ARACING

Product report

Aalborg University | May 2023 |MSc04 ID9
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TITLE PAGE

Title	ARacing
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Main supervisor	Linda Nhu Laursen
Co-supervisor	Jørgen Asbøll Kepler
Pages	24

TABLE OF CONTENT

ABSTRACT

The following product report was developed by three graduate students as part of a master's thesis in the education of Industrial Design at Aalborg University. The report presents the design proposal, ARacing, an interactive gaming system designed for electric rental go-karts.
Go-karting is a familiar activity for most, but within the segment of young people, it is rarely visited, due to its significant emphasis on racing and individual performance, resulting in a downgraded social experience not desired to be tried more often.

The vision for this project builds upon the wish to create a go-kart experience targeting young people, making them want to try it again. The experience is based on augmented reality technology providing a new immersive go-kart activity emphasizing team play and a unique driving experience.

ARacing is a three-part solution consisting of the ARacing front part, a display integrated within the front part, and the ARacing steering wheel. The new front brings a more modern look to the go-kart and provides the base for the integrated display. Through the integrated display, a videogame emerges, combining the real and digital worlds, creating an exciting track layout varying from lap to lap. The ARacing steering wheel is designed to be the link between the driver and the game, hence having integrated buttons to be used when driving and playing the game.

CONTEXT

The focus of the project revolves around indo- or rental go-kart centers. Rental centers can be found in many locations, with ten indoor rental centers located in Denmark alone. The tracks vary in size, with lengths from 300 to 1250 meters allowing for up to 36 driven go-karts at a time.

Go-karting appeals to various user segments and every age group above seven years by being an activity visited by the likes of families, friend groups, and in relation with school trips and company events.

THE PROBLEM

Within the target group of young people, the activity of go-karting is rarely visited, nor has it in some cases ever been visited. Here, due to it being based on an experience most suitable for people having an interest in racing, hence its focus lies on individual performance and the singular goal of getting the fastest lap time. The activity is described as being very repetitive with not much different to put focus on, while driving around a track that stays the same for all laps to come. As the main goal revolves around improvement of one self by being faster every lap, a loss of momentum can be experienced, when better results are not achieved.

Go-karting is an activity, with most of the social situations happening before and after racing, hence creating a state of loneliness when driving and thereby being an activity not suitable for people wanting do something together in the purest sense.

A new and more including go-kart experience is therefore needed if wanting to bring back the segment of young people more often, which would be a desired wish for multiple stakeholders within the area of rental go-karting.

THE SOLUTION

ARacing is an interactive gaming solution system for electric rental go-karts. ARacing is created with the intention of providing a new, immersive, and fun experience for young people wanting to try out a social and exciting activity with their friends. Embracing the best of the worlds of gaming and go-karting, ARacing provides an experience not seen before in the rental go-karting context. The experience is based on augmented reality technology, creating a new and modern way of driving go-karts more fitting for the younger generations.

ARacing is a three-part solution consisting of a redesigned front part, a display integrated within the front part, and a redesigned steering wheel. Together they form the foundation for a real-life videogame, cherishing team play and an ever-changing fun driving experience one would want to try again.


STOP !
ADVARSEL !
WARNING !
HOLD TIL HØJRE
KEEP RIGHT

THE FRONT

The first seen part of ARacing is the newly designed front part with a design language combining principles seen in gaming and go-karting, creating a unique modern expression while still having roots in current go-karts. The front part is the base for integrating the component box, connecting the elements within one assembly. With its triangular illuminating cutout, the front emphasizes a new kind of experience, hence enhancing the identity of the brand ARacing.

THE DISPLAY

The display visualizes the game in front of the driver with a 10-inch screen using an integrated camera on the back of the display cabinet. The display cabinet is mounted within the component box, which serves as the housing for all electrical components, which among other things, contains a microcontroller and a speaker, keeping them in one place and protecting them from dust and impacts. At the front of the component box, a control switch lets the driver control the state of the go-kart. Outlets for sound are made to let auditive gaming tones shine through while driving.

THE STEERING WHEEL

The steering wheel lets the driver control the car and interact with the game while driving. The steering wheel takes inspiration from gaming controllers with its squared design and bright colors. The steering wheel signals a gamified driving experience while accommodating a comfortable and controllable grip even when turning in the sharpest corners. The steering wheel has a hollow top with room for electric components that connects with the microcontroller in the component box.

THE GAME

The new go-kart experience builds on the aspect of gamification by incorporating elements seen in the gaming world with the principles of go-karting, making the driving experience feel like a real-life videogame. Through the display, the track ahead changes with the placement of virtual elements that adapt to the drivers' movements, making them be seen like real objects on the track.

ARacing presents the game, KartMANIA, inspired by the world-famous game of MarioKart, embracing the adrenalizing fun of go-karting and the immersive and ever-changing environments of gaming.

KartMANIA is a two-team-based game allowing for a fun experience to be shared with others, letting all feel part of the activity. The teams fight each other to gather the most points before the time runs out by collecting virtual elements placed around the track. Points can be collected by driving into green elements appearing throughout the track while looking out for and avoiding red elements deducting one's points if driven into. The popular gaming principle of power-ups is conceived in the game, letting the driver pick up orange-colored elements, giving the driver certain advantages to be use, where one of the advantages lets the driver drop these red elements onto the track forcing each driver to think strategically when battling for the most team points.

When driving, the display presents useful information besides the visual showing of the virtual colored elements, scoreboards are presented, giving a feel of connection within the team.


START

GAME INTERACTION

The steering wheel serves as the interaction link between the driver and the game. Taking inspiration from gaming controllers, the steering wheel has integrated push buttons allowing the driver to influence the game, activating power-ups by pressing on them. When hitting objects and using power-ups, integrated vibration motors provides haptic feedback to the driver's hands, hence creates a more vivid feeling. Furthermore, will the integrated speaker in the component box enhance this feeling providing auditory feedback with tones correlation to the situation.

If in need of help on the track, the red help-button on the steering wheel can be pressed, alarming the personnel.

More buttons have been added than necessary for the game KartMANIA to work. This is done to have an adaptable platform for more games to be added to the ARacing gaming catalogue in the future.

THE SYSTEM

For the experience to work as intended, an external system connecting all go-karts is needed. For processing the game, an external computer will be installed within the rental center. For augmented reality to work in real-time, the external computer needs positional and video data from each go-kart. With Bluetooth beacons and an installed WiFi network, the triangulation method will be used to determine the positions of the go-karts before being sent over WiFi to the computer. An integrated microcontroller within the component box handles this data before sending it to the main computer.

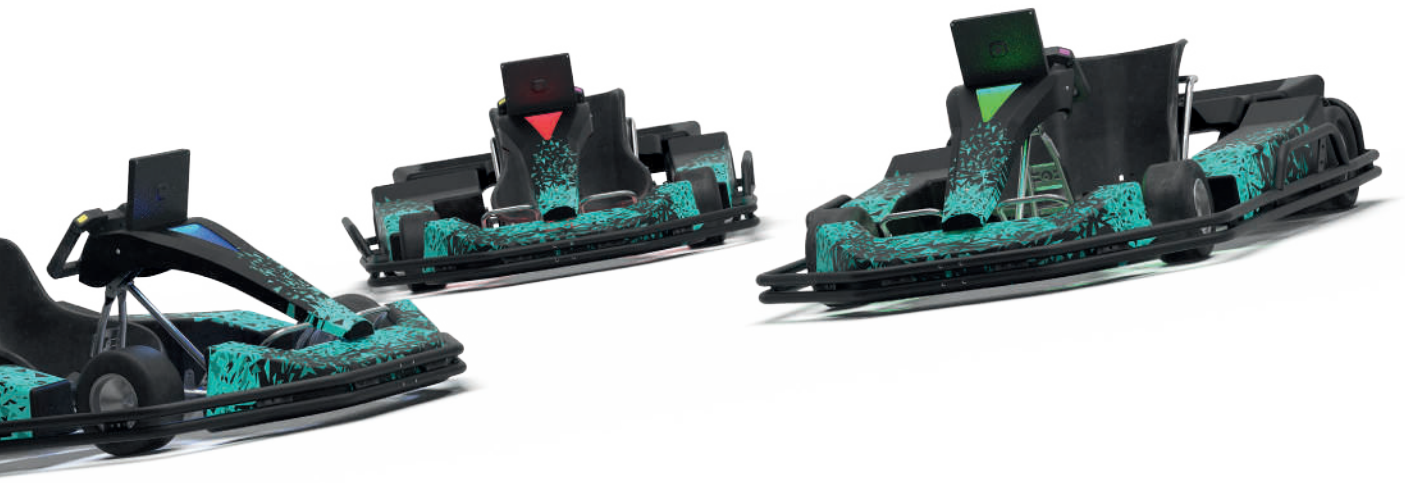
AUGMENTED REALITY

The game is made possible by the use of augmented reality technology. The data from the camera module is sent to the external computer, which analyses the recordings and, using computational algorithms, places a virtual overlay consisting of the placement of the virtual colored elements before sending the video data back to the display to be shown in real time.

Driving on asphalt can cause the go-kart to vibrate a little. To ensure that the electric components do not get damaged due to these vibrations, a dampening mechanism is mounted below the component box. Four rubber bushings will form the connection between the front part and the component box allowing it to move up and down hence staying more stable when driving. The bushings can be easily replaced by others with different stiffnesses, making the solution suitable for driving on various surfaces.

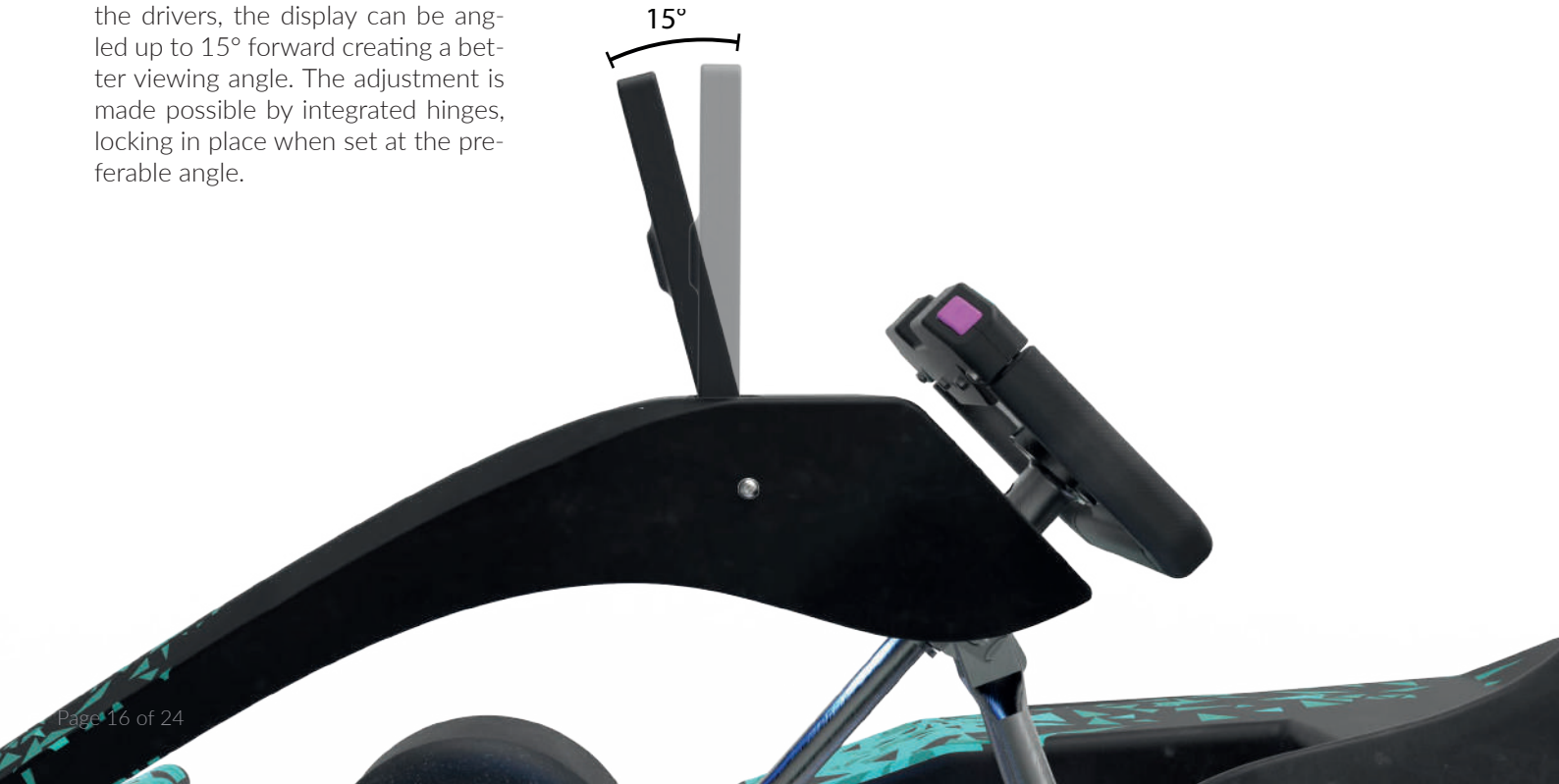
CUSTOMIZABLE LIGHTING

The illumination seen at the triangular cutout is made possible due to an underlying light diffuser, glowing up a semi-transparent acrylic element. The feature is inspired by gaming equipment commonly recognizable by their vibrant light element. The diffuser is illuminated by an attached adjustable LED strip, allowing multiple colors to be shown. To differentiate the teams driving, the cutout will light up in different colors.



ADJUSTABLE DISPLAY

To accommodate various heights of the drivers, the display can be angled up to 15° forward creating a better viewing angle. The adjustment is made possible by integrated hinges, locking in place when set at the preferable angle.

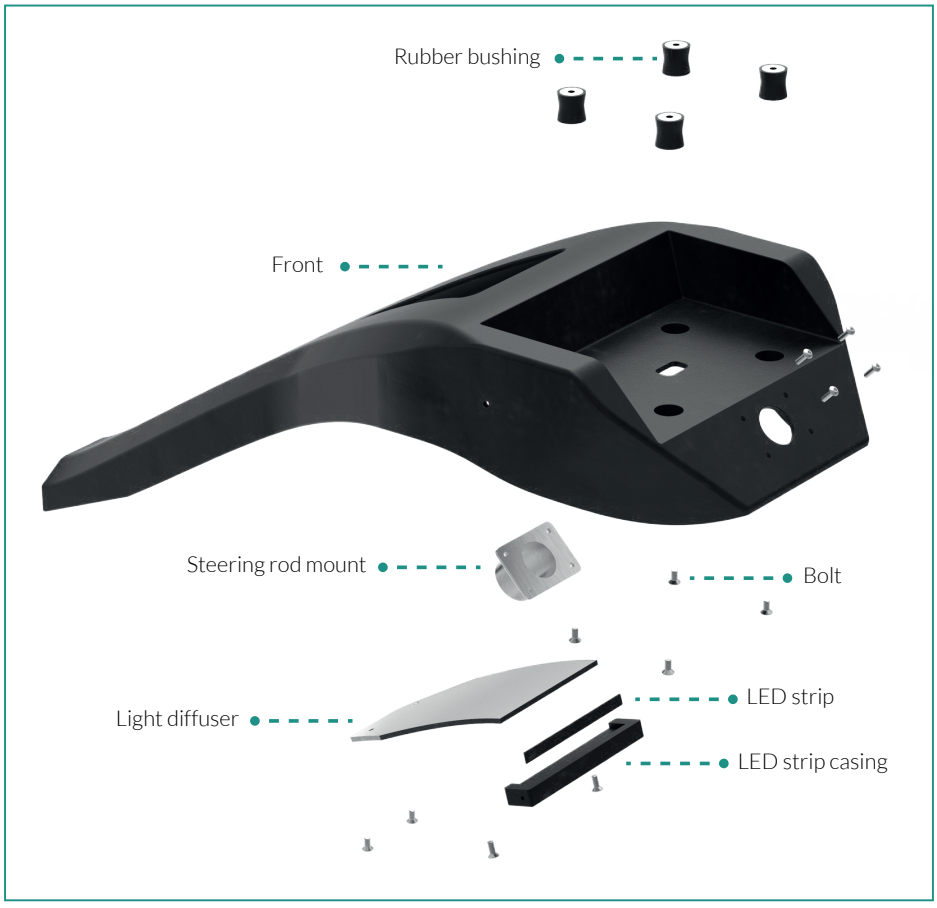


MOUNTING

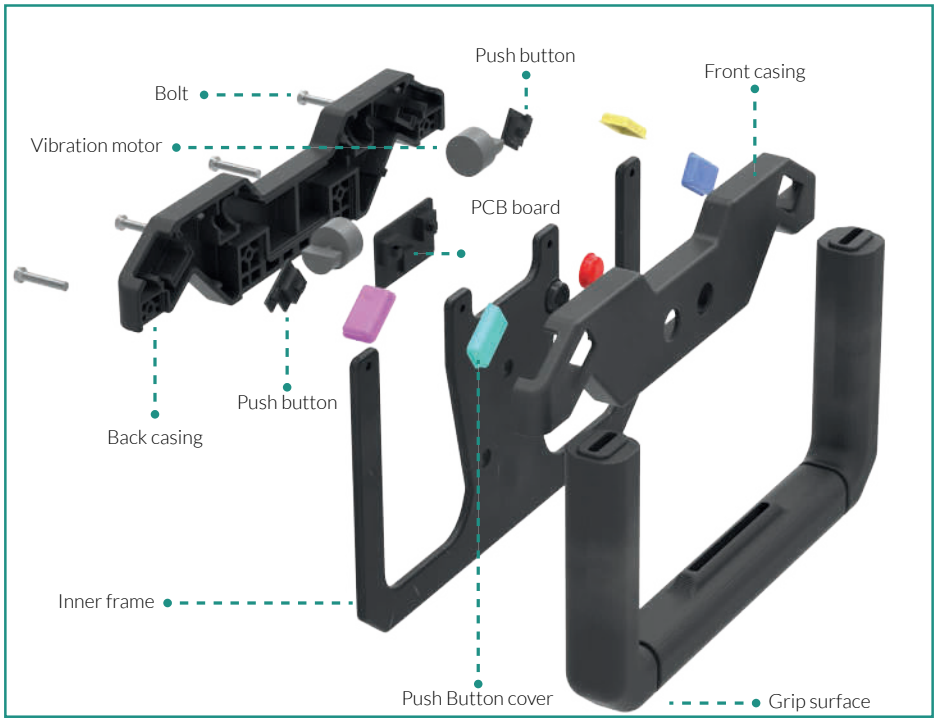
ARacing is a system solution designed for mounting on existing go-karts by bolts. The front is mounted and thereby locked in place by four attachment points.

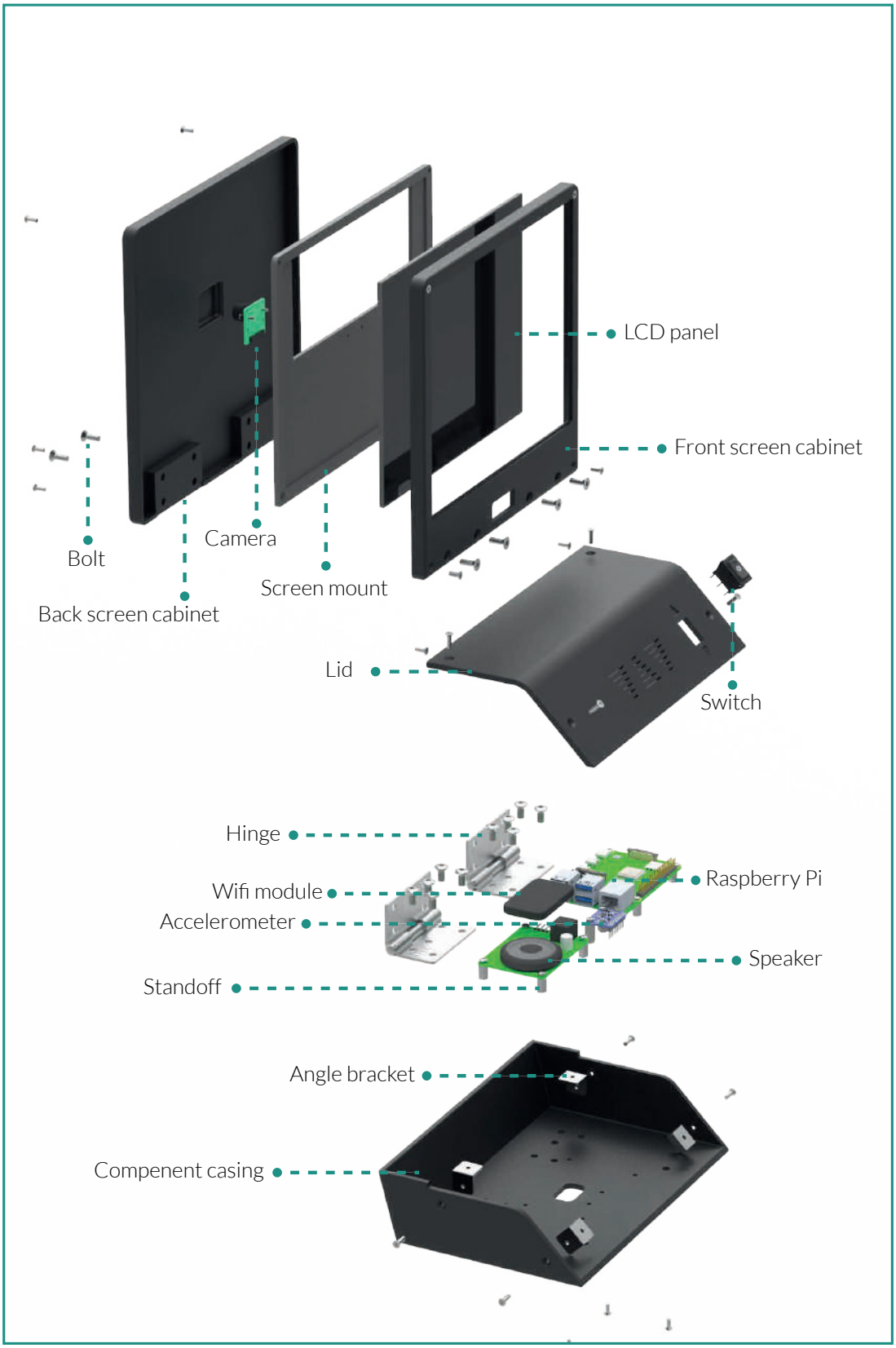
EXPLODED

FRONT

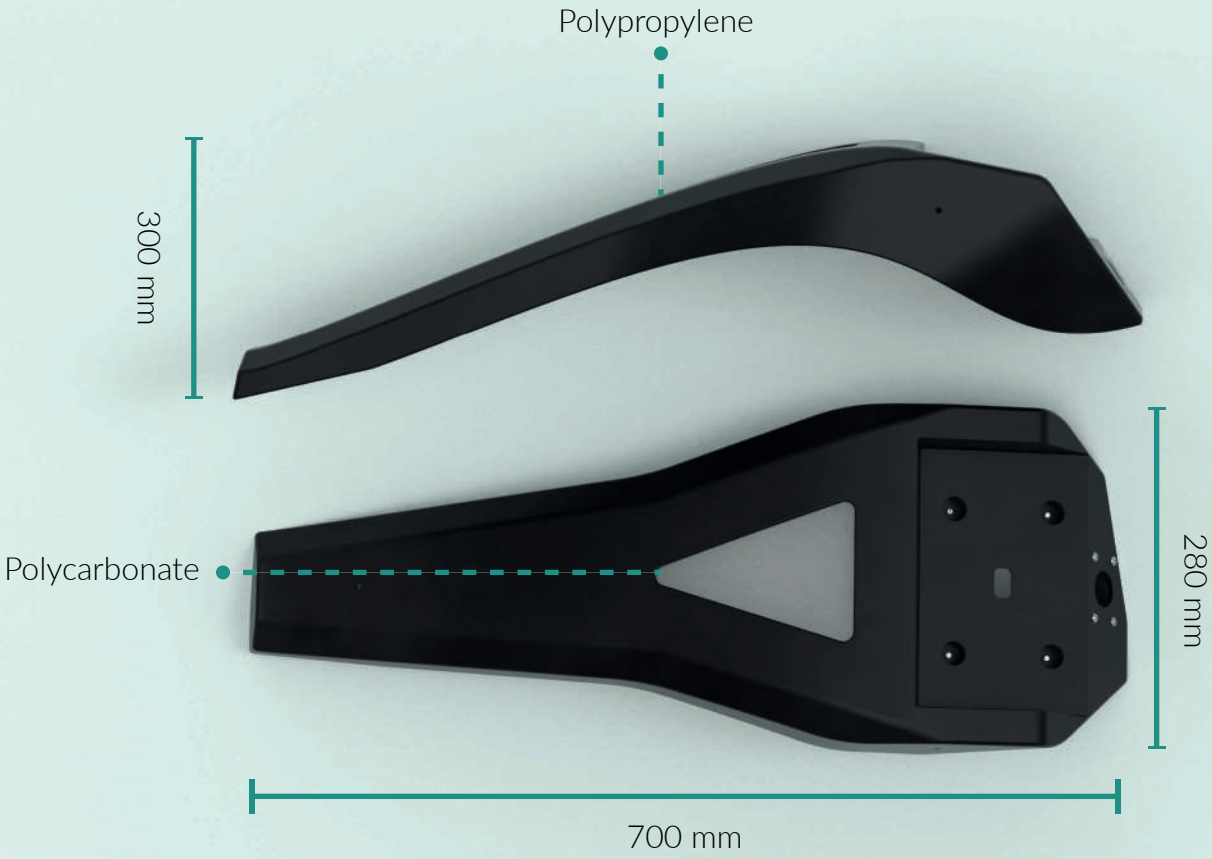


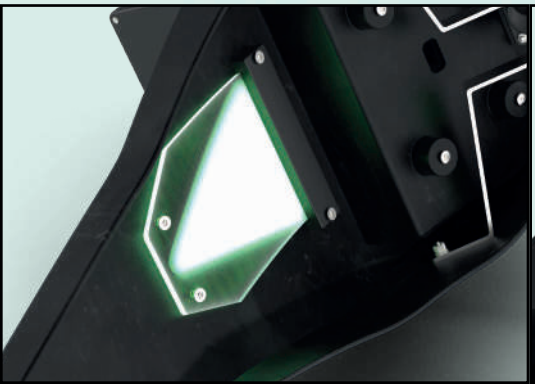
STEERING WHEEL

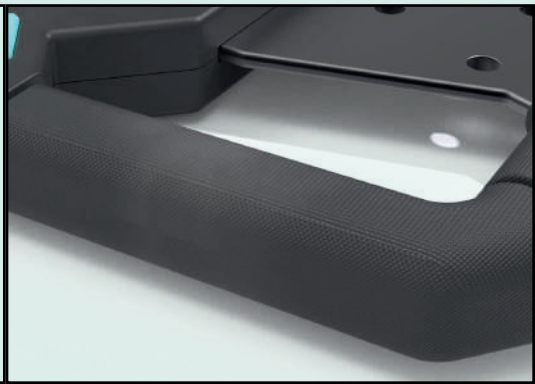


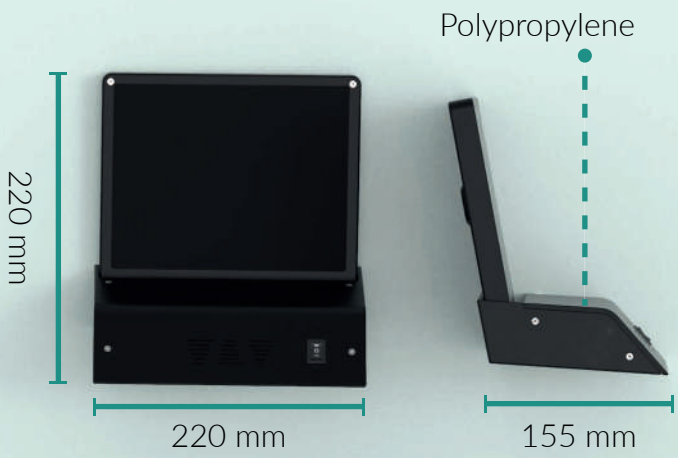

LCD panel
Front screen cabinet
Bolt
Camera
Screen mount
Back screen cabinet
Lid
Switch
Hinge
Wifi module
Accelerometer
Raspberry Pi
Speaker
Standoff
Angle bracket
Compenent casing

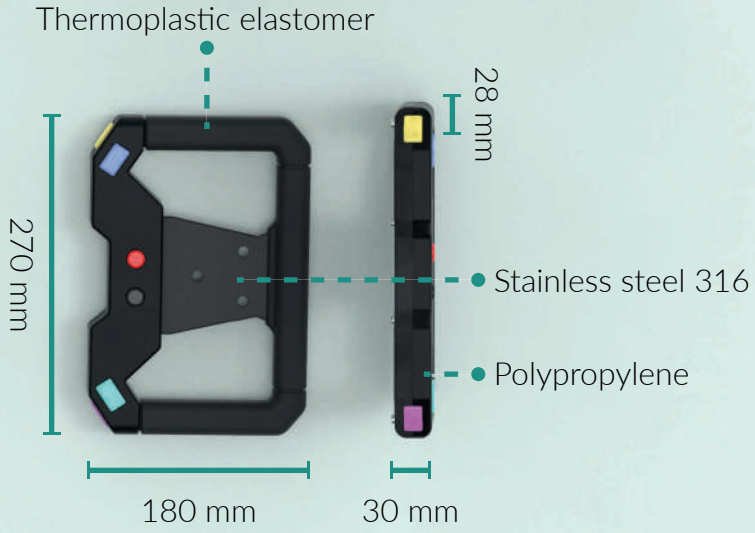
SPECIFICATIONS











SELLING POINTS

- Unique driving experience
- Interactive steering wheel with haptic feedback
- Opportunity for more games
- New modernized design
- Appearance customization for brands/rental centers
- 10” inch display
- Integrated camera module
- Integrated speaker
- Universal front fit
- Easy mounting
- Adjustable display
- Customizable front light
- Easy component replacement
- Component dampening mechanism

BUSINESS STRATEGY

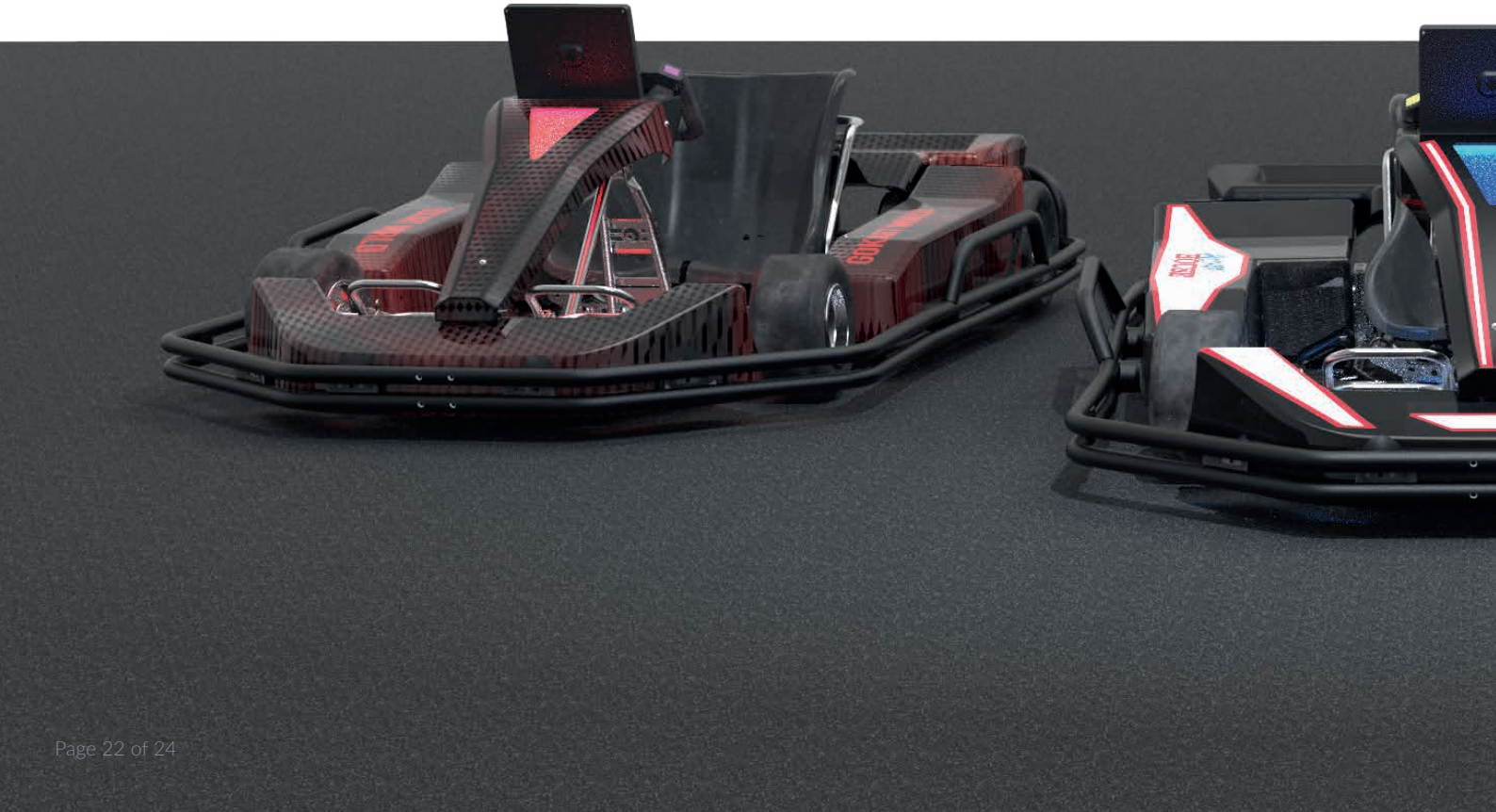
ARacing is designed as a sub-part for an entire go-kart, meaning collaborations with go-kart brands are essential for the business to succeed. Partnering with known go-kart brands will provide easier access to go-kart centers and valuable knowledge on the area for the business to start expanding. Rental go-kart markets such as the ones seen in the US, have been in heavy growth in the previous years, hence being a market ARacing would look into after having an established base with clients.

SCALING

ARacing is designed to be an interactive go-kart experience that builds upon creating new experiences with every visit. The showcased game KartMANIA is just one of many possible games with the solution allowing for endless possibilities.

ARacing can be aimed at different target groups by developing different games and using the benefits that augmented reality provides. Racing enthusiasts or even the professional racing sector could be targeted by displaying the ideal racing line and letting them drive against their own set lap time hence providing tools to help them improve.

ARacing has great scaling opportunities in the future. The current solution focuses on creating an experience within rental go-kart targeting groups of young people. Broadening the scope, it could be used for racing enthusiasts, training professional go-kart drivers, or even being rented directly to users to be used at parties. The scaling could furthermore consist of designing a low-cost product that allows direct sales to owners of go-kart centers by being a scaled-down version focussing on being a direct add-on to the existing go-kart front.



PRICE

The combined solution of ARacing will cost 10.000 DKK, with an additional 3000 DKK per. game. The solution has a variable cost of 3.500 DKK and a fixed cost of 744.196 DKK, resulting in a payback time of 355 units sold, considering the investments made.

VARIABLE COST
3.500 DKK

PRICE
10.000 DKK

PAYBACK TIME
355 UNITS

AALBORG
UNIVERSITY

ARacing

Technical drawings

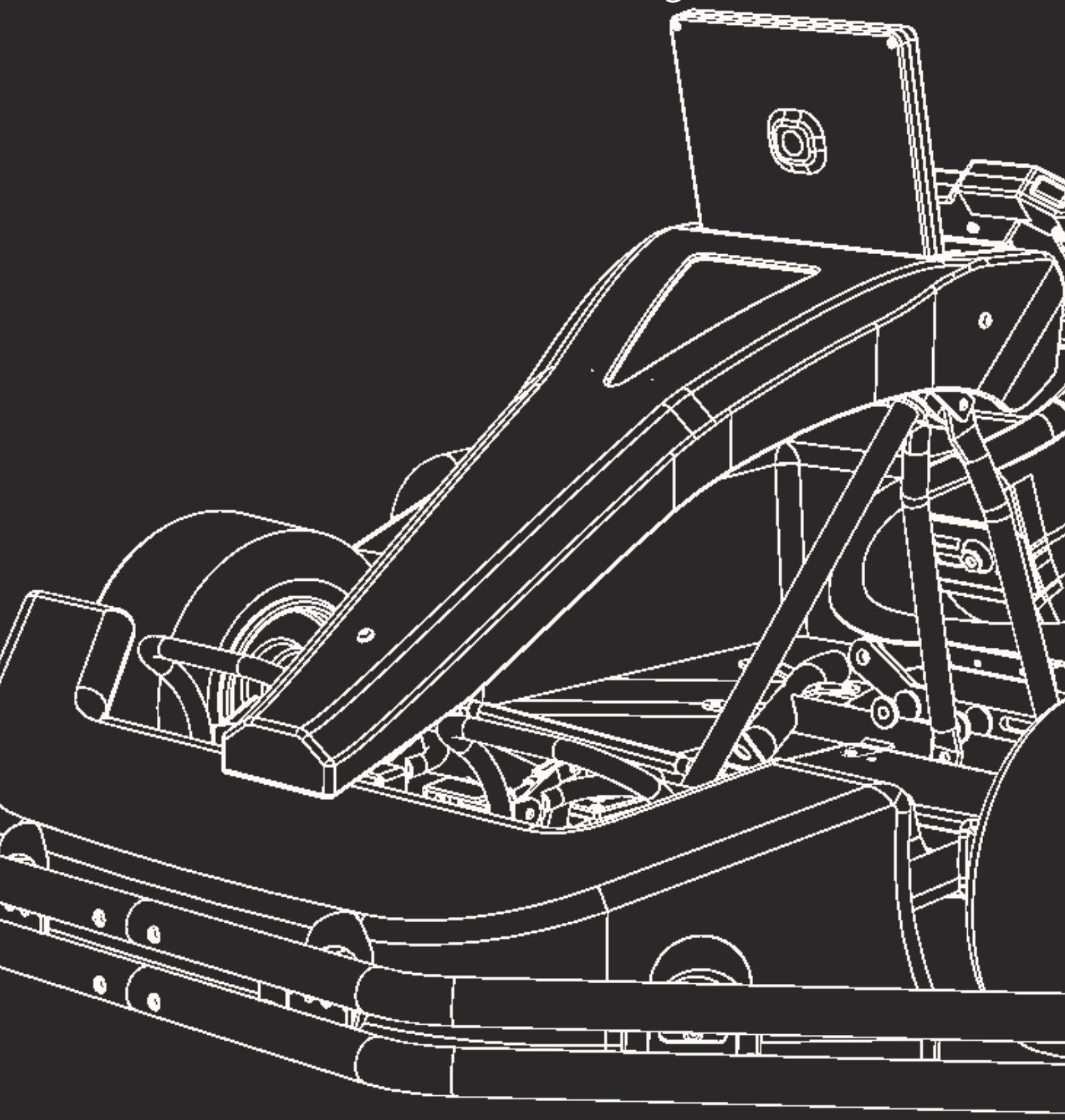


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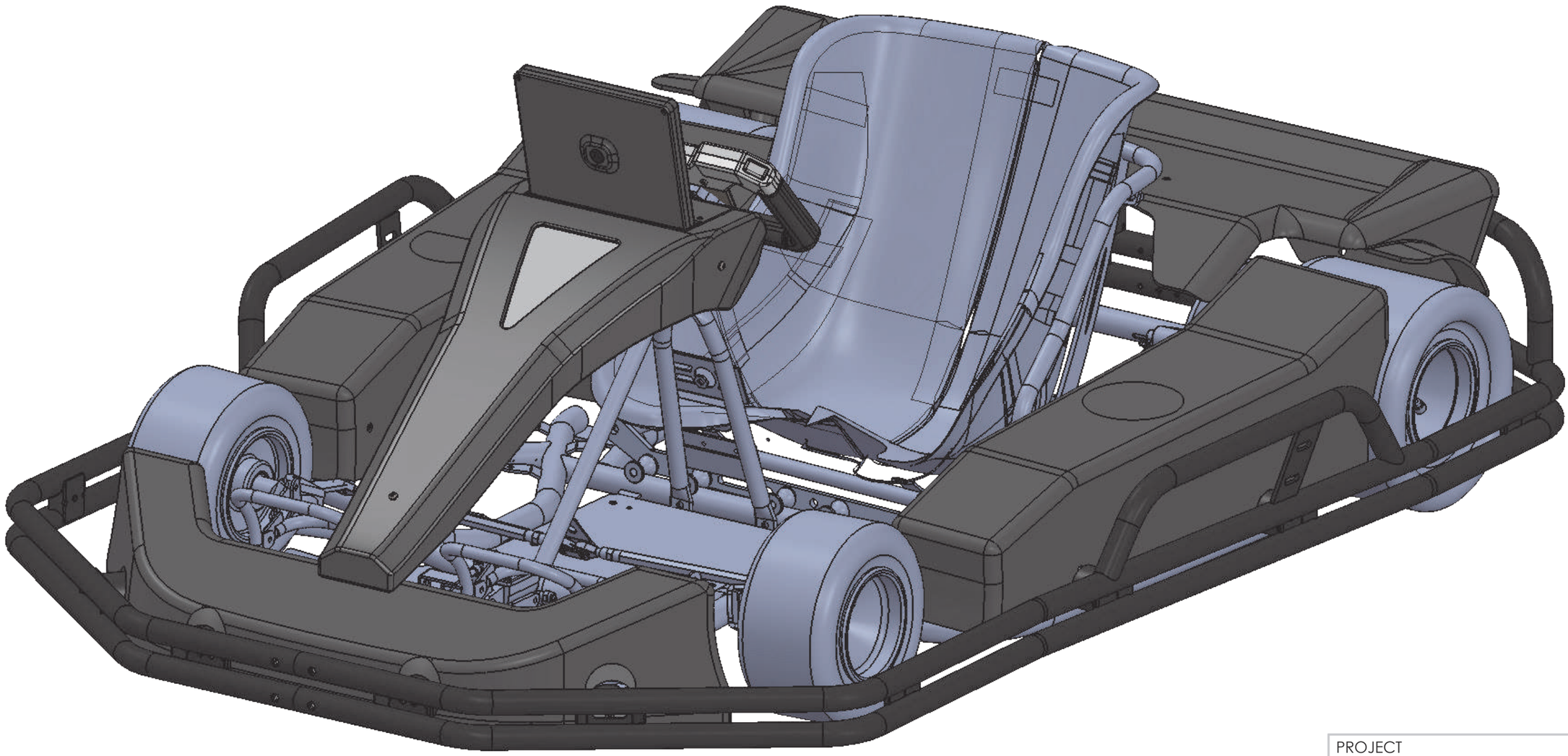
TABLE OF CONTENT



DRAWN BY	DATE	PROJECT	
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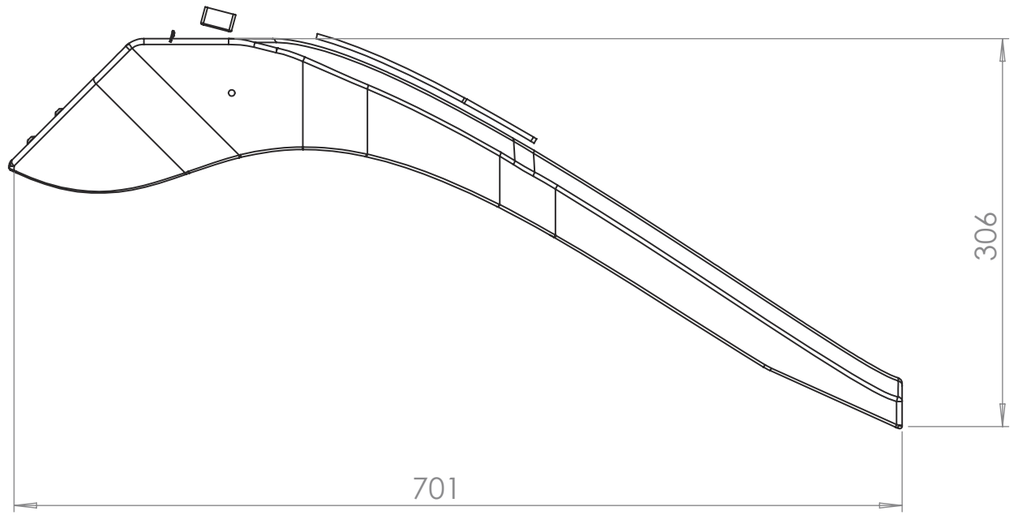
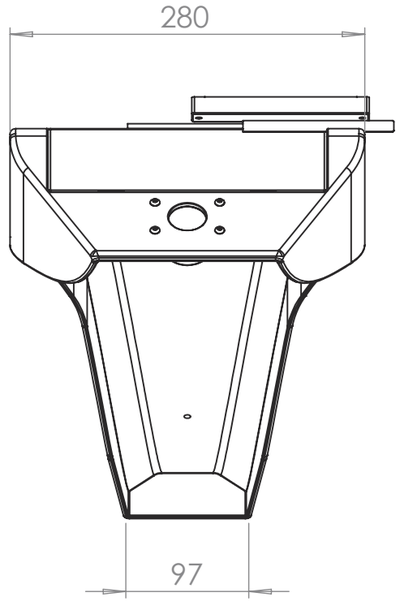
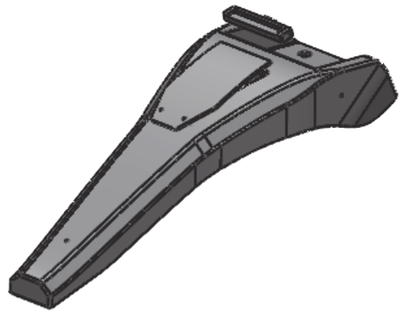
PRODUCTION		PART NAME Principle drawing	
MATERIALS		PART NO.	A3
TOLERANCES:		SCALE: 1:5	SHEET 1 OF 12







