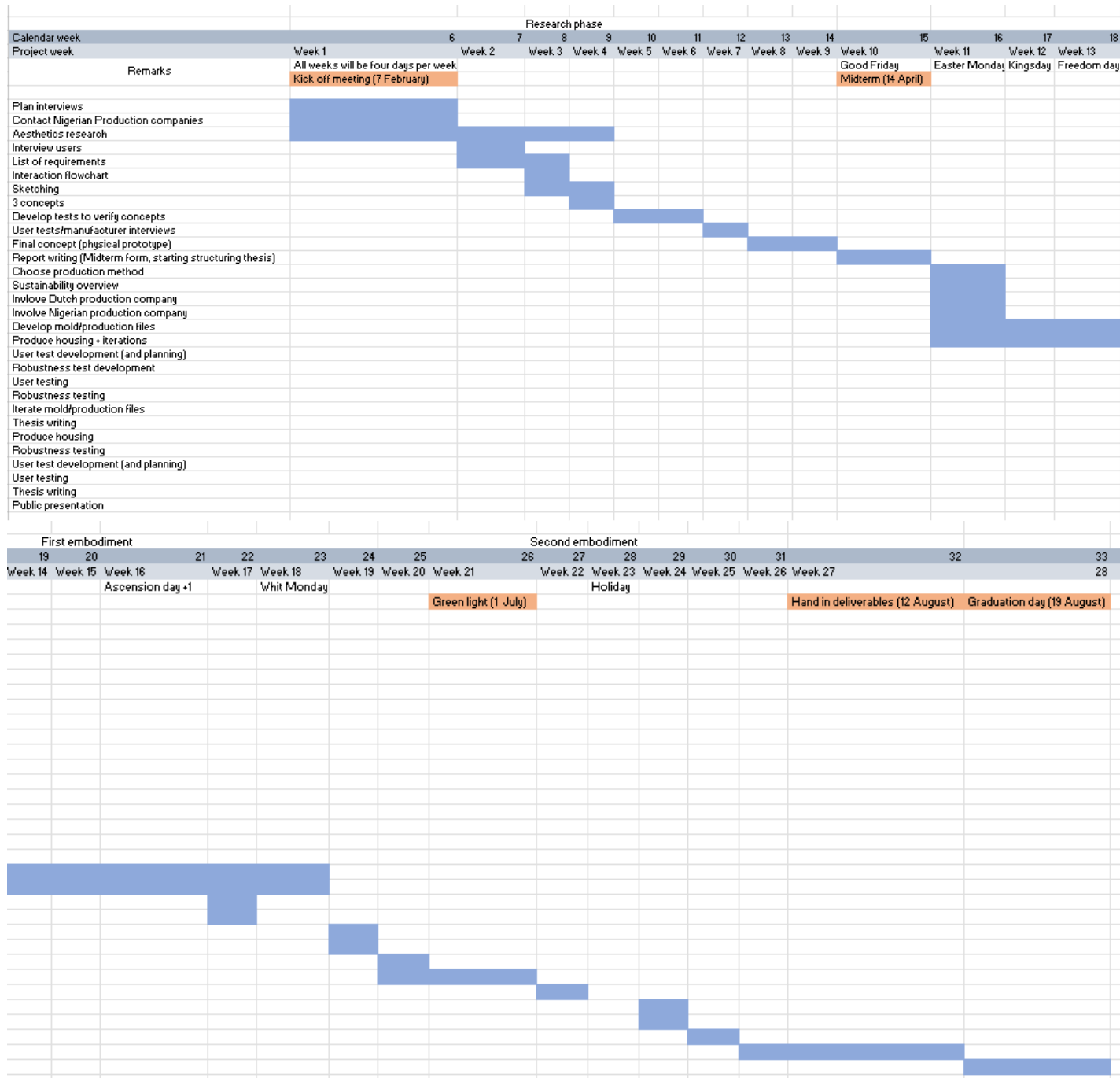


APPENDIX 1 - PLANNING



APPENDIX 2 - REQUIREMENTS

<p>1. The embodiment should fit in the medical sub saharan context</p>	<p>a. The appearance of the microscope should be conform the appearance of other medical devices in the sub-Saharan context</p> <p>b. The color of the housing should be white mainly</p> <p>c. Details should be blue</p> <p>e. The embodiment should function in circumstances from 15 to 40 degrees</p> <p>b. The material of the housing should have excellent UV-resistance</p> <p>f. The embodiment should be dust/sand resistant</p> <p>g. The embodiment should be reasonable waterproof</p> <p>h. The embodiment should be able to withstand humidity</p> <p>c. The embodiment should be robust enough to withstand transportation by car over unpaved roads</p> <p>f. The housing should be able to withstand cleaning detergents without degrading</p> <p>a. The embodiment should have an integrated screen</p> <p>c. The embodiment should be easy to carry around</p> <p>d. The device should work without being attached to the power grid</p>	<p>a. The housing should be cleanable with soft tissues</p> <p>b. Parts that are frequently touched should not be clear white because it gets dirty very fast</p> <p>a. The housing should enable cooling of the microcomputer</p> <p>a. The sample insertion opening should be closed when the device is not used</p> <p>b. The device should be able to perform a scan with a closed sample insertion opening</p> <p>a. The embodiment should be waterproof according to ISO IP63/IP64 standards</p> <p>a. The electronics of the device should be protected from condensation and humidity</p> <p>a. The connections to and from the housing should be shock resistant</p> <p>a. The material of the housing should be made of medical grade plastic</p> <p>a. The screen should be 10 inch</p> <p>b. The position of the screen should be adjustable to the preferences of the user</p> <p>c. The screen should be able to be controlled by means of touch, mouse and keyboard</p> <p>d. The screen should be able to be extended trough HDMI</p> <p>e. The screen should be easy reachable to clean</p> <p>g. The screen should be protected from direct 'hits'</p> <p>h. The screen should be attached to the device, not a separate unit</p> <p>i. The screen should be positioned in such a way that it is on the same side as the sample insertion during use</p> <p>j. The main communication should be done by via the screen, not additional lights</p> <p>k. The mechanism attaching the screen to the housing should be robust</p> <p>l. The mechanism attaching the screen to the housing should be 'stiff'</p> <p>m. The mechanism attaching the screen to the housing should be small</p> <p>n. The wires connecting the screen to the housing should not stick out</p> <p>o. The screen should be powered from the accu directly</p> <p>a. The handle should not stick out of the embodiment</p> <p>b. The handle should be integrated in the flow of the design</p> <p>c. The embodiment should be compact</p> <p>d. The embodiment should be light enough to be carried by strong adults</p> <p>e. The embodiment should fit in a backpack</p> <p>a. The device should have an accu</p>	<p>a. The housing should be cleanable with soft tissues</p> <p>b. Parts that are frequently touched should not be clear white because it gets dirty very fast</p> <p>a. The housing should enable cooling of the microcomputer</p> <p>a. The sample insertion opening should be closed when the device is not used</p> <p>b. The device should be able to perform a scan with a closed sample insertion opening</p> <p>a. The embodiment should be waterproof according to ISO IP63/IP64 standards</p> <p>a. The electronics of the device should be protected from condensation and humidity</p> <p>a. The connections to and from the housing should be shock resistant</p> <p>a. 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The device should have an accu</p>	<p>Creative session</p> <p>Interview MIS lyona, Interview Brice</p> <p>Creative session, Alternative coverup test</p> <p>Interview Animashaun, interview Brice, Creative session, Alternative coverup test</p> <p>https://www.who.int/publications/item/9789240018648</p> <p>Customer journey</p> <p>Customer journey, Alternative coverup test</p> <p>Alternative coverup test</p> <p>Creative session, Interview Brice II</p> <p>Customer journey, Alternative coverup test</p> <p>Customer journey</p> <p>User experience map</p> <p>Interview Animashaun, interview Brice, Creative session, alternative coverup test</p> <p>Alternative coverup test, interview Brice II</p> <p>Interview Brice, Creative session, Company</p> <p>Interview Brice, Company</p> <p>Interview MIS lyona</p> <p>Interview Brice, Creative session, alternative coverup test</p> <p>Interview Brice</p> <p>Interview Brice, Creative session</p> <p>Interview Brice</p> <p>Foam prototyping</p> <p>Hinge screen prototyping</p> <p>Hinge screen prototyping</p> <p>Hinge screen prototyping</p> <p>Hinge screen prototyping</p> <p>Interview Brice, Creative session</p> <p>Alternative coverup test</p> <p>Alternative Brice, Creative session, alternative coverup test</p> <p>Customer journey, alternative coverup test</p> <p>Interview Brice, Creative session, alternative coverup test</p> <p>Interview Brice, Company discussion, https://www.who.int/publications/item/9789240018648</p> <p>Interview Brice, Company discussion</p>
<p>2. The housing of the embodiment should be able to be produced by local manufacturers</p>	<p>a. The device should work when being attached to a power grid</p> <p>a. The production technique should be available in Nigeria</p> <p>b. The material should be locally sourced</p> <p>c. The production technique should be feasible with a batch size of 100 products</p>	<p>a. The device should have a power inlet suitable for connection to main grid</p> <p>a. The production technique should be a 'basic' technology</p> <p>a. Parts should be made by means of injectionmolding or Thermoformen</p> <p>b. The embodiment should consist out of prepurchased parts mainly</p>	<p>a. The device should have a power inlet suitable for connection to main grid</p> <p>a. The production technique should be a 'basic' technology</p> <p>a. Parts should be made by means of injectionmolding or Thermoformen</p> <p>b. The embodiment should consist out of prepurchased parts mainly</p>	<p>Interview Brice, Company discussion</p>
<p>3. Use of the device should be intuitive</p>	<p>a. The device should stand stable on the surface it is going to be used</p> <p>b. It should be clear how to use the device on first sight</p> <p>c. Training to work with the device must require less than one day for community volunteers and lay persons</p> <p>d. The use of the device should be easy to understand by means of a (online) manual</p> <p>e. The device should make sound when it is scanning</p> <p>f. The device should indicate when the scan is finished</p>	<p>a. The on/off button should be positioned in eyesight</p> <p>b. It should be obvious how the data will be presented</p> <p>c. It should be obvious where to put in the sample</p> <p>d. It should be possible to print out a report of the results</p>	<p>a. The on/off button should be positioned in eyesight</p> <p>b. It should be obvious how the data will be presented</p> <p>c. It should be obvious where to put in the sample</p> <p>d. It should be possible to print out a report of the results</p>	<p>Thesis Sodos, alternative coverup test</p> <p>Interview Brice, creative session</p> <p>Interview Brice</p> <p>Interview Brice</p> <p>Alternative coverup test</p> <p>https://www.who.int/publications/item/9789240018648</p> <p>https://www.who.int/publications/item/9789240018648, creative session</p> <p>Creative session</p> <p>Alternative coverup test</p>
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<p>4. The device should be able to be maintained locally</p>	<p>a. The occurrence of the mainaince should be max. once a year</p> <p>b. The housing should be able to be disassembled and assembled multiple times while staying intact</p> <p>c. The optical parts should be reachable for cleaning purposes</p>	<p>a. The product should look intriguing</p> <p>b. The product should look dedicated</p> <p>c. The product should look professional</p>	<p>a. The product should have variety in materials, shape and colors</p> <p>a. The important functions should be obvious and stressed</p> <p>a. The product should have a remarkable trait in order to stand out in its environment</p> <p>b. The product should look like as belonging to an existing brand</p> <p>c. The shape of the product should be stressing the function of the product</p> <p>d. The shape of the product should only be composed out of needed elements</p> <p>e. The design of the device should be 'fluent'</p> <p>f. The design of the device should be symmetrical</p> <p>a. The product should have obtuse angles, consistant over a longer surface/area</p> <p>b. The product should have textured faces</p> <p>c. The product should look dense</p> <p>a. The whole system should be designed with eye to intuitive portability</p> <p>a. The device should have a clean electronic look</p> <p>a. The product should have robust edges in order to look designed for accidents</p> <p>b. The product should be shaped for endurance</p> <p>a. The product should look like being made of one piece</p> <p>a. The product should belong in its environment through its medical look</p>	<p>Company</p> <p>Company</p> <p>Interview MLS lyona</p>
<p>5. The appearance of the device should be pleasing</p>	<p>a. The Aesthetics should be improved</p> <p>b. The Meaning should be improved</p> <p>c. The Emotion should be improved</p>	<p>a. The product should look intriguing</p> <p>b. The product should look dedicated</p> <p>c. The product should look professional</p> <p>a. The product should feel robust</p> <p>b. The product should feel portable</p> <p>c. The product should feel modern</p> <p>a. The product should evoke trust by the user</p> <p>b. The product should inellip impenetrability</p> <p>c. The product should radiate confidence</p>	<p>a. The product should have variety in materials, shape and colors</p> <p>a. The important functions should be obvious and stressed</p> <p>a. The product should have a remarkable trait in order to stand out in its environment</p> <p>b. The product should look like as belonging to an existing brand</p> <p>c. The shape of the product should be stressing the function of the product</p> <p>d. The shape of the product should only be composed out of needed elements</p> <p>e. The design of the device should be 'fluent'</p> <p>f. The design of the device should be symmetrical</p> <p>a. The product should have obtuse angles, consistant over a longer surface/area</p> <p>b. The product should have textured faces</p> <p>c. The product should look dense</p> <p>a. The whole system should be designed with eye to intuitive portability</p> <p>a. The device should have a clean electronic look</p> <p>a. The product should have robust edges in order to look designed for accidents</p> <p>b. The product should be shaped for endurance</p> <p>a. The product should look like being made of one piece</p> <p>a. The product should belong in its environment through its medical look</p>	<p>Appearance research</p> <p>Appearance research</p> <p>Appearance research</p> <p>Semantic network of product experience</p> <p>Semantic network of product experience</p> <p>Semantic network of product experience</p> <p>Interviews</p> <p>Interviews</p> <p>Appearance research</p> <p>Appearance research</p> <p>Semantic network of product experience, creative session</p> <p>Appearance research</p> <p>Appearance research</p> <p>Appearance research</p> <p>Semantic network of product experience</p> <p>Appearance research</p> <p>Appearance research</p>

