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QUAKE-IP Control de calidad y evaluación en la Producción

Trabajo Fin de Grado

Grado en Ingeniería en Diseño Industrial y Desarrollo de Productos

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RESUMEN:

Proyecto multidisciplinar, realizado en equipo con 4 estudiantes de distintas disciplinas, que consiste en diseñar y fabricar un prototipo de una máquina, que se usará en el control de calidad del sector del doblado de planchas metálicas. Esta máquina mediante un sensor laser, escaneará y representará una sección de la chapa ya doblada, que se podrá medir mediante el uso de CAD, agilizando y mejorando la precisión del proceso del control de calidad.

Este proyecto consistirá en diseñar, haciendo uso de piezas normalizadas, y haciendo uso de componentes que podemos encontrar en el mercado, además se deberán cumplir ciertos requisitos propuestos.

Finalmente se fabricará un prototipo, totalmente funcional.

PALABRAS CLAVES: Prototipos, Diseño CAD, Normalización

KEY WORDS: Prototyping, CAD Design, Standardisation

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PREFACE

We are honored to present you this report, written as part of our project carried out throughout this semester at the University of Applied of Sciences of St. Pölten (FH St. Pölten). As a group, our main aim was to present our project and its various phases, while highlighting our experience as an international team made up of members from all over Europe.

We are grateful for the opportunity and the chance to work together, despite our varied backgrounds and areas of expertise. This diversity has enabled us to learn from each other and develop valuable intercultural skills. As a group, we would like to express our sincere gratitude to everyone who has contributed to the success of this project.

Firstly, we would like to thank Bernhard Girsule, Florian Taurer and Thomas Felberbauer for their support and valuable input throughout our project. Their advice, ideas and expertise enabled us to deepen our understanding of the subject and overcome the challenges we faced. We also would like to thank all people that help us and the other team members Christian Jandl and Gernot Rottermanner for their help.

Finally, we would like to express our gratitude to our respective universities and to FH St. Pölten University for giving us the opportunity to spend this semester abroad and to participate in this exciting project. This experience has been enriching in many ways, allowing us to develop our academic, professional and personal skills.

We are proud of the work we have achieved as an international team, and we hope that this report is a testament to our commitment, creativity and determination to see this project through. We are convinced that this experience will benefit us in our future academic and professional careers.

We thank you for your attention to this report

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PREFACE......2
1. Introduction......4
2. CIDAN Machinery Group......4
3. Status Quo of QUAKE-iP......6
4. Research......7
  3D scanners in the industry 4.0......7
  Related work......8
  User journey......9
5. Concept designs......10
  Specifications......10
    Portable by 2 people......10
    Not more than 2-3 actions for making the prototype portable.......10
    Stability......10
    Alignment of the part......10
    LED feedback system......10
    Safety switch......10
    A case......10
    Limitations......11
  Cardboard prototype 1......11
  Brainstorm 1......11
  Sliding concept......12
  Folding concept......12
  Detachable concept......13
6. Midterm co-creation......13
7. Finalizing the concept......14
  Brainstorm 2......14
  Cardboard prototype 2......15
8.Final concept......16
9. Assembly......16
  The Maker's lab......16
  Tools......16
  The Main frame......16
  3D printed parts......17
    Attachment emergency stoppers-slider......17
    Attachment laser-slider......17
    Attachment Plexiglass – frame......17
    Stoppers......17
  The folding frame......17
    Testing......18
    Axis......18

Hinges 18
Parts for Detailing 18
10. Testing 19
Calibrating 19
Company visit 19
11. Project Vernissage 19
12. Conclusion 20

1. Introduction

Quality control, industrial design, and prototyping are essential elements of successful manufacturing processes. Quality control is a crucial process in industrial manufacturing, aiming to ensure that products meet established standards and specifications. It encompasses various activities such as inspection, measurement, testing, and evaluation to detect defects, variations, or anomalies that could affect the quality of the final product. The primary objective of quality control is to ensure customer satisfaction by providing compliant, reliable, and high-quality products.

Industrial design is a discipline that focuses on creating and developing products that meet user needs while being aesthetically appealing, functional, and easy to manufacture. It involves designing the shape, structure, and ergonomics of products, taking into account various constraints and specifications. Our project was based on these principles.

Our goal was to create an innovative solution designed to address the specific challenges faced by operators in the metallurgy industry, in collaboration with companies such as Metaflex and CIDAN. Our vision was centered around creating an improved, mobile, and compact prototype that could bridge the knowledge gap between what is needed and what can be achieved within the industry.

We aimed to develop a product that would reduce the time required to perform certain tasks in the metallurgy industry. Our objective was to increase the accuracy of operations, resulting in a decrease in errors and waste. We sought to bridge the gap between understanding the industry's needs and applying solutions to meet those needs.

By working with researchers from the university for the company CIDAN Machinery group, we hoped to create a prototype that meets the specific requirements of the metallurgy sector, while providing an efficient, reliable, and operator-friendly solution. Our ultimate goal is to improve industry performance and productivity while adhering to the highest quality standards.

2. CIDAN Machinery Group

The Cidan Machinery Group is a company that offers smart, easy-to-use machines for sheet metal processing. Their machines are designed for saving time, materials and the environment (CIDAN Machinery Group, 2023).
In this company there is a department nuIT. This department specializes in the software of the CIDAN machines. They stand in for more clarity into the industrial processes, and thereby raise the efficiency of companies. For nuIT, digitisation is the key (Start Page | Nu-it, n.d.).

Figure 1: CIDAN machinery

Figure 2: Metaflex company

In the same building as nuIT - which is based in St. Pölten, the company Metaflex is situated. Metaflex produces folded sheet metal parts, which are used for all kinds of building applications (*Figure 3*). Their unique selling point is the ability to make the metal parts easily personalisable with an online drawing tool (*Figure 4*). A customer can go to their online shop, simply draw the part they need and it will be produced - folded - in a short period of time. Metaflex' online drawing tool was made possible by the software of nuIT (Home | METAFLEX Kanttechnik - Kantteile per Mausklick in 48 Stunden, n.d.).

With the help of the CIDAN Machinery Group, Metaflex is continuously getting more efficiënt and digitalized. In their current production line, there still is a significant gap. The workers in the factory still have to do the quality check by hand. They manually measure and check the produced parts, which takes a lot of time.

Together with researchers from the FH St. Pölten, CIDAN is trying to fill in this gap by making an Industrial machine. The research and testing for this machine is carried out in the project QUAKE-iP (Quality Control & Evaluation in Production). The past semester, it was our task to help make the industrial prototype that controls the quality of Metaflex' sheet metal parts.

Figure 3: Building applications of Metaflex' sheet metal parts

Figure 4: Metaflex' online drawing tool

3. Status Quo of QUAKE-iP

When we arrived in St. Pölten, the project QUAKE-iP was already in progress. The parent researchers had previously made a proof of concept (*Figure 5*). In the concept, the functioning of the machine had been defined. A 3D scanner - that uses a laser - scans the edge of the sheet metal part by moving in a horizontal direction on a motorized slider. Metaphorically it could be compared to a scanner in a paper copier, only this scanner scans in the 3D environment.

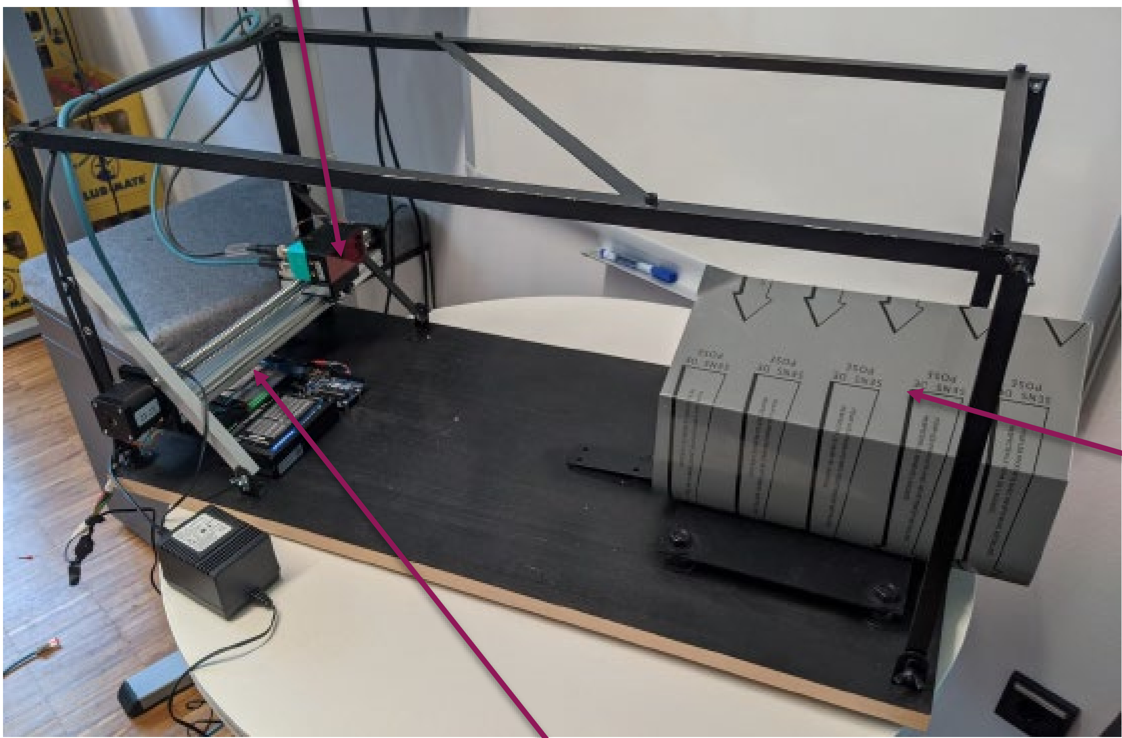


Figure 5: 1st prototype

Our task for this semester would be to integrate this proof of concept into a more professional and presentable industrial prototype.

4. Research

The first month, our initial focus was to understand the scope of QUAKE-iP. With a research phase, we broadened our understanding of the quality control for sheet metal parts. We focused our research on 3 subjects: 3D scanners in the industry 4.0, related work in the scope of quality control and the user journey of the operators in the factory.

3D scanners in the industry 4.0

3D scanners in Industry 4.0 are devices used to capture the geometric information of three-dimensional objects. They are employed in the context of automation and the integration of digital technologies in manufacturing processes. 3D scanners enable the creation of digital 3D models of physical objects, making them useful for applications such as reverse engineering and quality control. They aid in understanding the design of existing objects, verifying the compliance of manufactured parts, and detecting defects (Haleem et al., 2022).

Because the quality control of the metal part is done with a 3D scanner, it is a necessity to explore this context.
We have conducted research on 3D scanners in Industry 4.0 and compiled this information into a mind map.

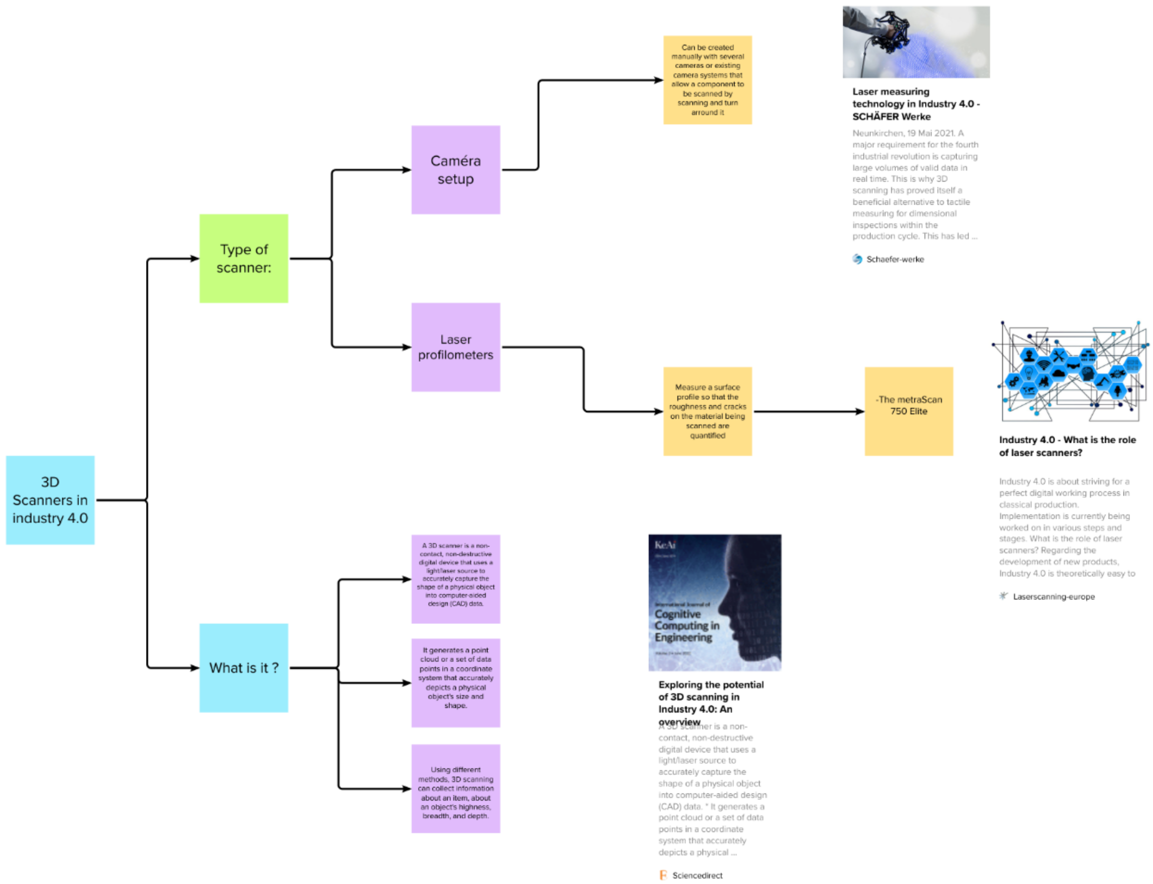


Figure 6: Mind map

Our vision of what a 3D scanner is and does became clear. 3D scanner technology is coherent with industry 4.0. On the strength of the ability to digitalize and implement physical shapes in computer visions and data, 3D scanners support the transition from Automatization to Cyber-Physical Systems (Winter, 2021).