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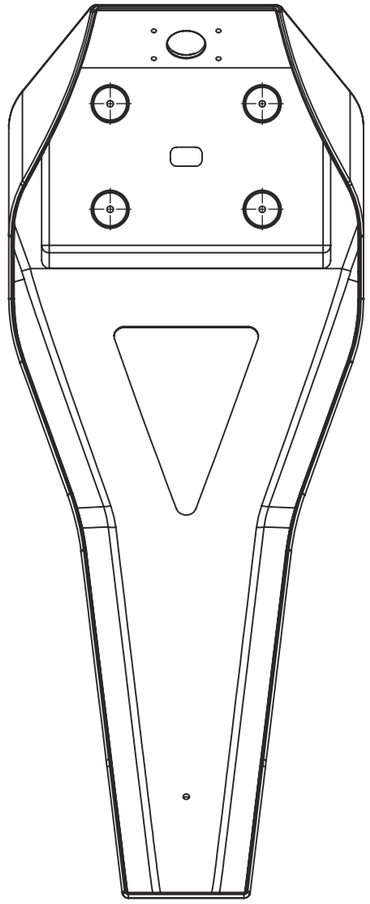

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PRODUCTION Vacuum formed		PART NAME Main drawing - front
MATERIALS PP		PART NO. A3
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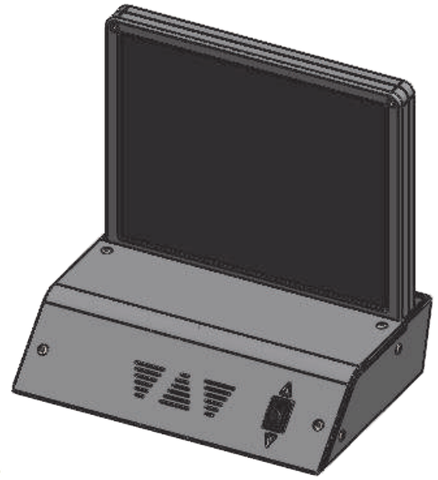

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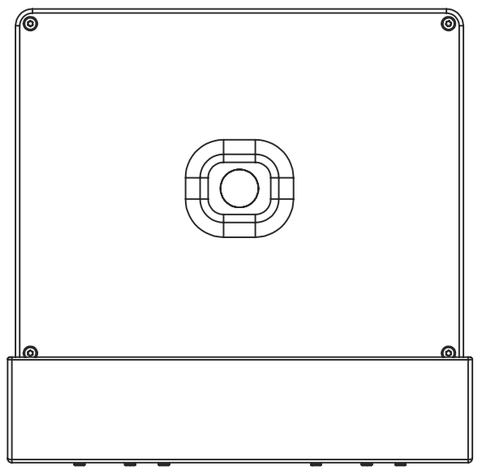

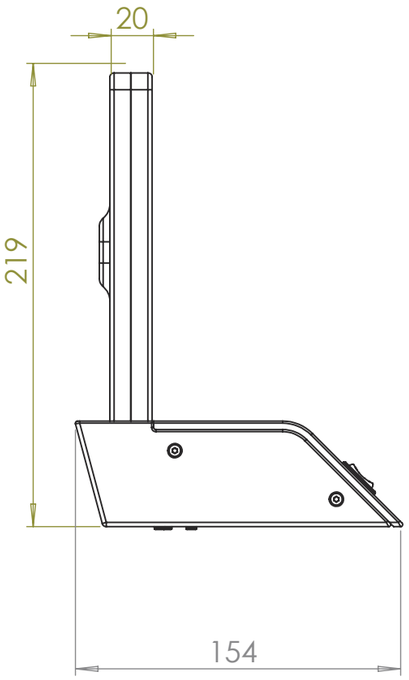

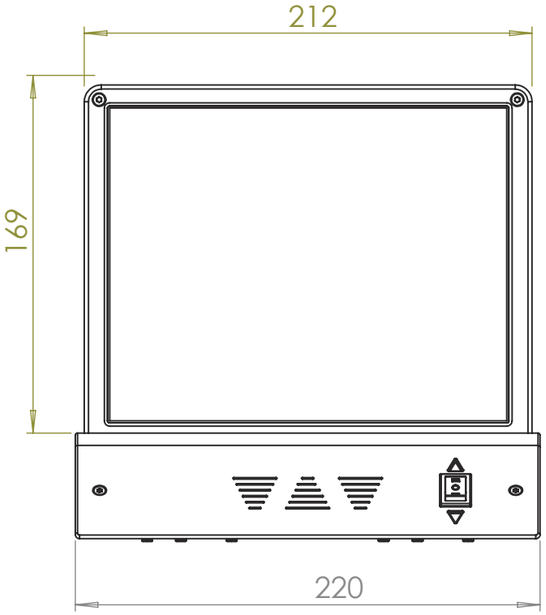

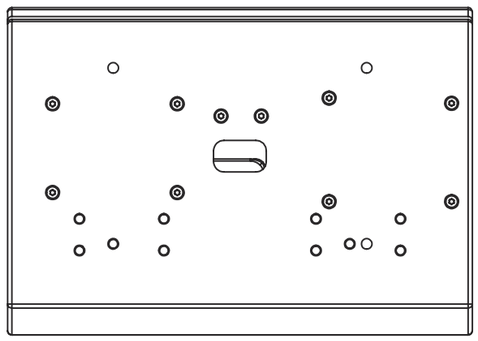

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Industrial Design, MSc04 Masters thesis	
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MATERIALS: PP	PART NO. / A3
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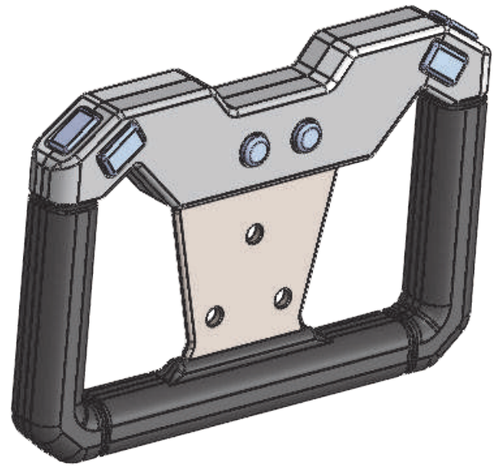

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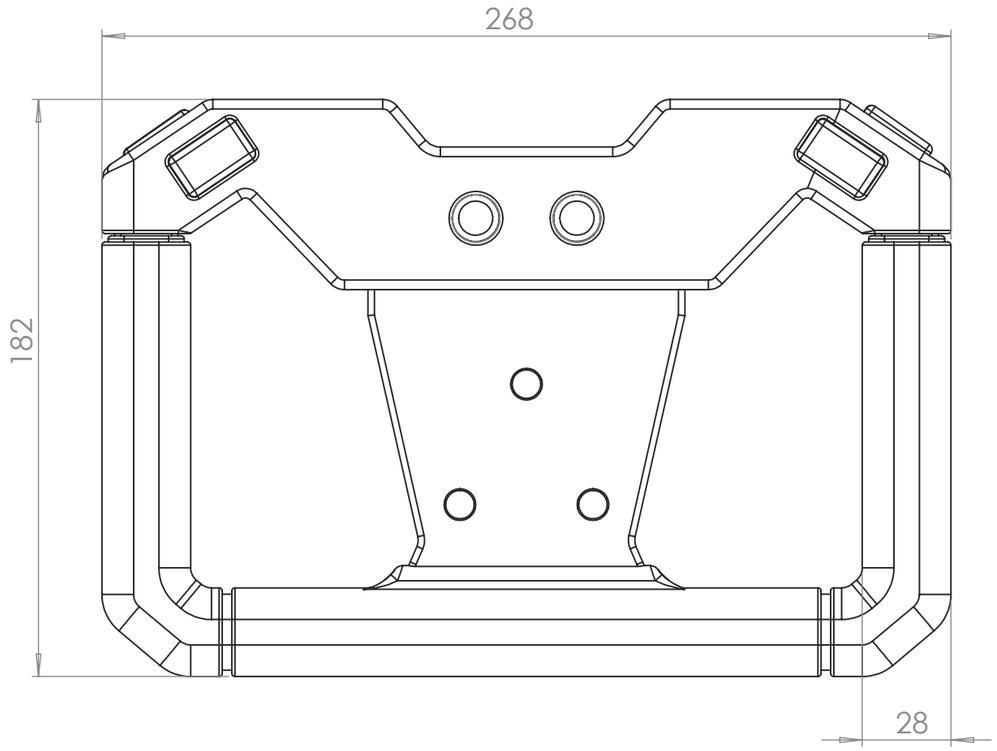
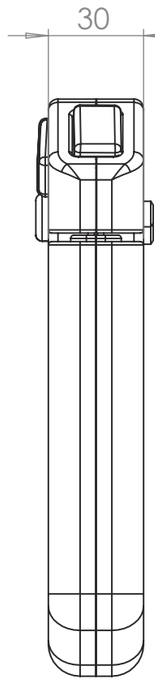




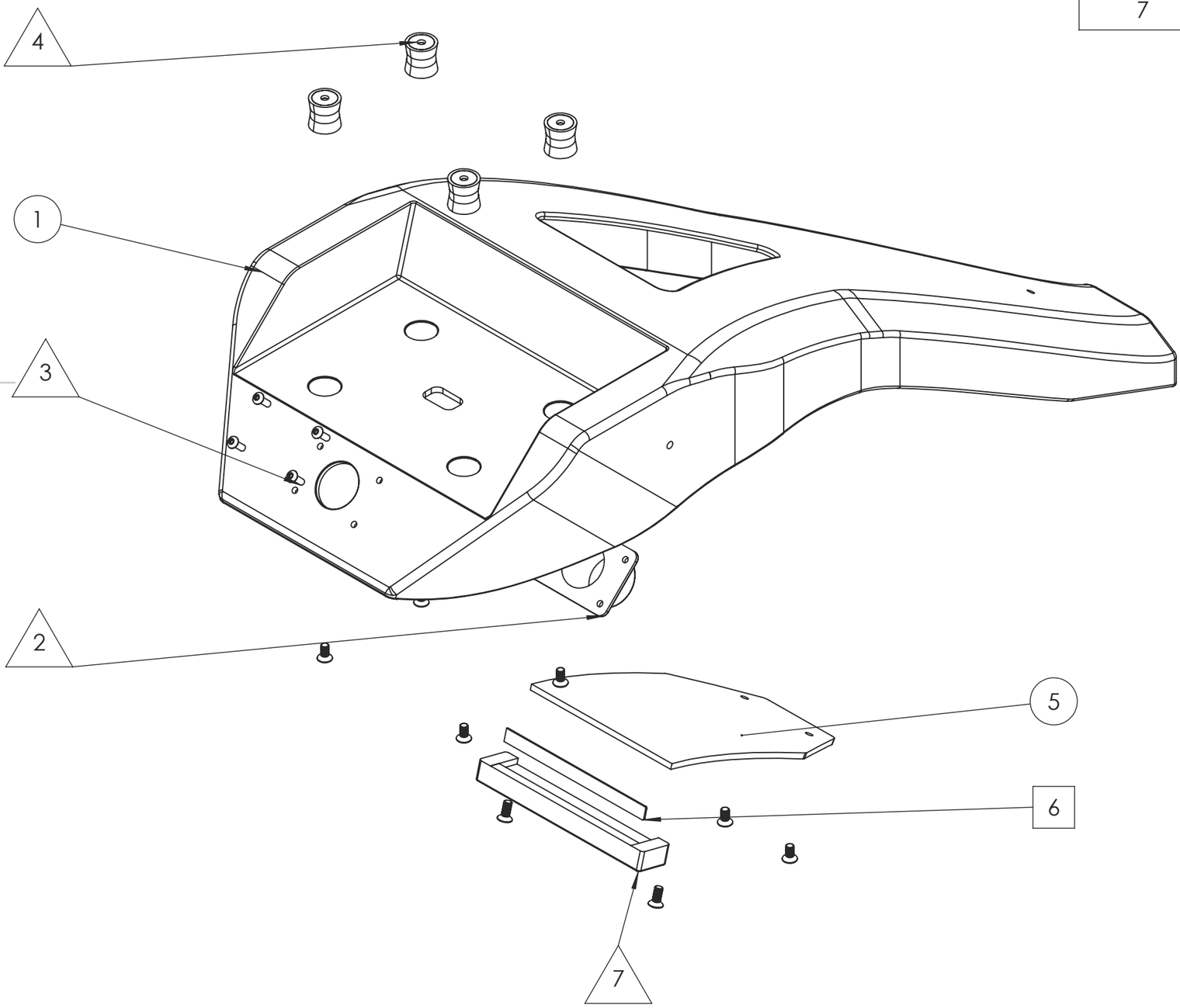
PROJECT	**ARacing**
DRAWN BY: MSc04, group 9	DATE: 26/05/23
	Industrial Design, MSc04 Masters thesis
PRODUCTION: Injection molding, laser cut	PART NAME: Main drawing - steering wheel
MATERIALS: PP, TPE, Stainless steel 304	PART NO. A3
TOLERANCES:	SCALE: 1:2 — SHEET 4 OF 12

STANDARD PART

CUSTOM PART

ELECTRONIC PART

ITEM NO.	PART NUMBER	MATERIALS & PRODUCTION	QTY.
1	Front	PP, vacuum formed	1
2	Steering rod support	Standard component	1
3	ISO 7380 - M4 x 12 - 12N	Standard component	12
4	Vibration Damper	Standard component	4
5	Transparent glass	PC, cut and bend	1
6	LED strip	Standard component	1
7	Mount for lightstrip	Standard component	1



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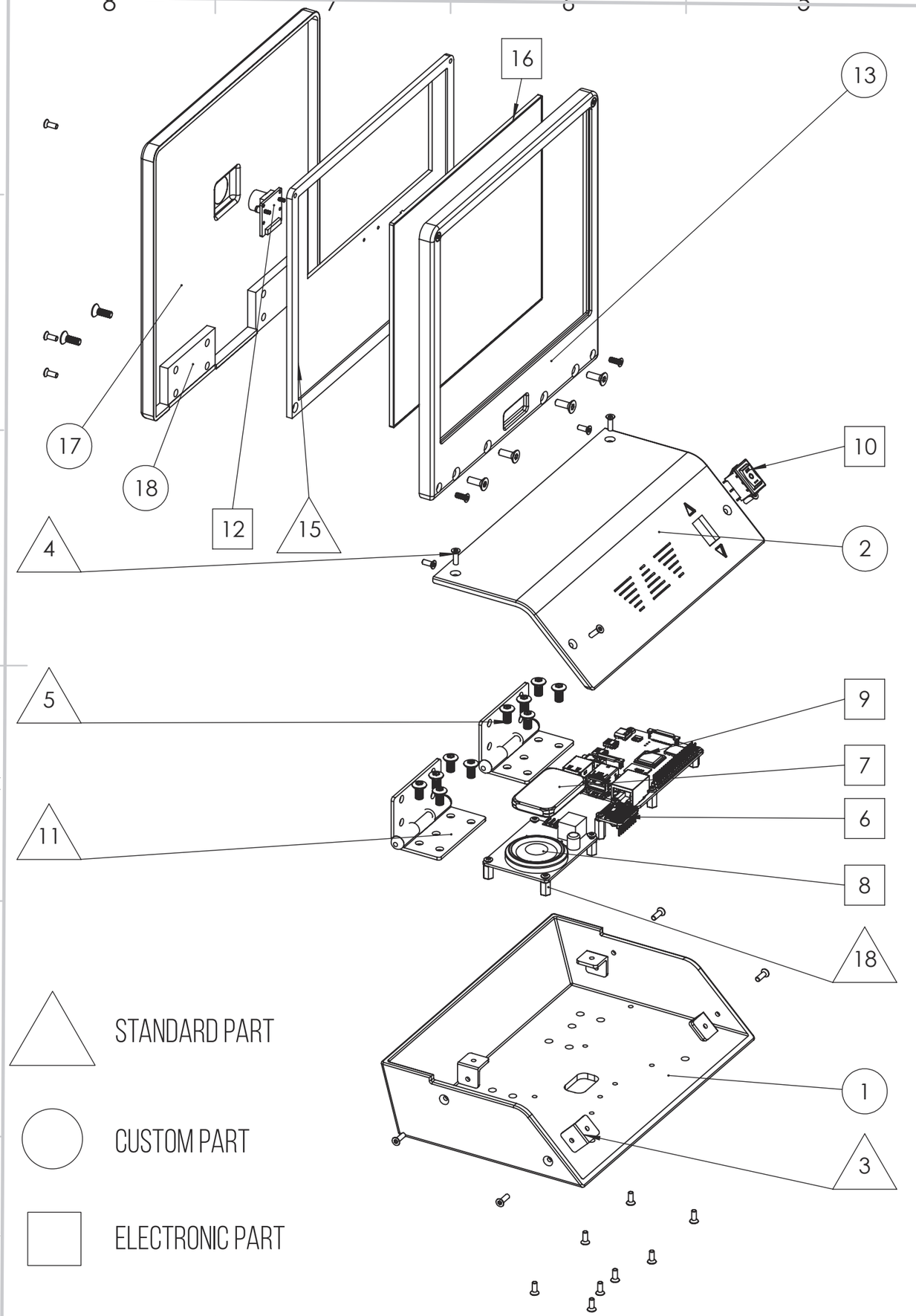
PROJECT: ARacing Industrial Design, MSc04 Masters thesis	
PRODUCTION: Vacuum forming, cut, bending	PART NAME: Exploded - Front
MATERIALS: PP, PC	PART NO.: A3
TOLERANCES:	SCALE: 1:3 / SHEET 5 OF 12



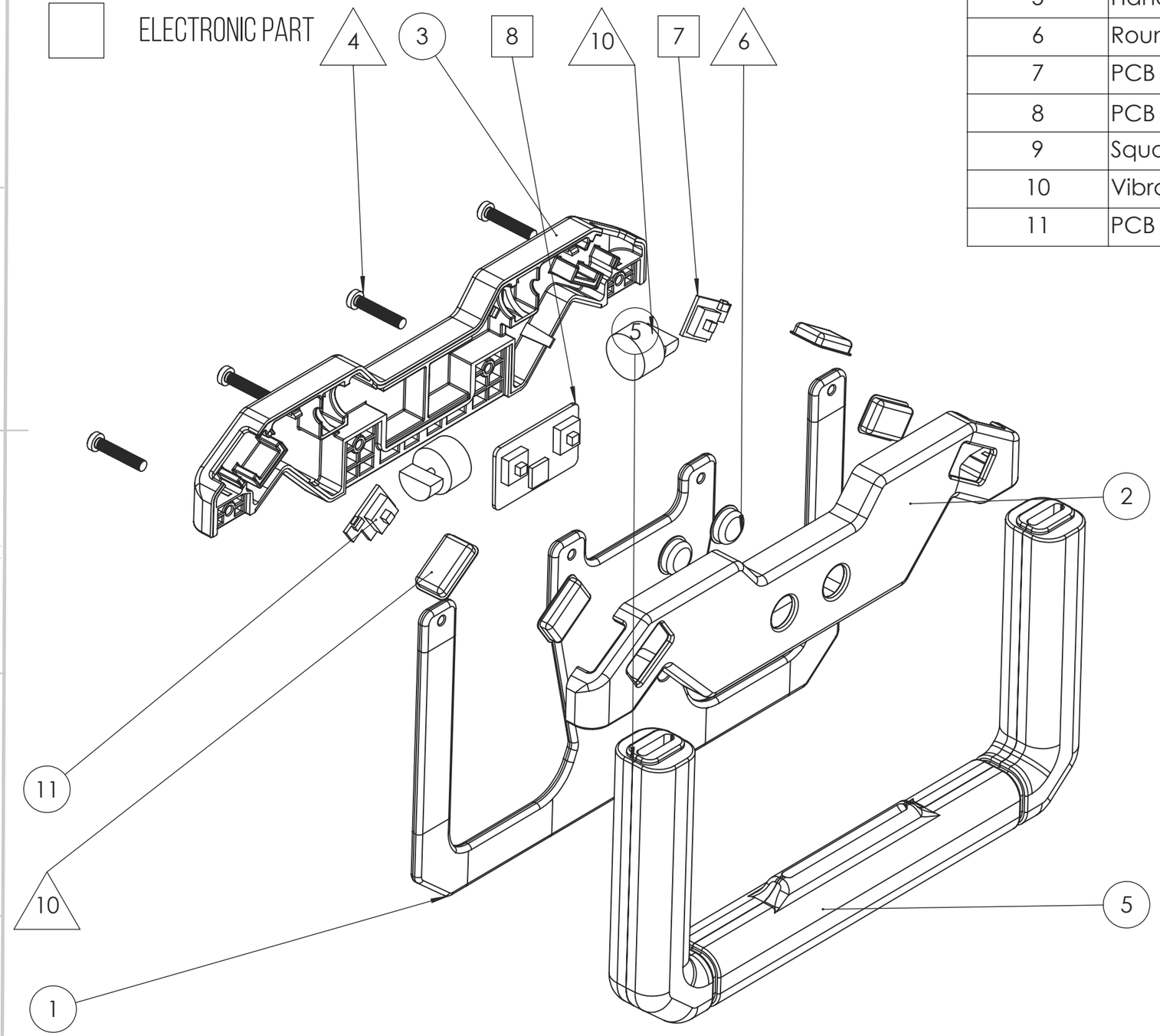
ITEM NO.	PART NUMBER	MATERIAL & PRODUCTION	QTY.
1	Box buttom	PP, vacuum formed	1
2	Box lid	PP, cut and bend	2
3	Angle bracket	Standard component	4
4	ISO 14581 M3x10x10-N	Standard component	45
5	ISO 14584 M5x10x10-S	Standard component	10
6	ADXL345 Digital Accelerometer	Standard component	1
7	Adaptador Wifi v3	Standard component	1
8	Amplified speaker for Raspberry PI	Standard component	1
9	Raspberry Pi 4 Model B	Standard component	1
10	Rocker Switch	Standard component	1
11	Hinge	Standard component	2
12	IMX477 Camera	Standard component	1
13	Front cabinet	PP, vacuum formed	1
14	Back support Screen	Standard component	1
15	LCD screen	Standard component	1
16	Back cabinet	PP, vacuum formed	1
17	Standoffs	Standard component	18
18	Standoffs box	Standard component	2

DRAWN BY: MSc04, group 9	DATE: 26/05/23
PROJECT: ARacing Industrial Design, MSc04 Masters thesis	
PRODUCTION: Vacuum forming, cut, bend	PART NAME: Exploded - box, screen
MATERIALS: PP	PART NO. / A3
TOLERANCES:	SCALE: 1:3 / SHEET 6 OF 12

STANDARD PART

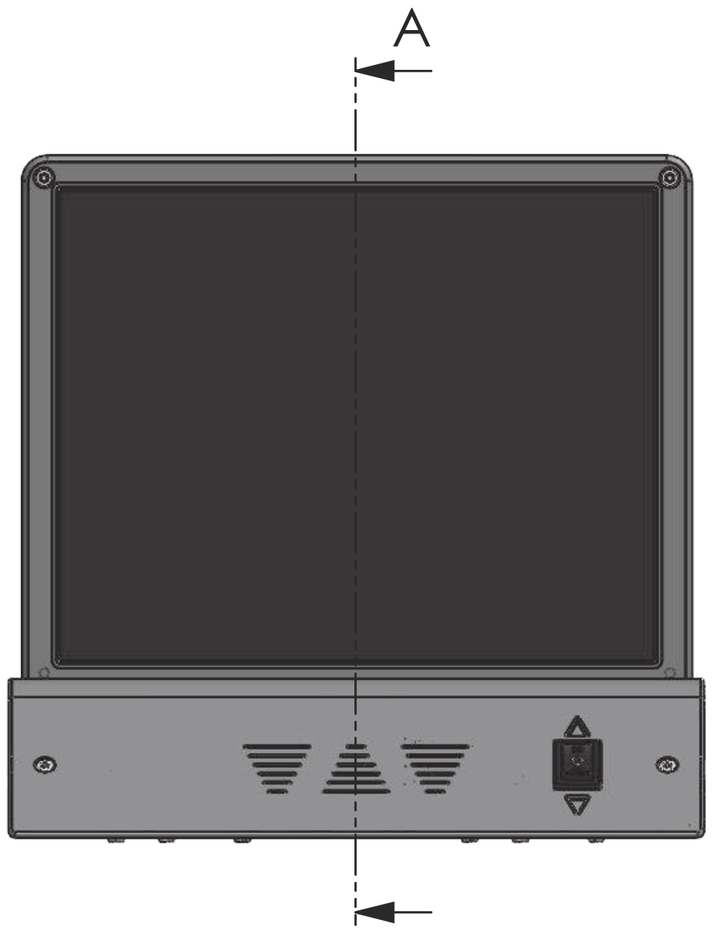
CUSTOM PART

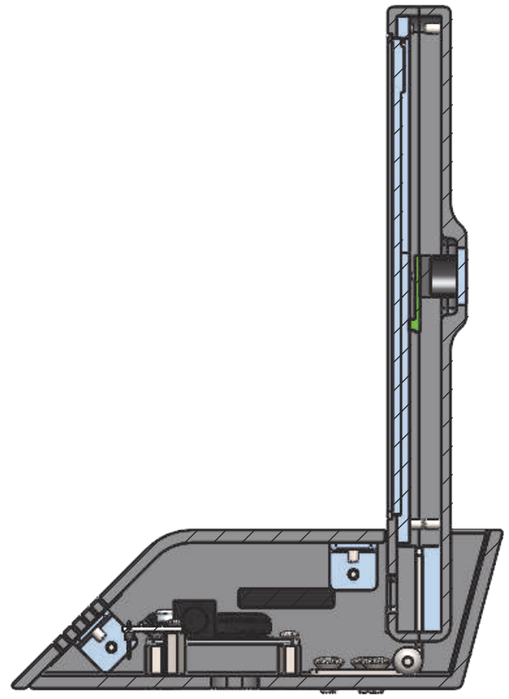
ELECTRONIC PART



ITEM NO.	PART NUMBER	MATERIAL & PRODUCTION	QTY.
1	Frame	Stainless steel 304, laser cut	1
2	Front shell	PP, injection molding	1
3	Back shell	PP, injection molding	1
4	ISO 14583 - M4 x 25 x 23.6 - 4.8-S	Standard component	4
5	Handle front and back	TPE, injection molding	2
6	Round buttons	Standard component	2
7	PCB with push button	24x18mm custom	1
8	PCB + microcontroller	51x30mm custom	1
9	Square button	Standard component	4
10	Vibration motor	Standard component	2
11	PCB with push button	24x18mm custom	1

DRAWN BY	DATE
MSc04, group 9	26/05/23
PROJECT	ARacing
	Industrial Design, MSc04 Masters thesis
PRODUCTION	Lasercut, injection molding
PART NAME	Exploded - Steering wheel
MATERIALS	TPE, PP, Stainless Steel 304
PART NO.	1
A3	
TOLERANCES:	
SCALE: 1:2	
SHEET 7 OF 12	





SECTION A-A

SCALE 1 : 2

PROJECT

ARacing

Industrial Design, MSc04
Masters thesis

DRAWN BY	DATE
MSc04, group 9	26/05/23

PRODUCTION

PART NAME

Section view - Box, screen

MATERIALS

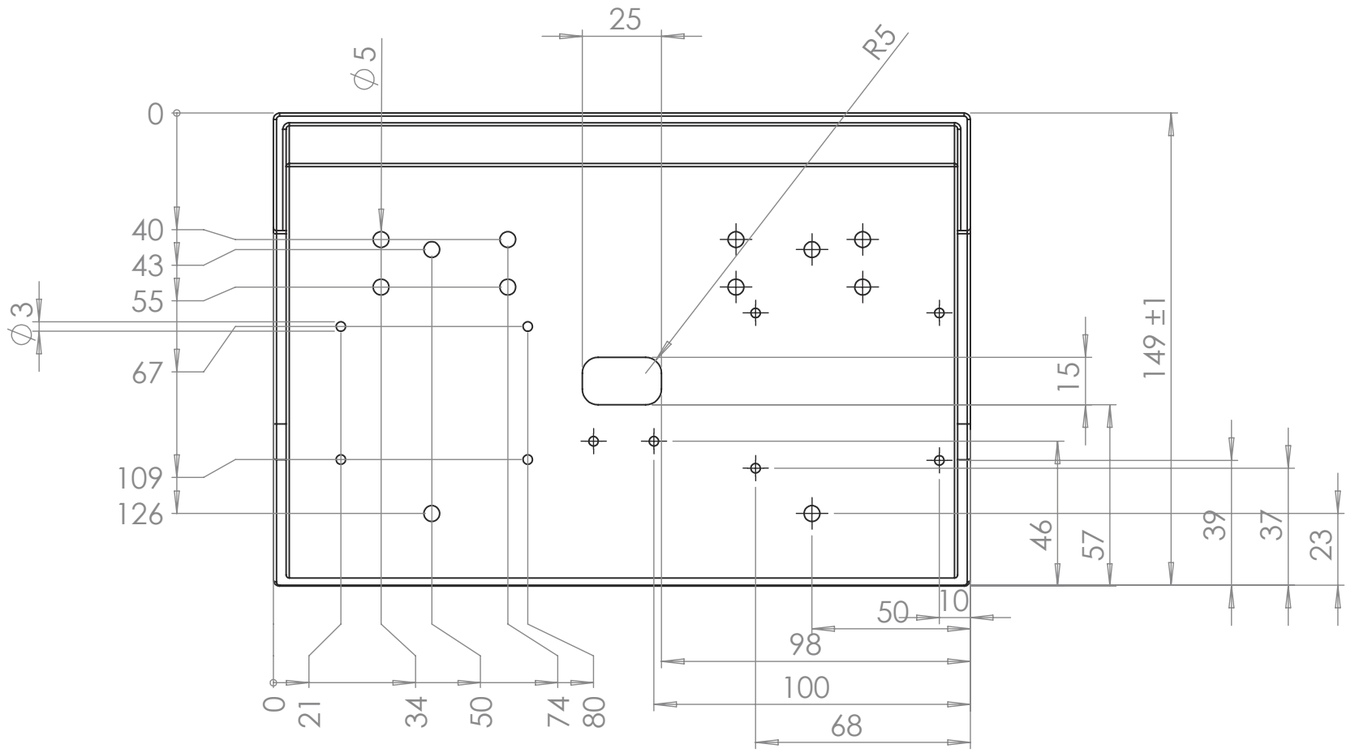
PART NO.

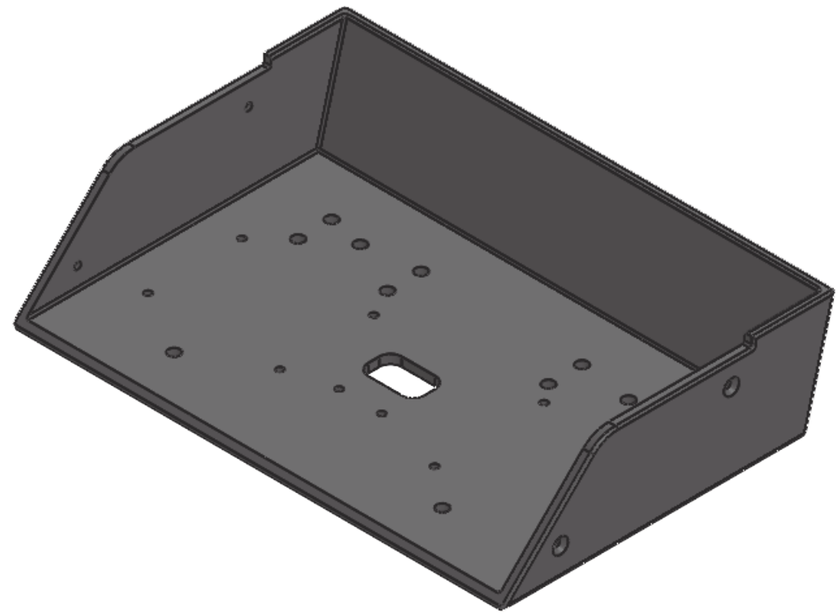
A3

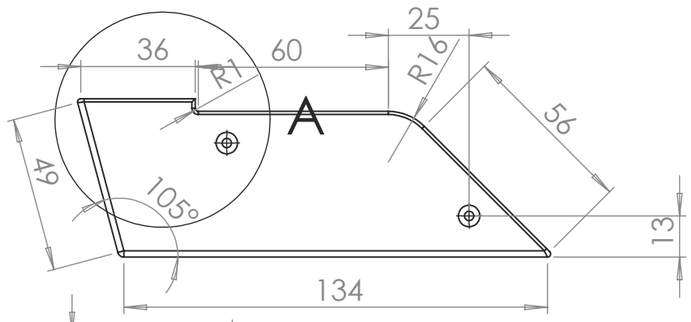
TOLERANCES:

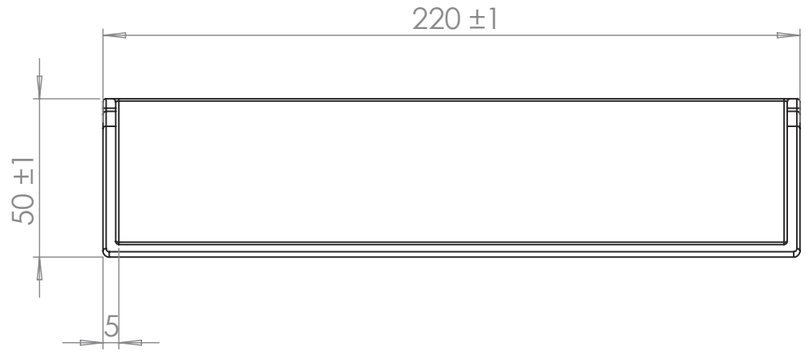
SCALE: 1:2

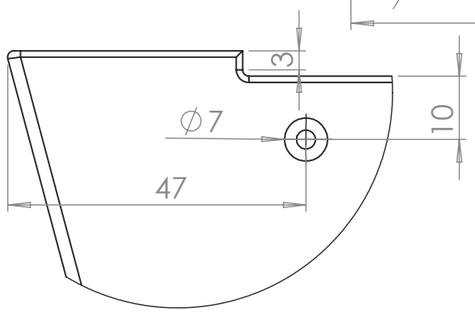
SHEET 8 OF 12







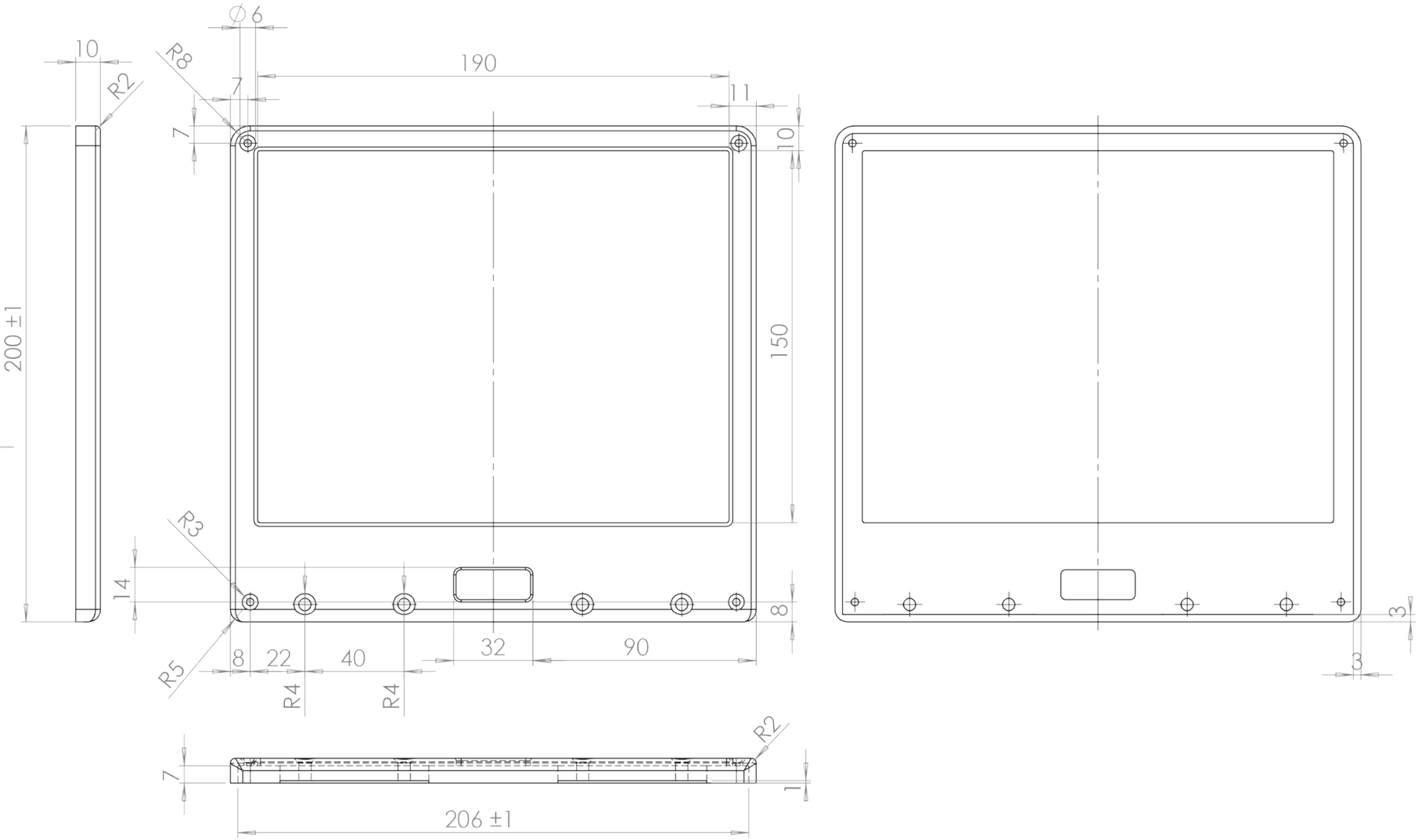




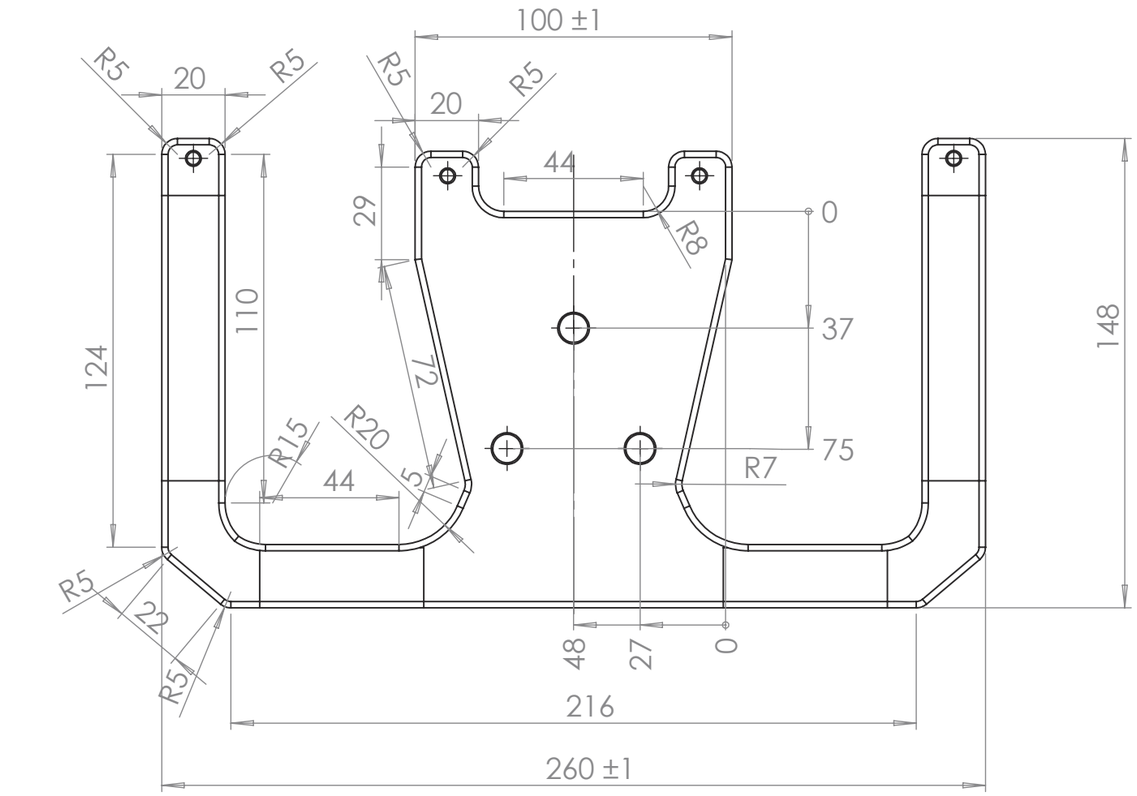
DETAIL A

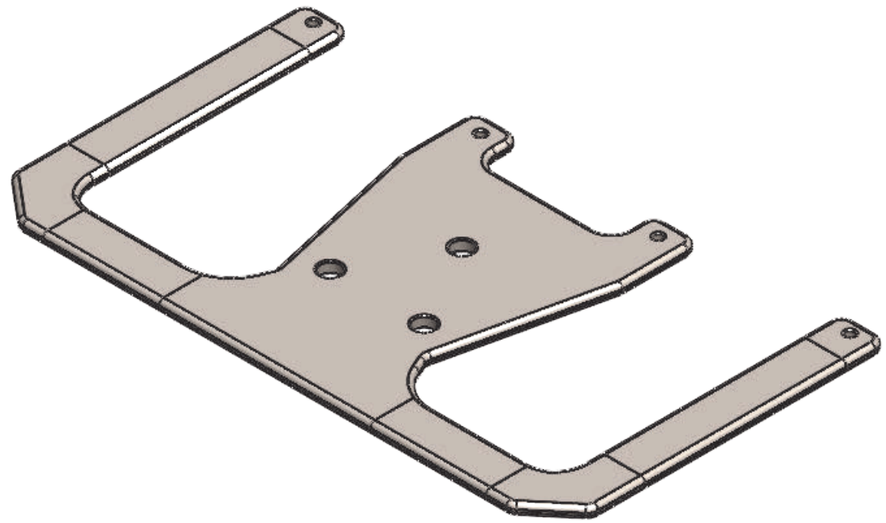
SCALE 1 : 1

DRAWN BY	DATE	PROJECT **ARacing** Industrial Design, MSc04 Masters thesis	
MSc04, group 9	26/05/23		
PRODUCTION Vacuum formed		PART NAME Box bottom	
MATERIALS PP		PART NO. 1	A3
TOLERANCES: DS/ISO 2768-1-m		SCALE: 1:2	SHEET 9 OF 12

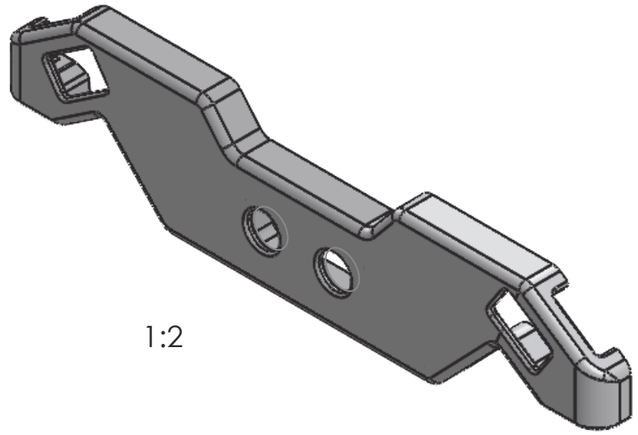


PROJECT	**ARacing**
	Industrial Design, MSc04 Masters thesis
DRAWN BY: MSc04, group 9	DATE: 26/05/23
PRODUCTION: Vacuum formed	PART NAME: Front cabinet
MATERIALS: PP	PART NO.: 13 — A3
TOLERANCES:DS/ISO 2768-1-c	SCALE: 1:2 — SHEET 10 OF 12





DRAWN BY: MSc04, group 9	DATE: 26/05/23	PROJECT: **ARacing** Industrial Design, MSc04 Masters thesis
PRODUCTION: Laser cutting		PART NAME: Frame
MATERIALS: Stainless Steel 304		PART NO.: 1 — A3
TOLERANCES: DS/ISO 2768-1-m		SCALE: 1:2 — SHEET 11 OF 12



