Titan

ESPORTS EQUIPMENT

PRODUCT REPORT

Aalborg University / Spring 2017
Industrial Design / MSc04 ID3

Satellite

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Abstract

Dette afgangsprojekt omhandler udviklingen af et produkt til den relativt unge esports industri med en vision om at gøre gaming 'sporty'.

Den hurtigt voksende industri har haft svært ved at følge med sin egen succes, med større og større krav stillet til de unge spilleres fysiske formåen, hvor tiden på toppen ofte er flygtig. I modsætningen til mange andre sportsgrene, så er esports udstyret ikke blevet udviklet med specialisering og høj ydeevne i tankerne, til at understøtte de mange hurtige bevægelser og den relative belastning som kroppen udsættes for. Flere og flere spillere får skader og må pensioneres fra sporten inden de er fyldt 25 år, hvilket er et kæmpe problem både for spillerne personligt, men også for sporten som helhed.

Projektet her arbejder med at udvikle et produkt, der formår at minimere risikoen for at få de mest typiske skader, som forekommer i musearmen.'Titan' er et produkt, som erstatter den traditionelle mus ved at være et mere professionelt perifert input device mål-rettet det kompetitive og meget populære online spil, League of Legends, der spilles på computer platfor-men. Titan er udviklet med biomekaniske principper i tankerne for at minimere belastningen som musklerne konstant udsættes for, uden at gå på kompromis med spillernes høje krav til ydeevne.

Title	Titan
Theme	Esports Equipment
Project period	February 1st. 2017 - May 18th. 2017
Project team	Satellite / MSc04 / ID3
Main supervisor	Christian Tollestrup
Co-supervisor	Mikael Raino Larsen
Issues	7
Pages	28 pages
Characters	20881

Esports

noun

1. *(usually used with a plural verb) competitive tournaments of video games, especially among professional gamers.*

The abbreviation of Electronic sports, indicating competitions performed among esports athletes on a variety of gaming platforms in an array of games

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THE WORLD OF ESPORTS

Esports is young in the sporting world, but it is also one of the fastest growing industries worldwide (Newzoo, 2016a). It has a culture of its own, with a dedicated fan base showing up and cheering at events that are comparable in size to other major sports events. The world championships in the online game League of Legends, for instance, have been at the STAPLES Centre in Los Angeles with 21.000 seats sold-out. The viewership for that same event has in the last three years also been considerably higher than for the finals of other popular leagues such as in Basketball (NBA) or Baseball (MLB). The currently most popular online game is League of Legends, which has a unique monthly player base of 100 million people.

The fast growth of the industry takes its toll on the players that have a hard time keeping up with the continuous demands of performance at highest level. Unlike other sports, the equipment used has not been developed with specialisation and high performance in mind to fit the unique task of playing a certain game. This has created a challenge within the world of esports, as more and more sports injuries are emerging, ending careers prematurely, costing stakeholders a lot of money, and leaving disappointed fans seeing their idols retire at a young age.

Titan is a new input device, developed for esports players specialising in League of Legends, to substitute the gaming mice currently on the market. Players who are serious about their sport and are interested in optimising their game while safeguarding their future through minimising the risk of injuries, would benefit tremendously by playing with Titan.

ESPORTS ATHLETES

The implications of playing videogames professionally

Esports appears static and inactive compared to other sports, and it still faces a lot of prejudice and aversion from outside its community to be acknowledged as a sport due to the seemingly minimal physical exertion. However, according to professor Ingo Fröbose from the German Sports University in Cologne, esports are just as demanding as most other types of sport, if not more demanding, with both recordings of high cortisol levels, high pulse, and fast movements.

Putting this type of stress on the body, without being properly supported by the equipment, comes at a price. More professional players have in the last couple of years come forward and announced both breaks and retirements due to injuries and at the same time Dr. Levi Harrison, a hand and arm surgeon based in Los Angeles, informs that, besides MMA fighters, his most frequent patients are esports players (Plunkett, 2015).

The most common injuries found in esports are categorised as Repetitive Stress Injuries or RSI, where in particular carpal tunnel syndrome and tennis elbow are widespread. These injuries cause both numbness, pain, reduced mobility, and could potentially become chronic if left untreated.

Tennis elbow

Micro cracks in the extensor tendon due to repetitive tensile forces applied to the muscle

Tear

Tendons
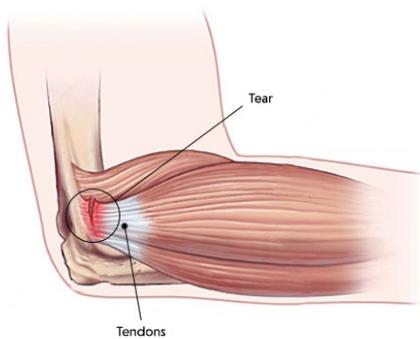
Carpal tunnel syndrome

Compression of the median nerve due to swelling from repetitive movements and pressure applied to the area

Compressed
Median Nerve

On top of these problems there is another issue, as 75% of surveyed League of Legends players report getting cold hands while playing. Cold joints resultsin joint stiffness and an increase in strain put on the muscles concerned. Not only does this provoke injuries, but it also influences performance, as cold joints are proven to reduce finger dexterity.

The new esports input device, Titan, is developed to help decrease the strain put on the muscles, which will aid the players by gaining higher endurance and reduce the risk of injuries.

Cortisol levels
as high as a race driver

160-180
bpm almost equivalent to a marathon runner

400 movements
per minute, which is four times as much as an average person

Titan

The new esports control device

Titan is a specialised input device for esports athletes playing League of Legends competitively, developed by team Satellite. It offers features, that regular gaming mice are currently lacking, with optimised ergonomic positioning and without compromising performance. It also aims at providing an immersive and tailored user experience of both being free and in control, turning the hand itself into an input device with quick access to features enabling a faster and more fluent gameplay.

Identity

The development of Titan's identity has been inspired by the sports shoe industry, emphasizing the functionality with streamlined details, mixed with the more futuristic and techy appearance found in classic gaming, therewith creating more of a sports reference and status while being true to the origins of gaming.

The name, Titan, is derived from the biggest moon of Saturn and is meant to exude the great impact Satellite hopes to provide to the industry of esports.

Techyness

The armoured pads on the back of the hand accentuate the bone structure, giving a techy and athletic look. Incorporated functions, such as the buttons, are brought out to underline the futuristic appearance fitting the gaming industry.

Sporty textile

By having a textile with bigger mesh patterns, as seen in sports shoes, by the wrist, Titan emphasizes the functionality of being flexible in this area. The rest of the glove mainly provides comfort, wherefore a more soft looking structure has been chosen.

SUPPORT
The neutral position

30°
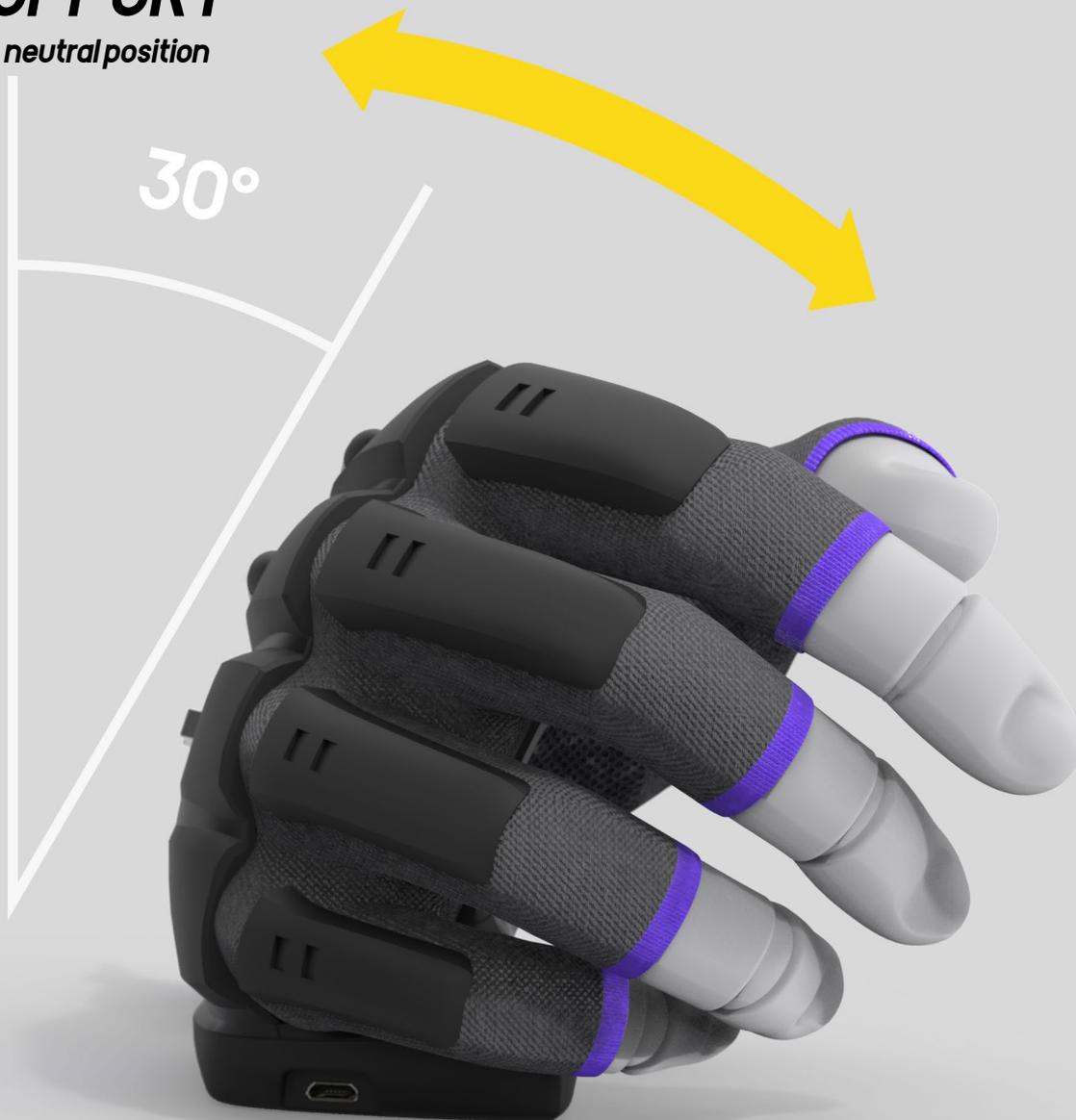
Titan aims at providing the players with a feeling of freedom, while assisting to obtain better ergonomic conditions. By improving on simple biomechanical principles, strain put on the muscles is minimised, where the vertical support is a main contributor to a more relaxed playing style. The product does not intent to restrict the players in their abilities to perform, which is why some freedom is possible in both the wrist and vertical position, enabling ease of control when conducting micro-movements.
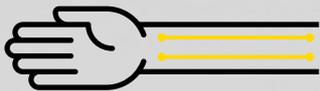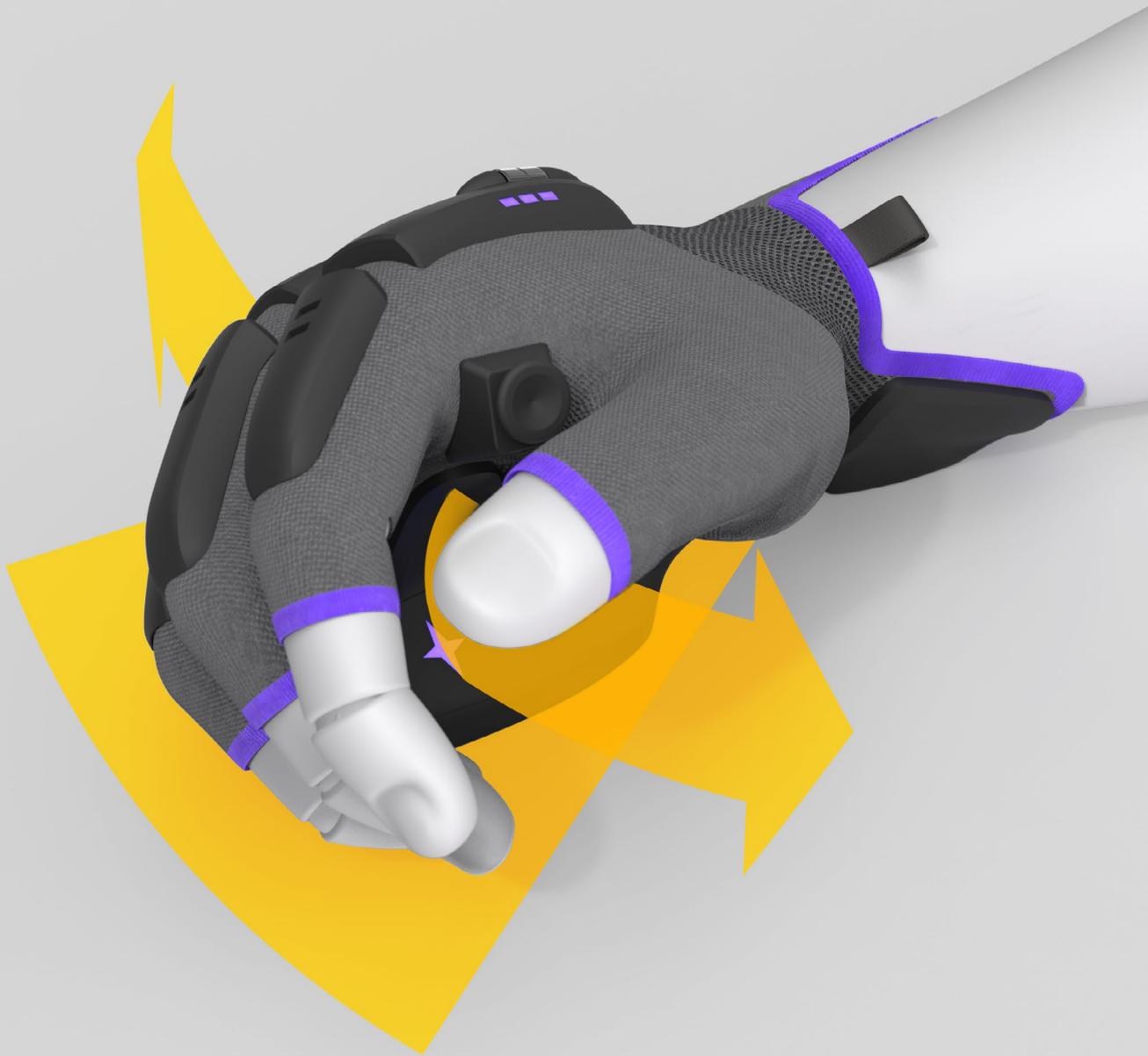
Neutral hand position

Removes tension in the muscles by maintaining an optimal neutral hand position of 30 degrees from vertical.

Straight wrist

Keeps the wrist straight when relaxed, avoiding both tension in the extensor muscles and a constant stretch to the opposite flexor muscles. Pressure of the wrist is eliminated reducing the risk of getting carpal tunnel syndrome.
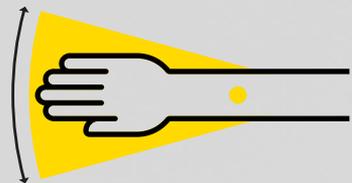
Supports the wrist

The length of the glove on the forearm, provides some support that gives a natural urge to use the entire arm more and the wrist only for the precise micro-movements.

NAVIGATION
High precision

Esports athletes are highly concerned with the precision of their devices, as it could make the difference between winning or loosing. An optical sensor is used for navigation as it is consistent and reliable. DPI shortcuts are placed on the backside of the glove for easy adjustment of settings when in a game, where LED makes it easy to keep track of which setting has been chosen.
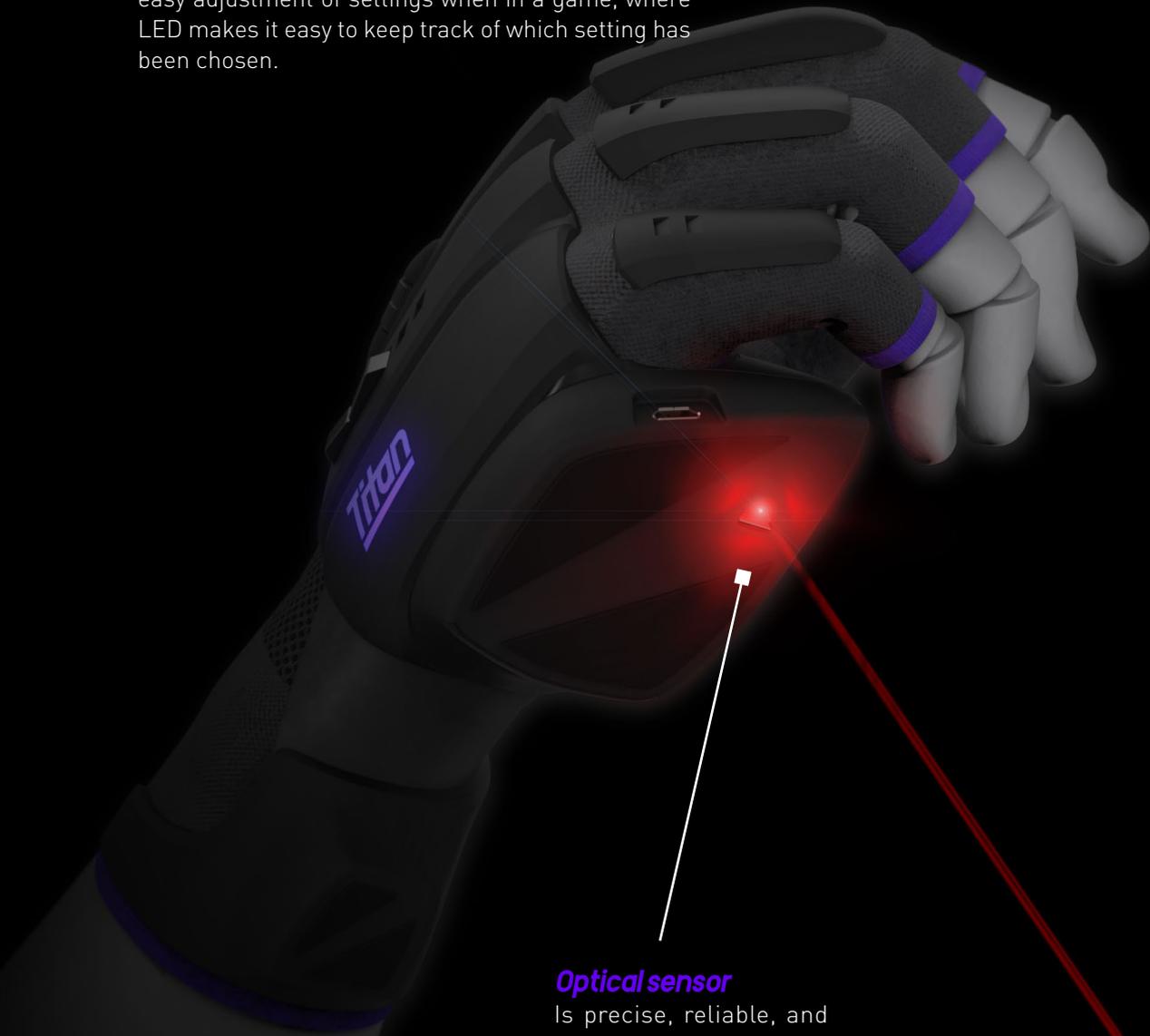
Optical sensor
Is precise, reliable, and works on every surface

DPI buttons

Enable switching between different pre-programmed DPI settings

LED

When pushing the DPI buttons, visual feedback tells the player which DPI setting is chosen among the three pre-programmed options.

CONTROL
## Clicking and controlling

Click adjustment
The wheels can be turned to loosen or tighten the click, making the player feel like "the mechanic" adjusting his specialised equipment.

Titan has main clicks placed on the index and middle finger, where players are able to set their own preference in relation to which finger should act as "left" or "right" by adjusting the settings in the computer. The adjustable wheels in continuation of the fingers satisfy the need of customization by enabling the players to "tighten" or "loosen" the click to optimise according to physiology and preference. Incorporated in the fabric is a linear resonant actuator, that provides the player with the feeling of a regular click, creating reliability in the product.

The main clicks are optimised in relation to more optimised biomechanics by being conducted vertically, from a neutral finger position, activating the stronger flexor muscles instead of the extensor muscles.

A 5-way-switch, encompassing shortcuts, is placed to be controlled by the thumb. Two of the directions are set as scroll functions (Page up and down), but can be changed along with the other three directions to fit the individual playing style.
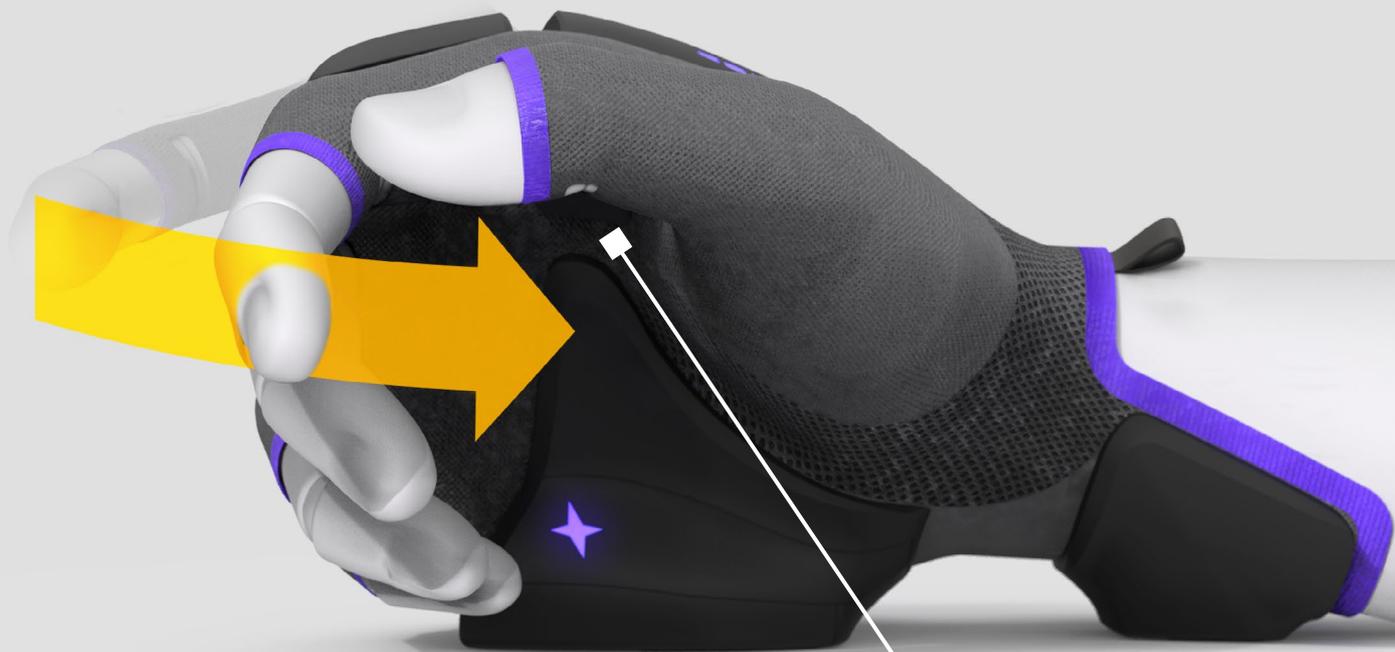
Keystrokes

The 5-way-switch can be programmed to have keystrokes incorporated, such as the D, F, and B keys, making the play style more fluent.

Neutral finger position

The product allows for a completely relaxed finger position, not restricted by a surface as seen with regular mice.

Flexion over extension

Clicking from a neutral finger position means that the flexor muscles are activated, instead of the extensor muscles. These muscles are up to 60% stronger, providing better endurance and a reduced risk of injuries

Working with gravity

With the vertical hand position the clicks are not conducted directly against gravity as they would be with a horizontal hand position, reducing the relative strain put on the muscles.

EQUIPPING
Wearing the equipment

Wrist strap
Helps with equipping by providing a better grip and helps open up the glove
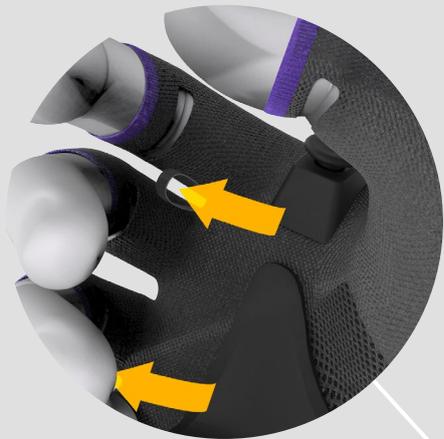
Finger straps
Provides a firm grip during removal.

It is important that the player can trust the equipment in the sense that it responds to every movement. That entails having a perfect and slim fit, which Titan offers through the elastic glove, available in three different sizes. A wrist strap helps with equipping the glove, and a cut-out in the top part provides eased inserting of the hand.

When taking off Titan, finger straps can be used for pulling with the other hand, thereby avoiding turning the glove inside out.

CONNECTION
Computer connection

Micro USB
Titan is charged through micro USB, using a 2m long and flexible textile cord, enabling playing at all times

The connection of Titan is wireless to provide freedom when in use and a 500mAh battery ensures many hours of playing. When power gets low, three small LED indicators will give a warning by continuously pulsating. Charging happens through connection to the computer via a micro USB in the bottom part of the support. The long cord ensures that the game can be continued.

A disconnect feature is incorporated to automatically turn of the navigation and click functions, when not in contact with a surface. This allows the player to for instance chat on the keyboard with teammates without having to worry about conducting accidental actions.

Disconnect

When the optical sensor is not in contact with a surface, Titan disconnects, enabling typing on the keyboard with both hands, without having to fear accidental clicks.

COMPONENTS

Technical description

Linear Resonant Actuator

Flex sensor

5-way tactile switch

Mouse Encoder Wheels

Main Circuit board

Mini push button switches

Circuit board with LED

DPI Buttons
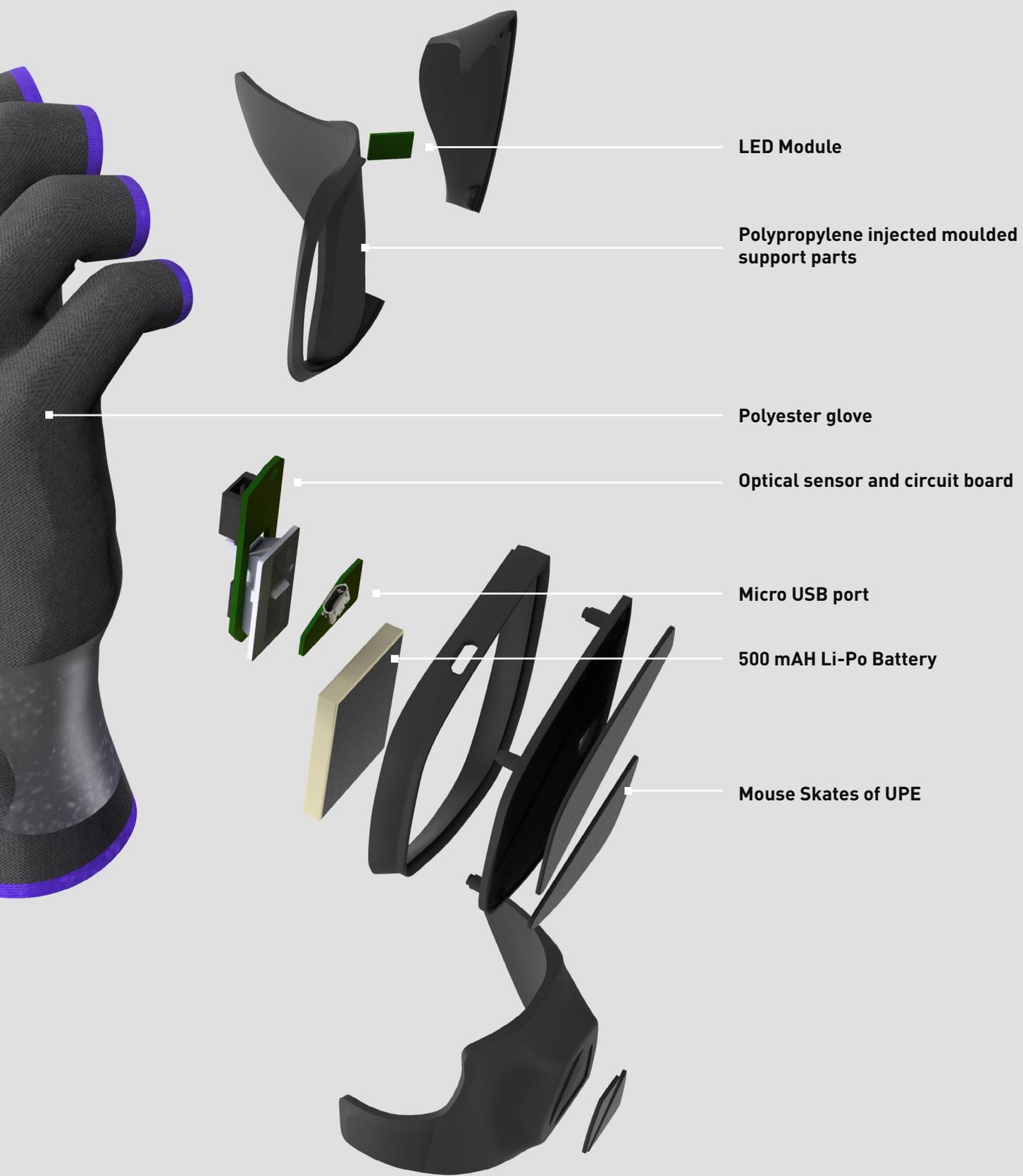
LED Module

Polypropylene injected moulded support parts

Polyester glove

Optical sensor and circuit board

Micro USB port

500 mAH Li-Po Battery

Mouse Skates of UPE

CREATING VALUE
Go-to-market strategy

PLAYERS

The main audience of Titan is the next generation of full-time professionals, a group of players highly devoted to their gear and interested in gaining a competitive edge. Titan is developed with this profesionalisation in mind, enabling greater control for the player through a more direct input device, which is adjustable in its clikcs to fit individual needs. Players can rely on Titan's support to help them play for hours with reduced strain on the muscles compared to regular mice. Players will experience greater endurance and will be less exposed to injuries, potentially prolonging their careers.

Titan also reaches another audience, being the hardcore gamers, by providing value through a more immersive experience and offereing newness with a cool gadget.

CLUBS AND TEAMS

Clubs and teams are interested in creating a professional and serious envrionment to enable high player performance, eventually leading to team victories. Titan will help achieve this objective by supporting the players with greater endurance and creating lower injury occurences on the team. This can prolong the careers of the players creating the possibility of keeping a team together for a longer period, gaining better collaboration, and thereby achieveing greater performances.

INVESTOR

The investor expects the team to perform well when financing parts of it and eventually gaining a return of investment. Titan helps the investor to better secure his investment by minimising the risk of injuries on the team.

VARIATIONS

Besides from sizing, it is a natural development of Titan to make it available in different colours to fit the likings of the individual player.

Satellite

MARKETSIZE

The player base of League of Legends alone consists of 100million monthly players, meaning that Titan can reach 100.000 sold units just by reaching 1 out of 1000 players. Expanding into other games, such as Overwatch (20million monthly players) or Dota 2 (15million monthly players), creates an even bigger market. By primaily looking at only online played games, an even bigger market is leaved out. This is on purpose becuase the games played are not focused on the competivetive aspect of esports.

MARKETAPPROACH

Satellite is intended to be a Danish start-up with the calling to ease the life of professional gamers.
From ideation to the successful launch of the final product, Satellite will have to go through six different phases, and the intention is to partner up with the gaming peripherals company, Steelseries, to gain the support and sparing needed to reach important milestones. They have both the experience and the vision of becoming the front runner in the gaming market, making them an obvious collaboration partner.

Since Satellite is a start-up with no financial resources, the team is highly depending on finding investors to fund the venture during the first phases.