APPENDIX 3 - JOURNEY MAP REPORT

Stuck in the process

After my initial burst of creativity, following a structured way of design, I got stuck. Together with my mentor I realized that I was designing in phase 'one' of the product design circle. During this phase I used all my OWN knowledge and inspiration for designing the next AiDx NTDx.

We came to the conclusion that I needed to step out and involve people that will be working with the AiDx assist in the future. The goal is to involve them in such a way that they will be 'designing' the AiDx NTDx from their perspective. Ultimately I will combine their world of ideas with my world in order to come up with the best redesign.

Approach

In order to reach the users I wanted to work with, I contacted a lecturer at the Adeleke University in Nigeria with the help of Temitope. She connected me with a group of six community health final years students who have been trained to use the AiDx NTDx during a field visit in November 2021. These are also the future users of the device.

To steer their minds in the right direction and sensitize them before our meeting, I created a Journey map on MIRO with the main tasks from getting the assignment to screen a certain village until they finished their assignment. The students were asked to spend approximately 15 minutes on this Journey map and fill in all the 'pain' and 'gain points' they experienced. Also I asked them to comment on the order of activities in the journey map. The set up and results of this Journey map can be found on the next page

With these students I planned a creative session in which we discussed how they would approach certain design challenges. These design challenges originate from my analysis and the journey map they filled in

With these students I planned a creative session in which we discussed their reactions on the Journey map and how they would approach certain design challenges. These design challenges originate from my analysis and the issues they filled in on the journey map.

After this I discussed the Journey map, the insights I got from the students, interaction and the design challenge with Brice in order to verify my assumptions and insights from the students. Brice is a PhD parasitology student at Leiden University originally from Gabon. He has three years of training to be able to distinguish NTD's and malaria. Current expertise is new diagnostic devices benchmarking; evaluating diagnostic devices in the local context. He is doing this by taking devices to tropical countries like Nigeria and Gabon.

Journey map set up

Instruction

With this assignment I want to get some insight in the process and your experiences of going on a mission in order to test a part of the population in a rural village on a disease. Please imagine that you are going on such a mission with the AiDx assist you have been working with.

In the top part, steps that you go through during such a mission are listed chronologically. Feel free to add steps I forgot. In the bottom part positive and negative experiences are shown. Please provide me with what kind of experiences or thoughts you would have during this process. This can be negative thoughts, but also positive. Please add as much thoughts as possible!

In order to add negative thoughts, edit the red text boxes. For positive thoughts or experiences, edit the yellow text boxes. If there are no fields left, please add new fields to fill in. I already added some positive or negative thoughts. If you would not experience the aspect as I expect, please edit that textbox too!

No thought of experience is wrong! You are the experts in this case, because you know the situation in which it will be used better than me! (the best way you can help me is to come up with as many negative experiences as possible)

As seen on the right of this explanation block, each of you have their own Journey map to fill out.