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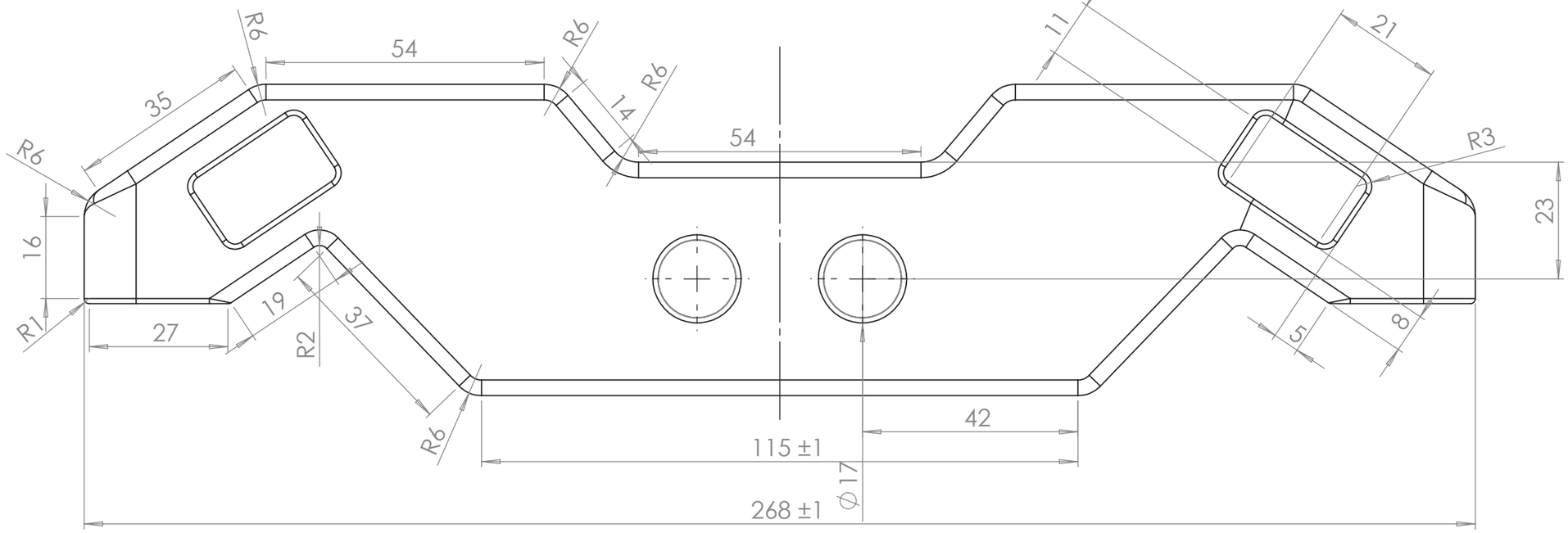
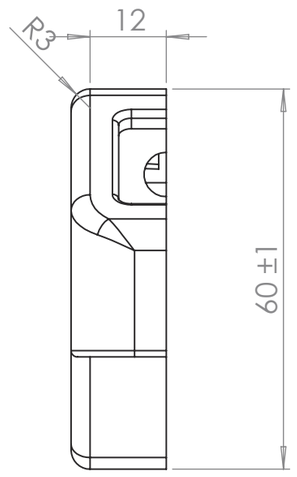
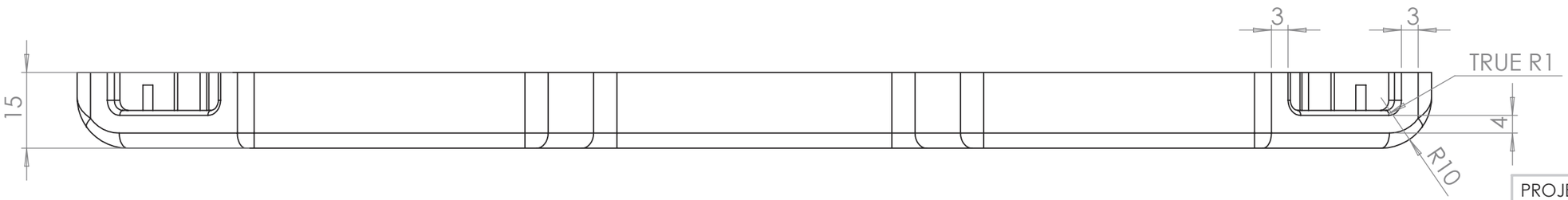


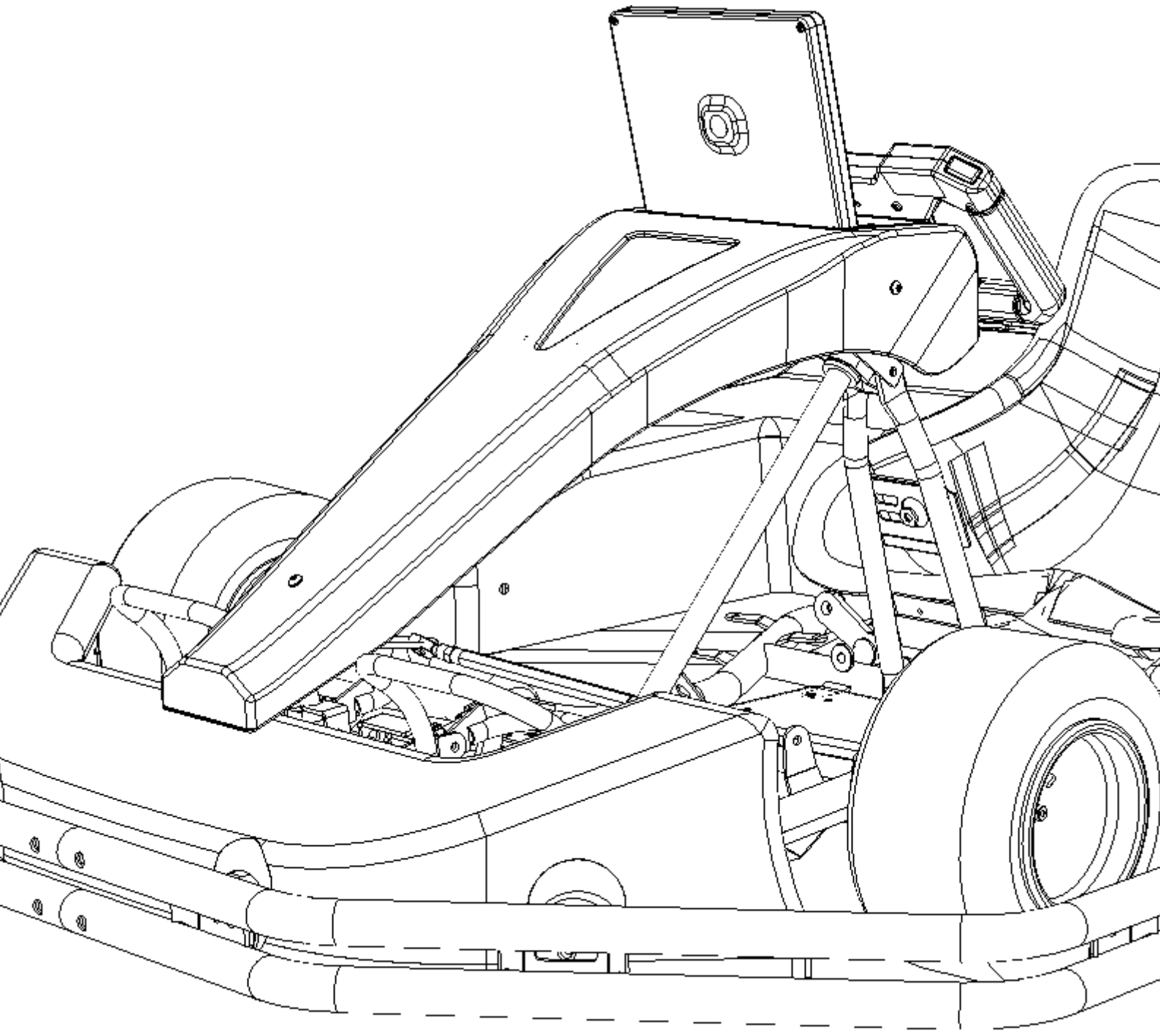




PROJECT	**ARacing**
	Industrial Design, MSc04 Masters thesis
DRAWN BY: MSc04, group 9	DATE: 26/05/23
PRODUCTION: Injection molding	PART NAME: Front shell steering wheel
MATERIALS: PP	PART NO.: 2 — A3
TOLERANCES: DS/ISO 2768-1-m	SCALE: 1:1 — SHEET 12 OF 12

ARacing

Process report



Aalborg University | May 2023 | MSc04 - ID9
Caroline Fromsejer Nøkleby, Frederik Holm Sørensen & Lasse Tøt

TITLE PAGE

Title	ARacing
Theme	The experience of go-karting
Project	Master's thesis
University	Aalborg University
Education	Industrial Design
Report type	Process Report
Project team	MSc04 - ID9
Project period	01.02.2023 - 30.05.2023
Main supervisor	Linda Nhu Laursen
Co-supervisor	Jørgen Asbøll Kepler
Pages	100, excl. front and back page
Appendix	111 pages

THE DESIGN TEAM

FREDERIK HOLM SØRENSEN CAROLINE FROMSEJER NØKLEBY LASSE TØT

ABSTRACT

This process report was developed by three graduate students as part of a master's thesis in the education of Industrial Design at Aalborg University. The report describes the iterative process toward designing a new experience within the electric rental go-kart area. The project deals with the problem of go-karting being a rarely visited activity within the segment of young people, with most stating they had only tried it once in their lives. Here, due to it being based on an experience most fitting for people having an interest in racing, hence its focus lies on individual performance and the singular goal of getting the fastest lap time.

In conjunction with the go-kart brand DINO Kart and through research, field studies, and various testing within the target group, the solution, ARacing, was created. ARacing is an interactive gaming solution system for electric rental go-karts based on augmented reality technology providing a new immersive go-kart activity emphasizing team play and a unique driving experience. ARacing is a three-part solution consisting of a redesigned front part, with an integrated display and camera, and a redesigned steering wheel accommodating the interactive activity. While driving, a videogame emerges through the display, combining the real and digital world, creating an exciting track layout varying from lap to lap.

ACKNOWLEDGEMENTS

On behalf of the project group, a big thank you to all the people who helped throughout the process contributing to the discovery of essential insights and making it possible to create this project.

A big thank you to the main supervisor Linda Nhu Laursen and co-supervisor, Jørgen Asbøll Kepler, for valuable guidance that pushed the project in the right direction and for supporting the team throughout the semester.

Secondly, a big thank you to Rasmus Nørgaard from DINO Kart, who has been of great help during the project providing valuable information and a deeper look into the world of go-karting. Furthermore, thank you to DINO Kart for renting out one of their go-karts which have been essential in developing our solution.

READING GUIDE

This project consists of four overall parts: Primarily a Product report and a Process report, which is recommended to be read in this order, with the addition of Technical drawings and an Appendix. The process report is structured into nine overall phases describing the different aspects of the project. Every phase starts with a short introduction and ends with a sum-up highlighting important insights and requirements.

Throughout the report, references have been made to the appendix by (App. XX), which presents an elaborated describing and showing on various research and tests. The Harvard method was used for referencing; a complete reference list can be found at the back of the report.

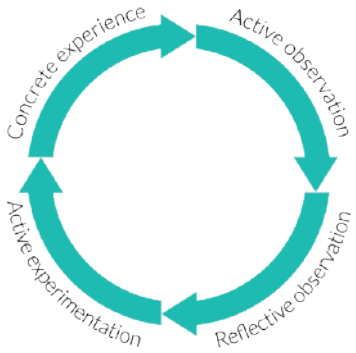
Throughout the report, the following icons will appear:

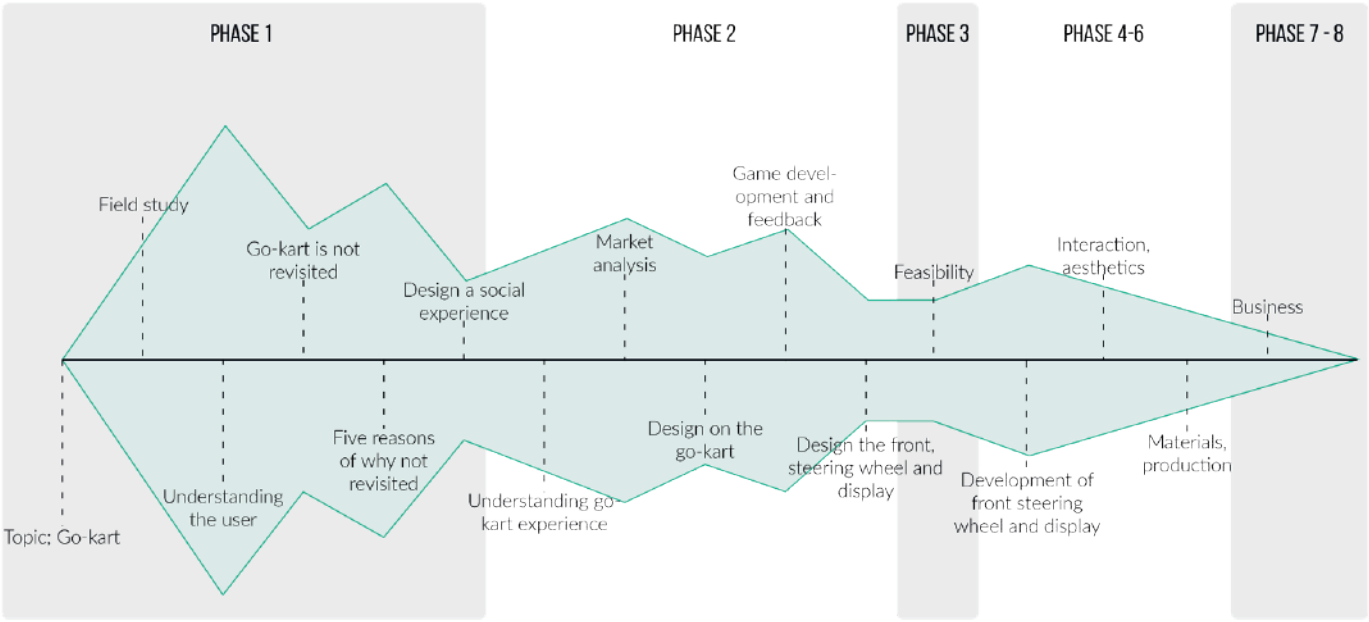
- Describing an important insight and observation
- Describing a requirement
- Describing something to be aware of
- Describing a wish

PROCESS TIMELINE

The Double Diamond (Dubberly, 2004) has been used to illustrate the overall process of the project as it has consisted of converging and diverging phases. The illustration presents important milestones throughout the process.

Throughout the process, Kolb's Learning Cycle (Kolb, 1984) have been the overall approach used when testing hence discovering new things leading to new understandings.





Ill. 1 - Process timeline

CHOICE OF TOPIC

The project started based on a shared interest in motorsport, hereunder the genre of Formula 1. It was seen as an interesting topic to look into, but a less comprehensible topic was needed due to the challenges regarding finding users, testing in proper conditions, and Formula 1 is a complex area. The go-karting area was looked more into, as this was a far more comprehensible topic due to it being more accessible within Denmark, allowing for field studies and easier testing with users. Therefore, the initial idea was to investigate the market of go-karting, trying to find a feasible problem to base the project on.

INTRODUCTION

Rental go-karting is a commonly known activity that can serve as the revolving focus of the day when doing a social event with friends or families. But, as a group, it can be hard to persuade everybody to join in on it, as it is very focused on the aspects of racing and individual performance, not falling into the taste of everybody. Hence, go-karting is rarely revisited, especially by younger people, as they do not find it fun to try out in a group.

The current rental go-kart market is up for a change due to current petrol-driven go-karts being made illegal as a part of the green transition within the vehicle segment. As of this, electric-driven go-karts are gaining momentum, changing how the activity of go-karting is experienced.

This thesis aims to follow along with this new transition, creating a new experience to be used on electric rental go-karts to enhance the current activity. The new experience is for younger people tagging into their preferences, making the activity more likely to be revisited.

Ill. 2 Motorsport Nordjylland

TABLE OF CONTENT

01 FRAMING

In the following phase, the project is started through a series of field studies investigating the different areas of go-karting. The findings and understanding of these areas through observations, interviews, and desktop research lead to the overall framing of the project, by describing the target group, context, and the initial problem area. The phase results in an initial design brief serving as the foundation for the ongoing process throughout the project.

Ill. 3 - Power Racing

UNDERSTANDING THE CONTEXT

In the initial phase of the project, the goal was to gain a comprehensive understanding of the various areas and facets of go-karting. Here with the intention of discovering problem areas that could serve as the main topic for this project. Through desktop research, go-karting could be divided into the areas of racing, rental, and manufacturing. Several relevant people were contacted to gain insight into these areas, and visits to race tracks, rental centers, and a go-kart manufacturer were arranged. (App. 1-5)

The following chapter presents these field studies thematically and highlights important insights, quotes, and problems gained through semi-structured interviews (Kvale, 1996) with persons on site. The chapter ends in a conclusion highlighting the key takeouts, and a reflection upon opportunities within the different areas highlighting topics that need further investigation. (App. 6)

OBS

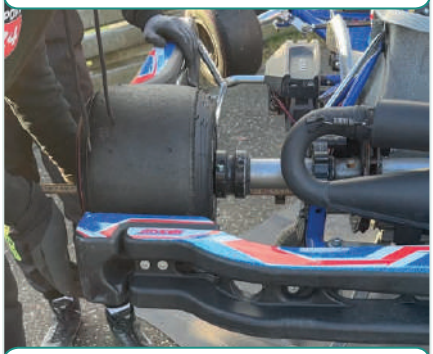
Racing: The area related to professionals competing in official tournaments.
Rental: The area related to amateurs driving for the sake of fun and amusement.

THE RACING MARKET

VIBORG MOTORSPORTS KLUB

Viborg motorspots klub is the smallest racing track in Denmark, where all ages can come and race. At this track are there drivers who both drive professionally while others do it as a hobby. (App. 1)

Tires are changed every 1-2 weeks



Adjustments - Depends on the weather conditions

Cleaning and maintenance is an important and time consuming factor

They use DIY solutions for storage and transport

Gadgets are used on track, to get information on laptime, speed, etc.

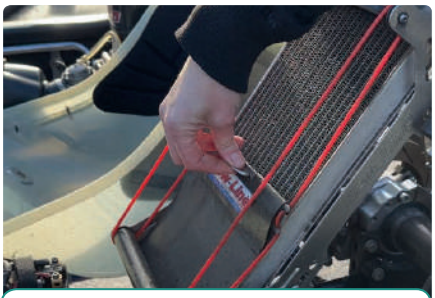
Ill. 4 - Viborg motorsports klub

MOTORSPORT NORDJYLLAND

Motorsport Nordjylland is a racing track where both professional racers and hobbyists come to drive go-kart. They are also hosting several competitions for their members and outside racers. (App. 2)

Bumpers are used in several forms and materials to protect the chassis

Weight adjustments is done using lead, by attaching it to the seat



The motor needs different cooling settings throughout the race

Ill. 5 - Motorsport Nordjylland

ISABELLA & MICHAEL

- Isabella trains once a week
- Competes in races
- Michael is father to Isabella. Help setup and adjust the go-kart

JACOB & SØREN

- Jacob is a professional driver and competes in races
- Søren father to Jacob, always there to help out doing training and racing

ALEX

- Alex is a professional driver and competed in VM in France 2022
- Train several times a week
- Chairman of the go-kart department of Motorspot Nordjylland

THE RENTAL MARKET

GOKART WORLD

Gokart World is a rental go-kart center located south of Aalborg. It stores 12 go-karts where friends and family can try go-karting on a 400m long track. (App. 3)

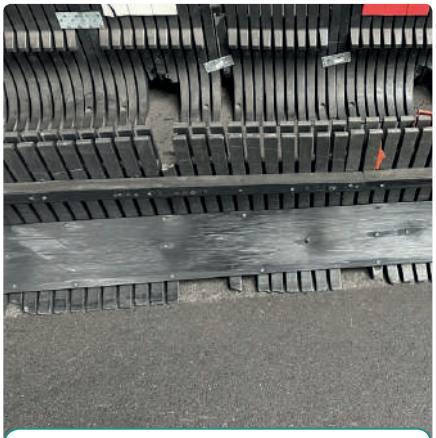
ALLAN

- Owner of Gokart World, Svendstrup

"It is often inexperienced drivers, so I design the track based on the expectation of them crashing" (There is enough space to brake before hitting the barrier if you have too much speed into the corner)

"It is usually groups and events like bachelor parties that visit"

The adjusted pedal somestimes get pushed down after a crash, making the driver unable to reach the pedal



Barriers - Uses home-made solutions to make the barriers fit his needs

- Mostly groups of young people or events visit Gokart World
- It is difficult and expensive to change track layout
- A race takes between 10-15 minutes
- The goal of the activity is the fastest lap time

Ill. 6 - Gokart World

ACTION HOUSE

Action House is a rental go-kart center located in Løkken which allows families to try one of the biggest go-kart tracks in the world of 1.1 km where 30 go-karts can be driven at once. It houses other activities such as bowling, lasergame etc. (App. 4)

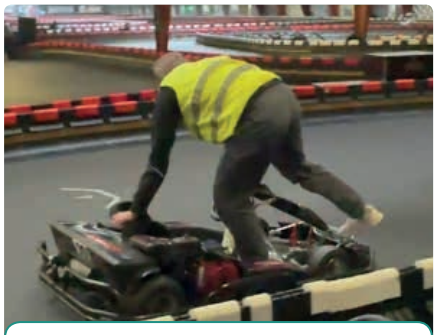
KARSTEN

- Owner of Action House, Løkken

"The most important aspect is the safety of the drivers"

"We want to generate the best experience for the customers [...] The track are design so they never reach top speed and can therefore always feel the acceleration"

"Entertain with the least amount of speed"



The instructor keep track of the drivers, prepare for next race, help drivers stuck on track, etc

- The go-karts are replaced after 2 years
- It is normally groups between 4-12 people who go gokarting
- A lot of age groups tries gokarting

Ill. 7 - Action House

MANUFACTORER

DINO KART

DINO Kart is the only danish manufacturer of rental go-karts located in Auning. They have over 60 years of experience selling and producing go-karts in their in-house production of go-karts and other parts. (App. 5)

The labels for the go-karts are custom made for the buyer

Ill. 8 - DINO Kart

RASMUS

- Engineer and developer at Dino Kart

"There is an increase of interest in electric-driven go-karts, especially in the US. The interest will also increase in other countries due to the ban of the petrol driven engines"

"I read that more woman want to try go-karts if they are electric driven, i think it is because the do not like the noise and smell from the go-karts"

- Their different go-karts are based on the same platform
- They produce 200 go-karts a year
- The buyers normally order in packs of 12-30 go-karts at a time
- They are developing their first electric go-kart
- Petrol-driven go-karts are soon getting banned in several countries

Following the field studies, it became clear the the area of go-kart persist of a lot of different problems areas, that could be investigated further. Furthermore it became clear that within the area there are a lot of different target groups, each with their own needs and demands.

In order to narrow down the problem area, all problems and insights were mapped and analysed based on the criterias of potential, fitting for a design project, and own interest. Within the area of racing, many of the highlighted problems were in the area of optimization where the solution was very dependent on the individual driver. Furthermore a lot of these problems were seen as not fitting this project due to them being too small and/or having none to little potential regarding design changes and market implementation (App. 6). Based on this the **area of racing is excluded and will not be investigated further.**

Rasmus from DINO Kart pointed out the situation in which electric go-karts are gaining momentum in the future due to multiple countries illegalizing the use of combustion engines hence making it illegal for rental centers to use petrol driven go-karts. He himself saw it as quite interesting situation as the demand for them was increasing, which resulted in that they at DINO Kart were in the developing phase towards creating an electric rental gokart.

Due to market potential and own interest, the area within electric rental go-karting will be the initial focus area and will be investigated further in the upcoming chapter.

Based on the conclusion more knowledge is needed in order to narrow down the scope of electric rental go-karting hence following questions are raised.

- **What does the segment of rental go-karting look like?**
- **What is the future of rental go-karting?**
- **Who is the target group?**

RENTAL GO-KARTING

The rental go-kart market is a globally well known activity with rental centers all around the world. Driving rental go-karts is possible from the age of 7 and with a minimum height of 120 cm (Action House). The rental market is the most common in the area of go-karting with its share of 60% of the market. To this, the market is in an annual growth as the forecasted CAGR from the period 2022 to 2029 is 4.14% (MMR, 2023). Rental gokarting is driven both indoor and outdoor with the majority of rental centers having tracks being located indoor. In Denmark alone, 20 rental centers are located with a slight majority being indoor centres. The sizes of the tracks within the rental centres can vary a lot, with length ranging from 300 meters and all the way up to 1250 meters. (App. 3-4)

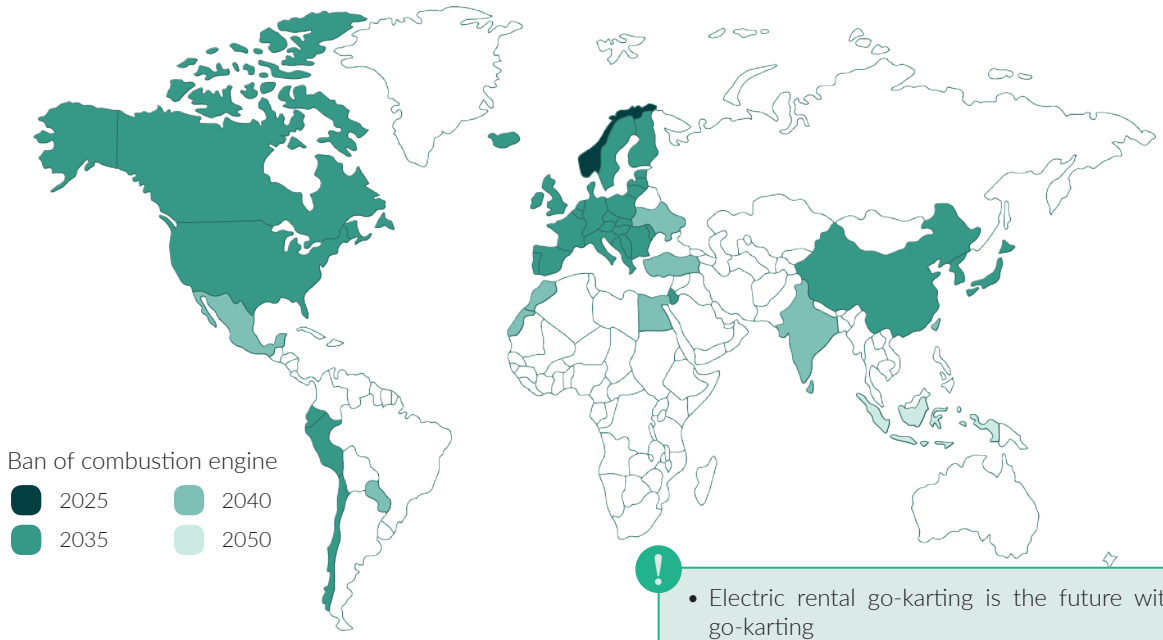
Ill. 9 - Rental go-karting

- Rental go-karting is the dominant market within the area of go-karting
- Rental go-karting can be driven from the age of 7 and a height of 120 cm
- Rental go-karting is most commonly driven indoor
- Rental go-kart tracks can vary from 300-1250 meters in length

THE FUTURE OF RENTAL GO-KARTING

Go-karting, like other areas within the vehicle segment, is facing tighter emmision restrictions as UN has set the goals of reducing emission by 45% by 2030 and reaching net-zero by 2050 (United Nations, n.d.). The likes of the US and great parts of Europe are taking actions upon this and has set goals to ban the sales of combustion engines within vehicles in the nearest future, with a county like Norway having set the goal of banning the sales om combustion engines as soon as 2025 (Southwell, 2022) (Wikipedia, 2023). As a response, multiple go-kart manufactures have been developing electric go-karts, and are already selling them, as a response to their petrol driven go-karts being unsaleable in the future.

As told by Rasmus from DINO Kart, and Karsten from Action House, a lot of advantages comes with having an electric go-kart, with them being the higher torque/acceleration and no need for having ventilated halls due to no emissions from the go-karts. Using an electric motor would too result in heavily reduced engine noise and totally remove the smell of gasoline. (App. 4-5)

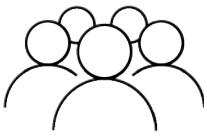


Ill. 10 - Ban of combustion engine

- Electric rental go-karting is the future within rental go-karting

STAKEHOLDERS

Within the market of rental go-karting the main stakeholders can be summed into the target groups of, rental center guests, rental center owners and go-kart manufactures.

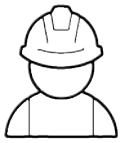


Ill. 11 - Guest

The rental center guests are the ones who are using the facilities within the go-kart centre. The clientele can vary alot based on age, gender, and usertype, with the most common usertypes being families or groups of friends (App. 7). The reasons for trying rental go-karting is often in relation to an event, such as birthdays and company events or just as a social event between friends and/or families, to spent time together.

Ill. 12 - Owner

The rental center owner is usually the one taking care of most of the tasks needed to run a rental go-kart business. They are the ones buying, preparing and maintaining the go-karts, instructs and guides the drivers, oversees the race, and takes care of the track. The owners designs the layouts of the tracks to make it as entertaining and challenging as possible in regards to safety and with the space given. Within bigger centres, usually more personnel is present to help out with the big amount of gokarts and guests and maintaining the bigger track.



Ill. 13 - Manufacturer

The manufacturer of go-karts is the one developing and manufacturing the go-kart used in rental centres. When developing, their main focus points are safety and entertainment, so that they can fulfill EU-regulations and be enjoyable by the users.

SCOPING

This chapter serves as a summarization of prior chapters with the intention of scoping the project to a more comprehensible size by presenting the overall thematic of the project, the context and the chosen target group.

INDOOR RENTAL CENTERS

Based on potential and feasiliblity, the market of rental indoor go-karting is chosen as the context, as it is the most common in the rental-segment.

ELECTRIC RENTAL GO-KARTS

The theme of outphasing petrol driving go-karts and replacing them with electric go-karts seemed for the group as an interesting topic, and as an area with a lot of market potential and different areas to look into. The electric rental go-karts is chosen as the initial theme for the project.

A GROUP OF YOUNG FRIENDS

Based on observations and interviews it became clear that the owners and the go-kart manufacturers are both dependent on guests visiting the rental centers and trying the go-karts. Furthermore it seemed as the target group in which most change could be made. Therefore the target group of rental center guests is chosen as the target group. To further narrow down this target group, it is chosen to look into the usergroup of young friends. This is a common guest type at rental centres and young people is often linked with easy adaptability which fits well within situation of electric go-karting being the new norm in the future. They are in for changes and a push in what rental go-karting is and can be in the future. (Goldwater, 2022)

OBS

The target group of young people is represented by the agegroup seen at persons studing at a gymnasium, university, or the like. This agegroup is chosen as it it commonly here where young people are starting to put more effort into doing activities together to bond, e.g. trying out go-karting.

POWER RACING

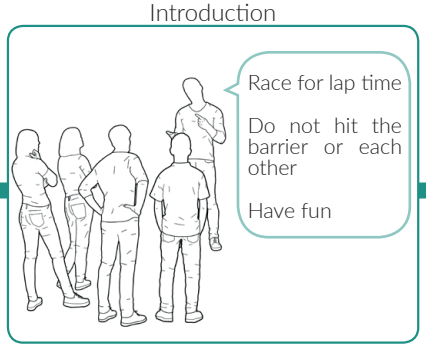
Based on the project scope, Power Racing in Herlev, Copenhagen was visited as it is the only rental place in Denmark offering electric go-karts. At Power Racing, personnel and guests were interviewed (Kvale, 1996) and acting-out (Bagger & Sperschneider, 2003) were done trying to drive the go-karts for 2 heats of 10 minutes, due to the go-karts having to recharge their battery. Futhermore, an observation of the target group driving was conducted. Observations and acting-outs serve as foundation for an as–is-scenario in the upcoming pages. (App. 8)

Ill. 14 - Power Racing

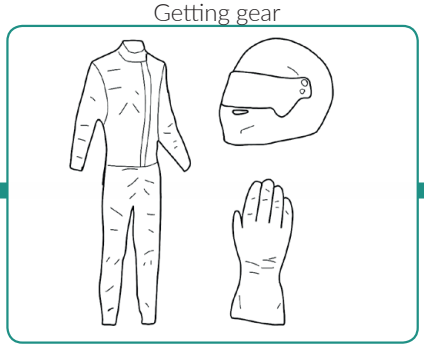
SCENARIO

The scenario below illustrates how a common situation would look like visiting a rental go-kart center, and highlights the different facets that unfolds within the activity. The scenario is based on shadowings of the target group during the activity from Action House and Power Racing and acting-out from Power racing (App. 4, 8). The scenario is used to get an overview over the entire activity with the intention to see how the target group acts and to discover aspects that can be looked further into, these are marked with bold.

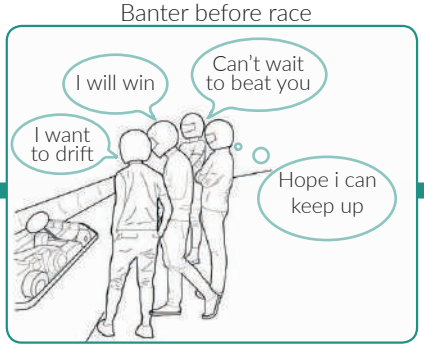
Introduction



Getting gear

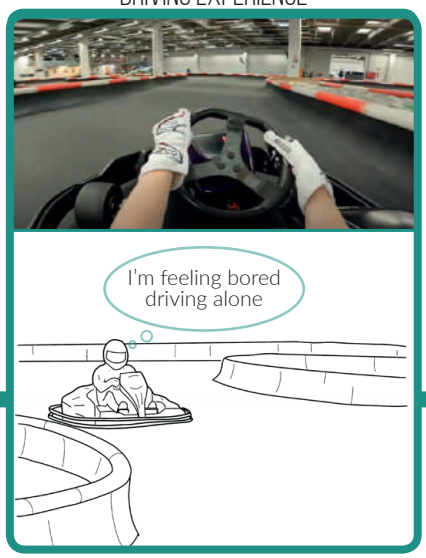


Banter before race

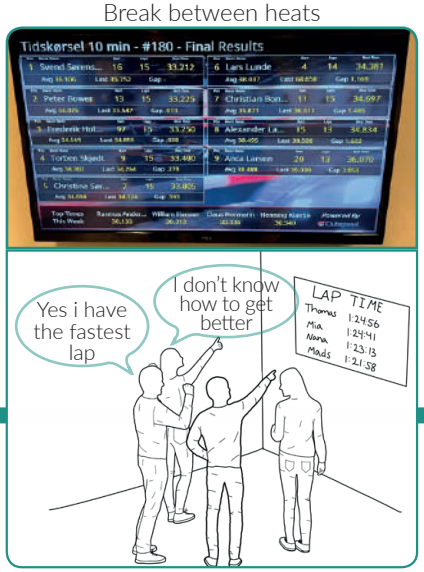


UNAWARE OF PROGRESS

DRIVING EXPERIENCE

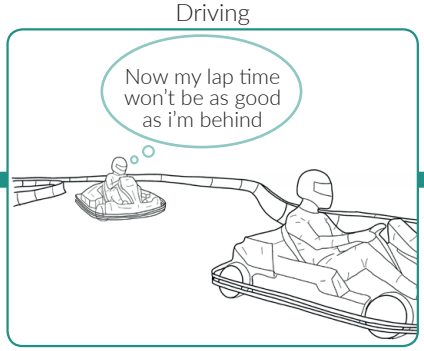


Break between heats

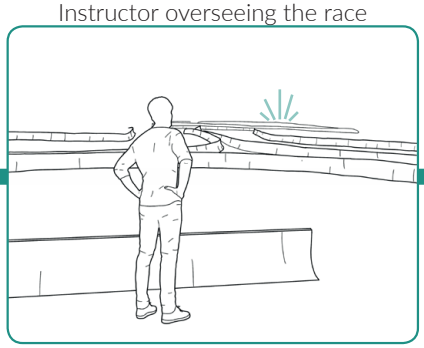


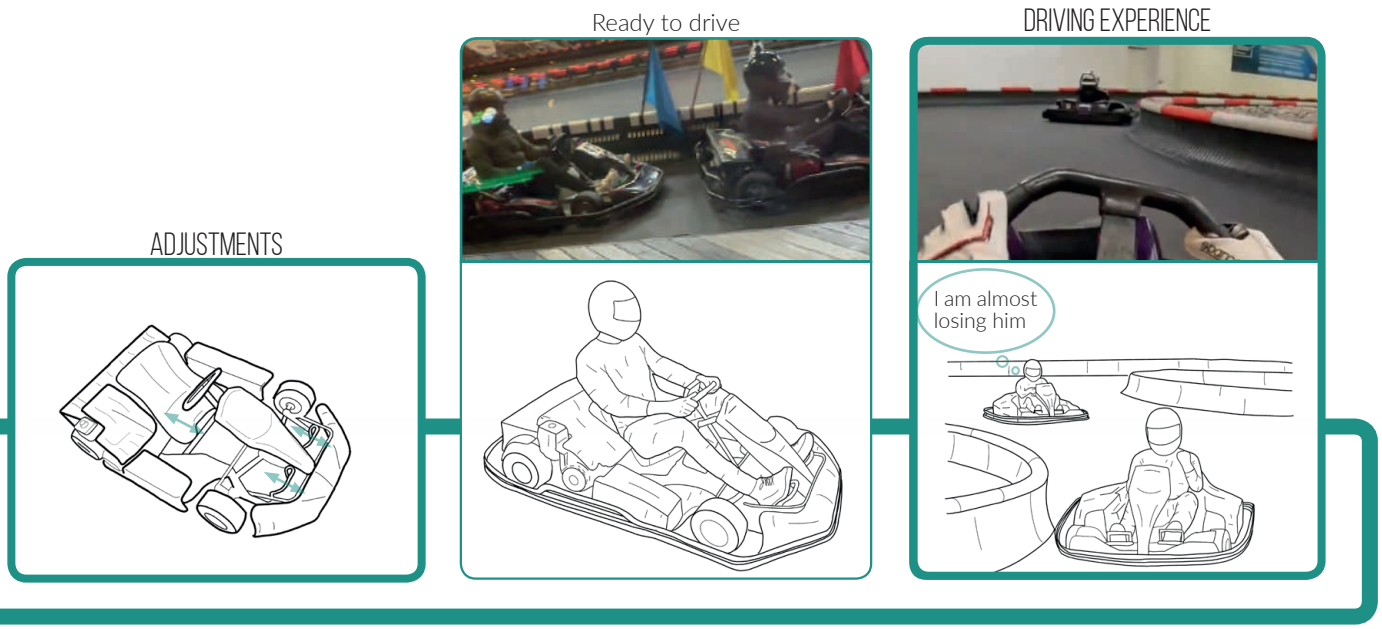
SAFETY ON TRACK

Driving

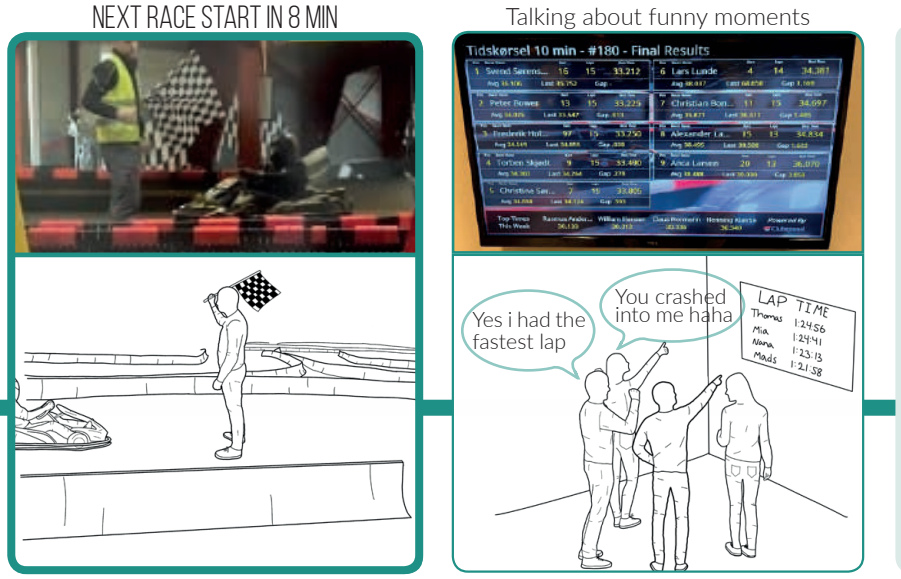


Instructor overseeing the race





Ill. 15 - As-is scenario



Summarize

The scenario has provided a broad understanding of the scenario and its different facets and how the target group acts during pre-race, the driving phase, and post-race.

As it's now known how the target group acts during the activity, it's relevant to dig deeper into how the feel about go-karting and what made them chose go-karting as an activity they wanted to try.

UNDERSTANDING THE USER'S EXPERIENCE WITH GO-KARTING

The investigation of the target group has been conducted by interviewing (Kvale, 1996) people from gymnasiums and universities (App. 9). The interviews are made as structured interviews and focused on their experiences with trying the activity. Here with the intention of discovering valuable insights and possible patterns.

From the interviews the aspects of speed and competition were pointed out as things they remembered best from trying go-karting. They see the activity as quite fun, and especially the time post racing as it could be used to compare lap times, brag and talk about funny moments during the race. They wanted to try go-karting to try an activity more adrenalizing than other activities such as bowling and minigolf. Almost every interviewees were not fans of motorsport, they wanted to try it as it was a social event with a group of friends.

Through the interviews an interesting pattern emerged, as almost all interviewees pointed out that they had only tried go-karting once or twice in their life and it was usually a long time ago. This was seen as an interesting problem which will be investigated further to gain an understanding of why.

Ill. 16 - Drivers

"I haven't tried it since 9. grade. I remember the competetive aspect, I like to win" - Nana

"I have tried it once. I just wanted to have fun with my friends. I enjoyed the speed and acceleration" - Frederik

"I tried it for the first time last year. It was fun to drift" - Mads

"First time i tried it was last year with my friends. I just enjoyed the speed and the competition" - Tommy

"I tried it in 2018 with my friends. It was fun to drive against the others and maybe hit them sometimes" - Jesper

"I have tried it two times. I would only go again for the social aspect, I do not like speed" - Lea

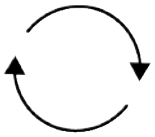
"I have only tried it once in Spain with my brother and dad, but I was alone on track because I was not as quick" - Christina

Ill. 17 - Users

- Aspects of speed, competition and sociality is important for the activity of go-karting
- Not all wants to try go-karting for the sake of speed and racing, but just for the social aspect

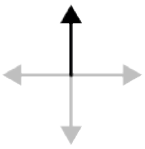
WHY IS GO-KART NOT REVISITED?

The issue of go-karting not being revisited was discussed with the interviewees with the intention to point out any specific reasons why. A sum-up of these interviews pointed out five main reasons for why most interviewees did not want to revisit go-karting.



Repetitive activity

The activity is highly repetitive and demands many similar repetitive movements. Furthermore, is the physical context very restricted as the track does not change. It is only when other drivers are near that the physical context change, as you need to be aware of them and act upon their behavior and movements.



Few opportunities

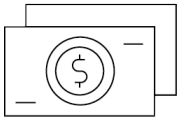
The activity possesses very few opportunities as the fastest lap time is the overall goal and winning criteria.

Hard to improve

As the main goal is to get the fastest lap time, it can be hard to improve yourself. After the first few laps, there is only minimal to no improvement which could potentially frustrate non experienced drivers.

Focus on the individual

Even though the activity is seen as a social event, the main goal of the activity is based on individual performance. Go-karting is focused on the individual driver which results in minimal social interaction during racing.



Price

In comparison to the time used at the activity, many commented on the prize being too high, if compared with the time you could get at other similar activities such as amusement parks, mini golf and the likes. The price can range between 175-300kr for driving times of 10-20 minutes.

Ill. 18 - 5 issues

Most issues was in relation to the actual driving experience and not the situation pre or post racing. It became clear that most interviewees did not have any special relation to the genre of motorsport but did it as it seemed fun as an social activity with friends. This highlights why many commented on, the activity being hard to improve on, as the only goal was to set the best lap time. Furthermore did many point out, that it became boring over time, and they felt alone throughout the race making the driving experience less social.

Price is a factor resulting in young people dont want to revisit, but due to the fact that the price is being determined by the owner of the rental center, and is based on many variables such as on number of visitors, rent, etc. **The element of price will therefore not be investigated further.**

The focus will be on the other four issues with a goal of **increasing the value of the driving experience** by countering the issues and letting it be an activity that can be enjoyed by all, whether enjoying racing or not.

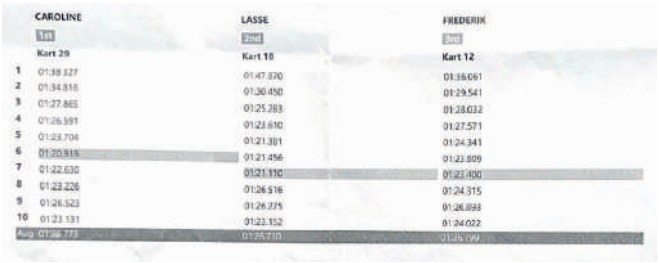
- Most issues are found within the driving experience

- The electric go-kart should enhance the driving experience for the target group

UNDERSTANDING THE EXPERIENCE ON OWN BODY

In order to better understand the experience and to get a more comprehensible grasp upon why the prior presented issues are seen as problems, a re-visit to Action House was initiated with the goal of performing an act-out (Bagger & Sperschneider, 2003) and trying go-karting as a group of friends would. Acting-out is furthermore used to validate the users' highlighted issues. The group drove one heat of 15 minutes.

This acting out confirmed within the group that the highlighted aspects of speed and competition were essential aspects of go-karting as it contributes with adrenalized feelings that are rarely felt in other activities. Learning how to drive the go-kart and learning the track generated a lot of adrenalin as the barriers were hit several times, and the three go-karts were driving very close. After a few laps, it was possible to remember big parts of the track and thereby the only surprises and changes in the environment were other drivers. At many points during the race, each group member drove by themselves which became boring and it was clear that the driving experience could not be seen as a social activity in itself. It was hard to know if one improved during the race, as only little information was provided through a little screen located at the steering wheel displaying lap times and the overall ranking of the drivers on track.



