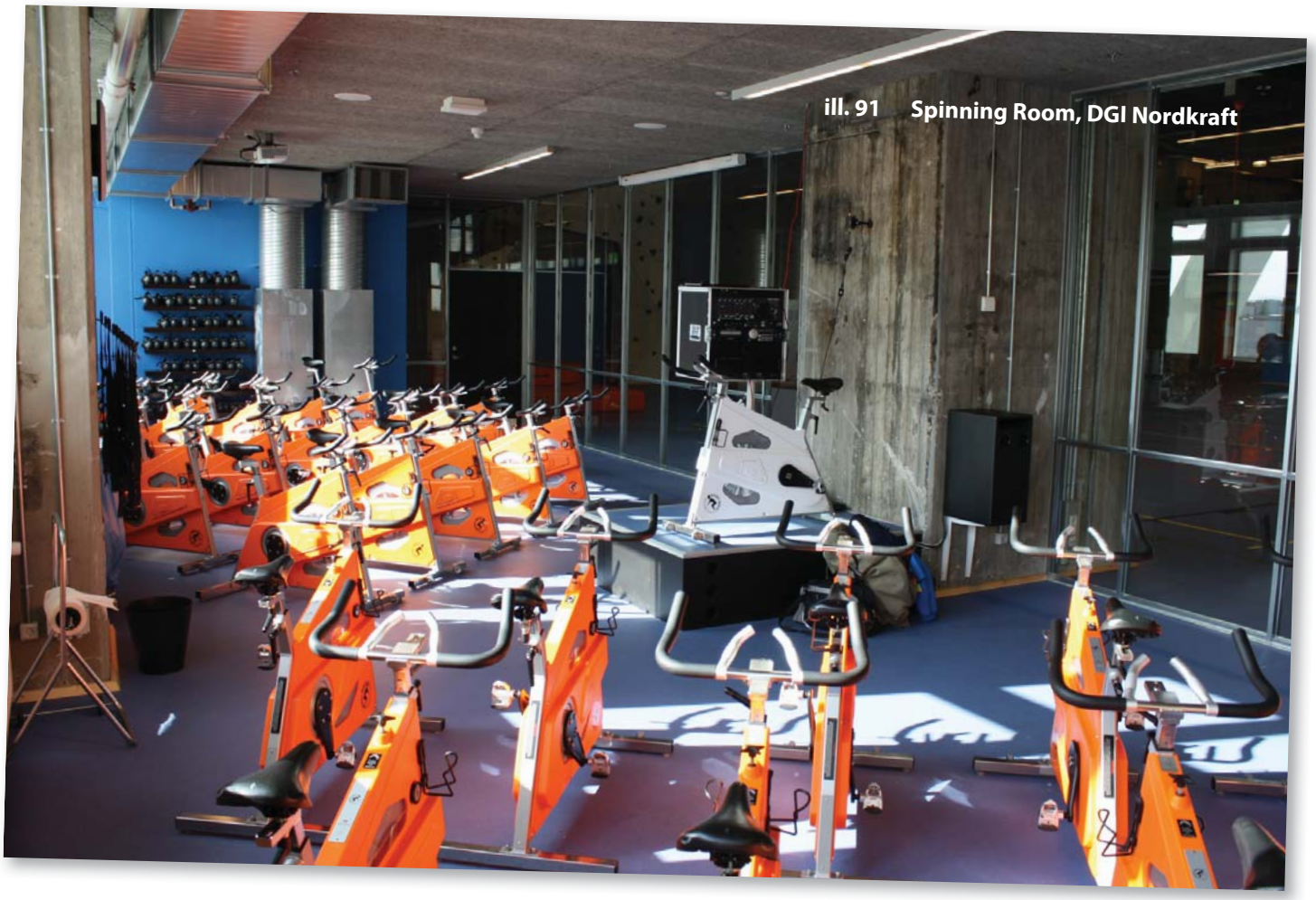
The design of the visible parts of the product, have been quite a challenge. The top shell has as primary purpose to shield the mechanics from the participants. As the part started to evolve it was clear a sportier look could be obtained by being inspired by the gas tank of a performance motorcycle. This is a paradox, development of an aerodynamic part for a stationary product, though this has been done before with great success, e.g. Raymond Loewy's Streamline Pencil Sharpener, ill. 85. We believe the shell designed by us makes the indoor cycle look more energetic, masculine and fast despite the fact that it is stationary.