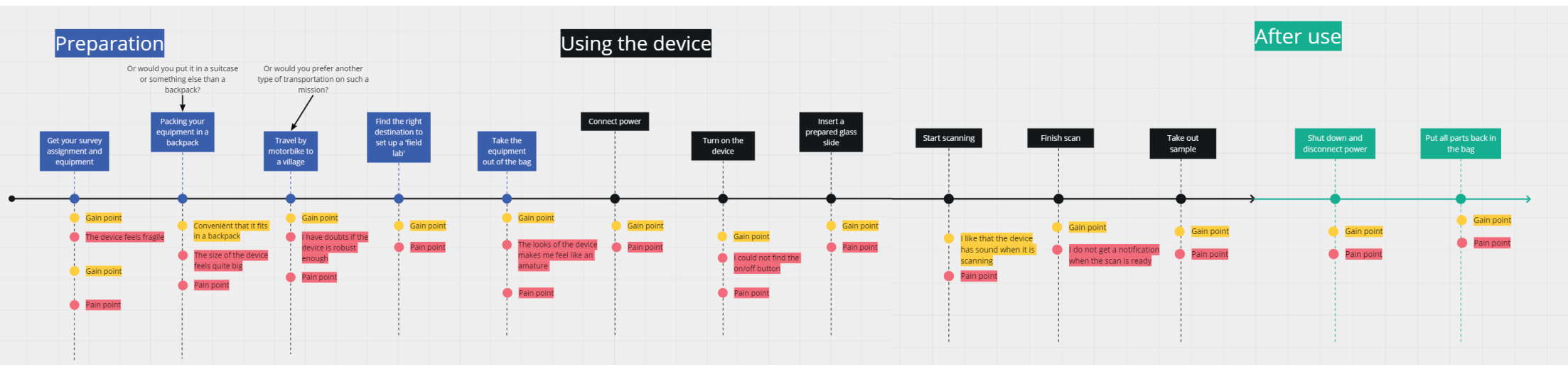
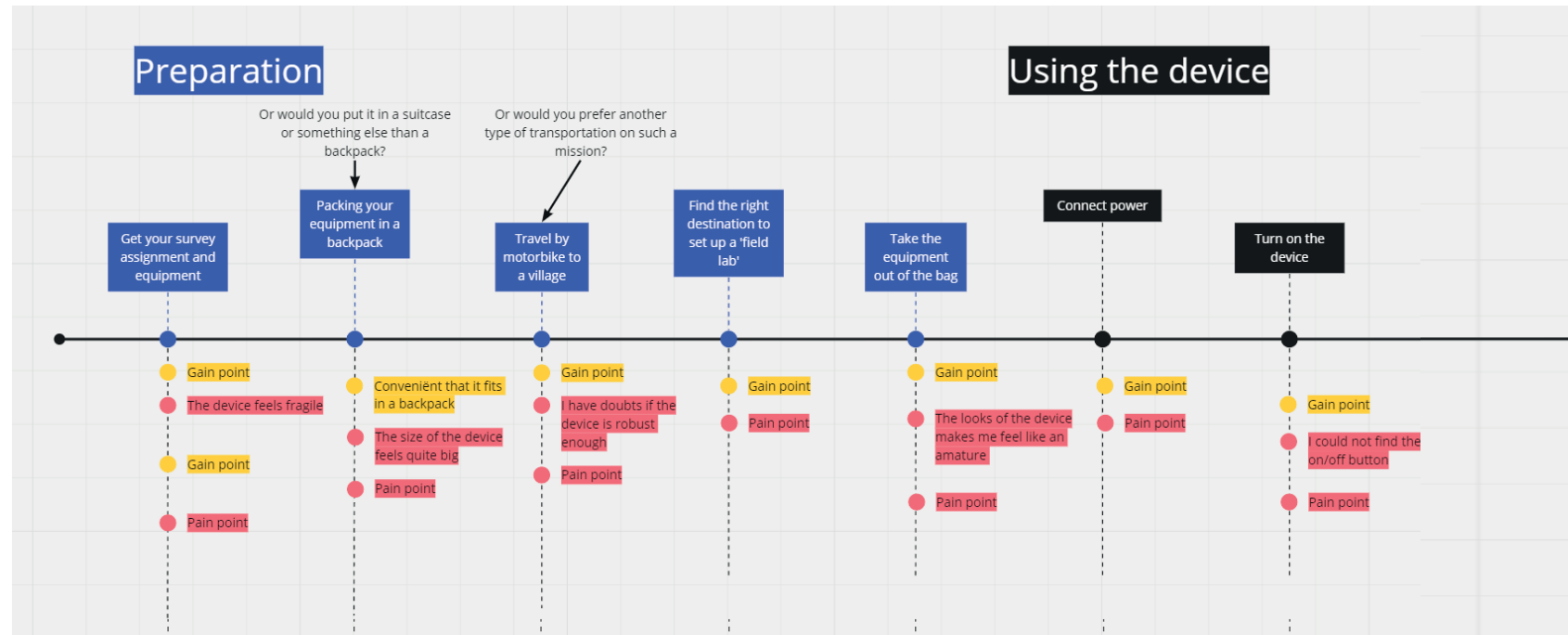


Fig. XX: Empty Customer Journey Map Miro to be filled in by the community health students

Journey map results



Student 1

Gain point for the work to be smoothly and meaningful. Yes, it feels fragile and also not portable	Yes and it's will be hard to be carry along anyhow and it's will not be benefit for people use especially in rural area The equipment cannot be easy to carry inside the backpack I think it's should be made smaller than before Yes, people living in rural area may likely not have access to it and it's will also hard to carry around	Motorbike transportation with the device will be more difficult to village because of bad roads and the larger of the device. I think we can get another means of transportation or make the device more smaller and portable to be carry around.	Yes the looks makes me feel like an amateur, because it's techniques It's must be easily taking out The screen should be minimal	Yes, the device needs electricity to operate. But I think you should also make it in solar power for the benefit and of people living in the rural area because the electricity supply there is very low	The equipment will not be useful because there must be on and off button in the device It's can takes some time and it's will be more stressful
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Student 2

		I think with the original size of the equipment the people in the rural community should be able to transport it with the use of motorbike but for those without a means of transportation I think it will be somehow inconvenient for them		So to make the device work there will be need for electricity but why can't you make it a solar and electricity dependable device because of those community without electricity (most rural community have no access to electricity)	
--	--	---	--	---	--

Student 3

	Yes, The size of the equipment feels quite big				No could not find
--	--	--	--	--	-------------------

Student 4

Gain point to make the work easier Yes, it's May require some effort because is heavier	Yes, but I think it's should be in smaller size for easy to carry along Yes, because it's big and its can be able to be carry around anyhow	No, it's not easier to be carry along with motorbike because of bad road and I think we can make another means of transportation The device is big for some means of transport around	Yes amateur because it's techniques The screen should be in form of phone size, so it's can be easy to operate	I think we should make its in solar form not only electricity especially for people in rural to be able make a prompt use of the device if there is no electricity supply	There should be on and off button to make the work easier and to ends and start the process
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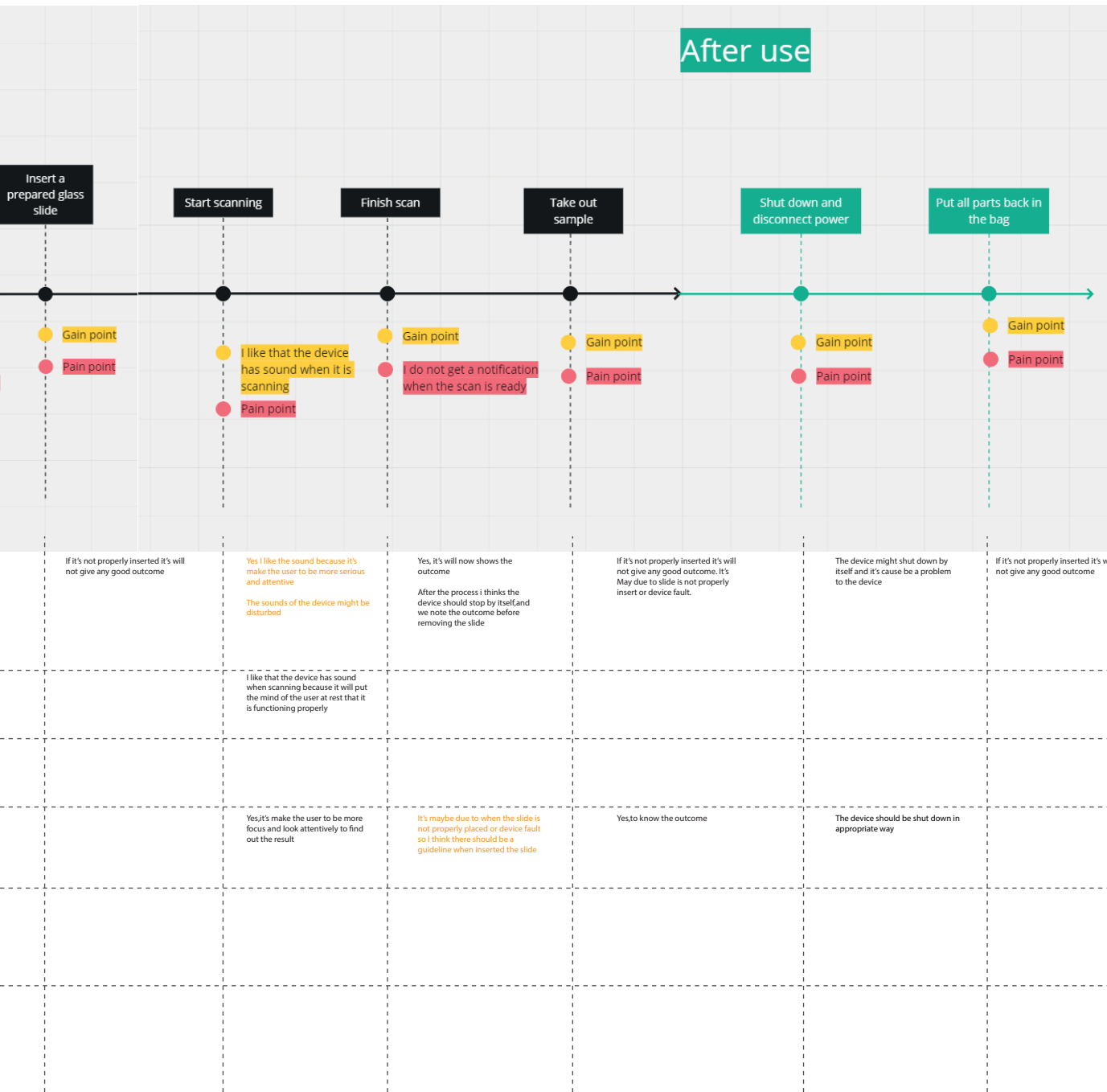
Student 5

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Student 6

--	--	--	--	--	--

Evaluation



After the student had filled in the journey map I studied their reactions. Unfortunately only four of the six students filled in the journey map. By putting in some example experiences of my own, I steered them into thinking about their experience in the same way. However maybe I suggested things that were not the case in their experience and they agreed, because I said so. Therefore I will ask deeper about their experiences around the sense of fragility, amature look and the sound during scanning.

Next to this I realized that my explanation was not clear enough because by every 'pain or gain' point I created they responded with 'yes' or 'no'. This did not affect the results of the journey map in a negative way I think. Because they reacted on each point like that, they had to think about each step in the journey in depth.

The most important insight from this journey map is:
- The device is currently too big for the intended goal

- Interesting things I need to explore during the session are:
- In what way does the scanning sound contribute to the experience of operating the device?
 - Why and how should there be a guideline when inserting the slide
 - What techniques makes you feel like an amature?
 - Why does the device feels fragile?
 - How big should the screen be?