IMPLEMENTATION
Go-to-market strategy

Design & Business proposal

User feedback

Investor

Steel Series Partnership

Beta test

I 4 months

II 6 months

III 6 months
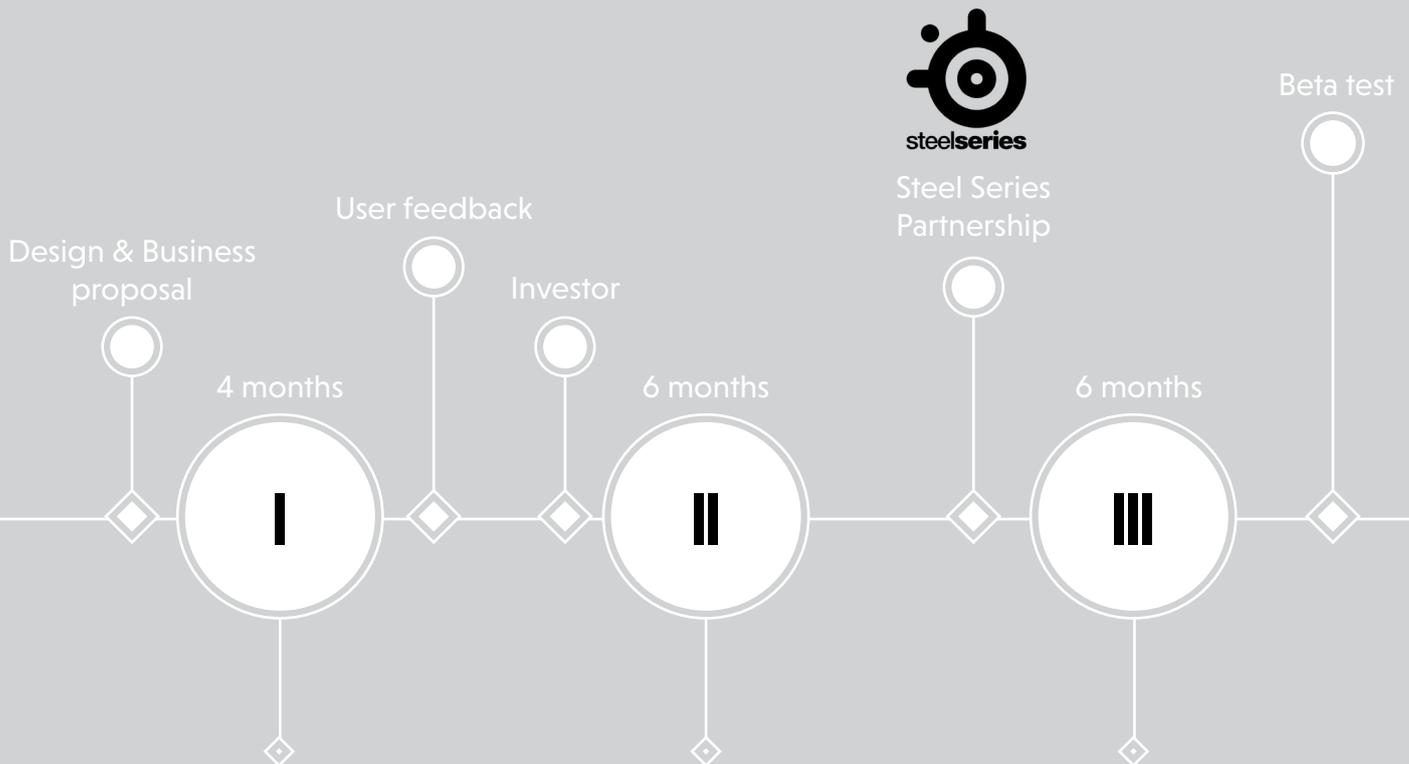
I. Concept development & business approach:

The first milestone was to convert the idea of a product that supports the professional gamer into a concept, and finally to transform this concept into a first product prototype as well as to research the market and create a business plan. This first step has been completed.

II. Development:

Experts in material science, electrical and mechanical engineers are needed to mature the product further and to make sure that Titan becomes a high-quality device. Lawyers and business consultants are essential during this phase as well to ensure that the business model is solid and all legal requirements are met. The development phase is also the phase in which real prototypes are being built (outsourced and supported by Steelseries) to allow for testing in real-life scenarios.

III. Testing:

The testing phase requires a finalised and functional prototype as well as willing individuals that fit the target market of Satellite.
Since this will be the final big test before the product launch, help from external usability testers and medical doctors will be required. The gamers will utilize the device for a few weeks while giving constant feedback about its feel and functionality. The performance of the product will be monitored and compared to a regular gaming mouse in relation to muscle activity and constraint (with EMG).

4,4 mio DKK

Promotion

Moulds

Type 0 test

4 months

4 months

IV

V

VI
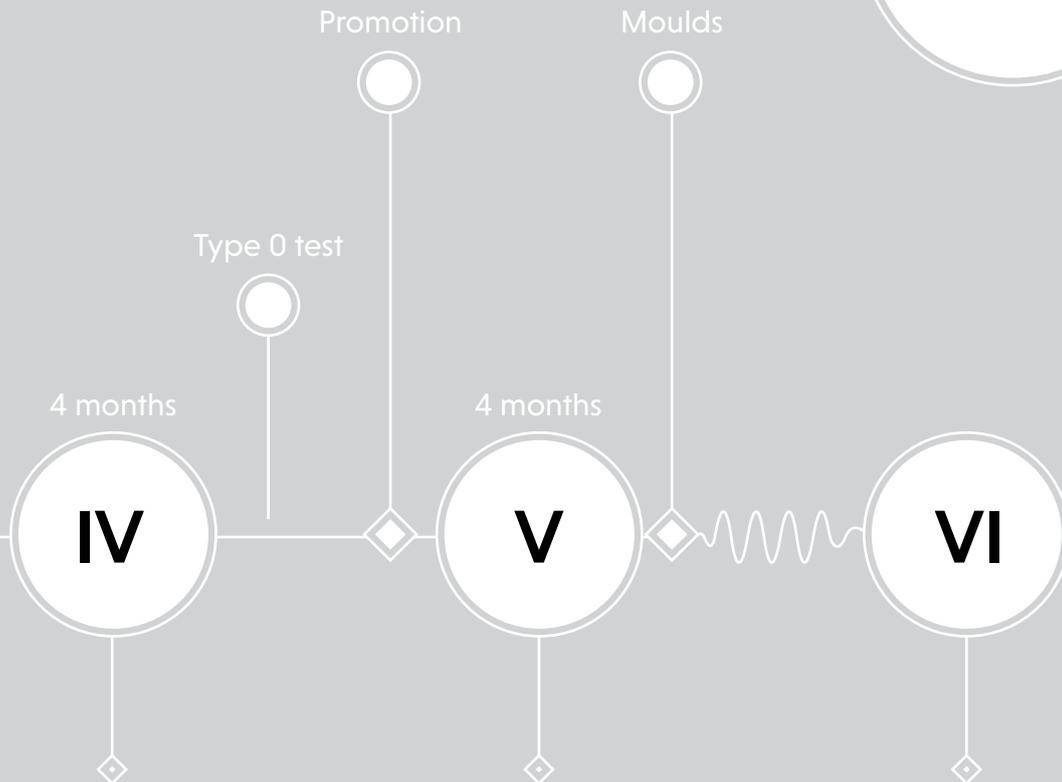
IV. Final development:
Milestone number four allows Satellite to process the feedback gotten from the testing period and to fine-tune the product in the last detail. Last changes to design and precision can be made. The experts from the developing phase will also here consult Satellite to put the finishing touches on the device and prepare a smooth launch.

V. Manufacturing:
Once Titan is ready to be produced, Satellite's partner, Steelseries, will help with manufacturing. Since they already have a large production, their expertise and work force will support Satellite tremendously. Steelseries' partners will manufacture the packaging of the device, which has been previously designed by Satellite.

VI. Launch:
This final phase is the most exciting one. The big launch needs to be prepared and executed. Once the first Titan has been produced and packaged, all marketing and communication efforts need to be in place as well as human resources allocated to the different tasks. Steelseries plays a huge role, as they will facilitate the launch.

BUDGET

PRODUCTION COST

The production cost of Titan is estimated from two scenarios, where standard electrical components are found at retail prices and a "best case" and "worst case" percentage i calculated [W075]. Regular kg prices for PP are found for the injection moulding, and a top down calculation has been made for an Under Armour training glove, to estimate the production price of the glove. Wages for assembly are included. The numbers shown are rounded off to the nearest whole number:

RETAIL PRICE

By applying traditional contribution margins, these production prices will result in the following retail prices (rounded):

BEST CASE
400 DKK

WORST CASE
600 DKK

BEST CASE
2100 DKK

WORST CASE
**3450 DKK**

BREAK-EVEN
(BESTCASE)

Satellite does not find it plausible that enough players would buy the product at the worst case pricing, which is why Return of Investment is calculated from a best case perspective. If the production price becomes higher than that, the contribution margin will have to be lowered respectively. It is estimated that at least 50.000 units can be sold by the end of year 3, which only constitutes 0,005 ‰ of the current League of Legends market.

Break-even point
1 year and 4 month
or
16543 units sold

Million DKK

BREAK–EVEN

Sales revenue

Contribution

Year

Investment

Operating cost

15

10

5

0

−5

−10

1   2   3   4
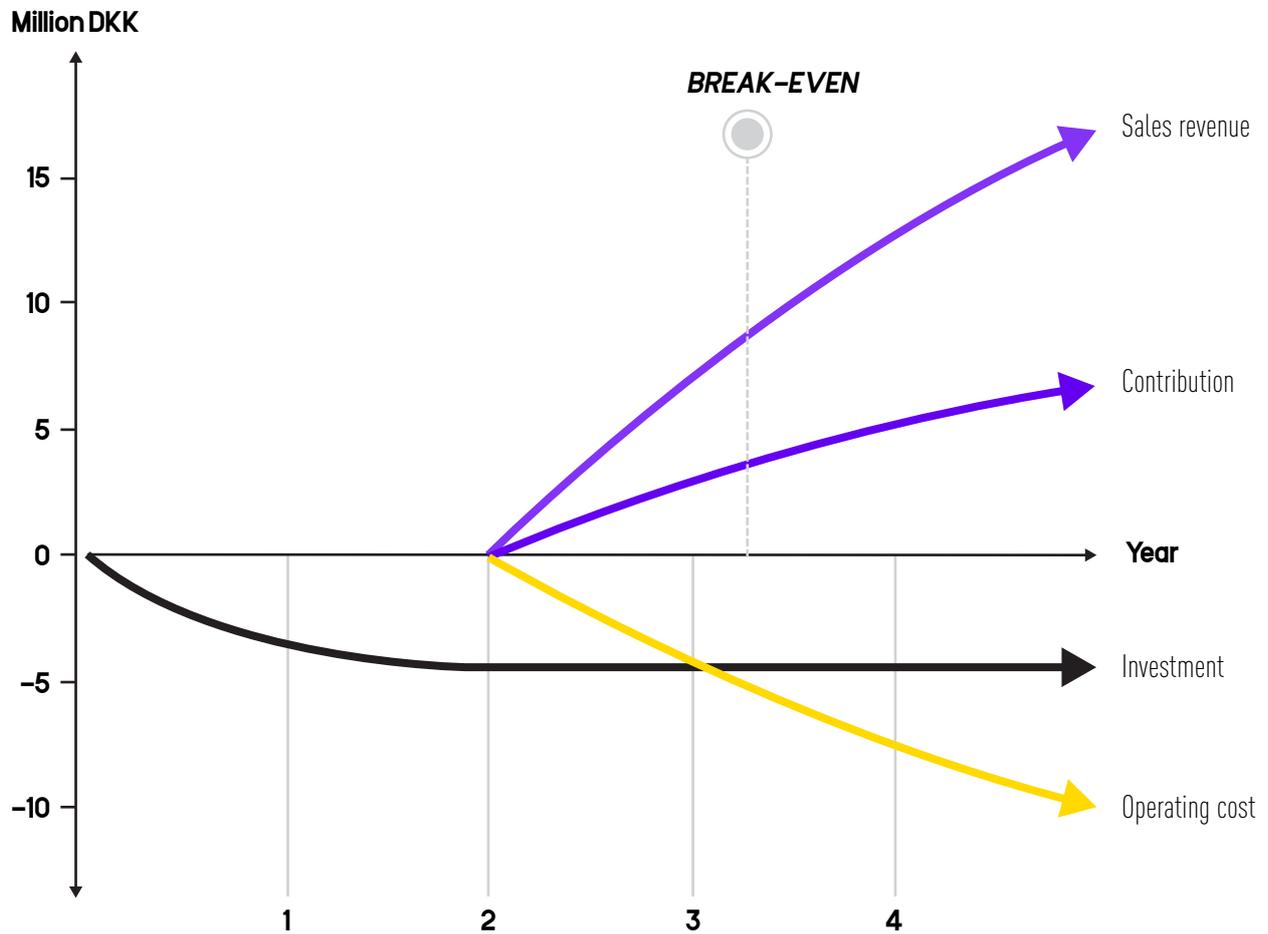
KEY NUMBERS

RETURN	CMR	ROI
14,4 MIO	40%	323%

INVESTOR ARGUMENTATION

Calculating a Net Present Value provides a good foundation for convincing an investor to invest his/her money in the project rather than in for instance stocks, providing the calculation turns out positive.

With the stated figures, the investment would be profitable.

7,3 MILLION DKK
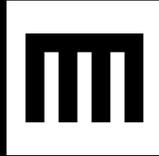
ARCHITECTURE & DESIGN

Aalborg University / Spring 2017
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Titan

ESPORTS EQUIPMENT

PROCESS REPORT

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Acknowledgement

Reading Guide

Documentation
The project is presented in four parts
/ Product Report: presenting the final design proposal.
/ Technical Drawings: presenting the specifications of the design proposal.
/ Process Report: presenting the process of the project.
/ Worksheets: acting as an appendix of activities and analyses made during the project, which can be found on the attached USB.

This is the process report, which is a summarised documentation and evaluation of the development process, consisting of six main phases: Understand, Ideate, Conceptualise, Detail, Implement, and lastly Epilogue.

To ease readability and keeping track of the process, four types of 'sum up' boxes are applied:

The task has given important insights to the solution that might need further investigation	⚡
The task has confirmed or validated a previous finding or hypothesis	✔
The task has dismissed or invalidated a previous finding or hypothesis	✖
The conclusion of a task has ended up in a chosen working principle	⚙

References
The references throughout the report are specified directly in the text in accordance with the Harvard method "(author, year), and the illustrations are numbered consecutively: "Ill. #: [descriptive illustration text]" and referred to in the text in a likewise manner: "*(Ill. #)*". Worksheets are referred to by number [W#].

The report uses Danish numeric notation as well as SI units.

Table of content

Introduction

This thesis is driven by the opportunities found within the increasingly popular and growing societal trend of esports, which is an industry trying to find its place as a professional well-established sport equivalent to other more traditional forms of sports such as football or tennis. Esports is the abbreviation of Electronic sports, indicating competitions performed among esports athletes on a variety of gaming platforms in an array of games.

As esports is relatively young as an industry, untapped potential is found in improving or rethinking the supporting equipment to enhance performance and minimise the risk of injuries during training and competition.

The topic is found to be both interesting and fitting, as the field is relatively unknown to the team members, which ensures more aligned individual expertise and keeps personal bias and preconceptions to a minimum. Furthermore, the topic provides a prospect of investigating and integrating various aspects like human factors, culture, business, technological possibilities etc., in which the team members get the opportunity to perform both individually and as a team.

Initial thoughts

Gaming, in a common sense, has often been perceived as a waste of time and associated with maladjusted youngsters in dark basements who have an unhealthy intake of fast food and soft drinks. However, esports on a professional level has come a long way from this notion, and the perception of it is shifting.

The initial hypothesis is that esports can be approached as traditional sports, where supporting equipment is developed to create a competitive edge or with the purpose of optimising specific aspects within the skillset of the athlete during training. Another hypothesis is that, with esports as an upcoming industry, there must be unaddressed problems or latent user needs, which a new product could help remedy.

// *Esports is the biggest thing to hit the tech industry since the launch of the iPhone in 2007.*
- Newzoo, data analytic service (Newzoo, 2016)

// *While esports, defined by rapid growth and fanatic fandom, still has a fair bit of growing to do before it is on par with traditional professional sports like baseball, football, or soccer, the industry is ripe with innovation opportunity for both businesses and individuals.*
- Nick Bertha from Fahrenheit 212 (Bertha, 2016)

// *Esports was a sideshow, and now everything that used to be the main show is now the sideshow to esports, and it's the exhibitors that are now piggybacking off of the competitions.*
- Michal *'Carmac'* Blicharz

Approach

Design thinking

The project's main methodology is Design Thinking, approaching the problem/opportunity space holistically considering all aspects interfering with the product development, be it cultural, human, business, technology, construction or manufacturing aspects. It is essential for the design process to have a user centred focus, incorporating the users in the process of learning by applying qualitative methods for identifying underlying reasons behind spoken needs or observed problems, but also to use quantitative methods to support and verify these. The combination of qualitative and quantitative research methods creates the foundation for an iterative process of understanding of the design space and learning from the users. Experiments and prototyping are used as means to validate findings and hypotheses developed throughout the process. Visualisation tools such as sketches, illustrations, models etc. should commonly be used to ensure a high level of internal alignment as well as being a tool for communicating with users and other stakeholders to make sure everyone is on the same page from project kick-off to the finish line.

The Logic Network

Inspired by the design theory of framing and process structures like the V-Model from system engineering, the team has developed the Logic Network as a requirements engineering tool in an effort to create a more tangible and structured process. The tool aims to map and manage the scope of the project and development of the solution space, ensuring traceability from the initial finding to the final solution.
While the development process is always a complex process of iterations, the Logic Network organises elements of development into strings of logic, which progress from an *insight* or *finding* and (created) *value*, through initial *criteria* and refined *requirements* to a final *working principle* that form part of the solution as a whole *(Ill. 1)*.
To see the Logic Network, look at attached appendix 1.

Project management

The project overview is managed by utilising a regular physical calendar, dividing the process into overall phases and pinpointing important deadlines *(Ill. 2)*. It is important to emphasize that the project phases are iterative, making them reoccur throughout the process, which is why there is no definite beginning and end shown in the illustration. This planning method is valuable to the team as it provides overall milestones to be achieved, creating motivation and structure, which will hopefully hinder standstills and ensure good time management and allocation of resources.
The planning of day-to-day tasks is mainly managed by using the Scrum board on a digital platform in coherence with daily sum-up meetings to define daily agendas. The board helps with visualising what team members are currently occupied with, and the meetings serve as a forum for sharing knowledge and concerns, and discussing further work.

DELIMIATION	INSIGHTS	VALUES (To whom)	CRITERIA The product...	VALIDATE	REQUIREMENT The product...	VERIFY	WORKING PRINCIPLE
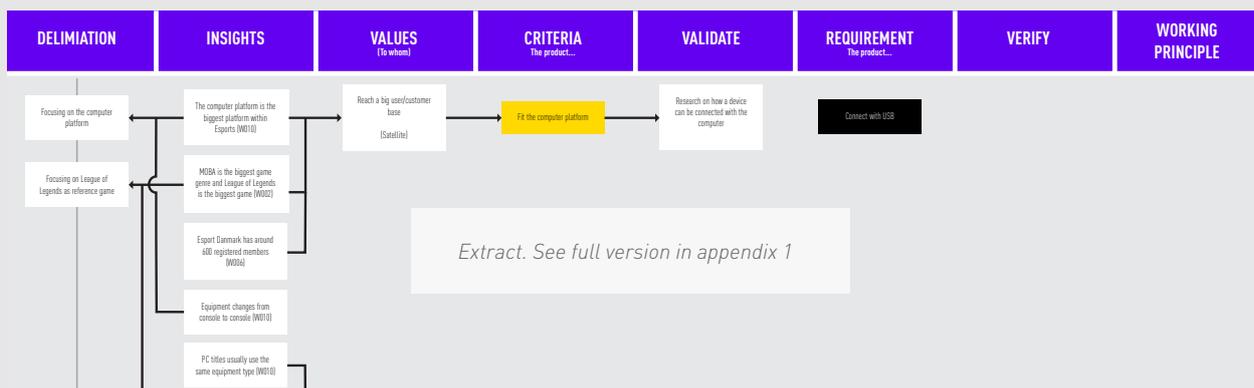
Ill. 1: An extract from the Logic Network

LCS Berlin

Design Brief

Concept
Directions

1

2
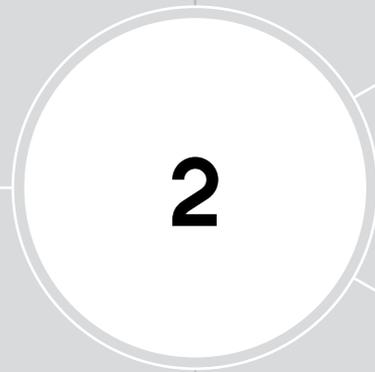
Vejle Sportscollege

Phase overview

The illustration is shown as linear, where iterations have been made between the different phases. The sizes of the circles simulate the duration in each phase.

1. Understand

The foundation for understanding the esports world is established in this phase, uncovering needs and opportunities from both a user and business point of view. The phase culminates in a project brief, summarising the scope and direction of the project for the following phases.

2. Ideate

Utilising the insights from the previous phase, the team starts to ideate on solutions and dive deeper into the problems, conducting investigations on solution principles.

Proof of principle

Interaction
Vision

Potential partners

3

4

5

Design
Proposal

User prototyping

User evaluation
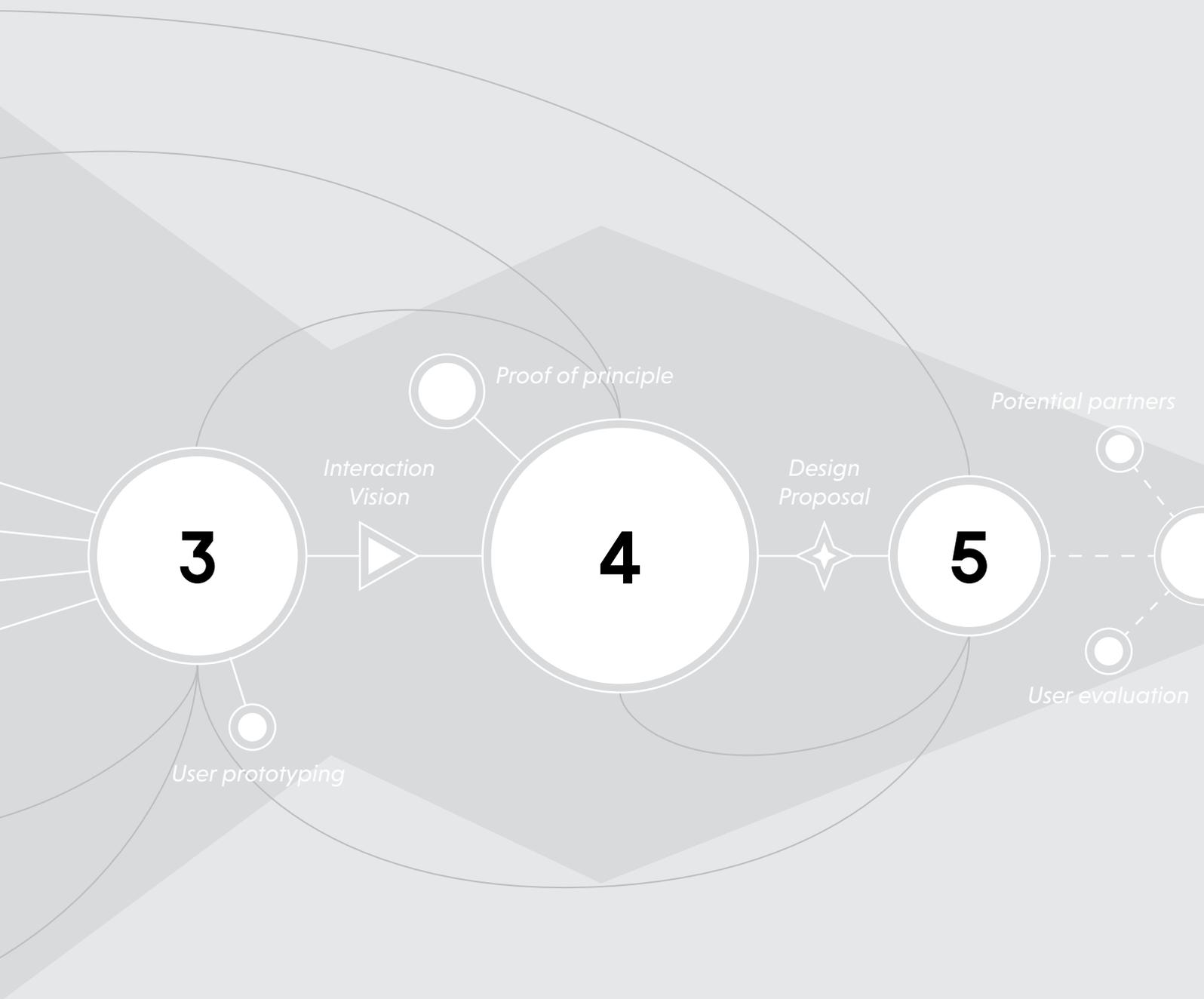
3. Conceptualise
Detailed design concept directions are developed and challenged through prototyping and testing with users and experts. The phase concludes with a concept freeze based on the team vision and project requirements.

4. Detail
The concept is broken down into elements, that need definition, including functionalities, technologies, materials, and dimensions.

5. Implement
In continuation of the detailing phase, the team looks into strategies for entering the market and creating a viable business model for the product.

Ill. 2: Simplified diagram illustrating key activities and the overall development process and phases of the project

UNDERSTAND

The foundation for understanding the esports world is established in this phase, uncovering needs and opportunities from both a user and business point of view. The phase culminates in a project brief, summarising the scope and direction of the project for the following phases.

Ill. 3: *Samuel "Samux" Fernández Fort and Zdravets "Hylissang" Galabov from the European team Unicorns of Love before a match*

Growth of Esports
Revenue and fan growth in millions

MILLION

1500
1200
900
600
300
0

2012 — 53 / 78 / 130
2014 — 89 / 117 / 194
2015 — 120 / 115 / 325
2016 — 161 / 162 / 493
2017 — 191 / 194 / 696
2020 — 286 / 303 / 1488

YEAR

■ Revenue (USD)   ■ Esports Enthusiast   ■ Occasional viewer
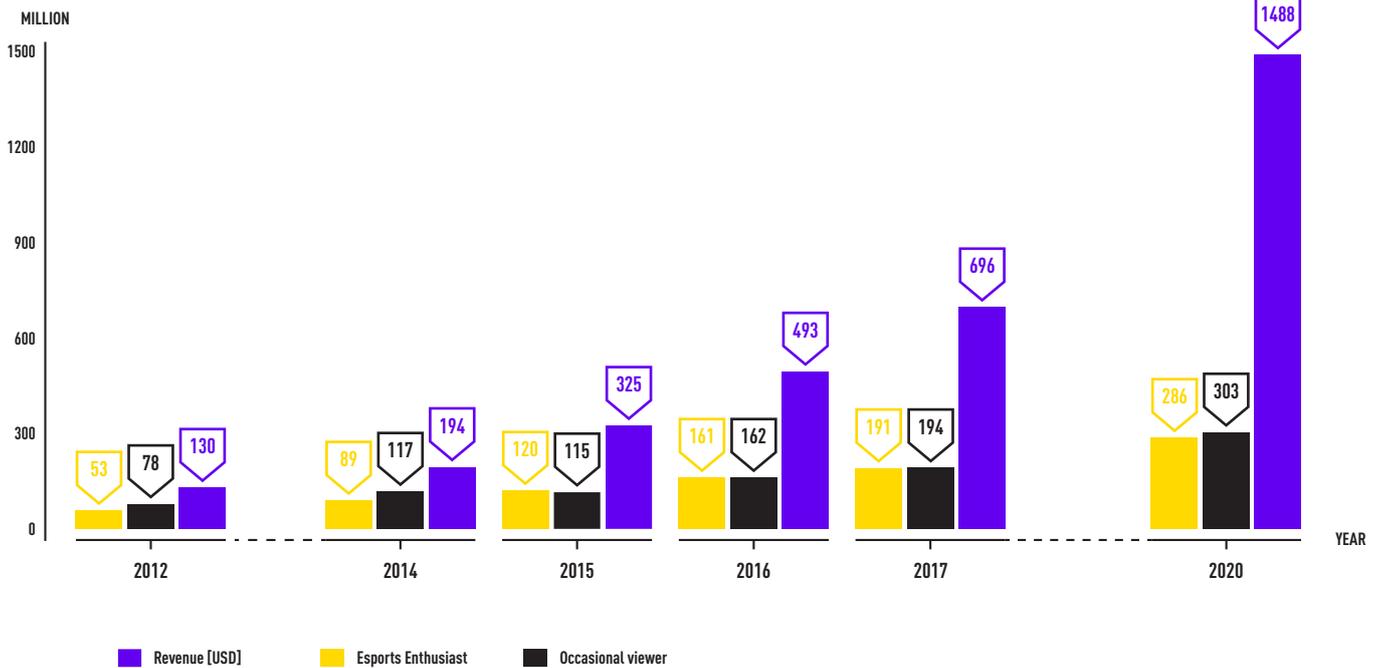
Ill. 4: *Esports revenue and fan growth in millions by the years*

What is esports?

To be able to unfold the potential and unspoken needs within the industry later on in the process it is essential to gain a general knowledge of the sport's definition, development, culture, and extent. This knowledge is obtained by conducting desk research [W000, W013].

The definition of esports is an abbreviation of Electronic sports, which defines organised, competitive computer gaming, usually among professionals (Dirs, 2014). It covers an array of games on multiple gaming platforms, where fine-motor skills, strategic overview, and a general knowledge of the game are often essential to become a master of the game. It is comparable to other traditional sports as it gathers a group of elite players in a stadium, competing for prize money, in front of both a live audience in the venue and a streaming audience over the internet (Lee, Stuart, Caluga-Pop, 2016).

The esports athletes require many hours of training to refine and develop their skillsets as well as to study strategies and techniques to be able to excel. Professor, Ingo Froböse, has studied esports athletes and found comparisons to regular sports, in the strains put on the body as well as the stress levels exposed to the mind while competing.

Increasing popularity
Esports has grown significantly in popularity over the years, increasing its audience from approximately 115 million viewers in 2015 to 162 million viewers the following year, *(Ill. 4)* (Newzoo, 2016a). Equally, the year-on-year revenue from 2015 till 2016 has also increased with staggering 51,7

% making the industry one of the fastest growing sports in the world, *(Ill. 4)* (Newzoo, 2016a).

// *In 10 years' time, it will be as big as NHL.*
- Leading gamer, Olof Kajbjer to CNN

Esports still has a long way to reach the popularity and revenues of major sports, as the revenues only represent a fraction of the revenue accumulated in sports such as football, *(Ill. 5)* (Lee, Stuart, Caluga-Pop, 2016). On the other hand esports had its first official tournament back in 1972 at Stanford University, and only really started to grow in the early 2000s whereas sports like football has existed for over a century (Fifa, 2017) (Alstrup, 2016).

Acceptance of esports
The sport still faces a lot of prejudice and aversion from outside its community to be acknowledged as a sport due to the seemingly minimal physical exertion it requires. This argument is also used by DIF (Danmarks Idræts Forbund), when discussing their willingness to admit esports into their organisation [W003] (Petersen, 2017). However, DIF is starting to come around on the issue, comparing it to the acceptance of both dart and table tennis, where the admission was influenced by the general societal acceptance of the sports (Petersen, 2017). DAF (Dansk Atletik Forbund) on the other hand has already embraced esports and sees a great potential in the collaboration, where esports will become part of the School Olympics program in 2017 [W003]

(Dansk Atletik Forbund, 2016).

In comparison, extreme sports faced similar scepticism as

// *To be admitted as a member of DIF, one must practice a sporting activity, and sitting and tapping on some keys is, in our opinion, not a definite sporting activity*

- Niels Nygaard, chairman at DIF

esports do now, when a more consistent press coverage began in the start 1990s. Starting with the X-games (the Olympics of extreme sport), the industry has grown in popularity, where a discipline, such as snowboarding, is now

featured at the official Winter Olympics (Young, 2016). In 2014, esports was for the first time accepted as part of the X-games with a tournament in the game Counter-Strike: Global Offensive and has reappeared since with tournaments in other games (MLG Network News, 2014).

Sum up
The research shows that esports is a fast growing industry, soon to be comparable to other major sports with its current development rate. A tendency indicates that esports will potentially be widely more accepted among the general public in the coming years. This information helps to confirm the team's assumption that a big business opportunity lies within this industry.

Revenue comparison 2016
Esports compared to other sports disciplines
in billions (USD)

Ill. 5: *Comparison between esports and classic sports industries*

The development of esports

1972 Stanford university students compete on arcade machines in the game SpaceWar (Alstrup, 2016).

1980 10,000 contestants in the USA compete in the game Space Invaders (Tewari, 2016).

1981 The gaming world record organisation, Twin Galaxies, is founded by Walther Day (Tewari, 2016).

1983 Walther Day creates the first national video game team of the USA (Tewari, 2016).

**1990** The first Nintendo World Championships takes place across the USA (Tewari, 2016).

1997 The Cyberathlete Professional League is founded, considered the pioneering organisation for professional Esports tournaments (Tewari, 2016).

1998 Blizzard released the strategy game 'StarCraft' (blizzard.com, 2017a)

70s

80s

90s

00

2000

The Korean Esports Association is founded as the world's first national association (Tewari, 2016)

OGN, a dedicated esports TV channel is launched in South Korea. It airs Esports day and night (Tewari, 2016)

2002

Blizzard releases the game 'Warcraft III', a sequel to the popular strategy game 'Warcraft II' (blizzard.com, 2017b)

2004

StarCraft becomes the unofficial national sport of South Korea, with 100.000 people attending the finals.