The references to the research on 3D scanners in the Industry 4.0:
(GmbH, 2021)
(Industry 4.0 - What Is the Role of Laser Scanners? | Laserscanning Europe, n.d.-b)
(Haleem et al., 2022)

Related work

We also took a look at how the quality of these parts can be controlled in different ways. The result is a context map of related work associated with edge detection.

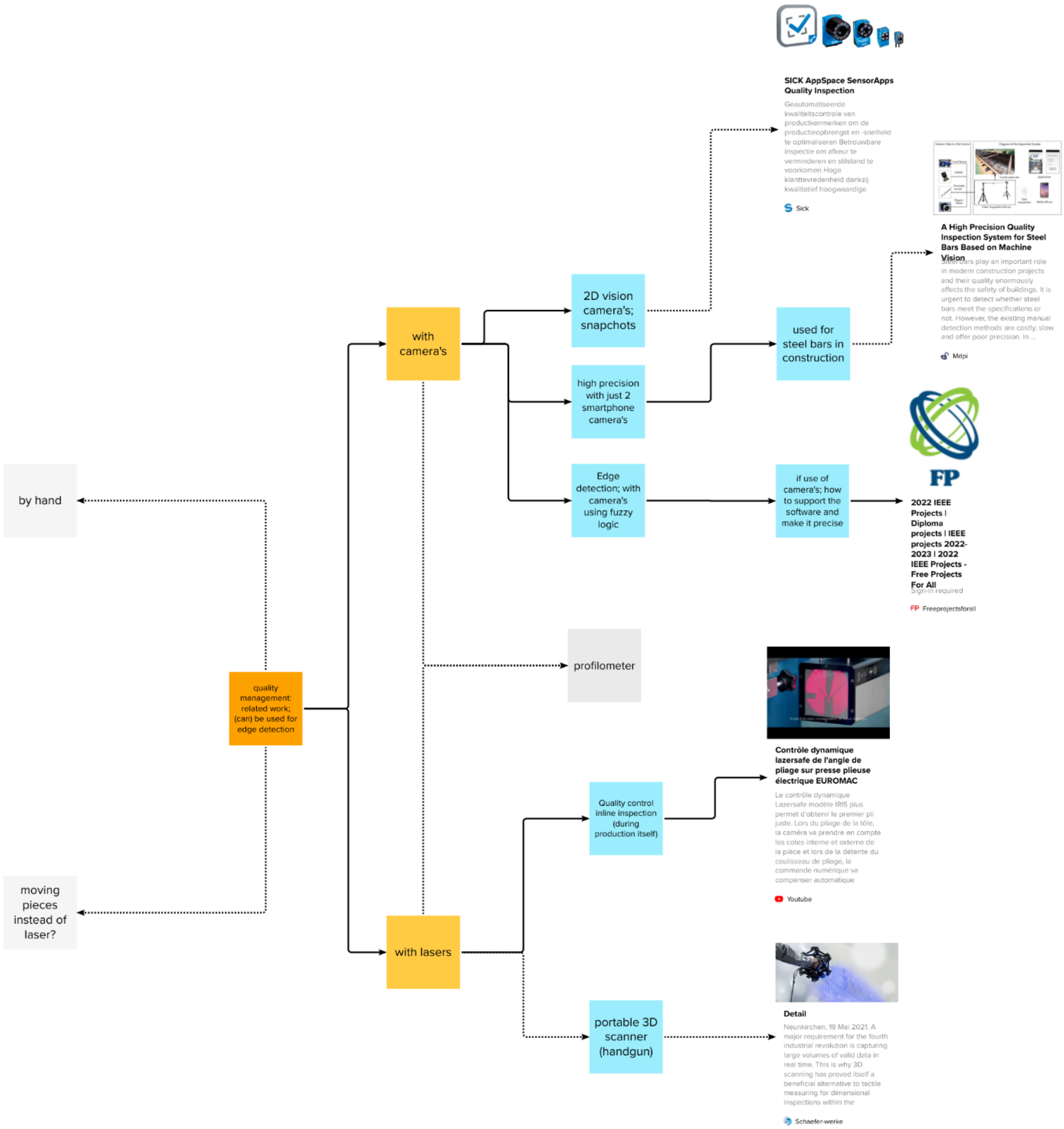


Figure 7: Mind map

The quality management of the edge detection of the sheet metal parts can be done in numerous ways. Compared to the manual method that Metaflex is using currently, the digital ways of work are mostly with lasers and cameras. In our project, the decision was made to use lasers. It is a cheaper option than cameras and it acquires less software to make it work.

The references to the research on related work in quality control:
(SICK AppSpace SensorApps | Quality Inspection | SICK, n.d.)
(Zhang et al., 2018)
(Anas et al., 2016)
(soclaform, 2018)
(GmbH, n.d.-b)

User journey

A research of the user journey is of importance to know in which context the prototype is situated. In fact, we need to determine these elements because it is essential to understand the intended use by the user in order to ensure effective quality control. By understanding how the prototype will be used on the production line, we can define the necessary specifications for it to adapt as closely as possible to the production chain and the operator. The use of this user journey card will allow us to accurately define the required specifications.

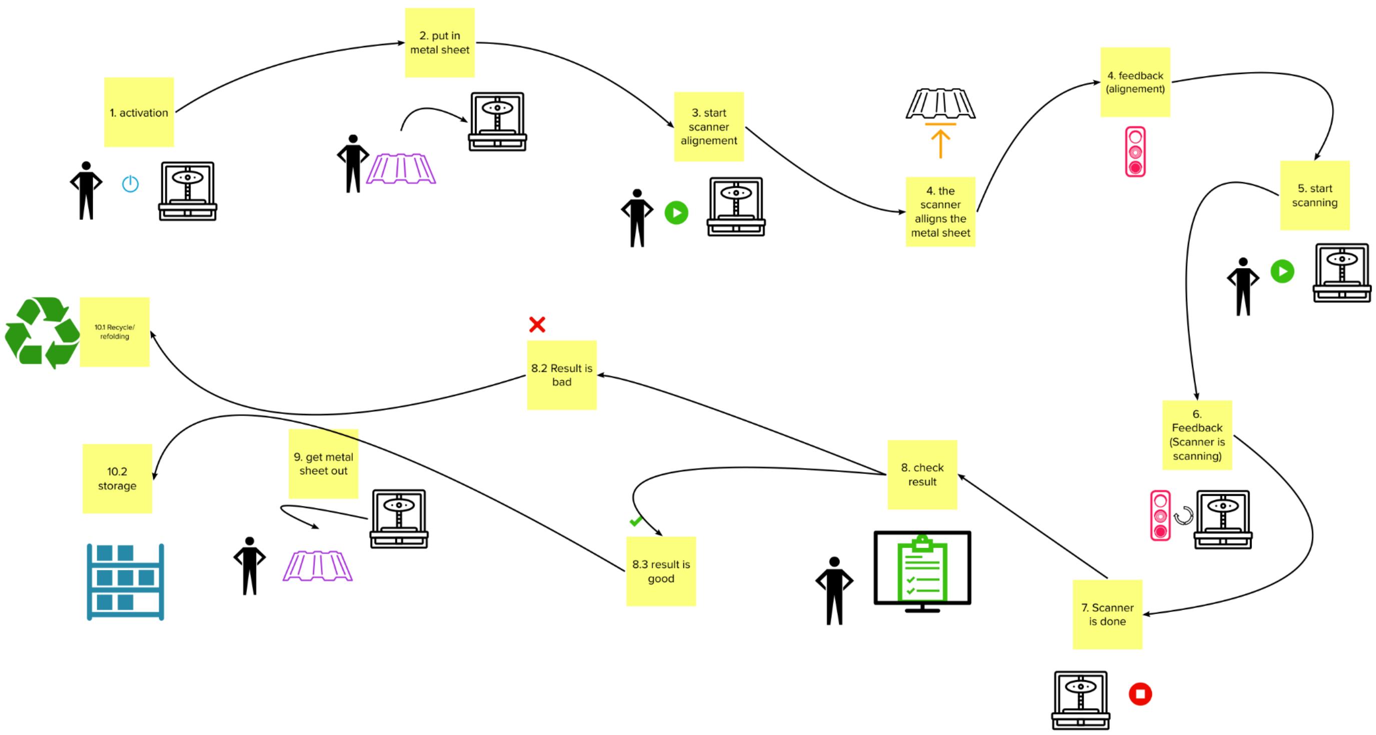


Figure 8: User journey

5. Concept designs

Specifications

Portable by 2 people

Because the prototype will be moved from one place to another, to show at fairs but also to transport from one machine in the production line to another. It has to be able to be carried by two people (max 40-45kg) and to be able to fit in a car.

Not more than 2-3 actions for making the prototype portable.

To assure that transporting the prototype goes smoothly, it should be designed in a way that it can be transformed from portable to unportable state in 3 actions or less.

Stability

For the prototype to work, it is important that it remains stable when in an unportable state, so that the 3D scanner doesn’t receive vibrations while scanning the metal part.

Alignment of the part

There should be a solution to align the metal part perpendicular to the movement of the laser. In this way, every part remains in the same position for the scanning procedure.

LED feedback system

To create a better interaction while controlling the machine, there should be an LED feedback system that shows the operator in which state the machine is in.

Safety switch

To protect the operator and the machine, safety switches should be integrated in the slider system to stop the motor when crossing the ultimate end point.

A case

The prototype should be in a closed state/case while transporting it. So the internal components are safe and secure in a portable state.

Limitations

Next to the specifications we also had some limitations. The components that would be installed inside the prototype were already defined. The biggest part is the slider system, which has a length of 840mm. The laser also had a specific range that had to be considered.
The structure (frame) of the prototype had to be built in certain Aluminium profiles.

Cardboard prototype 1

This first cardboard 'scrap' prototype was used as visualization while brainstorming on the different concepts. It made designing for the portability aspect a lot more tangible.

Figure 9: 1st cardboard prototype

Brainstorm 1

Firstly, we wrote some ideas on post-Its on how we could make the prototype foldable. Then we chose the 4 ideas that made the most sense to us, and we divided those ideas in 3 groups: sliding, portable and foldable. Each group could be shown with the cardboard prototype.
Secondly, we did some fast 3D models, and then we presented those 4 ideas to the researchers, and they gave us the pros and cons of each concept.

Sliding concept

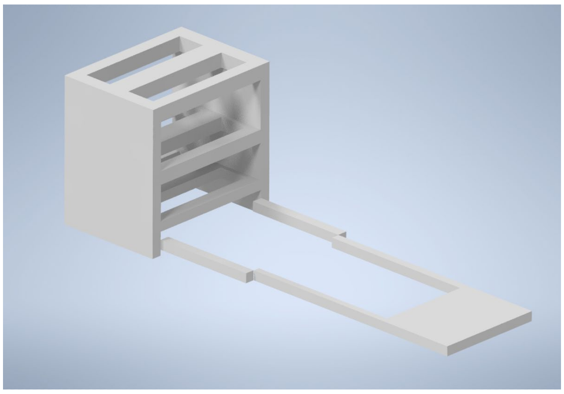


Figure 10 : Sliding concept

PROS:
- Very easily storable table

CONS:
- Sliders would have to be bought, this would be time-consuming again
- Sliders is an expensive solution

Folding concept

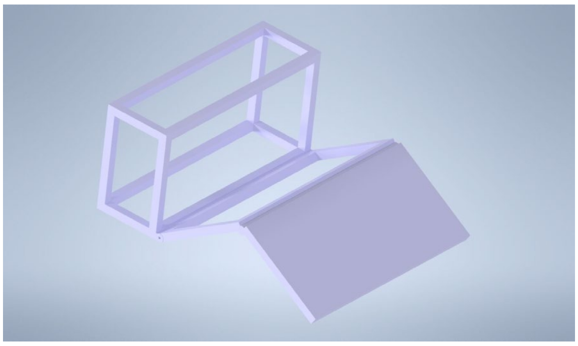


Figure 11 : Folding concept 1

PROS:
Covers the Laser if not in use
Easily storable “table”

CONS:
Big metal surface required

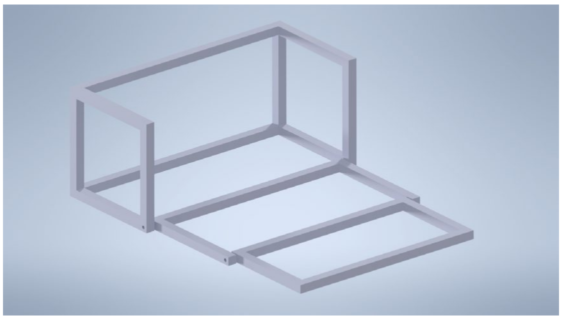


Figure 12 : Folding concept 2

PROS:
- could cover the laser if not in use
- Easily storable “table”
- It is no requirement that the table reaches up to the left and right side of the scanner