This project has focused on the on the BODY BIKE Classic Supreme. However, the BODY BIKE Classic is constructed in the exactly the same way as Classic Supreme. Therefore there is an immediate and significant market expansion in designing a new top for the Classic. The mechanics will fit right on the frame since they are identical.
The project has been a mixture of both product and service design, with the main focus on the product. The service is a supporting feature of the product and vice versa, instead of just doing service design or product design it has been a nice challenge to make it come together. In the perfect scenario we would have had 100% mechanical product design project, but the in a way we properly learned more from connecting the two paths in industrial design.

For further development the log system can be incorporated in other sorts of electrical exercise equipment so you can log your step or rowing workout.

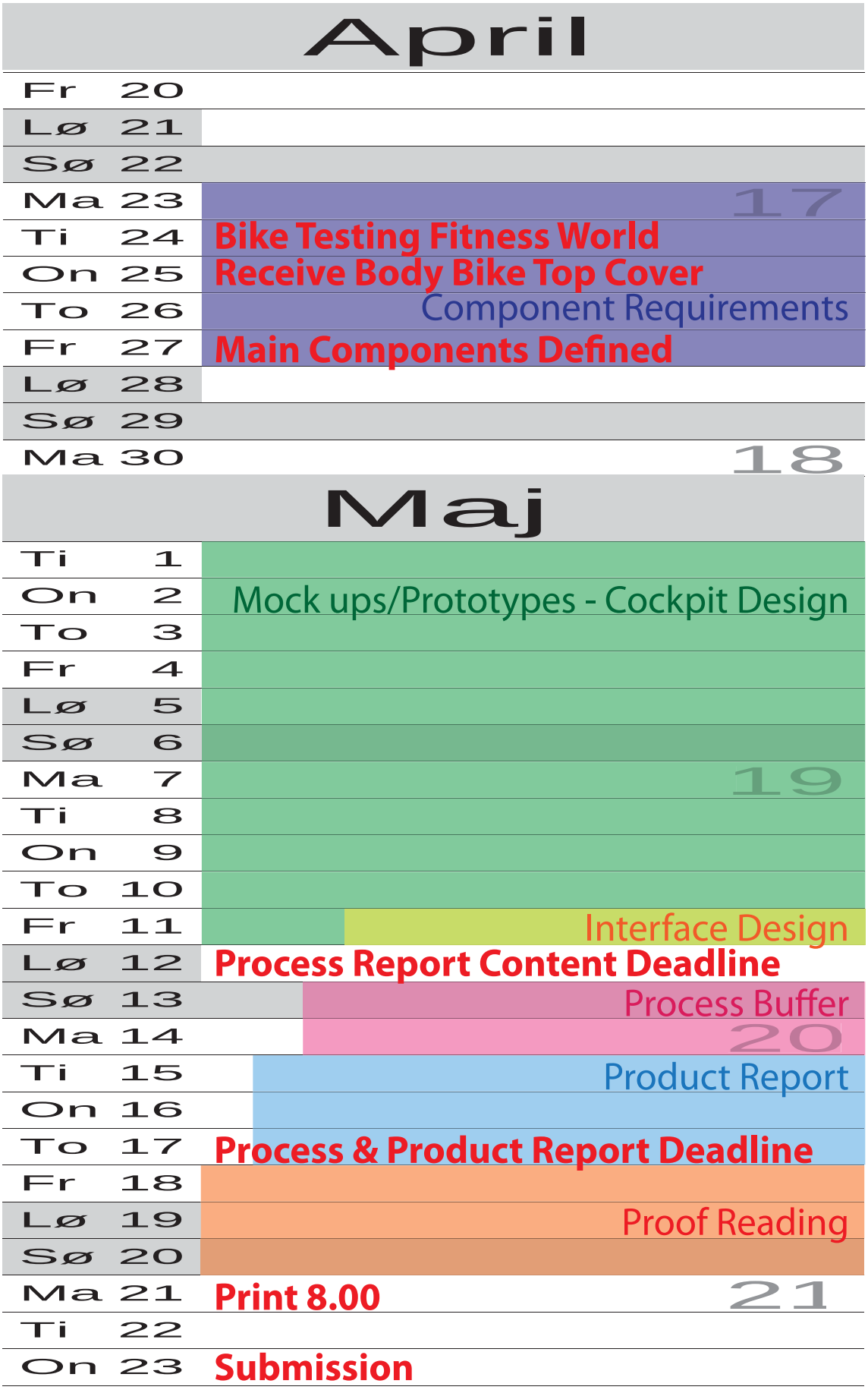
Time Schedule

ill. 92 Initial Gannt Chart



ill. 91 Spinning Room, DGI Nordkraft

ill. 93 Time Schedule Final Month



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Web 1
BODY BIKE
(http://www.bodybike.dk/about-body-bike/-story-body-bike)
[20-05-2012]

Web 2
AllPsych Online - The Virtual psychology Classroom
(http://allpsych.com/psychology101/motivation.html)
[20-05-2012]

List of illustrations

All 'blanks' are own illustrations

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9	ill. 3	Johnny G on the original bike	http://www.indoorcyclingassociation.com/blog/wp-content/uploads/2011/12/Johnny-G-original-bike.jpg
9	ill. 4	Wulffmorgenthaler Comic Strip	www.heltnormalt.dk/striben/2012/04/05
10	ill. 5	BODY BIKE Classic "Signal"	http://www.bodybike.dk/downloads/Product%20images
10	ill. 6	BODY BIKE Time line	http://www.bodybike.dk/about-body-bike/-story-body-bike
11	ill. 7	BODY BIKE Basic, Classic, Classic Supreme and Connect - Same frame	http://www.bodybike.dk/downloads/Product%20images