2008

The International E-sports Federation is founded by 9 national associations, including Denmark (ie-sf.com, 2016).

2009

Riot Games releases the MOBA game 'League of Legends' (wikipedia, 2017b)

2010

Pinnacle launches the world's first dedicated Esports betting website (Tewari, 2016).

2011

Twitch.tv makes it possible for fans to stream live events online (Tewari, 2016).

2014

The Leauge of Legends world championships in Seoul attract a record breaking live audience of 40.000 people (Tewari, 2016).

2015

World championships in League of Legends and Dota 2, two of the most popular competitive games, have record breaking prize pools of $3.6mil and $25mil respectively (Tewari, 2016).

2016

226 million people are watching Esports globally, which is a big increase from 115 million people in 2015 (Tewari, 2016).

2017

University of Utah becomes first Power Five School to offer an esports program (Burns, 2017)

Games market

Market split across platforms

Mobile 37%

PC 32%

$99.6 Bn
in total revenue created on the global games market in 2016

Handheld

29%

Consoles

Ill. 6: *Total revenue of the global games market divided by platform*

100

50

20

15

5.5

3

Counter Strike: Global Offensive

World of Warcraft

Dota 2

Overwatch

Hearthstone

League of Legends

Ill. 7: *Top 6 most popular games with players shown in millions*

Competitive games

To narrow down the scope to a more specific market within esports the team will investigate the different gaming platforms, its related competitive games and genres, and the supporting hardware needed for playing at competitions. The team will use desk research to obtain the needed information for the mapping.

Platforms of the global games market

There are four general global games markets: *'Console'*, *'PC'*, *'Handhelds'*, and *'Mobile' (Ill. 6)*. The four markets are umbrella terms for platform segments, where *Console* for example includes platforms such as the PlayStation, Xbox, and Wii and *Mobile* includes all phone and tablet devices. The numbers cover all game related revenues in each category, from the ads and in-app purchases downloadable expansions to actual hard copies of games. While the numbers do not indicate anything specifically about competitive game titles, it does illustrate a profitable industry across all platforms, except the *Handheld* segment, which only has 3% of the total games revenue (Newzoo, 2016c).

Taking a closer look at the games specifically played competitively provides a more detailed picture of the market *(Ill. 8)* [W002].

Equipment

The hardware used in esports depends on the gaming platform and the type of game played, but common for them all is that headset and microphone are only used in team-based games or if the player needs to communicate with a coach during the game *(Ill. 8)*. For Video Game Consoles, the primary equipment used is a controller, which has different designs depending on the console brand. When playing racing games the controller is exchanged for a steering wheel. The mobile devices do not need physical controllers as the touch screen is both the controller and screen in one. With the handhelds, no equipment is needed as the controls are

incorporated in the device. The PC is the platform requiring the most equipment as most competitive PC games require a keyboard, mouse, and headset with microphone for playing.

> The PC platform is the biggest esports platform, indicating a platform worth focusing on ⚡

Game genres and popular game titles

Games are generally divided up into game genres based on gameplay mechanics. Most competitive titles are played online against other players. Looking at online game titles by popularity provides a clear indication that Multiplayer Online Battle Arena (MOBA) is the most popular game genre with both League of Legends and Dota 2 in the top 6 most popular games *(Ill. 7)*. The most popular MOBA game, being League of Legends (LoL), attracts around 100 million unique players monthly. LoL is also the most played game overall followed by Hearthstone, Overwatch, Dota 2, and Counter Strike: Global Offensive (CS:GO) with respectively 50, 20, 15, and 3 million players per month (Nowloading.com, 2016). The total amount of players per month (playerbase) is determined as the amount of players who log in and play for at least an hour during a month. While this does not indicate how many players are playing the game on a competitive level, it still provides a good indication as to which games are most popular.

> MOBA is the biggest online game genre ⚡

> League of Legends is the game with the biggest player base ⚡
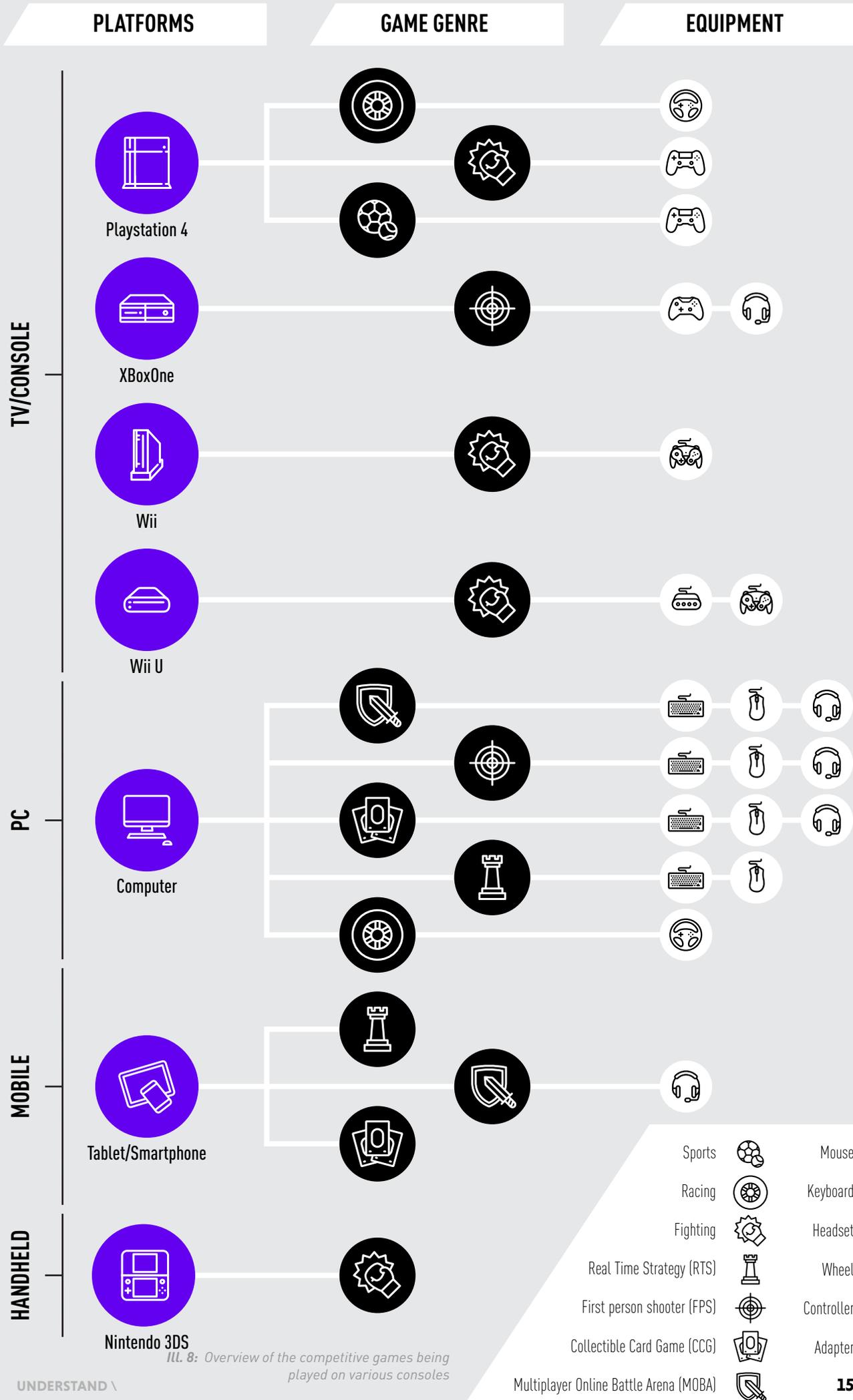
Ill. 8: *Overview of the competitive games being played on various consoles*

PLATFORMS

- Playstation 4
- XBoxOne
- Wii
- Wii U
- Computer
- Tablet/Smartphone
- Nintendo 3DS

TV/CONSOLE

PC

MOBILE

HANDHELD

GAME GENRE

EQUIPMENT

Legend:

Sports	Mouse
Racing	Keyboard
Fighting	Headset
Real Time Strategy (RTS)	Wheel
First person shooter (FPS)	Controller
Collectible Card Game (CCG)	Adapter
Multiplayer Online Battle Arena (MOBA)	
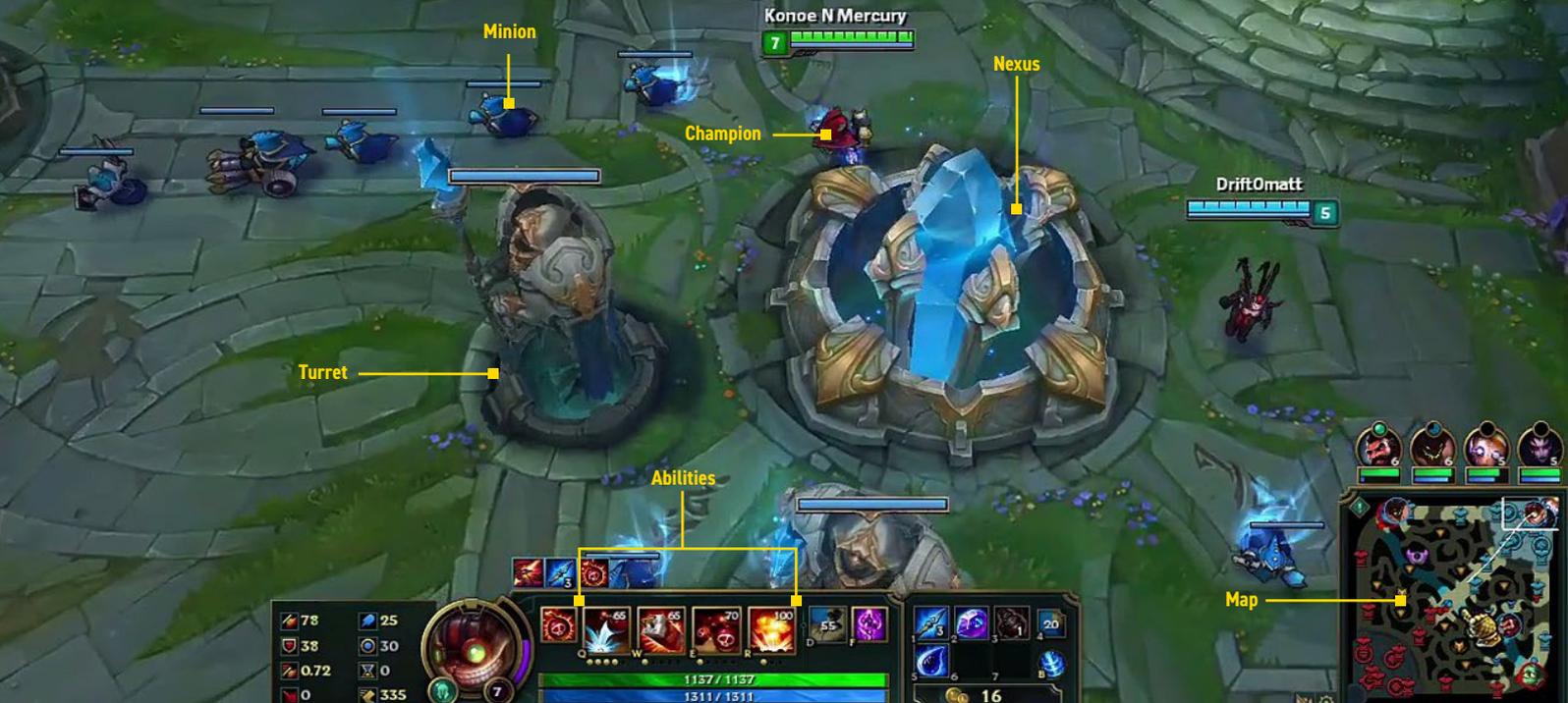
Gameplay

To better understand the MOBA genre, it is useful to understand the popular game League of Legends. To do so, the team will investigate the game, its objectives and the roles of each team member. This will help identify the equipment's role in the game and to uncover the shared and the individual needs of the play-ers, which the team hypothesise will be different depending on team roles. To investigate, the team will perform desk research, interviews with players and try out the game themselves.

League of Legends

League of Legends is a Multiplayer Online Battle Arena game played by two teams, each traditionally consisting of five play-ers controlling their own single unit, known as a champion. The objective of the game is to destroy the opposing team's main structure; the Nexus, which is located in the base of the team in opposite corners of the map (bottom left and top right) and accessed through three paths called 'lanes' *(Ill. 10)*. These lanes are defended by a chain of powerful defen-sive structures called 'turrets', which need to be eliminated consecutively to gain access to the Nexus. Between each lane there are neutral areas called 'the jungle'.

Each team starts in their respective base with a small amount of gold as in-game currency. Waves of small autonomous troops, known as 'minions', spawn from the Nexus peri-odically and marche through the lanes to clash with the minion wave of the opposing team further down the lane. Champions advance or 'push lanes' in collaboration with the allied minions to take down opposing minions, champions or turrets and earn gold and experience points (xp). Xp are used to level up and upgrade abilities to aid them in their battles while gold is used at the shop to buy items/gear to power up characteristics of the champions, which influences said abilities/spells. The team also collaborates to take down enemies, which are then suspended from the game for a duration of time, giving the team an edge in taking down further objectives and ultimately, the Nexus (gameinfo. na.leagueoflegends.com, 2016).

Team composition

On experienced teams, every player has a specific role to fulfil in the game, similar to football, where players can be offence, defence, etc. Before the game starts the players choose a unique champion from a champion select screen. The champion is chosen strategically based on the player's
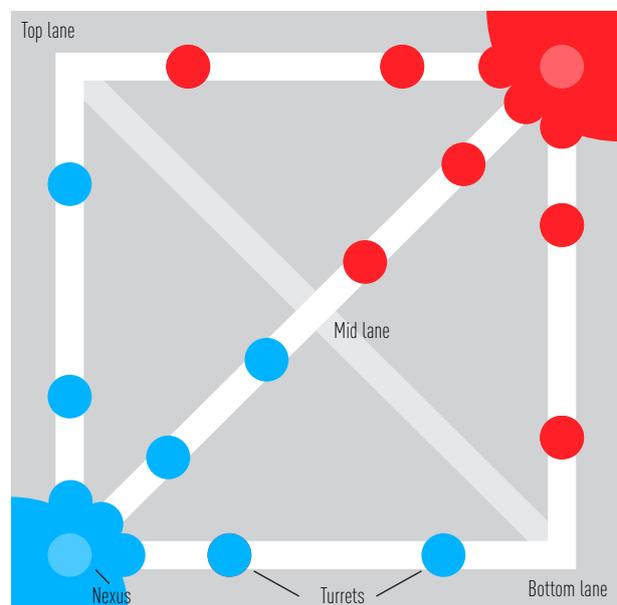
Ill. 10: *A simplified view of the 5v5 arena 'Summoner's Rift' in LoL*

role and individual playstyle but also as a tactical counter to the champions picked by the opposing team. Team roles are usually determined by position (Niek, 2013):

/ **Top laner** - usually a 'fighter' or 'tank' role: A lot of hit points (HP) and good fight engaging abilities.

/ **Jungler** - usually roaming around the jungle area: Helping the other team members when needed.

/ **Mid laner** - usually a 'mage' role: Ranged and high magic damage output

/ **Carry** - usually a 'marksmen': Ranged and high damage output but low HP.

/ **Support/Utility** - usually someone with abilities that can support the Carry and the rest of the team in teamfights.

LEFT CLICK:

Allows you to select items, targets, drag inventory items around, or confirm actions like casting

ITEMS:

Numbers 1-7 correspond to the items in your inventory. If an item can be used or consumed, press that button

RIGHT CLICK:

What you use to move to a location or to attack a target

CHAMPION ABILITIES:

Q, W, E and **R** keys are the your primary abilities. Some abilities may require a target, direction, or left click to use

RECALL:

The **B** key is the Recall button! Press B when you want to return to base

SUMMONER SPELLS:

D and **F** are special summoner spells. They're like a primary ability only with a far longer time between each use

Ill. 11: *An overview of the interface used to control and play League of Legends. Keys corresponds with abilities seen in Ill. 9*

Interaction points

League of Legends is a point-and-click game, seen from a top-down view.

One hand is placed on the keyboard for activating abilities and items while another hand is placed on the mouse which, is used controlling the champion *(Ill. 11)* [W025]. Right clicks are the main click type as, they are used for movements, targeting and buying items in the shop, while left clicks are only used for certain abilities. Some champions have specific abilities called 'skillshots', which require a left click in correlation with pressing the ability key, meaning that these champions will have more left clicks. When playing with unfamiliar people online, the keyboard is also used for chatting to align strategies.

Player roles do not influence how the players interact with the keyboard and mouse, but players can have shortcut preferences. Keystrokes such as D, F and B are only used occasionally, but some players prefer placing shortcuts for these on the mouse [W016].

Players do not have individual needs dependent on the team role when it comes to equipment	✕
Players use the entire keyboard when chatting	⚡
Some players prefer placing shortcuts on the mouse	⚡
The game requires two main actuators	⚡
The mouse is used for navigation in game	⚡

The world of esports

To understand the context a new type of esports equipment will be used in, it seems imperative to get a feeling and understanding of its culture by breaking down preconceptions and experiencing how an actual event looks and feels, how the audience behaves, what the setup looks like, how spectators cover the game, etc. To attain this, the team attended a League of Legends Championship series match in Berlin, and conducted phenomenological investigations and interviews with fans and professionals [W000, W001, W003, W004, W061].

Similar to other sports, League of Legends, is played in various tournaments during the season, where players hope to win titles and earn their keep. Among the important international tournaments is the Intel Extreme Masters (IEM), which is a tournament with smaller qualifying events leading up to the IEM World Championships featuring other games such as CS:GO and Starcraft II.

The European League of Legends Championship Series (EU LCS) is comparable to the Champions League in football, where teams compete against each other every week to win the league and qualify for seedings in the yearly League of Legends World Championship, often referred to as 'Worlds' [W001] (lolesports.com, 2016).

Worlds is hosted by the game developer Riot Games, and is considered the most important and acknowledged event to the players as it is a dedicated League of Legends tournament and all the best professional teams participate to win the honour of becoming the world's best team [W004]. For the professionals the league is important as it provides media exposure and helps secure sponsorships to the team [W004] (Cooper, 2016).

Just like football esports has a huge fan base and a culture of its own. During a night of matches in the EU LCS studio in Berlin, for example, one will encounter riled up fans wearing the jerseys of their favourite team and cheering them on during the matches.

// *It's the same as if you go to a football match and you're jumping up and down, you enjoy the moment with people you don't even know. It stays with you*

- Shaun 'Apollo' Clark, Commentator for Starcraft II
(Young, 2016)

Comparing 'Worlds' viewership to the finals of other big sports leagues such as NBA and MLB shows a huge following *(Ill. 14)*. Though NBA and MLB are only American leagues and League of Legends World Championship is international, it provides a good image of the popularity of esports [W001] (Felix, 2015).

Teams

League of Legends teams are divided into tiers depending on their skills and success (*Ill. 15*). These tiers work very similar to divisions in other sports like football or basketball. The tiers are split into four levels ranging from A-D, where teams in tier A and B compete on an international level in the League of Legends Championship Series (LCS) while teams in tier C and D compete on a local or national level. Teams in tiers A-C are organised with tier A teams typically having rosters in other competitive games (e.g. teams like Fnatic or G2 have rosters in most of the top competitive games like League of Legends, Dota 2, CS:GO, Hearthstone or even FIFA or Call of Duty (g2esports.com)). Teams in tier D are considered amateurs and are typically without organisation [W061].

The League of Legends Challenger Series (CS) is a league the teams compete in to get promoted to the League of Legends Championship Series (LCS) and ultimately qualify for Worlds (lolesports.com). If teams perform poorly in the LCS they can also be relegated back to the CS.

Sometimes investors (often former sports professionals) invest in a team, or put together a team from high ranking players, to compete in the CS. These so-called 'kickstarted teams' hope to gain exposure and establish their name in the hope to get picked up by one of the higher tier teams or clubs [W061].

Finals viewership: Esports vs Sports
Fans in millions
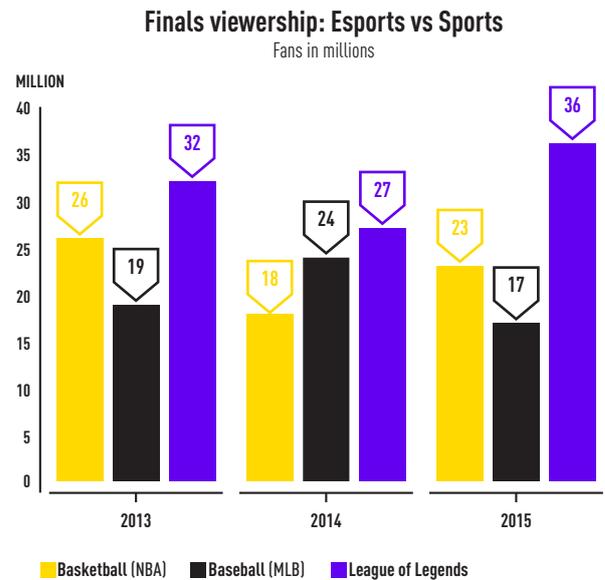
Ill. 14: Finals viewership: esports vs. Sports
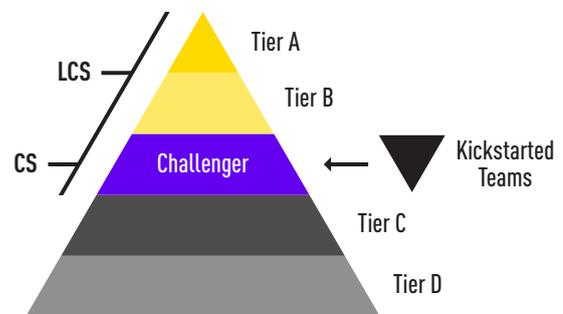
Ill. 15: The hierachy of teams

Official regulations

The official regulations for LCS states that players and teams are allowed to bring their own equipment for the competition in the following categories:

/ PC Keyboard
/ PC Mouse and cord holders
/ PC Mousepad

The equipment must be submitted to an LCS official for approval in advance (League of Legends Championship series, 2017). The regulations does not, state what the specifications or requirements are for the equipment to be acknowledged under these categories, meaning that the regulations can be interpreted for a new product to fit under one of the categories. As an example, the League of Legends player, Kerp, played with a trackball mouse in the LCS in 2013-2014, which is an alternative to the regular gaming mice seen on the market, *Ill. 19* (Lol.gamepedia.com, 2016).

Ill. 17: *Logitech trackball mouse, used by the player Kerk in LCS*

> Equipment falling under the categorisation of PC Mouse and cord holders can be brought at big tournaments ⚡

years, are a big source of income in esports *(Ill. 16)* (Esportsearnings.com, 2017)

/ Esports teams do not earn a substantial amount on merchandise in contrast to the big European football teams, where shirt sales alone are estimated to bring in a yearly revenue of $11-20 million (Srivastava, 2015) (Pan, 2015)

/ Player transfer fees are not significant in esports, as careers of esports athletes are rather short, most players retire before they turn 24, while they cannot go professional before they turn 17 [W004] (League of Legends Championship series, 2017).

Sponsorships

In esports, it is not as common to have personal sponsorships as it is often seen in traditional sports, except for the superstars of full-time professionals. Instead, most professional esports teams have sponsorships with manufacturers of gaming peripherals, where players are able to choose preferred equipment within the product portfolio [W004].

> Opposite regular sport, esports main media channel is through streaming sites, such as Twitch, and not TV-coverage ⚡

> Transfer fees is only a small part of the business within esports as the career of esports athletes is short ⚡

> Brands use sponsorships for product exposure ⚡

The ecosystem

To understand appropriate entry and business opportunities the team will look into the ecosystem of esports through desk research and a semi-structured interview with a manager from Aab Esport and both aspiring, active and retired professional players as well as a manager from Aab Esport [W004].

Comparing the ecosystem of traditional sports and esports shows that similar types of stakeholders are involved but that the revenue streams between the stakeholders, products, and service offerings reveal distinction *(Ill. 18)(Ill. 19)* (Pan, 2015).

/ Sponsorships are the largest source of revenue in esports, whereas NFL only gets 10% of its income from sponsorships (Pan, 2015)

/ Prize winnings, which have increased over the

League of Legends World Championship
Prize pool in million USD

| 1.9 | 2.0 | 2.1 | 2.1 | 5.0 |
| 2012 | 2013 | 2014 | 2015 | 2016 |
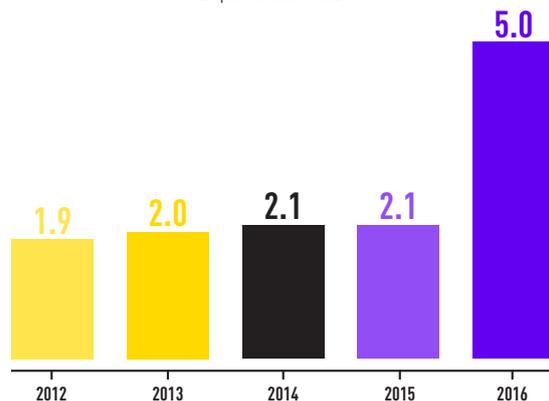
*Ill. 16:* *The LCS prize pool winnings development*

THE SPORTS ECOSYSTEM
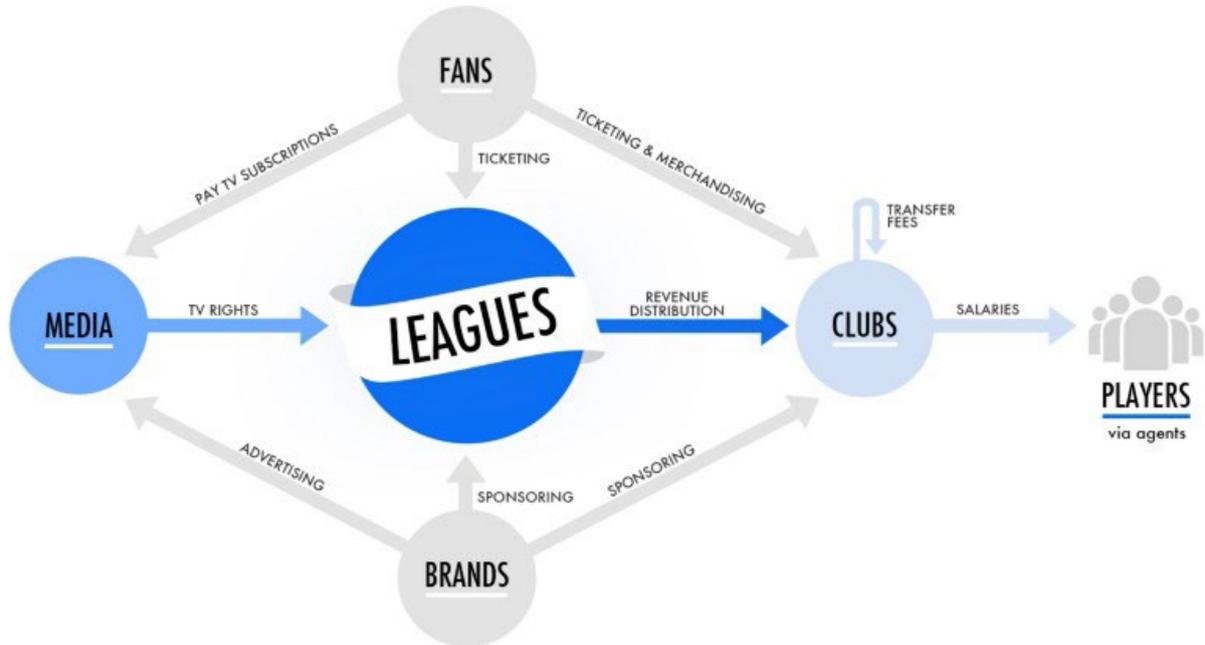
Ill. 18: *The sports ecosystem, simplified NFL example (Pan, 2015)*

THE ESPORTS ECOSYSTEM
CENTRAL LEAGUE MODEL
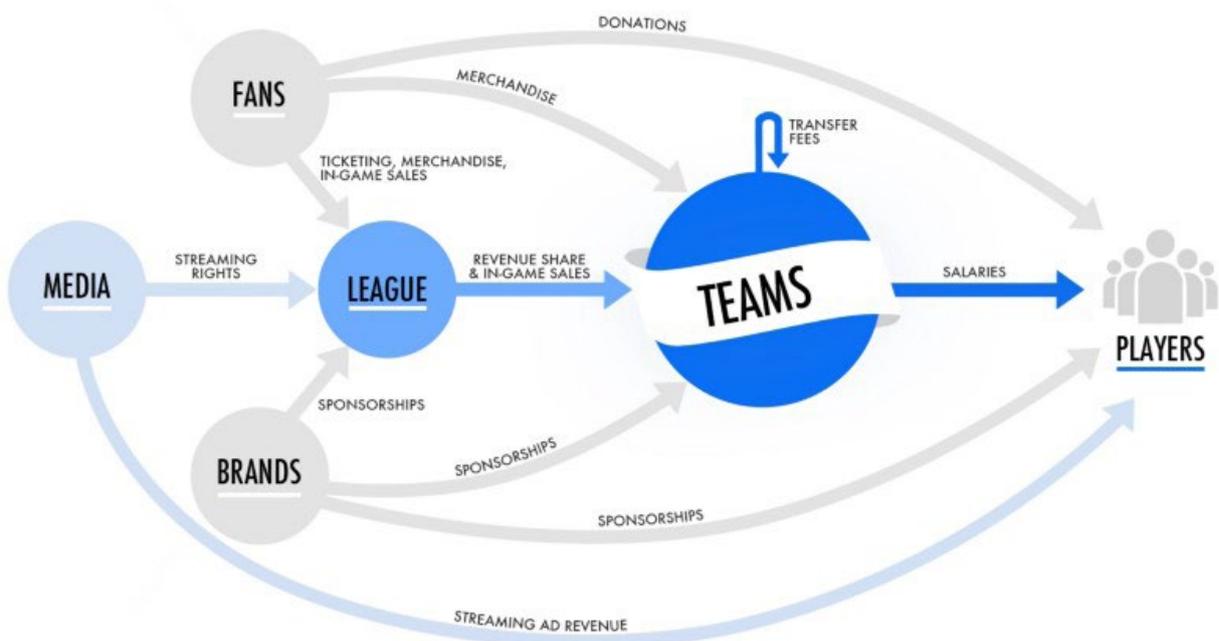
Ill. 19: *League of Legends ecosystem, simplified League of Legends (Pan, 2015)*
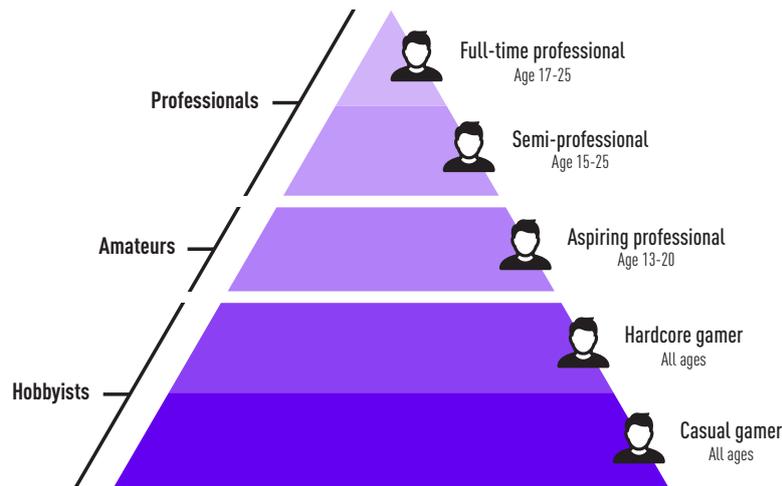
Esports players

Archetypes

To narrow down the broad spectrum of users to a more tangible target group a categorisation of the archetypes within esports has been made. The archetype categorisation will be the basis of further analysis and prototype testing. The categorisation analysis is based on semi-structured interviews with an elite esports coach, esports enthusiasts, players, and the chairman of Esport Danmark.

The archetypes are arranged in a pyramid corresponding to the amount of players in each category *(Ill. 20)*. The model signifies that to play games on a hobbyist level is most common and that only a few becomes full time professionals. The model is divided into three overall categories: Professionals, who earn money from playing, Amateurs, who would like to earn money from playing, and Hobbyists, who play as a recreational activity. These categories are further divided into five subcategories.

Full-time professional
Full-time professionals play at the highest international level and participate in major tournaments all over the world. [W004] (Creadon, 2015).

Playing: 8-12 hours of daily practise as part of a team [W004]

Earnings: Yearly earnings range from $30,000.00 to $1.000,000.00 depending on how skilled and popular the player is (Creadon, 2015). Additional earnings from prize money and streams.

Hardware: Get sponsored equipment and is able to choose from brand portfolio [W004].