CONS:
- Stable and fixable hinges have to be designed or bought

Detachable concept

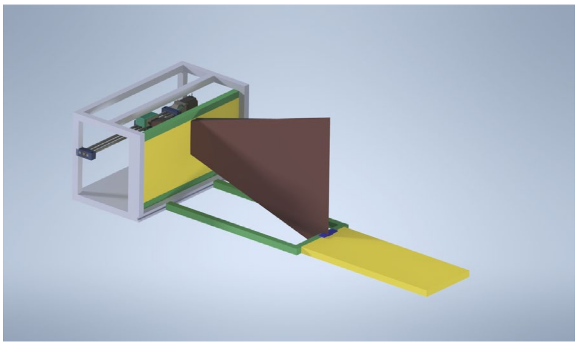


Figure 13 : Detachable concept

PROS:

- Laser on the top: The height of the prototype can be chosen just as much as the beam angle requires

CONS:

- Table has to be deconstructed every time it is stored: Much work and error-prone

6. Midterm co-creation

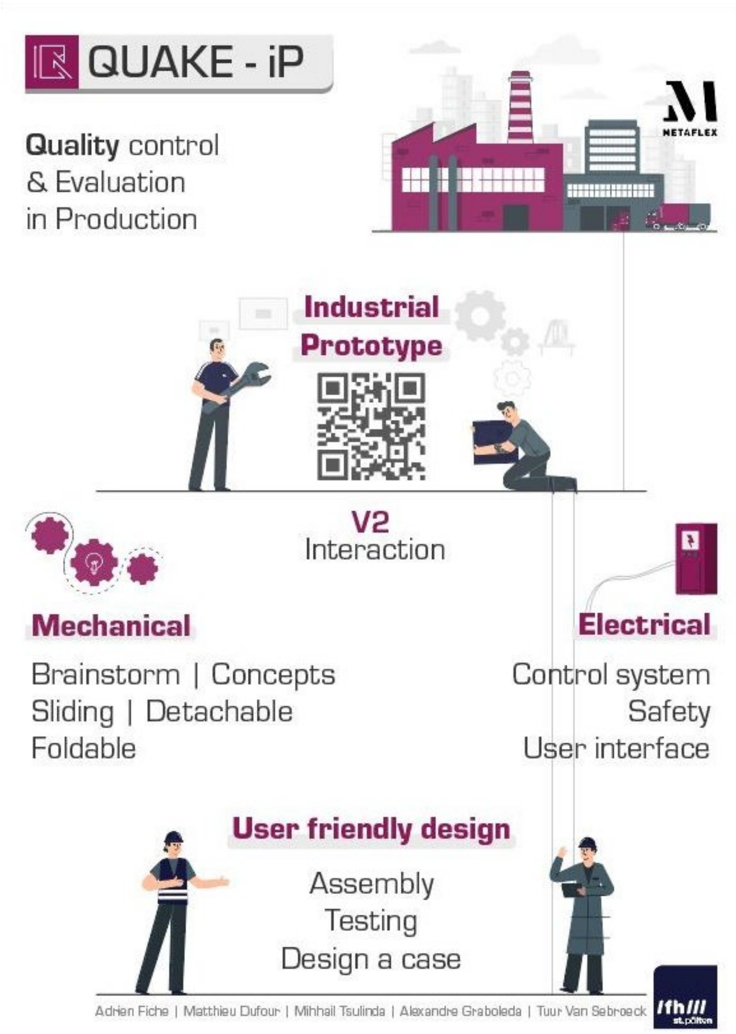


Figure 14 : Poster Midterm co-creation

The Midterm Co-Creation was the first time where we had to do a speech about our project, in front of an audience.

Along with the speech we did a poster with some key data about the project.

The poster has a QR code that brings you to a video that we did to try to explain easily how the machine works.

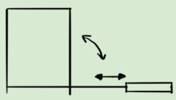
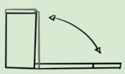
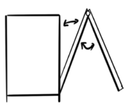
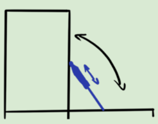
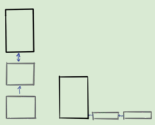
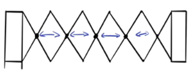
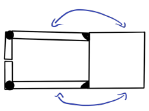
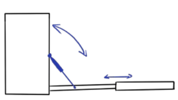
In the video you can see a preliminary version of the machine, and how it will work.

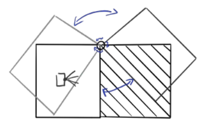
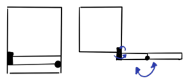
You can find the video scanning the Qr code or in the following link: https://youtu.be/0fXxOXt_PS0

7. Finalizing the concept

Brainstorm 2

After the foldable concept was chosen to further develop, we organized a second brainstorm. In this brainstorm we decided to draw a lot of different folding systems, then we selected 10 ideas. Secondly we chose the 5 features that seemed to be most important to us : Stability, Coolness, Compactability, Simplicity and Buildability.
Then we did a matrix where we evaluated the ideas with a score and we got the 4 best options

	IDEA	STABILITY	COOL	COMPACT	SIMPLE	BUILDABLE	TOTAL
1		9	6.5	9	9	9	42.5
2		7	8	8	8	7	38
3		6	5	8	7	7	33
4		10	7.5	9	10	9	45.5
5		9	2	8	9	9.5	37.5
6		5	5	8	5	6	29
7		7	5.5	9	6	6	33.5
8		8	7	8	6.5	7.5	37

9		6	8	8.5	7	5	34.5
10		7	4	8	7	6	32

We calculated that the best options were the nº1,2,4,5. We analyzed each idea individually, because we wanted to know more about them.
Finally we chose idea number 2. In order to improve the idea, we decided to add one more joint, so then we have 3 "arms" instead of 2.

Cardboard prototype 2

Once we had a clear idea of what we wanted to do, we made a cardboard model of it to test its functioning and experiment with it.

Figure 15 : 2nd Cardboard prototype

8.Final concept

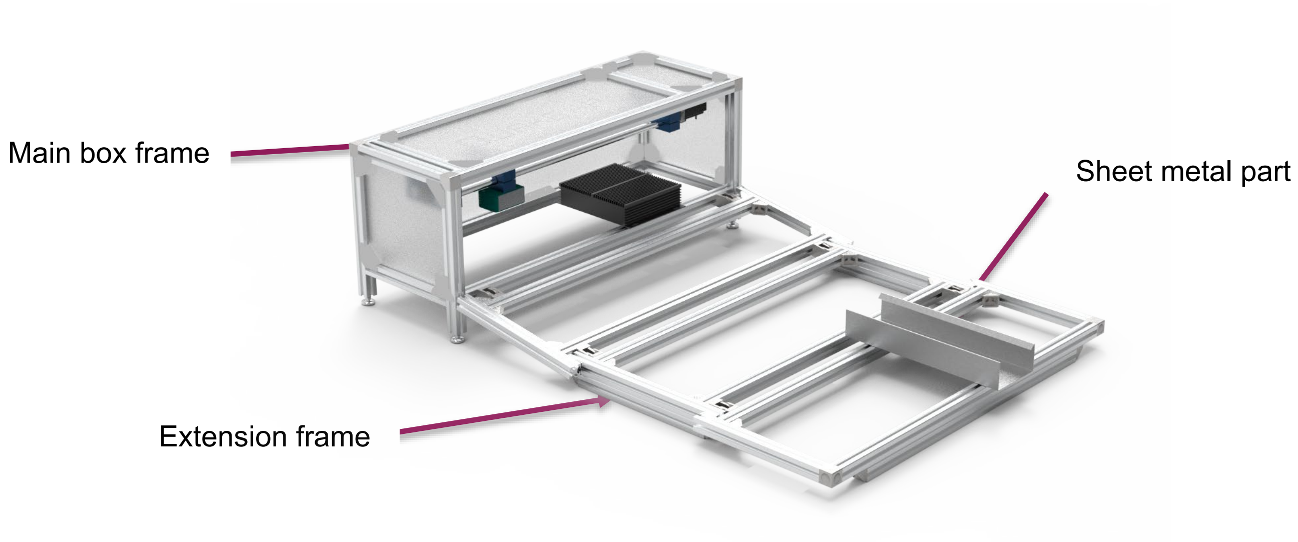


Figure 16 : Render of final concept

As can be seen in the cardboard prototype, the portability aspect is achieved by folding the extension frame over the main box frame. In that way the inside components are also protected while transporting the prototype.

In the assembly we would also need to add handles so that it can be carried by two people.
The hinges or axis that are used for (un)folding need to be of certain strength. So that the extension frame does not shift in an unfolded state. A continuous stability is important as mentioned earlier in the specifications.

The sheet metal part will be aligned by placing it against a mounted Aluminum profile. This alignment profile will be further explained in '9. Assembly'.

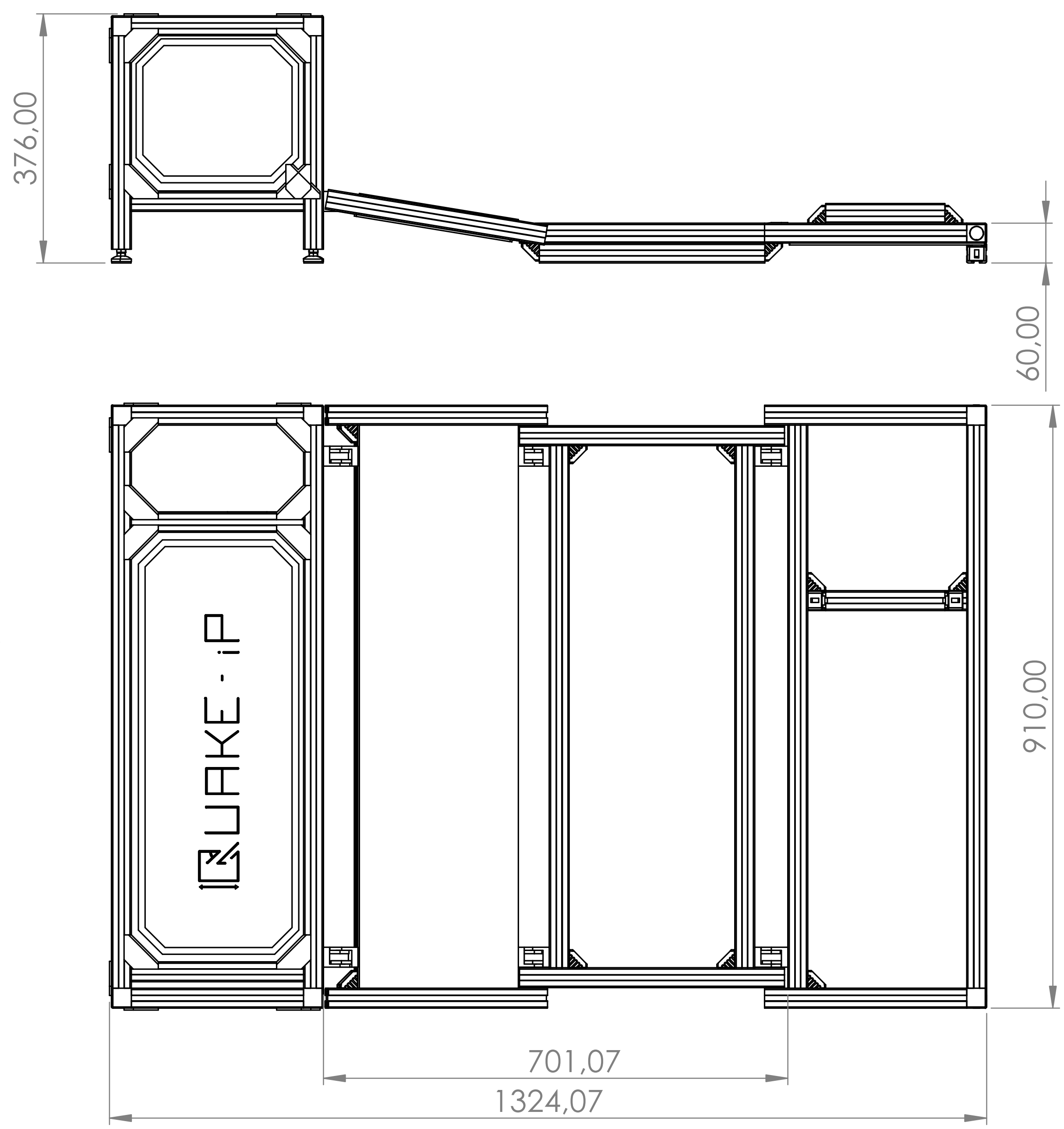
We decided to add plexiglass in the areas where the prototype is open. This would have two functions. One the one hand it would close off the inside components from the environment - then there would be no need to build a separate case for transporting the machine. On the one hand the plexiglass would function as a diffusion of the LED feedback system, to make it more professional and presentable.

As can be seen in the render, the two biggest inside components - the slider system and the mini-PC are considered when integrating them in the prototype.

The prototype is built with Bosch Rexroth components.