Ill. 19 - Action House

EXPERIENCE MAP

Based on the acting-out from Power Racing and Action House, a mapping of the experience is made highlighting the different phases and the feelings felt throughout the experience. It is important to notice how the feeling of being social occurs throughout the activity, as the social aspect is important for the target group. During racing, the social feeling only peaks when overtaking others, whereas during pre-race, break, and post-race it is much higher as they compare statistics and moments that happened during the race. Go-karting becomes less challenging after the first laps as nothing new happens, and it can be frustrating when it gets harder to improve.

STAGES	PRE-RACE		RACE					POST-RACE	
PHASES	INTRODUCTION	SETUP	LAP 1-2	LAP 3-10	BREAK	LAP 11-16	LAP 17-22	SEE RESULTS	PODIUM
ACTIONS	Explaining rules Talking/banter Who will win	Sitting down Adjusting Getting ready to drive	Learning how to drive Feel the speed and acceleration Feeling your limits Hitting barrier	Learning your own limits - Driving alone Find the best line Being overtaken Remembering the track	Talking about results, overtakes, mistakes, analysis of the driving Trying to relax Getting back in the go-kart	Planing overtake Driving different lines Trying to overtake Making a mistake	Driving the same line Not seeing a driver for several laps - Getting repetitive Excited to see the leaderboard	Talking about results Funny moments - Hitting barrier, making mistakes, spinning, hitting each other Cool overtakes and battles	Teasing each others Bragging rights

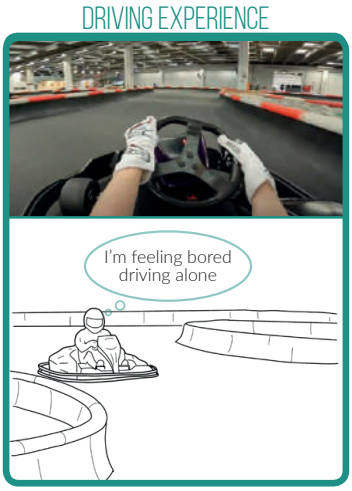
Ill. 20 - Experience map

FOCUS DELINEATION

Prior to this chapter, the focus has been on creating a solution surrounding the electric go-kart as a whole. Due to the gained information from interviews, acting-outs, and observations, it has became clear, that the main problem deals with the experience the target group has when driving the go-kart. Therefore, the focus will shift from creating a new electric go-kart to creating a new electric go-kart driving experience. The new experience should counter the previous stated issues, by making the experience less individual focused, less repetitive, and more including for people not focused on lap time improvement. The experience should enhance the value it gives the drivers compared to the cost of the activity.

This leads to the problemstatement:

How to design a new electric go-kart driving experience for a group of young people that enhances sociality between the drivers and makes the activity more inclusive?



Ill. 21 - Experience

DESIGN BRIEF

SUM UP

This phase narrows the scope of the project. The phase seeks problems within go-karting through interviews with racing, rental, and manufacturers. Through this, it was found that indoor rental go-karting is not often revisited by young people, as the experience during racing is repetitive and doesn't socialise the group of friends.

CONTEXT

The focus is on indoor rental go-kart and the translation to electric go-karts.

TARGET GROUP

The primary target group are a group of friends who are studying at a gymnasium or university.

PROBLEM SUMMARY

When young people are choosing an activity to do together it's often not go-karting as this is expensive compared to the value it gives in terms of it being repetitive and hard to improve.

PROBLEM FORMULATION

How to design a new electric go-kart driving experience for young people that enhances sociality between the drivers and makes the activity more inclusive?

Several of the insight in this phase is being summarized through, target group, context, problem summary, and the problem statement. The insights that have an impact are mentioned below and turned into a requirement or wish.

KEY INSIGHT	REQUIREMENT	SOURCE
A race takes between 10-15 min	The experience should last 10-15 min	Page 10 - Go-kart World

KEY INSIGHT	WISH	SOURCE
It is normally groups between 4-12 people who go gokarting	The experience should allow for 4-12 users	Page 10 - Action House
Rental go-kart tracks can vary from 300-1250 meters in length	The experience should work on tracks 300-1250 meters	Page 12 - Rental go-karting
	The electric go-kart should enhance the driving experience for the target group	Page 17 - Why is go-kart not revisited

02 THE EXPERIENCE

The following phase covers a deeper understanding of the users and their interests. An investigation into go-kart competitors has been conducted to understand the missing elements that the current go-kart experience lacks and how it can be achieved. Lastly, through testing ideas with users and interview with an expert a final concept for the experience and how this should be integrated into the go-kart environment have been accomplished.

III. 22 - Testing

USERS

As the first phase did not give a sufficient understanding of the different archetypes and characteristics within the target group, interviews (Kvale, 1996) with students were conducted. The interviews focused on getting to know their daily lives, hobbies, and what types of activities they find enjoyable to do with others. Here to discover patterns and valuable themes/aspects that could be used in developing a new go-kart experience.

NANA

Nana is studying at VIA University to become a Danish and English teacher. At VIA, she's part of the party planning committee. She is very social and loves to hang out with her friends, and they often do spontaneous activities together, like going to karaoke bars or the cinema. When Nana is alone, she most often watches TV series like The Office, but she has started gaming again by borrowing her boyfriend's Playstation to play the new Hogwarts Legacy game. Nana uses Instagram, TikTok and sometimes plays some mobile games. She stays in contact with her friends through Messenger or phone calls.

CHRISTINA

Christina is studying Industrial Design at Aalborg University. In her spare time, she enjoys cozy hangouts with her friends with good food and board games like Partners and Hint. Christina likes social activities like bowling, parties, or concerts with friends. She also wants to run and train in a fitness center. Christina also likes to relax and watch tv-series or reality tv. She uses Instagram and Youtube and writes to her friends through Messenger and Snapchat.

THOMAS

Thomas is currently starting his education to become a plumber. He spends his spare time with his friends, this being through parties, walking around in the city, or gaming online, mainly GTA 5. If nothing special is happening, he always tries to create an event. This could be a gaming session, as he likes spending time with others. When he isn't with his friends, he is on social media; Instagram, Youtube, TikTok, or gaming.

FREJA

Freja is currently studying in her last year of gymnasium. In her spare time, she often spends time with friends, going to cafes to talk, or going to activities such as bowling, as this is a calm activity where she can socialize with her friends. If she isn't spending time with her friends, she enjoys playing Sims on her Macbook or smaller games such as Hayday on her iPhone.

MADS

Mads is studying Medialogy at Aalborg University. In his spare time, he enjoys attending fitness or playing online video games with his friends, currently gaming Apex Legends. He likes video games as it is accessible and an easy way to connect with friends. He likes competing with his friends as a team or against each other. He is always ready to attend events with his friends but is never the one creating the events. He enjoys time alone, relaxing by watching Youtube or scrolling on TikTok.

TOBIAS

Tobias is studying Medialogy at Aalborg University. Tobias is in the same friend group as Mads. Tobias mainly enjoys gaming alone or with his friend, currently gaming Apex Legends. If he isn't gaming, he spends time with his cat, Simba, or browsing the internet to find new components for his computer, as he likes to have the latest gear. He could be better at attending events but always enjoys the moments he attends.

Ill. 23 - Users

- The users find being social as important
- The users have interest in the newest technologies
- Gaming is a part of almost everyones spare time

POPULAR SOCIAL ACTIVITIES

Based on conducted interviews (page 21), a short questionnaire was set up asking users within the target group what kind of activities they did with their friends. Here the purpose of highlighting certain activities that possess enjoyable elements. When doing the questionnaires, the respondents were asked how often they had done the activities. Only paid activities are highlighted to have a fair comparison to go-karting.

Ill. 24 - Market analysis

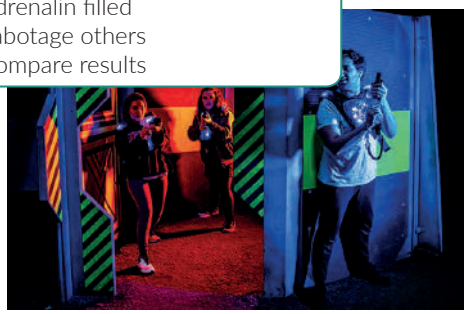
The highlighted activities have been mapped according to visit frequency, and it is seen that go-karting is one of the activities with the longest span between visiting it. To better understand the activities and how they differentiate, they have been analyzed based on specific aspects such as price, duration, and degree of sociality, (App. 10). The activities have likewise been analyzed individually to understand what makes them unique (App. 10). Three of the activites have been highlighted, where two of them have a high visit frequency, amusement parks and padel tennis, and lastly laser game as it possesses similar aspects seen in go-karting.

Amusement park

Whole-day activity
Different activities
Adrenalin kicks thoughout the day
Inclusive, activities for everyone

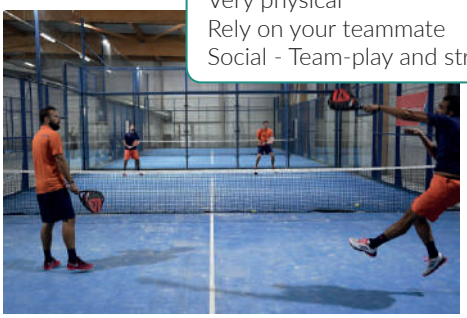
Laser game

Unpredictable
Impact and be impacted by others
Social - Team-play and strategy
Adrenalin filled
Sabotage others
Compare results



Padel tennis

Unpredictable (how the others play)
Very physical
Rely on your teammate
Social - Team-play and strategy



Ill. 25 - Activities

Looking into the terms describing each of the analyzed activities, many aspects could be summarized into the words of interaction and variation.

Variation: Unpredictable, surprise elements, reliant on the team, different goals/tasks
Interaction: Teamplay, influence others, multiple interaction points

Having activities that provided more goals/tasks to pursue and focused on teamplay was highlighted as activities they would revisit. Here due to, the activities letting the participants feel more connected during it and have more different content making it less repetitive from time to time. The terms variation and interaction will be the foundation for creating a new go-kart experience.

- Generate a go-kart experience that has enhanced the interaction and variation aspect

DEFINING THE EXPERIENCE

The terms interaction and variation are comprehensive descriptions with multiple meanings. To find common ground within the understanding of the terms so that they can be used actively through the development phase, the terms will now be defined using phrases and pictures to present the feelings wanted to be accomplished by the experience. The experience will afterward be summed up, leading to the project's vision.

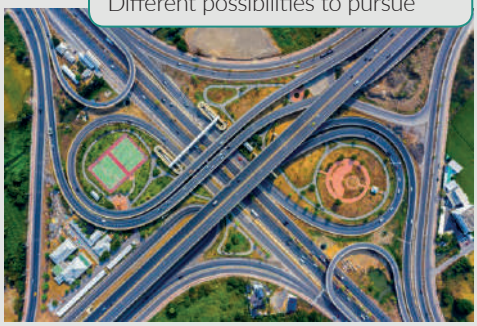
VARIATION

Definition by Google
"A change or slight difference in condition, amount, or level typically with certain limits"

Derived

The need for variety comes from the monotonous go-kart experience, as it only gives the user one goal to drive towards.

Different possibilities to pursue



Make the best move according to the situation

Enhancing variation by giving:
A sense of dynamics where the user can change focus while driving

INTERACTION

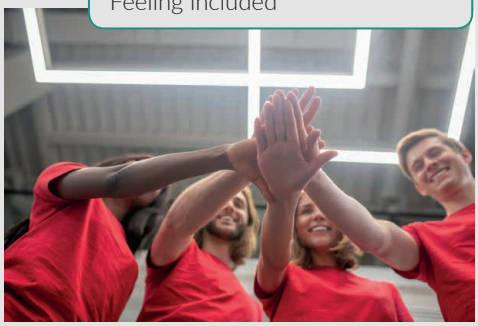
Definition by Google
"Communication or direct involvement with someone or something"

Derived

The need for interaction stems from the fact that while driving, go-karts have individual goals with few player-to-player interaction opportunities, which is why the interaction mainly occurs after the race.

Influence how another person acts

Feeling included



Enhancing interaction by giving:
A sense of involvement with others is where the user, through interaction, influences their own and others' experience.

Ill. 26 - Definition of variation and interaction

EXPERIENCE SUM-UP

Incorporating the aspects of variation and interaction within the go-kart experience will minimize the issues regarding repetitiveness, few opportunities, and the focus on the individual. The activity should too focus on letting the driver progress easier, making the activity less hard to improve. The aspects of teamplay and more goals/tasks to pursue/do is highlighted as key elements to consider when designing toward the new experience.

Despite a wish to change the current experience, the aspects of competition, speed, and adrenaline rush mentioned in phase 1 as important elements are still seen as essential and will be taken into consideration.

VISION

To create a go-kart experience emphasizing sociality and an ever-changing driving experience, you would want to try again.

Problem statement

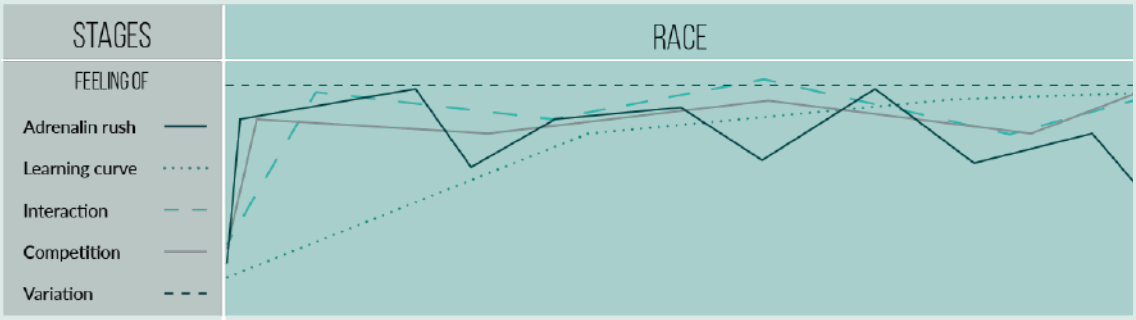
Based on new knowledge specifying the experience further, the problem statement is updated.

~~How to design a new electric go-kart driving experience for a group of young people that enhances sociality between the drivers and makes the activity more inclusive?~~

How to design a new electric go-kart experience for a group of young people that introduces a dynamic driving experience and enhances the interaction between drivers?

DESIRED EXPERIENCE MAP

A new mapping illustrating the desired experience is made and presented below. The competition and adrenalin rush aspects, defined by the current go-kart experience, are still high. It aims to create an experience with consistent high values within the elements throughout the experience.

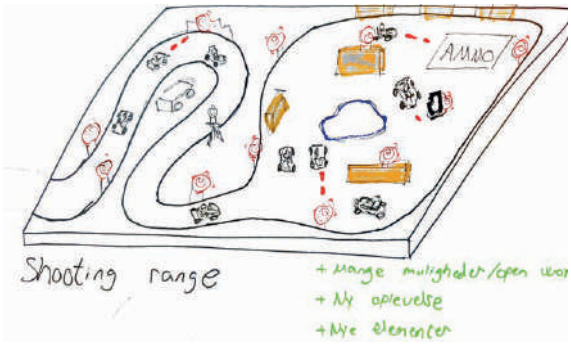


Ill. 27 - Desired experience

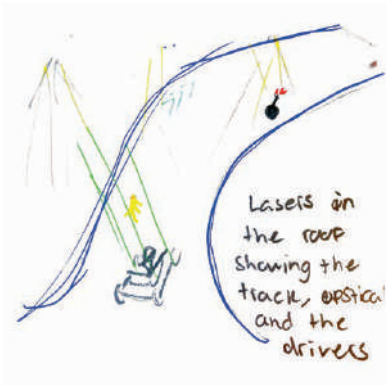
IDEATION - A NEW GO-KART EXPERIENCE

Based on the defined experience, ideation upon the theme ”a new go-kart experience” was conducted by two sketching rounds. The criteria were to incorporate elements of variation and interaction, which was done with the mindset that “everything is possible”. The two sketching rounds were based on designing a solution to be integrated within the go-kart or the track. (App. 11)

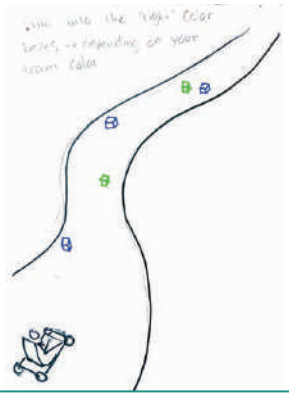
Solution for the track



Shooting range
Laser game and paintball inspirered
Open world, many opportunities



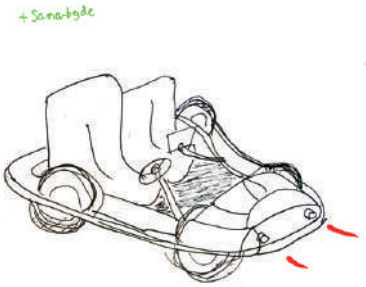
Lasers in the roof displaying the track and objects on the track
The track can easily change
Surprise elements



Physical obstacles on track
Mario Kart inspired
Purpose to avoid obstacles, not racing

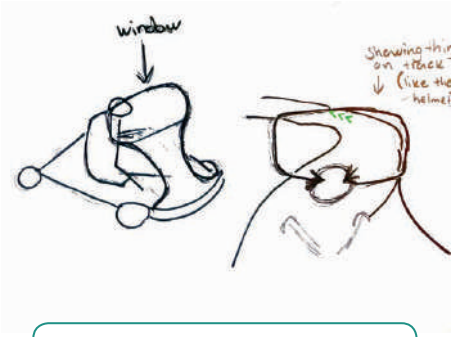
III. 28 - Ideation track

Solution for the go-kart



Two person go-kart
One drive the other aim and shoot
Team-work is essential

Team-work
One person explaining when to turn and the other person driving without looking



A window on the go-kart to display driver line or elements on track
Several opportunities to display

III. 29 - Ideation go-kart

The sketching rounds end with a better understanding of different possibilities to take and furthermore guide the project’s direction in terms of whether the solution should focus on changing the track, parts of the track, or the go-kart itself. The decision to focus on the go-kart itself and not the track was chosen since changing a track is expensive and takes a lot of time, as highlighted by the rental center owners from phase 1. Furthermore, can this solution affect the experience for customers who want to try ordinary go-karting, as the track would now accommodate the new experience the most. Based on this, the experience should be created by a solution integrated within the go-kart.

Evaluating the ideas for integrating the solution on the go-kart, it was seen that many of them took inspiration in some sort of element coming from video games, e.g., shooting each other, using some kind of screen, and dodging obstacles. Using elements from video games seemed like a fascinating and fun idea and would fit well into the target group, as seen from the interviews with the target group. The aspect of gaming will be looked further into.

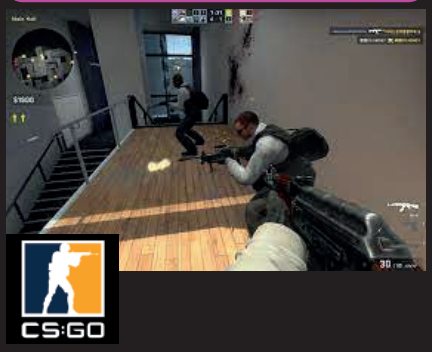
- Generating the experience with the design of the go-kart

GAMING

From interviewing the target group, it was clear that for many, gaming was a thing they used time on in their daily lives. The gaming trend is a popular activity with 3 billion active video game players globally, with an expected increase by 2024 to 3,3 billion gamers worldwide (Howarth, 2023). Due to its popularity, an investigation was done to understand what elements within video games make so many people play them so often (App. 12). The following video games are chosen due to their popularity and variety within the video gaming genre.

Counter Strike Global Offensive

- Team game
- Multiple game modes
- Choice of roles
- Nickname after ended game

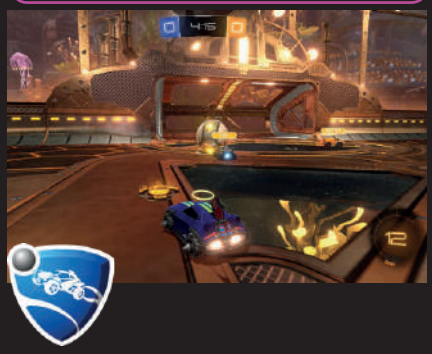


Minecraft

- Build own world
- Open world
- Achievements
- Collect items to build

Rocket League

- Cars mixed with sport (football, basketball, hockey)
- Freedom
- Team game
- Sabotage
- Weekly and monthly challenges



Mario Kart

- Pick-ups of power-ups
- Sabotage other drivers
- Choose own character

The Sims 4

- Imitates real life
- Levels of progression
- Creative
- Custom building of house, interior etc.

Ill. 30 - Games

26 users took the questionnaire at open house

Ill. 31 - AAU open house

Investigating popular video games highlighted several elements which seemed important for each game and video games as a whole, such as being able to sabotage one another, having upgradeable items, and different game modes. A questionnaire was set up to grasp better which elements are essential in video games regarding the target group (App. 13). At open house at AAU, 26 young people were asked. Based on the answers, the essential gaming elements could be narrowed down to the five elements shown below. These elements will be taken into consideration when designing the new experience.

GAMIFICATION

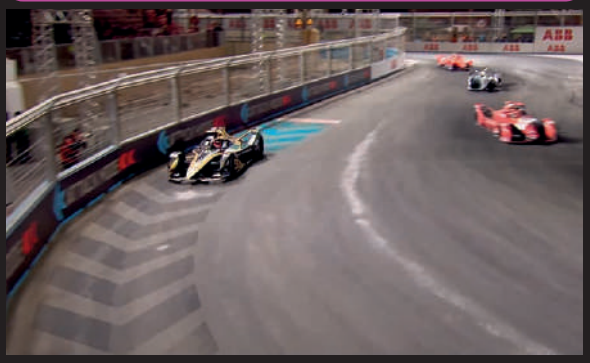
As the purpose of looking into gaming is to see how elements of it can be integrated within the physical go-kart, the area of gamification will now be investigated. How gamification is applied within other solutions and areas will be highlighted below.

OBS

What does gamification mean?
"Gamification is the application of game-design elements and game principles in non-game contexts. It can also be defined as a set of activities and processes to solve problems by using or applying the characteristics of game elements." (Fitz-Walter, n.d.) It involves using gaming elements and techniques that stimulate the players' interest and increase their participation and motivation.

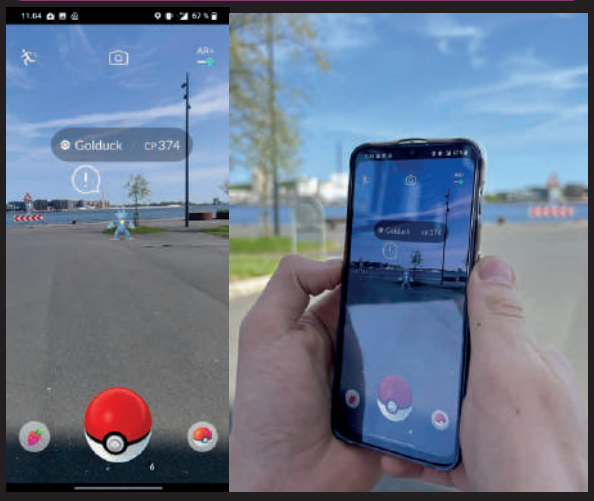
Formula E

Boosts vehicle speed by driving over the blue lines
Viewers can give boosts to their favorite drivers



Pokemon Go

Uses AR to enrich the surrounding environment, e.g., by displaying Pokemons.
Adds depth to the concept of walking
Makes walking motivating



Apple Watch

Sets health and fitness goals and shows progression here of
Displays awards when goals are achieved

Ill. 32 - Gamification

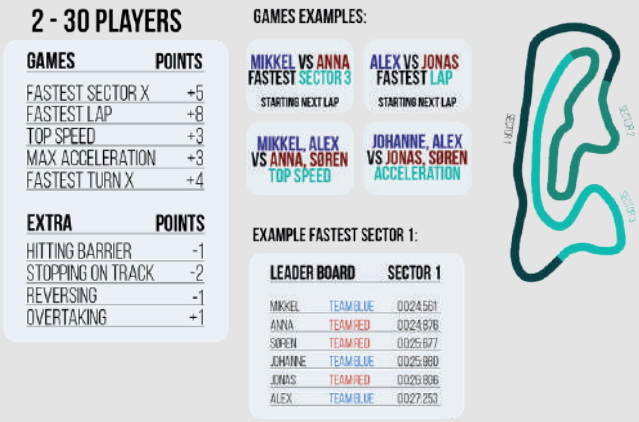
As the highlighted examples show, gamification is found in several contexts and applications. Using gamification is seen to enhance and transform the contexts and experiences and make them more engaging and unique. Combining real physical and digital gaming elements is an exciting way to create a new go-kart experience fitting for the target group. It will be further investigated on the following pages.

IDEATION: GAMIFICATION IN GO-KARTING

Knowing popular gaming elements and how they, through gamification, can create an engaging and unique experience, ideation based on the theme, "gamification in go-karting," was conducted. The purpose of this ideation was to come up with several ideas for new go-kart experiences containing gamification.

From initial ideation, it was discovered that to implement gaming elements into a new experience, the experience should build upon creating a video game. From here, six different games were developed (App. 14). Through discussion within the group and with users, four of the games were discontinued. This is due to the lack of driver interactions and the issue with the game targeting only one type of audience, e.g., relying on shooting aspects. The two game concepts most users liked were taken into a detailing round to refine and visualize the game before showing it to users again.

DUEL DRIVE



Duel Drive is a game based on aspects seen from the current go-kart experience but with more integrated goals to pursue and a competition form based on teams rather than individuals. The game is about scoring points by winning challenges against the opposing team. The challenges occur randomly and could be 1v1, 2v2, etc. There are also penalties for, e.g., hitting the barrier. The game seeks to keep the aspects of speed but integrates goals that seem reachable for them, not wanting to drive fast.

"It could be fun to be in a team" - Nicholas.

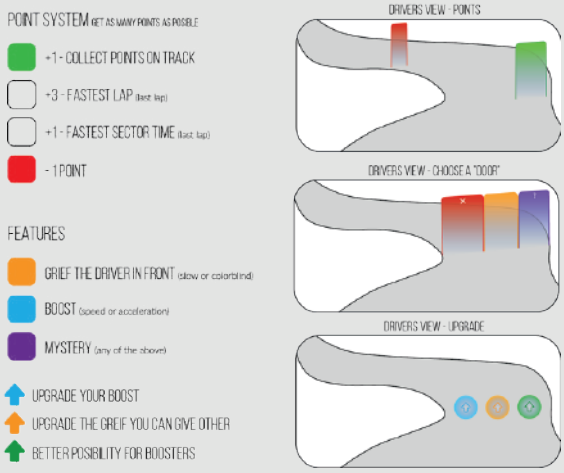
"I don't know what challenges will appear. I like that [...] What are the other drivers doing when there isn't a challenge? Are they blocking the other drivers?" - Martin

"Even if you are not quick, then you can still be a part of a winning team [...] If too much is happening (too many challenges), then it might be scary" - Nikoline.

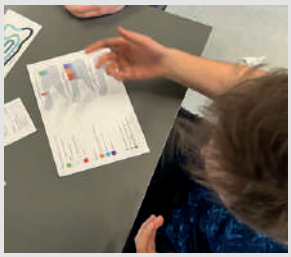
"It still seems like this game targets the ones who like to race and drive fast," - Sofie.

"I would perhaps be a bit confused over all the things you could get points from," - Danny.

AR OBSTACLE



AR Obstacle is an individual-based game where drivers fight each other. The game is based on the likes of Mario Kart, where objects virtually placed on the track should be collected to get points by driving into them and influencing the other drivers, e.g., slowing their speed and deducting their points. This game removes the aspects of racing and decreases the need for driving fast but is still rewarding for drivers who like this, e.g., giving points for the fastest lap driven.



"I can take different lines around the track [...] The upgrades are a little weird, and maybe there are too many" - Nicholas

"This sounds so fun, it's a combination of race and tactics [...] There is some randomness and luck to this game" - Martin

"It is like real-life Mario Kart. I like to try it; it could be really fun [...] I think maybe more girls would play this game" - Nikoline P

"It could be a tactic choice to drive slow, but you can drive fast if you want to" - Nikoline S.

"The aspects of having virtual elements on the track sound so cool! [...] It would seem like a totally unique experience!" - Sofie

"It's fun to "drive into" the obstacles." - Danny.

Ill. 33 - Duel Drive and AR obstacle

- Team-based makes go-karting inviting for more users
- Creating relations (e.g. real-life Mario Kart) gives an easy understanding/learning curve

FINAL GAME DEVELOPMENT

With the obtained feedback from the target group, the goal is to create a finalized game combining the highlighted positive elements from the two presented games. Overall, the interviewees most liked the AR Obstacle game due to its integration of augmented reality which seemed an exciting and fun addition to go-karting and the aspect of driving into something on the track. Duel Drive was highlighted as good due to its elements of team play which made the activity far more social and engaging. The finalized game will therefore take its origin in the augmented reality aspects of the AR Obstacle game and the team-based aspects of the game Duel Drive. Some interviewees pointed out that the games should not have too many different tasks/goals as it could make learning confusing and challenging as the activity only lasts 10-20 minutes. The game is detailed to discover needs that set requirements/wishes for the solution. The finalized game and visualization of it are presented below.

KART MANIA

Kart Mania is a team-based interactive game for go-karting. The teams fight each other on the track to gain the most points at the end by collecting virtual elements placed around the track by driving into them. The game consists of five different colored elements, all having different abilities.

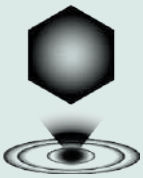
Obstacales

Gives one team point

Deducts one team point

Deducts two team points from the opposing team

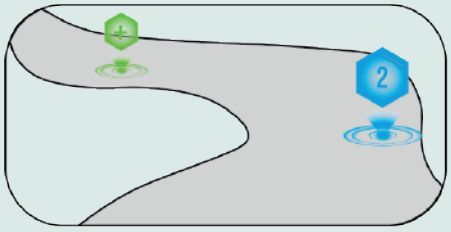
Gives a power-up, e.g., boosting speed, doubles collected points, colorblind (not able to see what the objects are), remove debuffer (negativ objects) from team mates, and slow speed



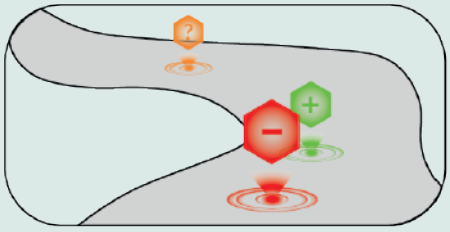
Initiates a minigame, e.g., collect five green elements. Appears only a few times. It gives five points if completed and deducts three if lost

Placement of objects changes every lap

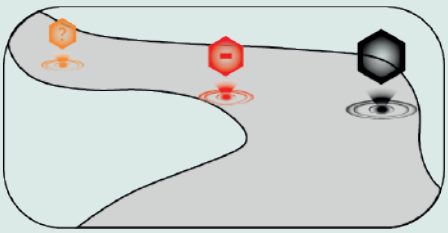
Lap 1



Lap 2



Lap 10



Ill. 34 - Kart Mania

For this game to work as intended, the technology of AR should be used so that the driver can see the virtual elements while driving. As it was determined from previous ideation, the solution for the experience should be implemented on the go-kart. To find out how the technology of AR should be implemented, it will be further investigated.

OBS

What is AR?
Augmented reality (AR) combines digital/virtual content and the real world. AR virtual content is displayed as a digital layer upon the real environment, providing the one seeing it with additional information. (Gillis, 2022)

OBS

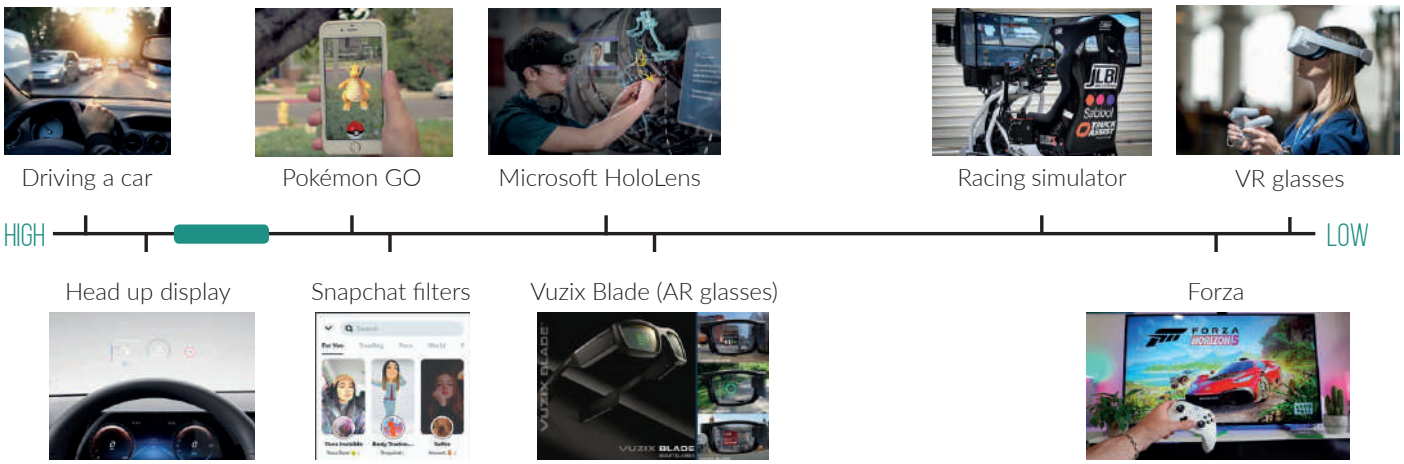
The possibilities with AR are endless as it relies on virtual aspects made possible through software. Implementing more games is a possibility, but for the sake of this project, only the game presented above with its requirements/wishes will be considered.

- The go-kart should visualize the obstacles

- The go-kart should visually differentiate each team

THE DEGREE OF REALITY

Augmented reality technology can be implemented in multiple ways with multiple degrees of reality. It can range from virtual elements only influencing small parts of the real environment to the real environment being almost wholly flooded with virtual features, as seen with virtual reality. The balance between reality and the virtual world is important to acknowledge, as the experience deals with moving vehicles. Therefore, it is necessary that the drivers avoid getting interfered with too much by virtual elements to reduce safety aspects. A mapping illustrating different degrees of reality/virtuality in other scenarios is presented below.



III. 35 - The degree of reality

The mapping was made to highlight the degree of reality the solution hence the experience should consist of. The situation of having a display in front of the driver, as seen in newer cars in the case of a head-up-display or a dashboard showing the road ahead with virtual elements as a layer on top of it, seemed like an exciting concept, as it already proved to work in moving vehicles. This kind of solution still gives the driver a clear vision of the road ahead and allows showing the virtual elements.

Looking into the Pokemon Go game also demonstrates this AR usage, where the real world is still in focus with small overlays of virtual elements. Having a display in front of the driver to show off the virtual elements is seen as the leading solution for implementing the game. The display will be investigated further in an upcoming chapter.

- The go-kart should visualize the game through a display

TESTING POTENTIAL

Knowing that the experience should be based on a display visualizing a game through AR, a test set-up was made to validate the experience's potential within the target group. The setup was based on a real rental go-kart placed on a premade track, with an iPad imitating the display and showing the environment in front, attached to the front of it. The iPad was placed just behind the steering wheel and at a height that allowed the driver to see ahead.

The test was done by letting a user drive around the premade track and acting upon the virtual AR elements shown on the display. The test uses the game Kart Mania in a simplified form, where colored obstacles should be driven into or avoided.

OBS

To imitate the display visualizing AR objects in real-time, a pre-recorded video was made of the same premade track where colored cardboard boxes were placed randomly. When doing the test, the boxes were removed, so they would seem to be placed as a virtual layer on the display when driving

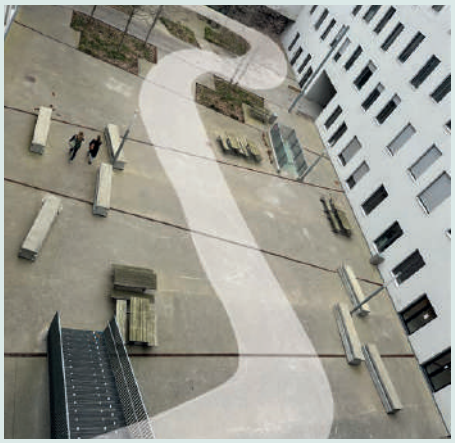
OBS

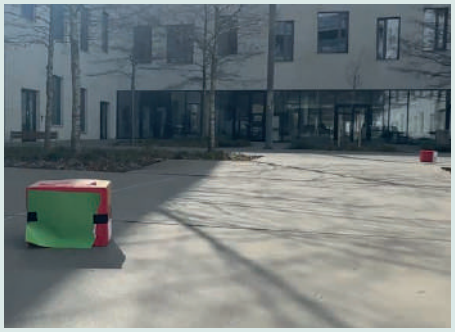
To imitate some sort of speed of the go-kart when driving, a handle was mounted at the rear end of it. A person could then push the go-kart forward. To make the video material on the display seem like real-time recordings, the person pushing would match the speed of the go-kart in the prerecorded footage

A face cam was mounted in front to record them while driving to see how much focus the driver would have on the display and the surroundings. Different users within the target group went through the test. How the test proceeded is illustrated below. (App. 15)

VIRTUAL OBJECTS

Track





*"F*** this is fun! [...] I did not at all think about the speed" - Camilla*

"It is so cool it is on the screen, i really like the digital aspect. This is defenetly more fun than the real objects" - Erik

"A lot was happening with the track, objects and someone pushing. If it was myself driving i would drive slower at the begining" - Christina

Hitting obstacles

"Every time I drove though them, then I tighten my body, so for me they felt real [...] This felt more actionpacked because I was both in the virtual and real world" - Camilla

"I'm not sure if I hit the objects" - Tobias

"One of the objects did I first see when it was almost 'underneath' my go-kart" - Katrine

Face cams

"I had no problems with looking at the screen and track at the same time" - Camilla

"I tried to only look at the screen, I only looked up to be sure I wouldn't hit anything" - Erik

"It did not feel challenging to look at the screen, it's like looking at the side view mirror in a car" - Tobias

Ill. 36 - Virtual objects

- The iPad enhanced the gaming experience and provided something completely new to gokarting
- The drivers had a lot of focus on the screen, but did look up around the corners of the track

Another test was conducted within the same context but tried to imitate the AR experience without a physical display, making it even more realistic. Here physical colored cardboard boxes were placed randomly on the track to be driven into or avoided by the driver. The users from the previous test were used again. A face cam was again put in to show the driver's focus throughout the test and to see if any differences could be discovered compared to the first test. The test is illustrated below.

PHYSICAL OBJECTS

Track

"This felt a lot slower than the other (with display) maybe because it didn't feel as dangerous" - Camilla

"I did not notice the track layout, I just followed the objects placements" - Nicholas

Hitting obstacles

"It felt really good driving into the objects" - Tobias

"I like the competitive aspect, so I was really focused on hitting the objects" - Katrine

"I liked the noise when I hit the objects" - Nicholas

Face cams

"I was risk assessing when driving, I would rather go off track or hit a wall so that I could hit or avoid the objects" - Katrine

Ill. 37 - Physical objects

Sources of error

The test is based on an experience only focusing on the driver alone, whereas the designed game is a team-based competitive game. Furthermore, the speed at which the experience was tried is far from the top speed of regular rental go-karting with speeds of 70 km/h. The track being marked up by crayons could have influenced the experience as the context was not the same as in real life.

Ill. 38 - Virtual objects

Conclusion

Based on the initial feedback from the users, all were heavily excited by the experience and found it entertaining and unique (App. 15). They liked using the iPad, which enhanced the gaming experience and provided something new. Even though they were the only ones doing it at the time of the test, they pointed out that it would be even funnier doing it with others. None of the participants had trouble with having a screen in front of them, as they did not find it disturbing to look simultaneously at the display and the track. The visual data from the face cam revealed that the participant looked at the track the most when driving through corners.

Even though the speed of the go-kart was heavily reduced compared to normal go-karting, it did not impact the experience, as stated by multiple participants, saying they did not need it to be faster. This could result from having more elements to focus on while driving, minimizing the attention to speed. This works well with the statement from Karsten, Action House, stating the wish: *"To entertain with the lowest amount of speed"*. Therefore the top speed of the go-kart is lowered during the activity. Due to safety reasons, the experience can not be tested at higher speeds. Thus, the requirement for top speed is set between 20 km/h and <70 km/h.

The most significant difference the participants noticed between the two tests was the feedback received when hitting an object. They found the test with the physical objects better, as they could hear and feel the vibrations when hitting the cardboard boxes. The go-kart should thereby accommodate feedback to the driver when driving.

Based on the tests, it can be concluded that there is potential regarding the new experience. The upcoming pages will investigate how the game will be implemented and what requirements it will set for the solution.

- The most joyful experience was the game with the physical elements as this has feedback when hitting objects
- The speed is not an important aspect while driving with the iPad

- The go-kart should accommodate haptic feedback
- The go-kart should accommodate auditive feedback for the driver while playing
- The top speed of the go-kart should be between 20km/h and <70 km/h

GAME REVIEW

The game company CEGO was contacted to test out the developed game and the experience and gain feedback from experts within the gaming field. An interview (Kvale, 1996) at CEGO was set up with one of their leading developers, Lars. (App. 16)

The team presented the project and showed off the experience and the game. Presented below is the primary feedback from Lars, separated into themes.

Comments on the game

The current game consists of five different colored elements with different characteristics. Lars pointed out the black one (minigames) as too much, as the driving time is only 10-20 minutes. Removing the element would mean reducing the number of elements which would be a positive upgrade for the game. Another comment from Lars pointed out that the red element (deducts one point) should be a power-up instead within the orange element, making it an obstacle for the driver to put out on the track for others to hit.

He highlighted the game as fun to try while go-karting, as it would emphasize team play and make the driving experience both fun and challenging. Essential criteria for games of this duration would be to embrace only a few elements, not to confuse players/drivers.

LARS

Works at CEGO as the leading game developer. He has been working here for 25 years. When designing games, he is inspired by everyday things and has a mindset of turning everything he sees into games.

Updated game

One point for the team.
Gets placed randomly on the track

Deducts two points from oponents.
Gets placed randomly on the track

Place on track

Deduct 1 point

Use as needed

Buffs:

Get 1 point

More acceleration

Remove debuffs (negative objects) from all team mates

Debuffs:

Colorblind (not able to see what the objects are)

Slow speed

Ill. 39 - Updated game

How to implement the game

Using a display to show virtual elements through AR was a feasible way to accomplish it. To display the content ahead, the go-kart would need a camera installed. For the display to know where the virtual objects should be placed at the display, Lars pointed out the need for an external system for the game hence the experience to work as intended. At the rental centers, the go-karts should be able to send data back and forth between a computer, with the data being its position on the track and video material from the camera. The computer would then process the data and return it to the go-kart. A later chapter will investigate the system, what it consists of, and how it should work.

- The experience needs an external system to work as intended

The connection between the driver and game

Lars highlighted the importance of physically interacting with the game while driving. As the feet are busy controlling the speed of the go-kart, the hands, specifically the fingers, can move while driving. Lars mentioned the steering wheel as connecting the driver and the game. In the same way, a console controller is related to a video game. Here by being the tool for interacting with the things happening during the game, e.g., use power-ups. As more games could be made to be played, the steering wheel should accommodate that by having universal interaction areas.

A great example of accommodating more games is seen on the controller used for the gaming console PlayStation 5. The controller has a very adaptable design accommodating multiple games, where each button is used differently.