Semi-professional
Semi-professionals participate in ordinary tournaments and occasionally major tournaments, but are eager to advance

to become full-time professionals

Playing: 4-8 hours of daily practise at home, as part of a team, or at clubs [W016].

Earnings: Small or no monthly salary. Additional earnings come from prize money.

Hardware: Sometimes get sponsored equipment. Choose a new mouse based on perceived durability, ergonomic fit in the hand, good specifications, and if it has extra functions. If they buy their own equipment they will typically be willing to spend 1000 DKK [W004, W016].

Aspiring professional
The aspiring professionals are young players dedicated to the sport, having a dream of becoming full-time professional. Participates in national tournaments.

Playing: 3-7 hours of daily practise at home, as part of an education, or in a club [W005, W016].

Earnings: Occasionally win prize money.

Hardware: Buys their own equipment. Choose a new mouse based on its looks, if it is perceived as durable, has extra functions, and if it is being recommended. They are generally willing to pay up to 2000 DKK for a new mouse if they think it will improve their game [W016].

Hardcore gamer
The hardcore game is an esports enthusiast playing as a recreational activity, to socialise, and have a good time.

Playing: 3-12 hours of daily play dependent on the individual [W022].

Earnings: Rarely participate in tournaments, but can occasionally win prize money

Hardware: Buys their own equipment. Choose a new mouse based on if it is customisable, feels good in the hand, has easy maintenance (cleaning), has extra features, and is percieved as durable [W022].

Casual gamer
A casual gamer plays occasionally, and sometimes watches events, but is not as dedicated as the hardcore gamer.

Playing: Once in a while.

Earnings: Never participate as a player in tournaments.

Hardware: Do not care about their equipment and mainly base their choice of equipment on low prices.

Full-time professionals and semi-professionals mainly get their equipment sponsored	⚡
Aspiring professionals and hardcore gamers are generally willing to pay a lot for their equipment if it fits their needs	⚡
Players base buying preferences on if it fits their hand size	⚡
Hardcore gamers base buying preferences on if it easy to clean	⚡
Players base buying preferences on if they perceive it to be durable	⚡

The full-time professional
To gain an understanding of what it means to be a professional esports player, the team interviews Jesper "Zven" Svenningsen (Ill. 21), a full-time professional League of Legends player from the team European team G2 Esports (Ill. 22) [W004].

The typical day of a professional
Professional esports players are typically young and often high school dropouts that have turned their hobby into a way of living (Hollist, 2016). Being a professional esports player means a lot of hard work to maintain and develop in-game skills and gameplay. This includes practicing strategy, team communication, and champion compositions as well as strategical analysis of matches and competitors *(Ill. 23)*.
The schedule shows an unbalanced circadian rhythm and extensive load of practicing hours in front of the computer in a combination of not very healthy food and very little physical activity.

Brains over equipment
In professional sports the key element is performance and the equipment is an important part of performing. Equipment preferences are a highly subjective matter. Some players swear to extra functions on their mouse and others, like 'Zven', just want a plain mouse without any extra buttons. These preferences are usually established before turning professional. According to Zven, he got his first keyboard for Christmas when he was a child and since then he has not changed his set-up much. Being a full-time professional also

// *In League, brains is the most important factor to be a good player*
- Jesper 'Zven' Svenningsen, G2 Esports

puts a lot of pressure on the athlete, as it is expected to keep performing, otherwise, the team might replace the player, as many are fighting for the chance to be a part of the big teams. For this reason, players expects high performance from the equipment and rely on their own skillset to keep their position.

Today, high quality equipment can be found in all configurations. Therefore, the deciding factor is the interaction between player and equipment. It needs to enable performance under high levels of stress and allow a perfect execution of the game plan.

Habits and preferences are formed before players turn professional	⚡
High performance is important to stay on a professional level	⚡
Professionals want their equipment to be similar to what they are used to	⚡

It does not happen to me

The extensive number of hours that players put in to practicing and playing takes its toll on the human body. Young players, however, are not really concerned about injuries, as long as they have not been injured themselves (Winkie, 2016). This could be due to the little attention the topic has received within the esports industry, but that is starting to change.

// *It is not a problem of mine but a lot of players have pain in their wrist from playing*

- Jesper 'Zven' Svenningsen, G2 Esports

These players are highly dedicated, but, in comparison to other sports professionals, they are not acting very professional, not acknowledging the many external factors that make an athlete, like restitution and diet. In other words they are more super enthusiasts than athletes.
Recently, the culture has been changing with small initiatives like stretching and minor warming up sessions are used to prevent injuries [W004].

Ill. 21: *Jesper 'Zven' Svenningsen at a match*

Ill. 22: *The G2 Esports club logo*

A day as a professional

11:30- Waking up and taking a bath.
12:00- Breakfast (eggs, bread, ham and cheese)
12:30- Walk through yesterdays scrims/practice games or last weeks EU LCS matches.
13:30- SoloQueue (individual online ranked games)
15:00- First scrim block (practice vs. EU LCS team)
18:00- Dinner - Often take out.
19:00- Second scrim block
23:00- Spare time, usually spend on SoloQueues.
03:00- Bedtime

Ill. 23: *The typical day for Zven*

Physical implications in esports

As the team has discovered the excessive hours the players spend on playing, while having a general knowledge of repetitive injuries found in regular office settings, it is considered obvious to investigate if the same issues can be found in esports. The hope is to identify problems or opportunities, both injury and performance related, that can be used as a piling mark during the concept development. The general understanding of medical consequences and terms are obtained through desk research and through a semi-structured interview with Jens Ehlers, specialist doctor in general medicine and assigned doctor at Team Danmark. Observations and interviews with players at Vejle Sports college on the esports programme have additionally provided insights into their experiences with injuries and symptoms.

// *The amount of cortisol produced is about the same level as that of a race-car driver combined with a high pulse, sometimes as high as 160 to 180 beats per minute, almost equivalent to a marathon. That's not to mention the motor skills involved. So in my opinion, esports are just as demanding as most other types of sports, if not more demanding.*

- Professor Ingo Froböse

Magnitude

A currently unrecognised problem within esports are the injuries that ensue from the many hours of playing.
The sport is still young, meaning that no exact numbers are currently present on the extent of the problem. Of the seven esports players at Vejle Sports College, one currently deals with an injury, while the others has had an injury, indicating a sad tendency [W016].

Even though esports may appear static and inactive compared to other sports, recent studies conducted by professor Ingo Fröbose from the German Sports University in Cologne say otherwise. Prof Fröbose found that the reason why esports seems static and inactive is because the actions of controlling the keyboard and mouse happen through fine dynamic repetitive movements at high speeds that require exceptional fine motor skills.

Professional players have come forward in the last couple of years and announced both breaks and retirements due to injuries. Dr. Levi Harrison, a hand and arm surgeon based in Los Angeles, says that, besides MMA fighters, esports

athletes are his most frequent patients (Plunkett, 2015). Players wearing wrist supports or using kinesio tape are also becoming a common sight at competitions *(Ill. 24)*. Teams rarely have their own medical staff and a health-care insurance is uncommon in players' contracts with no union or association to turn to for protection if they get injured. If this happens it could mean skipping a season of play or ultimately; a lost carrier. To the teams and clubs it means a lost investment and paying salary to players, who are not able to play. Compared to traditional sports, research shows that football teams lose between 10 to 30 percent of player payrolls to injuries, which could ultimately be the future of esports (Bräutigam, 2016).

The most common injuries in esports are categorised as Repetitive Stress Injuries or RSI. In addition to this, the athletes are also exposed to isometric work, meaning that they constantly sit in the same static position, leading to tired and strain muscles. Swelling, tension, and pain are symptoms of strained tissue and ligaments that can lead to irreversible injuries [W018]. The general tendency is to ignore these signs of strain and neglect restitution (W018). An interview with Brian Torp, esports manager at Aab Esport,

revealed that the injuries experienced in League of Legends are mostly around the mouse arm, especially the wrist, whereas In CS:GO inuries mainly occur in the shoulder as the game requires greater arm movement [W005].

Some players get injured from playing, while many show symptoms of possible future injuries	⚡
For League of Legends players most injuries occur in the mouse arm	⚡

Cold hands

According to the professional League of Legends player, Eugene Park, many players deal with the problem of getting cold hands and accommodate by using hand warmers before each game (Allen, 2017). The stages where competitions take place are often chilly, as the air conditioner needs to keep the PC's temperature low [W012] (Creadon, 2015).
Cold hands and joints reduces finger dexterity, resulting in both slower movements and reaction time, ultimately increasing the chance of mistakes in game (Havenith, Heus and Daanen, 1995).

According to specialist doctor, Jens Ehlers, cold hands are a contributing factor to injuries as cold joints lead to joint stiffness, straining the muscles because they try to compensate by applying more muscle force [W018]. A study also shows that cooling down the forearm, and thereby the muscles controlling finger movement, has an even greater impact on finger dexterity than cooling down the hand, explaining why players often wear long sleeved shirts during competitions (Leblanc, 1956).

Players get cold hands while playing, resulting in reduced finger dexterity and increased risk of injuries	⚡
Cooling of the forearm reduces finger dexterity	⚡

Typical Injuries

Neck and Back: The isometric work done when playing can lead to severe Lower Back Pain or (LBP), where bad posture also often leads to consistent neck pain and stiffness (Shim, 2016).

Shoulder: Extensive use of a computer mouse with bad technique or a weak shoulder can lead to a rotator cuff syndrome - an inflammation of the tendons and muscles around the shoulder that causes pain when in use *(Ill. 26)* (nhs.uk, 2016). If the shoulder is continuously strained, infiltrations can occur causing tenderness and radiations to the arm (sportnetdoc.net, 2011).

Elbow: Two of the classic RSI are the 'Tennis Elbow' and 'Golfer's Elbow which occur on opposite sides of the elbow *(Ill. 26)*. Pain occur in the bone protuberances on the outside of the elbow due to small tears in the connective tissue that fixates the muscles. The tissue becomes annoyed causing inflammation [W018].

Hand and wrist: The wrist is one of the joints where esports athletes experience the most strain. Poor wrist positioning when using the mouse in highly intense games puts strain on the ligaments, nerves and tissue causing injuries.

The most common one is Carpal Tunnel Syndrome which generates tingling, numbness, weakness, or pain in the fingers or hand, and radiate up in the arm *(Ill. 26)* (webmd.com). Another common injury for esports athletes is Tenosynovitis, which is an inflammation of the fluid-filled sheath that surrounds a tendon and leads to pain, swelling and difficulty in moving the fingers and hand, which according to special doctor, Jens Ehlers, can be partly mitigated by supporting the wrist and forearm *(Ill. 26)* [W018] (medlineplus.gov, 2014). Tenosynovitis can also lead to a 'Trigger finger', causing the finger to get stuck in a flexed position *(Ill. 26)* (ergovancouver. net, 2015).

|	
Support of the wrist and forearm can help relieve strain and pressure from the wrist	⚡

Rotator cuff syndrome

Rotary cuff
Tendons

Tennis elbow

Tear

Tendons

Carpal tunnel syndrome

Compressed
Median Nerve

Tenosynovitis

Tendons

Swelling in
Tunnel

Trigger finger

Swelling in
tendons
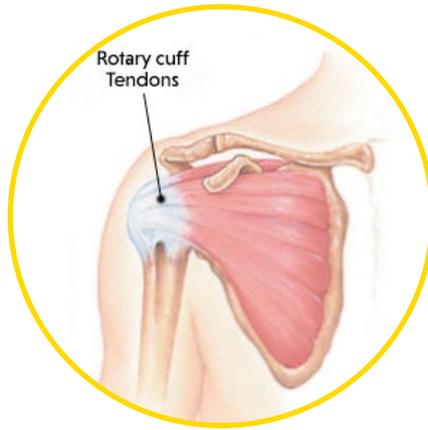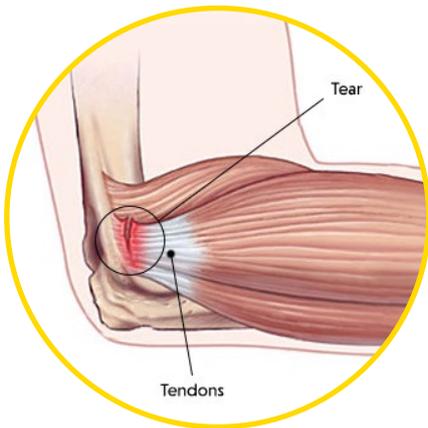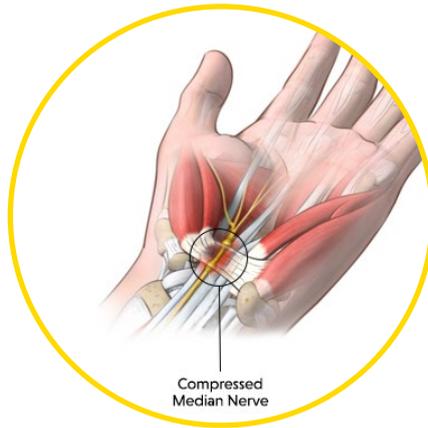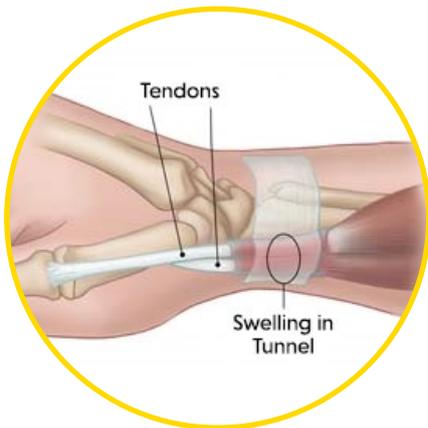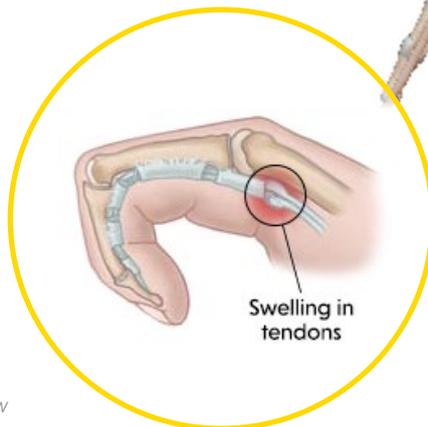
Ill. 26: Injury overview

Ill. 25: The anatomy of the arm

Project brief

Project overview
Esports is a fast growing industry, which is trying to find its place as a professional well-established sport, equivalent to other traditional forms of sports. The fast development has meant that esports ecosystem has blossomed, making the sport more accessible to both viewers and players. But it has also induced problems with injuries becoming a more common issue, particularly in the mouse arm, where wrist, elbow, and shoulders are the joints most affected by the fast and repetitive movements.

This project aims at designing equipment for the esports industry, which helps remedy the most common injuries found in the mouse arm, while also focusing on maintaining or enhancing performance during games.

Target group
As a preliminary target audience the team sees an opportunity in aiming a future product at the player archetypes; Hardcore players, Aspiring Professionals, and Semi Professionals. These players play so many hours that they are at risk of getting injuries. Additionally, these players are also the ones who are highly devoted to their equipment and are often willing to pay a little extra if they have a feeling a piece of hardware is more fitting to their needs.
Furthermore, the aspiring professionals and semi-professionals, will potentially become full-time professionals at some point, thereby addressing the injury issue for the next generation of full-time professionals instead.

Scope
To help make the project scope more tangible, the team has chosen to focus on the Multiplayer Online Battle Arena game genre, which has the largest player base. These games are mainly played on the PC platform with a keyboard and mouse.

Delimitation
Other genres played on PC, such as First Person Shooter, also have problems with injures but are put out of scope as the injures are of a different nature and the equipment is used differently.
The project is not focusing on the Full-time Professionals as the primary target group. This is because they are at a level, where they have established routines and are reluctant to change too much. Furthermore they are not buying their own equipment, but are choosing their equipment from the portfolio available by their sponsor. The team still sees an opportunity in using the Full-time professionals as means to promote and advertise for a new product.

Business potential
Esports presents a great business opportunity with a large player- and spectator base, which keeps increasing. Current numbers show 100 million monthly players, just in the online game League of Legends. The tendency indicates a larger acceptance of esports among the general public in the future. To enter the market, the team will be able to use existing gaming channels, such as the streaming site, Twitch, and possibly enter into an agreement with an existing gaming peripheral company to sponsor equipment to professional players. Most stakeholders around the players will benefit (financial or personally) from a device that reduces the risk of injuries. The entire business around esports could potentially be altered, if the average career of an esports athlete was to be prolonged ensuring a healthier and more profitable industry.
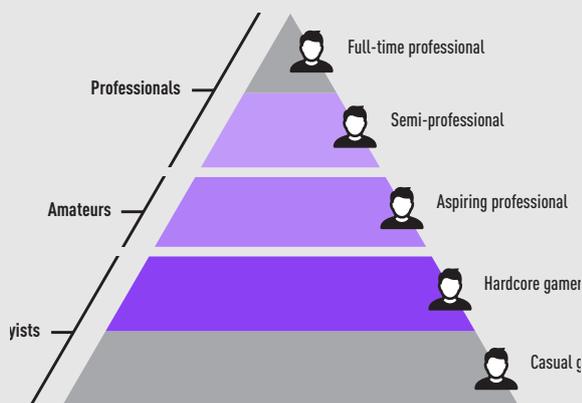
Ill. 27: *Highlighted target group*

Vision

The vision of Satellite is to turn gaming sporty.

Mission

The mission of Satellite is to create sporting equipment for the esports industry to reduce the risk of injuries and make the athletes perform their best during training and competition.

Criteria

The product criteria are based on initial findings in the research conducted so far. Throughout the concept development these criteria will be validated or invalidated through research and prototyping, and ultimately create a more refined list of product requirements. The insights, which the criteria are derived from, can be found on the page referred to.

The solution should:

/ Fit the computer platform *p. 14*

/ Be operated by the mouse arm *p. 26*

/ Have two main actuators *p. 17*

/ Control navigation in game *p. 17*

/ Not limit the performance of the player *p. 24*

/ Not be operated radically different, if replacing an existing piece of equipment *p. 24*

/ Support the forearm and wrist *p. 26*

/ Ensure a good working temperature of the fingers, hand, and forearm on the mouse arm *p. 26*

/ Should be able to fall under the categorisation of PC Mouse and cord holders *p. 20*

/ Enable chatting with both hands *p. 17*

/ Be adjustable to fit the individual's physiology *p. 23*

/ Have shortcuts *p. 17*

/ Be durable *p. 23*

/ Be easy to clean *p. 23*

/ Not exceed twice the price of similar products *p. 23*

IDEATE

Utilising the insights from the previous phase, the team starts to ideate on solutions and dive deeper into the problems, conducting investigations on solution principles.

Ideation

Round 1 - Kick-off

To kick-off the creative process, initial ideas and thoughts are sketched out by the team in an empty-your-head exercise [W023]. The objective of the session is a way to avoid stuck ideas blocking creativity in the following development.

A few rounds of five minutes are determined, where team members are to sketch out as many ideas as possible, with smaller evaluations in between to trigger new ideas through association. Several of the ideas evolve around creating support for the forearm and creating heat to avoid cold hands, but most can be determined as incremental changes or add-ons to an existing mouse *(Ill. 28)*.

Outcome
The exercise mainly shows the team that a more structured approach is needed, as the differentiation of ideas is minimal, and the level, in which the ideas are executed, varies from principles to whole concepts.
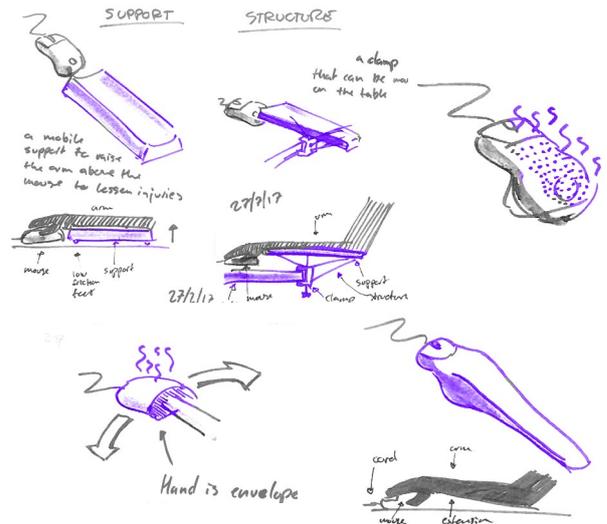
Ill. 28: Selection of sketches from the kick-off showing minor changes or add ons to existing mice.

Trend cards
As part of a visit to Vejle campus' esports programme, the team wants to investigate the aesthetic preferences of esports players. This is done through the use of trend cards to spark a conversation about their likes and dislikes [W017].

Eight categories of aesthetics within sports equipment are turned into individual trend cards *(Ill. 29)*. Sports equipment pictures are used over gaming equipment, as a bigger differentiation is seen within this industry, but also to avoid the players relating to a certain piece of equipment that they like based on the brand or its functional qualities.

The players are overall really excited about the *high-tech* trend card and explain it by the complexity and many details. They believe it to be professional equipment with high quality, where the bow and skiing boot looks specialised because of the possibility of individual customisation. *Simple* and *bulky* is seen as clumpy and boring by all but one of the interviewed players. The players are also fond of both *armoured* and *dynamic*. *Armoured* is by one described as looking well engineered and optimised for protection, with padding in "all the right places". *Dynamic* is described to look aero dynamic, being optimised for high speed. An overall agreement from the players is the fact that a new type of gaming equipment should not look like their parent's office equipment.

> Players seem to connect complexity with quality and professionalism ⚡
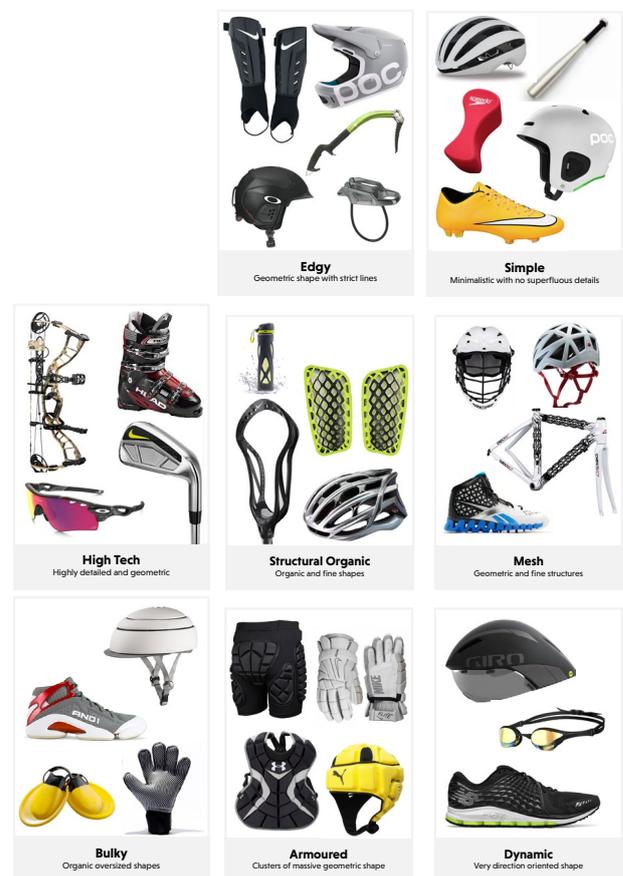
Ill. 29: 8 trend cards

Players want equipment to stand out from regular office equipment	⚡
Players seem to like when equipment expresses being optimised (e.g. speed, protection)	⚡

Innovation Scale

The kick-off ideation shows that it is needed to create a more common vision or metaphor for the development phase, for which the team can seek inspiration and create directions. Through a common brainstorm, desk research, and a team discussion, an Innovation Scale has been created, ranging from conservative to visionary [W033].

Based on general feedback from supervisors and students, the team has found it interesting to work simultaneously with different concept directions [W028]. Thereby dealing with the dilemma of creating something completely new for the athletes, which should still feel the same as their existing equipment (according to the full-time professionals). The team is aware, however, that the younger athletes, such as the aspiring professionals, are often more open-minded to new equipment, as they have not yet built up the same preferences as the full-time professionals, making it possible to challenge them more. The vision direction board is divided into three possible levels of innovation for the project, going from conservative to visionary *(Ill. 30)(Ill. 31)*. The redesign level is the small improvements made to existing mice. The new equipment level consist of more radical, creating new meaning to existing product categories. The future equipment is the visionary equipment, where the technology, needed for development, needs maturity before it can become a reality, which is found to be the most interesting to get close to achieve. The team aims at having concepts at different levels of the scale, working on them in parallel.

Ill. 30: Innovation Scale

Innovation of input device

| As is | The redesign | The new equipment | The future equipment |
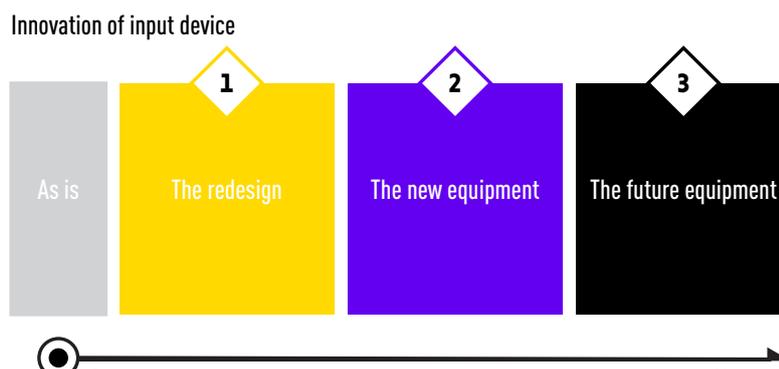
Ill. 31: Simplified vision direction board

Round 2 - Technologies

With inspiration from the vision direction board and to open up the solution space, the team is looking into different technologies (alternative ways of controlling). Desk research has been conducted into different possibilities [W030]. Moodboards are created on the basis of this, to be used as inspiration in the following sketching session.

The team has investigated the following control methods:

/ Gesture control
/ Voice control
/ Eye control
/ "Body" control
/ Foot control
/ Mind control

Mind control is quickly excluded after further investigation, as Electroencephalography (EEG) can only measure electrical activity, identifying which parts of the brain are active at certain times and at which "gear" they operate (Farnsworth, Mahler and Farnsworth, 2016).

Gesture control (and in particular EMG* technology) is found interesting to the team, displaying a more free way of controlling with a range of possibilities, indicated by the differentiation of pictures found for this moodboard *(Ill. 32)*. It also reflects in the outcome of sketches produced, where the majority is using gesture control *(Ill. 33)*.

Ill. 32: *Gesture control moodboard*

Outcome

The sketching session has provided some more futuristic out-of-the-box ideas, however, the diversity of ideas turns out to be few as sketching from the moodboards seems to restrict the team's creativity more than broaden it, confining it to variations of ideas seen on the pictures. The team also already knows that it is not possible to use voice control, as it counteracts the game specific activity of speaking with teammates.

A technology measuring muscle activity, which is sometimes used for controlling prosthetics.
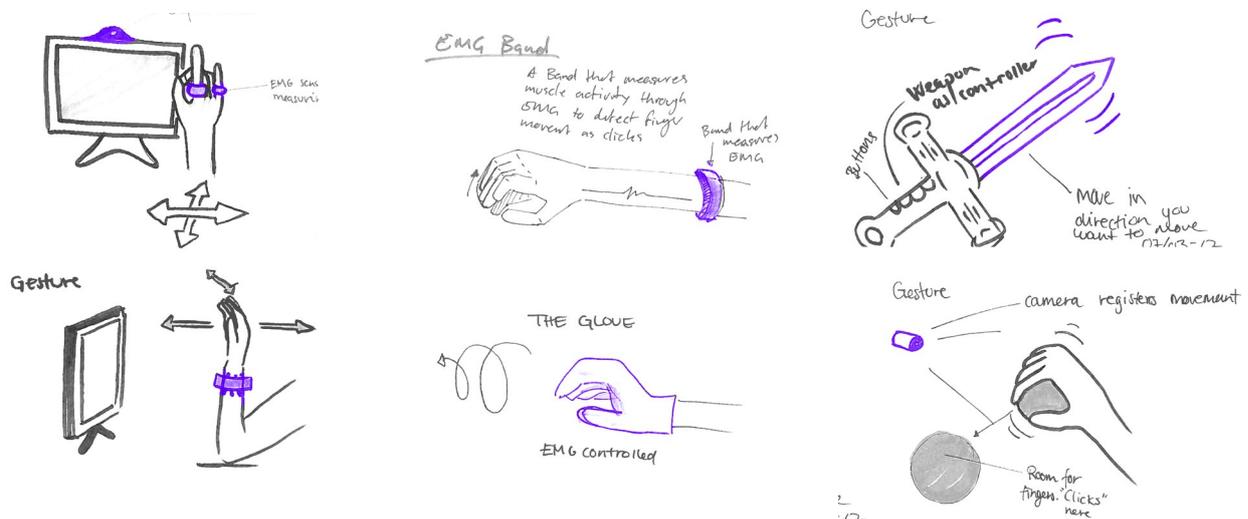
Ill. 33: *Sketches using variations of gesture control*

Interaction Loop

Input

| Orientation |
| Movement |
| Selection |
| Aim |

Arm · Mouse

| Items activation |
| Spells / Abilities activation |
| Chat |

Hands · Keyboard

| Talk / Communicate |

Voice · Microphone

Output

Screen · Vision

Speakers · Hearing
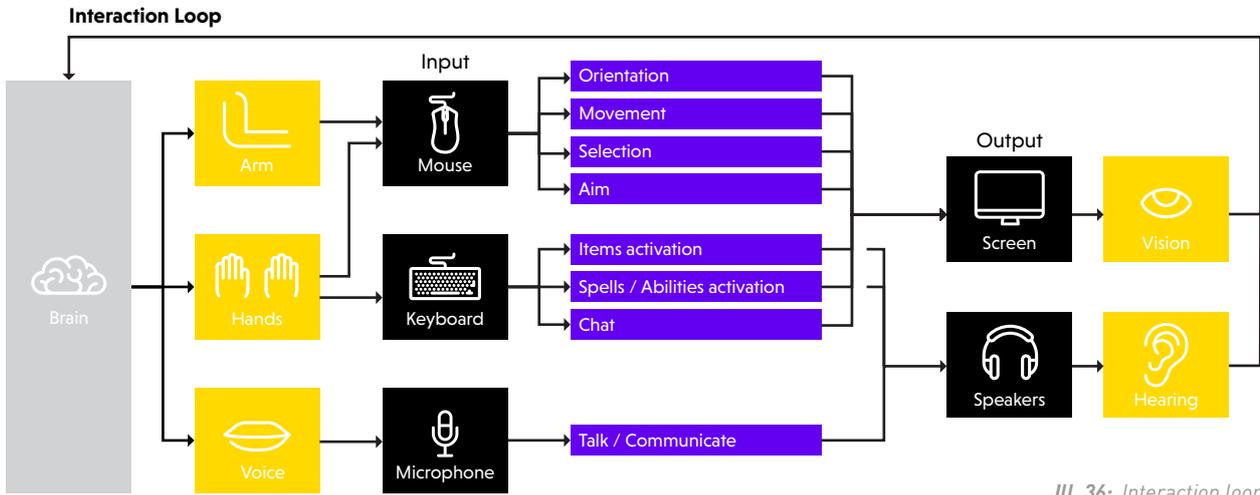
Ill. 36: Interaction loop

Player analysis

Human-machine interaction

The objective of this analysis is to explore and describe the human-machine interaction of League of Legends, to see how a new input device will affect the player [W025].

When playing League of Legends, the player interacts with the mouse, keyboard, and microphone, which act as an extension of the body into the virtual world. The physical actions are translated into on-screen virtual outputs (champion movements etc.) with complementary sounds. The player is able to translate and respond to these outputs and conduct new actions from them. The interaction loop illustrates this connection between inputs, the translation, outputs, and new translations *(Ill. 36)*.

The body combines the positions and movements of the musculoskeletal system with the planning and controlling of the motor commands in the brain and spinal cord to make actions in the game *(Ill. 34)*. When performing a movement, the brain holds its prediction of the movement and compares it with the actual feedback from the joints and muscles. As a result the prediction is adapted accordingly (Probst, 2016). This interaction is complex, where one type of movement can create diverse actions as seen in illustration *Ill. 36*, when using a mouse results in four different tasks. To help the brain with its translations and predictions, tactile feedback can be used to involve more senses to base predictions upon (Djajadiningrat et al. 2007).

| The brain predicts movements and compare it with actual feedback | ⚡ |

| Tactile feedback in interaction devices could ease the cognitive needs | ⚡ |

| Eye tracking cannot be used for control as the player already uses vision to translate outputs | ✕ |

Extension of the arm

Peripheral interaction theory is central to the Human-machine interaction of gaming, where peripheral interaction devices cover the hardware, which the esports players cur-

rently use. The diagram shows the relationship between peripheral work intensity and peripheral work volume *(Ill. 35)* (Blackwell & Edge, 2016).