Bill of Materials:

Name	quantity	Extra data	Reference (Rexroth store)
Profile 30*30*850	8	4 holes	3842990723
Profile 30*30*260	6	4 holes	3842990723
Profile 30*30*322	4	4 holes	3842990723
Profile 30*30*335	2	4 holes	3842990723
Profile 30*30*400	2	4 holes	3842990723
Profile 30*30*340	2	4 holes	3842990723
Profile 30*30*305	2	4 holes	3842990723
Profile 30*30*700	1	4 holes	3842990723
Profile 30*30*240	1	4 holes	3842990723
Profile 30*30*180	1	4 holes	3842990723
Cubic Joint 30*3	4		3842549864
Cubic Joint 30*2	2		3842549862
Gusset 30*30	38		3842523525
Printed corners (frame)	20		
Printed support	4		
Feet	4		3842502257
Printed laser support	1		
Printed sec.Switch holder	2		
Sec. Switch	2		
Laser	1		
Sliding bar	1		
Plexiglass top	1		
Plexiglass back	1		
Plexiglass top 2	1		
Plexiglass lateral 1	1		
Plexiglass lateral 2	1	Same as lateral 1 without holes	
See printed parts in next pages (Assembly)****			

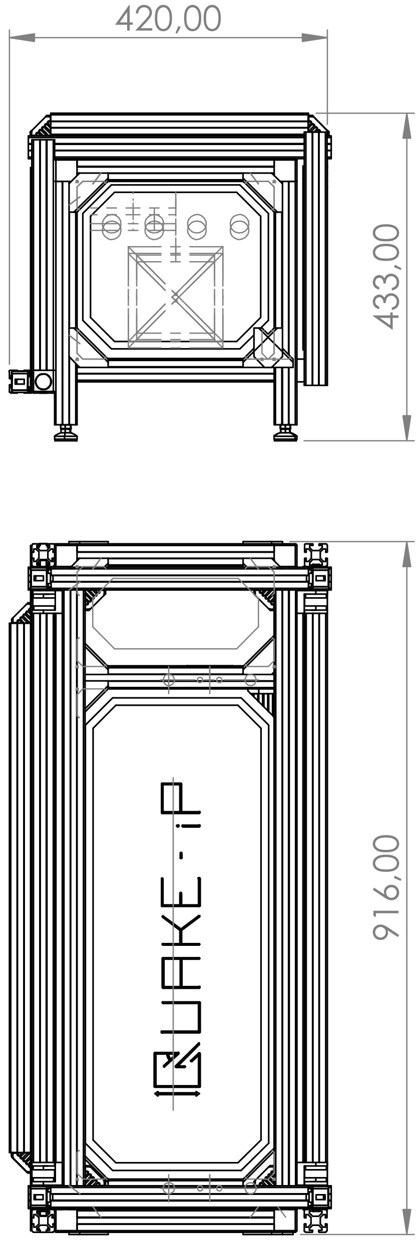


UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS

NAME QUAKE-IP SS23	DATE		TITLE: Protype "open"
		MATERIAL:	DWG NO.	A4
			SCALE:1:10	SHEET 1 OF 2

4 3 2 1

F E D C B A



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS			
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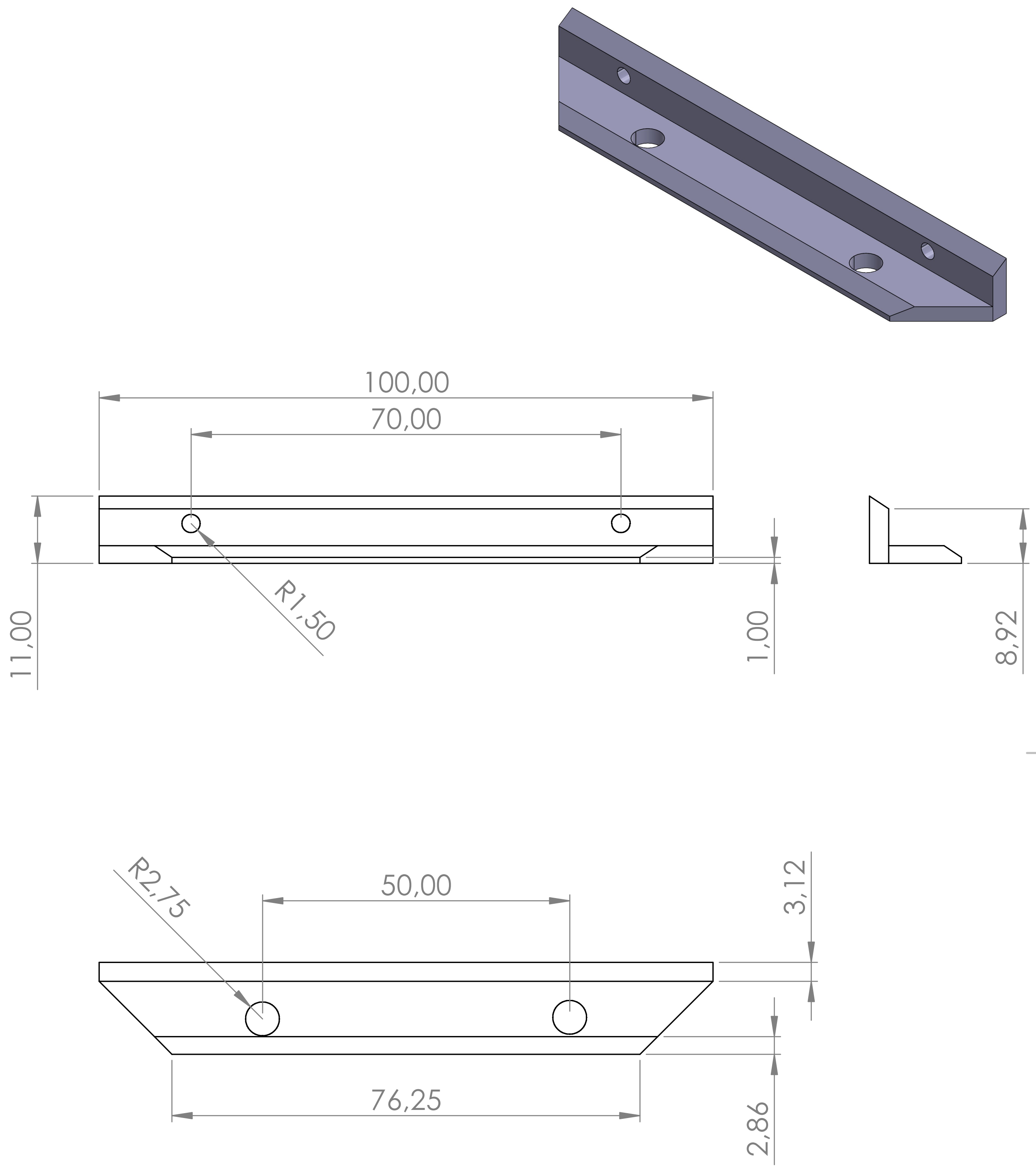
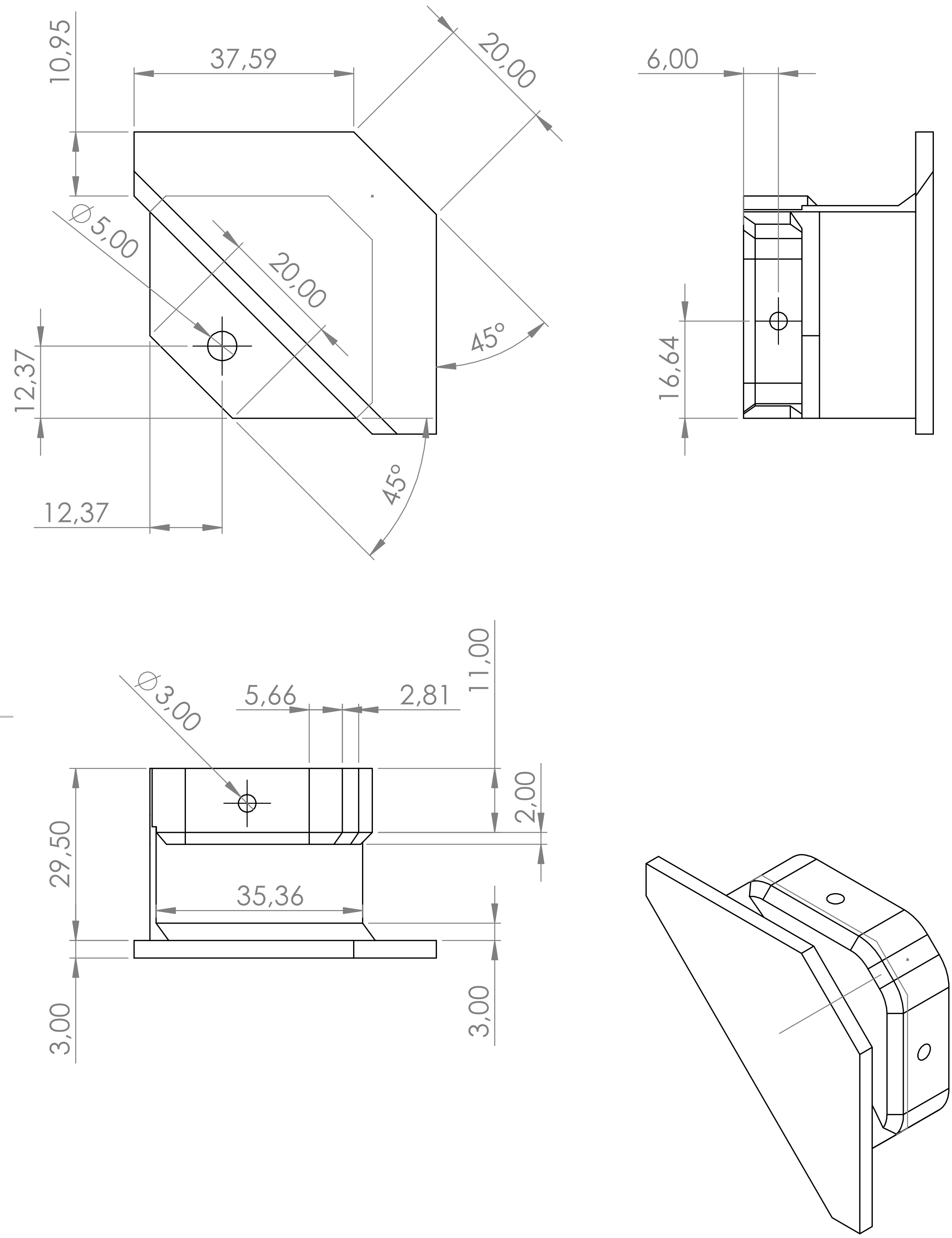
	MATERIAL:		DWG NO.	A4
		SCALE:1:10	SHEET 2 OF 2



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS				DO NOT SCALE DRAWING	REVISION
	NAME	SIGNATURE	DATE	TITLE:	
DRAWN					
CHK'D					
APPV'D					
MFG					
Q.A			MATERIAL: PLA	DWG NO. Plexiglass bracket	A4
			WEIGHT:	SCALE:1:1	SHEET 1 OF 6



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN			
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:

MATERIAL: PLA

WEIGHT:

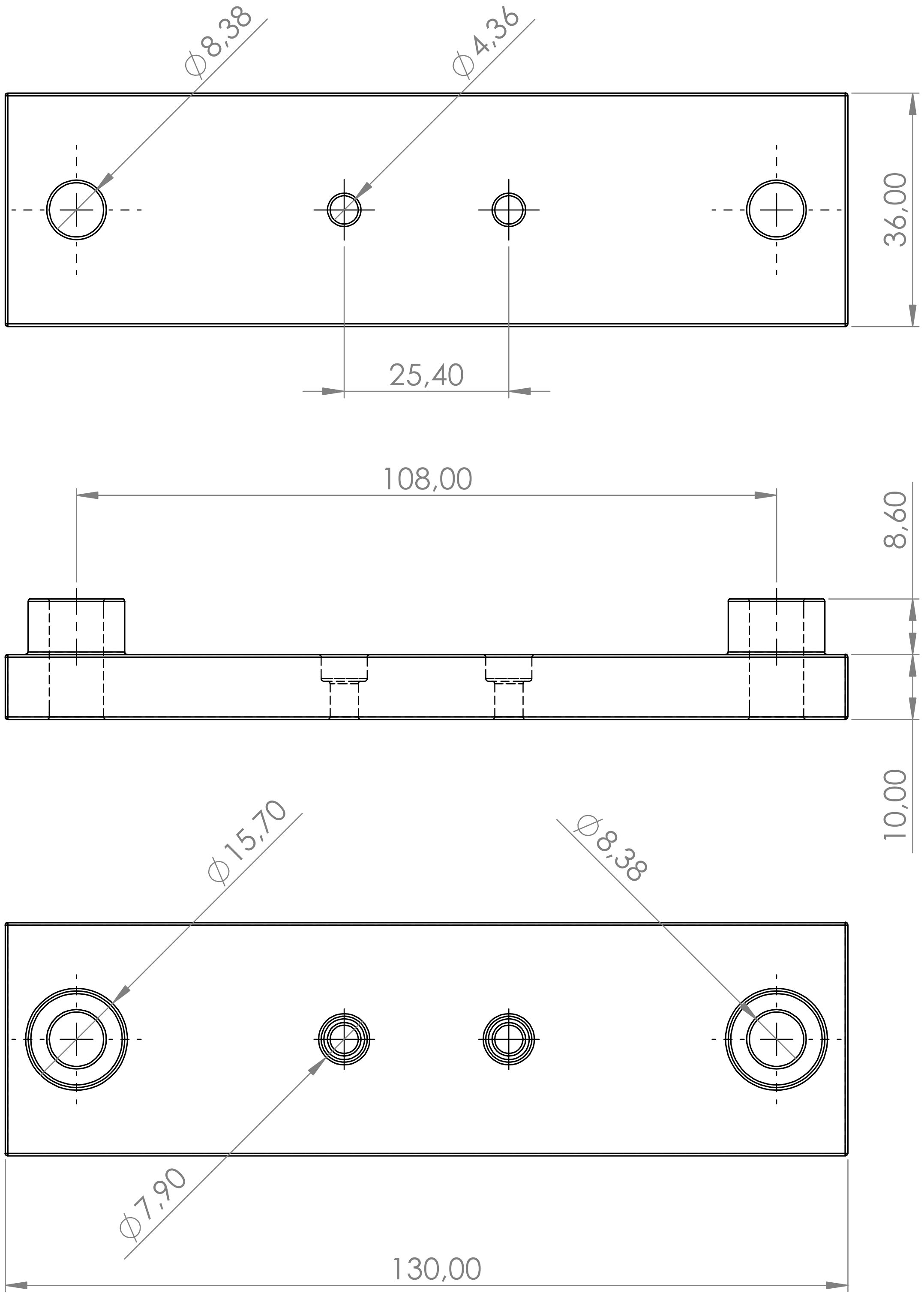
DWG NO.