Creative discussion set up

During this session we discussed the insights and questions based on the journey map. However the focus of this session was on having a discussion on 'how' to tackle certain challenges. Therefore the following focus points and questions were asked after some introductory questions.

In order to give them inspiration after their initial thoughts were given, I presented them with the exemplary devices as shown below. The outcomes can be seen on the next page.

Portability

Would you want to carry it around?
 How would you like to carry this device around?
 Would you prefer a strap, handle? a suitcase?

Robustness

How can you improve the robustness?
 Edges? Material?
 What portable robust devices do you know?
 How do you value the way robustness is implemented in these devices?
 Which of these devices seem the most robust to your opinion?

Screen

How to incorporate a screen in the housing?
 Should it be stuck on the device or should you be able to loosen it?
 Do you prefer it to be adjustable?
 How to make sure the screen is not damaged?

Professional look

What device in your environment looks medical to you?
 Why does it look medical?
 What specific characteristics in color shape etc.



Fig. XX: Exemplary devices shown to the students

Insights journey map questions

- In what way does the scanning sound contribute to the experience of operating the device?

The loud sound is positive because it helps us to know when a scan is finished while we are doing other things. Next to that it ensures us that it works in a serious way

- Why and how should there be a guideline when inserting the slide
Next to a manual, we like to get a warning when we did not insert the slide correctly

- What techniques makes you feel like an amateur?

The looks of the device do not ensure that it will survive rain.

- Why does the device feels fragile?

Because it is too light for its size.

- How big should the screen be?

As small as possible, maybe even get the results of the machine on your phone.

Insights Creative session

Portability

When the device is made smaller, the device would be transported by means of a backpack. The handle should be obvious and easy to reach.

Robustness

Include rubber to increase robustness because it does not add a lot of weight. To make it seem robust, make it compact through a dense shape.

Screen

Include the screen on the front because then you are the 'boss' over your machine. You can make it in such a way that you can take the screen off the device and put it in the bag separately to make sure it will not be damaged.

Professional look

Make sure that the design is in balance. Also include blueish details together with a white color.



Portability



Robustness



Screen



Professional look (unbalance)



Professional look (positive)

Evaluation Creative session

Whereas only four of the six students had filled out the journey map, during the creative session only three of the six students were present. This was mainly because the power and the internet was failing that day I heard. It was a quite difficult session because of bad connection, however I got a lot of valueable insights.

Through talking with them I realized that they really are the future users of the AiDx assist. Through this session, I got a more detailed image of the future user through which I can iterate the persona.

The medical students never have gone on a 'real' mission. After realizing this, I knew I had to verify some of the findings I got with an expert who has done some real missions. This expert is Brice.

Set up Interview Brice

With Brice I firstly walked through the Journey map and the insights I got from the group of students in order to validate the information they gave me. After this, I asked what they thought about the interactions I thought of including in the device. Lastly we discussed several possible solutions regarding portability, robustness, professionalism and the screen.

Insights interview Brice

Journey map

The updated journey map with the information of Brice and the students can be found on the next page. The most important assumptions that I made that are turning out to be wrong are:

- The device is going to be transported by motorcycle
- The device can be powered by means of net power or separate accu
- The looks of the device is less imporant than if it works

Interaction

Do not use a seperate light to indicate scanning status, this will result in extra workload for the mind. e.g. what does this light mean. I forgot. Rather display status on the screen in text.

Portability

Include a backpack with room for orther supplies. The handle should not stick out of the housing

Robustness

Make it smaller while keeping the weight the same

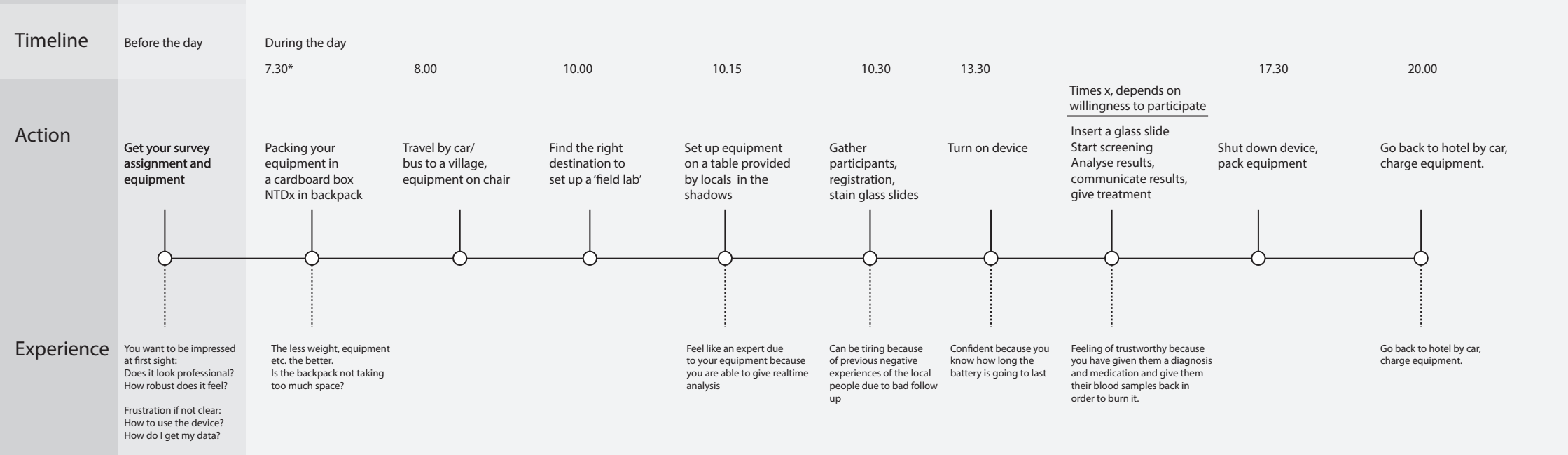
Screen

Include the screen in such a way that the screen is covered during transport. Make it able to fold in such a way that the screen is 'inside'. The screen should be attached to the device in order prevent theft and loosing it.

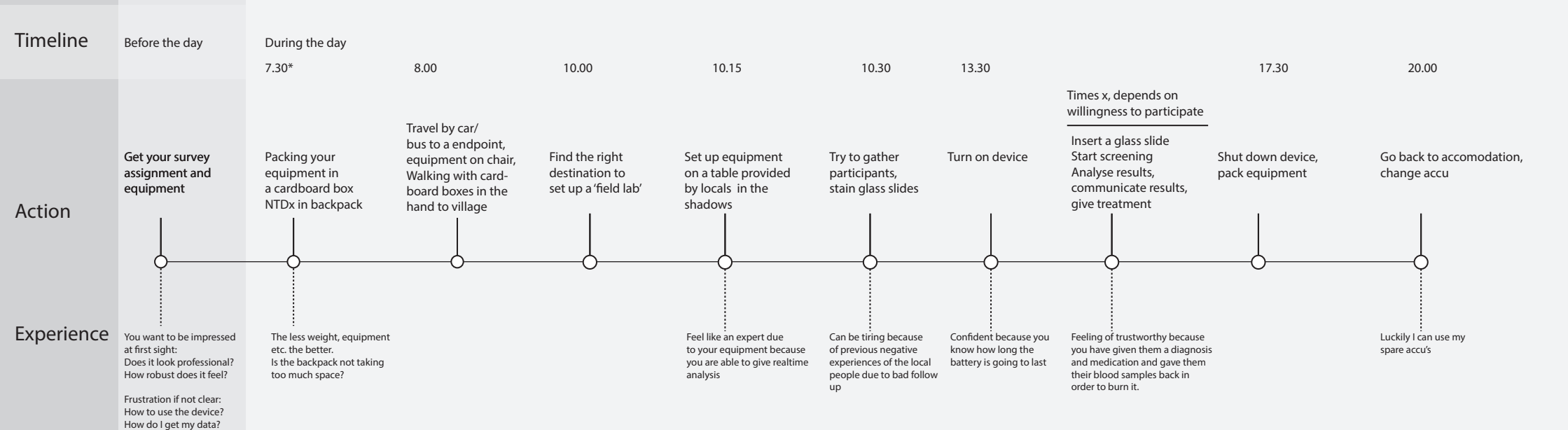
Professional look

Omit the black of the current design, include blue. The device should not have such a simple shape as it has right now.

Envisioned scenario: one day trip, roads and electricity are available



Envisioned scenario: multiple day trip, roads and electricity are unavailable



* Start time is dependent on how far away the village is

** These scenarios are checked with three Microscopists with experience in the field. A change made after consulting them is that the time in between staining and starting to scan should be 3 hours.

APPENDIX 4 - FRAME INNOVATION

Archeology

The problem we have is that we want to be able to screen a population in a remote area in Nigeria on NTD's. If people have these NTD's, they can spread it easily to others, or they can die from it. Especially in hard to reach regions NTD's flourish. Therefore the healthcare sector in Nigeria wants to treat these people. In order to diagnose the locals, advanced instruments are needed. However the problem is that no infrastructure is present to support these instruments in these area's. Also, in order to diagnose the people, skilled personel should be available that are able to diagnose locals on by looking through a microscope to the samples. This skilled personel is scarce in Nigeria (and the whole of Sub-Saharan Africa), and these skilled people are making human errors, especially when they are getting tired.

Previously, treatment teams were solving the problem by just treating everyone in a village, without knowing who is infected. When villages are treated like that, you are very inefficient: you do not know if someone is sick and you also do not know the result of your treatment. Next to that these teams can also take blood samples of locals and research them by using microscopy after which they are treated. This is a very time consuming and costly process, because it is all done by hand. Due to this and a limited budget, it is difficult to treat large populations and keep track of the result of your treatment. Also for some diseases Rapid Diagnostic Tests (RDT's) are available. The problem with these is that people do not trust these all the time because there are a lot of fake tests in circulation.