What the graph indicates is that interaction can remain peripheral from the players attention if the workload of the interaction does not consume so many resources that it becomes the focus of attention. The current interaction devices are able to balance this, so players do not pay attention to their physical movements, but to the outputs provided by screen and speakers.

| The workload of interaction should be kept at a similar level as with regular mice | ✔ |

Ill. 34: Motor behaviour
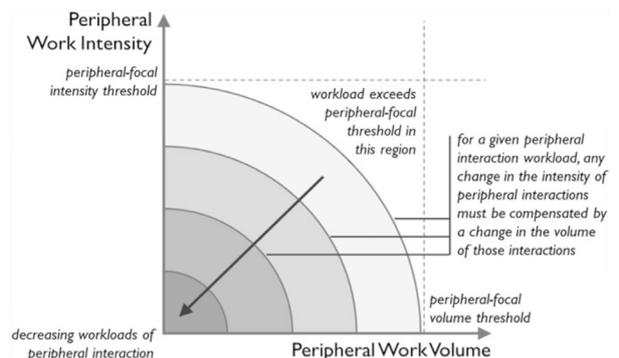
Ill. 35: Peripheral interaction trade-off

Biomechanics of the mousearm

The team wants to gain a deeper understanding of what causes the injuries within esports and what can be done as prevention. To do this, a biomechanical analysis has been conducted [W040], partly based on an interview with biomechanics professor at Aalborg University, John Rasmussen [W029] and desktop research including scientific literature and webinar material.

The Cinderella syndrome

It can be difficult to understand how simple movements of the wrist and fingers can lead to injuries such as a tennis elbow, when the muscle power required is only a fraction of what is needed when hitting a ball with a racket. The explanation lies within the muscles, which consist of thousands of muscle fibers divided into bundles, where motor neurons inside control either a few or hundreds of muscle fibers. All the fibers controlled by a single motor neuron constitutes a motor unit *(Ill. 37)*. Fine motor control is defined by the number of motor units in the muscle. The upper body has many, where the motor neurons control fewer muscle fibers than the motor neurons in the lower body, which is why the fingers have more fine motor control than for instance the toes [Martini, Nath, Bartholomew, 2012] [W029]. When wanting to click the mouse, the force needed to lift the finger is very small, but instead of the body activating all the motor units inside the muscle a little bit, it will only activate one motor unit, making the force relatively bigger on this unit [W029]. This phenomenon is known as the Cinderella syndrome, referring to one person doing all the work. Eventually, the motor unit will become damaged, if the movement is conducted enough times, resulting in injuries. For this reason, it is a good idea to divide the workload by constantly altering working position.

The Cinderella syndrome can be hard to identify in players, as measuring the activity with EMG is difficult, due to the small muscle activity, but mainly because EMG can be rather imprecise if the electrodes are not placed exactly over the muscle [W029].

> **// Is it actually a mouse they are using? You can say that esports is pretty established as it is now, so if you are to actually sit and use such a mouse as you use for office work, that's a bit crazy. It's a bit like playing tennis with a wooden bat!**
>
> – John Rasmussen Professor of Biomechanics

According to professor in biomechanics, John Rasmussen, the fact that esports players are still using a mouse is crazy,
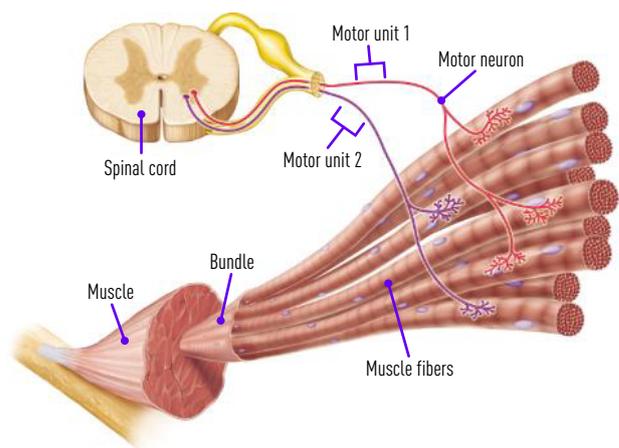
Ill. 37: The motor unit inside the muscle

because of the poorly optimised ergonomics to reduce the strain from the many movements conducted.

To divide workload among more motor units, altering working position is a good idea	⚡
Fine-motor skills are found in the upper body, meaning that controlling with the body and feet will be too imprecise	✕
EMG is imprecise if not placed exactly on top of the inflicted muscle, making it unable to be used as a controller technology	✕

Cold hands test

In extension of the analysis of the biomechanics in the mouse arm, the team wants to test out the knowledge previously obtained about cold hands, stating that the dexterity is reduced in the fingers when cooled down, and according to special doctor Jens Ehlers [W018], the risk of injuries is also increased. The test therefore serves as a confirmation or refutation of these insights [W047].

Two test subjects are tested 6 times each, while clicking on a mouse as fast as possible with their index finger for 10 seconds at different skin temperatures. Three times the hand is cooled down by holding it under cold running water at a temperature of 7 degrees Celsius for 20 seconds before clicking for 10 seconds, the other three times the temperature of the water is 37 degrees Celsius *(Ill. 40)* .

According to the data, there is a relation between the tem-

perature of the hand and the clicking speed it is able to perform. A remarkable difference is seen with test subject one, where the third round of cooling and the third round with heating have 62 clicks and 82 clicks respectively, an increase of around 33% when the hand is warm compared to when it is cold.

The problem is also more extensive than first assumed as a survey shows that 75% of League of Legends players experience cold hands while playing [W024].

Clicking speed is influenced by cold hands	✔

Ill. 40: Cooling of the hand

Analysis and optimisation

The team wants to optimise the working conditions for the athletes by reducing the strain put on the motor units, through conducting an analysis of the biomechanics, identifying errors (red in illustrations), where simple optimised principles (green in illustrations) are extracted to be used during the concept development. Ill. 38 and Ill. 39 illustrate the important muscles described in the analysis. Observations and video recordings of the players from Vejle Sportscollege are used to conduct the analysis [W007].

Ill. 39: Extensor digitorum (back of the hand and forearm)

Ill. 38: Flexor digitorum and abductor pollicis brevis (Front of the hand and forearm)
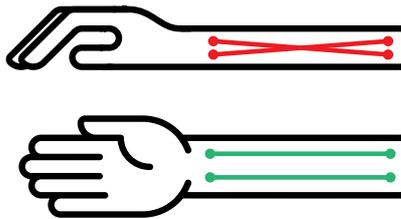
Ill. 41: Twisting the forearm

1. Twisting the forearm

When using a mouse, the hand is placed horizontal, which twists both the muscles and the bones of the forearm, resulting in a constant static strain of the muscles *(Ill. 41)*. According to the Danish standard "Ergonomics of human-system iteration - Part 410: Design criteria for physical input devices" - annex c, the most relaxed posture of the forearm muscles is believed to be with the palm 30 degrees from a vertical position and with a straight wrist (Dansk standard, 2008).

> 30 degrees from vertical is the most relaxing posture of the forearm ⚡

Ill. 42: Elevated hand and wrist pressure

2. Elevated hand and wrist pressure

The hand and wrist placement on the mouse results in a constant tension of the extensor digitorum muscle in the forearm, with a constant stretch to the flexor digitorum on the opposite side *(Ill. 42)*. At the same time, putting support and weight on the wrist is undesirable as it can result in injuries such as carpal tunnel syndrome or tenosynovitis [W040].

> A bend wrist causes tension and stretch of the muscles, and pressure on the wrist can cause carpal tunnel syndrome ✔

Ill. 43: Working against gravity

3. Working against gravity

As earlier described, one motor unit might be set to perform the task of lifting the finger. Even though the overall force required to do so is small, for one motor unit this force is relatively large. The force required becomes even greater when the motor unit within extensor digitorum has to lift against gravity *(Ill. 43)*.

> Working against gravity can provide a relative high extra force to muscles when activated ⚡

Ill. 44: Finger tension

4. Finger tension

If the hand is to rest entirely on the mouse, to most it will mean having to stretch the fingers from an entirely relaxed "hook" position *(Ill. 44)*. This means a constant tension of the extensor digitorum muscle in the forearm, with a constant stretch to the flexor digitorum on the opposite side.

> Resting the hand on an object creates tension, as the fingers are not in a neutral relaxed position ⚡
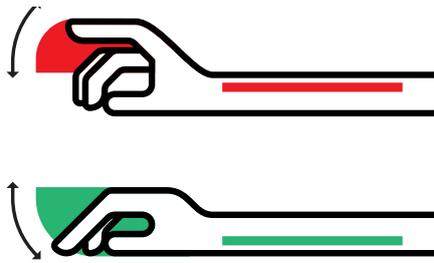
Ill. 45: Using the strongest muscle
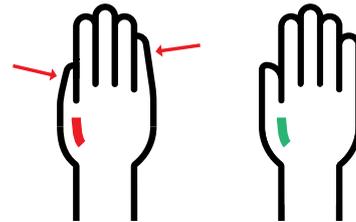
Ill. 47: Pinching

5. Extension over flexion

One of the errors with clicking on a regular mouse is that the finger is lifted to enable the click instead of being bent from its neutral position, thereby using the flexor digitorum over the extensor digitorum *(Ill. 45)*. The flexor muscle in the forearm is 40-60% stronger than the extensor, making it steadier and less prone to injuries (Salonikidis et al., 2011).

Flexor muscles are stronger than extensor	⚡

Ill. 46: Wrist movement

7. Pinching

Resetting the mouse is often done by lifting it with a pinching movement of the thumb and little finger *(Ill. 47)*. Also when navigating, players tend to squeeze the mouse. The thumb is here exposed to strain in the abductor pollicis brevis causing tenosynovitis, colloquially known as texting thumb [W040].

Navigating a mouse is often done by pinching	⚡

Pinching can cause texting thumb	⚡
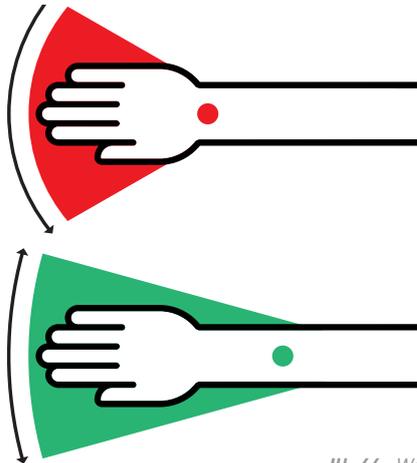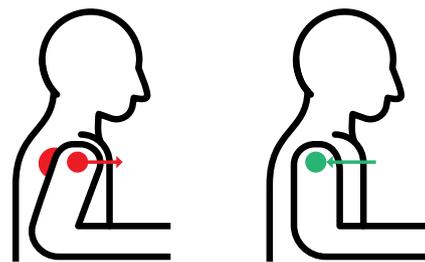
Ill. 48: Shoulder slouching

6. Wrist movement

Observation of players has revealed that they tend to use the wrist as a pivoting point for radial- and ulnar deviation, activating a few of the weaker muscles in the forearm instead of activating more muscles at the same time with bigger movements *(Ill. 46)*.

It is better to activate more and bigger muscles when navigating, instead of using only the wrist	⚡

8. Shoulder slouching

When caught up in the game, the players tend to slouch forward in the shoulder and moving the arm away from the body, creating unwanted strain, which could potentially cause an impingement syndrome *(Ill. 48)*. Here, tendons are impinged as they pass through a narrow bony space in the shoulder, called the subacromial space. With repetitive pinching, the tendons become irritated and inflamed [W040].

Shoulder slouching can cause injuries	⚡

Ideation continued

Round 3 - Principal sketching

Based on the experience from the previous sketching rounds, the team aims at getting more structure into the ideation and streamlining the level of the sketches. A breakdown is therefore conducted, determining function/requirement categories from both the biomechanical analysis, basic functions needed in the product, as well as the criteria stated in the brief, initiating the constructing of the table of requirements to be found at the end of this phase. To each category, 5 minutes are given to sketch as many principles as possible that could fulfil the category on Post-its, as possible without considerations to how plausible the principles would be [W035].The task is followed by a team evaluation, Ill. 49.

The team has found the following categories, where principles are to be deduced:

Ill. 49: *Evaluation of the principle sketching of the 15 categories*

1. **Reduce wrist strain**
   Avoiding pressure and a static elevated position of the wrist

2. **Reduce forearm strain**
   Avoiding controlling with only the wrist

3. **Actuators for actions in game**
   Alternative principles for right- and left click

4. **Adjustable precision**
   Actuators for adjusting the correlation of speed between physical movement and digital movement (DPI).

5. **Chatting in the game**
   Not being restricted by the device, to easily chat with both hands

6. **Connection stability**
   Types of connections between device and PC

7. **Adjustable to physiology**
   How to make it fit individuals

8. **Alternative working configuration**
   Ways of making a varied movement pattern, while using the product

9. **Durable**
   How to make the product appear durable (look, feel, sound etc.)

10. **Easy to clean**
    Ways to clean products

11. **Navigation in game**
    The physical movement to make the cursor move

12. **Neutral position**
    How to obtain a neutral finger and hand position when controlling

13. **Not look like office**
    What principles are not found in office equipment

14. **Reduce amount of lifts**
    Ways to avoid the pinching

15. **Optimal hand temperature**
    Ways to keep warm when hand temperature drops

Sum up

By structuring the sketching to focus on specific ways to solve requirements, more ideas have been accumulated. However, the team has learned that not all are actual principles, but several show to be variations of the same principle drawn in different connections as seen in *Ill. 50* with the principles being variations of navigation with joystick control. Furthermore, some categories seems to convey the same principles, while other categories seem obsolete at this point in the process, like the aesthetics. In W036, a list has been compiled by the team, reducing the categories to six and breaking down the principles within, creating a complete list of functional principles within the following categories:

1. Navigation
2. Actuation
3. Reduce strain on arm
4. Optimal hand temperature
5. Adjustable to fit
6. Connectivity

Testing actuation methods

From the new list of principles within actuation, the team has made a simple test to see if some actuation principles are more relevant than others. Each principle has been tested for 10 seconds on three test subjects. The number of actuations is counted from video recordings in slow motion and a qualitative statement is given upon the endurance of actuating this way [W032].The tests have been conducted as follows:

/ **Push:** clicking on a mouse
/ **Touch or tapping:** is for the test merged with push, as it in reality is more related to the feedback of actuation
/ **Tipping:** tipping a joystick
/ **Pull:** using an elastic band and pulling with the index finger
/ **Turn:** using a 3D mouse and turning it to one side
/ **Shake:** shaking a phone and counting the shakes using an app
/ **Hit:** knocking with a fist against a table top
/ **Squeeze:** squeezing a rubber figurine

With an actuation rate that is more than 20% higher than the others, Push, Pull, Hit, and Shake, easily eliminate the other ways of actuating. However, Shake and Hit cause other issues in terms of being able to navigate while shaking your hand at all times. Both of them are also really straining for the shoulder.

A variation of push or pull is the best way to actuate ⚡
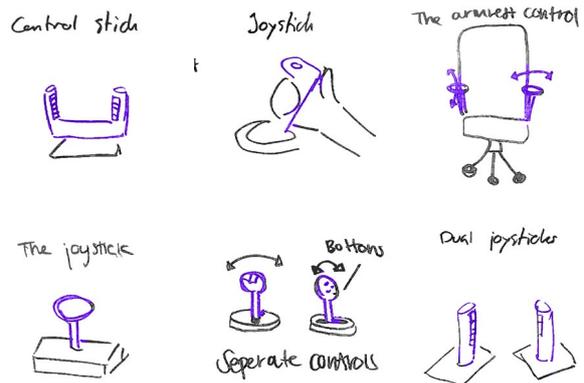
Ill. 50: Navigation category: variations of joystick principle

Free-hand   **Joystick**

New traditional   **Pointy**
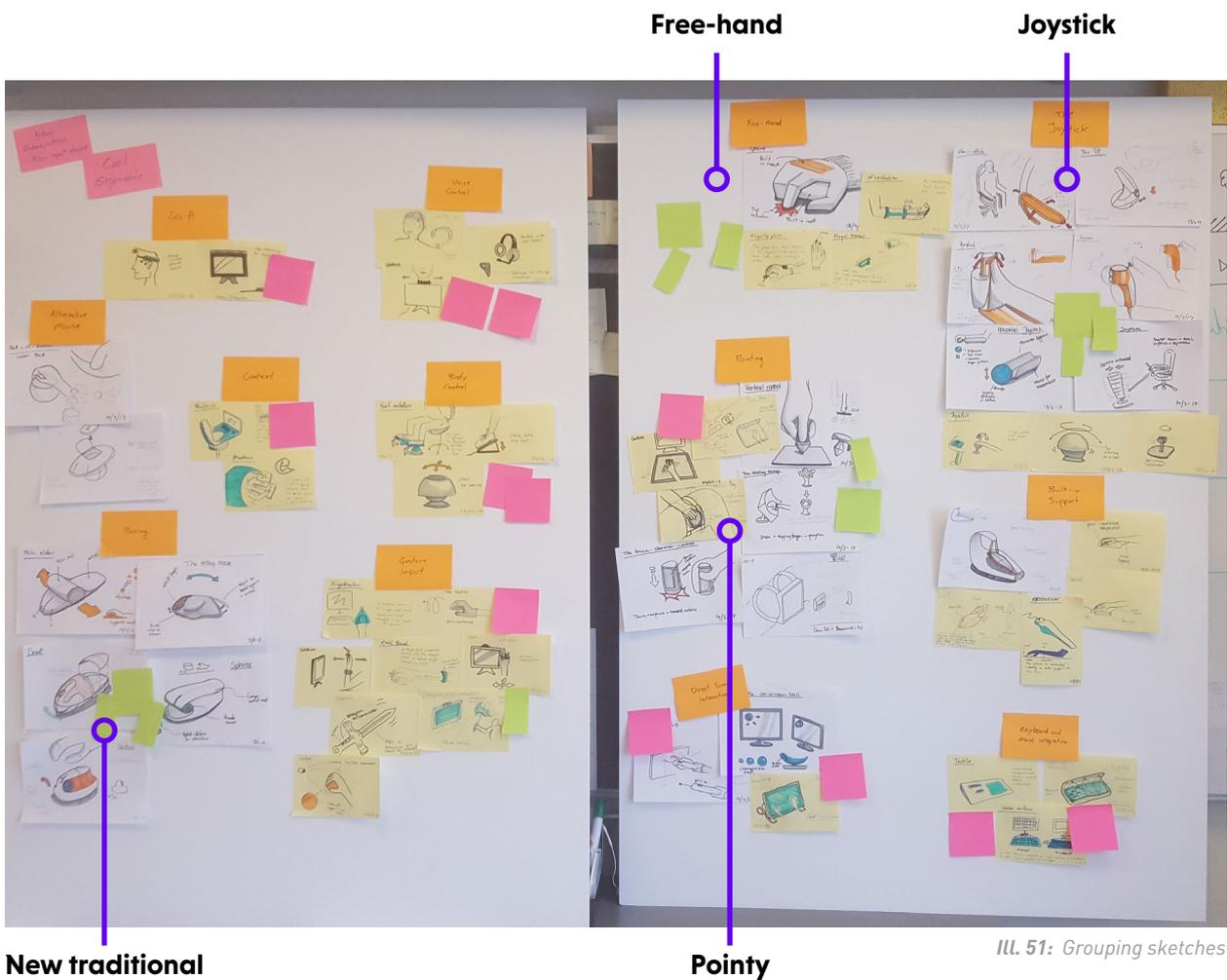
Ill. 51: *Grouping sketches*

Round 4 - Combining principles

The team wants to combine some of the principles into possible concepts. Through 7 rounds of sketching, a combination of a principle from three different categories are made. This is done randomly by rolling a dice to pick the category followed by rolling the dice again to choose a principle within the category [W037]. However, both navigation and actuation are incorporated each time, as the concepts would not make sense without these categories.

The sketching session provides more developed concepts, where the team is able to identify different patterns in the pool of sketches, including the ones from round 1 and 2 *(Ill. 51)* [W038]. A total of 13 directions are identified, but only

four seem plausible to fit with working on different levels (referring to the innovation scale). The others are either not possible (due to lack of technology advancement), provide poor navigation (due to the use of coarse motor function), are an addition to existing mice (a workaround), or would actually be worse in relation to strain (control in free air). The four directions chosen:

1. New traditional
2. Pointy
3. Joystick
4. Free-hand

New traditional

This direction is a redesign of an existing mouse, making alterations without rethinking the whole concept.

A. The ergonomic boat construction: having tilt for actuation and a scroll function for the thumb.

B. The supportive and adjustable mouse: inter-changeable palm rests.

C. Tilting mouse: eliminating the need for moving with the wrist by tilting for navigation.
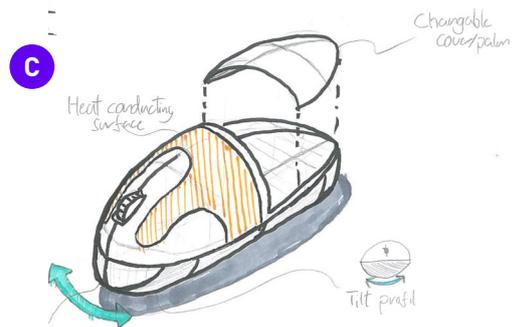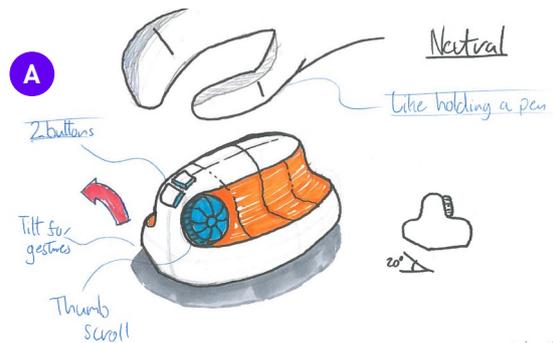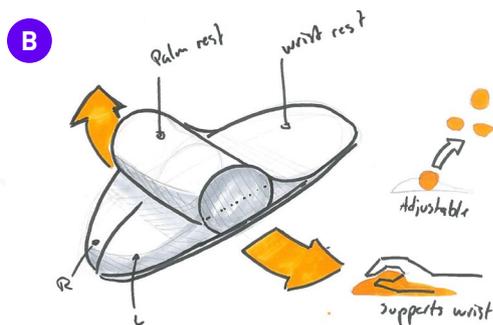
Pointy

This direction illustrates how the navigation is conducted using a surface, where the position on screen corresponds to the position on the surface.

A. Vertical control for working with gravity rather than against it: using a pointer to be supported by the fingers and clicking with the thumb.

B. Vertical attached surface: also optimised for work-ing with gravity by strapping on the surface at the side of a chair and using a pointer with a pull-acti-vated actuation.
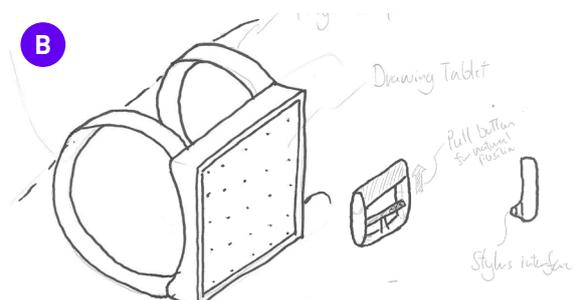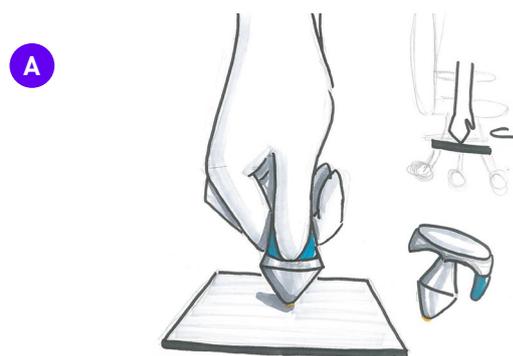
Joystick

This direction works with different variations of a joystick principle.

A. Attached joystick: attached on top of the armrest for support of the forearm, while playing.

B. Lying joystick: forearm supported joystick control with neutral finger position.

C. Trackball incorporation: trackball instead of the stick for controlling.
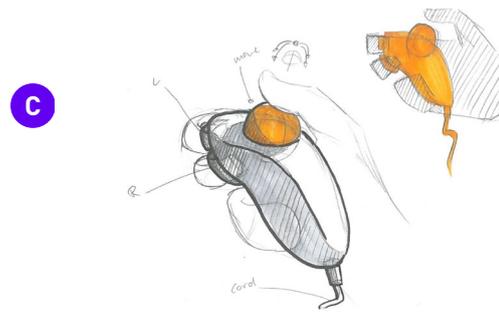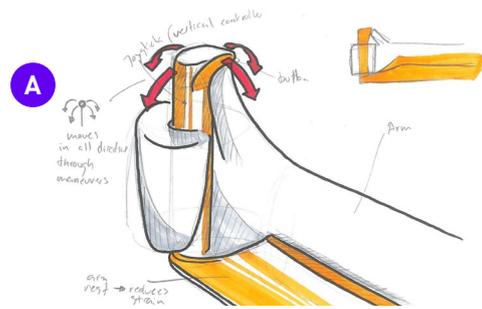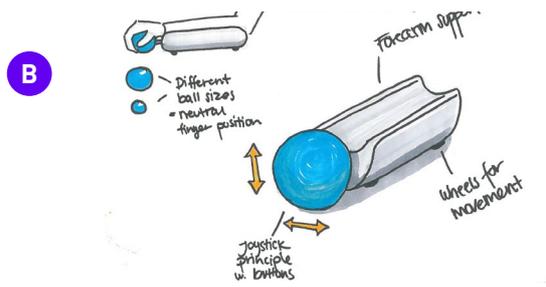
Free-hand

This direction works with the hand as the input device.

A. Free-hand. Build-in heating and support. Tapping with fingertips for clicking.

B. Exoskeleton. External mounted electronics on the arm with pull for clicking.
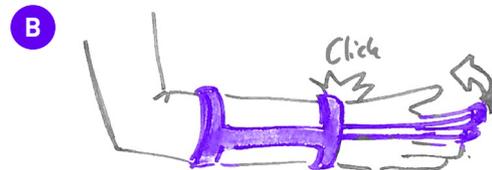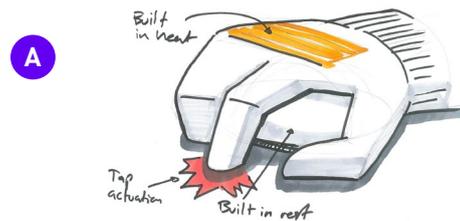
Sum up

From these four directions, the team aims at working in parallel as each direction can provide something different to the players. The new traditional direction might turn to be too incremental in a red ocean of mice, but the free-hand might be too radical in the way the players need to learn to play, illustrated by the placement in the innovation scale *(Ill. 52)*.
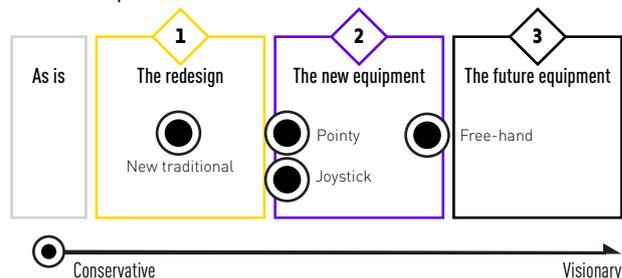
Ill. 52: Directions placed in the innovation scale

Table of requirements

A table of requirements is created from a development of the previously stated criteria and new gathered insights. It is divided into the two categories, quantitative and qualitative requirements, where the Kano Model has been applied for sub-categorising and prioritising of the things that have most influence on customer satisfaction (Malcolm, 2014). Basic covers the expected requirements, that do not bring extra satisfaction if well-executed, but on the contrary, make users very dissatisfied when executed poorly or if absent. Performance are the requirements, which the users find easy to articulate, making them easier to achieve. Delighter are the extra and unexpected values provided to the user. Because this value is not expected, it will generate satisfaction if executed well, while users will not miss it if absent. All requirements will over time fall in categorisation and end up as basic needs.

The requirements will be specified further through a product specification later in the project.

Quantitative	Qualitative
Basic	
/ Fits the computer platform / Is used for navigation in the game / Has precise correlation between physical movement and digital movement / Is operated by the "mouse arm" / right arm / Has two main actuators enabling actions in the game / Is actuated by a push or a pull movement / Enables the players to wear a long sleeved shirt / Is eyesight independent / Allows chatting with two hands on the keyboard	/ Can be controlled peripherally / Falls under the categorisation of PC Mouse and cord holders
Performance	
/ Has tactile feedback in the main clicks / Does not put pressure on the wrist / Costs a maximum of 2000 / Has shortcuts	/ Is easy to clean / Can be adjusted to fit the individual physiology / Does not look like office equipment / Looks complex / Looks as if it is optimised / Is durable / Reduces wrist movement
Delighter	
/ Is operated with a hand position 30 degrees from vertical / Does not need to be pinched for navigation	/ Is operated from a neutral finger position / Keeps the hands warm / Provides alternative working configurations / Works with gravity rather than against it / Helps to avoid shoulder slouching / Is operated from a straight wrist / Mainly uses flexor muscles over extensor muscles
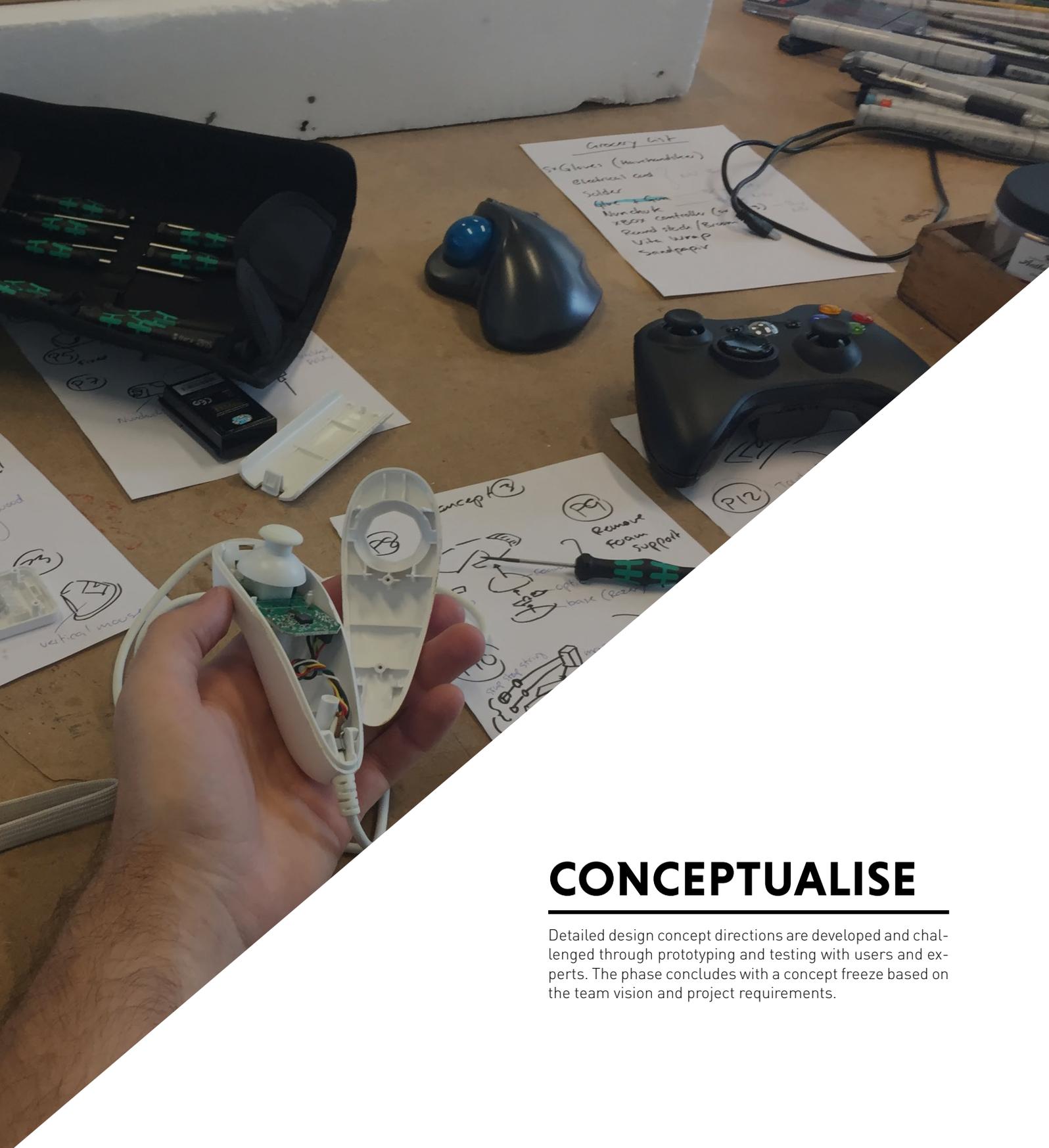
CONCEPTUALISE

Detailed design concept directions are developed and challenged through prototyping and testing with users and experts. The phase concludes with a concept freeze based on the team vision and project requirements.