The steering wheel can connect the driver and game

Ill. 40 - The connection between the game and the player

- The steering wheel should accommodate multiple games
- The steering wheel should accommodate interaction with the game

Relying on feedback

Lars pointed out the importance of having feedback within the solution to highlight and tell the driver when something has happened. Feedback consisting of auditive, visual, and haptic stimuli is an excellent way of helping the player understand the game. He added;

"You are supposed to understand the game with your eyes closed"

- The go-kart should accommodate visual feedback for the driver while playing

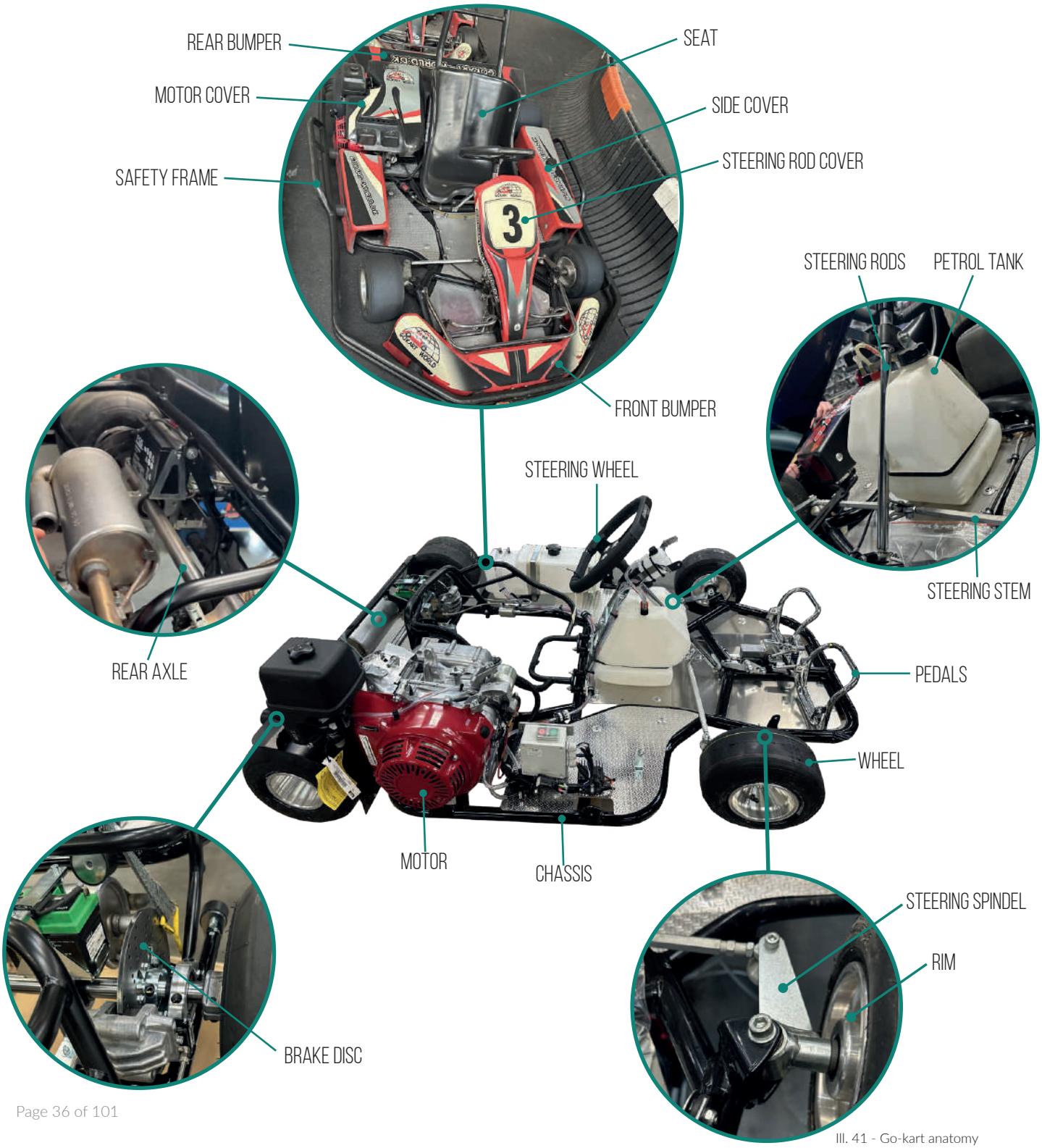
Contacting an expert in video game development helped immensely in understanding what is important to consider when designing a video game. The interview with Lars gave important insights and set requirements for the solution. As the group doesn't know much about designing games, contacting an expert earlier in the process could have been more beneficial.

With knowledge of how the game should be created and an emphasizing the steering wheel as an essential factor, what elements need to be designed within the go-kart to develop the experience will be investigated in the next chapter.

WHAT TO DESIGN?

Within the group, a question emerged of what was essential to redesign to create a new go-kart experience with the implementation of the AR game. From testing the potential of the target group and interviewing Lars from CEGO, it was highlighted that essential elements for the experience would revolve around a display visualizing the game and a new steering wheel connecting the driver with the game.

From this, redesigning the entire go-kart is not seen as essential. When the group visited DINO Kart and talked with Rasmus (App. 5), he demonstrated how a go-kart works and what parts it consists of. A mapping presenting all the main components is illustrated below.



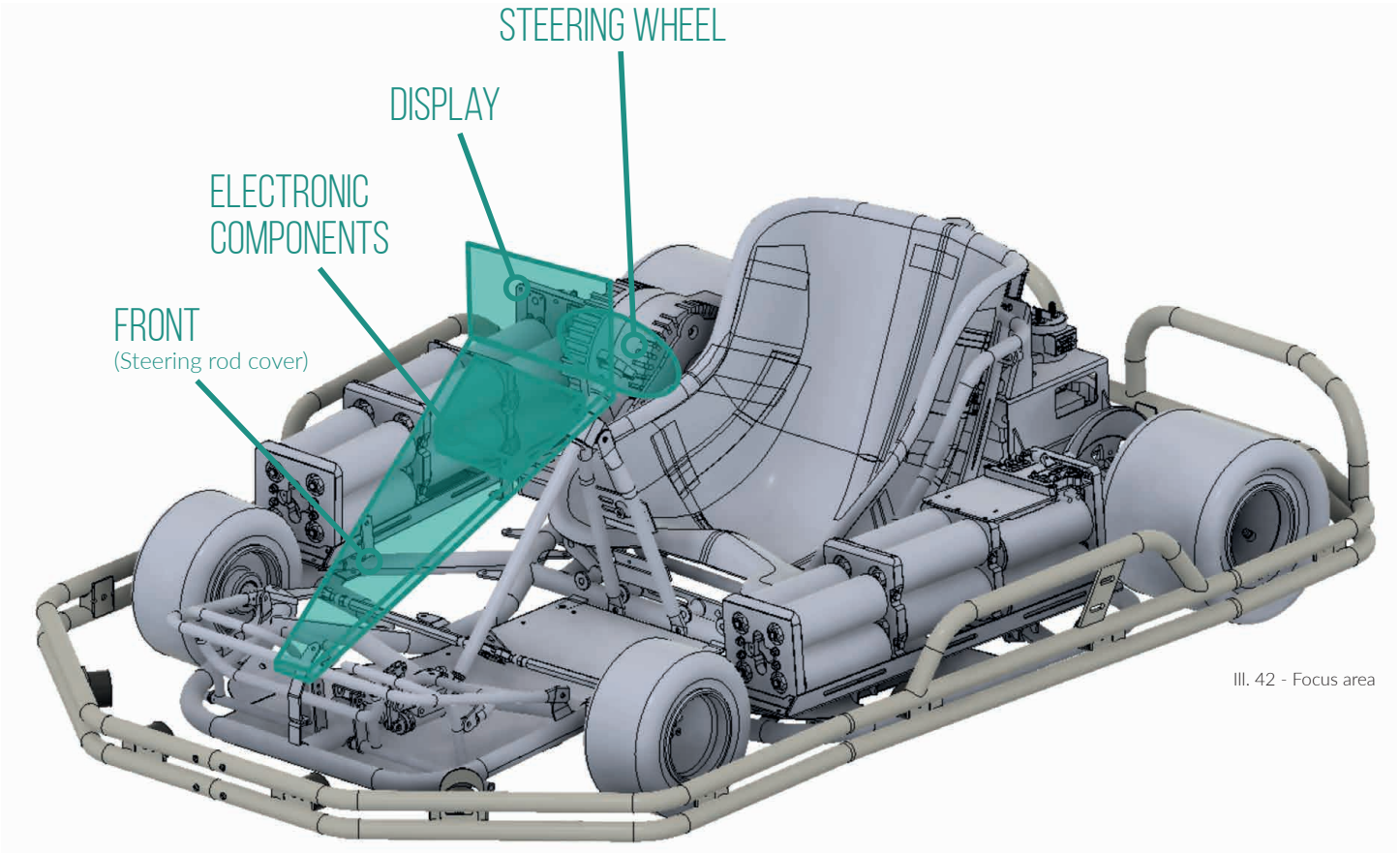
Ill. 41 - Go-kart anatomy

By looking into the different components, a discussion was conducted upon which would be necessary to design regarding creating the new experience. From previous chapters, it was made clear that the display should be placed in the front of the go-kart, making it an obvious choice to integrate it within the steering rod cover. It is decided to use this part as the base for integrating the display hence creating a redesign of it. Furthermore, in the interview with Lars, he mentioned that some electronic components should be placed on the go-kart to make the game work. Due to the size of the front part, it seems possible to integrate electronic components within this as well.

The upcoming chapters will thereby focus on redesigning the steering wheel and the steering rod cover with the integration of a display and electronic components.

OBS

In the following phases the steering rod cover will be refered to as the front.



Ill. 42 - Focus area

!

- The front should be redesigned to accommodate for display and electric components integration
- The steering wheel should be redesigned to accommodate feedback and interaction with the game

DESIGN BRIEF

SUM UP

This phase defines the experience into interaction and variation in an AR game that can be played in the go-karting context. This phase furthermore, defines the physical part that needs to be designed, as of where the display should be integrated into the front, and how the user physically interacted with the game through the steering wheel.

VALUE PROPOSITION

The solution should provide an interactive, social experience that creates unity within the friend group.

PROBLEM FORMULATION

~~*How to design a new electric go-kart experience for a group of young people that introduces a dynamic driving experience and enhances the interaction between drivers?*~~

How to design a system for an electric go-kart that enhances the driving experience and interaction between drivers, for a group of young people?

KEY INSIGHT	REQUIREMENT	SOURCE
	The go-kart should visualize the obstacles	Page 29 - Final game development
	The go-kart should visualize the game through a display	Page 20 - Degree of reality
	The go-kart should accommodate haptic feedback	Page 33 - Testing potential
	The go-kart should accommodate auditive feedback for the driver while playing	Page 33 - Testing potential
	The top speed of the go-kart should be between 20km/h and <70 km/h	Page 33 - Testing potential
The experience needs an external system to work as intended	The solution should have an external system	Page 35 - Game review
	The steering wheel should accommodate multiple games	Page 35 - Game review
	The steering wheel should accommodate interaction with the game	Page 35 - Game review
	The go-kart should accommodate visual feedback for the driver while playing	Page 35 - Game review
The front should be redesigned to accommodate for display and electric components integration	The front should accommodate for the display and electric components	Page 37 - What to design?

KEY INSIGHT	WISH	SOURCE
	Generate a go-kart experience that has enhanced the interaction and variation aspect	Page 22 - Popular social activities
	The go-kart should visually differentiate each team	Page 29 - Final game development

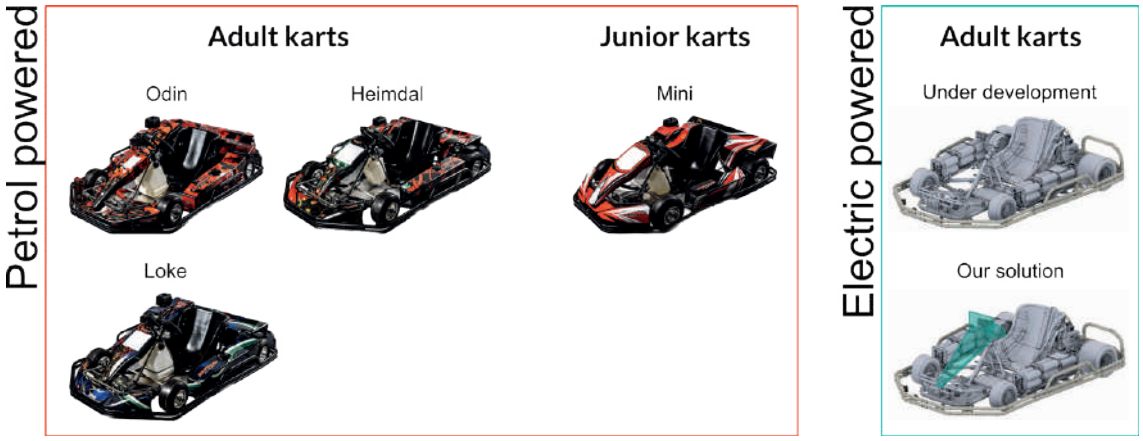
03 FEASIBILITY

The following phase focuses on understanding how the experience and system can become feasible. This happens through an investigation of how the experience should be displayed and what the system requires in terms of software and components to run.

MARKET POTENTIAL

Having verified the potential within the experience and narrowed down the solution from an entire go-kart to a sub-system meant to be mounted on an existing go-kart, it will now be investigated whether the solution has potential from a market perspective.

Through the project, DINO Kart has been of great help in providing knowledge and lending the group a physical go-kart to be used for test purposes. DINO Kart themselves are underway developing their first electric go-kart. Therefore, a business approach of partnering with DINO Kart was presented as a way of getting the solution to the market. By collaborating with DINO Kart, developing the solution could be done using their facilities and go-karts with the trade-off of DINO Kart being the first brand to sell electric rental go-karts with the integration of the solution. Within their product portfolio, a new branch could emerge based on their electric go-kart platform. Here having a go-kart with the project's solution could help expand their product portfolio and reach new markets by having go-karts targeting different audiences. An example of their portfolio with the addition of the solution is illustrated below.



Ill. 44 - Market potential

Through DINO Kart, multiple rental centers could be reached, spreading the name of the new experience. DINO Kart is a company that is broadly used in Denmark and Europe and plans to approach the American market. On the American market, DINO Kart pointed out the solution's potential as they see go-kart more as an amusement experience rather than just a racing experience.

As the solution only focuses on a part of the go-kart, it could also target other go-kart manufacturers; hence, it should be designed to fit multiple go-kart brands.

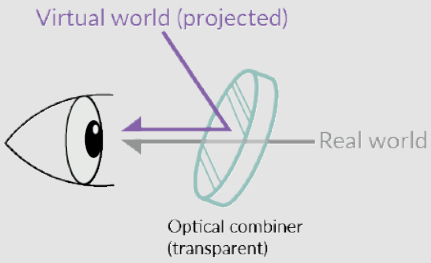
A question appeared whether the new solution should only accommodate the new experience, hence making the current go-kart experience far less suitable. From a business perspective, having the solution fitting in with the current go-karting experience would make the most sense, as the go-kart would not be redundant in cases of guests visiting the rental center only wanting to race. It is stated that the solution should be suitable, to an acceptable extent, for use within the current go-kart experience; thus, the project will focus on designing a solution targeting the new experience.

- The solution should accommodate being used on multiple go-kart brands

DISPLAYING AR CONTENT

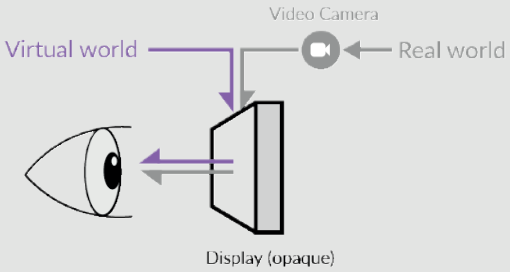
As concluded from the previous phase, a display should be integrated for visualizing the game hence the AR elements. Researching the market of display types shows two ways of displaying virtual elements with AR; Optical see-through (OST) and Video see-through (VST). (ThirdEye Gen, 2018)

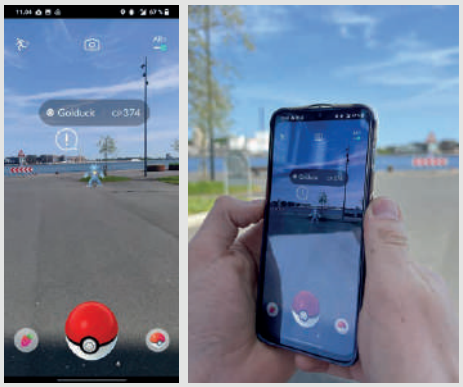
OPTICAL SEE-THROUGH



OST uses a transparent display-element where the user can see the surrounding environment through it. The virtual elements are projected and reflected on the transparent display-element, showing the virtual elements as they were placed into the real environment. A positive aspect of OST is that it allows for a seamless transition from the display-element to the real environment. The technology of OST is seen in newer modern cars in the case of a head-up-display (HUD), where information is reflected upon the windshield.

VIDEO SEE-THROUGH





VST is based on a regular display, as seen in TVs. To use AR, the display relies on a camera recording footage of the environment to be displayed in real-time. From here, by using a processing unit analyzing video data, the AR elements are put on top of the recordings as an extra layer that visualizes the elements as they are placed in the real environment. A positive aspect of VST is that it allows for high brightness of the displayed content. The technology of VST is seen in applications such as the mobile game Pokemon GO.

Ill. 45 - OST and VST

The technology of OST was an exciting solution because it had the virtual elements appear on a transparent display-element, allowing the driver to have a clear view of the track ahead. Furthermore, does the solution appear modern and high-tech, which would fit well within the target group.

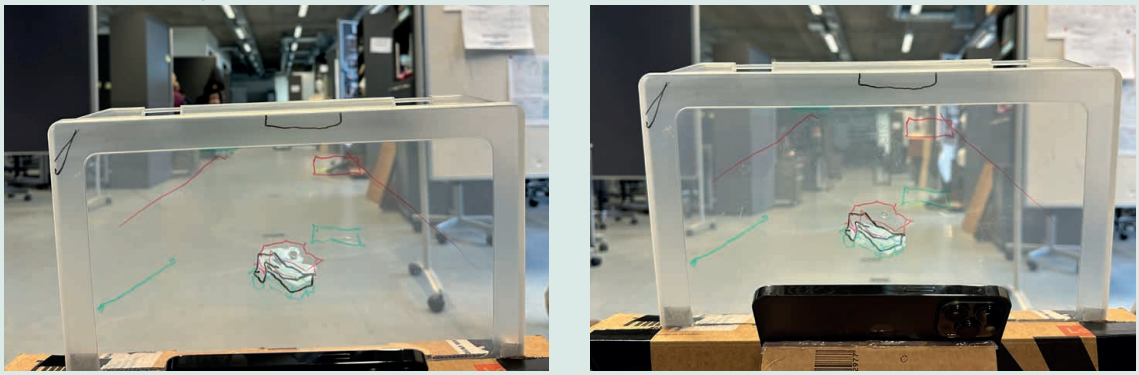
TESTING OPTICAL SEE-THOUGH

How OST would look in real life and what limitations it possesses was tested through a low-fi mock-up. The mock-up was made by setting a transparent plastic lid in front of the go-kart. From here, a smartphone displaying a green arrow was placed behind this lid with an angle allowing a reflection of the screen content to appear on the plastic lid. Now, sitting in the go-kart and looking through the transparent plastic lid, a green arrow would appear as physically placed on the ground in front. It was discovered through initial testing that the arrow's location would change depending on how the driver would look at it. Persons with different heights were asked to sit in the go-kart and outline where they saw the green arrow. A cardboard box was placed 10 meters ahead of the driver to have a physical object to compare with. The participants should likewise outline this box.

The test highlighted that the relative placement of the reflected object onto the way in front and where the cardboard box was seen on the screen heavily depended on the height of the person sitting in the go-kart, see ill. 46. The test was conducted by persons with heights of 160, 178, and 190cm.

For an OST display to work correctly and have the objects placed at the exact location regardless of the driver's height, an eye tracker locating the driver's eyes and movements would be needed. Likewise, as seen from the test, taller persons could see a shorter range of the track ahead through the plastic lid ahead than a shorter person. To accommodate this, the display should be bigger, moved further up, or moved further away from the driver.

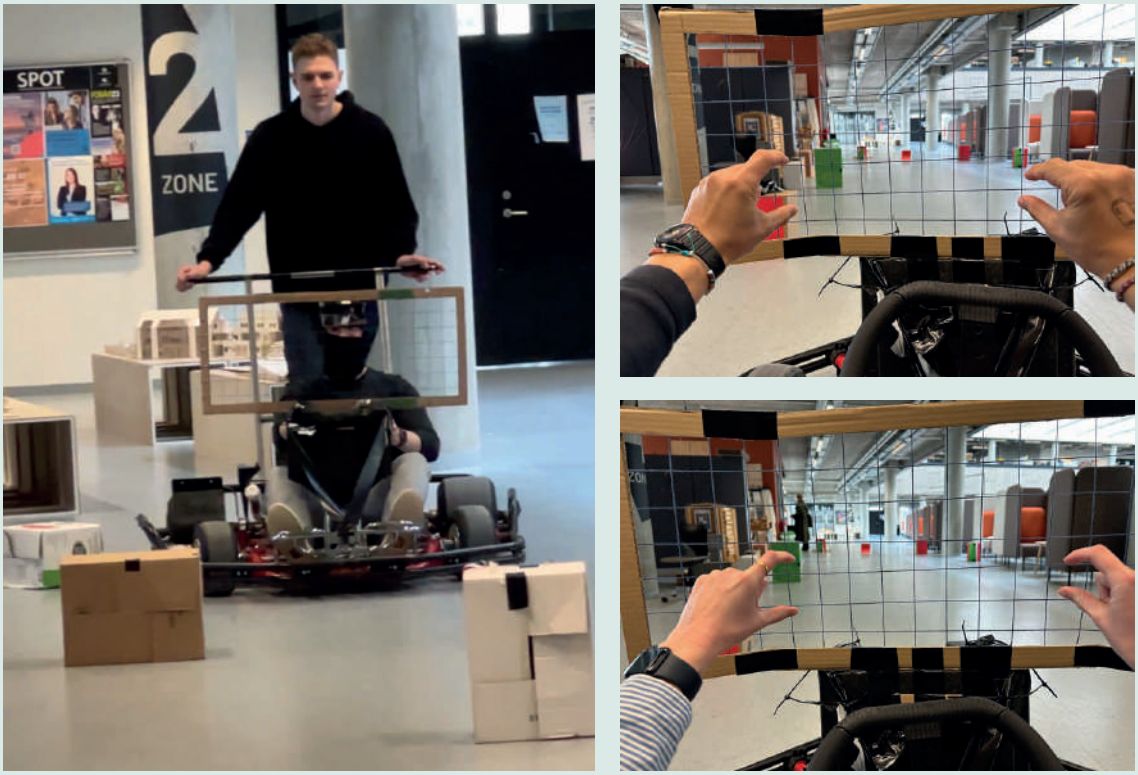
Test low-fi mock-up of OST



Ill. 46 - Mock-up OST

In continuation, a test of the preferred screen size was conducted, see ill. 47. Here to highlight how big the display needed to be for drivers of various heights to see virtual elements ahead. Due to the go-kart driving with a speed of 20-<70 km/h, it would cover around 17 meters every second at top speed. For the virtual elements not to pop out with minimal reaction time for the driver, the screen should accommodate the driver seeing the elements at least 17 meters away.

Test of screen size



Ill. 47 - Display size

Looking into how the technology of OST would be implemented, desktop research was conducted. It was discovered that the construction needed for a head-up-display in a car was too big to be implemented within the front area of the go-kart. Furthermore, OST solutions, not requiring a big setup, were quite expensive and not fitting for the context, as they were seen as too fragile. Several upcoming technologies have presented far smaller and cheaper constructions, making them realistic to be used in the solution in the future. (App. 17) From here, a question appeared within the group;

Design for the present of the future?

From the discussion of market potential from the previous chapter, a collaboration with DINO Kart would require designing a solution that could be used today. Furthermore, as the concept of electric rental go-karting is still new, it makes sense from a business perspective to make something to push out along with the new electric go-karts. In upcoming years, when the technology is more mature, it could be incorporated into future versions.

From the test, testing the potential, see page 30, a regular LCD screen was used with the technology of VST. None of the participants had noticeable issues with having a nontransparent display in front of them as the display presented the environment. An LCD display is sturdy, cheap, and bright and will therefore be used as the display type for the solution. Therefore, a camera is needed to record footage to display on the LCD screen.

- The display is made from an LCD panel
- The solution should consist of a camera

CREATING THE SYSTEM

From the interview with Lars, see page 34, the aspect of an external system setup was pointed out for the experience to work as intended. The following chapter investigates the fundamentals for this system and presents how it should work in order to verify its feasibility. Through this process contact was made with an expert in the field verifying the assumed solutions and helping with the understanding of the system and its requirements. (App. 18)

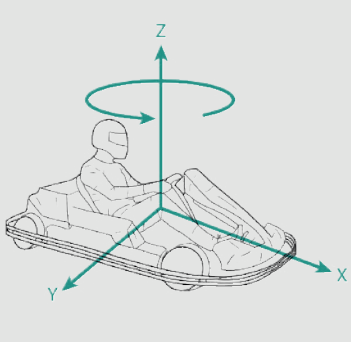
DANIEL

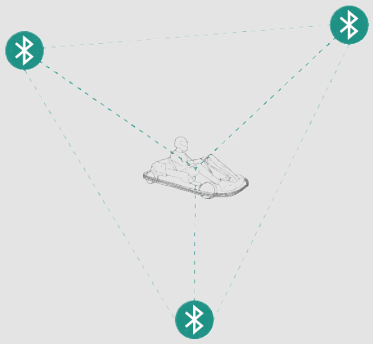
- Systems Engineer, at team. blue

Initial desktop research was made to discover how a system in this context would work on a basis. For the game to know where to put virtual elements, location and orientation of the go-kart and video data is needed. A unit processing the video data as well as the location data is needed to make the game run. And lastly, as the game is team based the go-karts need to be connected through a system that allows for data transfering. The different aspects will be discussed and presented below.

LOCATION DATA OF THE GOKART

To locate the go-karts movement, its x, y coordinates, and the orientation around the z-axis is needed. Through desktop research different possibilities for locating data was found. As the activity is indoor, using low energy blueto-oth beacons (BLE) and placing these around the track would be most beneficial. By using the method of trilateration, the position of each go-kart can be determined. To determine orientation of the go-kart a built in accelerometer into the solution could be used.





Ill. 48 - Location data

- The system shall use BLE beacons for determining the location data
- The solution shall have built in accelerometer for determining orientation data

PROCESSING DATA

To process the data, two ways can be highlighted; a processing unit on board the go-kart or an external processing unit that each go-kart connects to. As AR technology does require heavy processing power, the most feasible way would be to use an external computer thereby avoiding having expensive computers on every go-kart as stated by Daniel. The external computer shall have the power to process location and video data from at least 12 go-karts. As the go-kart needs to collect the location data itself, a smaller microcontroller could be used for this purpose.

- The system shall use an external computer for processing data
- The front part shall have an integrated microcontroller

SENDING LOCATION AND VIDEO DATA

As the processing part does happen at an external computer, the go-karts need to send the data to this unit. For this, a WiFi network will be used connecting the go-karts and the external computer. For this, a WiFi-router and integrated wifi modules within the solution is necessary. WiFi is a feasible option as it accommodates for low latency and high amounts of data transferring, which is necessary as the game should run fluently and in real-time.

How the computer hence the system, works are presented in simple terms below:

External computer receiving	External computer processing	External computer sending
Go-kart positioning data Video data Orientation data	Where to place virtual elements and keeping scores	Virtual element to show on display and updated team scores

- The system shall use a WiFi network to transfer data to and from the karts
- The solution should have a built in WiFi module

It will now be investigated how much data must be sent back and forth between the go-karts and the computer. Here to determine what components to be used within the system.

The data must be converted to bytes to send data from the go-karts. X-coordinates, Y-coordinates, and the go-karts orientation use 6 bytes. Knowing that 1 byte is equivalent to 8 bits, 48-bit will represent the location data. As the computer has to receive and send the data, this number will be double; 96-bit.

When dealing with moving vehicles that shall display AR objects in real-time, latency is significant to consider. Due to data transferring rates, a delay can not be avoided. A delay of 10 milliseconds would be acceptable, as this would, in the case of the go-karts driving 40 km/h, mean that the game refreshes for every 0,11 meters driven.

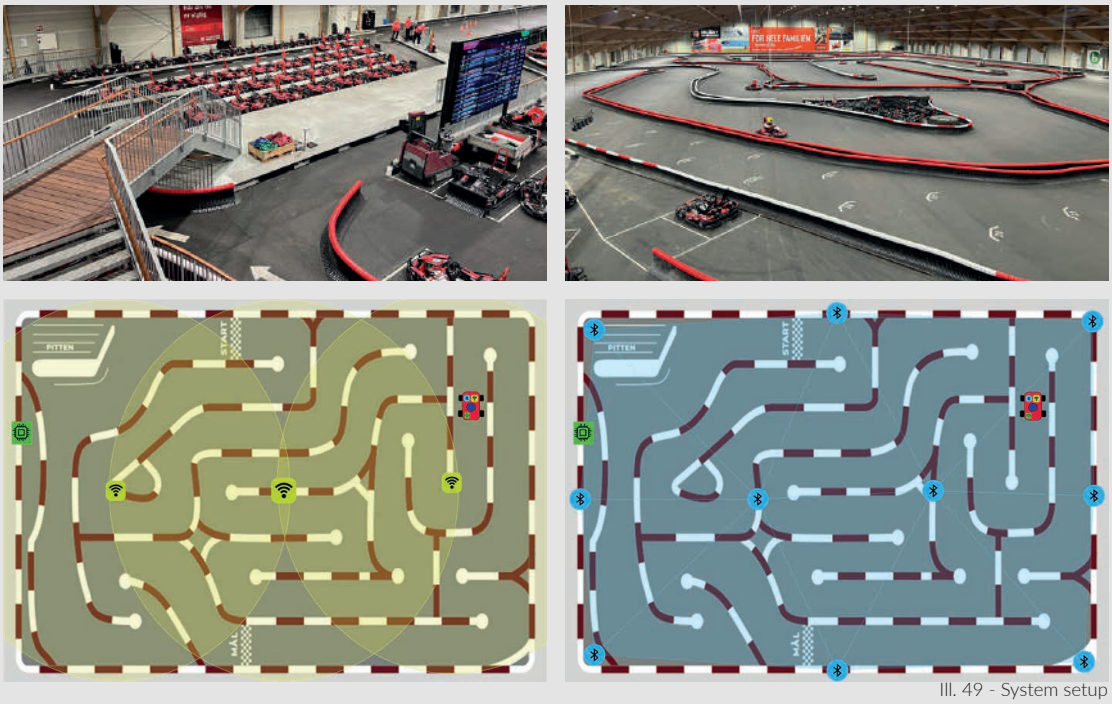
Sending data back and forth every 10th. milliseconds would require the system to handle a transfer rate of 0,0096 Mbps. Assuming that ten go-karts drive simultaneously, the system should be able to upload 0,096 Mbps. Additionally, to the location data, the go-karts will need to send video data of the track, which would further require 10 Mbps per go-kart for 1080p 30fps video (Google support, n.d.). The system would need to send similar video data back rated at the same amount per second, 10 Mbps. In total, the system should handle transfer speeds of 200 Mbps.

WiFi 6 will be used to transfer the data, as it has a transfer speed of up to 9,6 Gbps, which is more than what this system requires (Intel, n.d.). Additional data might come from the game, but it's assumed that additional data can be sent through WiFi 6.

- The system should have a WiFi Router
- The system should have a maximum delay of 10ms

THE SYSTEM SETUP

Illustrations presenting the system setup is shown below. The setup is based on a worst-case scenario that could play out at CPH Racehall, as it is the biggest indoor rental center in the world.

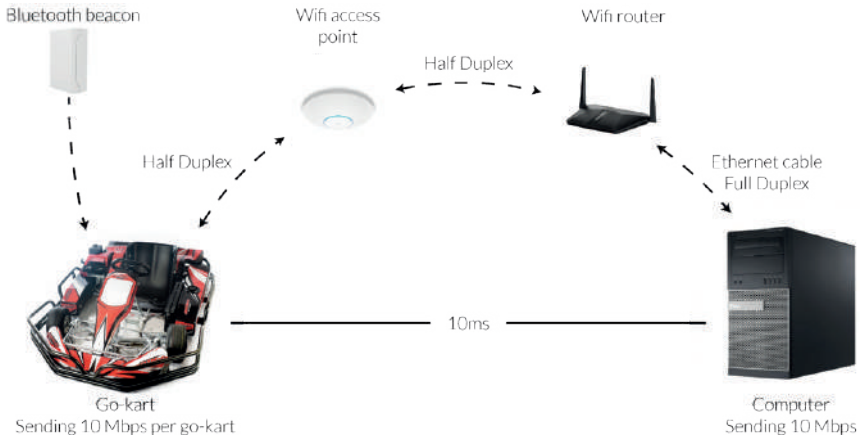


Ill. 49 - System setup

The illustrations show how the WiFi-network and the BLE beacons could be placed. If the track consists of any tunnels or walls, possibly more BLE beacons and WiFi access points are needed.

SETUP FROM GO-KART TO COMPUTER

An illustration presenting the data transfer setup is shown below. To send and receive the data from the go-karts, a Raspberry Pi 4 will be used, due to its flexibility and low cost. The WiFi access points will be placed around the track. Due to this, the connection will be Half duplex instead of Full duplex. Half duplex means it can only send and receive data one way at a time. The main WiFi router is placed as a receiver between the computer and WiFi access points.



Ill. 50 - Data transfer

- The system should have WiFi access points around the track
- The system requires setup time around the track

PHASE SUM UP

SUM UP

The phase investigates how the AR game can become integrated into the go-kart and furthermore the needed setup for this. It is necessary to use an LCD screen instead of an optical see-through solution as the technology isn't developed enough yet to be implemented. The setup requires an external system which includes Bluetooth and WiFi modules around the track to be able to transfer all the data each of the go-kart produces to an external computer.

BUSINESS CASE

The focus of this product is to implement the solution on a go-kart, e.g. DINO Kart, as it is expensive to develop and produce a whole go-kart. Therefore the business will start by approaching go-kart brands to partner with. Likewise, would potentially SYBO and Virsabi be contacted to develop the game and possibly other games as well.

REQUIREMENT	SOURCE
The solution should accommodate being used on multiple go-kart brands	Page 40 - Market potential
The display is made from an LCD panel	Page 43 - Displaying AR content
The solution should consist of a camera	Page 43 - Displaying AR content
The system shall use BLE beacons for determining the location data	Page 44 - Creating the system
The solution shall have built in accelerometer for determining orientation data	Page 44 - Creating the system
The system shall use an external computer for processing data	Page 44 - Creating the system
The front part shall have an integrated microcontroller	Page 44 - Creating the system
The system shall use a WiFi network to transfer data to and from the karts	Page 45 - Creating the system
The solution should have a built in WiFi module	Page 45 - Creating the system
The system should have a Wifi Router	Page 45 - Creating the system
The system should have a maximum delay of 10ms	Page 45 - Creating the system
The system should have WiFi access points around the track	Page 46 - Creating the system
The system requires setup time around the track	Page 46 - Creating the system

04 DEVELOPMENT OF DISPLAY

The following phase revolves around developing the display, its positioning on the go-kart, how the components and display are integrated into the front, while tackling problems occurring from testing such as vibration and reflection from the light.

The next three phases 4, 5, and 6, which revolve around the design of the display, the front, and the steering wheel are being developed simultaneously but are split into three individual phases for better understanding. For each phase, the timeline resets to the start of the development.

Ill. 51 - Testing display

TEST OF INTERFACE

From phase 3, Display AR content, page 41-43, a LCD screen was chosen to display the content of the game. Before going into dimensions and placement of this screen on the go-kart, it would be beneficial to test out first the interface, meaning, what the screen should display to the driver. Based on the final game, see page 34, it was discussed what elements/ information should be displayed while driving. Having information about team scores, individual scores, and power-ups would be essential to make the game work and create the feeling of teamplay. From the interview with Lars, see page 34, he highlighted the importance of severel feedback types, as of why when achieving a point or power-up an auditive respond in the case of a short sound should be played. To test out the assumptions, the interface on the display was tested under the same conditions and with the same setup as seen from the potential test, see page 30-33. Illustration of the interface is presented below.

Ill. 52 - Interface

The participants drove following the premade track, and while driving a prerecorded video was playing showing power-ups and updated team scores and individual points when an “AR-element” was hit.

Ill. 53 - Test interface

Post testing, the users gave feedback on the interface and were furthermore asked if the did notice all the content on the display while driving (App. 17). The test showed that few participants did notice all the content on the screen, due to this being either too small or presented near the sides. What all participants did see was the team-score located at the top middle of the display. Most participants found the presented information on the display as essential as they would want to be informed on this while driving, but it should be highlighted some more for the driver to see it easier. The information regarding team scores were seen as the primary element where power-ups and individual scores were seen as seconday. The information should not be placed in the middle of the display, as it would interfere with the AR elements and the track ahead. The addition of sound provided great feedback while driving, and gave the feeling of playing while making the game easier to understand.

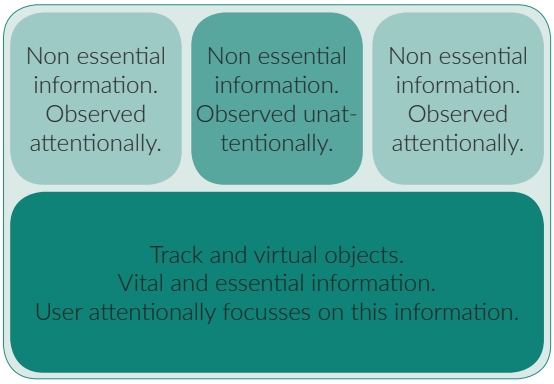
- This test furthermore gave an insight into where the obstacles should be placed, and where they shouldn’t. It was clear that right after corners the user didn’t have a reaction time or would perhaps do a dangerous turn to achieve the point. Therefore the obstacles should be placed a distance from the corner. This length should be tested further. To figure out the optimal distance of this, it should be tested with the actual speed while playing the game.

- A speaker should be integrated within the solution

UPDATED INTERFACE

Based on the feedback illustration 54 presents where the different information/elements should be located.

With the knowledge gained from the test a finalised interface is made. The interface displays the most essential knowledge at the top middle of the screen. Primary information is placed at the top middle with secondary information located near the sides. To highlight the information located near the sides more colors were incorporated to make the content stand out more.



Ill. 54 - Placement of information on display

Ill. 55 - Final interface

DIMENSIONING AND POSITIONING OF THE DISPLAY

Knowing the content of the interface will now be used to determine the needed size and positioning of the display allowing most users to have a good field of view of the track while still being able to see the content on the display.

TEST OF DISPLAY SIZE

The interface from the previous chapter will be used as a baseline for the following test, which revolves around testing the display size to find the size most suitable for the context. A screen size of 10 inches has been tried out in previous tests, so a screen size below and above 10 inches will be tested. The screen will be placed just behind the steering wheel.

A screen size of 6 inches was seen as too small for all participants, as the content was hard to see. To accommodate this, the screen should be placed almost in front of the driver's head, not fitting within the solution or the context. A screen size of 15 inches was seen as too big, as it covered too much of the field of view ahead and did not look fitting for a go-kart. A screen size of 10 inches was seen as the sweet spot, as it could display the content in a readable size and did not interfere too much with the field of view ahead.

Ill. 56 - Test display size

- The screen size should be 10 inch

TEST OF DISPLAY POSITIONING

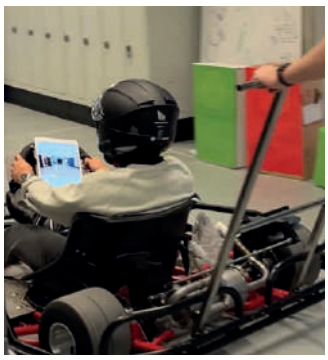
Test of display distance from steering wheel

Seen at Action House, see page 18, a small display was mounted at the middle of the steering wheel displaying personal lap times and lap times on the other drivers on the track. From previous tests, the display was mounted just behind the steering wheel, being the only location in which the display has been mounted. A test was conducted to determine if the display should be placed at the steering wheel instead.

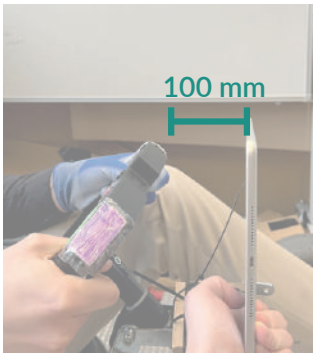
The participants commented on the positioning being too annoying due to the necessity of looking down to see where the virtual elements were placed. Furthermore, the participants highlighted that they would feel uncomfortable driving with a display located on the steering wheel. A location behind the steering wheel is therefore wanted. The location of the display concerning the distance from the steering wheel and the floor, respectively, will now be investigated.

Through testing, it's concluded that the display should be no closer than 5 cm and no further away than 20 cm from the steering wheel. Here to accommodate the hands not touching the display while turning and having the content at a readable distance. A wish is to have the display at close as possible. Therefore the display is placed 10 centimeters from the steering wheel.

Test display on steering wheel



Distance 100 mm



Ill. 57 - Placement of display

- The display shall be placed 5-20 cm behind the steering wheel

Test of display height

Now that the distance to the display is determined, the height placement of the display will be tested (App. 20). People with heights ranging from 160 cm to 190 cm are used as participants. It is a wish to find a distance from the floor, letting the driver have a good field of view ahead and not letting the steering wheel interfere with the displayed content.

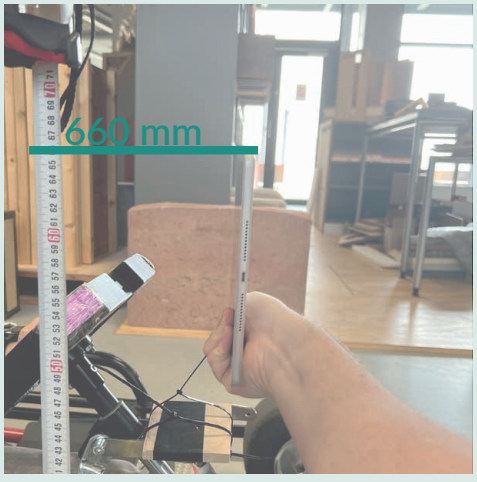
To determine how much of a clear sight the driver must have (e.g., how far away they should be able to see the course of the track and react upon it), a person's reaction time will be used as a benchmark. The course of the track will be determined by the barriers that have a height of 60 centimeters. An average reaction time for a person is around 0,2 seconds (Human benchmark, n.d.).

A safety factor of 6 is used, giving the driver 1,2 seconds to react. An average top speed of a rental go-kart ranges from 60-70 km/h, which makes the go-kart cover a distance of around 20 meters every second. When considering the safety-factored reaction time, a covered distance would be about 24 meters. Therefore, the driver needs to see the course of the track (the top of the barriers) at least 24 meters ahead.

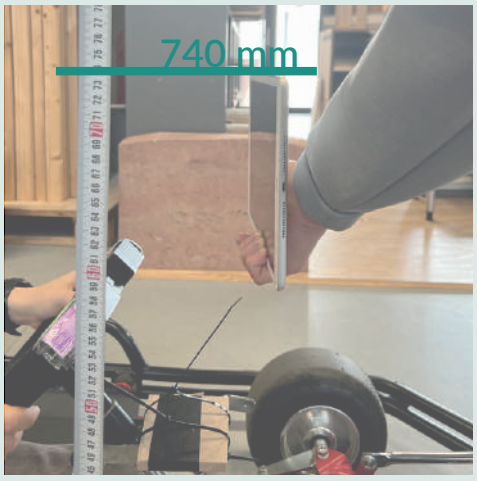
The test setup was made by placing a go-kart 24 meters from a wall. On that wall, a line 60 centimeters from the floor was drawn. A participant was placed in the go-kart, and the display with a 10 cm distance to the steering was lowered until the participant could see the line on the wall. From here, it was further lowered until the top of the steering wheel would interfere with the content on the display. It was discovered that the lower the persons were, the lower the display needed to be. As a short person would have the lowest line of sight, the requirements will be based on that person's test.

It is concluded that the top of the screen should be at least 66 centimeters and not above 74 centimeters from the ground. The lowest placement of the screen is preferred because this will increase the field of view of the driver.