Paradox

What makes this problem hard to solve?

Because NTD's flourish under Nigerian people in remote area's with poor infrastructure, these people should be treated.

Because Nigerians with an NTD should be treated, huge amount of Nigerians should be tested to determine who to treat.

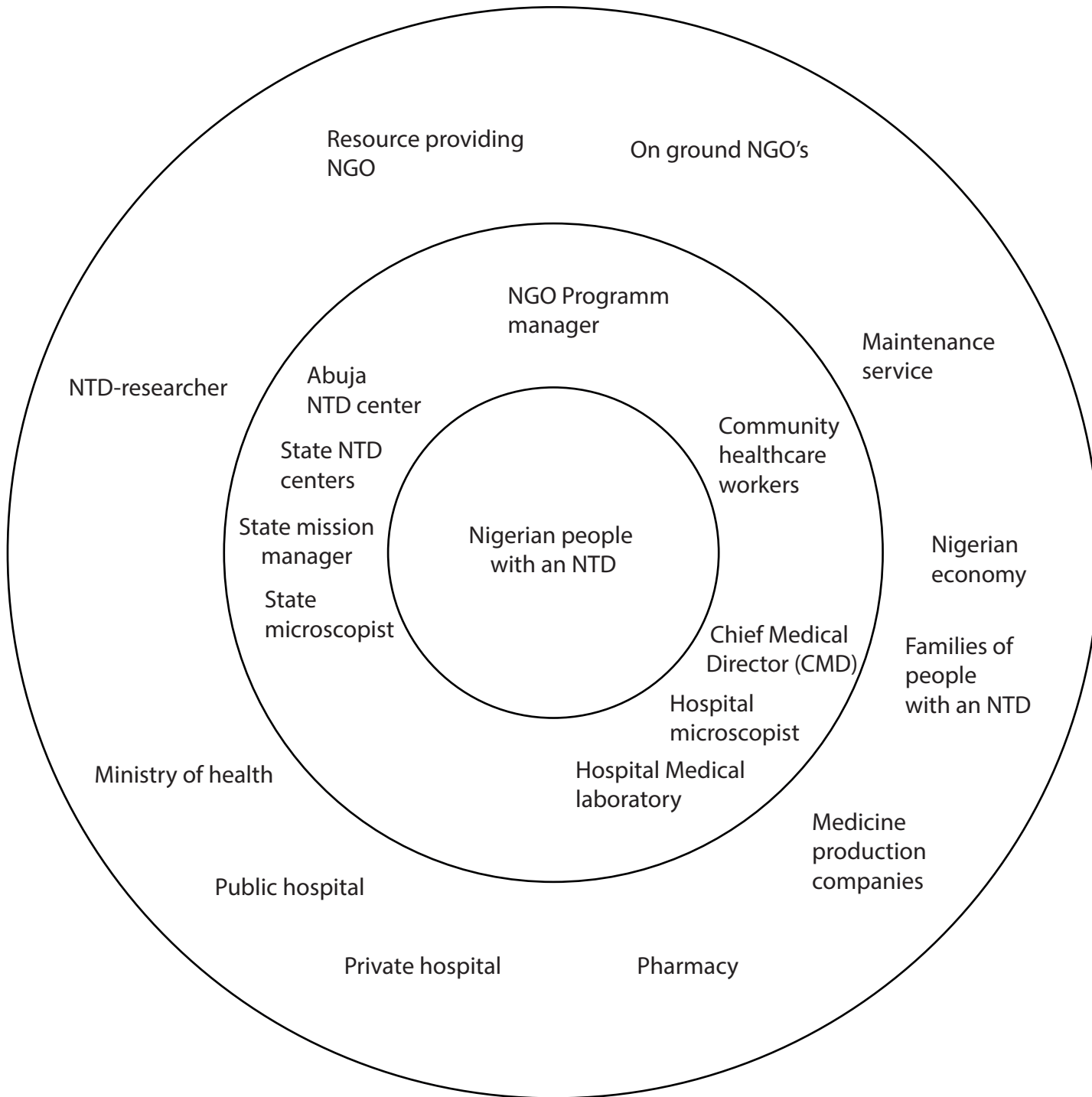
Because a huge amount of Nigerians should be tested, advanced instruments should be used to test efficiently.

Because advanced instruments do not work in a remote area setting without infrastructure, Nigerian people living in these area's can not be treated.

The context

The inner ring of stakeholders dealing with this problem are the Nigerian people in remote settings having a NTD. These can be people that are feeling sick already, but also people that are carrying the disease with them without them knowing it. Also NGO's and missions providing treatment to these groups are in close contact with this problem. Lastly, the microscopists screening the samples of Nigerians and treating them are stakeholders. These groups have been involved in the mentioned interventions to eradicate NTD's in Nigeria.

The technological space for change is constrained by the poor infrastructure and difficult changeability of that situation in remote area's of Nigeria.



Resource providing NGO's provides money for NGO's that are executing the microscopist tasks on ground. The last NGO's have specific program managers per country and/or NTD who will contract State microscopists for the duration of a treatment/diagnostic mission of a few months.

The State microscopists are employed by a state mission manager normally. These state mission managers are executing a treatment/diagnostic mission on behalf of a state NTD center. The Abuja NTD center is the 'head' of all these centers. These centers are financed by the Ministry of health.

These missions are only executed if a community healthcare worker has prepared the local population in such a way that they support the treatment. These community healthcare workers are known and trusted by the locals. That way the missions can be executed safely.

Next to this, people sometimes find help for their diseases themselves. Most of the time they end up by public hospitals. In these hospitals the CMD determines the available diagnostic instruments. In the hospital medical laboratory the diagnostic tests are performed by the hospital microscopists. Sometimes people with NTD end up in a private hospital, but that only occurs in rare cases where a private hospital is founded by churches or retired healthcare workers and located in a remote area; NTD's are diseases for the poor.

NTD-researchers are distant stakeholders in this scenario, because they are involved in providing 'heat maps' of the presence of NTD's but not treating the population.

The field

The broader social field for the treatment of NTD's in Nigeria is very huge. I will go in more detail to a few stakeholders, the other stakeholders can be seen in [figure xx](#). Approximately 100 million people are affected by NTD's in this country. Not only the people getting these NTD's are affected, but also their families. Secondly, the regional and national economy is affected through a decrease in productivity of the population. Also the public and private hospitals are stakeholders. They provide treatment to people arriving sick to their hospitals. Fourth, the companies providing medicine in order to treat these diseases are stakeholders. Fifth community healthcare workers who are confronted with villagers with NTD's when teaching and helping a local community with regard to healthcare are involved. Lastly the regional and national department of health of the government is affected because the Nigerian population expects the government to take care of their citizens by organizing treatment.

Themes

Trust

One theme coming back in this problem is trust. The trust people should have in the people and technology that are diagnosing and treating them. This trust could be gone through previous actions by researchers by not coming back to treat people after they researched the samples of the local population and false test results.

Scaleable quality

In this context, the theme 'scaleable quality' is a theme that can be encountered in multiple situations. The available money, time and expertise should be spent efficiently in order to maximize impact in a scaleable way. Previously, initiatives were focussed and organized in a local way resulting in good diagnostic results very locally with good quality follow up. Other initiatives are focussing on a big group, but the diagnostic and treatment results (sometimes even not checked from behind) in these cases are not good enough to be able to determine the quality of given treatment.

Measuring

With the previous theme the theme 'measuring' is closely related. Not only should be measured who has a certain disease in order to treat them, but also the results of the treatment should be measured in order to validate if the treatment has worked.

Isolation

NTD's are most common in distant areas. The people living there are isolated from the rest of the world. Therefore the diseases they have are also not frequently present in the rest of the world, isolating the diseases in this population from the rest of the parasite-landscape. Lastly the infected people will get isolated from the rest of their community because they will not be strong enough to work and provide for their families when they are not treated.

Frames

Saviour

The treatment of NTD's in a remote area relies on missions send by an external party mostly . This can be the government or an NGO. Therefore the local population that are sick (knowingly or unknowingly) will get saved by an external party outside their village. By 'strangers'. The AiDx NTDx can also be seen as a saviour. It comes from abroad to the country to save the local people from parasites.

Verification

In order to determine the type of infection and the type and amount of needed treatment, skilled personal should be available. Currently the training of this personal requires a lot of time. At the same time a many uncertified people claim that they have the skill to diagnose and treat without this training. This results in misdiagnosis and mistreatment.

If the problem situation is approached as if it is a problem of instilling trust in the outcome of a diagnostic test, then the solution should be that:

The outcome of the test should be a hundred percent trustworthy and be communicated to the tested people in a transparent way. This way of communication must be so clear that everyone can see for himself that the result is trustworthy as well.

If the problem situation is approached as if it is a problem of scaling up high quality diagnostics in an affordable way, then the solution should be that:

A solution should be developed that is able to perform multiple tests in a affordable way. The solution should not rely on an abundant presence of skill and money, but it should be easy to operate and understandable for common people.

If the problem situation is approached as if it is a problem of measuring then the solution should be that:

There are easy accessible measuring locations throughout the area. People should go to these measuring locations regularly and their results should be registrated in order to measure the quality of the treatment and the infection load under the population. There can be thought of making it a standard of living that you should do yearly checkups.

Futures

If the problem situation is approached as if it is a problem of isolation of the local population then the solution should be that:

Better infrastructure should be developed in order to make the local population less isolated from the rest of the world. Make it easy for people to go in and out of the area. That way treatment is always closeby. Also it can be thought of bringing the solution in isolation as well. If the population is quite isolated we can also enter the isolation and make a solution that works very well in isolation which can also be maintained in isolation. Bringing the treatment in a place where the isolated population will pass by already like a water reservoir or specific markets will increase the reach from within the isolated population.