Four concept directions

Concept exploration

The four directions are explored further through a new sketching session with the objective to create a pool of ideas, from which a more defined concept can be determined [W038]. The ideation session also serves as a way to determine principles to be tested out on players.

A

B
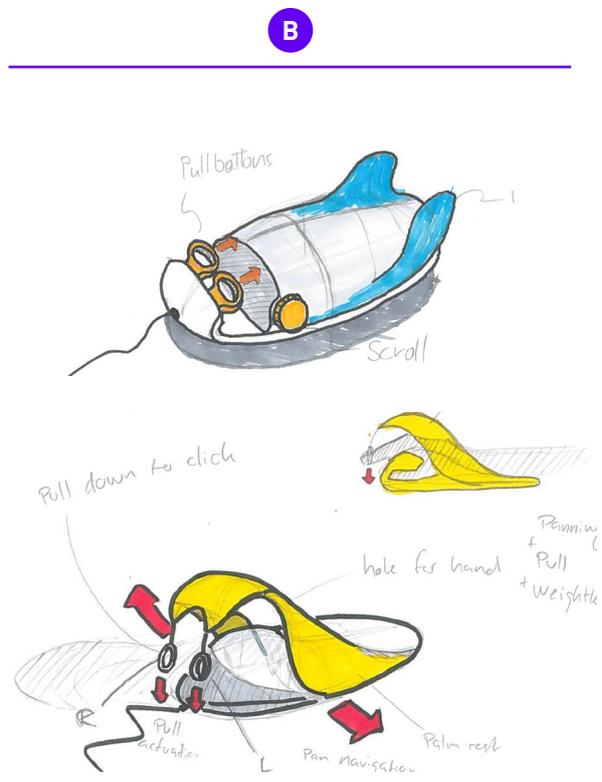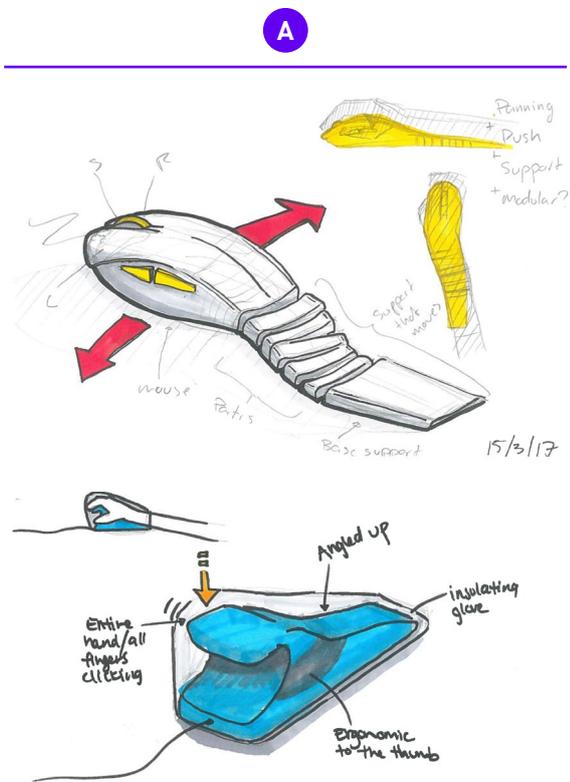
New traditional

This direction works with relieving strain from the shoulder, wrist, and forearm by exploring ways to use the previously stated biomechanical principles in a redesign of the traditional mouse. A supports the forearm. B obtains a neutral finger position and uses the flexor muscles to click by pulling.

The team decides that it would be relevant to test variations of forearm support on actual players. Therefore, prototypes with different support length are made *(Ill. 53)*. Furthermore, the team wants to test the player's comfort when using a vertical mouse instead of a regular mouse.
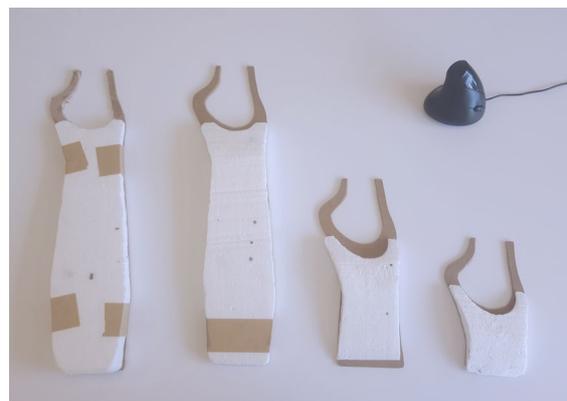
Ill. 53: *Support lengths: 40cm angled down, 40cm angled up, 20cm angled up, 10cm angled up. Vertical mouse*

A

B
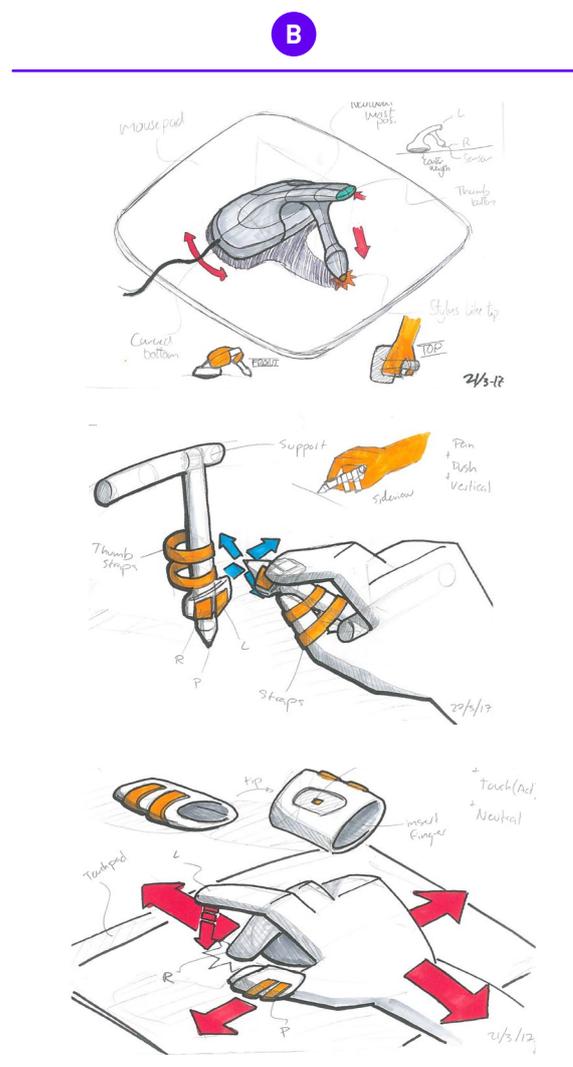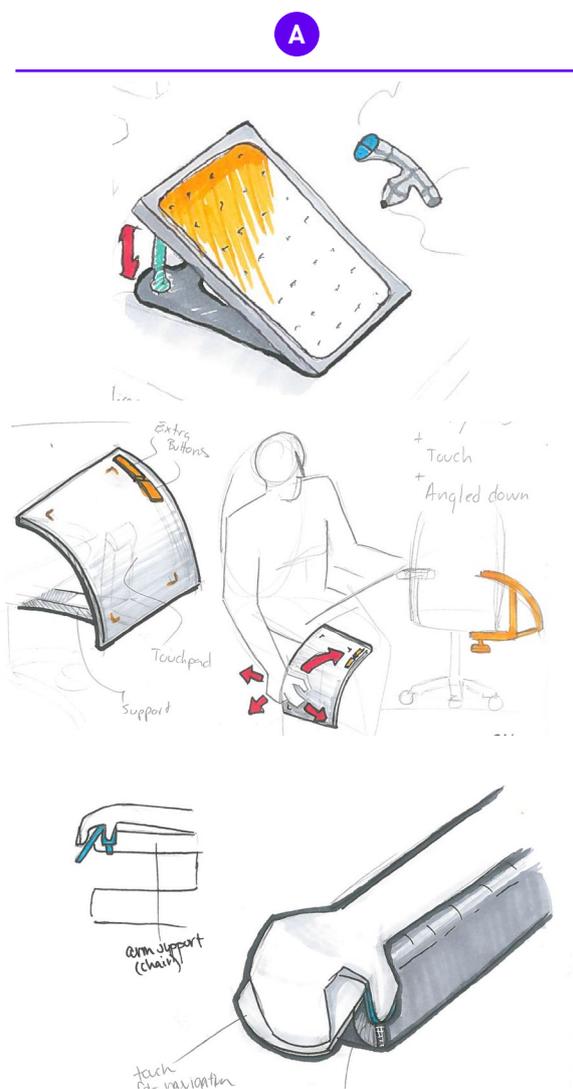
Pointy

In the pointy direction, the team is exploring placement and angling of the surface to obtain a both relaxed and intuitive gaming position (A). Different types of devices for navigating on the surface are explored as an alternative to using touch (B).

The team wants to test the difference between using touch and using an input device for navigating on a surface (using a Wacom with and without the Wacom pen) *(Ill. 54)*. Furthermore, the placement of the surface needs to be tested to see whether it can be placed vertically for working with gravity.

Ill. 54: Adjustable vertical pylon with Wacom

A

B

C
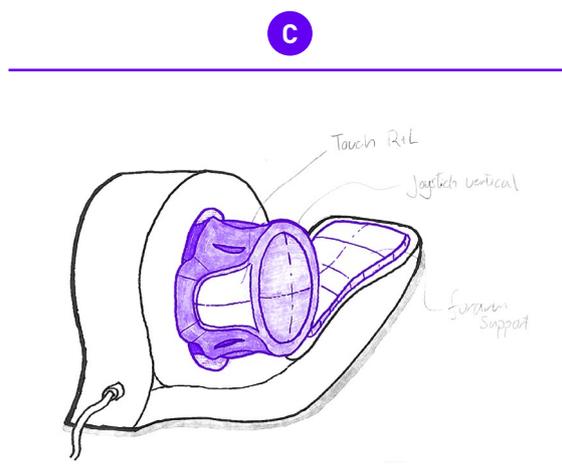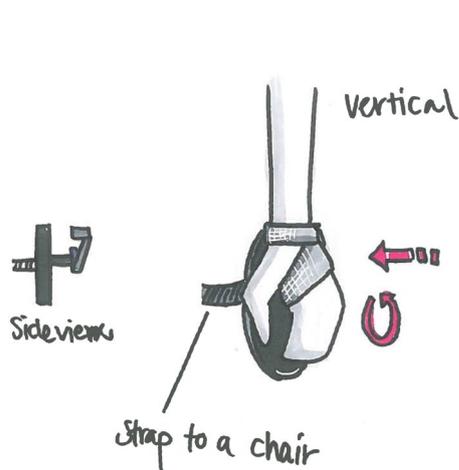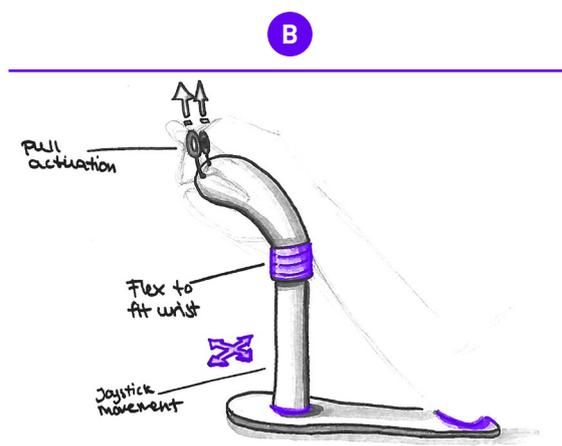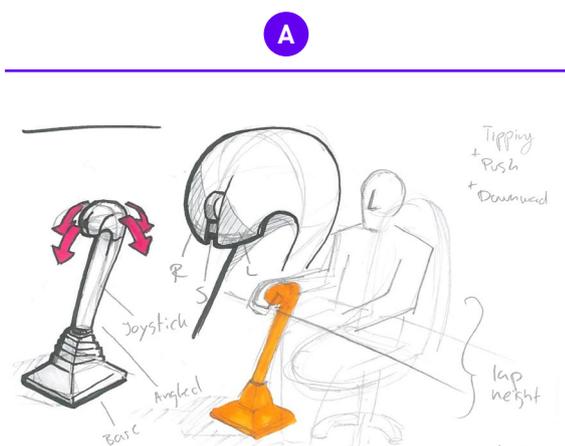
Joystick

The joystick principle is explored by trying out different positions. One direction is placed on the floor to be used as a gear lever (A). One placed on the table, supporting the elbow and wrist (B). And C, resting the arm on the device, controlling the joystick while having the forearm vertical.

However, for testing, the team finds it more urgent to try out the two types of joystick technologies, the analogue stick showed in the sketches and the trackball principle illustrated in sketching round 4 *(Ill. 55)*. Furthermore, the team would like to get feedback on having a hand-held controller instead of a controller placed on the table.

Ill. 55: Trackball controller and Play station 3 controller to simulate an analogue stick

A

B

C
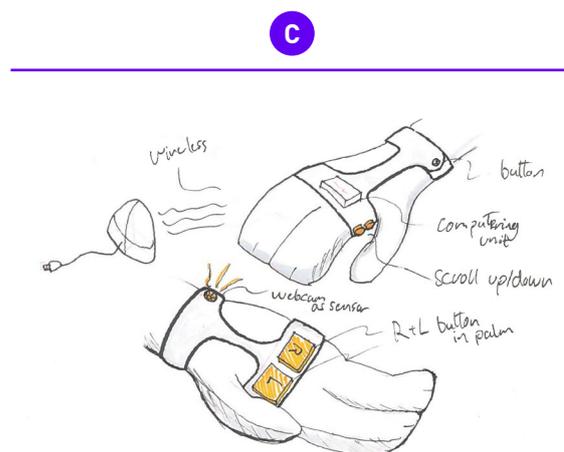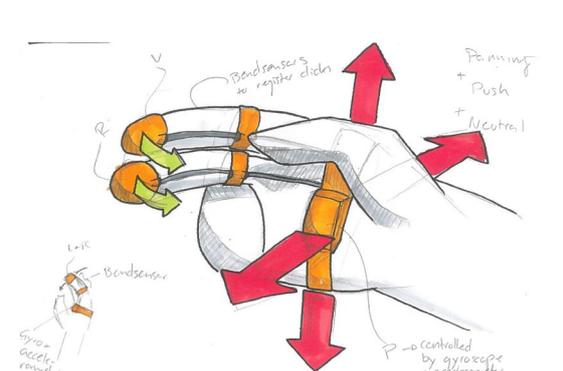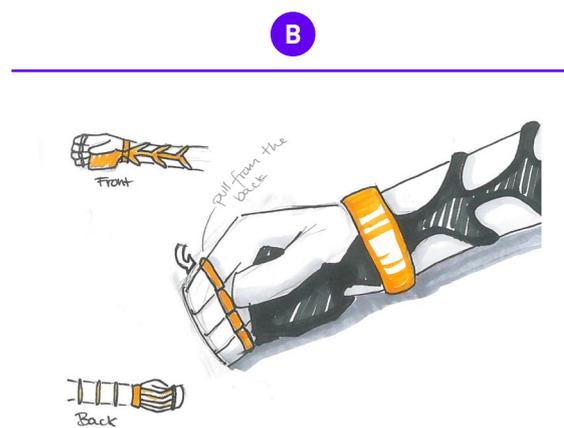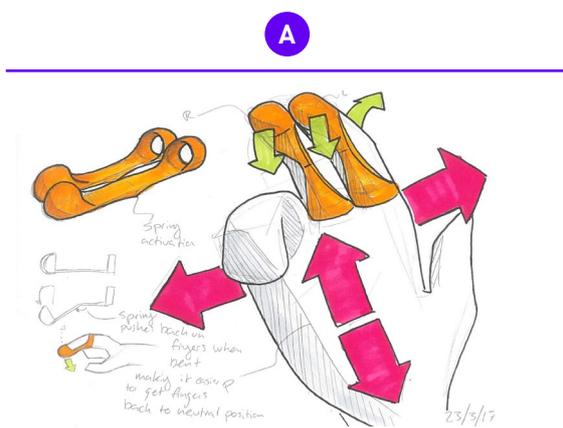
Free-hand

The main part of the sketches explores different types of actuation, from just flexing (A), over a pull mechanism (B), to buttons placed inside the hand (C).

In this direction, the team wants to test how two different ways of actuation feel: with a vertical hand position on the table, clicking in free air using flex sensors *(Ill. 56)*. Or with the hand placed horizontally on the table, clicking with the fingertips on the table.

Ill. 56: *Flex sensor glove and push button glove. Both with optical sensor from disassembled mouse*

Prototyping

The prototypes are first tested internally, where alterations to both the prototypes and the general test setup are decided [W041]. The new setup is tested on Medialogy students from Aalborg University, as some of them represent the user group of hardcore gamers [W042].

Three test subjects are set to use the prototypes to a video of two people debating. Using a U-movement, the test subjects are to move the cursor to the person speaking, continuously left- and right clicking respectively *(Ill. 58)*. This type of movement has been chosen to get the test subjects to use the prototypes in all directions (right, left, up, down). None of the prototypes are connected, as the trackball prototype is not a functional prototype, which showed to be difficult to disregard when conducting the internal test [W041].
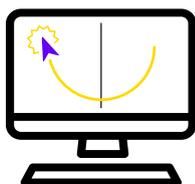
Ill. 58: The U-movement conducted

Feedback

New Traditional

Support in different sizes and a vertical mouse are tested within this concept direction. Observing the test subjects showed a correct use of both the supports and vertical

> **// I am surprised that it was as comfortable as it was (to have a support)**
>
> - Daniel, Medialogy student [W042]

mouse. However, they all find the two long supports too extreme, both in appearance as well as in lack of mobility, but they are split between the small and medium when it comes to preference.

Support feels comfortable as long as it is not too long	✔
Test subjects are open to having a vertical hand position for control	✔

Pointy

Using touch or a pen on either a vertical (next to the chair) or horizontal surface is tested within this direction. The observations reveal that the test subjects keep making mistakes when using the prototypes, both with a pen and with touch. The test subjects also express that, over time, the vertical position is straining and that it is hard to understand how the translation of movement reflects on to the screen.
Both using a pen and touch is found straining, due to pinching and lack of support respectively.

Joystick

The test subjects are testing a trackball controller and a joystick on a PS3 controller within this direction. Besides from not having an optimal shape for one-hand handling, the test subjects point out that the joystick is limited by the technology and would not be as fast or precise as a regular mouse or trackball. When using a mouse, the physical movement corresponds to the digital movement in the game, but with a joystick, the physical movement only corresponds with the direction of the movement within the game, where the speed is software dependent. The principle of the trackball is well received, but it also has some challenges in relation to sizing of controller and trackball, placement of buttons, and the fact that it is in free air, which is found straining.

It is more relaxing to have equipment in contact with a table than in free air	⚡

Free-hand

Two gloves, one with flex sensors for actuation and one with push buttons at the fingertips, are tested within this direction. The test subjects express that they like the freedom the glove provides, especially with the flex sensor controlling it vertically. Two of the three test subjects choose this prototype as their favourite of them all.

// *Generally, we are getting used to the more direct input/interaction with the screen and using our own body as input device, which is why I like the glove and the freedom it provides*

- Mark, Medialogy student [W042]

However, they lack the feedback, which the push buttons can provide, and the navigation at the wrist is found to be annoying.

Feedback is important	✔
It is needed to have a correlation between physical movement and digital movement	✔

Sum up

Too many downsides from the pointy concept direction result in the decision to eliminate it. The other directions are still valid, where New Traditional could work with a shorter support of the forearm and the hand placed in a vertical position, The Joystick could work with a trackball in an optimised shape placed on the table, and the Free-hand could work vertically with the freedom from flex sensors and incorporating some tactility.
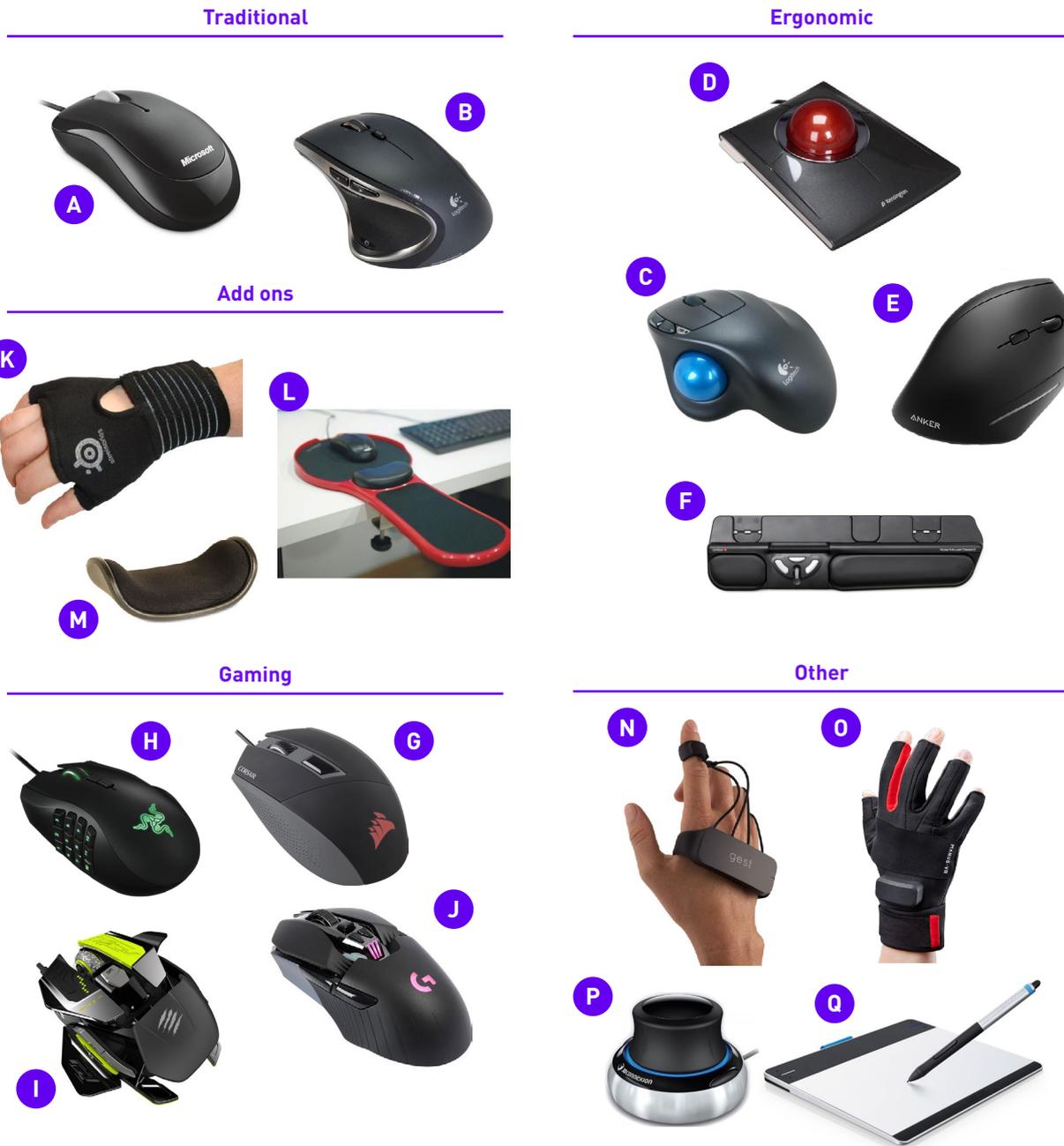
Market exploration

The team has a defined preconception of how the market looks in terms of input devices with both traditional office mice and gaming mice, but wants to challenge this view and explore other possibilities, and perhaps discover a blue ocean to help converge three concepts into one. The team makes an evaluation based upon the fulfilment of set parameters, which is done by conducting desk research and applying the biomechanical principles stated earlier [W031].

Traditional

Traditional mice are generally available at fair prices (Microsoft basic mouse (A) has a retail price under 150DKK), stripped of unnecessary extra functions, and are only designed to get the job done, often compromising ergonomics *(Ill. 60)*. Aesthetically, they do not stand out, but have a more traditional appearance.

It is worth mentioning that the mouse has created an entire new market of equipment to support its shortcomings, which include both gaming gloves (K) and heating pouches. But products to support the poor ergonomics of mice today are also avaiable, such as forearm supports to be attached to the table (L) and different versions of wrist supports to be placed under the wrist (M).

Gaming

Gaming mice have extra buttons for shortcuts and adjustable DPI settings (correlation of movement speed on screen with the physical movement of the mouse), which are features traditional mice are lacking. Gaming mice, however, still do not accommodate a desired ergonomic working configuration *(Ill. 60)* and the extra features also comes at a higher price as with Logitech G900 (J), having a retail price of around 1500DKK. They do, however, stand out when it comes to appearance with varying degrees of futuristic and edgy looks, spiced up with lighting details. There are some mice that have extra features, such as the Mad Catz R.A.T. Pro X (I), which has adjustable parts for perfect hand fit, and the Logitech g502, which is able to adjust the weight by adding or removing 3,6g weights. More and more gaming mice

	Vertical hand	Straight wrist	Relaxed fingers	With gravity	Flexor over extensor	No pinching	Not only wrist movement	Helps with sit up straight
Microsoft Basic Mouse (A)	○	○	○	○	○	○	○	○
Logitech MX Performance (B)	○	○	○	○	○	○	○	○
Logitech M570 (C)	○	○	○	○	○	○	●	○
Kensington Slimblade (D)	○	●	○	○	○	●	●	○
Anker Vertical Mouse (E)	●	●	○	●	○	○	○	○
Contour Rollermouse Classic2 (F)	○	○	○	○	○	○	●	○
Corsair Katar (G)	○	○	○	○	○	○	○	○
Razer Naga (H)	○	○	○	○	○	○	○	○
Mad Catz R.A.T. Pro X (I)	○	○	○	○	○	○	○	○
Logitech G900 Chaos Spectrum (J)	○	○	○	○	○	○	○	○

Ill. 60: *Comparing traditional, gaming, and ergonomic mice on biomechanical principles*

also come with the option to switch between being wired or wireless, by having a removable cable.

Current gaming mice offer DPI adjustments	⚡

Most gaming mice are either wired or have the option of being wired	⚡

Ergonomic

It is a bit more complicated to make general conclusions on the ergonomic mice, as they differ a lot. They are naturally optimised for better ergonomic use, but still only approach one or a few of the biomechanic challenges, found by the team *(Ill. 60)*. In several instances, the solution only moves a problem to a new location, as it is the case with the Logitech M570 (C), where the strain put on the abductor pollicis brevis might cause a texting thumb instead of a wrist injury (Ergov-ancouver.net, 2015). In relation to features and appearance, they are comparable to traditional mice.

Controlling a trackball with the thumb might cause texting thumb	✕

Other

Other input devices are available optimised for specific purposes, such as the wacom tablet used in graphic work by simulating physical drwaing (Q), or a 3D mouse, easing the workflow when working in 3D (P). A few input devices are also starting to rise in connection with virtual reality becoming more popular (N, O).

Sum up

Only ergonomic mice seem to deal with the biomechanical principles for more optimised work positions, further confirming the need for esports specific equipment to help relieve strain. The exploration also reveals a market filled with versions of trackball controls, the team did not know about before.

Defining the interaction vision

In order to specify a concept direction it would be beneficial to hold them up against a frame or vision of what the team hopes to create. Based on the prototyping tests, the team has developed an interaction vision that explains the aspired experience of user interaction.

The vision is to 'turn gaming sporty' by reducing the risk of injuries and make the athletes perform their best during training and competition. Here, sporty describes a professionalisation of gaming by ensuring performance and improving endurance. To achieve this kind of image, the solution needs to express seriousness and give the user a feeling of being an expert and being in control of a device only they master, like Tom Cruise in the film Minority Report *(Ill. 61)*.

To make the interaction vision more comprehensible it can be broken down to three parameters created based on the findings of the project:

/ **Comfort**
A comfortable interaction is an ergonomic solution that enables the user to do his/her job and is both comfortable to use and lowers the risk of injury.

/ **Futuristic**
A futuristic interaction is about a solution that seems complex but smart at the same time, like an Iron Man suit that equips itself.

/ **Specialised**
A specialised interaction is a solution which, like a surgical tool is optimized for a specific purpose that needs a high skill set and a pre-understanding to operate or use.

The three parameters create a tension field that encompasses the solution space *(Ill. 62)*. Evaluating the concept directions against each interaction parameter outlines the solution space for each direction. For comparison, similar exercise is done for existing computer mice and for 'gaming mice' based on the findings in the competitor analysis *(Ill. 60)*.

The **'New Traditional'** concept direction focuses on creating a more comfortable interaction through more ergonomically correct hand and arm posture and through controls not far from the controls of traditional mice.

The **'Joystick'** concept direction plays with the way the user controls the game, making the interaction more advanced while offering a free and comfortable form of interaction that is not far from the preconception of a video game controller.

The **'Free Hand'** concept direction aims to eliminate the

Ill. 62: The solution space of each direction

mouse altogether, making the hand the controlling device, allowing highly advanced and smart ways to control the game.

Solution spaces

The tension field indicates that the concept direction *Free Hand* has the largest solution space, but is also the least defined concept direction of them all. While this allows the concept to move in very different directions it also makes it difficult to evaluate whether the concept is the right solution space or not. While the solution space of the *New Traditional* might be small, it is both more clearly defined and stands stronger in terms of ergonomics. It is also a more direct redesign of the traditional mouse and might therefore have better cognitive ergonomics as the interaction is more recognisable for the user. The size of the solution space for *Joystick* is similar to the *New Traditional*, but is not as clearly defined in its direction ranging between a handheld mouse to a surface based joystick.

Ill. 63: 1988 Slam Dunk Contest: Michael Jordan wearing the Nike Air Jordans III while doing his now iconic Free Throw Line Dunk.

Reframing

Although the concept directions are different, they all hold the possibility to solve the problem and live up to most requirements. Furthermore, the tension field provides no definitive conclusion as to which concept direction is most suitable. To better determine a direction, a more defined project frame is needed.

Part of making esports professional is to offer specialised equipment for the athletes to help them utilise their skillset. At the moment the main device for (MOBA) esports is the computer mouse which, interaction wise, has not evolved significantly since its invention by Douglas Engelbart back in 1970 *(Ill. 64)*.

Ill. 64: The first mouse

A similar case can be found in sports shoes back in the 1980's, where sports companies like Nike and Reebok designed shoes engineered specifically for particular sports (Chai, Neville, 2017). One example of this is the Air Jordan, which was designed specifically with basketball players in mind. The idea behind the basketball shoes was to create a shoe that supported the feet of the athlete in all the right places in just the right way. Tinker Hatfield, shoe designer at Nike at the time, used Floater, a specific kind of soft leather, to make the shoe feel like it was already broken-in. He also used a low mid-rise ankle cuff to provide the athlete with both ankle support and enough freedom to move and jump appropriately (Kamer, 2015).

// Our feet were made to walk, and run and climb once in a while. Bare feet can be great at all of that. But what the modern athlete asks of their feet is far beyond what they were originally designed to do.

- Tinker Hatfield, Lead Designer at Nike

The basketball shoe was not just another shoe to place your foot in, it was a platform, tailored to the function and purpose that was needed in the sport.

This seems to match the problems the esports industry is facing and is an ideal source of inspiration for the project.

To create a concept similar to that platform, but for esports, requires a more radical approach. This means that concept directions like the *New Traditional* or *Joystick* are too conservative approaches, as they are both trying to improve on a product platform that is 'broken' to begin with, in categories already filled with similar products.

The *Free Hand* concept direction is not supportive enough and some concepts incite the user to move unnecessarily without any added benefit causing more harm than traditional mice. Reframing the *Free Hand* concept direction, focusing more on the part about building an input device around your hand could serve as a basis for a more 'tailored experience'. Turning the *Free Hand* into an *'esports Glove'* and engineering every part around the hand enables it to perform under more ideal conditions.