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25	ill. 33	Batteries	http://toolmonger.com/wp-content/uploads/2009/08/sony-batteries72-450.jpg
25	ill. 31	Reelights	http://www.cykel-fix.dk/2529-2784-thickbox/reelight-sl100-induktion-lygtesaet.jpg
25	ill. 34	Power Chord	http://store.antec.com/productimages/Originals/root/PowerCord.jpg
25	ill. 32	Bicycle Dynamo	http://www.sjscycles.co.uk/images/products/medium/1064LBLK.jpg
26	ill. 35	In-session screen iteration 1	
26	ill. 37	In-session screen iteration 3	
26	ill. 39	In-session screen iteration 5	
26	ill. 36	In-session screen iteration 2	
26	ill. 38	In-session screen iteration 4	
27	ill. 40	Bike layout sketch 1	
27	ill. 41	Bike layout sketch 2	
27	ill. 42	Bike layout sketch 3	
28	ill. 43	Final bike layout sketch	
29	ill. 44	Mood Board	http://www.porhomme.com/wp-content/uploads/2009/01/ducati-desmosedici-gp9-11.jpg http://www.rushlane.com/wp-content/uploads/2012/04/Ducati1200R_0.jpg http://www.designshoot.com/vectrix-modern-electric-super-bike-by-robrady-design.html/ http://www.brenhamyamaha.com/images/B-RyanHouston3.jpg http://1.bp.blogspot.com/_bmm--eHJ6r8/TOO-XXzf3qI/AAAAAAAAAMc/V5Ckpo4n97U/s1600/design+motorcycle+1.jpg http://www.ducatistore.co.uk/ducati-i/ducati-1198-sp-red.jpg
30	ill. 45	Sketch 2.2	
30	ill. 47	Sketch 2.6	
30	ill. 51	First T-Spline Top Rendering 1	
30	ill. 50	Sketch 2.8	
30	ill. 46	Sketch 2.3	
30	ill. 48	Sketch 2.5	
30	ill. 52	First T-Spline Top Rendering 2	
30	ill. 49	Sketch 2.9	
31	ill. 58	Console Concept 5	
31	ill. 54	Sony PSP	http://upload.wikimedia.org/wikipedia/commons/5/5d/Sony-PSP-1000-Body.png
31	ill. 57	Console Concept 2	
31	ill. 56	Console Concept 4	
31	ill. 59	Console Concept 3	
31	ill. 53	TOMTOM GPS	http://www.odense.dk/Topmenu/Borger/Voksneaeldre/Demens/Projekter/~/media/AEHF/Gamle%20AEHF%20-%20indtil%202012/Demens/Billeder/DemensInfo/GPS.ashx
31	ill. 55	Console Concept 1	
32	ill. 61	Display Console Concept 2