If the problem situation is approached as if it is a problem of relying on saviours then the solution should be that:

The saviours should always be present. It should not be people or devices from outside. Diagnostics and treatment should be from the local people for the local people. This way treatment will always be available for the locals. We can create this by teaching dedicated local people how to use the device and how to treat the diseases that are encountered.

If the problem situation is approached as if it is a problem of verification of the personnel, then the solution should be that:

The device should only be accessible by trained personnel. The equipment to diagnose and treat should only be available for certified persons. This means that someone seen with a 'diagnose kit' automatically can be seen as an expert.

Two broad possible future directions can be distilled out of the previous themes.

The first future direction pictures a diagnostic center at a central point where a large part of the population comes over time with other purposes. During this trip that people are used to undertake a yearly test can be done in order to diagnose diseases. This yearly checkup will become a standard for the people. The people performing the test at these centres should be local people educated by a certified organization. This makes sure that the quality standards are reached. Also because the center will be manned by locals, people will know each other and trust each other with regard to the diagnosis. Through the regular yearly checkups, people will create a bond with these centers creating even more trust. It can also be that these centers are moving to a different place each month, but repeating the same locations every year.

The other future direction pictures local people educated like the community healthcare workers by a certified organization going from village to village. They bring all they need with them. By means of their equipment, appearance and local knowledge, they instill trust in the locals. Because they are locals, they know the areas where to look into because they will hear where their service is needed the most. Also they can target the required areas quite specific because they are highly mobile.

In both scenarios the equipment should be very easy to use because it relies on teaching locals how to deal and operate with the equipment.

Transformation

The first envisioned future explained in the previous section requires a change in ways of working of the organizations. They should establish multiple centers all over the remote area and maintain them. Also they need to find people that are willing to do this job. The conditions will be harsh because you will have to move from area to area. Also the amount of locations where a center should be placed is quite high. The amount of money and effort needed to organize this will be too high.

The other scenario will require less change for the current organizations. The only requirement for this is to have all the equipment they need with them. The only thing missing right now is a portable diagnostic device that can work in remote areas. The transformation that should be made is that an initial investment should be made in the purchase of such a device. Also community healthcare workers should be trained to operate and maintain the equipment.

Concluding, the latter is an easier transformation than the first 'envisioned future'.

Integration

With the second option, the transformation should be initiated by the organizations that are currently performing the diagnostics already. They need to diagnose the local population in remote areas. When there is an easier solution where they can scan a larger amount of people with less needed effort, but with a little investment on beforehand they will pursue that option. They have a little money to invest because they are operated by the government or NGO's. The people who have the most to win in this case are the people who should take the biggest action. Therefore this future can be integrated in the broader context relatively easy.

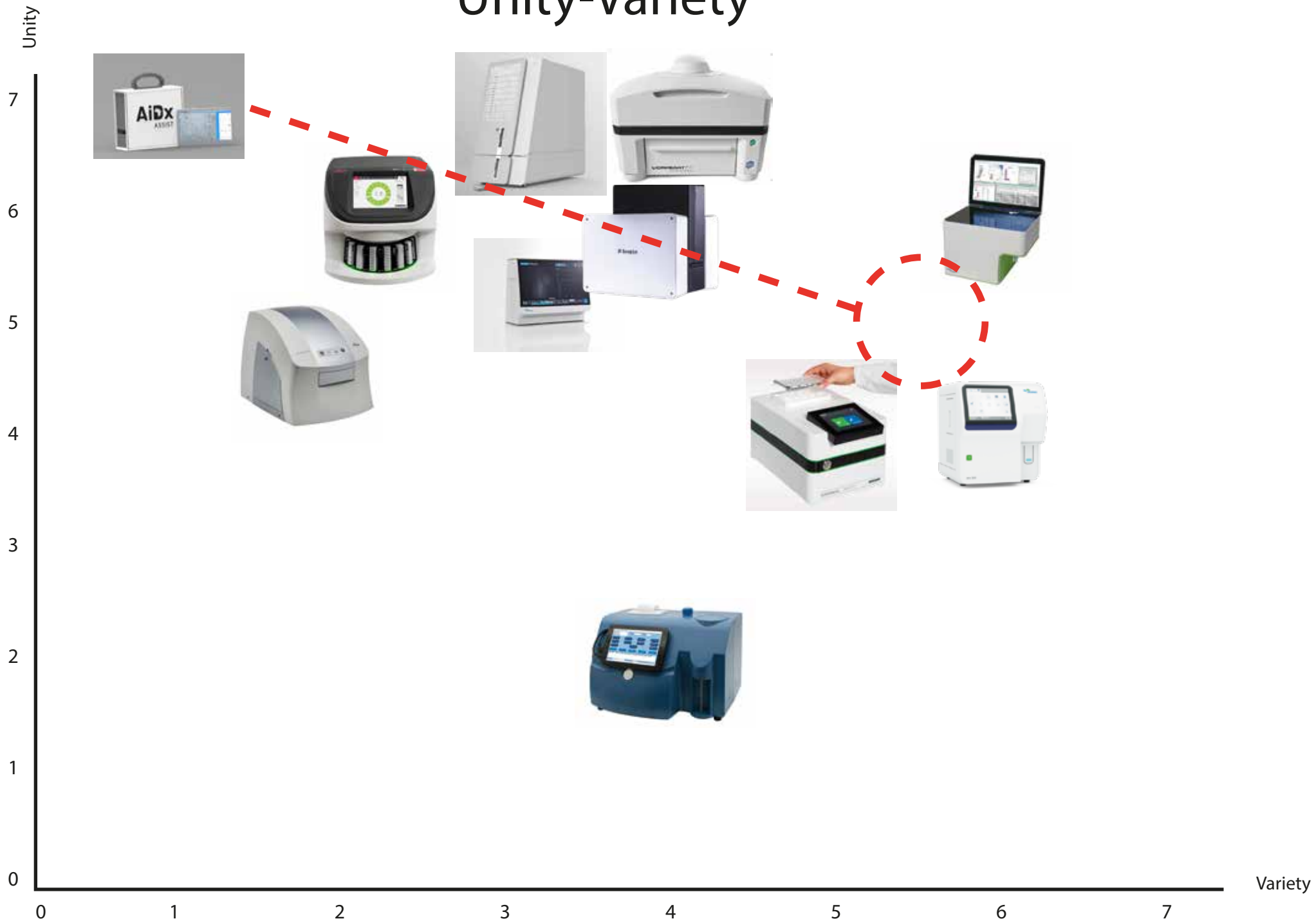
APPENDIX 5 - 9 MOMENTS OF APPEARANCE

I chose the microscope on the next page because they all belong to the product category of diagnostic microscopes. Furthermore a selection criteria was that they should work in combination with a screen. This could be a monitor or an onboard screen. Lastly I selected a few microscopes from Sysmex because they are seen as one of the outstanding automated microscope brands in the world.

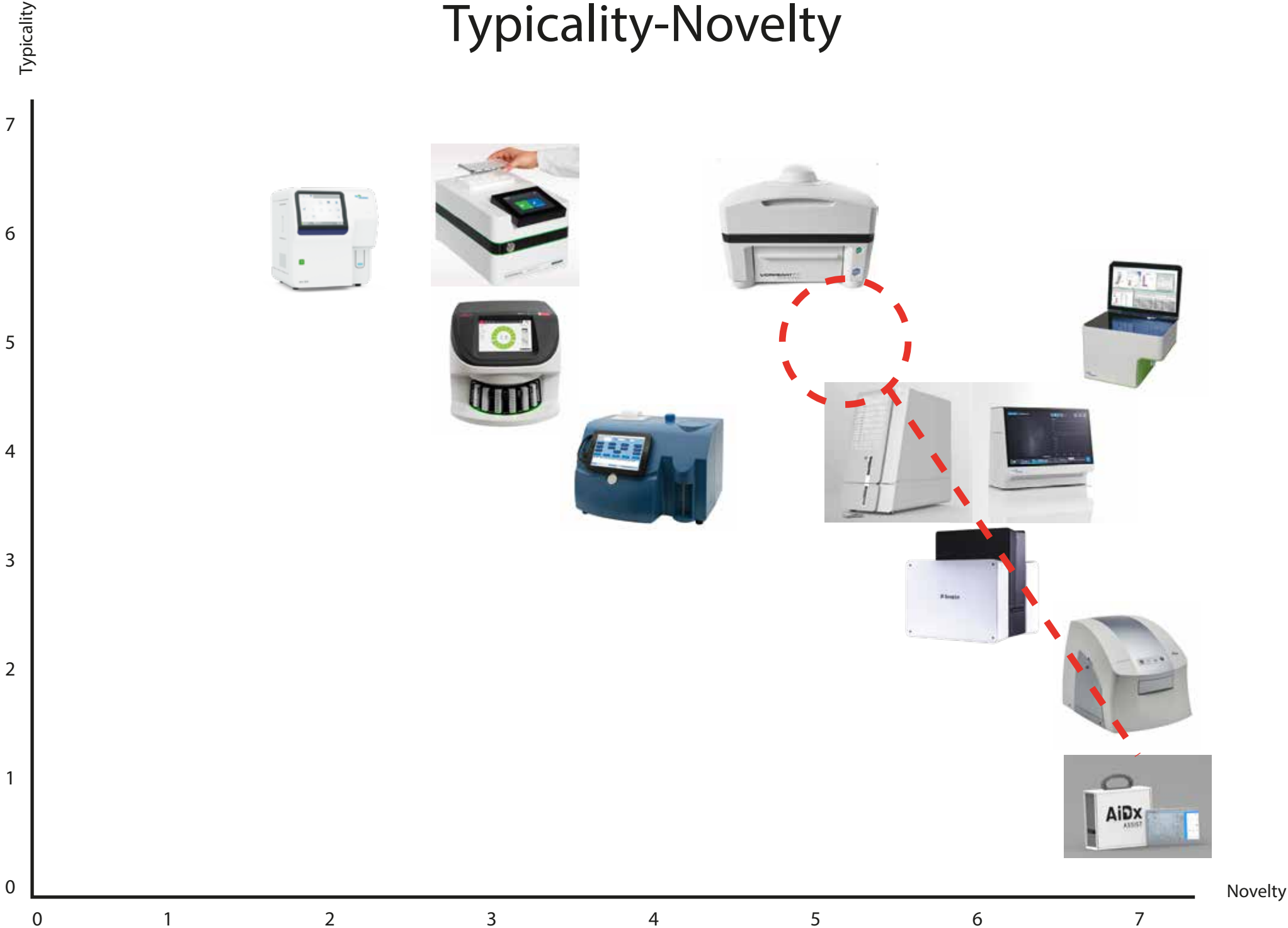
On basis of this analysis I can say that the Unity of the AiDx Assist should be reduced by increasing its Variety. Next to that, 'novel designs' score high on Aesthetics. Therefore I should make the design look more novel to increase the Aesthetics. However I should investigate how much value the future user acknowledges to novelty. Including different textures and at least one shiny surface will increase the novelty. Lastly the autonomy should be improved. Including robust design features will surely increase the autonomy.