In the following the team will build on to the new concept direction *esports Glove,* developing the concept of an ergonomic and wearable input device.
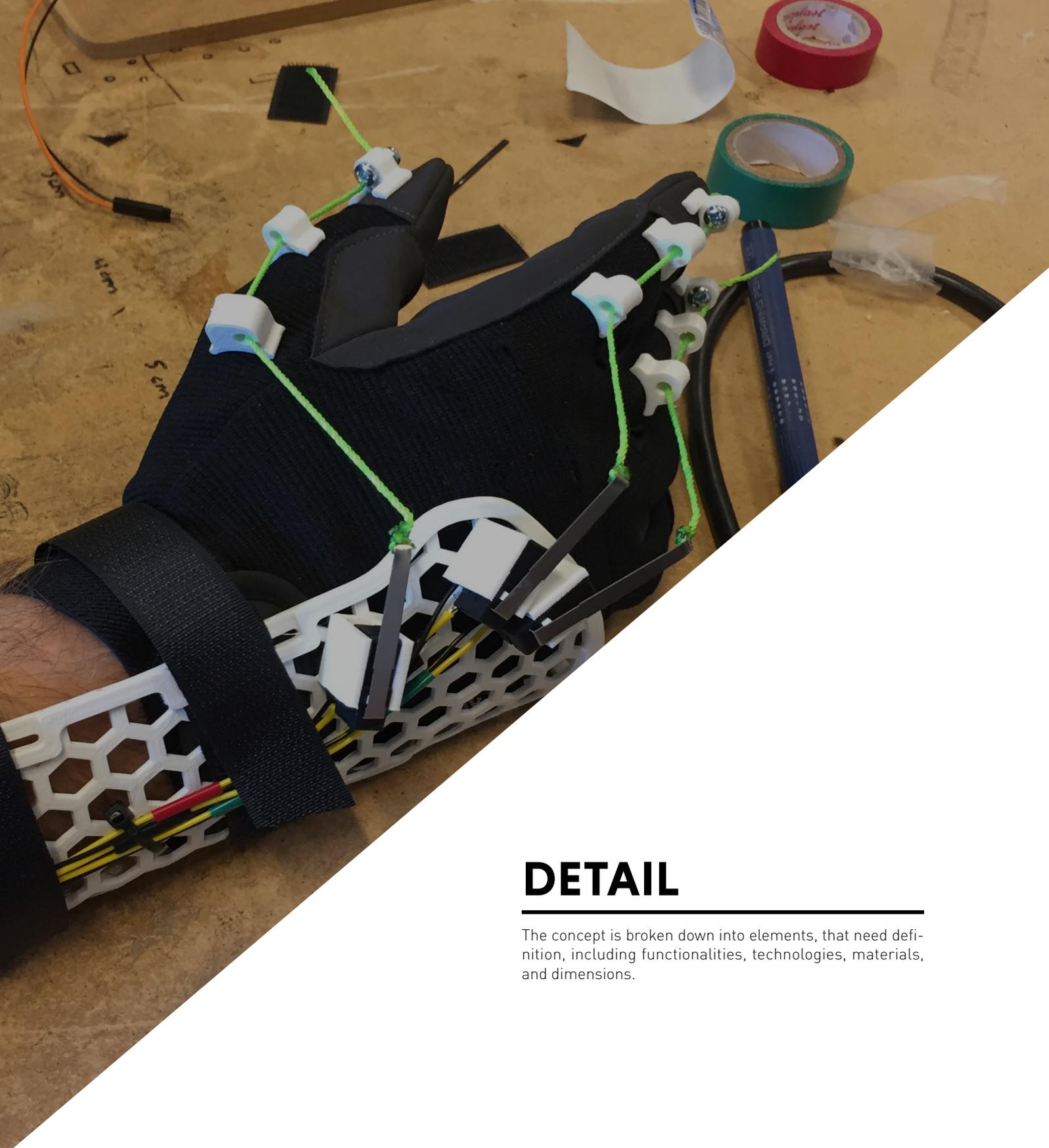
DETAIL

The concept is broken down into elements, that need defi‐
nition, including functionalities, technologies, materials,
and dimensions.

Proof of principle

Developing prototype

The team wants to test a functional prototype before starting to detail on the concept to potentially pivot in case the principle fails. A collaboration with the biometric research consultancy, iMotions, is established as they can offer EMG measuring equipment for the test (comparing muscle activity) and help with the setup in return of getting the results subsequently [W052,W054].

The brace

For the prototype, the team wants to make a brace to live up to the biomechanical principles stated earlier in relation to ensure the wrist not being used as the primary movement and the hand being angled 30 degrees from vertical.

A brace is found online for supporting an injured wrist, which can be flat printed and shaped afterwards by heating the plastic *(Ill. 65)* [W048]. As the principle proves to be functional, the team aims at implementing it in the prototype.

To specify the shape and comfort of the brace, four plaster gauze models are created and tried internally where the following insights are gathered *(Ill. 66)* [W046]:

The wrist should be supported	✔
Hard support should not cover the knuckles and fingers to avoid restricting movement when clicking	⚙
The height of the support inside the palm should be up to the height of the top of the middle finger	⚙

Another round of plaster gauze models are created from these insights to determine more precise dimensions and shape [W053]. The best fitting model is trimmed and a cloth is cut out in the shape of the support to be used for drawing the flat 3D model *(Ill. 67)*. The length is set to be the same as the initial printed support. Another iteration of the brace is conducted, relocating the support to keep the angle seen in *Ill. 67.*

Ill. 65: *Testing thermoforming of 3D printed brace*

Ill. 66: *Four plaster gauze models to test support*

Ill. 67: *Left: Cutting out cloth template. Right: 3D printed brace*

Actuation principle test

The team needs to establish how the main clicks should function in the prototype, which entails figuring out which fingers should actuate. A simple test is conducted with medialogy students, trying five different ways of clicking, followed by an evaluation of the feeling when clicking with these configurations [W050]. A test is also conducted to get feedback on the feeling of fixating the wrist.

A support model is constructed to hold the hand in the neutral position of 30 degrees from vertical *(Ill. 68)*. The first test involves wearing a wrist support to get feedback on the fixated wrist. The test subjects find the wrist support comfortable to wear and the team is thereby confirmed in the conviction that the prototype should have a fixated wrist (W050) *(Ill. 68)*.

In the actual actuation test, the test subjects are to put on a glove where tape is added to fixate fingers in relation to the different click configurations:

1. **Traditional:** Clicks are conducted with the index- and middle finger as on a regular mouse *(Ill. 69)*. Index finger = left click. Middle finger = right click
2. **Pairs:** Fingers are taped to conduct clicks in pairs *(Ill. 69)*. Index + middle finger = left click. Ring + little finger = right click.
3. **Index and thumb:** The last three fingers are taped together *(Ill. 70)*. Index finger = right click. Thumb = left click.
4. **Pinch:** The last two fingers are taped together *(Ill. 70)*. Clicks are conducted through pinch. Index finger to thumb = left click. Middle finger to thumb = right click.
5. **Whole hand and thumb:** Four fingers are taped together *(Ill. 71)*. Thumb = left click. Index + middle + ring + little finger = right click

Using more than one finger to click is found awkward and seems redundant, which eliminates both actuation method number two and five. It is not possible to make a definitive decision upon the three remaining methods, as both one and four feel natural, but number three has a good relation to shooter games when using the index finger for main clicks. The team decides to make the functional prototype able to test the remaining three constellations and base a decision upon the outcome from the test with iMotions.

> Main clicking as Pairs or with Whole hand and thumb is found awkward   ✕

Ill. 68: *Left: Simple support. Right: Wrist support*

Ill. 69: *Left: Traditional. Right: Pairs*

Ill. 70: *Left: Index and thumb. Right: Pinch.*

Ill. 71: *Whole hand and thumb*

Actuation technology

Initially, the team wanted to use flex sensors as the actuation technology in the prototype, however, calibration of the sensors turned out to be a bigger task than first anticipated *(Ill. 72)* [W055]. Instead, a mechanical solution is constructed, using a string to pull switches, which are linked to a circuit board from a disassembled mouse *(Ill. 72)*. The switches are attaches on top of the 3D printed brace and strings are put through 3D printed guides attached on a glove to be adjusted using screws at the end *(Ill. 73)*. For the Pinch actuation, push buttons are attached on a glove, using Velcro on the fingertips of the index and middle finger. The location of the buttons can be adjusted by moving the buttons on the Velcro *(Ill. 73)* [W059].

Navigation technology

From the initial prototype testing, the team learned that the optical sensor applied was rather big in its current form (using the entire bottom of a disassembled mouse). Another solution is therefore applied for this prototype, utilizing a wacom tablet and pen as the technology for navigation *(Ill. 74)*. In addition, it has the advantage of tracking the location of the pen, even if it is not in direct contact with the surface. The downside is that the navigation is restricted to the confined area on the tablet, a wooden support is constructed to fit as an extension of the surface for smoothing the transition between table and tablet.

To finish up the model, Velcro bands are sewed on the brace and the final prototype is tested internally before the test with iMotions *(Ill. 75)*.

Ill. 72: *Left: Flex sensors. Right: Connecting switches*

Ill. 73: *Left: Adjustable string system. Right: Push buttons*

Ill. 74: *Left: Wacom pen. Right: Wacom tablet and wood support*
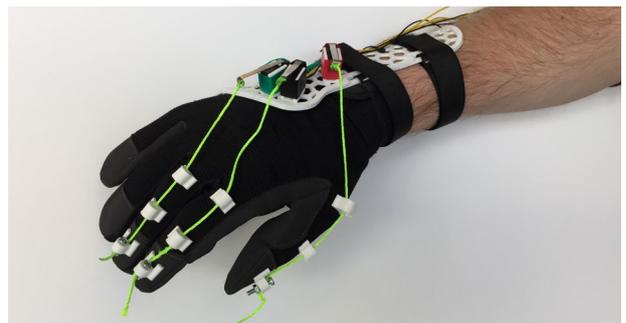
Ill. 75: *Assembled prototype*

Electrodes for
Abductor Policis

Electrode for
Control

Electrodes for
Extensor Digitorum

Electrodes for
1st Dorsal

Electrode for
Control

Electrodes for
Extensor Capris
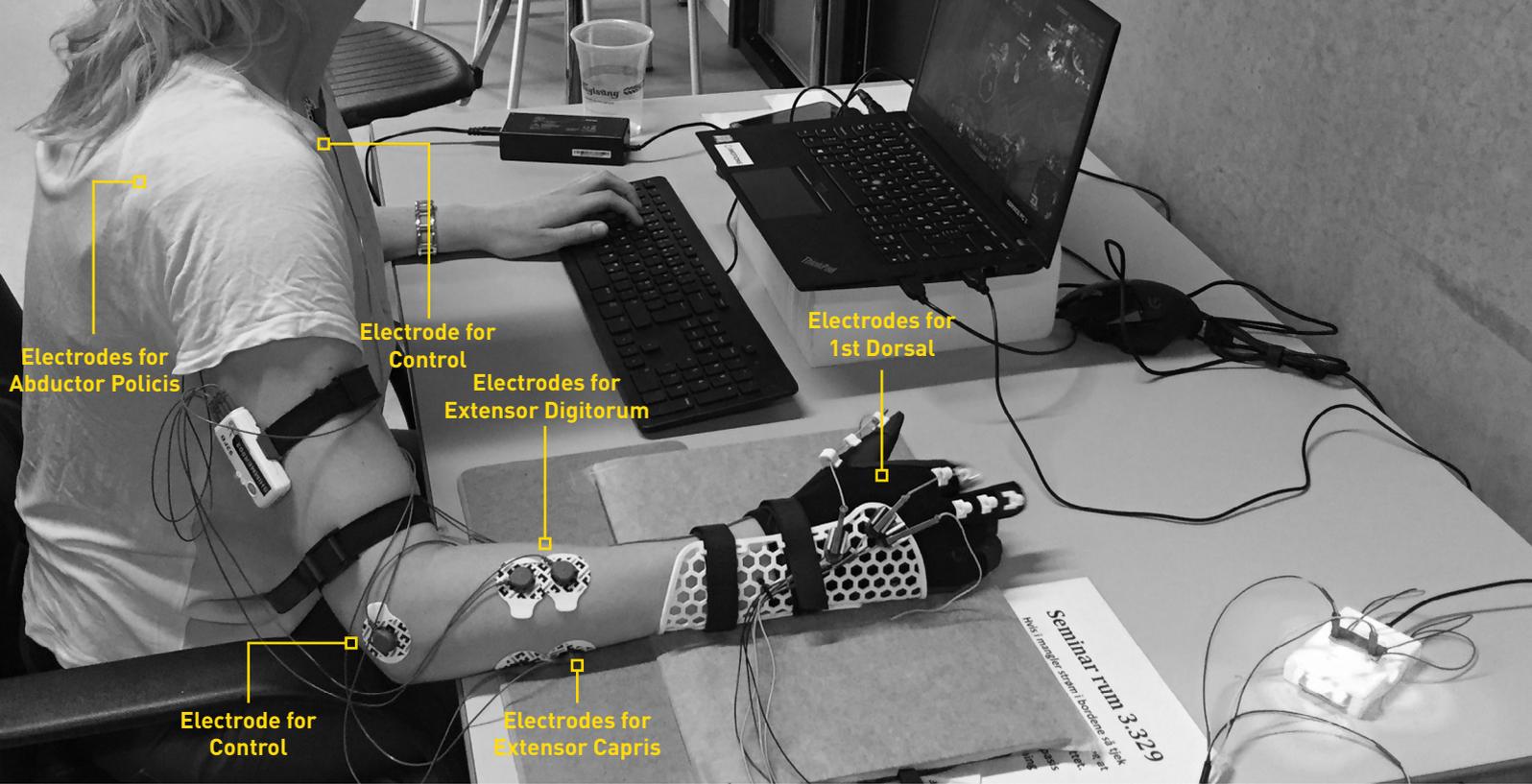
Ill. 76: *Test setup with functional prototype*

Testing with iMotions

The prototype is tested in collaboration with iMotions to get the prove of principle, where the muscle activity is recorded for the three types of actuation and with a regular mouse for comparison [W060].

The muscle activity is measured by using the technology, Electromyography (EMG), which, through electrodes, measures an electric current inside the muscle when contracting. EMG can determine the activation level of the muscle, which in this test has been based upon a percentage relative to maximum amplitude (Base-lining from maximum voluntary contraction). Testing is conducted on eight test subjects, on four muscles, determined from the biomechanical analysis *(Ill. 76)*:

/ Extensor digitorum (lifts fingers and wrist)
/ Abductor policis (shoulder movement)
/ 1st Dorsal (controls pinch from thumb)
/ Extensor Capris (Ulnar deviation, movement of the wrist)

Results

The data in *Ill. 77* illustrates a lower muscle activity measured when using the prototypes (especially bend index + middle) compared to a regular mouse. When using the thumb for actuation, the activity is lowest in extensor digitorum, but at the expense of a higher activity in the other muscles. Pinch performs overall better than a regular mouse, but on average, it performs worse than the two other actuation methods *(Ill. 78)*.

The principle of the esports glove has lower muscle activity compared to a regular gaming mouse	✓
Index finger and middle finger actuation creates the least strain in muscles	⚙

Per muscle – muscle contraction for prototypes in % relative to max amplitude

Legend: Bend (Index + Middle) | Bend (Index + Thumb) | Pinch | Regular mouse

Categories: (1) Extensor Digitorum (Finger stretching) | (2) Abductor Policis (Shoulder) | (3) 1st Dorsal (Thumb Pinch) | (4) Extensor Capris (Wrist)
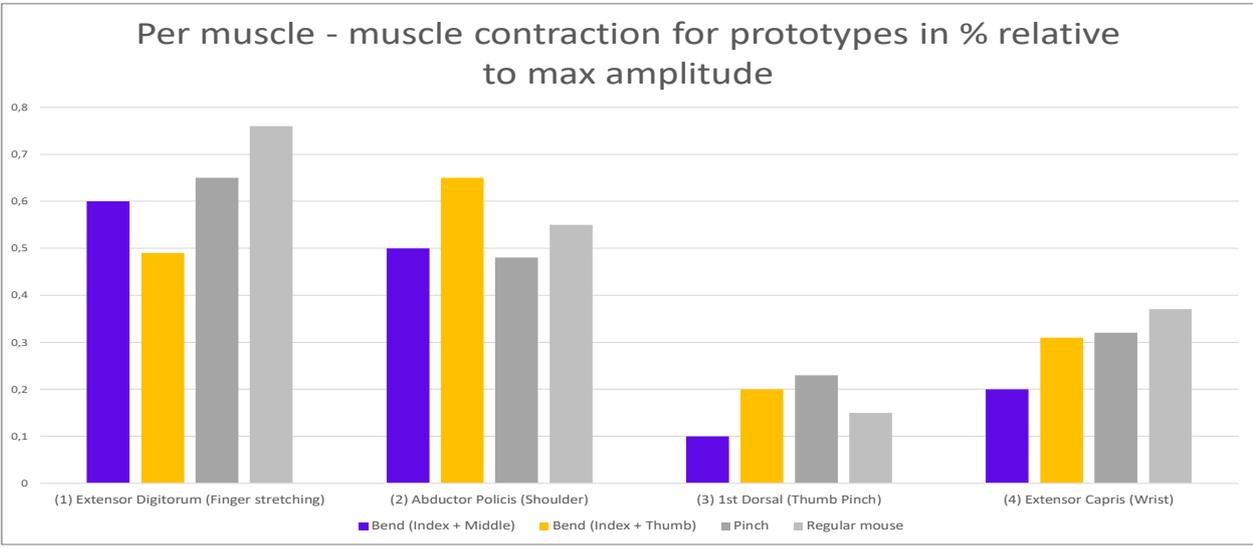
Ill. 77: *Muscle contraction for prototypes in % relative to maximum amplitude illustrated per muscle*
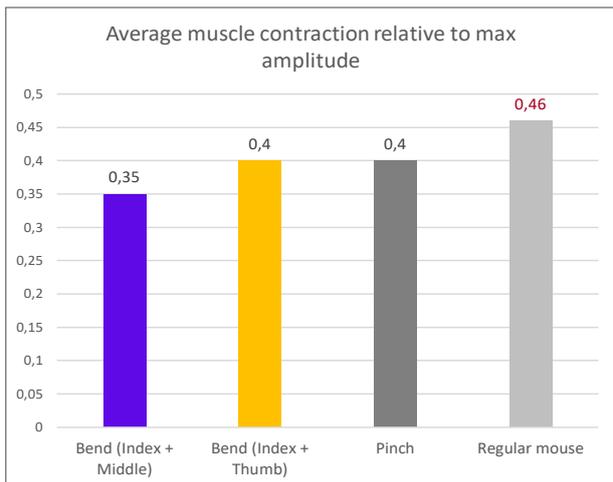
Ill. 78: *Average muscle contraction relative to maximum amplitude*

Micro-movement precision might be improved by minimising friction	⚡
Micro-movement precision might be improved by moving point of navigation closer to the fingers	⚡

Clicks

Index and middle finger is the favourite actuation method among five of the eight test subjects, but three express that it could be even better if the right click could be conducted with the index finger, as it feels faster. However, a bigger challenge is the lack of tactility in the prototypes. The test subjects express that it is nice to hear the clicks, but usually headphones would leave out the sound, creating a need for physical feedback, only seen in Pinch as is. Two test subjects could sense the string pulling in the glove and explains it to be very helpful, which highlights the need for greater tactility in the concept.

Audible feedback is not sufficient	✖

Feedback

Interviews with the test subjects conducted in extension of the tests has provided the following feedback, which has been categorised to ease readability:

Experience

Wearing the esports glove provides a new dimension regarding the experience of gaming. One test subject describes it as feeling like an extension into the game - being in control and assisted much more than with a regular mouse.

// *It feels more interactive - It feels more as being a part of the game*

- Test subject 2, 25, League of Legends player [W060]

The 'esports glove' creates an immersive experience	⚡
Users are generally positive about building an input device around the hand as a 'tailored experience'	✔

Brace support

The brace is constructed to follow the shape of a team members hand, resulting in the brace being too tight for some of the test subjects. Having the vertical angle of the hand is explained to be relaxing, but it is suggested to allow some flexibility in both the wrist and in the angle to create a feeling of more freedom. A flat bottom would feel more natural in relation to stability. A test subject also mentions the bottom two fingers are getting squeezed by the rest of the fingers, which could be ideal to solve.

Sizing of the brace is important to fit individual physiology	✔
30 degrees angling of the hand from vertical feels relaxing	⚙
A completely fixed position reduces the experience of freedom	⚡
A flat bottom would increase stability	⚙
Little finger and ring finger are getting squeezed when using the 'esports glove'	⚡

Navigation

A test subject has expressed that the navigation was much easier than expected, however, a common problem pointed out by all the test subjects is difficulty with micro movements. A combination of a lack of fine-motor skills in the palm, a small screen used for the test, and high friction between surface and prototype seem to be part of the problem.

Aesthetics

The test subjects are divided in their preferences towards the identity of the concept. One suggests emphasising the technology, and another, making it more sleek and professional like a golf glove or riding glove. What the test subjects agree upon is the idea of accentuating the functionalities of the glove, being where to adjust, where it is stiff, where it is flexible, where it supports, etc. Moreover, it should exude being a glove and not a stationary device for the table.

// *To see somebody wearing a device like that, I would think: "Yeah, that right there, that looks nice!"*

- Test subject 3, 24, League of Legends player [W060]

| The functionality of the product should be accentuated | ✔ |

Click speed

During the test setup, the team agrees that a performance comparison of the prototypes and the regular mouse would be relevant as it is an important factor to esports athletes. A click speed test is conducted on the remaining five test subjects.

The click speed test is conducted with performing as many clicks as possible over 30 seconds. In *Ill. 79* the results from actuating with the index finger are shown for the five test subjects, relative to the clicks made with a regular mouse. The results show an actual increase in performance by three of the test subjects, which is surprising taken into account that it is the first time trying the prototype.

Test subject	% Relative to regular mouse
Test subject 4	86,92 %
Test subject 5	103,83 %
Test subject 6	101,51 %
Test subject 7	101,35 %
Test subject 8	82,59 %

Ill. 79: *Click speed results relative to regular mouse*

| Click speed is potentially higher with the esports glove | ⚡ |

Market acceptance

The team is looking into market acceptance of wearable technologies as the product will have no impact if players are not willing to wear it, even though it proves to reduce the risk of injuries. For this reason, the team is looking into the likelihood of acceptance for the esports glove by investigating the general market acceptance of wearable technology and the development of this societal trend. Desk research is used to conduct this task [W049].

Wearable technologies are becoming more popular, especially with the younger customer segment, where GlobalWebIndex has found that 71% of those aged 16 to 24 want "wearable tech" (Lipman, 2014). They also found that among the global internet users, 64% have already used wearable technology or are eager to try it in the future (Lipman, 2014). In *Ill. 80*, the industry growth is illustrated along with the expected revenue for the coming years, supporting a greater acceptance of wearable technology (Krify, 2017).

Forecast for wearable tech revenue growth
In billions of U.S. dollars
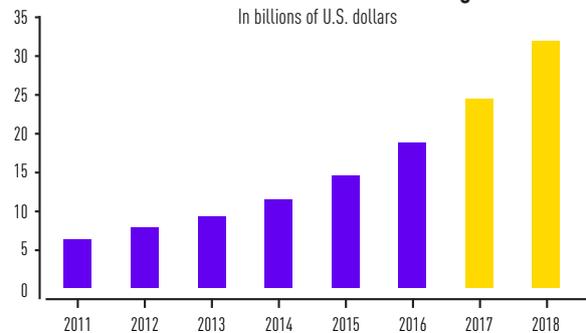
Ill. 80: *Wearable technology industry growth*

Two sectors are already utilising wearable technology and embracing it. The fitness industry has had great success with fitness trackers among others, whereas health monitoring has gained ground within the healthcare sector. Besides from these two sectors, PriceWaterhouseCoopers has pointed out sectors having the largest opportunity when it comes to advancement and growth, where the sector of Entertainment, media, and communication tops the list (Grace College, 2016). The argumentation for that being the possibility of making games more immersive and fun with wearable tech, which was also confirmed by test subjects at the iMotions test.

| Wearable technology is becoming more accepted and widespread | ✔ |

Glove
Simple
All soft
Maximum comfort
Little assistance

Mix
Simple and complexity mix
Mix between soft and hard
Medium comfort
Medium assistance

Minimum viable
Simple
Fully mechanical
Minimum comfort
Minimum assistance

Mech
Complex
Fully mechanical
Minimum comfort
Maximum assistance

Style direction

Before detailing of the concept can begin, a style direction needs to be chosen as it will influence the tests, research, and eventually choices to be made in this phase.

The team has identified the four most plausible directions and plotted them inside the tension field of the interaction vision *(Ill. 81)*. *Minimum viable* is disregarded as not fulfilling the parameters of the interaction vision. This is also the case with *Glove*, only having good comfort to offer.
Mech could be interesting, but the team is worried that the concept might become too futuristic in regards to being sporty, and sees challenges in relation to mounting and obtaining more comfort.

Mix has a good distribution between the three parameters and a merge between being complex, soft, and hard is thereby chosen. More defined aesthetics will be explored later in the process.

Concept breakdown

As the team has chosen a style direction, a breakdown of the
concept is conducted to specify the parameters in need of
definition through testing and research *(Ill. 82)*.

Main clicks
Technology, tactility,
and adjustment

Connection
Type and placement

Aesthetics
Total form, element
form, and colours

Extra functions
Types, placement,
and technology

Deactivation
Allow typing on
keyboard

Navigation
Placement and
technology

Construction
Dimensioning and
Flexibility vs. stiffness

Comfort
Avoid squeezing of
fingers

Materials
Function and type

Equipping
How and adjustment

Ill. 82: Concept breakdown

Navigation

Through the prototype testing with iMotions, the team has become aware of big challenges regarding micro-movements. This issue needs to be dealt with, and solution principles that might solve the problems need to be tested.

Point of navigation

The team hypothesises that by placing the Wacom pen near the fingertips instead of in the palm, the micro-movements will become easier, as the fingertips have fine motor skills. A simple test is conducted to confirm or disconfirm this theory (Ill. 83) [W064].
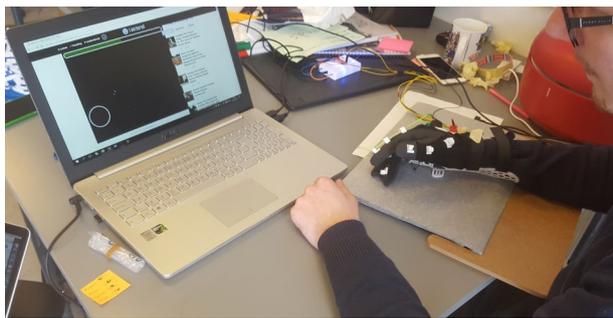
Ill. 83: Test setup

Three test subjects are to try an online mouse test to check ease of movement, accuracy, and consistency with the Wacom pen attached at four different locations *(Ill. 84)*. The test is also conducted with a regular mouse, to use for relative comparison.

The test results are taken as the best of two attempts, where the online test has provided a total score from the movement-, accuracy-, and consistency test. The results are in *Ill. 83* translated into a relative percentage from the test with a traditional mouse, where purple highlights the highest scores [W064]. Conducting the test has not provided the expected results, where the finger position would be optimal. This means that other factors need to be altered to ease micro-movements.

Placement	Test subject 1	Test subject 2	Test subject 3
Fingers	91%	75%	62,4%
Palm	**100,3%**	50%	**70,4%**
Wrist	77,6%	**82,9%**	58,3%
Forearm	77,9%	37,9%	45,6%

Ill. 85: Table showing the overall score of the four placements in %

Placing navigation at the fingertips does not ease precision	✕

Wrist freedom

As changing the point of navigation does not provide more precise movements, the fine motor skills must come from the wrist instead, as both the elbow and shoulder are more gross. This entails testing the wrist movement, when flexibility is provided [W068].
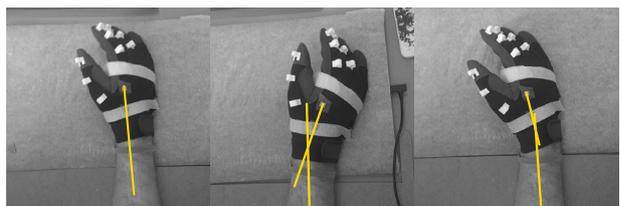
Ill. 86: Test subject 1: Normal, extension, and flexion

The test, investigates how much freedom in the wrist is utilised if it is not locked. Test subjects are equipped with a glove that has a flexible support, enabling complete freedom of the wrist. While playing a short game of League of Legends, the subjects are recorded from above, and the material is subsequently analysed to determine how big the deviation in flexion and extension is from neutral.

Test subjects finds micro-movements easy, when wrist is free	✔
Extension deviates up to maximum 21 degrees	⚡
Flexion deviates up to maximum 15 degrees	⚡

Ill. 84: Wacom pen placement

Wrist resistance

Giving freedom might bring back the problem of only using the wrist for navigation, as it is often seen with the regular mouse. The team has the idea of reducing the flexibility to nudge the players to only use the wrist for the micro-movements and use the arm for bigger movements.

Ill. 87: Wrist resistance test setup

Speaking to Gorm Fogh Rasmussen, physical trainer and master thesis student in biomechanics, the team is agian made aware that it is often a bad idea to completely limit the movement as good ergonomic practise is mainly about constantly shifting position and activating more muscles to divide the workload. The team presents the idea of giving the players a small exponential resistance, when bending the wrist to be used as nudging to get back to the optimum position. Gorm finds this idea interesting and a viable possibility, but cannot give a definite answer to whether or not it would work.

The team sets up a test to determine the level of resistance needed, based on qualitative statements from test subjects about the comfort at different resistance [W073]. The test setup shown in *Ill. 87* has metal pieces at 50mm in length and at different thickness, to be deflected to 15 degrees in flexion (Corresponding to 13,4mm at the end, using triangle calculations). The metal with the best responses has a thickness of 0,3mm, corresponding to 3,65N.

A resistance of 3,65N is the most comfortable in wrist flexion	⚡
Textile should be able to provide the small resistance of 3,65	⚙

Vertical hand angling freedom

In relation to constantly altering the working position to activate more muscles and even the workload, the team wants to enable the players to deviate from the optimal vertical hand position (30degrees from vertical) when moving the hand.

Ill. 88: Test subject 3: Neutral, pronation, and supination

The same test setup is applied as before, but with recordings from the front *(Ill. 88)*.
Due to the small deviations, the team aims at making the support material flexible enough to enable this freedom. The movement directions are illusrtated in *Ill. 89.*

Pronation deviates up to maximum 6 degrees	⚡
Supination deviates up to maximum 5 degrees	⚡
Material should be flexible enough to enable the small freedom	⚙
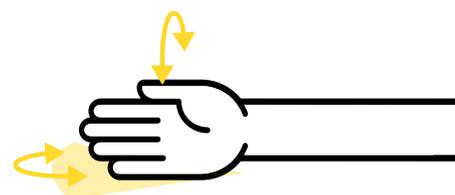
Ill. 89: Movement directions

Technology

As the Wacom technology has shown disadvantageous other technologies will be explored in order to determine how the desired navigation can be created [W066].

Navigation in computers is the correlation between hand movement (physical movement) and cursor movement. Important concepts to understand in navigation are resolution and acceleration. In mice, 'resolution' describes the sensor's translation between physical movement and the cursor movement distance (turning radius). When the mouse makes the turning radius differ, depending on the speed of the physical movement, it is called 'mouse acceleration' or 'resolution error vs speed'. This typically happens due to high sensor sensitivity picking up too much noise during fast movements, which is then translated wrongly (Fenlon, 2015).

Three sensor technologies have the potential to work:

1. Optical (infrared LED)
2. Laser (vertical-cavity surface-emitting laser)
3. Accelerometer (MEMS tri-axis accelerometer)

Optical sensors work on almost any soft or hard opaque surface while laser sensors are very versatile and function on any hard opaque and specular surface (Kizilarslan, 2015). An accelerometer does not need a surface to track movement and can therefore be used on any type of surface and be placed anywhere on the product.

When it comes to tracking resolution, laser sensors have a higher resolution and sensitivity than optical sensors. This also makes laser sensors more prone to acceleration issues which can be a problem in games if players are relying on muscle memory or reflex actions (logitech, 2014; Kizilarslan, 2015). An accelerometer has no resolution errors like the laser sensor but has according to Thomas Kristensen, assistant engineer at AAU, some difficulty staying still, even when it is not moved. This might, to some degree, be solved through programming or by using another tracking sensor to act as a reference/origo point for the accelerometer (Toni, 2017).

Both optical and laser sensors are frequently used in gaming mice, but an optical (infrared) sensor seems to be the most reliable option while still providing sufficiently high resolution (Fenlon, 2015).

An optical sensor has good relation between reliability and precision ⚙

Friction

To ensure a smooth use of the product, the team is looking into the contact material used in traditional gaming mice, also known as the mice skates or feet. Desk research is conducted and the different options are evaluated subsequently to determine a material to use for the skates in the product.

The team is especially interested in two parameters when it comes to choosing a material for the skates. The ability to smoothly glide across surfaces, determined by the coefficient of friction and the abrasion resistance, as the product will be exposed to many hours of abrasion daily.

Two different materials are used by the big gaming companies:

1. PTFE (Polytetrafluoroethylene) colloquially known as Teflon is used by big companies such as Razer due to its very low coefficient of friction (Curbell Plastics, 2014).
2. UPE (Ultra-high-molecular-weight polyethylene) is used by companies such as Steelseries as it has low costs with a very low friction - not as low as PTFE, but with better resistance to abrasion (Curbell Plastics, 2008).

UPE has a low price and a good relation between coefficient of friction and abrasion resistance ⚙

Main clicks

To determine the technology used for the main clicks executed with index- and middle finger, the team has analysed and written up pros and cons for 10 different switch and actuation types and four of these are found of plausible use [W065].