Plexiglass Corner bracket

A4

SCALE:1:1

SHEET 2 OF 6



All corners: R= 0.4 mm

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS		DO NOT SCALE DRAWING		REVISION
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DRAWN				
CHK'D				
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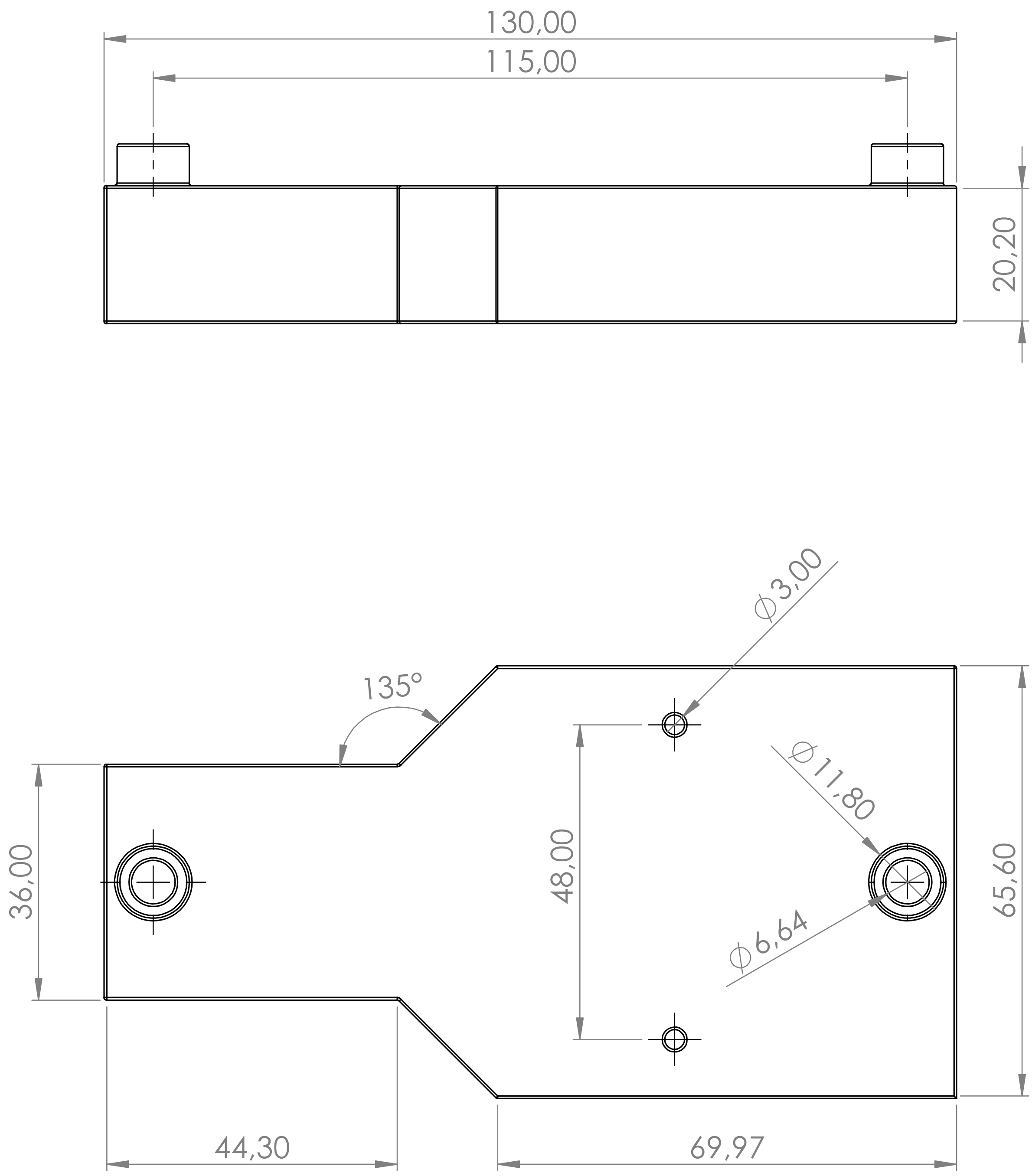
MFG				
Q.A			MATERIAL: PLA	DWG NO. Slider attachment — A4
			WEIGHT:	SCALE:1:2 — SHEET 3 OF 6



All corners: R= 0.4 mm

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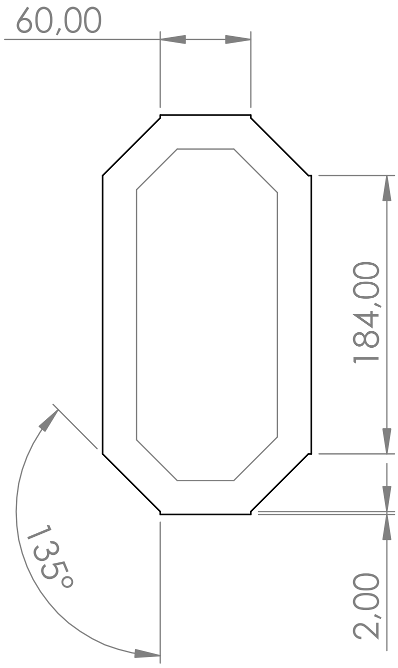
Top 1



Top 2

thickness of 3 mm

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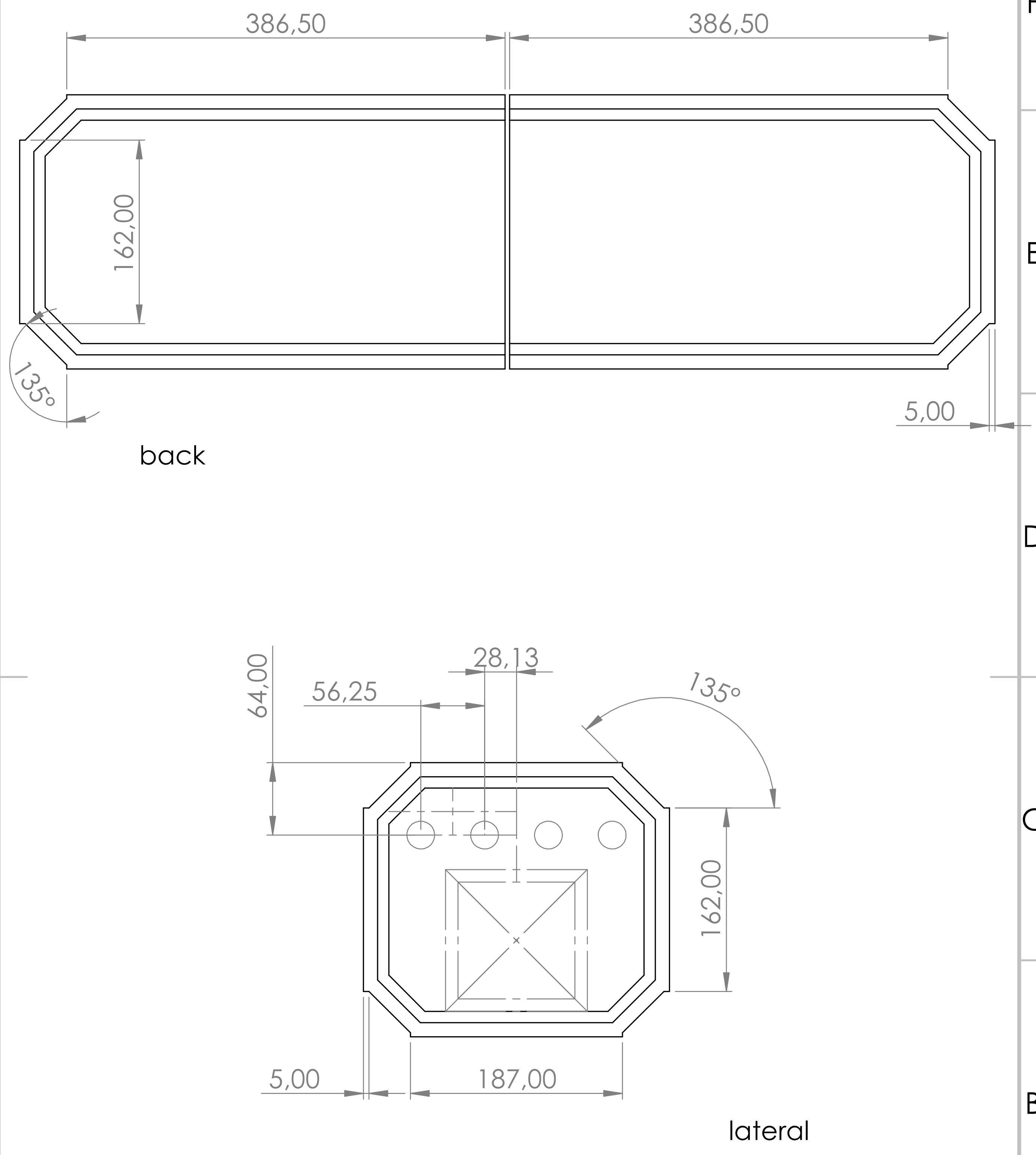

thickness of 3 mm

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DRAWN					
CHK'D					
APPV'D					
MFG					
Q.A			MATERIAL: PLEXIGLASS	DWG NO. Back and lateral	A4
			WEIGHT:	SCALE:1:5	SHEET 6 OF 6

The Electrical System

Throughout the course of our project, we continually evolved our electrical schematic design using KiCad, with frequent interactions and modifications in collaboration with our lecturers. This iterative process was driven by the necessity to refine our design to meet project needs, and ensure robust, efficient performance.

Our final concept involved the adoption of Controlling as our primary interface for communication between the middleware operating on the computer and the peripheral devices such as the stepper motor, safety switches, and sensors. The decision was motivated by Controlling's reliable performance and compatibility with our system requirements.

Additionally, we made a strategic decision to segregate the LED system from the primary operational functions. The rationale behind this decision was the complex communication and resource-intensive nature of the addressable LED strips. To handle this complexity, we opted to use a separate microcontroller, specifically the Teensy-LC. This approach allowed us to manage the LED system independently, ensuring optimal performance of the primary functions.

Moreover, to further delineate the essential and secondary functions of the prototype, we incorporated two distinct electrical circuits into our design: a 24V DC circuit for primary functions, and a 5V DC circuit for the lighting system. This separation helped us manage the power requirements of different components more efficiently and minimized the risk of any potential cross-system interference.

Finally, our system included two separate serial communication lines between the prototype and the computer. This design choice further ensured the distinct operation of the primary and secondary systems, enabling smooth, uninterrupted performance.

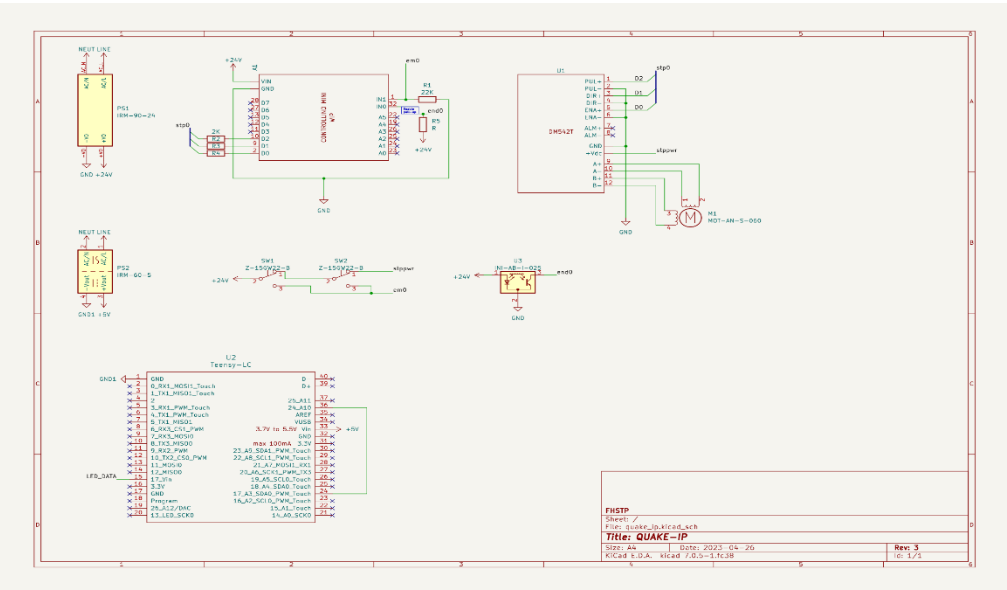


Figure 17 : Electrical circuit

9. Assembly

The Makers' Lab

Once the design had been finalized and validated, we were able to start assembly. For this, we had the help of Bernhard, who cut the pieces of Aluminium profile to the right size. We had the Makers' Lab at our disposal. This laboratory consists of two rooms. The main room houses the 3D printers, as well as tools for working on electrical components and a laser cutting machine. The second room, where we set up shop, has all the tools needed to assemble the prototype. These include a drill, a drill press, a saw, several Dremels and basic tools. A fully equipped tool chest was also made available to us. Thanks to this environment, we were able to start the assembly with a peace of mind.

Figure 18 : Picture of the maker's lab

Tools

We sometimes had to use the drill to make holes in the profiles, the saw to cut pieces of profile or the Dremel to cut screws or plexiglass. We took great care with these tools, which were partly responsible for the success of the assembly.