Display height min 660 mm



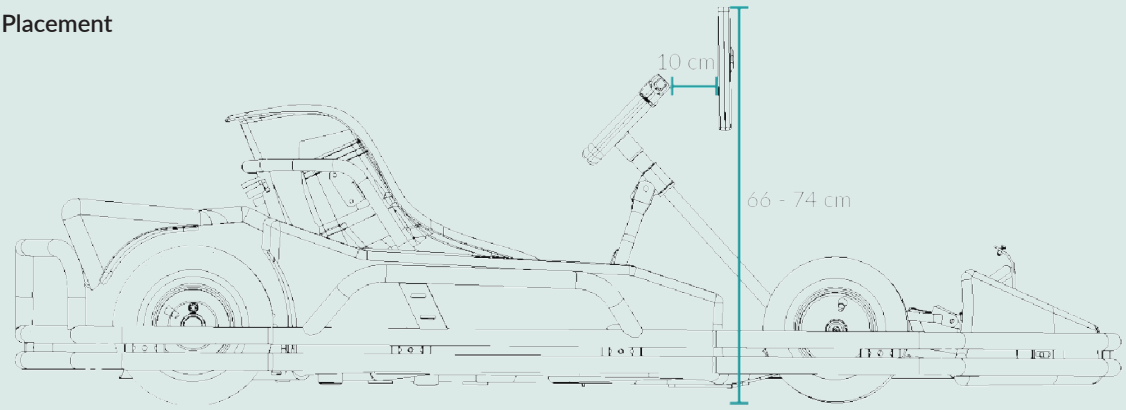
Display height max 740 mm



Ill. 58 - Height placement of display

- The top of display shall be placed between 66-74 cm from the ground

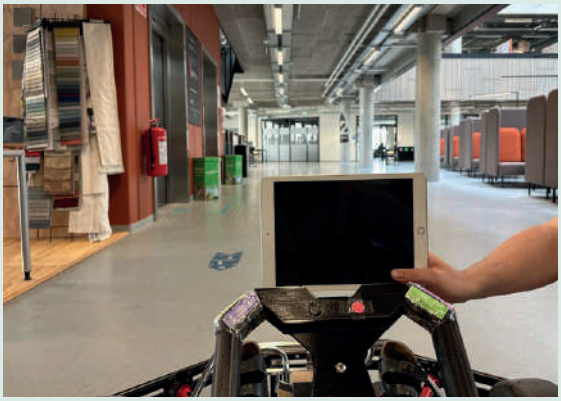
Placement

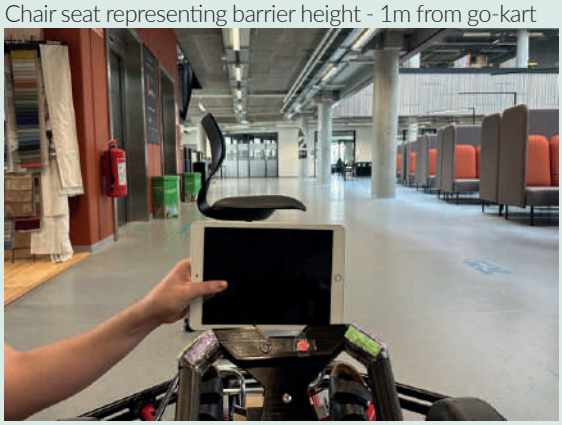


View from seat

View from seat

Chair seat representing barrier height - 1m from go-kart

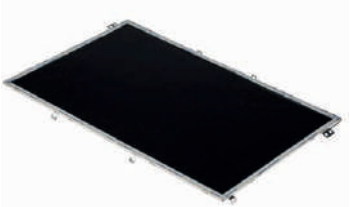




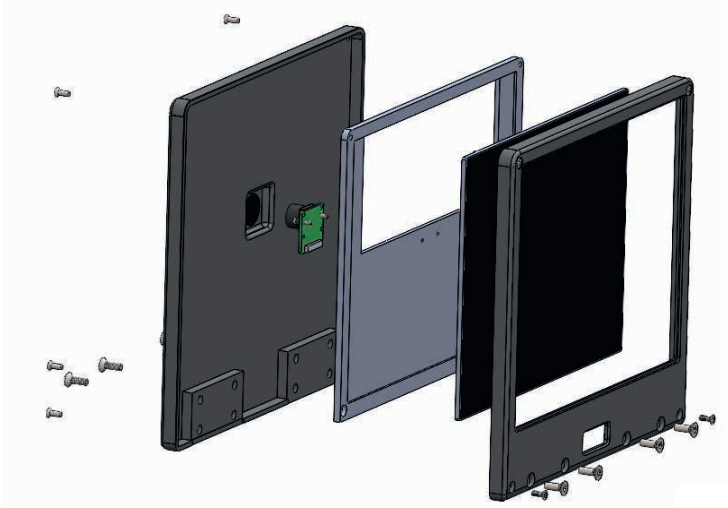
Ill. 58 - View and placement of display

DESIGNING THE DISPLAY CABINET

An iPad/tablet has been used as the display mock-up through various testing. However, this would not be a viable solution for use in a real case due to costs and the tablet's software and hardware integration difficulties. As a microcontroller should be incorporated within the solution, all components should be microcontroller compatible. Relying on a self-chosen screen panel makes the solution far more flexible and, thereby, easier integrative. As stated in previous chapter, the display should be based on an LCD panel, which can be found cheaply in the desired size.



Ill. 59 - 10-inch LCD panel

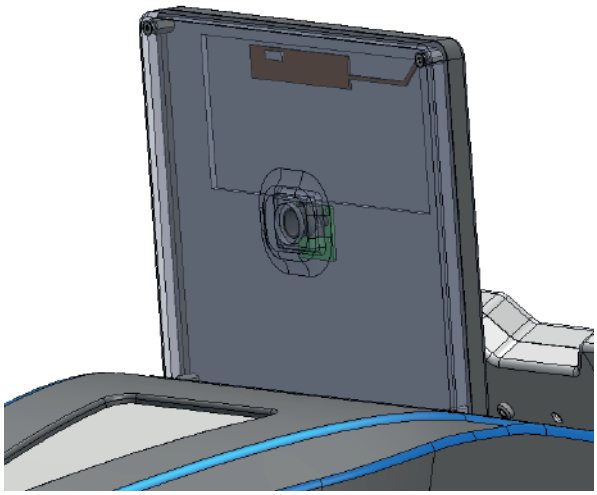


Ill. 60 - Exploded cabinet

POSITIONING OF THE CAMERA

Knowing that a camera should be implemented into the solution to record video footage to be shown on the display, a test investigating its position of it was conducted. The placement of the camera impacts how the content on the display is viewed in comparison with the surrounding environment. It is a wish to have minimal distortion within the transition between the display and the surroundings. Different camera placements and their influence on the content shown on the display are presented below.

From the tests, having the camera as close as possible to the driver's line of sight would result in a less distorted transition. Due to this, the camera will be placed within the screen cabinet on the back, hence protecting it as well. Furthermore, the lens and the camera's zoom influenced the shown image, as this would affect the perspective. The camera component will be a camera module with a standard zoom, and a wide field of view will be chosen for the camera component.

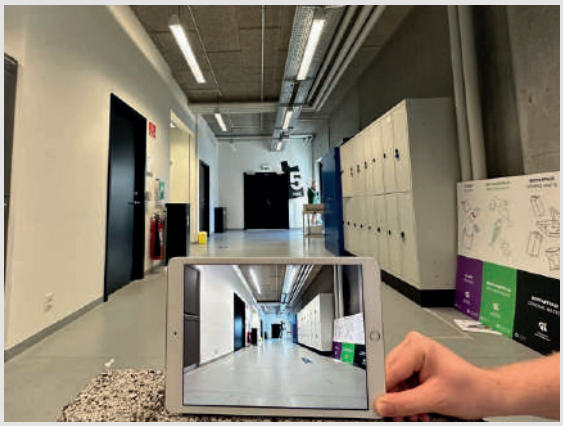


Ill. 61 - Camera placement

CAMERA POSITION - DISPLAY LEVEL

1x zoom

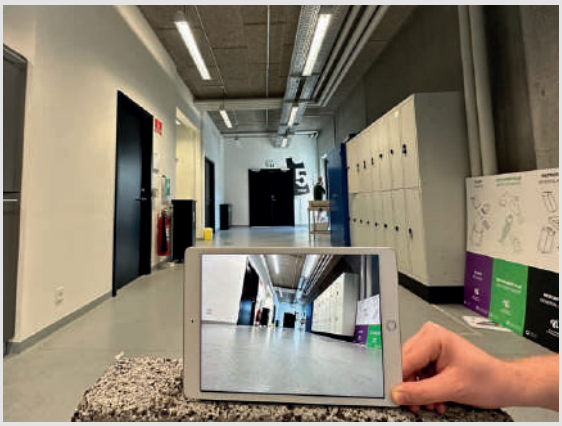
0,5x zoom



CAMERA POSITION - GROUND LEVEL

1x zoom

0,5x zoom



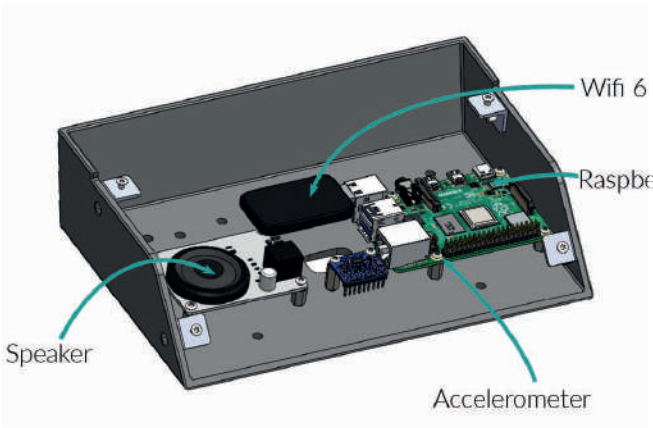
Ill. 62 - Test camera placement

- The camera should be placed behind of the screen

DESIGNING THE COMPONENT BOX

As mentioned in the "What to design?" chapter from phase 2, see page 37, it was pointed out the need to integrate several different electrical components into the solution. A viable solution is gathering all these components within one box, making it a simpler construction, easier assembly, and easier repair and replace broken components. This box could serve as the base for the screen cabinet connecting and collecting all electric components in one place. The required components and their placement within the box will be presented below.

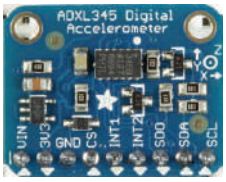
The box is made simple for cheap and easy construction, and the components are fastened by standoffs that can be screwed into the bottom, making them easily replaceable. The screen cabinet is mounted with screws within the box, making it stiff and easily removable.



Wifi 6 module

Raspberry Pi 4 with integrated bluetooth 5.0

Accelerometer



Speaker

Ill. 63 - Electric components

To protect the components within the box, a cover lid will be fastened upon the box by screws, making entering the components accessible. Outputs for sound from the speakers have been made in the cover lid so the driver can hear the sounds more clearly.

As the components should be easily reachable at the rental center, the box must be placed on the top side of the front. Due to having the display integrated within the box, the box must be located close to the driver. Known from Power Racing, the engine of their electric go-kart can be controlled by a 3-way rocker switch changing the state of the engine to forward, neutral, and reverse.

Upon the lid, a similar rocker switch will be placed. Having it on the box instead of the redesigned steering wheel would ensure that the driver would not hit the switch unintentionally while driving, as it only should be used when the go-kart is not moving.

Ill. 64 - The box

THE ASPECT OF VIBRATION

While testing the interface, see page 49 it was observed that the display shook a bit while driving. Knowing that the screen cabinet and the component box consist of sensitive electronic components that could malfunction if exposed to high vibrations. The go-kart's only dampening system is within the tires, absorbing some of the unevennesses from the surface. The vibrations could thereby be a problem for the electronic components and will be investigated in the upcoming chapter.

Vibration of screen

Ill. 65 - Vibration of screen

TESTING VIBRATION

When designing to avoid vibration in a specific object, a goal is to prevent the object from hitting its own natural frequency, as this could lead to damaging the object (Cadence, 2022). A test was conducted to determine the vibration level on board the go-kart while driving (App. 21). The test was done by attaching a smartphone to the go-kart. Using an app utilizing the smartphone's integrated accelerometer, acceleration along the X, Y, and Z axis could be measured, indicating the vibration level/frequency. The go-kart was pushed on an asphalted road, with a surface similar to what you find at rental go-kart centers. The test was done over 17 seconds with a speed of approximately 7 km/h. The readings are focused on acceleration along the Z-axis, e.g., how much and often the phone would move up and down. The setup and readings from the test are presented below.

WITHOUT DAMPER

WITH DAMPER

Ill. 66 - Test of vibrations

An assumption was that putting something shock-absorbing under the smartphone would decrease the acceleration levels, hence reducing the amount of vibration. Here by laying some damping material (soft foam) beneath the smartphone. The same test setup was done once more. When comparing the two test results, it could be seen that the acceleration levels were decreased. Therefore putting in some damping materials could reduce the acceleration levels hence the vibration. Further investigation is needed.

Reviewing the test results

Retrying the tests highlight inconsistency within the data which points out flaws within the sampling method. This could be due to unawareness of sampling rates, and more specialized equipment would be used to measure vibrations in an ideal case. Within petrol-driven go-karting, much of the vibration comes from the motor. As the solution targets electric-driven go-karts, vibration from the engine will not be an issue. Therefore most vibrations would be due to unevenness on the track surface. Even though the results might not provide any validity, the vibration aspect is still to be considered. Therefore the subject of dampening elements will be investigated in the following chapter.

REDUCING VIBRATION

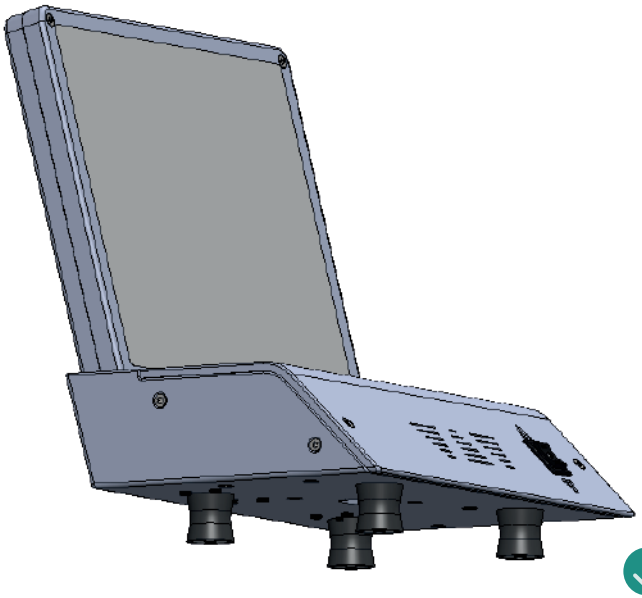
With desktop research, an investigation into the market of dampers within similar environments was made. Here the brand of Quad Lock was discovered. Quad Lock specializes in smartphone mounting gear for various vehicles hereunder, bikes, cars, and motorcycles. They have made a vibration-dampening mechanism to accommodate the many issues people had with their smartphone cameras malfunctioning due to high vibrations when mounted on a running motorcycle at moderate to high speeds.

Ill. 67 - Quad Lock

The dampening mechanism consists of a silicone rubber dampening ring attached to the phone with three rubber bushings placed to absorb vibrations between the phone and the attachment point to the motorcycle. Quad Lock demonstrates a viable solution to reduce vibration within an object mounted on a running vehicle. (Quad lock, n.d.)

The mechanism of rubber bushings will be used to reduce vibration within the electric components. As all electric components are collected within the component box, it would be most feasible to dampen the box. As a result, the box is connected to the front part by rubber bushings.

As the levels of vibration are an unknown factor that can vary from track to track, it is essential to consider for an easy dismantling of these rubber bushings. Different rubber bushings with different hardnesses, e.g., rubber mixes, could accommodate various tracks and surfaces. A vibration test could be done at the specific rental center to know what kind of bushing to install within the solution, thereby getting the solution with a suitable dampening mechanism.

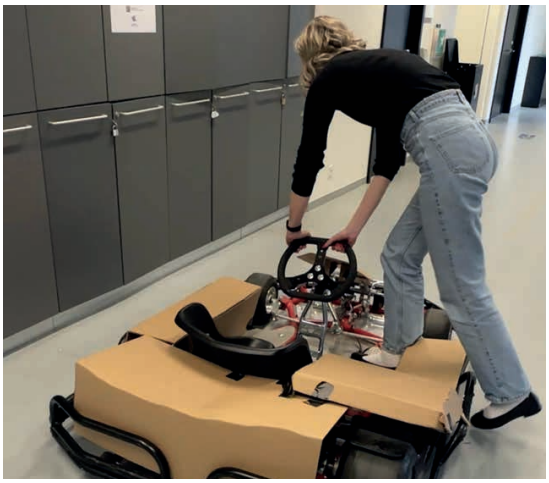


Ill. 68 - Dampers

- The display setup should have interchangeable dampeners

INTERACTION WITH THE DISPLAY

Through observations from the rental centers and previous tests, it was noticed that for the user to get in and out of the rental go-kart, they would, in most cases, grab the steering wheel and/or the seat before getting down. This is because the seat is very close to the ground, and something to hold onto is needed to keep balance while lowering oneself down the seat. The steering wheel and the seat were targeted objects in this situation as they are the highest points on the go-kart.



Ill. 69 - Interaction point getting into the go-kart

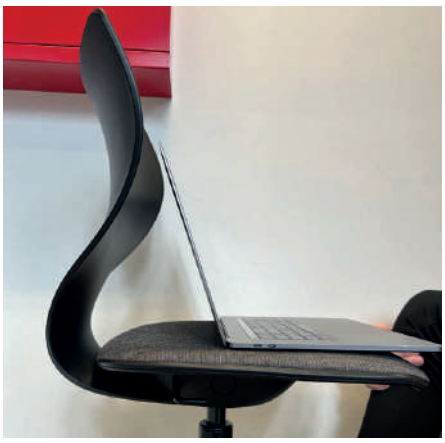
Having the display on the front would create a new highest point, making it the point users would use to gain balance. It was discussed within the group if it was desirable for the users to use the display as a grabbing point; hence it would set some requirements for its strength. Due to the display being a fragile element, it would be beneficial making the users seek another point of the go-kart to grab. Therefore, the display should signal weakness by letting the user know that the display is not for holding onto before lowering oneself.

The display is relatively thin, already signaling low strength, but its rigid fastening could still invite for usage when first grabbing onto it. A short ideation was made with ideas on how to make it feel like a non-grabbable object. The idea of making the display move in the sense of making it rotate back and forth a bit seemed an interesting idea as this would make the display seem loose. This would accommodate another mentioned problem, with users stating that the angle at which they looked at the screen was bothersome. This issue did appear the most for people above the height of 175 cm as they would look more down at the display than people with lower heights. The display should thereby be able to rotate in the same manner as seen in laptop computers.

The angle at which the display should be rotated will be tested and presented below. A screen was set up in front of a test participant with the determined positioning from the driver and floor. The participants were then asked to angle the display until a desirable angle was reached. Participants with heights ranging from 160-190 cm were asked.

95°

105°



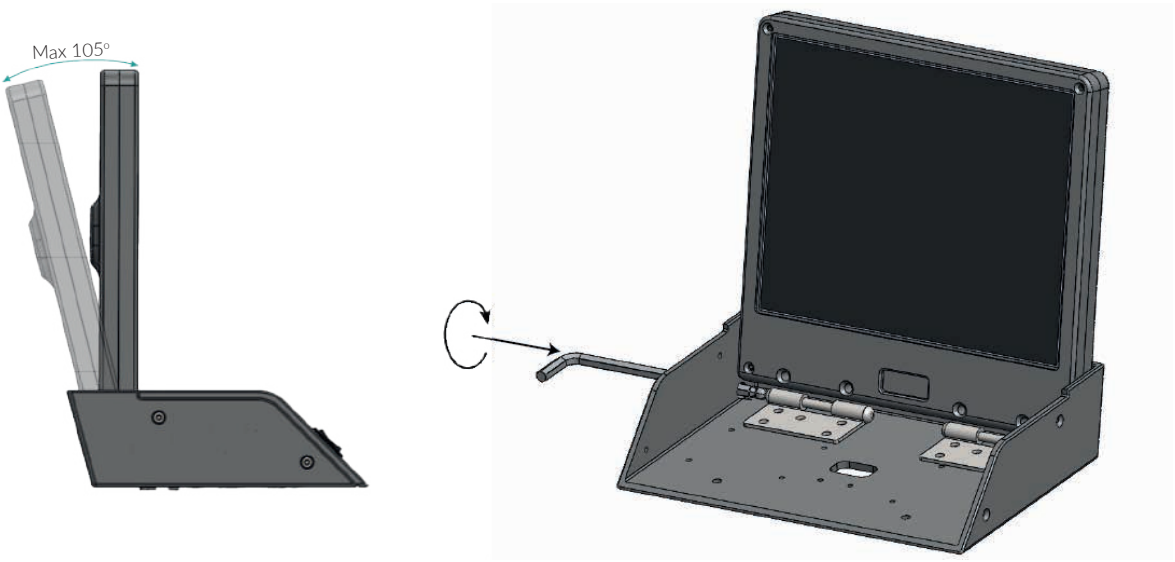
Ill. 70 - Test of display angle

Angles ranging from 95 degrees to 105 degrees backward were seen as most preferable to look at. During the test, it was too highlighted that angling the display could help users avoid top lighting reflecting upon the screen.

- The display should rotate backward to a maximum angle of 105 degrees

A hinge should be incorporated to accommodate the display's rotation. A criterion for the hinge is that it needs to be tight enough for the screen not to rotate by itself or even when deaccelerating the go-kart and loose enough for the user to rotate the display themself. Furthermore, should the hinge's tightness be easily adjustable, letting the workers at the rental centers tighten the hinges if the display seems too easily rotatable.

Different hinge solutions could be used, and further testing in a real environment would be needed to determine the exact hinge type. For the sake of this project's focus, the hinges will be looked into no further.



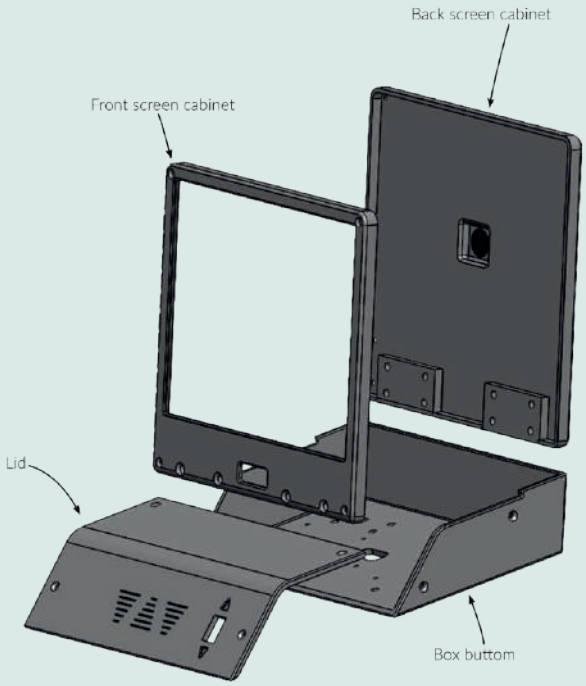
Ill. 71 - Hinge

MATERIAL

The material for the display cabinet and the component box needs to be lightweight, flexible, and resistant to impacts. The plastic type of polypropylene has been chosen to accommodate the stated criteria (Hindle, n.d.). Furthermore, polypropylene is a commonly used plastic in various parts within the car segment.

PRODUCTION

The display and the component box will be produced through vacuum forming as this is an inexpensive production method capable of handling the designed parts. For creating the molds to be used for vacuum forming, these will be 3D printed with a material capable for vacuum forming multiple times. The simple part of the component box, the lid, will be produced by bending and cutting a sheet of polypropylene plastic. All holes and cuts will be made by drills afterward.



Ill. 72 - The box

PHASE SUM UP

SUM UP

This phase investigated the dimension, placement, and problems that occurred by having a screen on a go-kart. The problem of vibration needs additional equipment and testing in the right context to understand how critical this is in the context of implementing the solution on an electric-driven go-kart.

REQUIREMENT	SOURCE
A speaker should be integrated within the solution	Page 49 - Test of interface
The screen size should be 10 inch	Page 51 - Dimensioning and positioning of the display
The display shall be placed 5-20 cm behind the steering wheel	Page 51 - Dimensioning and positioning of the display
The top of display shall be placed between 66-74 cm from the ground	Page 52 - Dimensioning and positioning of the display
The camera should be placed behind of the screen	Page 54 - Designing the display cabinet
The display setup should have interchangeable dampeners	Page 57 - The aspect of vibration
The display should rotate backward to a maximum angle of 105 degrees	Page 58 - Interaction with the display

05 DEVELOPMENT OF FRONT

The following phase covers the development of the front of the product solution. This phase defines the identity of the design, the design process through market research and ideations, and lastly, describes the construction in terms of mounting, materials, and production of the front.

Ill. 73 - Feedback on front design

MARKET RESEARCH

The front is seen as a prominent part due to its size and placement on the go-kart, one of the first areas people notice. As the solution is only a sub-part of the entire go-kart, the front part must fit in well with the rest of the go-kart's design and form. Thus, this should still, through its design, signalize something else and something new. Talking with Rasmus from DINO Kart highlighted the essential aspect of variation as electric-driven go-karts should stand out from the original petrol-driven ones.

To understand how different go-karts look today, market research was conducted highlighting different brands of go-karts and how they vary in design and style. Both electric-driven and petrol-driven go-karts have been considered. Six different go-karts with associated adjectives describing their key design elements have been highlighted.

Electric-driven

Futuristic
Sharp edges
SlimPlayfull

Bulky
Heavy
High-tech
Geometric

Big surfaces
Modern
Abrupt transitions
Restrained

Petrol-driven

Aerodynamic
Organically shaped front
Slender form
Simple

Visible chassis
Deconstructed
Minimal bodywork
Honest

Bulky
Massive
Curved

Ill. 74 - Market research

Looking at the electric-driven go-kart, a different design language and style is present compared to the petrol-driven ones. The petrol-driven ones signal more speed and racing with their slim, organic shapes, while the electric-driven ones are more massive in form and signalize more modernism with their geometric shapes. Looking more into the front part, the electric-driven go-karts are more massive, emphasizing straight lines and sharp edges. Thus this reduces some of the characteristics regarding speed, as seen with the more slim and organic shapes of the petrol-driven go-karts.

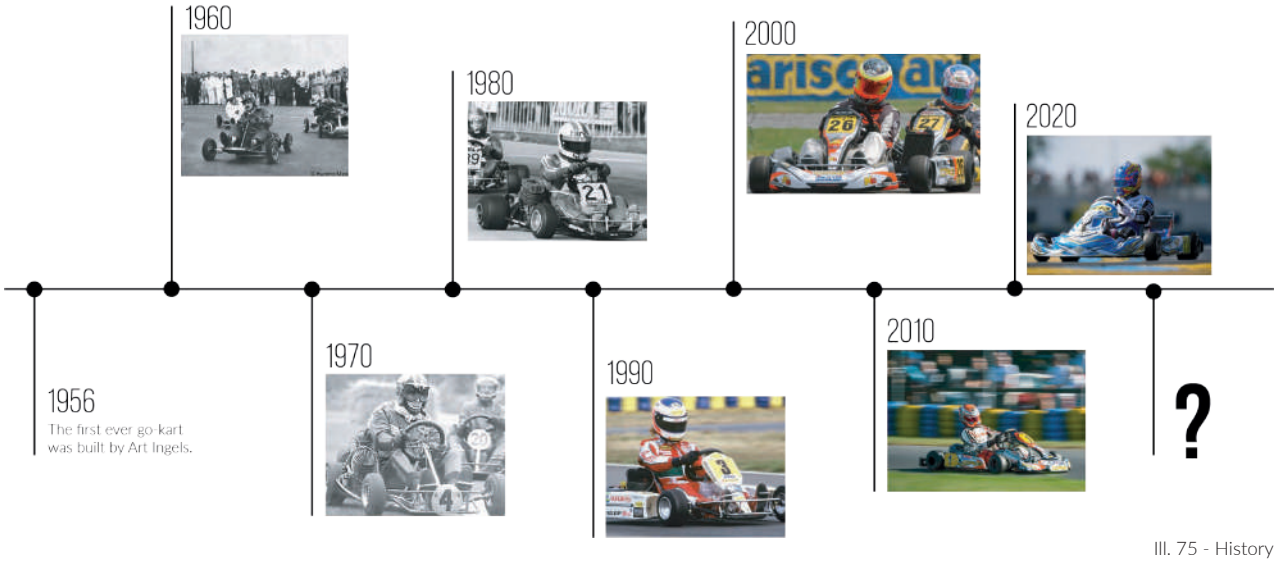
It is a wish to make a front signaling uniqueness in terms of gamification and suitable for the design language of an electric go-kart. From the market potential from Phase 3, see page 40, it was stated that the solution hence the front part, should accommodate for original go–karting (racing). Thus, the design language should take inspiration from current petrol-driven go-karts and the context, as the solution targets existing rental centers.

- The design language of the front should signalize uniqueness
- The design should express gamification
- The design language should fit an electric-driven go-kart
- The design language should accommodate racing and the current context

THE HISTORY OF GO-KARTS

From interviewing Karsten from Action House, it was pointed out that the design of the go-karts had stayed the same for many years (App. 4). Desktop research was conducted to highlight the go-kart design throughout the years (FIA karting, 2023).

The research showed that the design has been similar, with few incremental changes over the years. To emphasize the new experience, the target of another market/user group, and the electric drivetrain, some newness in the design language is needed. With the acquired knowledge from the market research, some reference points have been made that will serve as the baseline for designing the front part.



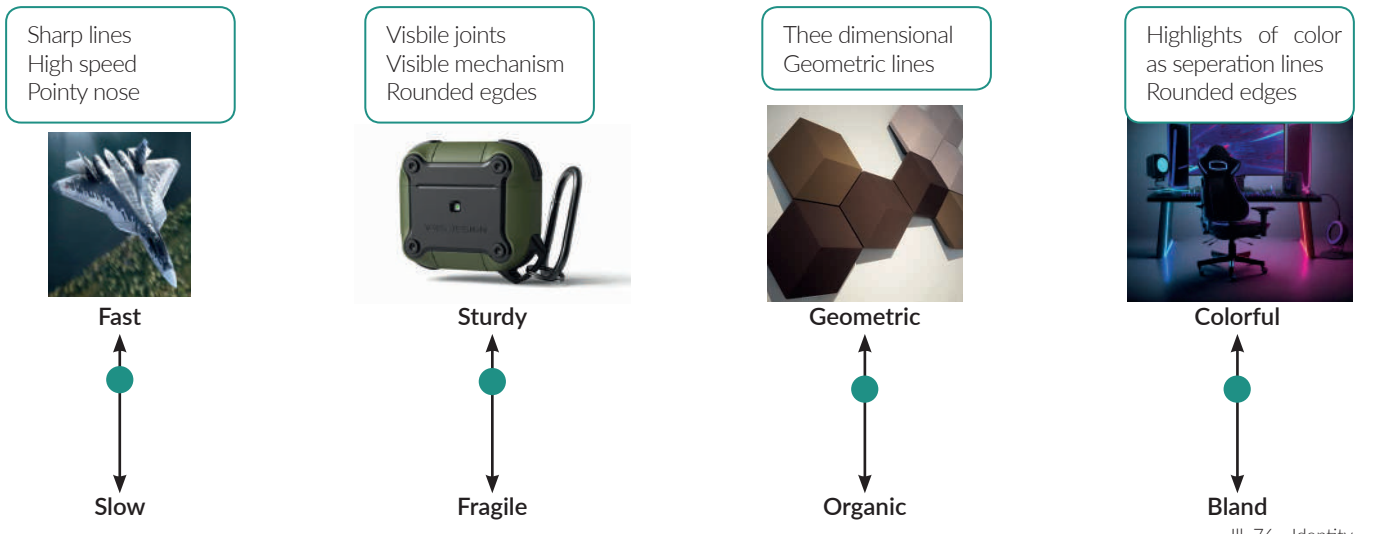
Ill. 75 - History

- The design language should signalize newness

DEFINING THE IDENTITY

Based on the previously stated wishes, the identity of the solution will now be investigated to highlight some keywords to be used when ideating upon the design of the front. The design should take inspiration from gamification, hence gaming and the current go-karting, why these words will be used as a baseline for describing the wished identity.

The identity should be described as fast and sturdy to fit into the context of go-karting and geometric and colorful to signalize gaming/gamification hence the new experience.

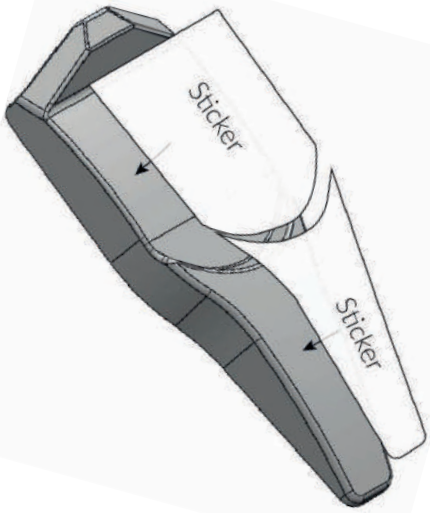


Ill. 76 - Identity

- The front should have a design language signalizing fast, sturdy, geometric, and colorful

DESIGNING FOR VARIATION

The Go-kart manufacturer of DINO Kart sells go-karts to multiple rental centers. They use stickers on the bodywork to change the go-karts style to offer a more personalized go-kart well fitting for the rental centers. From the field studies, see page 3-4 it was discovered that many rental centers had stickers on their go-karts showing their colors and logos. Due to the bodywork of large plain surfaces, stickers are an easy and cheap way to offer variation and personalization. This technique will be adapted, which sets requirements for the surfaces on the front part, allowing large stickers to be placed. Therefore, this aspect will be considered when designing the front.



Ill. 77 - Stickers

- The front should accommodate placement of large customizable stickers

IDEATION OF FRONT

An ideation was conducted based on the knowledge of identity and the need for stickers. Six concepts were made, each based on the identity words at different levels to allow for variation and test the poles of go-karting and gaming. Furthermore, integrating the display and component box and its coherence with the front part was considered.

The front part was placed on an existing go-kart to test out its coherence with an existing go-kart. The concepts on the go-kart were printed out and shown to the target group to gain feedback on its form and design language concerning the experience and the current context. Furthermore, a 3D file was shown, where the participants could see the concepts from all angles. The concepts are presented in the following pages with associated comments from the participants (App. 22).

Ill. 78 - Feedback on front design

OBS

During the time of this ideation, the finalized design of the display and component box was not done. Hence the only thing designing from was the requirement of having the display hence the component box at the top side of the front part

Concept 1

Concept 1 takes **inspiration in supercars** with inward surfaces with a combination of slits with highlights of colors. The display has a smooth transition to the front part.

*"It looks sturdy [...] It is **alien** to the go-kart context" - Camilla*

*"Looks like an **add-on**" - Nikoline*

Concept 2

Concept 2 is taking **inspiration in gaming** with colored lines highlighting the edges. Here the display is covered by the front, making a coherent design of the screen and front. This also makes the design look more bulky and sturdy.

*"A bit **foolish** in its appearance [...] Too **heavy** in its form " - Camilla*

*"**Looks like a mask**. It doesn't say go-kart or speed" - Christina*

Concept 3

Concept 3 is taking **inspiration in the original go-kart** front where small gaming details are placed, such as a colored triangle triangular cutout. The concept has the screen exposed, with an abrupt transition.

*"If you would like to **show of the screen**, the abrupt transition is nice" - Christina*

*"Looks well thought through [...] Gives **gaming vibes** [...] Looks **fast** [...] **Its okay to make it look like, what it is** (referring to the obvious screen)" - Nikoline*

"It looks like honest design" - Camilla

Concept 4

Concept 4 emphasized on an **organic and aerodynamic expression**. A red color was used to signalize speed. The use of blue and black colored details was used to incorporate gaming elements.

*"**Nice integration** between sharp edges and curvatures [...] **Does not stand out** compared to the current go-karts" - Christian*

*"**Pretty nice with the shapes** [...] The transitions is good" - Danny*

Ill. 79 - Front concepts

Concept 5

Concept 5 is taking inspiration from **geometric shapes** found in **gaming equipment**. A cutout with a transparent element letting light run through it was added through the middle. The front is covering half of the display giving a less hard transition.

*"So **cool with the see-through** element" - Camilla*

*"Nice with the **gaming features** of the transparent element" - Martin*

Concept 6

Concept 6 is based on concept 5 but has a smaller cutout through the middle. The transition to screen is made less abrupt. Green colors are added to symbolize gaming.

*"**Nice combo with the colors**, but doesn't fit with the go-kart" - Christian*

*"**Too clumsy** [...] Needs more rounded edges to have a more finished design" - Danny*

Ill. 80 - Front concepts

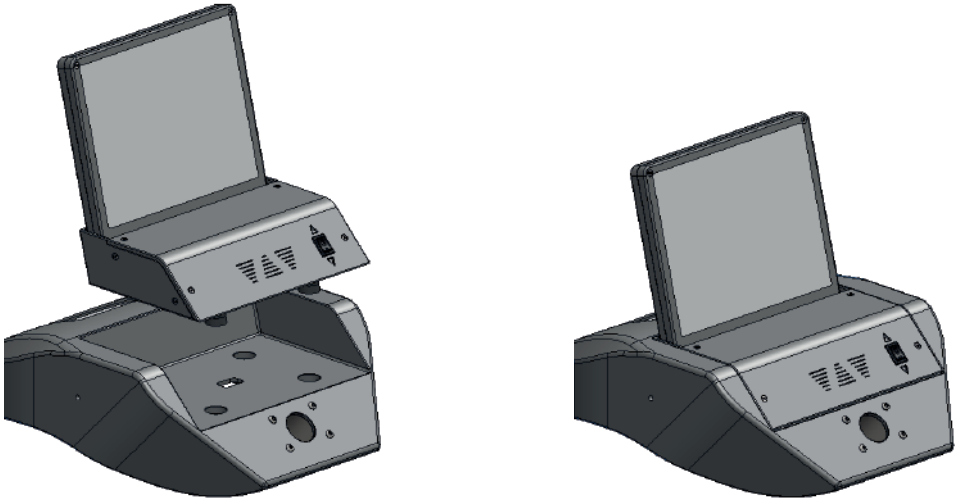
Overall, the participants most liked the form and design language of Concept 3 and Concept 4. Here due to them fitting well with the go-kart and their sleek design, signaling speed. They, too, expressed something new and unique, further highlighting the experience. Concept 3 did signal gaming most of the two, as it was sharper, more geometric, and had a black-colored base. The participants highlighted that the facet of gaming was clearly shown by incorporating some color elements, e.g., lines in gaming colors (green or purple). From Concept 5, almost all participants pointed out that the principle of having a transparent element from which light could come through was very neat. It provided the feeling of the go-kart being gaming equipment without making it too caricatured. It was pointed out that the screen should not be hidden within the front, if it was a design feature, that should be visible hence supporting the feel of the new experience.

To conclude, upon the feedback gained, the front should have a design language consisting of a mix of Concepts 3 and 4 while having the principle of a transparent element from Concept 5. Overall, the color of the front should be kept black with some colorful features on it.

INTEGRATION OF THE COMPONENT BOX

From phase 4, the development of the display, the finalized display, and the component box were presented. As stated, these components should be integrated within the front and mounted with rubber bushings. To have a seamless transition making the box a visually integrated part of the front, an immersion in the front of the front part was made.

The bushings are fastened in the bottom of the component box and afterward mounted to the front. This makes the component box, the display, and the rubber bushings easily replaceable.



Ill. 81 - Integration of box

FINALIZED FRONT CONCEPT

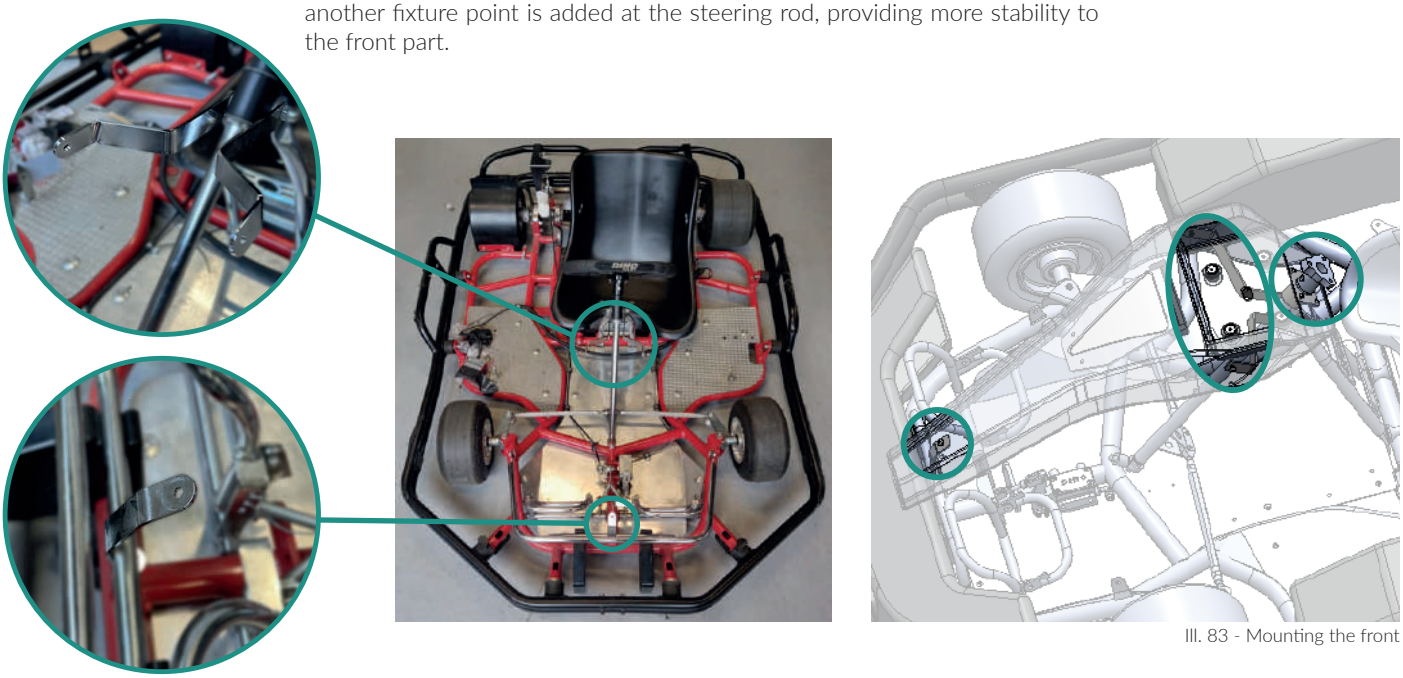
Knowing the desired preferences of the target group, a final concept of the front was made. The front combines the sharp geometric edges from Concept 3 with the organic curvatures from Concept 4, showing a unique form and expression signaling gaming and speed while being suitable for the current go-kart context. In the middle, a triangular cutout has been made with a transparent element beneath that can light up using LED strips. The screen should be seen as a symbol of the solution and why it's highlighted by letting it stand independently.

Ill. 82 - Final front design

CONSTRUCTION

MOUNTING

As mentioned in phase 2, section; “What to design?”, the solution will be produced in partnership with DINO Kart, meaning that the front part should be mounted on their go-karts. Their front parts are mounted at three points and fastened by screws, as seen on ill. 83. This mounting type is quite common, seen on multiple go-kart brands. As more weight is added to the front part, another fixture point is added at the steering rod, providing more stability to the front part.



Ill. 83 - Mounting the front

MATERIAL

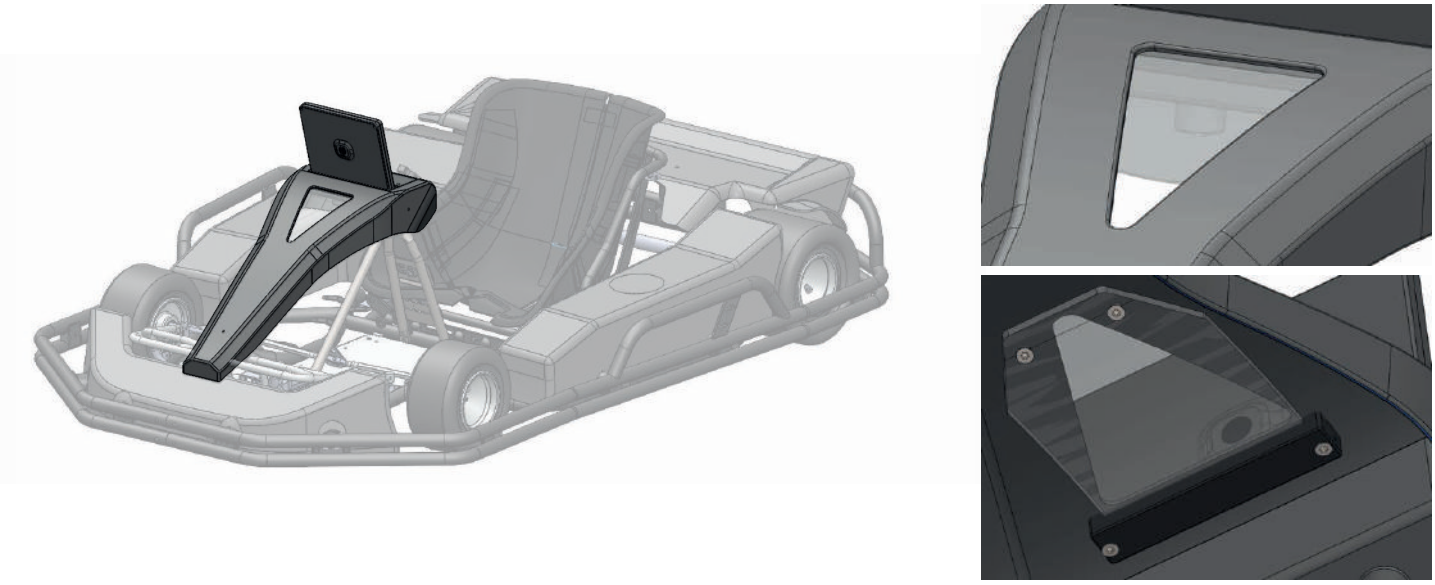
The current bodywork parts of DINO Karts go-karts are made of polypropylene, which will be chosen as the material for the front part. Having the same material used in the display cabinet and components box will generate coherence letting the three objects be seen more as one.

Polycarbonate will be used as the transparent part of the front cover as it offers good light transmission properties and can distribute light along the length of the plastic sheet. Here LED strips will be attached along the side.

PRODUCTION

The front part will have a thickness of 4mm as seen at the bodywork used by DINO Kart, and will get its desired shape by vacuum forming. The mold will be 3D printed in the material PEI as this is capable of use within vacuum forming as its melting point is 170 degrees where PP has a melding point 100 degress celcius. (Rydtooling, 2022).

The transparent polycarbonate sheet will be cut to the desired shape and attached to the front with screws. A module with an integrated LED strip will be integrated onto the polycarbonate before attaching it to the front.



Ill. 84 - Front

PHASE SUM UP

SUM UP

This phase investigated the front, where the market, users, and context were taken into account. The front is designed to use the same mounting points as the current go-kart which allows for using the product on multiple brands. The design language of the front has combined aspects of the current go-kart aesthetics and gamification, by signalizing characteristics as fast, sturdy, geometric, and colorful.

REQUIREMENT	SOURCE
The front should accommodate placement of large customizable stickers	Page 64 - Designing for variation

WISH	SOURCE
The design language of the front should signalize uniqueness	Page 62 - Market research
The design should express gamification	Page 62 - Market research
The design language should fit an electric-driven go-kart	Page 62 - Market research
The design language should accommodate racing and the current context	Page 62 - Market research
The design language should signalize newness	Page 63 - Market research
The front should have a design language signalizing fast, sturdy, geometric, and colorful	Page 63 - Defining the identity

06 DEVELOPMENT OF STEERING WHEEL

This phase covers the development of the steering wheel from the initial ideations to implementation in the go-kart context and tackling problems that might occur in doing so. This phase concludes with a final concept for the steering wheel.