Ill. 90: *Push button*

Ill. 91: *Limit switch*

Ill. 93: *Force sensor*
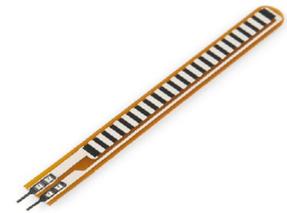
Ill. 92: *Flex sensor*

To find and determine the right type of actuation for the product, the four candidates have been assessed on their potential within: adjustment options for clicking position, feedback, size, and placement options *(Ill. 94)*.

Push button switch
The classic push button switch is a momentary switch which means that it is only active momentarily when pushed, contrary to maintained,where an extra click is needed to turn it off *(Ill. 90)* (Sparkfun.com, 2017a).

Limit switch
Limit switches are similar to momentary push buttons. They can be found with or without a leaver, where the leaver is available in different shapes and sizes depending on the area of application *(Ill. 91)* (Sparkfun.com, 2017b).

Flex sensor
Flex sensors have polymer ink printed on them with conductive particles embedded inside. When bend, a resistance can be measured between these particles, read as a voltage difference *(Ill. 92)* (Sparkfun.com, 2017c).

Force sensor
This type of sensor translates force into an electrical signal. It is able to measure the electrical change in resistance in response to the strain applied to it *(Ill. 93)* (Sparkfun.com, 2017d).

Sum up
The table shows flex sensors as the potentially best candidate, even though it does not have any integrate feedback, which should be considered in the further detailing process. It does, however, The flex sensor is chosen regardless the lacking feedback because of it properties of size, flexibility and adjustment.

> Flex sensors have good relation between size, adjustment options, and mounting ⚙

Push button	Limit switch	Flex sensor	Force sensor
+ Cheap + Small in size + Tactile feedback (feel) + Easy placement	+ Relatively cheap + Tactile feedback + Audio feedback + Easily modified leaver	+ Very thin + Easy attachment + Programmable adjustment + No mechanical adjustment + No mechanisms for click.	+ Easy attachment + No mechanical adjustment
- Need for click mechanism - Weak audio feedback - Need for adjustment mechanism.	- Large in size - Need for click mechanism - Need for adjustment mechanism.	- Medium priced - No audio feedback - No tactile feedback	- Expensive - Large in size - No audio feedback - No tactile feedback - Need for click mechanism

Ill. 94: *Pros and cons table*

Tactility

Choosing flex sensors for clicking means that a type of feedback needs to be incorporated in the product. During the test with the functional prototype, test subjects expressed a preference towards a physical feedback, as with those where one could actually feel the string pulling. The team investigates different solution principles.

Ill. 95: iPhone 7 mimic a mechanical home button with haptic feedback

A mechanical workaround is considered to get the feeling of a click, but this type of solution could take up a lot of space and would be difficult to adjust to get coherence between when you click and when you actually receive feedback. Instead, the team takes inspiration from the iPhone 7, using a haptic feedback in their home button, feeling exactly like a click, but conducted by vibrations from a small motor *(Ill. 95)*. Motors to conduct haptic feedback can be categorised as either Essentric Rotating Mass Vibration Motors (ERM's) or Linear Resonant Actuators (LRA's), which determines if the motor vibrates in one or two directions *(Ill. 96)* (Precision-microdrives.com, 2017). It makes sense to choose the LRA as only one vibration direction is needed. A type is chosen with a thin round profile, to make it fit on the finger, where it is to be mounted with the vibration direction towards the finger. Through programming, two haptic feedback will be able to work in association with the two flex sensors (one for each finger).
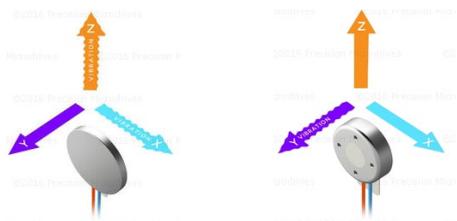
Ill. 96: Vibration motors. Right: ERM with two directions. Left: LRA with one direction

A LRA can mimic physical clicks, is small, and is programmable to collaborate with flex sensors ⚙

Clicking resistance

As part of incorporating tactility in the clicks, the team hypothesises that having some resistance in the fingers would bring greater comfort. A test is conducted on resistance in the clicks in a similar manner as the wrist resistance test, with pressing metal plates of different thickness a distance of 10mm and translating it into forces (Ill. 97) [W073].

Ill. 97: Finger resistance test setup

The results of the test show that test subjects prefer to have a resistance of 0,132N with 10mm deflection. These forces are very low, which is why the team derives that no extra resistance, besides the natural resistance from the glove, is needed.

No additional resistance is needed for main clicks ✕

Extra functions

For the esports glove to replace existing gaming mice, it needs to offer some of the same functions that the players frequently use. According to a questionnaire, League of Legends players on average prefer their mouse to have a minimum of five extra buttons, disregarding the main clicks and scroll function [W024].

In *Ill. 98*, the functions needed are stated including the unique functions required in the esports glove.

An investigation of possibilities and placement of the different functions is conducted [W072]. For the keystrokes, the best solution found is to incorporate a "joystick" solution to flick in different directions with the thumb, creating different shortcuts *(Ill. 99)*. This solution makes it possible to have five extra functions, where the scroll function is able to be incorporated as a page up and down function.
DPI is only regulated a few times during a game, maybe once or twice at most. It makes sense to use the left hand for this function, since the regulations are not done at critical moments during the game, as it could be the case with the keystroke functions *(Ill. 100)*. The requirements for the buttons are only being momentarily and small.

Adjusting the flex sensors and thereby the sensitivity of the main clicks is done before the game starts. The left hand is able to make adjustments by turning an actuator located in an intuitive position near the position of the flex sensors.

An activate/deactivate function is important to quickly write on the keyboard when chatting during games.

A heating function has initially been intended to be incorporated to avoid cold hands, but the team decides that wearing the glove would be sufficient, as players now solve the problem by wearing gloves.

Functions	Number of actuators
Keystrokes - keyboard shortcuts	3
DPI settings - up and down	2
Scroll (OR page up and down)	1 (2)
Adjusting main clicks	2
Activate/deactivate navigation and clicking	1
(Heating on/off)	(1)

Ill. 98: *Functions and number of actuations needed*

Ill. 99: *Keystrokes and scroll. Left: Placement. Right: 5-way Tactile Switch component*
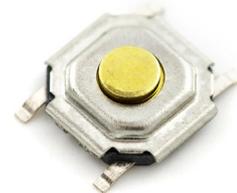
Ill. 100: *DPI settings. Left: Placement. Right: mini push button switch*

Ill. 101: *DPI settings. Left: Placement. Right: Mouse encoder wheel*

A 5-way tactile switch is small and has five programmable directions for shortcuts	⚙

DPI adjustments can be conducted by the other hand	⚙

Mini push button switches are small and momentarily	⚙

Clicks adjustments can be conducted by the other hand	⚙

Mouse encoder wheels are small and can be used for adjustments of main clicks	⚙

Optical sensors can be programmed to deactivate when not in contact with a surface	⚙

The glove works as an insulator	⚙

Connection

The esports glove should provide an experience of freedom, which connection with a wire would oppose. The team is investigating if it should be wired or not.

For years, gamers have argued that wireless mice are not as accurate and fast as wired mice. This could pose a problem, and it might have been true years ago, but today's technology provides wireless mice with the same speed and accuracy as wired mice (Fenlon, 2015B). Professional players are now also seen using wireless at competitions, which was not the case just a couple of years ago.

Ill. 103: *500mAH Li-Po battery*

Wireless is chosen due to its similar speed and accuracy compared to wired, and a standard bluetooth connection is chosen, just requiring a bluetooth USB dongle to be placed in the PC for connection.

A physically small battery is found with 500mAH, corresponding to the battery inside the Logitech MX Master, which claims to have 40 days of battery with an average of six hour work days (Logitech.com, 2017). A micro USB port placed in the support enables charging of the battery, also while playing if needed.

Bluetooth is a standard technology used in wireless mice	⚙
A small 500mAH battery can provide power for several days before needing a new charge	⚙

Construction

The construction of the support entails dimensioning of where the support is needed. Previous tests with plaster gauze models have established that following the lines inside the palm feels comfortable, and is not in the way of bending the fingers [W053]. The length of the support from the wrist and down the forearm still needs to be defined, as well as making a solution to avoid squeezing the bottom fingers [W069].

Length of underlying support
Test subjects are to test four different supports with different length while playing with a vertical mouse to simulate the right angle (Ill. 102).
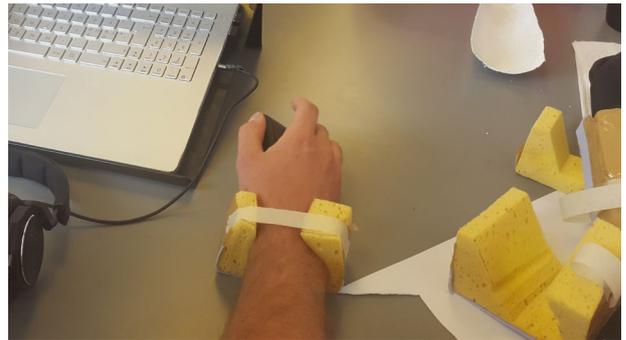
Ill. 102: *Test subject trying the 40mm support*

The lengths of the supports are 40mm, 80mm, 120mm (used in functional prototype), and 190mm. The bottom of the supports are applied cloth to reduce the impact friction would have on the qualitative statements.
A length of 80mm or a little shorter is the preferred length by the test subjects.

Underlying support of 70mm is comfortable	⚙

Height of underlying support

The feedback provided at the test with the functional prototype, pointed out that the little finger and ring finger are squeezed between the table and the other fingers. A possible solution principle is tested.

Ill. 104: *Test with adding or removing cloths*

The team wants to solve this issue by giving a little increasing height in the support towards the fingers. A test is conducted where test subjects are to add or remove cloths until a comfortable height is obtained, which is measured subsequently.

Test 1	Test 2	Test 3	Test 4
10,6 mm	10,8 mm	10,6 mm	10,0 mm

.   ***Ill. 105:*** *The height preferred by the four test subjects*

Giving the support height, gives space for the little finger and ring finger	✔

A height of 10mm support is found comfortable	⚙

Aesthetics

The style direction of the esports glove has been established earlier to be a combination of the comfortable soft textiles of regular gloves and a more stiff construction for support. Still, the team needs to explore the aesthetic expression of the esports glove within this style direction. Options are explored through sketching:

A. Keeping the shape simple and only mounting extra details where it is needed. This direction needs a bit more of the complexity in the details that the players are asking for as it does not exude any 'wow-factor'.

B. Functionality, such as flex is highlighted in the construction, and organic shapes create the foundation with edgy shapes on top. The team likes how the functionality can be seen in the construction, but does not feel that it quite captures the sporty professional feel as it looks a bit like a splint. The visible wires also make it look fragile.

C. The chunky futuristic and detailed glove: the complexity and futuristic look becomes too salient in this direction, where the feeling of comfort and durability get lost in the mix.

A

B

C

The sporty direction

The team wants to accentuate the vision of making esports sporty, where inspiration is taken from sports shoes. Sports shoes have proven to be good at combining flexibility with stability in the right places, where especially Nike flyknit has given inspiration with their weaving technique using polyester yarn. Inspiration is found in several other products as well to add to the vision, where specialisation, professionalism, quality, futurism, and functionality are keywords encapsulating the interaction vision. *Ill. 106* illustrates the aesthetic direction the team aims for, where inspirational photos emphasise the details and their intentions, also including thoughts in relation to equipping.

Specialised
Reflex camera giving a feeling of professionalism and specialisations with its high-tech looking buttons.

Futuristic armour
A paintball glove emphasising an amoured look, where protection is needed. Giving a more futuristic look.

Functionality and quality
Xbox one controller joystick giving a feeling of quality and optimised functionality with a concave shape and grip patterns.
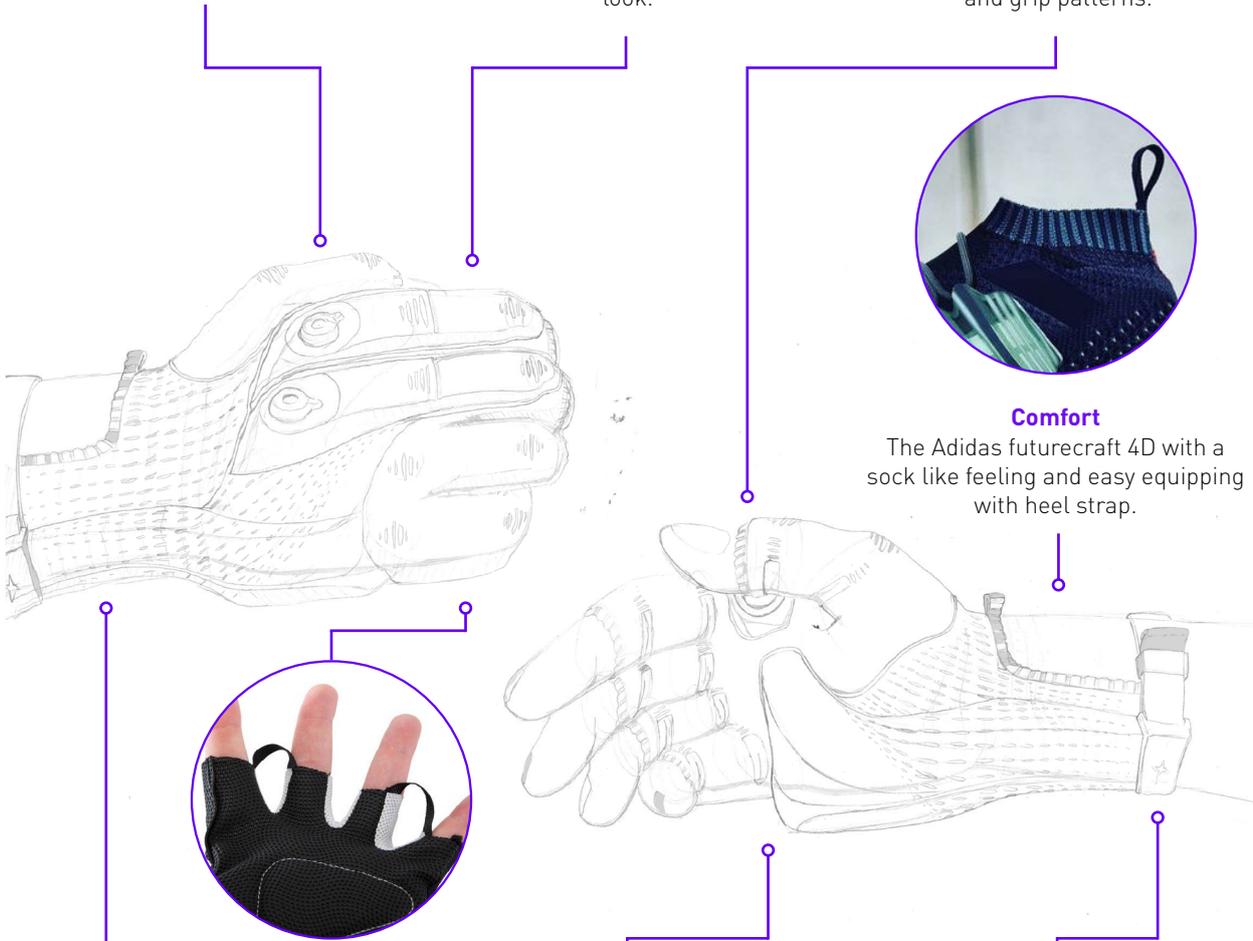
Comfort
The Adidas futurecraft 4D with a sock like feeling and easy equipping with heel strap.

Simple dequipping
Inspired from training gloves, finger straps can help with dequipping

Highlight flexibility
Knitted mesh accentuates function-ality in Nike Flyknit shoes with the same material transitioning from dense to rough giving a sporty feel.

Combining support and comfort
Under armour shoe combining hard plastic with the soft textile in an elegant way.

Sporty adjustment
Silicone bands optimum for sports activities. Also giving the design an edge with chamfers.

Ill. 106: *Aesthetic direction: encapsulating the vision of sporty*

Product specification

Category	Specifications	Reference
Actuation	Two main actuation points	p. 60
	2 x Flex sensors on top of index finger and middle finger	p. 68
	2 x Mouse encoder wheels for adjustment	p. 70
	2 x Linear Resonant Actuator on fingers for feedback	p. 69
	Five additional actuation points	p. 70
	1 x 5-way tactile switch for programmable shortcuts	p. 70
Navigation	Point of navigation in palm	p. 65
	1 x Optical sensor as technology	p. 67
	Wrist movement is allowed up to 20 degrees in extension and flexion	p. 65
	2 x Mini push buttons for DPI adjustment	p. 70
Deactivation	Programmed in optical sensor	p. 70
Ergonomics	Flexibility in plastic material provides angle freedom of 6 degrees in supination and pronation	p. 66
	Resistance in wrist is provided by textile	p. 66
	Hand position in 30 degree angle from vertical	p. 61
Support construction	Height inside the palm goes up to the top of the middle finger (Size dependent)	p. 57
	Flat bottom	p. 61
	Length of 70mm from wrist	p. 71
	Height of 10mm by the finger linearly decreasing to table height by the wrist	p. 72
Heating	Glove as insulator	p. 70
Connection	1 x 500mAH Li-Po battery	p. 71
	1 x Bluetooth connection with USB dongle	p. 71
	Micro USB port in underlying support	p. 71
Material	Textile of polyester yarn	p. 77
	Support of Polyproplene	p. 77
	4 x Mouse skates of UPE	p. 67

IMPLEMENT

In continuation of the detailing phase, the team looks into production, strategies for entering the market, and creating a viable business model for the product.

Manufacturing

Materials

The team has looked into materials and production methods to finalise the product, taking into consideration the functionalities needed along with the experience desired. Electrical components are not included in this section as they are standard components and skates are described earlier in the detailing phase.

Textile

The parameters influencing the choice of textile are especially the elasticity and durability. The synthetic fabric, polyester, has a tensile strength between 500-1100 MPa, where cotton as an example only has 300MPa. Elongation is also higher with 11-40% in polyester against cottons 8% (Nemr, 2012). Using polyester yarn allows the team to make a glove with different types of mesh with a seamless technology as seen in both Nike flyknit shoes and 2XU running shirts, giving the team great possibilities in relation to aesthetics and where to give more or less support *(Ill. 107)* (Shishoo, 2015). Polyester yarn is often used for sports wear, due to its strength, elasticity, and efficient warming capabilities (varindraindustries.com, 2017).

Ill. 107: 2XU running shirt using seamless technology

> Polyester yarn has a good relation between elasticity, strength, durability, and warming capabilities ⚙

Plastic

The support needs to be able to hold the hand, but it also needs to be flexible and withstand bending for the small vertical deviation of the hand. Polypropylene (PP) is characterised for having good resistance to fatigue, but it also has some other desirable features being (Lefteri, 2014)):

/ Low cost
/ Good electrical insulator properties
/ Resistant to fat and most organic solvents
/ Blends well with other materials
/ Versatile processing

> Polypropylene has desirable features, such as low cost, withstanding to bending, and being a good electrical insulator ⚙

Production

Glove

The glove could be produced by the method of integral knit-ting, which is conducted on large machinery, where bigger areas are knitted in one piece with only few seems or none at all, as it is seen with Nike Flyknit shoes *(Ill. 108)*. This means minimising processes such as cutting and sewing and the textile can be knitted to be optimised with more support in certain areas, but it requires a machine to do it (Shishoo, 2015). The team hopes to enter into an agreement with a partner where they or their suppliers have such a machine and the knowledge to construct a glove with the technology.

The straight forward and standard approach for gloves is the cut and sew method, where different textiles can be applied at certain areas, but no fluent transition can be made in mesh density (Peterson, 2007). However, with this method, the team is certain that the glove is able to be constructed.

> Cut and sew is the standard and straight forward approach for creating gloves ⚙

Support and other hard parts

Injection moulding is able to process the thermoplastic Polypropylene, while creating a precise detailed surface for mounting the electrical components, which thermoforming or vacuum forming is not able to do. Injection moulding works by heating polymer granules in an Archimedean screw and injecting the tempered plastic into the die cavity, where only a short cooling time is needed before ejecting the finished parts(Thompson, 2007). Tooling costs are high when using injection moulding, but the team finds it reasonable to es-timate a sale of at least 10.000 units, which only constitute 0,01% of the monthly League of Legends players alone, justifying the big tooling cost for these parts. Besides, when the production is up and running, the unit cost is really low.

An alternative to injection moulding is 3D printing, which could help with more individually customised products, but this method is both slower than injection moulding and has a higher unit cost.

> Injection moulding is a fast and precise production method suited for the quantity of the 'esports glove' ⚙

Assembly

To finalise the esports glove, an adhesive is used to glue together the plastic and textile, similar to regular shoe pro-duction.

Ill. 108: *Integral knitting in Nike Flyknit*
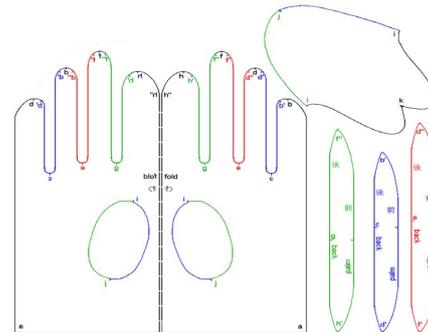
Ill. 109: *Cut and sew pattern of standard glove*

Product cost

The production cost of the esports glove has been estimated from two scenarios, where for instance the standard electri-cal components are found at retail prices and a "best case" and "worst case" percentage have been calculated [W075]. Regular kg prices for PP are found for the injection mould-ing, and a top down calculation has been made on an Under armour training glove, to estimate the production price of the glove. Wages for assembly have been added and prices shown are rounded.

Best case	Worst case
400 DKK	660 DKK

These prices will result in the following retail prices if applying traditional contribution margins *(Ill. 111)(Ill. 110)*:

Retail price - best case			
Actor	**Kind**	**%**	**DKK**
Retail	Sales price VAT (25%)	20	**≈ 2.000 DKK** 416
Retailer	Sales price contribution	50	1.666 833
Wholesaler	Sales price contribution	20	833 166
Factory	Sales price contribution	40	666 266
Product	Cost		400

Ill. 110: Retail price calculation - best case (numbers are rounded)

Retail price - worst case			
Actor	**Kind**	**%**	**DKK**
Retail	Sales price VAT (25%)	20	**≈ 3.450 DKK** 688
Retailer	Sales price contribution	50	2.750 1.375
Wholesaler	Sales price contribution	20	1.375 275
Factory	Sales price contribution	40	1100 440
Product	Cost		660

Ill. 111: Retail price calculation - worst case (numbers are rounded)

A requirement based on player statements says that the product should not exceed 2000DKK. The requirement, however, is taken from a viewpoint of regular gaming mice, but it gives an indication of the price level players are willing to pay. It is found unlikely that the product will sell in bigger quantities if the price exceeds the 3000DKK. Though, a high price could be used as a selling point to underline a high quality product. The team aims at getting a retail price just above the 2000DKK, either by obtaining favourable component prices or attempting a product optimisation. Otherwise, adjusting the contribution margin accordingly could be an alternative solution.

Business model

A business model is created using the Business Model Canvas (Osterwalder and Pigneur, 2010). The model is created from the assumption that a partnership with the gaming peripheral company, Steel Series, is established utilising their key resources, channels etc.

The customer segment is, as previously described, hardcore gamers, aspiring professionals, and semi-professionals. All players dedicated to the game and their equipment. Satellite's key resources is knowing the customer segment and the industry needs, creating a value proposition focusing on perfect support, high performance and control, looking cool, and enjoying the ability of playing for many hours. The product promises an unforgettable experience, while reducing the strain on the muscles. Satellite's main activities will therefore consist in product development and customer relations (participating in expos and fairs, joining gaming communities etc.) *(Ill. 113)*.

Satellite will partner up with Steel Series, who will be in charge of manufacturing, distribution, and product marketing. As the product differs from their current product portfolio, by using textile, Steel Series will benefit from entering into an agreement with a sports company (e.g. Nike). This will add key resources such as brand reputation and expertise within integral knitting .

Existing Steel Series- and gaming channels (steelseries.com and twitch.com) will be used to reach the customer segment, along with using streamers and Full-time professionals to work as brand ambassadors.

Revenue streams occur from transaction revenues resulting from one-time purchases of the product. Satellite will get part of this revenue from the agreement with Steel Series, which needs to be negotiated.

Marketing strategies

A marketing strategy could be to target the surrounding stakeholders of the next generation of full-time professional *(Ill. 112)*. Through education of these stakeholders, their individual incentives could be supported by the product as they are made aware of its potential (injury risk reduction, improved endurance). The investor is interested in securing his investment, Teams and Clubs are interested in providing a serious and high performance working environment etc. This could position Satellite as expert and forerunner within the industry, creating a word-of-mouth potential and high credibility.
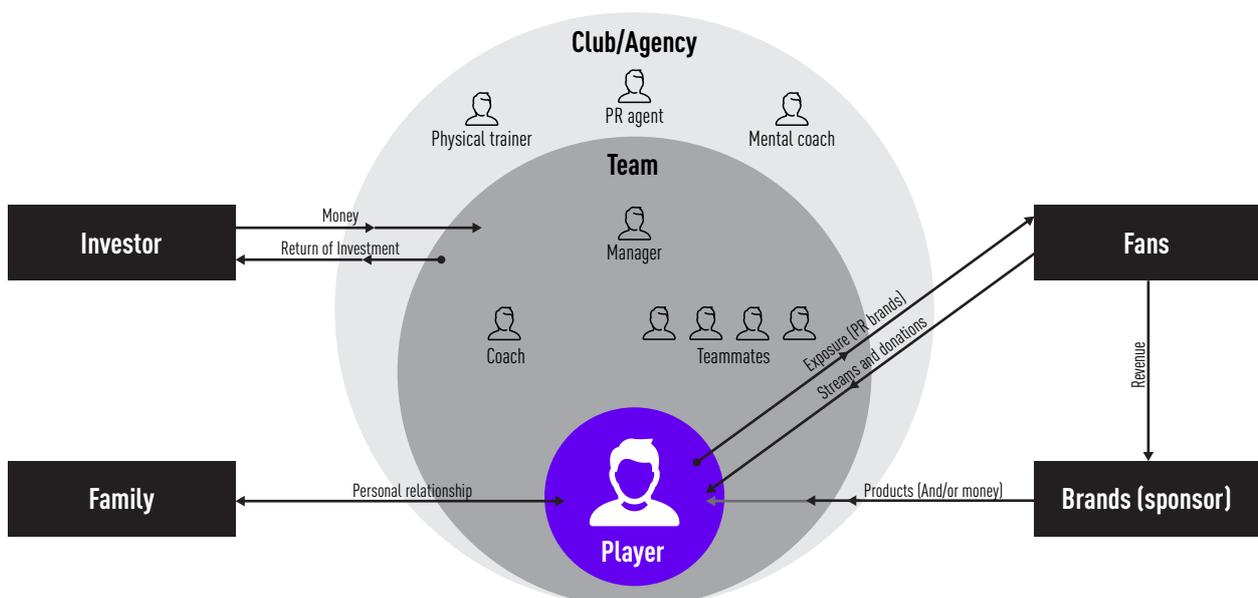
Ill. 112: *Relations between stakeholders*

Customer Segment

**Semi-professional
Aspiring professional
Hardcore gamer**

Value proposition

The high performance esports
device: creating an immersive
experience and reduces risk of injuries

Customer Relationships

Satellite: Personal assistance (e.g.Expos)
Gaming communities
Self-service

Channels

Steel Series website
Satellite website
Brand ambassadors (Sponsorships)
Streaming sites (e.g. twitch.com)

Satellite

Key resources & activities:
- Experts within the field
- Customer and industry knowledge
- Product development

Key partner

Steel Series Key resources & activities:
- Brand recognition
- Production
- Distribution
- Gaming peripheral knowledge

Revenue share (Through agreement)

$

Outsourcing glove

Key partner

Nike Key resources & activities:
- Brand recognition
- Knowledge in integral knitting
- Production

Cost structure:
- Human resources

$

Cost structure:
- Production
- Distribution

$

Revenue streams:
- Product sales

$

EPILOGUE

Final thoughts about the project are stated here, along with an evaluation of both the process and product.

Conclusion

This master thesis project has worked with the relatively young industry of esports, envisioning to turn gaming ´sporty´ through the development of a new peripheral input device for esports athletes. Studying the industry has uncovered an increasing problem of player injuries within esports. This causes problems for the players, as it means reduced performance and short careers, but it is also a great problem for the well-being of the industry.
The process has been test-driven with frequent user involvement capturing the physical requirements and desires of the players, ensuring a product balancing player perception of comfort with the specialisation needed to perform in the game. The research and development have lead to 'Titan', an esports glove that replaces the regular mouse as a more professional device, aimed at the competitive genre of Multiplayer Online Battle Arena games played on the computer platform.

Titan focuses on ensuring optimum ergonomic movements and thereby reducing the risk of injury without compromising performance. It also aims at providing an immersive user experience of both being free and in control by turning the hand into the input device with quick access to features enabling a faster and more fluent gameplay.
The identity of Titan has been developed taking inspiration from the sports shoe industry especially by emphasizing the functionality with streamlined details, mixed with the more futuristic and techy appearance found in classic gaming. It creates more of a sports reference and status, while being true to the origins of gaming.

All things considered, Titan creates a new category of esports equipment, benchmarking a paradigm shift within the industry, focusing more on optimisation and utilising the skillset of the athlete without compromising careers.

Reflection

Product

The proof of principle indicates that the concept lowers strain when playing, but the development has since led to some compromises between performance and protection.

Construction

Part of the stiffness of the brace was removed to allow more freedom in the wrist, (re)enabling players to make small and precise movements. While many of the ergonomic principles are preserved, the lack of stiffness around the wrist might still be problematic and should be tested out. Simple tests have been conducted to quantify feelings of comfort, as is the case with wrist resistance. For further development, test subjects would have to try playing with different types of wrist constructions in the glove, to be able to make a conclusion on the construction. Part of the idea was also to allow freedom in the angle of the support by creating a feature that enables users to configure the angle. This would permit users to change working position from time to time, as the rule-of-thumb for good ergonomics predicates. Instead, the material itself provides a little angle wiggle-room which might help, but needs long term testing both in terms of comfort, muscle strain and performance.

Actuation

One of the important things to address is the actuation technology. While the team has tested simple calibrations with the flex sensors used for 'clicking', their actuation accuracy still need to be verified. The correlation between flex sensor actuation and haptic feedback should also be precise to not give misleading information to the user. If these are not tested and working precisely it could very well be a deal breaker for the users.

Another concern is the programmable thumbstick used for key bindings/shortcuts. Earlier tests have showed that the thumb should not be used too heavily as it strain easily when used for repeated work. While the thumbstick is meant to be used occasionally possible side-effects should be investigated.

Use

During development the strap/armband was removed as the team theorised that the glove material itself should be tight enough to secure the whole thing in place. This, however, should be tested with the proper or similar material and construction principles to test if the glove needs to be secured further.

One of the main things that remains unresolved is the maintenance of the product. The parts containing electronic components cannot be detached from the product in the current construction setup, making it difficult to wash the glove or replace broken components. Ideally the glove and the plastic parts can be separated, so that the glove can be both machine-washed and changed. Another topic that remains untouched in the project is the case of left-handed players. While it has not been part of the scope of the project it would be useful to investigate whether there is a need for a left-handed version.

The feedback from users has generally been positive throughout the development phase, but a feedback from core users on the final product is still needed. After hand in, the team will conduct interviews with core users.

Process

To understand the topic the team went through a thorough assessment of the industry and its business potential, which provided a good understanding and overview. The team quickly found an interest of the industry in turn but at the same time had difficulties creating a proper delimitation as all seemed relevant and interesting during investigation. Looking back at the process, it seems that a lot of the information obtained at first has almost been redundant to the development process.

Approach

Testing all the smaller parameters influencing the product has resulted in most working principles being quantifiable. This approach has shown to be very valuable but also unexpectedly time consuming. The general approach has been to use The Logic Network as a development tool as it gives a good overview of the process and the decisions made, however, it proved to be a bit too ambitious and demanding when developing the method on the go. Macro-planning of the project with specified milestones on a physical calendar worked well in the beginning of the project but an underestimation of the detailing phase has resulted in time pressure towards the end. Using a digital Scrum Board for micro-planning has its advantages as it is always available, but the lack of a physical board has meant that it has sometimes been neglected.

Team learnings

Working with a mostly unfamiliar topic has proven an advantage as it created a curious foundation with limited preconceptions, which pushed the team to get information from several external sources. The project has in general been very curiosity- and vision-driven aiming more at a paradigm shift rather than an incremental change to solve the relevant problems. This has proven challenging, pushing the team out of its comfort zone, as working with textiles and electronics as a unity is unfamiliar territory. It has forced the team to be test-driven and to broaden out the topic as much as possible, and members have learned the value of breaking down concepts into more tangible parameters to test.

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