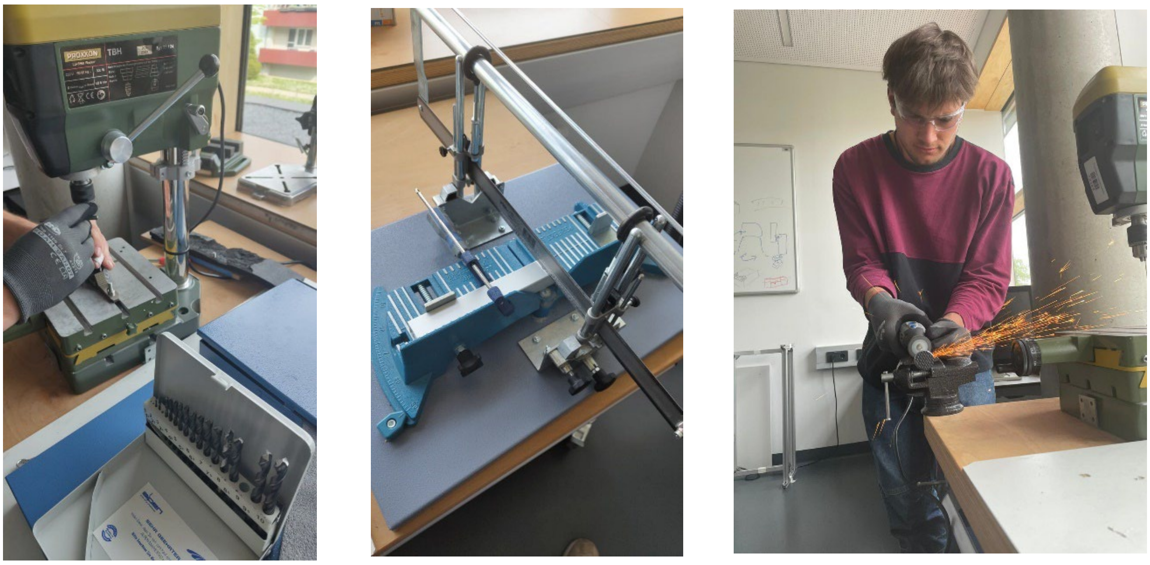
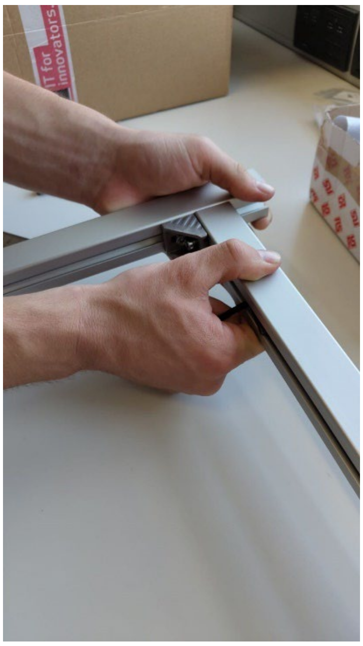
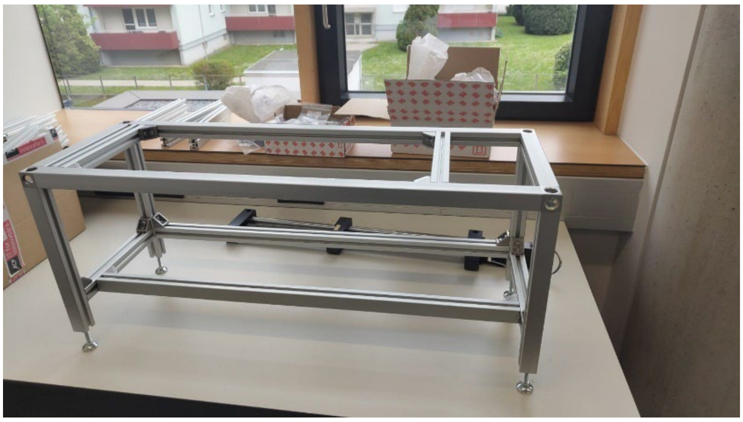


Figure 19 : Pictures of Tools

The Main frame

We built and assembled the main frame first. This is the block where all the components would be mounted. This assembly was fairly easy and completed in a day. Because an assembly plan had been drawn up, but also because the profiles had been cut quite exact.
The slider system was then added onto the main frame.
The different parts of the folding part were also assembled separately using the same principle as the main block. We then had 3 different assemblies. We didn't yet have a solution for assembling them together to make the 3 parts one folding whole. This was one of the subjects for future work.





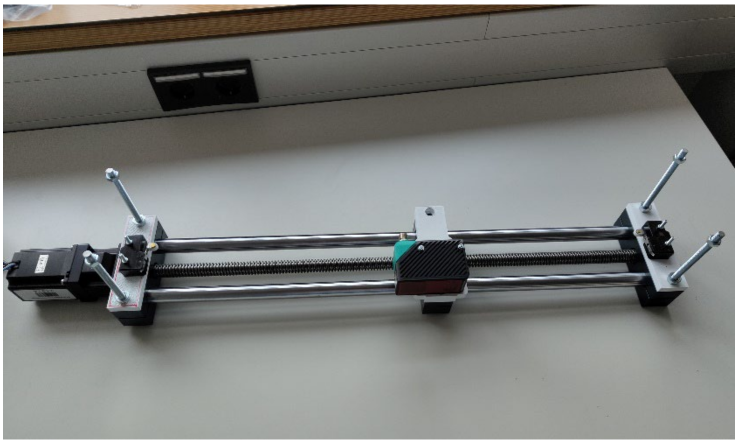
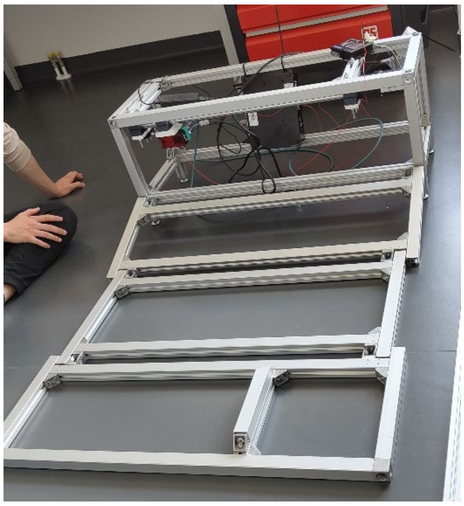



Figure 20 : 6 Pictures of the Assemby of the prototype

3D printed parts

During assembly, we encountered a number of problems. To solve these problems we used 3D printing, which we had easy access to. We then had to invent and create these parts. To do this, we used design software. With the help of our knowledge, this was done quickly and accurately.

Attachment emergency stoppers-slider

The first part is a link between the slider and the emergency stoppers. This part enables the stoppers to be fixed directly to the slider in the right place. All you have to do is use a screw and a nut to fix the stopper to the printed part. The printed part is fixed directly to a part of the slider using a threaded rod and a nut. You can see this part below.

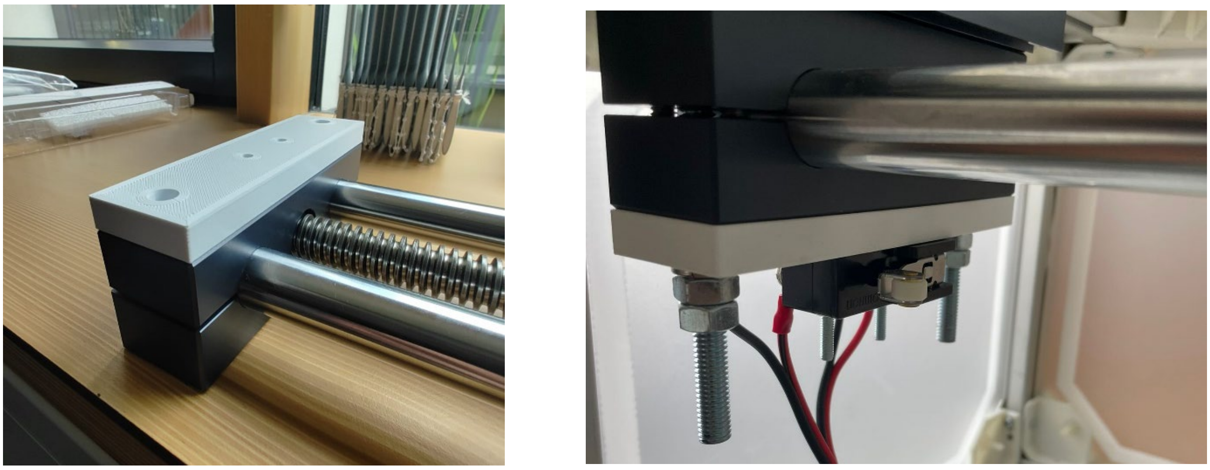


Figure 21 : Emergency stopper-Slider

Attachment laser-slider

This second part is very important because it fixes the laser to the slider. We used the same principle as for the first part. The part has been designed to fit the shape of the slider perfectly. The part is inserted and clipped onto a block on the slider, which is then brought into position. Two screws were used to hold it in position, and these were screwed into existing holes. This part was designed according to what the slider would allow, so we had to take various measurements to be as precise as possible when designing it.

Figure 22:Attachment laser-slider

Attachment plexiglass – frame

We'll see later that we added plexiglass around the prototype to make the LED feedback system look more professional. To fit the plexiglass pieces in the prototype, we also created some 3D printed parts. These parts allow the plexiglass to be placed on top and fixed. These pieces will be found in each corner of the main block and also as a support in the middle where there are long pieces of plexiglass, i.e. on the top and the back. However, the disadvantage of these pieces is that we had to fix them directly to the profiles. So the profiles had to be drilled first. This stage was quite long and difficult because we had to be very precise to ensure that the pieces were in the right place.

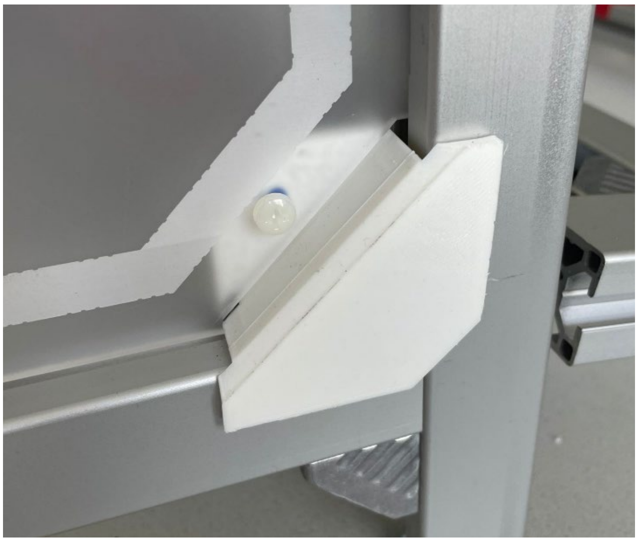


Figure 23 : Attachment Plexiglass – frame

Stoppers

3D printing has also been used to create small stoppers on which to rest the folding part of the prototype. This avoids damaging the main block, but also allows the height of the folding part to be adjusted so that it fits perfectly. These parts are then small square blocks with a round surface on top on which we glued a rubber surface. These parts are then fixed to the profile using double-sided tape.

Figure 24 : Stoppers

The folding frame

As we said earlier, the folding part still needed to be fully assembled. We had to find the parts to make the folding part fold and link the 3 parts together. To do this we carried out various searches on the internet. However, we didn't find anything interesting. This part must allow the 3 parts to be linked but also to rotate. We decided to go to a hardware shop to get more ideas. During this trip we found several auxiliary components for the prototype and also 2 potential ideas for the folding part: hinges and axes. We then bought what we needed but also some parts for testing.

Testing

Axis

The solution was to drill and join the parts together with a pin. However, after testing, the pin screwed and unscrewed every time we folded it. We therefore concluded that this solution was not appropriate for our prototype.

Figure 25 : Axis

Hinges

The role of the hinge solution was to join the parts together but also to allow a 90° movement, which was what we were looking for. We carried out an initial test which was conclusive. We then decided to use these hinges throughout the prototype. To do this, we had to screw them on and consequently drill holes. We then carried out some tests and unfortunately the hinges weren't strong enough and bent. The stability was not respected, and it didn't look professional. This idea was then abandoned, we dismantled the hinges and continued our research to find the best solution.

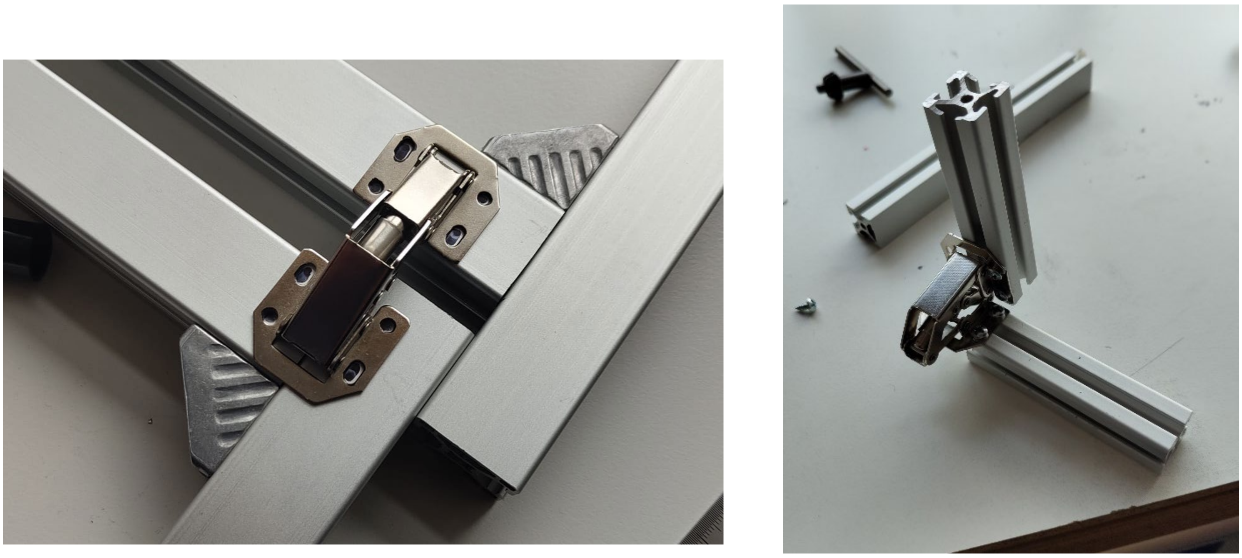


Figure 26 : Hinges

Because of that, we decided to search in the Bosch Rexroth store some hinges, as was the producer of all the other components. We found just the part we were looking for, a solid connector that would not only link the parts together, but also allow them to rotate as required. The advantage of this part is that it's easy to fit and adapts to the profiles. So, we bought 6 pieces like these to link the parts together and also to make the link between the folding part and the main block. The only disadvantage of this connector was its price. The tests carried out with these connectors were very positive and satisfactory. So, we're keeping this solution, which fits in perfectly with what we want.