	Aesthetics	Unity	Variety	Typicality	Novelty	Connectedness	Autonomy
Aperio GT 450	3 The appearance is too rugged for a typical microscope. Also the textures of the different colours are the same, making it boring.	6 It has clearly compartments. The black and the white which gives it a unified look	3 The product clearly has two compartments, however the lack of different texture decreases the variety	5 The material and colour usage is typical	3 The texture and shape is boring and commonly used	5 The colors and textures are right for this product category. Also the shape is quite normal.	3 This device is very normal for a medical device, no outstanding shape or colors
Lactoscan MCC	2 The colour does not fit in the typical microscope category, making it not typical at all	2 All features are distributed over the device, so no order	4 It has no compartments, however it has many different elements	4 The shape is a typical medical device shape	4 The colour on the whole device is very novel, however the shape is decreasing the score	2 People in the medical field like mainly white products the most	6 The outstanding blue colour gives me the means to distinguish myself!
Lionheart FX	5 The symmetry of the device makes it attractive, however the lack of variety makes it a little boring	7 Very symmetrical and has two compartments	4 Through its high symmetry the product does not have much variation. However it clearly has different parts	6 The colours, material and texture are typical characteristics	5 The round shape of the top part is novel	4 The main shape and the colors are exactly what you can expect in this product category, however the bended upper side makes it like the rest	3 This device is very normal for a medical device, the curved upper side of the housing is the only thing it differs from other devices
Euroimmun MERGITE!	4 This design is very typical, but does not have much novelty	4 The device is unified through the black in the middle. However the black screen reduces the symmetry	5 The product has different parts made up by black and white boxes	6 The colours, material and texture are typical characteristics	3 It is a rectangle box mainly	6 The shape and colors are exactly what you can expect in this product category	2 This device is very normal for a medical device, no outstanding shape or colors
Ativa Essent	5 The novelty of the design is high, however the variety is a little lacking	7 The colours fit with each other. Also clear division between the interaction part and the rest of the housing	4 The colour contrast is low. However it has clearly different parts.	4 It does not have the typical contrast colour, however it has the typical white colour	6 The oblique shape of the front makes it novel	3 The right colors are missing to belong in the product category.	6 The shape of the front of the device in combination with the sharp edges is autonomous
Sysmex HM 1000	7 This device scores high on novelty. Through the contrast between the mat white and the shiny black it has a high variety.	6 Clear division between the interaction part and the rest of the housing	3 Obviously this design has two main parts. Besides from this not much variation is present	4 The colours and textures are typical, however the shape is not typical	6 The shape is novel. The size of the screen is novel	5 The colors are normal, also the shape is quite like a 'box'	7 The big screen that makes up one whole side makes it easy to stand out
Scopio	5 The shape of the black part gives the design a novel look. The lack of the amount of detail (variety) on the device decreases the aesthetics	6 High symmetry and use of symmetry to draw attention to the interaction parts	4 The design has three parts. However two of these parts are the same, reducing the variation it has.	3 The colours and texture are typical, but the shape is not typical	6 The shape is novel	3 The colors are normal, however a microscope consisting out of three upright modules is not normal	5 The colours or structure of the housing is very standard. However the shape is quite outstanding
Sysmex XN-350	5 The shape is a little 'boring', resulting in a high typicality. However the variety is present through the different colour accents	4 Clear where the focus should be through the black screen. The white colour makes it coherent too.	6 The minor details are scattered all over the place, in different colours	6 The shape of the box is very typical	2 The design is very common in medical devices	7 The box is a typical microscope with the right colors	2 This device is very normal for a medical device, no outstanding shape or colors
Sysmex CyFlow Cube 6	6 The contrast of the colors and different textures gives it a high variety and novelty, however its unity is still present because of the plain face	6 Clearly ordered. Green for the sample placement, black for the interaction and white for the rest of the housing	6 Variations in colour, and textures	5 The shape and colours are quite typical	7 The way the screen is included is novel	6 The colors and shape connect to the field of microscopes	7 The way the screen is integrated in combination with the colors makes it easy to stand out
Aperio LV1 IVD	1 The lack of variety and contrast in colors of the device reduces the overall aesthetics. Also the shape of the device is too curvy making it too novel for the product category	5 Clearly ordered by using different colours	2 The variation in colours is insufficient	2 The only thing that is typical is the white colour	7 The shape with rounded and elegant edges is novel	2 In the field of microscopes, it does not connect with other designs through its grey colors	3 This device does not stand out by its design in the lab. It is just an ordinary medical device
AiDx Assist	2 Through the high unity and low variety in combination with the low novelty and connectedness, it scores very low on aesthetics	7 The box is very symmetrical, without any variation in colors	1 The variety is very low. It does not have different colors, textures or 'odd' shapes.	4 The box has a rectangle shape and the typical colors white and black. However the edges are not 'soft' like a normal medical device	7 The device is just a box, totally not similar	3 Through the overall shape and color can it be tolerated in the medical world	2 Through the box design, it does not stand out.

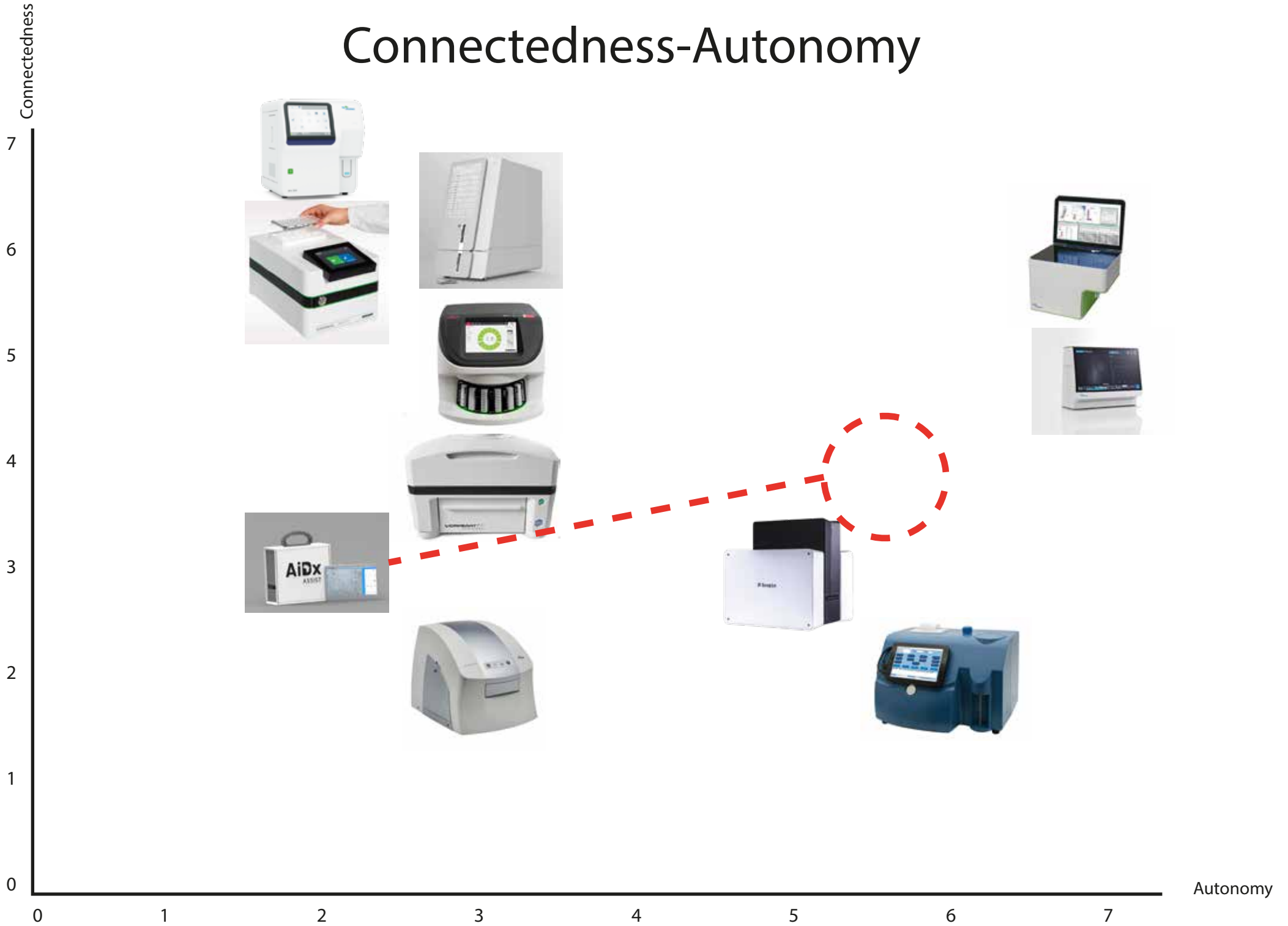
Unity-Variety



Typicality-Novelty



Connectedness-Autonomy



Three moments of Aesthetics

Micro

Macro

Meta

Aesthetics



Technical

A lot of unity, no variety in materials, shape and colors

Too much novelty included through the use of a rectangle, plain box

Connectedness is very low because the future user seen with this device will not connect with the medical field