Ill. 85 - Steering wheel test

INITIAL IDEATION - COMBINING STEERING WHEELS AND CONTROLLERS

From the interview with Lars, CEGO, see page 34, the steering wheel was highlighted as an important aspect of the new experience, as it should be the connection between the driver and the game, hence not only being a tool for controlling the go-kart. A redesign of the current steering wheel is needed to accommodate for interaction and thus make the steering wheel suitable for the new experience.

MARKET RESEARCH

As it is a wish to let gaming controllers inspire the new steering wheel, market research has been conducted by desktop research. Here looking into different gaming controllers and steering wheels in various contexts to better understand the principles surrounding the two.

Based on the research, it's seen that gaming controllers accommodate various interactions by having multiple buttons integrated. Furthermore, most gaming controllers are designed to fit well within the hand. A steering wheel allows a firm grip for a controllable feeling and the hands to move around the outer surface. This market research will be used as inspiration for further development.





Ill. 86 - Market research

DEFINING THE IDENTITY

From phase 5, see page 63, the identity of the front was described by a combination of the words "go-karting" and "gaming." To allow for a coherent design language, the redesigned steering wheel should implement this identity hence taking inspiration from principles from go-kart steering wheels and gaming controllers. The principles of the original steering wheel must be considered due to the solution being made for the existing go-karting context. The PS5 Dualsense controller and DINO Kart steering wheel will be used as a baseline defining the principles.

?

Multiple interaction points
Visual and haptic feedback
Vibrant colors
High-tech

Visible joints
Low-tech
Bland colors
Simple form

Ill. 87 - Steering wheel identity

INITIAL IDEAS

Based on the defined principles and the identity stated in phase 5, see page 63, initial ideas were made trying to combine the likes of gaming controllers and go-kart steering wheels. The ideas were created in cardboard to better visualize the sizes (App. 23). The cardboard models were used to test the grip and whether it was comfortable to hold onto. The ideas were tested on various people, and the three most liked are presented below; hence, most appreciated the second idea.

To get a better understanding of if the idea could be used on the go-kart, the idea was 3D printed, making it more durable and realistic.

Ill. 88 - Initial ideas

INITIAL TESTING

The 3D-printed model was mounted on the go-kart, and people were asked to try it out while being pushed around. This test gave feedback regarding the size of the steering wheel being too small, having too thin handles, and being uncomfortable to hold onto while turning. Furthermore, it highlighted that people felt like their hands slid off the handles when turning, as the model had an open bottom.

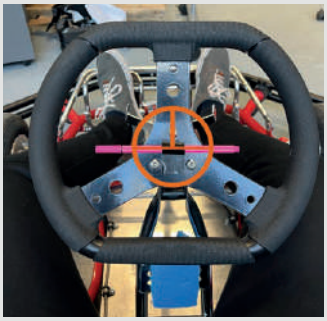
Based on this test, it was pointed out that the steering wheel should be prober dimensioned. Therefore, the upcoming chapters will investigate this.

Ill. 89 - Initial testing

STEERING WHEEL ROTATION ANGLE

A test highlighting the maximum steering angle was conducted based on the feedback regarding people feeling uncomfortable when turning.

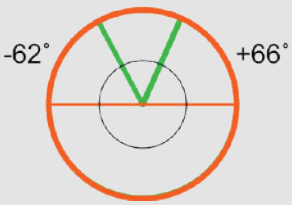
Neutral



Max rotation left

Max rotation right

Sum-up



Ill. 90 - Rotation angle

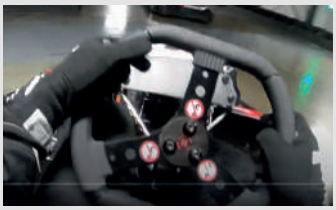
- The steering wheel shall accommodate a steering angle of +66° / -62°

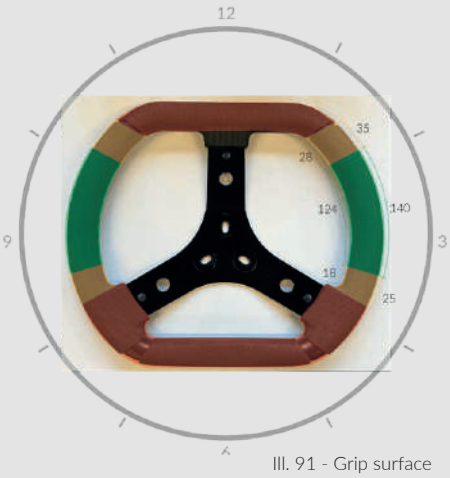
DIMENSIONING THE STEERING WHEEL

The following chapter investigates the outer dimensions of the steering wheel through testing. Here to discover acceptable sizes fitting for different sized users and allowing for a comfortable and controllable grip when turning and driving straight.

GRIP SURFACES

Before determining the dimensions, knowing where the target group would place their hands on the steering wheel while driving is essential. From field studies and acting out, as well as desktop research, it was discovered that most people have a minimal adjustment of their hands while driving, hence locking them in place on the steering wheel. Illustration 91 highlights the areas on the steering being most used. It is seen that the top and bottom are never used since the steering wheel has a slight rotation compared to what is seen in regular cars, which allows for larger rotations of the steering wheel. (App. 24)





Ill. 91 - Grip surface

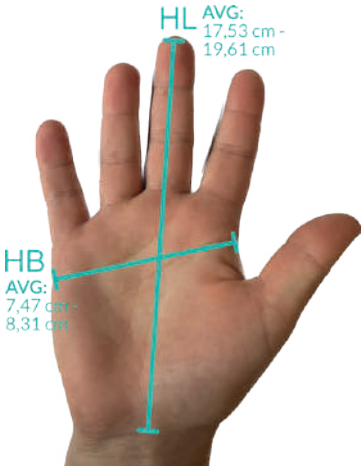
- People do rarely move or adjust their hands while driving

- The steering wheel should have a grip area between 9-10, and 2-3 o'clock

HEIGHT OF GRIP SURFACES

Knowing where the target group would place their hands, the size of this area will now be determined. The size should accommodate different hand sizes allowing them to grip the entire length of their handbreadth.

The gripping areas should therefore have a height of minimum 8,3 cm.



Ill. 92 - Averages hand sizes, men and women. Hand-length and hand-breadth.

- The gripping areas should be a minimum of 8,3 cm in height

WIDTH OF STEERING WHEEL

Different-sized steering wheels with an acceptable grip height were mounted on the go-kart, hence tried by participants ranging in heights from 160-190 cm. (App. 25)

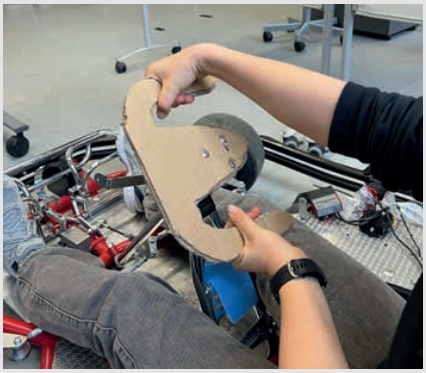
22cm width

160: Comfortable grip. No need for bending forward when turning. In control when turning.

183: Difficult to turn. Painful on the wrists.

190: Too narrow grip. Hands do not hit legs when turning.

27cm width



160: Acceptable reach when turning. Legs under steering wheel. Good feeling of control.

183: Comfortable grip. Do not interfere with legs.

190: Easy to turn. Good feeling of control.

32cm width

160: Having to move the body forward when turning. A bit too wide.

183: Easy to turn. Hands interfere with legs when turning. Fine feeling of control.

190: A bit too wide. The legs needs to be spreed a bit more.

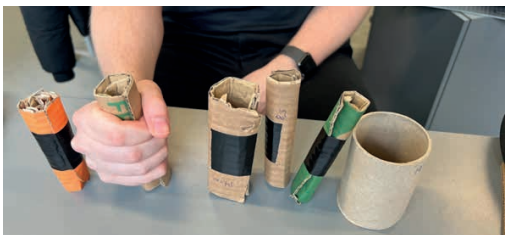
Ill. 93 - Width

The tests conclude that a steering wheel with a width of 27 cm accommodates most people, allowing for control and comfort.

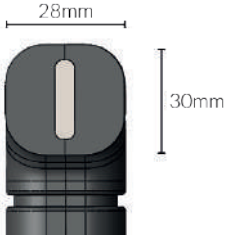
- The steering wheel should have a width of 27 cm

GRIP THICKNESS AND FORM

Participants with different-sized hands tried different-sized grips with circumferences ranging from 7,5 cm to 14 cm. Participants with larger-sized hands did prefer sizes between 10-12 cm, whereas participants with smaller hands did find lengths of 8-10 cm more comfortable. A circumference of 10 cm is chosen as the grip thickness to accommodate both large and small hand sizes.



To accommodate the shape of the hand when gripping around something, the grip will be made asymmetrical with rounded corners, hence also seen on the go-kart's original steering wheel.



Ill. 94 - Grip thickness and form

- Grip thickness shall be 10 cm
- The grip shall be asymmetric width a depth of 2,8 cm and a width of 3 cm
- The grip shall have rounded corners

INTERACTION WITH THE STEERING WHEEL

As it is a requirement that the steering wheel should be interacted with while driving to play the game, it is essential to understand how it should be interacted with. From previous chapters, it has been stated that the interactions should take inspiration from gaming controllers hence why interaction with a controller will be analyzed below.

CONTROLLER ANALYSIS

An X-box controller has been the baseline of the analysis, here highlighting the different interaction areas and how the controller is handled when playing. Furthermore, it highlights the other feedback methods a controller provides when interacting with it.

The controller has different buttons and joysticks around its faces, most of which are at the front facing the person using it, and the last of them on the top.

The controller is meant to be held with two hands and, when held correctly, allows for interaction with every button by the thumbs and index fingers. On the controller, a distinction is made between active and passive buttons and primary and secondary buttons. The passive buttons are not for use while gaming, these are placed towards the center of the controller, making them just reachable by stretching the thumbs. The primary buttons, meaning the ones most used when gaming, are mainly placed on the front and used by the thumbs.

As a feedback method, the controller uses integrated vibration motors that make the entire controller vibrate when something happens in the game/the user interacts with some of the buttons.

Ill. 95 - Controller analysis

This analysis highlighted the overall placement of the main interaction areas to be at the front while having passive interaction areas placed somewhere that can not be reached without adjusting the hands. The thumbs will be seen as the primary way of interacting with the steering wheel.

- Main interaction areas should be placed at the front facing the driver
- Main interaction areas should be placed within reach of the thumbs
- Passive interaction areas should be placed out of reach when driving
- The steering wheel shall have integrated vibration motors

THUMP RANGE

Knowing that the thumbs will be used to interact with the steering wheel, a test is conducted investigating the range of the thump hence stating how far away interaction areas can be placed. Participants with large and small hands were used in the test.

The tests illustrate the areas the thump can reach, hence where interaction areas can be placed. As the thumb can bend, the placement of the interaction areas will be based on people with small hands, allowing for all hand types to be set at the 9-3 o'clock and 10-2 o'clock positions.

Ill. 96 - Thump range

- Users can reach 75 degree inwards

IDEATION: FORM AND DESIGN LANGUAGE

From having knowledge regarding the steering wheel's dimensions and an overall idea of how it should be interacted with, an ideation with a focus on form and design will be made (App. 26). The ideation was initially started with one sketching round, with the ideas being discussed based on their identity concerning gaming and go-karting. Four ideas were chosen due to their different levels of integrating principles of gaming/go-karting and detailed further within 3D software. The four concepts were then shown to participants within the target group to gain feedback on their form concerning the desired identity.

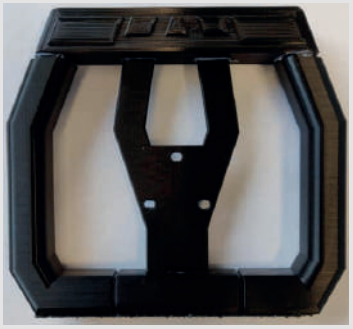
Concept 1

Concept 1 is an octagon steering wheel where the interactive buttons are placed at the top part of the steering wheel.

*"It look more **futuristic electric car** steering wheel, looks more like a normal steering wheel than a controller" - Nicholas*

*"This is the best one as it seems **more normal** to car's due to it being round" - Cecilie*

*"**The detail of metal, in the middle, seems go-kart like**" - Danny*



Concept 2

Concept 2 is a futuristic wheel taken inspiration from planes with an open top. Its mounting point is placed backward to give a three-dimensional feeling.

*"It look like a **jet steering wheel**, it looks cool and fast" - Rikke*

*"It looks for something **meant for racing**" - Kasper*

*"Was **nice to hold**, as I didnt have to move the hand much" - Cecilie*

*"It may be **too far from the principles of gaming**" - Danny*

Concept 3

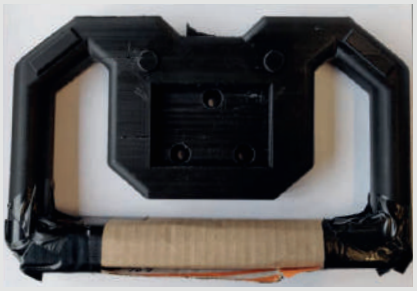
Concept 3 takes inspiration from gaming controllers such as the Nintendo 64 and Nintendo 3DS. Its made with sharp edges and is overall lower with its rectangular shape.

*"It has a **gameboy nintendo vibe** because its rectangular ved curves in the top" - Danny*

*"**Looks gameboy like** with the square in the middle" - Rikke*

*"It does remind me a bit of an **F1 steering wheel**" - Jacob*

*"It looks like something you could game with, but it still **symbolizes race** in some way" - Nicoline*



Concept 4

Concept 4 is a thin structured organic steering wheel that has the minimum needed to be able to interact and steer.

*"It looks in some way **fragile** [...] not something I would feel safe grabbing while driving fast. " - Rikke*

*"It looks too much like a **toy**" - Nikoline*

Ill. 97 - Ideation form and design

The concepts receiving the most positive feedback were concepts 2 and 3. The participants liked the compact game-like design of concept 3, but the concept lacked racing elements and looked more like a controller to a Nintendo but with the design principles of an Formula 1 steering wheel. Whereas concept 2 expressed more the context of go-karting due to its shape and sharp edges. Concept 2 gave a feeling of speed accommodated by its raw look with the open top and square handles. Due to the feedback, the steering wheel should have a form and design language based on a combination of concepts 2 and 3 hence gaining principles from both gaming and go-karting.

TESTING THE CONCEPTS

As the form should accommodate, too, for a good feeling of control and comfort while driving, in addition to showing the participants the concepts, they were asked to try them out in the go-kart physically. For this, each concept was 3D printed and mounted on the go-kart respectively. To get an initial understanding of how the users would interact with the steering wheel, some areas were marked with colors or a slight bump signaling a pushbutton, with its placement being based on knowledge gained from the previous chapters in this phase.

Concept 1

*"Seems like there is **too much space** below and above the hands, which isnt being used" - Nicholas*

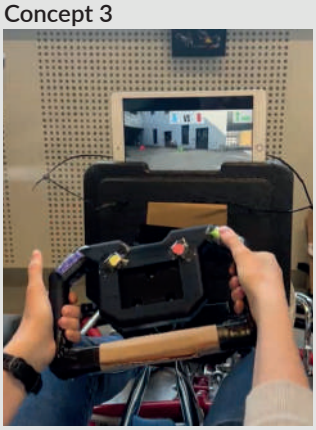
*"**Had to hold different than what I wanted,** so I didnt have to move my hand much." - Cecilie*

Concept 2

*"It is a placed a bit high, so I am **resting my hands on the bottom part**" - Rikke*

*"The form is nice, as it is abit squared, it makes it more intuitive, **it feels natural**" - Danny*

Concept 3



*"Good length, **very defined of where to hold**" - Nikoline S*

*"The buttons is just where I want them, **I dont have to move my hand**, only my thumb abit." - Rikke*

Concept 4

*"Feels like I'm **forced to hold higher**, so the buttons are close" - Rikke*

*"It too long to reach the button, the lower part of **the handles doesnt make sense**." - Cecilie*

Ill. 98 - Testing concepts

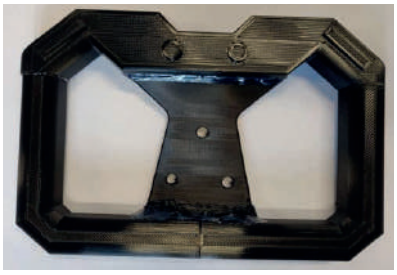
This test led to understanding how the users would handle the steering wheel and interact with the placed interaction areas. In providing a comfortable and controllable grip, concepts 2 and 3 were once more highlighted as the bests due to their even handles allowing for a good grip. Concept 3 was pointed out as the best of the two, as its closed form gave the feeling of security while turning. Both concept 2 and concept 3 had good placement of the buttons allowing for thump reach at all times by different-sized hands. Concepts 2 and 3 will therefore be used as the baseline for further development of the steering wheel.

- The form of the steering wheel should be a closed contour
- The steering wheels grip areas should be in textured rubber

FINALIZING THE FORM

With the feedback given from the previous chapters, a new ideation was done with the focus of combining the highlighted concepts into one final concept. The ideation started with a sketching round, emphasizing the gained feedback. (App. 27)

Discussions of the form of each new idea were made within the group, resulting in a final form that was further detailed and 3D-printed to visualize its shape and design language better. The final concept was then shown to the target group, and feedback was gained again.



Ill. 99 - Finalizing the form

"The shape of it is very unique" - Christina

"It is like you have combined the likes of a gaming controller and a racing steering wheel" - Danny

"It feels good to hold" - Nicholas

INTERACTION AREAS

The following chapter investigates the interaction areas and, through testing, explores the needed amount of interaction areas, their optimal placement, as well as the different types of buttons, their shapes, and colors. The final form concept from the previous chapter will be used as a baseline.

THE NUMBER OF INTERACTION AREAS

The designed game from Phase 2 pointed out the need for having at least one area to be interacted with when using power-ups, hence it would be seen as a primary interaction. Furthermore, due to the stated wish of letting the steering wheel accommodate multiple games, there is a need for integrating more interaction areas. Here, allowing for future games to be made more complex hence needing more interaction areas, as seen with gaming controllers. As it is still essential that the driver keeps focusing on the track, the amount of interaction areas should be minimal for easy remembering and in reach of the thumps and index fingers. Therefore secondary interaction areas will too be integrated. Interaction areas allowing for more passive actions should be considered, e.g., gaming modes, calling for help, and changing the interface to make the entire experience more fluent and adaptable for the individual.

THE TYPE OF INTERACTION AREAS

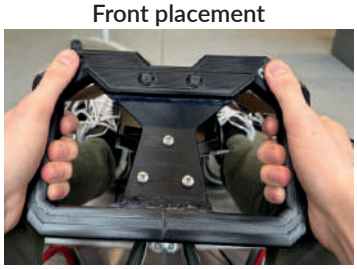
As the interaction areas shall be interacted with by the fingers, the type of interaction will now be investigated. As seen on gaming controllers, interactions are primarily done by push buttons and joysticks. As joysticks are commonly used as controlling movements in games, these will not be looked into as the steering wheel itself accommodates this. Push buttons are the optimal solution, as they provide haptic feedback when pushed and are easy to figure out. It furthermore enhances the interaction by letting one push translate to one action done. In addition, pushbuttons can be used while having gloves, as gloves are used at several rental centers.

- The interaction with the steering wheel shall be done by pushbuttons

PLACEMENT

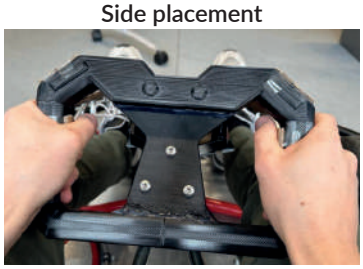
Knowing that most primary interaction areas are placed in front and should be placed within reach of the thumbs, a test was conducted to try out different placements. In addition, the placement of secondary and passive interaction buttons will be tested. As the concept does not have the same shape as the analyzed gaming controller, placement elsewhere than on the front will be tested to investigate if the newly designed form accommodates interaction with the thumbs elsewhere.

Front placement



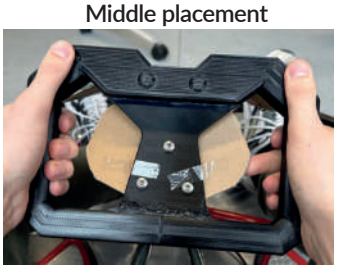
The front placement is a position that is accessible for all types of hands. It allows for quick interaction and doesn't get pressed randomly.

Side placement



This placement used the inside of the steering wheel handles. It has easy access and can be pressed without moving the hand. Due to the placement of the hands, the buttons in these areas can be pressed unintentionally.

Middle placement



This placement uses the middle fingers and a different type of button, as this is seen more as a switch. Through testing, this placement seemed confusing about whether they should be pushed forward or backward.

Top placement

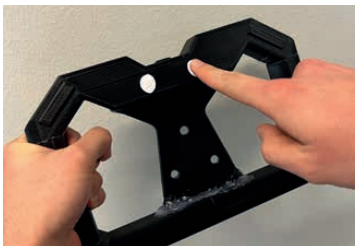
This placement needs a more extended movement of the finger, therefore, it won't be pressed unintentionally

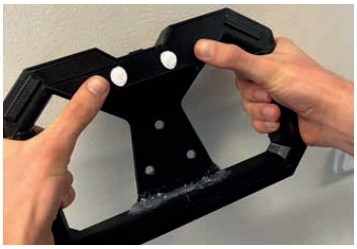
Back placement

Ill. 100 - Placement of buttons

This placement uses the index finger with a shorter movement compared to the top placement. But this placement is out of vision for the driver. For people trying the experience for the first time, having the buttons on the back can confuse them, as they can be hard to locate using their fingers alone.

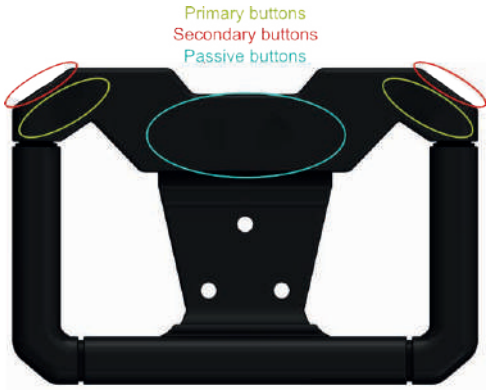
Passive buttons





The passive buttons are placed towards the middle of the steering wheel, making them unreachable while driving, hence making them useable when holding still.

Interaction with the buttons should not interfere with driving and should not be pressed unintentionally. Therefore primary interaction buttons will be placed on the front, verifying the requirement seen on page 75, Controller analysis. In contrast, secondary and passive buttons will be placed at the top and front middle, respectively. This furthermore makes all buttons visible while driving.



Ill. 101 - Passive buttons

- Secondary buttons shall be placed at the top of the steering wheel
- Passive buttons shall be placed in the top middle of the steering wheel

SHAPE OF BUTTONS

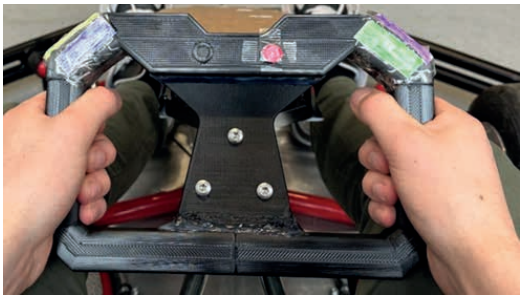
The shapes of the buttons shall accommodate easy pressing while highlighting the different contexts of use. The primary and secondary buttons will be large squares accommodating pressing from a large area. The passive buttons will be smaller and have a round shape illustrating another usage.

Ill. 102 - Shape of buttons

HIGHLIGHTING THE BUTTONS

To make the buttons stand out, hence making them easily visible while driving without directly looking at them, the buttons shall be colored. Using different colors could furthermore highlight the various interactions that each button provides.

Using colored patterns is inspired by the buttons seen on various gaming controllers, whereas the full-covered ones emphasize high visibility. As seen from gaming controllers, vibrant colors make them pop from the commonly black and white colored base. Having colored patterns was seen as too caricatured compared to gaming controllers, as to why fully-covered buttons were chosen.



Ill. 103 - Highlighting the buttons

TEST OF FINAL CONCEPT

From creating the final form and determining the place and shapes of the interaction areas, a finalized concept was made and shown to the target group.

Participants with different hand sized were asked to try out the steering wheel and its interaction areas.

Width: 7,5cm - Height: 16cm

Width: 10,5 cm - Height: 21cm

Ill. 104 - Test of final concept

"It fits good in my hand, and the buttons are easily reachable" - Mathias

"It seems very nice, I think the placement of the buttons makes sense!" - Nikoline

"Good idea to keep the number of buttons at a minimal [...] having more would probably make me forget the usage of them" - Martin

"It balances the aspects of gaming and go-karting very well" - Sofie

CONTRUCTION

The following chapter presents the steering wheel's construction by highlighting how it should be mounted, the different elements, and how the steering wheel accommodates the integration and replacement of electrical components.

MOUNTING OF THE STEERING WHEEL

As seen from the DINO Karts go-kart, the steering wheel is mounted by three screws in the middle, attaching it to the steering rod. Due to its simplicity and proof of working in the context of go-karting, the new steering wheel will be mounted similarly.

Ill. 105 - Mounting

- The steering wheel should be mounted like the current go-kart

CONTRUCTION OF THE STEERING WHEEL

The construction of the steering wheel takes inspiration from the current go-kart steering wheel. Here by using an inner metal frame with a rubber-like material being cast around it. The metal frame provides the stiffness needed when grabbing the steering wheel and turning, while the casted rubber on the outside allows for more friction between the hand and the surface, allowing more control.

As a difference, the new steering wheel shall accommodate for the integration of electrical components, hence these shall be placed within the construction of the steering wheel. As all push-buttons are placed at the top, the construction will be split into two main parts. The bottom part consisting of the rubberized handles with the inner metal frame, and the top part consisting of a hard shell, with room inside for the components.

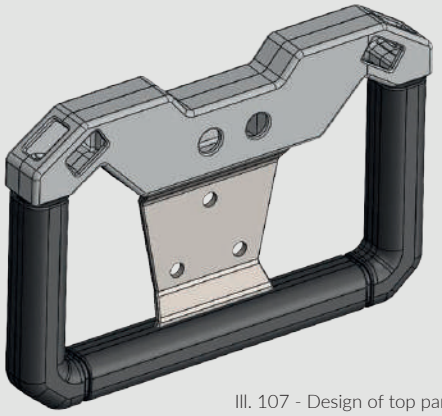
Ill. 106 - Construction

OBS

As the top is not meant for grabbing while driving, only the bottom part will have a metal frame, as this allows for a hollowed top part with room for the various components.

DESIGN OF THE TOP PART

To make the top less desirable to grab upon, a more squared design has been made with less rounded edges making it contrasting the more soft-looking rubberized handles, hence guiding the user to grab there instead. (App. 28)



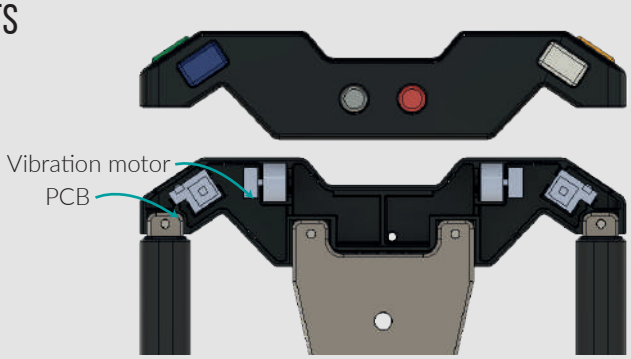
Ill. 107 - Design of top part

The top parts click together first holding them in place and are hereby fastened to the bottom part by screws. This solution makes it easy to replace broken components, as the two parts can be dismantled, e.g., no need for a new top part if the metal frame bends or a new bottom part if one of the electric components breaks. This setup furthermore accommodates making a platform for future new top parts uses in different rental go-kart contexts having different button setups etc.

Ill. 108 - Assembly

PLACEMENT OF ELECTRICAL COMPONENTS

The components of pushbuttons and vibration motors are placed within the top shell, as shown below. The components are connected by wiring and connected and driven by wires leading from the back of the steering wheel to the component box on the front part.



Ill. 109 - Placement of electrical components

TESTING DURABILITY

The following chapter investigates the durability of the steering wheel by looking into the scenarios highlighting the interactions people have with it pre, during, and post-driving. With this, FEA is made to determine the needed materials and point out the most vulnerable areas of the construction, hence verifying the steering wheel's strength and usage within the go-kart context. (App. 29)

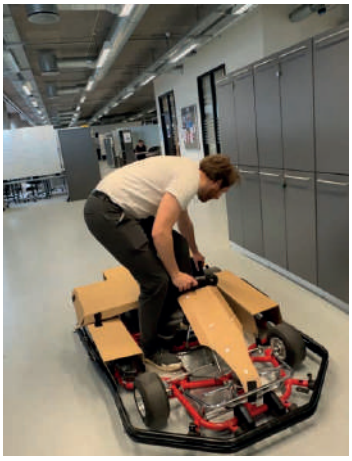
INTERACTION SCENARIOS

Based on the field studies made in Phase 1, see page 9-11 and the many tests made with participants, it was discovered that the steering wheel gets interacted with a lot besides only being a tool meant for driving.

As seen from the scenario pictures, most people use the steering wheel to retrain balance when entering and leaving the seat. Furthermore, when personnel handles the go-karts, they usually push them by the steering wheel. The scenarios gave an understanding of the loads applied on the steering wheel and will serve as a foundation when doing the FEAs.

GETTING IN THE GO-KART





GETTING UP FROM THE GO-KART


EXTREME CASE - CRASHING

MOVING THE GO-KART



Ill. 110 - Interaction scenarios

FEA

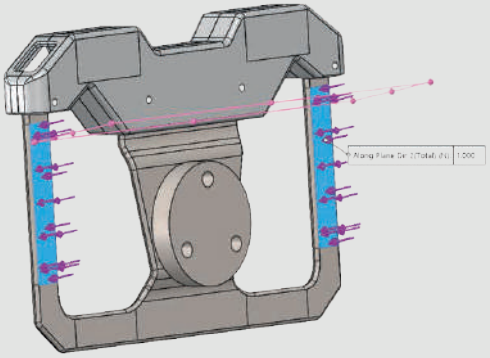
A luggage weight has been used to determine which interaction scenario applies the most significant load onto the steering wheel. Each scenario was recreated hence discovering the applied load. The worst-case scenario was seen when users grabbed onto the steering wheel's top or sides while lowering themselves down the seat. The load was discovered to be 23 kgs applied by a participant weighing 90 kg.

The load of 23 kg will be used as a baseline when doing the FEA. The 23 kg is rounded up to 25 kg, and a safety factor of 4 is applied, making the applied load 100 kg/1000 N. The analysis applies the 1000 N onto the back of the sides while fastening the steering wheel around the three mounting holes, as would be the case on the real go-kart.

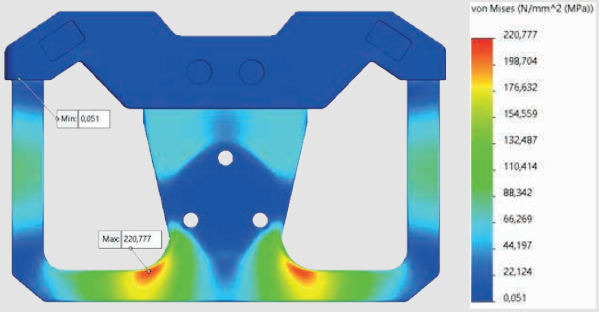
Getting in the go-kart

Testing force applied

Force applied



Results



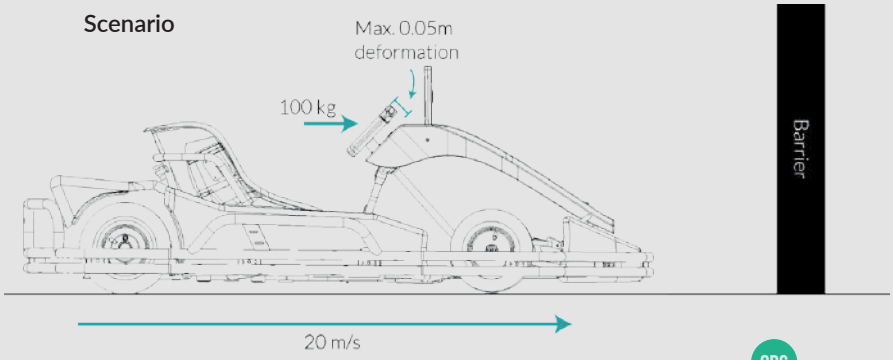
Ill. 111 - FEA

Through the FEA, it was highlighted that stress concentrations of 220 MPa were appearing in the lower middle region of the metal frame. Here due to the placement of edges/corners. To withstand stress concentrations of the size, the steel type 316 stainless steel is chosen, as it has a yield strength of 252 MPa. (316 Material datasheet, 2023)

Another worst-case scenario would be in the case of a crash, where the go-kart stops and, as a result of this, send the driver forward at high speed, putting his/hers entire weight on the front of the steering wheel. To figure out the loads applied in this scenario, a case is set up; a person with a mass of 100 kg drives 20 m/s into a wall making the steering wheel deform 5 cm, allowing the driver not to be pierced by the steering rod. To this, the kinetic energy is calculated to be 20.000 Nm. Knowing the performed work, and the distance, the force can be calculated to be 400.000 N.

This case does not consider the deformation of the barriers and the go-kart, resulting in an applied force much higher than it would be in a real crash case. As many factors are unknown, a proper crash test would be needed to determine the forces applied. This case will therefore be investigated no further. The current steering wheel on a go-kart has an inner metal frame with a thickness of 3 mm. To ensure that the new metal frame can withstand the different contexts, a thickness of 5 mm has been chosen.

Scenario



Force applied

$$m = 100kg, v = 20\frac{m}{s}, \Delta s = 0{,}05m$$

$$\frac{1}{2} * m * v^2 = F * \Delta s$$

$$\frac{1}{2} * 100kg * 20^2\frac{m}{s} = 20.000Nm$$

$$F * \Delta s = \frac{20.000Nm}{0{,}05m}$$

$$\frac{20.000Nm}{0{,}05m} = \mathbf{400.000N}$$

Ill. 112 - Worse case scenario

OBS

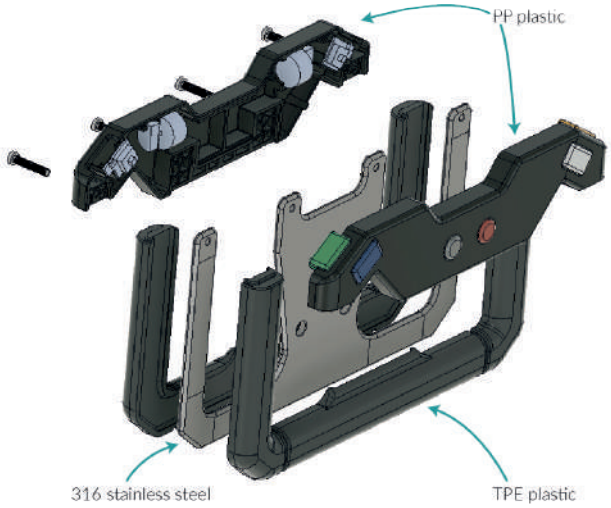
This case would only be viable in cases where the go-karts do not have implemented safety belts

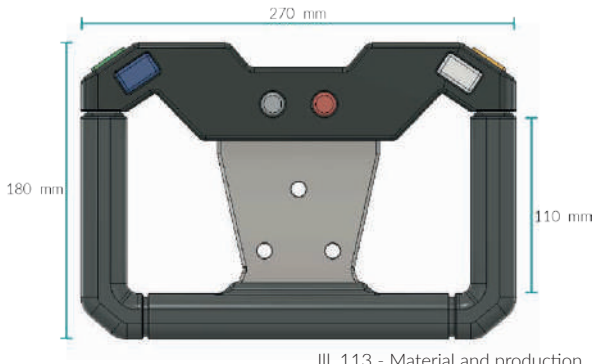
MATERIAL

From the FEA, the metal type of 316 stainless steel is chosen as the material for the inner frame due to its high strength. The rubber cast around the frame will be made from TPE, thermoplastic elastomer, as it is often used for steering wheels due to its soft touch and wear-resistant properties. The top part will be made from polypropylene due to its sufficient strength and wear resistance properties. Polypropylene is used within the front part and component box, keeping coherence between the three parts. The buttons are made from Polypropylene due to its wear-resistant properties allowing for reduced wear and tear over time.

PRODUCTION

The inner frame will be laser cut from 5 mm steel to the desired shape. The rubber will be created by molding it around the inner steel frame. The rubber will have a light texturized surface, enhancing the grip and made possible by texturizing the surfaces of the molds. The top part will be made from injection molding, needing two molds as the front and back differentiate in form.





Ill. 113 - Material and production

OBS

Reevaluating the design of the inner frame has changed it to become entirely flat compared to having the middle part of the frame skewed a bit backward, as this allows for cheaper production, hence a greater stiffness.

TEST OF FINAL STEERING WHEEL

The final steering wheel was tested on the target group to verify its design within the new experience. The test was set up in the same context as in Phase 2, see page 30-34. To have a baseline, the participants were first asked to try the current steering wheel before switching to the new one.

Current go-kart steering wheel

"A round steering wheel, just how I used to know it."

"Does not give much coherence to the new experience."

New design of steering wheel

Ill. 114 - Test of steering wheel

"It feels more like a video game due to the shape."

"Using the buttons with my index finger and thumb was fairly easy."

"It still feels like a steering wheel for a go-kart, which is nice."

Upon the final testing, all participants found the new steering wheel cohering a lot better with the new experience. They like the new design stating that it fits well within the context of go-karting while still emphasizing gaming.

PHASE SUM UP

SUM UP

This following phase investigates the steering wheel, where the market, users, and context were taken into account. The focus areas have been combining the aspects of go-kart and gaming, this is seen through the design language of the steering wheel. The dimensions of the steering wheel have been determined by several user tests. An analysis of gaming controllers was used as inspiration for the placement and design of the interaction points/buttons. The steering wheel is designed to use the same mounting points as the current go-kart which allows for using the product on multiple brands. Lastly, an interaction scenario with the steering wheel was used as a foundation for an FEA analysis.

REQUIREMENT	SOURCE
The steering wheel shall accommodate a steering angle of +66° / -62°	Page 72 - Initial ideation - Combining steering wheels and controllers
The steering wheel should have a grip area between 9-10, and 2-3 o'clock	Page 73 - Dimensioning the steering wheel
The gripping areas should be a minimum of 8,3 cm in height	Page 73 - Dimensioning the steering wheel
The steering wheel should have a width of 27 cm	Page 74 - Dimensioning the steering wheel
Grip thickness shall be 10 cm	Page 74 - Dimensioning the steering wheel
The grip shall be asymmetric width a depth of 2,8 cm and a width of 3 cm	Page 74 - Dimensioning the steering wheel
The grip shall have rounded corners	Page 74 - Dimensioning the steering wheel
Main interaction areas should be placed at the front facing the driver	Page 75 - Interaction with the steering wheel
Main interaction areas should be placed within reach of the thumbs	Page 75 - Interaction with the steering wheel
~~Passive interaction areas should be placed out of reach when driving~~ Passive buttons shall be placed in the top middle of the steering wheel	~~Page 75 - Interaction with the steering wheel~~ Page 79 - Interaction areas
The steering wheel shall have integrated vibration motors	Page 75 - Interaction with the steering wheel
The form of the steering wheel should be a closed contour	Page 77 - Ideation: Form and design language
The steering wheels grip areas should be in textured rubber	Page 77 - Ideation: Form and design language
The interaction with the steering wheel shall be done by pushbuttons	Page 78 - Interaction areas
Secondary buttons shall be placed at the top of the steering wheel	Page 79 - Interaction areas
The steering wheel should be mounted like the current go-kart	Page 80 - Construction

07 INTEGRATION

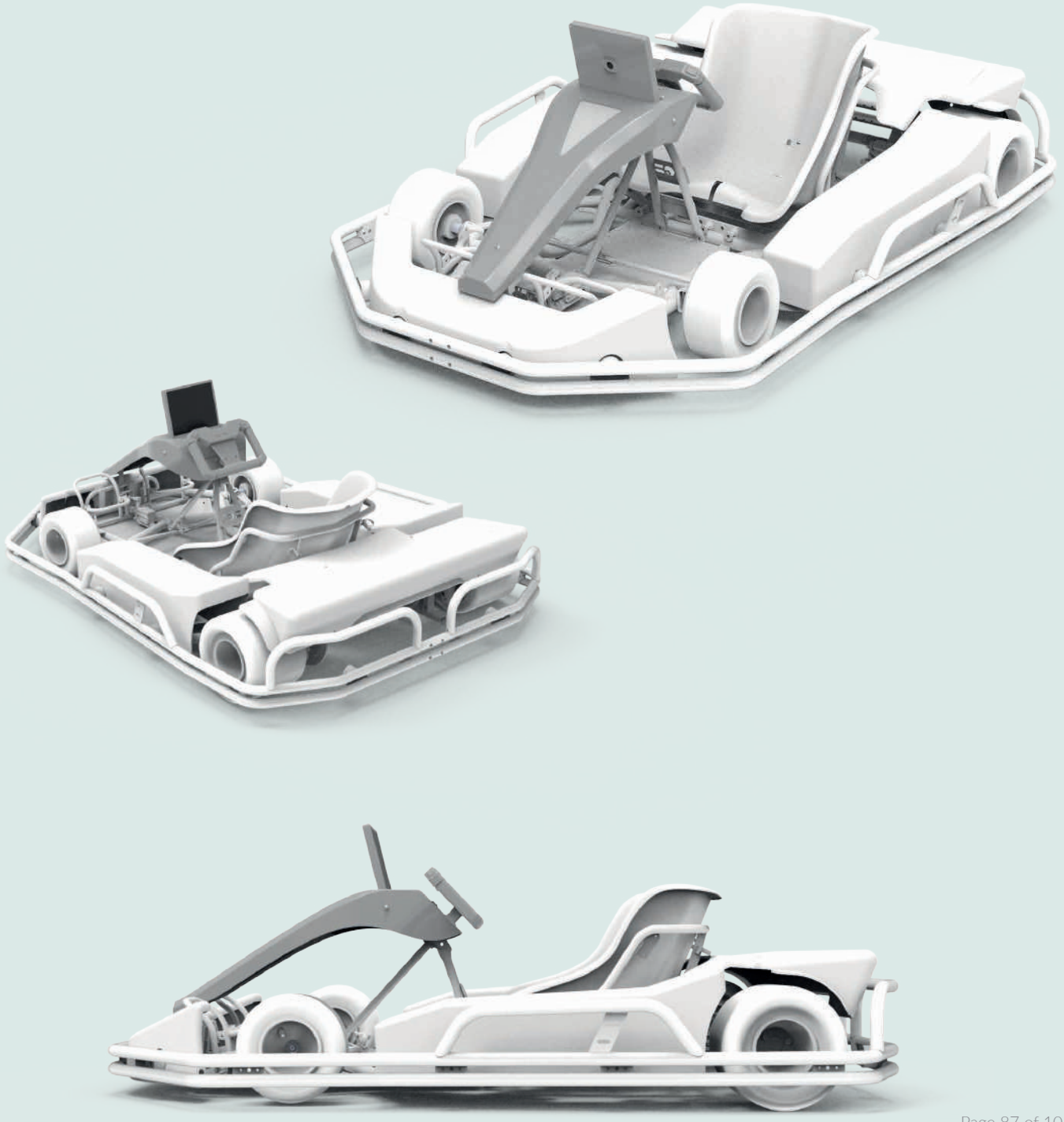
This phase sums up the designed product and experience and how they are integrated. It covers what is being processed by the system, how the final design looks on a go-kart, and a final round of feedback from the manufacturer, DINO Kart, and the target group.

Ill. 115 - Integration

COMBINING THE ELEMENTS

Having finalized all the elements, the final solution is presented below. It revolves around a new go-karting experience based on a simple team-based AR game displayed through the integrated screen. Integrating a game makes the driving experience unique, creating variation and the need for interaction within every driven round.

The screen mounts to the newly designed front bringing design elements from gaming and go-karting together while allowing for seamless integration of the electric components needed to realize this experience. Through the redesigned steering wheel, the driver can interact with the game, influencing it and the rest of the players.



Ill. 116 - ARacing

FEEDBACK FROM DINO KART

The finalized solution was presented to Rasmus from DINO Kart to test its feasibility. During the presentation, a big emphasis was made on the more technical aspects of the solution and the business approach. A 3D model were placed on the ground and shown to Rasmus through an iPad allowing him to walk around to see all the details.