Figure 27: Big hinges

The alignment profile

To assure that the metal sheet profile is positioned in the same place every time a scanning procedure is held, an alignment profile was mounted on the extension frame.
When an operator wants to scan the edge of a metal part, he or she simply slides the part against the aluminum profile.
The alignment profile had to be manually cut and assembled with adjusted - we redrilled holes to a bigger size - corner pieces.

Figure 28 : The alignment profile

Handles

In order to make the prototype portable, we added handles on each side, allowing two people to carry it. We looked for sturdy handles capable of supporting the weight of the prototype, so we ordered it from an online shop. Unfortunately, the handles we initially received did not respect our requirements in terms of strength and size. Therefore, we designed our own handles using suitable profiles. We assembled three profiles using corner pieces, and then we attached them to the upper parts of the prototype using additional corner pieces (Figure 29). In addition to being robust, these handles perfectly matched the rest of the prototype as we used the same type of profile that was used in its fabrication.

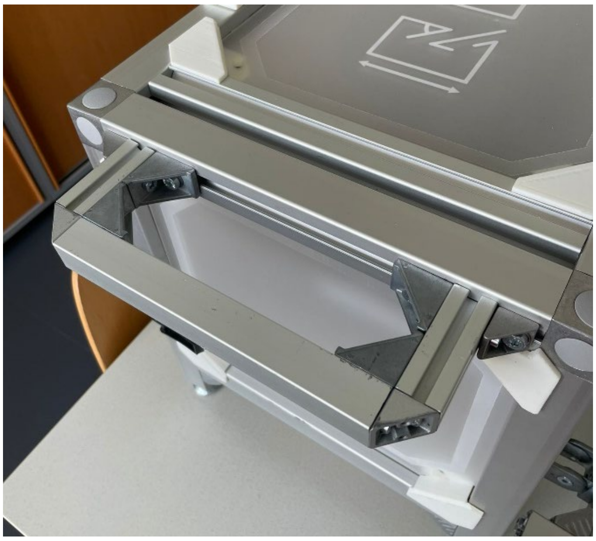
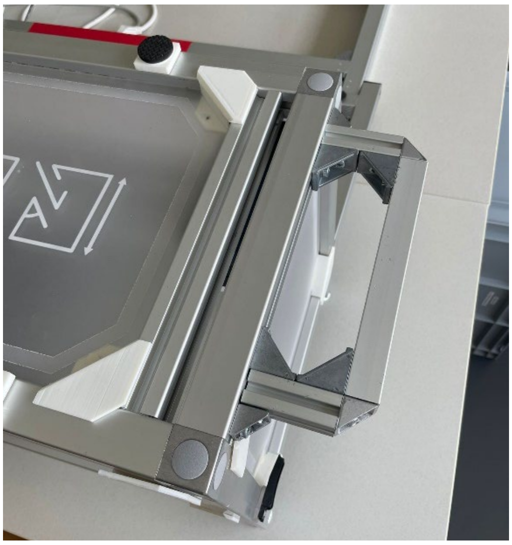
 

Figure 29 : Handles

Parts for Detailing

At the same time, we were thinking about the details we could add to make the prototype better and more professional. We thought about the closing system for the folding part of the profile, something to lock it when it's closed. At the hardware shop we found a click system, made up of two parts that fit together when they're in contact. All you have to do is put one part on the folding part and one on the main block. When you close the folding part, it clips onto the block. So, the folding part is held in place. For added security, we've added toggle switches on the sides to close and lock the prototype when it's in position. The photo below shows the locking system.

We've also added rubber feet under the legs to increase stability and make it easier to move on a table.

We also used laser cutting to personalize the plexiglass. We added the logos of the university (FH. STP), CIDAN, EFRE, QUAKE-iP and the names of those who worked on the project. See photo below. These details make the prototype more presentable and professional. It highlights the people who contributed to the project. What's more, they are illuminated by LEDs.

Figure 31 : toggle switches

Figure 30 : Clips

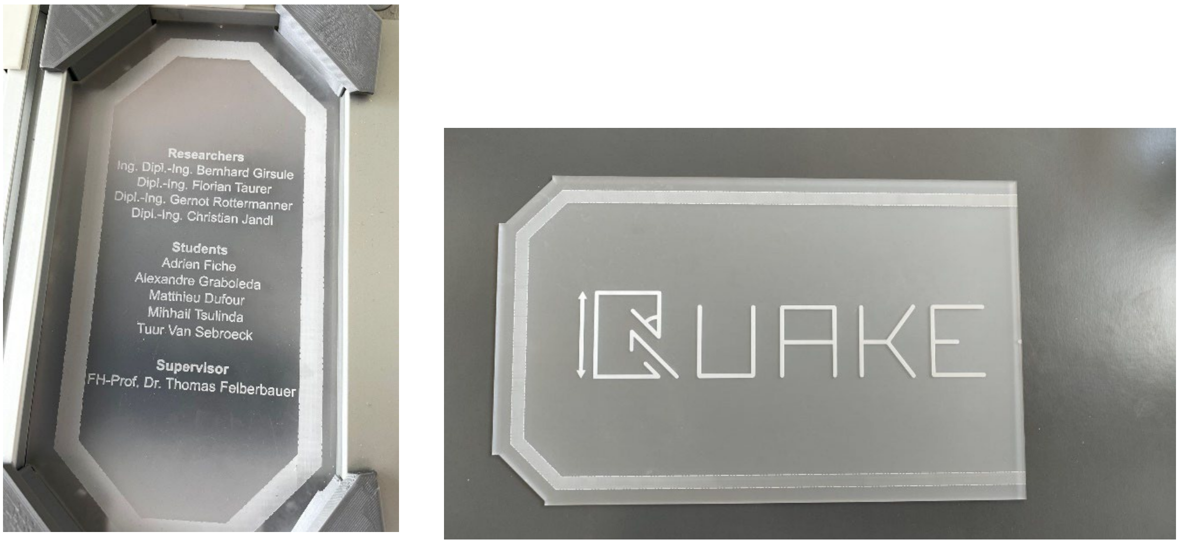


Figure 32 : Plexiglass

The Electrical System

The assembly of our prototype's electrical system required careful planning and placement of numerous components. This included two power supplies, two controllers, a computer, a power supply for the computer, and a stepper motor driver. In addition to these, we had to incorporate various input/output ports, such as AC power in/out, USB ports, and an HDMI port.

We decided to place the main components on the bed of the prototype, utilizing metal profiles for robust support. We also employed plexiglass which allowed us to secure the components firmly while ensuring ease of access for future modifications or troubleshooting.

The ports presented a separate challenge, as they needed to be both accessible and secure. To tackle this, we put holes in the side pieces of plexiglass. This provided an organized, clear panel through which the ports could be accessed.

To ensure neat and manageable wiring, we implemented cable channels throughout the design. These channels not only tidied the setup but also simplified the task of tracing a wire back to its source, thereby making maintenance and troubleshooting easier.

Furthermore, we added an electrical distribution box into the design. This central hub ensured efficient distribution of power across the system, contributing to the overall reliability and stability of the electrical operations.

The LED system was integrated into the prototype's design in a unique way. We installed LEDs within recesses in the metal profiles, which were then covered with plexiglass panels. This arrangement presented a challenge, as the LED strips had to be manually sliced and soldered to accommodate the shape of the prototype. However, the result was an aesthetically pleasing and functional lighting system that enhanced the prototype's overall appearance.

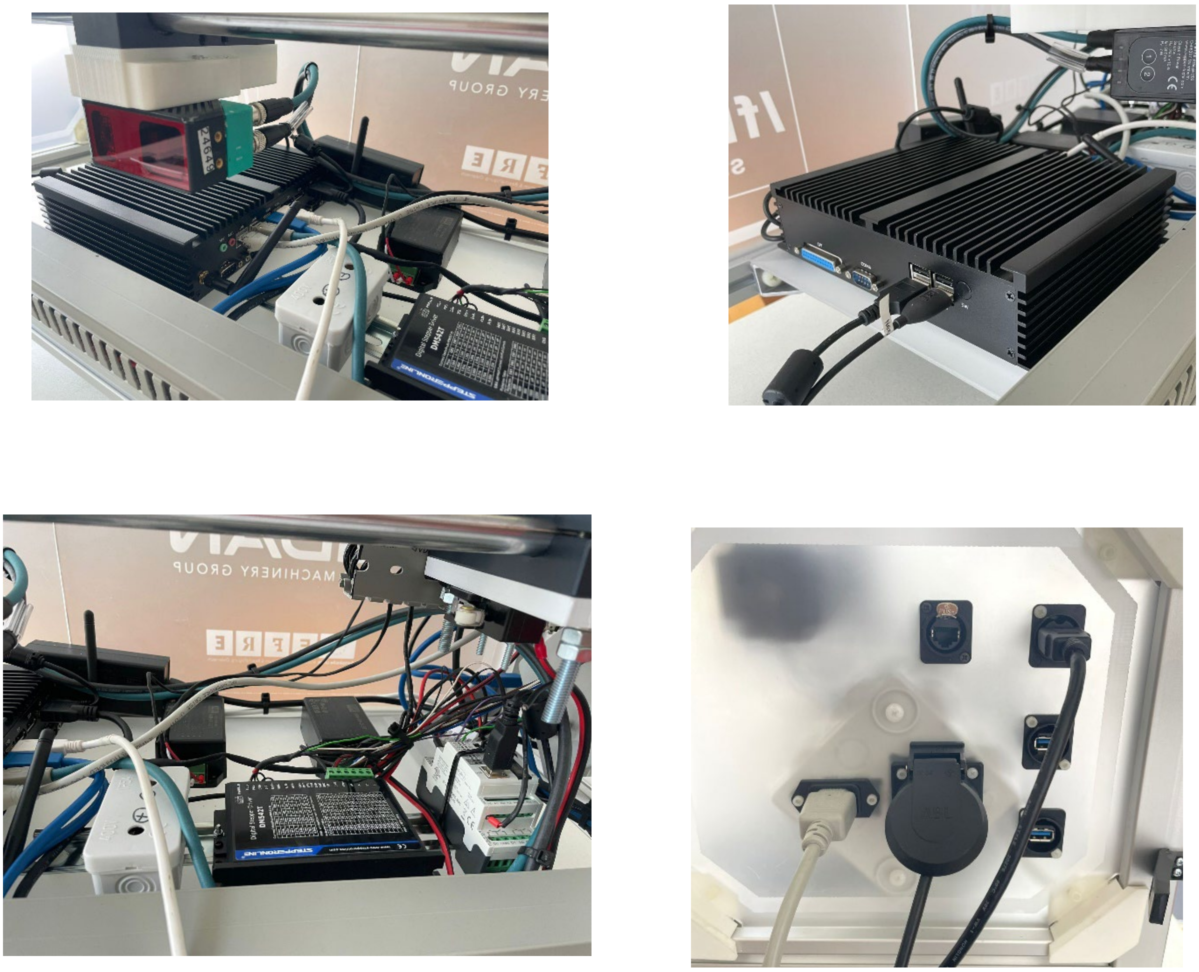
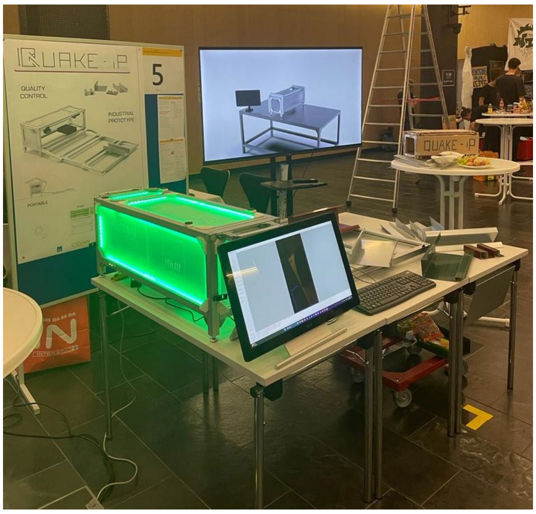
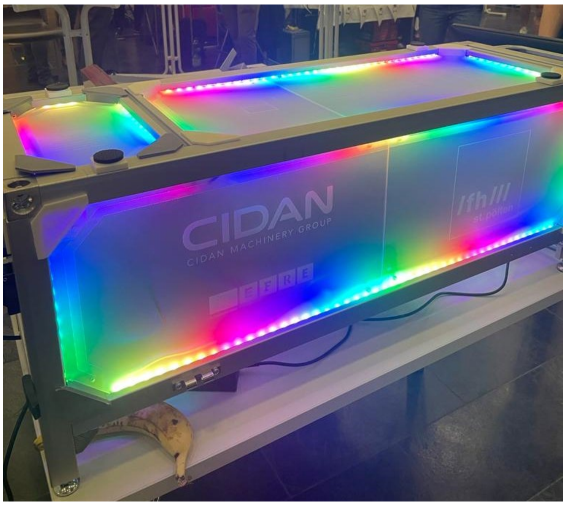


Figure 33 : The Electrical System





10. Testing

Calibrating

Upon completion of the assembly, we undertook the crucial process of testing and calibration. This phase was integral to verifying the functionality of the software provided by the parent project's lecturers, as well as assessing the performance of the microcontrollers implemented in the prototype.

The calibration process was primarily handled by the lecturers, given their intimate understanding of the proprietary software. This allowed us to shift our focus to testing the primary functions of the microcontroller, as well as the secondary functions of the LED controllers. The aim was to ensure that all components were functioning as expected, and that their integration into the overall system was seamless and efficient.

As part of the testing procedure, we closely scrutinized the operation of all the safety and normal switches incorporated into the system. We were pleased to find that these components performed effectively and consistently, confirming their reliability in the practical context of the prototype.

Furthermore, a critical part of the testing involved checking the communication between the computer and the microcontrollers. It was of paramount importance to ascertain that the information exchange was faultless, given that it is the backbone of the operations of the prototype. Our testing did not reveal any significant faults in this area, which was a testament to the effectiveness of our assembly process and the robustness of our design.

Company visit

On June 7th, we had the opportunity to visit the Metaflex company and meet with the manager. During this insightful visit, the manager took the time to provide us with a detailed presentation of both CIDAN and Metaflex, offering valuable information about their mission, expertise, and offerings.

We were fascinated by the production line that we had the chance to observe. Through various workshops, we closely witnessed the different manufacturing processes involved in creating the metal sheet profiles. Sophisticated machines were diligently shaping the materials to produce high-quality products.

During our visit, we also had the privilege to present our prototype to the manager. We thoroughly showcased and explained the features of our prototype. We conducted a real-time test right in front of them, demonstrating its functionality and performance. This highlighted its compatibility with their production line and its ability to enhance process efficiency for quality testing purposes.

This visit and interaction with the manager were pivotal milestones in our development journey. They allowed us to establish a direct connection with the Metaflex company and gain insight into the environment where our prototype could potentially operate. Consequently, we became more determined than ever to improve and finish our prototype to meet their specific needs and ensure its excellence for the Project Vernissage.

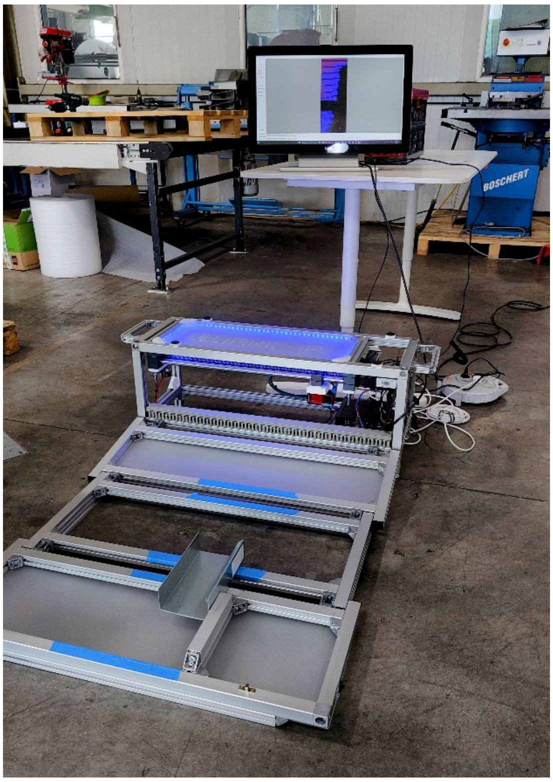


Figure 34 : Company visit and test of the prototype

Figure 35 : production line METAFLEX

11. Project Vernissage

Figure 36 : Team during the project vernissage

The project vernissage was the highlight of our project. This was where we could show to our fellow students what we had done for the past semester. In the picture you can see what our booth design looked like.
Central in the middle, the prototype with the additional display - for controlling the machine - was placed. In the background a simple animation video of how the prototype works was shown. This gave the people that passed by a quick look and understanding of what the machine does. A poster (*Figure 37*) with some keywords and clear renders connected the appearance of the physical prototype with the animation video. The second cardboard prototype gave insight of where we came from. To show where it all began. As a finishing touch, we added sheet metal parts that could be scanned by the prototype.
We were happy that the machine did what it was designed to do and that we could let people experience a demo.

The video can be seen with the following link: https://youtu.be/ri-hkvMAV40

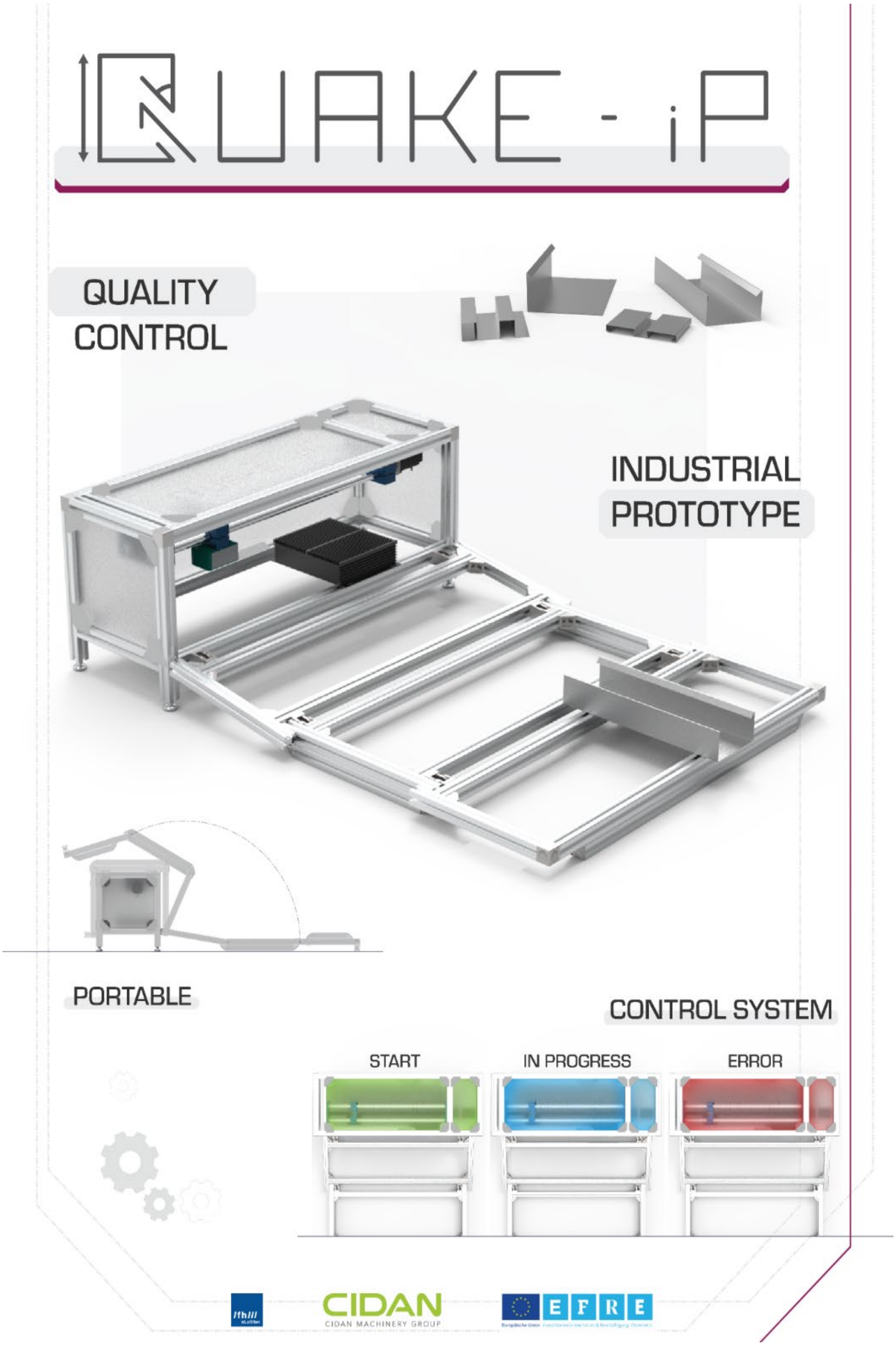


Figure 37: Poster for Project Vernissage

A demo

When people arrived at our booth, we first introduced the company - CIDAN - and their need for a more efficient quality control. After that a demo was shown.

In the demo we explained how the prototype and the scanning procedure works. The result of the scan (*Figure 38*) could then be seen on the additional display. We explained that after the scanning procedure took place, the result will be compared with the original data of the sheet metal profile in another software package.

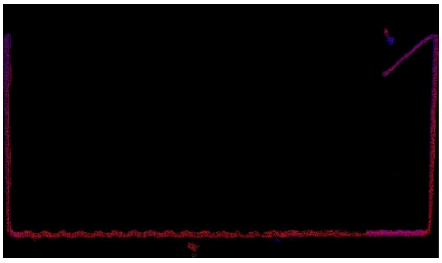


Figure 38 : Result of the scan

People that just passed by or were waiting on our explanation, could have a look at our poster and the 3D animation video.

Figure 39 : Final render of the prototype in the environment of Metaflex

13. Conclusion

To conclude, the semester is coming to an end and we've completed all the tasks we were supposed to. The prototype is finished and functional. What's more, we've made it as professional as possible by adding certain details. We've worked hard to achieve this result and we're proud of this project, which can be considered a success. We went through the different phases that make up a project. First there was a phase of brainstorming and pooling ideas. Then there was the design phase, where we were able to put our ideas into shape using design software or by making cardboard prototypes. Once our concepts had been validated, we moved on to the creation and assembly phase. Finally, we had to calibrate and test our prototype and present it at various events.
Thanks to this project, we got acquired with working together in a multidisciplinary team. We also learned how to manage our project using Jira, an IT Scrum tool. The budget and the various deadlines to be met were also factors to be taken into account and set the pace for the project. We learned a lot from each other thanks to this project, both from a personal point of view and in terms of more technical knowledge.
Our contribution during this EPS was very beneficial to the project because we managed to build the new version of this machine. This was achieved in a very short space of time, thanks to a motivated and ambitious group. Our contribution can be seen as a boost for this project.

All the objectives and prospects set at the start of the project were achieved. We had a good grasp of the subject from the outset, which enabled us to get on the right track quickly and work efficiently. We set ourselves the goal of completing the prototype and we achieved it, having acquired a great deal of knowledge.

The prototype will now be combined with the Metaflex production line. CIDAN Machinery Group will carry out a series of tests and validation of this quality control solution. The aim is to improve and push research further to obtain the perfect product.

DOCUMENTS VERSIONS

Version number	Date	Change	Author
1	15-05-2023		EPS Team

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Michael Tsulinda	Exchange Student (Computer Science)	Student
Alexandre Graboleda Tornero	Exchange Student (Industrial design engineering)	Student
Adrien Fiche	Exchange Student (General Engineering)	Student
Thomas Felberbauer	Studiengangsleiter Smart Engineering	Supervisor
Bernhard Girsule	Junior Researcher Digital Technologies	Researcher
Florian Taurer	Junior Researcher Studiengang BSE	Researcher
Gernot Rottermanner	Researcher Studiengang MDH	Researcher
Christian Jandl	Forschungsgruppenleiter Digital Technologies	Researcher

FILES STORAGE

Teams storage

Figures

Figure 1/CIDAN machinery ... 6
Figure 2 : Metaflex company ... 6
Figure 3: Building applications of Metaflex' sheet metal parts ... 7
Figure 4:Metaflex' online drawing tool (3,...) ... 7
Figure 5: 1st prototype ... 8
Figure 6 : Mind map ... 9
Figure 7:Mind map ... 11
Figure 8:User journey ... 12
Figure 9 : 1st cardoboard prototype ... 14
Figure 10 : Sliding concept ... 15
Figure 11 : Folding concept 1 ... 15
Figure 12 : Folding concept 2 ... 15
Figure 13 : Detachable concept ... 16
Figure 14 : Poster Midterm co-creation ... 16
Figure 15 : 2nd Cardboard prototype ... 18
Figure 16 : Render of final concept ... 19
Figure 17 : Electrical circuit ... 29
Figure 18 : Picture of the maker's lab ... 30
Figure 19 : Pictures of Tools ... 31
Figure 20 : 6 Pictures of the Assemby of the prototype ... 32
Figure 21 : Emergency stopper-Slider ... 33
Figure 22:Attachment laser-slider ... 33
Figure 23 : Attachment Plexiglass – frame ... 34
Figure 24 : Stoppers ... 35
Figure 25 : Axis ... 36
Figure 26 : Hinges ... 36
Figure 27: Big hinges ... 37
Figure 28 : The alignment profile ... 38
Figure 29 : Handles ... 39
Figure 30 : Clips ... 40
Figure 31 : toggle switches ... 40
Figure 32 : Plexiglass ... 40
Figure 33 : The Electrical System ... 41
Figure 34 : Company visit and test of the prototype ... 43
Figure 35 : production line METAFLEX ... 44
Figure 36 : Team during the project vernissage ... 44
Figure 37: Poster for Project Vernissage ... 46
Figure 38: Result of the scan ... 45
Figure 39: Final render of the prototype in the environment of Metaflex ... 47

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