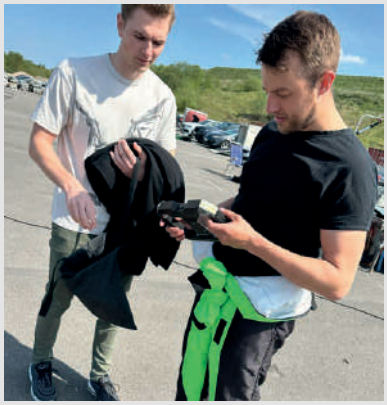
"I think its looks cool"

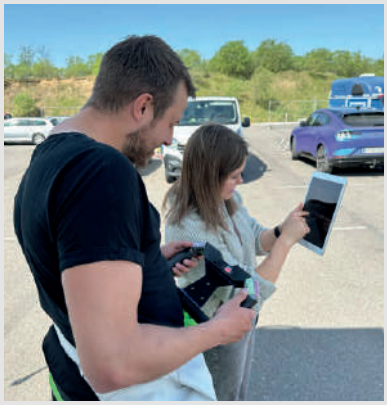
"The front can easily be made in our production"

"It brings something new to the market, which I think its great"

"I think this experience has great potential in the USA"

Showing the solution to DINO Kart showed that the implementation into their go-kart and system wasn't unrealistic as he could see the potential in the product and the business approach.





Ill. 117 - Feedback from Rasmus

FEEDBACK FROM THE TARGET GROUP

In addition to showing the solution to DINO Kart, users from the target group were invited to see the solution, hence providing feedback. During the presentation, a big emphasis was made on the initial problem and how the solution would counter it.

"Its a breath of fresh air for the current go-kart experience, and I think it needs it"

"I would definitely try this again, especially if more games could be developed [...] it would seem like a new experience every time"

"It feels like an all day thing, you would want to try"

"The system feels coherent, and I really think that front part looks unique and exciting"

"The best of both worlds [...], real-life Mario Kart, who would not want to try that?"

"Certainly, I would try this more than once over a 10 year span"

"The design makes it look way cooler and newer than the current ones"

From showing the solution to the user group, most found it interesting, highlighting it as an exciting product. They could understand the reasoning behind the choices, hence stating the solution would certainly help in many of the areas the group presented as problems.

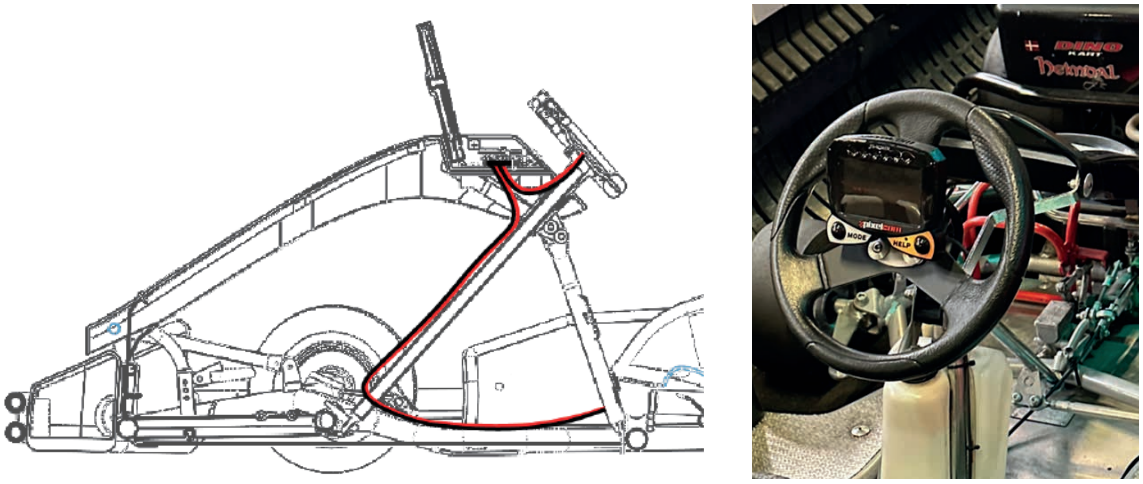
Many of the participants stated that they had never tried go-karting before as it was not something they found amusing due to the speed and racing aspects. But due to the solution and the experience not focusing on these aspects, they showed a greater attraction to the solution. Here due to, it revolved around emphasizing team play and goals that seemed more reachable for people who do not like to race.

Ill. 118 - Feedback from Target group

WIRE ROUTING

As the different parts consist of electrical components, they need to be connected and further connected to the battery to gain power. An illustration below highlights the overall connections of the different elements and presents how the wires run through the go-kart without interfering with the driver.

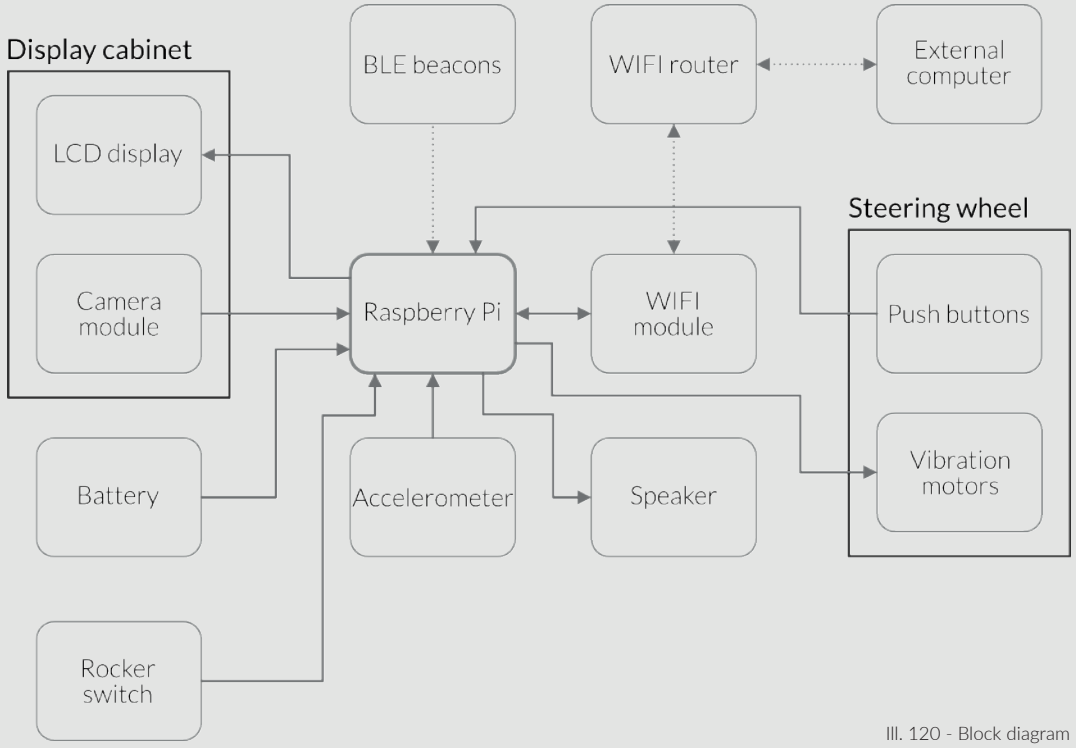
From Action House, a similar situation was seen, with them having a small screen on their go-karts steering wheel, which wires ran along the steering rod and into the battery. Due to it being an electric go-kart, the system can be connected directly to the battery, as they are designed to be able to power external systems such as this solution.



Ill. 119 - Wire diagram

BLOCK DIAGRAM

The following block diagram shows how each component is connected within the solution. The connection with the external system will likewise be illustrated here with dotted lines. A flow diagram have likewise been made, see app. 30.



Ill. 120 - Block diagram

SPECIFICATIONS

Below is the requirement for the product; the front, the steering wheel, the display, and the external system. This specification is used as a sum up for all the requirements throughout the process.

PART	CATEGORY	REQUIREMENT	SOURCE
STEERING WHEEL	DIMENSIONS	The steering wheel shall accommodate a steering angle of +66° / -62°	Page 72
		The steering wheel should have a grip area between 9-10, and 2-3 o'clock	Page 73
		The steering wheel should have a width of 27 cm	Page 73
		Grip thickness shall be 10 cm	Page 74
		The grip shall be asymmetric width a depth of 2,8 cm and a width of 3 cm	Page 74
		The grip shall have rounded corners	Page 74
	INTERACTIONS	Main interaction areas should be placed at the front facing the driver	Page 75
		Main interaction areas should be placed within reach of the thumbs	Page 75
		The form of the steering wheel should be a closed contour	Page 77
		The steering wheels grip areas should be in textured rubber	Page 77
	COMPONENTS AND PLACEMENT	The steering wheel shall have integrated vibration motors	Page 75
		The interaction with the steering wheel shall be done by pushbuttons	Page 78
		Secondary buttons shall be placed at the top of the steering wheel	Page 79
		The steering wheel should be mounted like the current go-kart	Page 80
FRONT		The front should accommodate placement of large customizable stickers	Page 64
THE DISPLAY AND SYSTEM	DIMENSIONS	The screen size should be 10 inch	Page 51
		The display shall be placed 5-20 cm behind the steering wheel	Page 51
		The top of display shall be placed between 66-74 cm from the ground	Page 52
		The camera should be placed behind of the screen	Page 54
		The display should rotate backward to a maximum angle of 105 degrees	Page 58
	SYSTEM	The display is made from an LCD panel	Page 43
		The solution should consist of a camera	Page 43
		The system shall use BLE beacons for determining the location data	Page 44
		The solution shall have built in accelerometer for determining orientation data	Page 44
		The system shall use an external computer for processing data	Page 44
		The front part shall have an integrated microcontroller	Page 44
		The system shall use a WiFi network to transfer data to and from the karts	Page 45
		The solution should have a built in WiFi module	Page 45
		The system should have a Wifi Router	Page 45
		The system should have a maximum delay of 10ms	Page 45
		The system should have WiFi access points around the track	Page 46
		The system requires setup time around the track	Page 46
		A speaker should be integrated within the solution	Page 49

08 BUSINESS AND IMPLEMENTATION

The following phase investigates the business approach as to who is the key partners and an initial price point for the product is determined through the calculation of variable and fixed costs. Lastly is the scaling opportunities reflected upon.

FIRST YEAR PLAN

The first-year plan highlights the main key elements and stakeholders needed to develop a feasible solution. The business is made as an own start-up, with the approach of teaming up with the Danish go-kart brand, DINO Kart, making them an investor and key stakeholder for the business. With the help from DINO Kart, a low cost minimal viable prototype will be constructed, and hence tested in house, to verify its potential and feasibility.

DINO Kart	ARacing
Exclusive first buyer of the new versions	Contact with established rental centers
Percentage of future sales to other brands	Gained credibillity working with acknowledged go-kart brand
Publicity through ARacing	Contact with manufacturers
	Expert knownledge within the go-kart field

Ill. 123 - Partnership with DINO Kart

OBS

The partnership with DINO Kart
DINO Kart will be made partner of the startup, hence owning a part of the brand, ARacing, in return for providing facilities and materials for developing the solution. Other advantages of this partnership are presented in ill. 124.

To gain a better understanding of how to develop the game, hence how to make use of AR, the danish companies of Virsabi and SYBO are contacted. Virsabi is a company specializing in AR and VR technology, creating solutions suitable for multiple purposes. With their expert knowledge, how to implement the technology of AR within the solution will be highlighted. SYBO is a game development company focusing on mobile gaming apps. These companies will be used as stakeholders and help developing the game towards making a complete functional prototype that can be tested.

Having a functional prototype, the company of pixeltiming will be contacted. Pixeltiming is a company specializing in system tracking solutions for rental go-karting and will therefore be a stakeholder hence providing knowledge and materials needed to create the external system for the game to work.

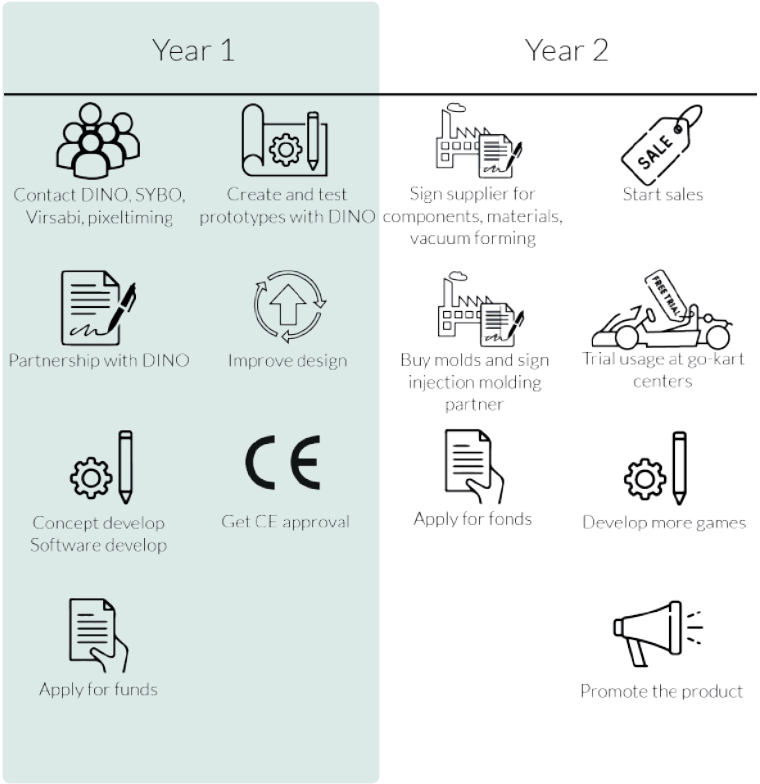
Testing of the functional prototypes will be at chosen rental centers already having DINO Kart as go-kart provider, hence letting the tests be seen as trials. The tests will use the target group as participants to gain feedback on the solution and proof the product potential. With the knowledge gained from the tests the solution will be further developed towards creating a more finalized design that can be produced.

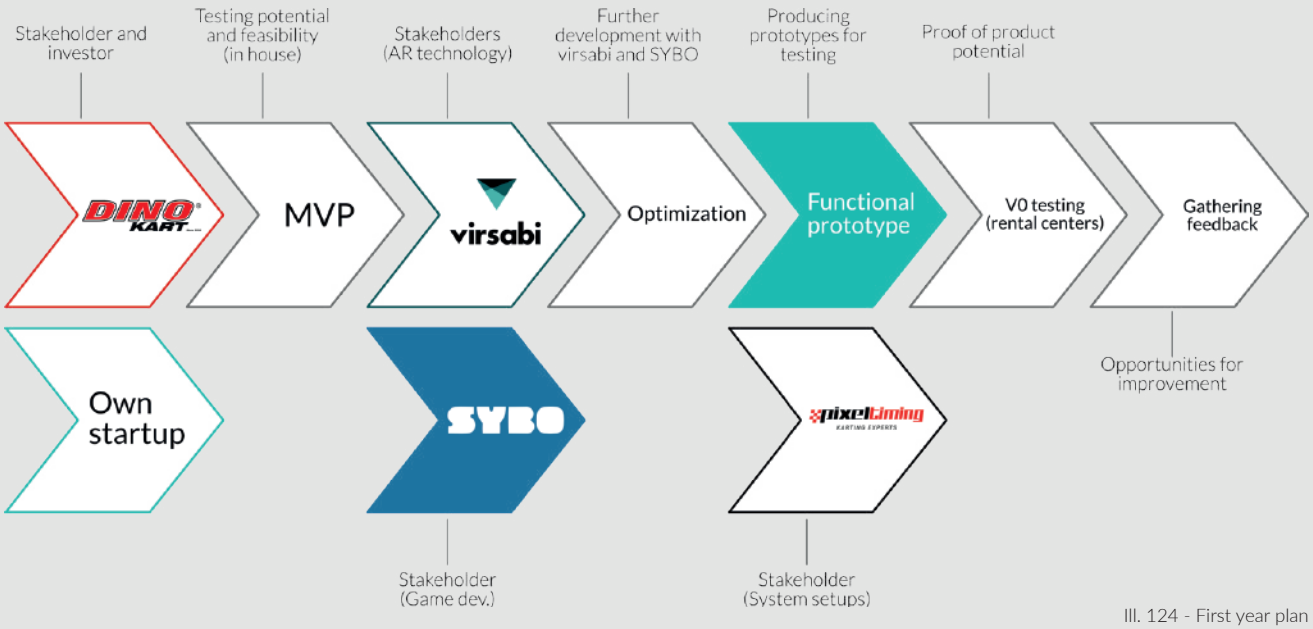
EXECUTION PLAN

The execution plan presents an overview of the process going from the development phase to the finalized solution being sold on the market. The plan is presented as a timeline, highlighting the big milestones and explains briefly what happens within the first seven years of developing the product and the business.

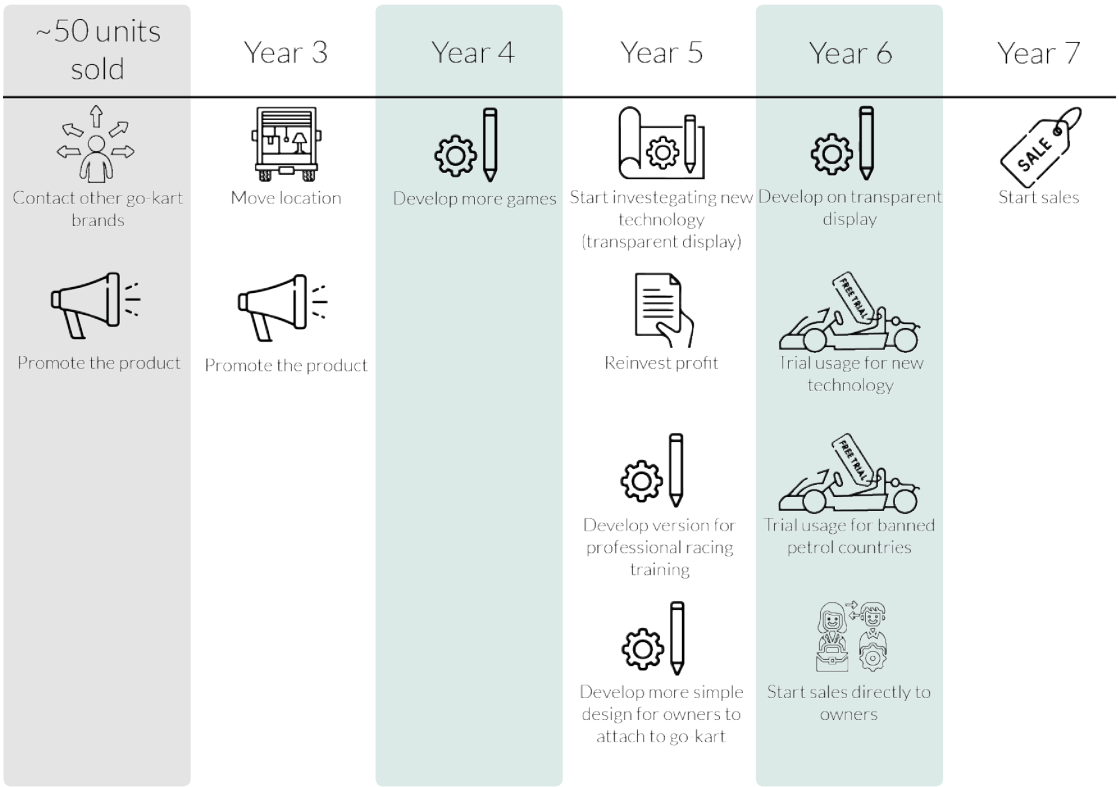
Within the first two years, an estimated 50 units are sold, hence allowing the business to expand and contact other go-kart brands to increase sales per year. Heading to year five the profit gained is reinvested to develop a new set of products/versions. Here by updating the existing solution according to new available technology and develop new ones suitable for other target groups/contexts. Throughout the years some of the profit gained, will be invested back into the business by investing in the development of new games. This is of high priority, as a more varied game portfolio will provide an additional profit to the business while at the same time targeting a broader customer segment.

The timeline is defined by time and sales, where it is expected to sell 50 units at the end of year two.





Ill. 124 - First year plan



Ill. 125 - Execution plan

BUSINESS MODEL CANVAS

The business model canvas has been used as a tool to structure aspects and insights of the business, by describing the customers, what value propositions are offered through what channels, and how the business will generate money. The model will furthermore highlight the key activities, key resources, and key partners needed for the business to become successful. (Athuraliya, 2022)

The canvas board has been used to visualize and communicate the business model of the project and could be a tool to visualize the business to possible investors, the illustration shows the key points of the model. A more thorough explanation of each point can be read in app. 31.

KEY PARTNERS

Manufactures, DINO

Owners of go-kart centers

The guests

Færdselsstyrelsen

DASU

SABO

Virsabi

PixelTiming

Invester

KEY ACTIVITIES

Research and development

Assembly

Out-sourcing

Evolve go-karting as an activity

KEY RESOURCES

Physical

Molds, materials, components, equipment

Human

Designers, quality control, installer

Intellectual

CE- certified

EMC, ISO 26262

Finansial

Loan, grants, investors

VALUE PROPOSITION

New experience for each visit

Combine virtual and real world

Attracts multiple target groups

Easy assembly

Repairable

CUSTOMER RELATIONSHIP

Creating a fun experience they want to revisit

Developing new experiences

CHANNELS

Social media

Traditional salesman

Collaborate with manufacturers

Sales through webshop or contracts with external partners

COST STRUCTURE

Fixed

Salaries

Development

Machines

Variable

Components

Materials

Manufacturing

Shipping

REVENUE STREAMS

Direct sales throguh a fixed price

Monthly payment

CUSTOMER SEGMENTS

Manufacturers

Owners of go-kart centers

Young people

Professional racers

Racing enthusiasts

Ill. 126 - Business model canvas

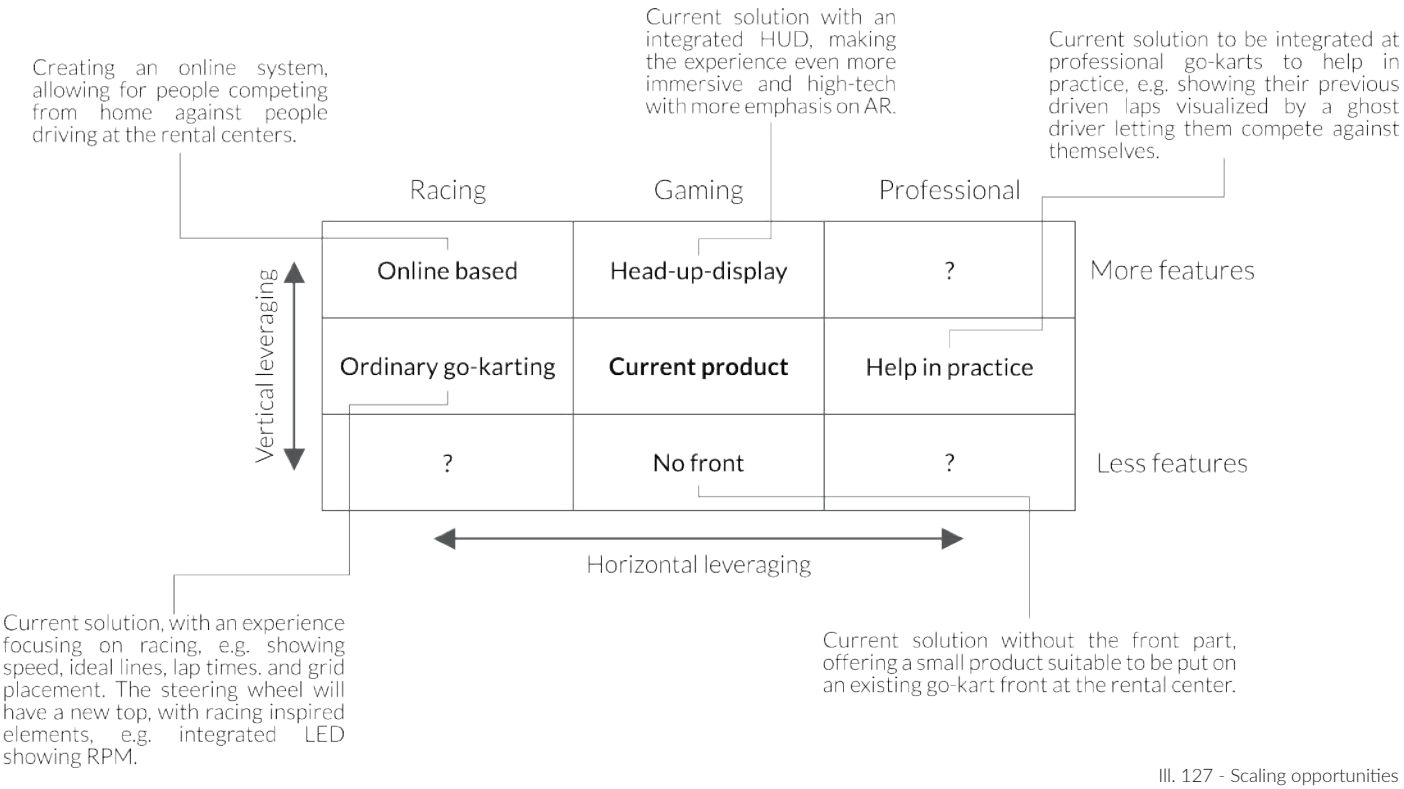
SCALING OPPORTUNITIES

Scaling the business could be done by taking the beachhead approach (Meyer, 1997) which is initially understood as a low-cost but effective way of scaling the business to fit new markets and customer segments. The idea is to build a solid customer base, and then use horizontal leveraging broadening out the solution to new segments, targeting e.g. racing enthusiasts and the professional segment. Here by using the original product but making it suitable by changing the software, e.g. letting the experience focus on racing and improvements in training. Broadening the customer base could expand to selling directly to rental center owners, and be an add-on to the current petrol-driven go-karts. As mentioned by Rasmus from DINO Kart, within the US, the product could, accompanied by a go-kart, be rented directly to the users having big road parties, where they could be used in e.g a parking lot.

When being established with the different markets, the solutions could be scaled up and/or down by vertical leveraging letting it fit more users. A scale up could see the solution add more features hence provide a more intriguing and "crazier" experience while a scale down could strip away unneseccary elements making it cheaper for more customers to be able buy it.

As the product is based on software, the possibilities of creating new experiences are seen as endless, as multiple different user groups could be targeted. Furthermore, due to the coming of new technology, the experience could be upgraded to fit more users.

As this product is merging the real and virtual world, it could eventually move more into the virtual world, where the users could join online to compete with drivers physically on the track. This would allow friend groups that might be able to see each other physically to do activities together. Likewise, could the users who focus on improving their lap time practice the track at home and then physically compete against the lap time that was set at home. This also opens up the possibility to get professional racing drivers to set a lap time for others to beat, or learn from.



Ill. 127 - Scaling opportunities

REALIZATION BUDGET

The realization budget shows the expected income and outcome of cash-flow throughout seven years of the business (Ulrich and Eppinger, 2011). To see the fixed cost, variable costs, liquidity plan, and components can be seen in app. 32.

The budget is based on a sales in batches, and will in this example be 16 units. Carsten from Action House, and Rasmus from DINO Kart stated the fact, that rental centers commonly makes orders to replace their entire go-kart fleet, ranging from 12 to 32 go-karts at a time.

The first sales are aimed to be at the start of the second year of the business' life. Within the first two years investments are seen low, due to the partnering with DINO Kart. At the start of the second year, a 350.000 DKK investment is needed to buy the moulds and pay for the development of the first game.

The goal for the second year is to reach a sale of 3 batches of 16 units each. Due to this low number of sales, out-sourcing has been chosen as the procedure for producing the units. This allows for easier changing of production methods and pivot if necessary which would not be possible if the production was done in-house as all machinery would have been bought. Having it in-house would furthermore, increase the fixed cost as a bigger warehouse would be needed and DINO Karts location might not house this.

Due to this project approaching a locked market with a new product, not many products can be used to determine the price of the product. Instead, this has been done through the price calculation and setting a requirement that the product may not cost more than 10% of the go-kart. The prices of new electric go-karts are around 100.000 DKK, therefore setting this product to a price of 10.000 DKK. Taking taxes into account the revenue is 7.500 DKK per unit.

The variable cost ends roughly at around 3500 DKK per unit. Calculating this gives a payback time of around 355 units when taking the initial own investment of 50.000 DKK into account.

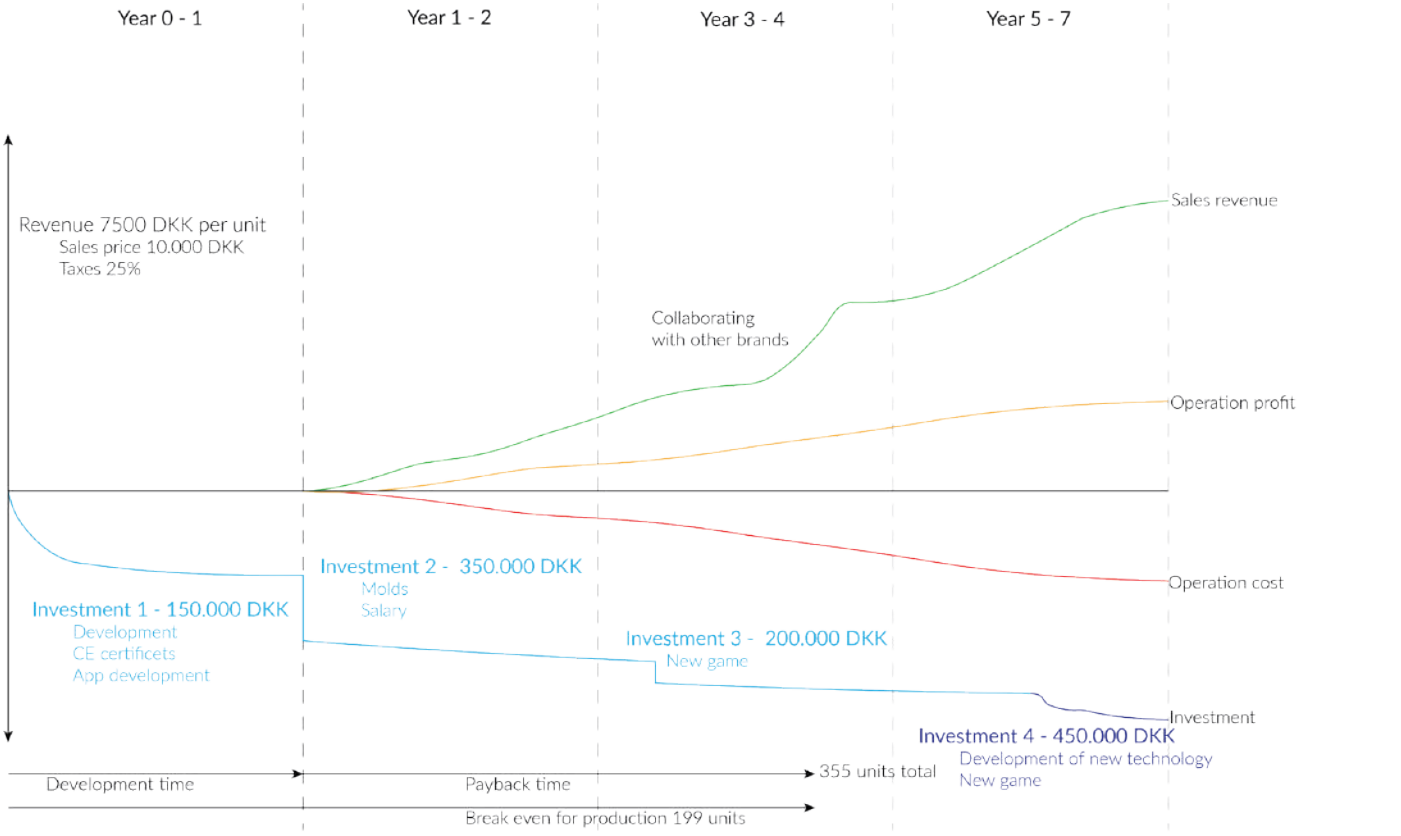
With each batch sold a game is bought as well. This has a set price of 3.000 DKK. Having the game as a secondary product will in the future when more games are developed, allow existing customers to buy the new games for their go-kart center.

Approaching the third year, the company expects to collaborate with five other go-kart brands and thereby increase the sales with additional 3-4 batches per brand per year. To keep the interest of the first customers a new game is being developed and announced, and an investment of 200.000 DKK is necessary. Year 4 is set to focus on marketing and creating a brand around the business and the solution, trying to break through into the US market. Year 4 is likewise used to raise the capital needed for updating the product with the use of new technology. This update is expected to happen in years 5-6, where a reinvest of profit of 450.000 DKK will be needed for the development of updated product, and an additional new game.
Variables such as inflation have not been taken into account.

Sales of 1400 unit	
Variable cost	
Material	68600
Components	3424472
External system	792312.5
Assembly	420000
Shipping from China to Denmark	270000
Man hours of molding	18150
Total	4993534.5
Total cost pr. unit	**3566.810357**

Fixed cost	
Rent	336000
Salary	5040000
Marketing	240000
Molds	345000
Game development	450000
Total	6411000
Total cost pr. unit	**4579.285714**

Ill. 128 - Variable and fixed cost



	Year 1 - 2 Sold 50 units - Molds + game	Year 3 - 4 Sold 550 units - New game	Year 5 - 6 Sold 800 units - New game	Summary Sold total of 1400 units
Worst case scneario +20% operation cost	Revenue 375.000 DKK Operation cost 914.000 DKK Operating profit -590.000 DKK	Revenue 4.125.000 DKK Operation cost 2.621.000 DKK Operating profit 1.504.000DKK	Revenue 6.000.000 DKK Operation cost 3.474.000 DKK Operating profit 2.526.000 DKK	Revenue 10.500.000 DKK Operating profit 3.440.000 DKK
Baseline	Revenue 375.000 DKK Operation cost 731.000 DKK Operating profit -356.000 DKK	Revenue 4.125.000 DKK Operation cost 2.096.000 DKK Operating profit 2.029.000 DKK	Revenue 6.000.000 DKK Operation cost 2.779.000 DKK Operating profit 3.221.000 DKK	Revenue 10.500.000 DKK Operating profit 4.894.000 DKK
Best case scneario -20% opeartion cost	Revenue 750.000 DKK Operation cost 584.000 DKK Operating profit -209.000 DKK	Revenue 4.125.000 DKK Operation cost 1.677.000 DKK Operating profit 2.448.000 DKK	Revenue 6.000.000 DKK Operation cost 2.223.000 DKK Operating profit 3.777.000 DKK	Revenue 10.500.000 DKK Operating profit 6.016.000 DKK

Ill. 129 - Realization budget

09 EPILOUGE

This phase concludes upon this project with a conclusion and reflection on the solution ARacing and the process leading to it.

Ill. 130 - Group room

CONCLUSION

In the initial stages of the project, the intention was to create a new electric go-kart, but due to the lack of proper framing, the project needed a shift in focus hence why the idea of creating an entire go-kart was scrapped. The main aim for this project was then set to redefine and enhance the experience of go-karting for young people.

During various visits to rental go-kart centers and interviewing different stakeholders, the context of go-karting was understood, hence multiple insights were discovered, influencing the further project. Interviewing users of rental go-karting, it was discovered that the activity was rarely revisited within the segment of young people. Here due to the experience being very repetitive, emphasizing greatly on individual performance and racing, hence reducing the social aspects while driving and mainly targeting people who like to race. From this, a need for a new experience was highlighted, which was defined, through field studies, testing, and analyzing users' everyday life and hobbies to be based on variation and driver interaction.

The outcome was a new AR-based gaming experience combining the favorable aspects seen in video games and go-karting. Through multiple tests, using mock-ups and the lent-out go-kart from DINO Kart, with various users within the target group, a system consisting of a redesigned front with an integrative display and redesigned steering wheel was created. The solution culminated in ARacing, a unique experience for young people, emphasizing team play, gamification, and a new felt experience every time while giving the go-kart a present look suitable for the upcoming electric go-karts.

Due to its digital display and software use, the scaling possibilities are endless, as new games can be made without needing a new design. The steering wheel is furthermore made with scalable versions in mind, having an interchangeable top allowing for a new style of steering wheel targeted other segments of go-karting.

The project aimed to push the traditionalistic established assumptions and norms of go-karting, what this activity implies, and who it targets. It aims to start pushing the norms regarding the experience seen at the current go-karting and the aesthetics, as this has been the same since the beginning of rental go-karting.

Due to dealing with a solution requiring implementation on a real driving go-kart, the potential within the current context can not be concluded upon, as this would require further testing needing a more functional prototype. However, throughout the development and testing of the solution, hence the experience, the potential was highlighted by participants, as they found it very amusing. Likewise, several stated they wanted to try it in real life and would be more than happy to test the experience again as they would like to go around the premade track one more time. It can therefore be concluded that the experience does appeal to young people and, at the same time, enhance the activity's current experience level.

REFLECTION

PRODUCT

ARacing is still in a concept phase, meaning there is still a need for proof of principle through physical tests in the proper context. Testing should be conducted using a fully functional prototype with the target group and other stakeholders within the rental go-karting segment.

Usage

As the experience is defined, and parts of the go-kart necessary for providing the experience are designed, the next question will be, how will this be used in the actual context? The tests done simulating the experience during this project have been at speeds of around 20 km/h, which is far from how it would be in real life. The requirement; the go-kart, during the activity, should have a speed between 20 km/h and <70 km/h is too unspecified and would require additional research and testing in the actual context. Testing with proper speeds would validate whether the project's aim is possible regarding whether the user could drive a go-kart at a higher speed while playing the game. A situation could also emerge: going that fast is not needed or wanted by the users. Having the system integrated on an electric go-kart would mean, that the top speed could be regulated at will from the owners' side. Testing of the setup would furthermore test the aspect of vibration hence setting the needed requirements for the dampening mechanisms.

Aesthetics

The aesthetics of ARacing is aimed to push the design of go-karts into a new era, by adding gaming characteristics. As the focus has been on only one type of user of go-karting, the references to gaming might not appeal to other popular groups of users, such as groups of families, birthday parties, bachelor parties, and especially racing enthusiasts.

The goal of pushing the aesthetics of the front has been accomplished by adding gaming elements. Thus, the overall basic form of the front is quite similar to the ones seen at current go-karts due to multiple test participants pointing out that the design should not stray too far away from current ones. The weighing between pushing the boundaries and making it suitable for a traditional go-kart has been difficult. The gaming elements have been the group's way of pushing the aesthetics of the front.

Implementation

As the solution approaches a new kind of experience, implementing it in the actual rental centers could be problematic since the context of go-karting is very locked. Thus, having the solution as a system meant for mounting on an existing go-kart could be a viable option, as it would be easy for the manufacturers, hence the rental owners, to implement it, resulting in minimal change for them. The problem could lie within the need for the external system set-up, as this could scare off some rental center owners. The approach would be to get a manufacturer onboard and convince an owner of a go-kart center to test out the solution on his/hers customers, to create a demand for this new type of experience.

PROCESS

A project founded on a theme

Based on the group's interest in motorsport, the area of go-karting was chosen to work with due to its availability and smaller scale making it more comprehensible. Due to the group going into the project with a theme compared to a problem, which has been the case in most previously completed semester projects, the group spent a long time searching for a problem. In the initial stages, a lot of field research was conducted to find a problem area. But most found problems were minor issues, not fitting for a project of this type. Hence, finding a proper framing for the project with enough depth to be used as a baseline for a new design solution was problematic. Through talking with stakeholders and focusing on narrowing down the context and target groups, a problem was discovered, giving the baseline for framing the project. The initial found problem area of the green transition in motorsport has, throughout the framing phase and the development of the solution, lost its importance as the final reframing of the problem area ended with rental go-karting not being revisited. However, this initial problem led to wanting to create something new, which initiated the investigation of what users see as important aspects of go-karting, hence leading to the problem of go-karting not being revisited.

The problem of wanting too much

The group started with the intention of developing a whole new electric go-kart, however, through the development, it was found to be too optimistic, hence it was difficult determining which parts the go-kart that should be spent the most time on. Furthermore having the entity go-kart up for a redesign seemed unnecessary concerning the project's problem statement. The scope was narrowed down several times until the focus was only on creating the system of the front, the display, and the steering wheel. The late-found focus helped not overwhelm the group and made it possible to develop the three main elements in-depth, thereby creating the concept of ARacing.

The challenging context

Having the context of rental go-kart centers was a challenge in some areas, as it was difficult to maintain a lasting contact with the rental center owners. As a result, mock-ups could not be quickly tested in the proper context because they were mostly unavailable and not close by. Furthermore, bringing users to the rental centers was difficult too, as it required a lot of planning and was very time-consuming. Therefore, many choices have been made on speculations that could have resulted in sources of errors. Thus, the rental centers should have been in use some more, as it could have provided the project with useful knowledge not being obtainable elsewhere. Having a physical go-kart to test on has helped the group bring in some part of the context, enhancing some of the feelings one would get when driving at a rental go-kart center.

A big emphasis on testing

Creating small mock-ups and testing them on users have been the go-to solution when discussing various aspects needing answers throughout the process. From the start, verifying most of the created content on users has been a priority, hence gaining their feedback for further development, as this provided far more valuable insights than discussing it within the group. Using testing as a way of deciding things has fitted well within the group, as all group members are fond of the more practical way of solving problems.

Throughout the project, Kolb's learning cycle was intended to be used. It has been used throughout the development phases when designing the steering wheel both physically and aesthetically and the front aesthetically. Here the concepts have been user-tested, which have later been reflected and concluded upon, leading to new ideation and testing based on the feedback and insights gained. Using this method structured the approach of designing each part of the product and is something that will be useful in the future.

The missing mock-up

Testing has mostly been based on physical mock-ups made from cardboard, paper, and 3D print. Most mock-ups have been of low quality; hence their intention could have been misunderstood. This could be seen in the testing of the steering wheel due to it being 3D printed and thereby does not contain the same strength principles, making it seem breakable when used on the go-kart.

The steering wheel was the only part of the system that got a physically made prototype, besides the used iPad, due to this part is the only one that should be interacted with.

The design of the final component box, front, and display have been 3D modeled and placed on a 3D modeled go-kart. These concepts have been tested through pictures and showings of the 3D model. Having the solutions shown digitally and not physically reduced their understanding of them, as they were harder to grasp. This might have left some unknowns regarding the interaction with the entire concept of ARacing but also how users will perceive the overall system. A physical model of all parts would have been beneficial for a better understanding of how the user would interact around the solution, e.g., if they would still want to grab the steering wheel or use the display to gain balance when entering or exiting the seat of the go-kart.

Working with many users

Collaborating with and including users has been essential in designing the finalized solution. Initially, getting to know all the different users within the go-karting context was necessary, as it provided a more wholesome image of what go-karting is. Due to the project focusing on a target group, being young people, it was necessary to include as many persons as possible when gathering information regarding them as persons, hence gaining a more comprehensible understanding of the group as a whole and the different individuals within it. Testing has also been done on various people within the target group to get unbiased answers, as already-tested participants would have insights into the project. Thus, multiple people have been used again, as they provided prior knowledge of tests that could be used as a baseline.

LIST OF ILLUSTRATIONS

Ill. 1 - 24 Own illustration

Ill. 25 https://tinyurl.com/bf6w4wwr
https://tinyurl.com/337aztas

Ill. 26 https://tinyurl.com/ymjsy4r7
https://tinyurl.com/3s5c3e4s
https://tinyurl.com/3s5c3e4s
https://tinyurl.com/4spke4eu
https://tinyurl.com/3wmy649t

Ill. 27 - 29 Own illustration

Ill. 30 https://tinyurl.com/yms4vcja
https://tinyurl.com/mvswbkrt
https://tinyurl.com/sf4jeafh
https://tinyurl.com/sf4jeafh
https://tinyurl.com/4wr89k92
https://tinyurl.com/yrkbr8hz
https://tinyurl.com/6f49mb2w
https://tinyurl.com/5dhhyec7

Ill. 31 https://tinyurl.com/ynwx494j

Ill. 32 https://tinyurl.com/mr2kspfz
https://tinyurl.com/mrrn3r9a

Ill. 33 - 34 Own illustration

Ill. 35 https://tinyurl.com/ynkxdf77
https://tinyurl.com/2a34bw84
https://tinyurl.com/yucjcbsj
https://tinyurl.com/s8j83229
https://tinyurl.com/yc258jr7
https://tinyurl.com/bddbyesw
https://tinyurl.com/26cefb8c
https://tinyurl.com/yc2xpaxc

Ill. 36 - 43 Own illustration

Ill. 44 https://tinyurl.com/3hmcd8fm

Ill. 45 https://tinyurl.com/3tp9xywx
https://tinyurl.com/mvrdkm2h

Ill. 46 - 58 Own Illustration

Ill. 59 https://tinyurl.com/7hy2wct4

Ill. 60 Own illustration

Ill. 61 https://tinyurl.com/3b2en75t

Ill. 62 Own illustration

Ill. 63 https://tinyurl.com/3yucka8f
https://tinyurl.com/mv49scku
https://tinyurl.com/3yjj36xt
https://tinyurl.com/mua55wa8

Ill. 64 - 66 Own illustration

Ill. 67 https://tinyurl.com/25ptmm5w

Ill. 68 https://tinyurl.com/yc67wdwk
https://tinyurl.com/3a5w7spz

Ill. 69 - 73 Own illustration

Ill. 74 https://tinyurl.com/5d752py5
https://tinyurl.com/5d752py5
https://tinyurl.com/yzradksp
https://tinyurl.com/yejpyxc2
https://tinyurl.com/2p9hu9m4
https://tinyurl.com/bddha94v

Ill. 75 https://www.fiakarting.com/history

Ill. 76 https://tinyurl.com/bddj7h8n
https://tinyurl.com/yxj4scsj
https://tinyurl.com/2s3ew7px
https://tinyurl.com/yb8m6yrm

Ill. 77 - 85 Own illustration

Ill. 86 https://tinyurl.com/3mh36ym8
https://tinyurl.com/mvzj5w5u
https://tinyurl.com/5fr6fnm5
https://tinyurl.com/2as32py8
https://tinyurl.com/yrhdz3eh

Ill. 87 - 130 Own illustration

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