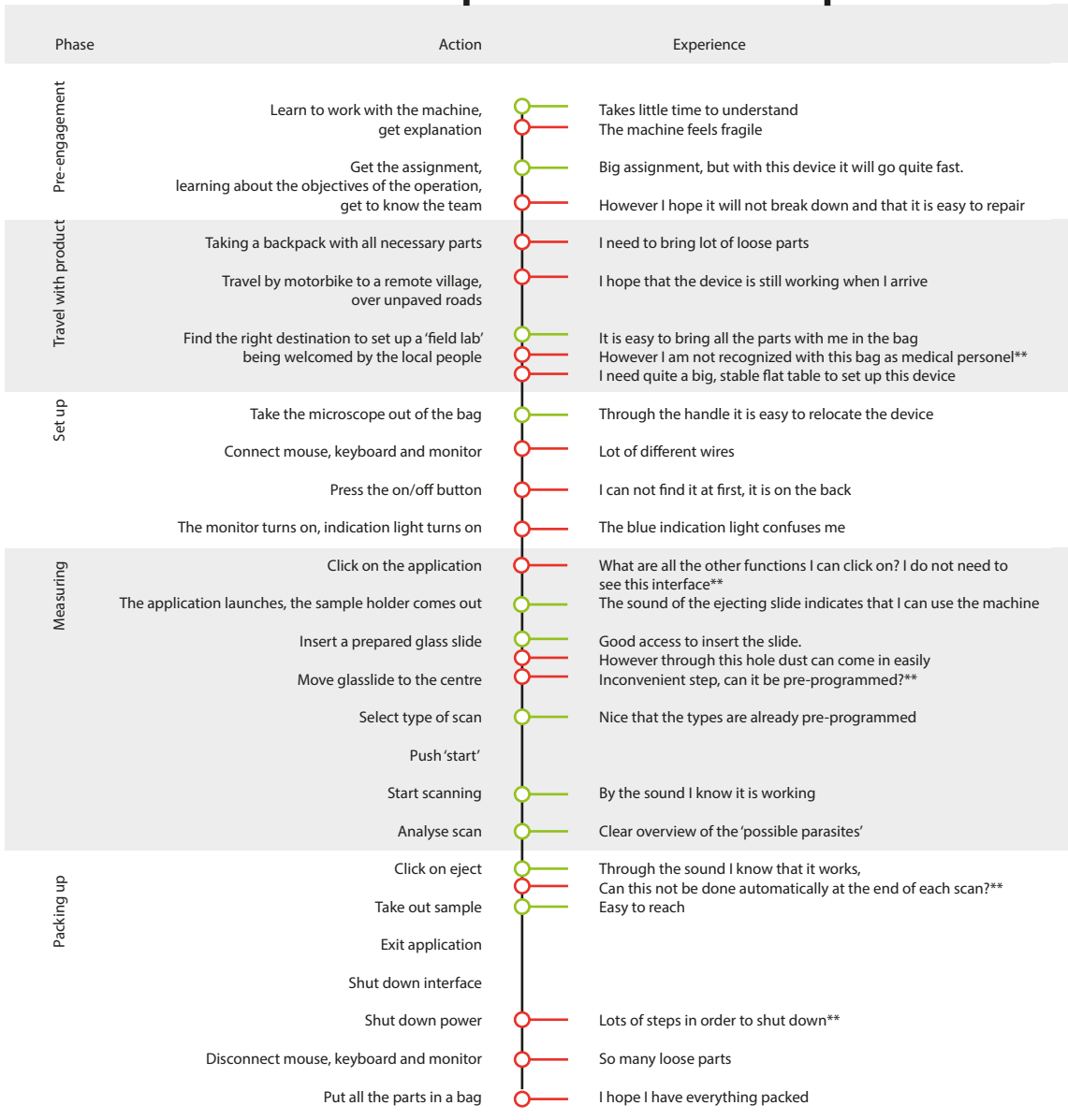
Experience

Feels boring

Feels like there is no style and the pride of being special; being a microscopist/ community health worker is taken away

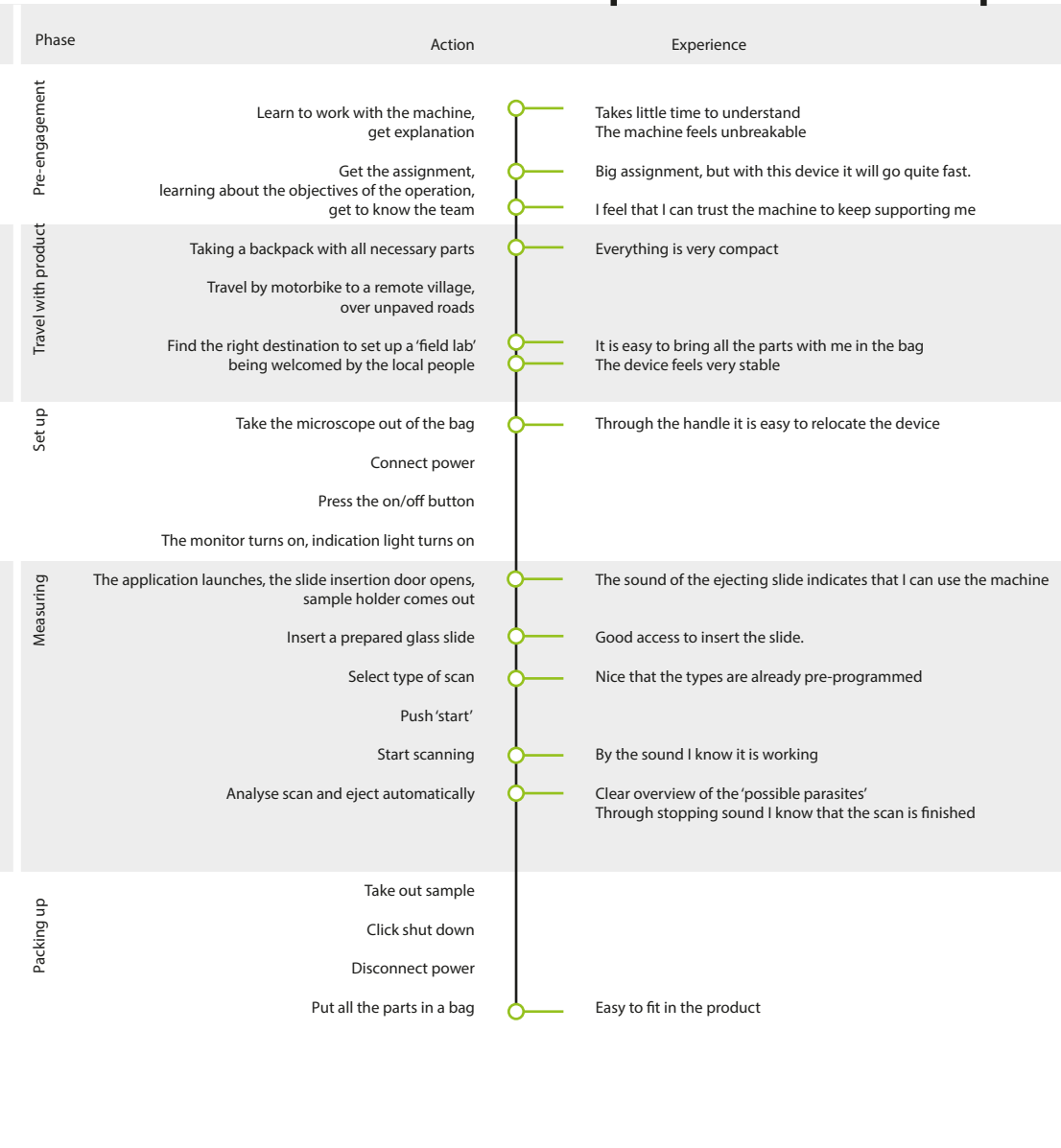
Amature identity

User experience map



Marked with ** means that I will not focus on improving this aspect

Envisioned user experience map



Marked with ** means that I will not focus on improving this aspect

Persona



Name	Joy
Age	32
Education	Primary school, Secondary school
Occupation	Mother, Community health worker
Experience	Worked with community health worker
Values	Committed, pragmatic
Goals	Creating a healthy and growing community
Frustrations	Not enough surveillance of infectious diseases Unable to diagnose by herself easily Not enough available diagnostic instruments

Character

After Joy finished primary school, she started to work in the pharmacy of her neighbor. Through this work she saw the need of community health workers and she volunteered for this job. Joy is proud that she can fulfill the role of community health worker in her village now for ten years already.

Meaning

Micro:

The white housing is clean
The black housing is dramatic
The rectangle shape looks sturdy
The simple shape looks dull
The sharp edges look cheap
The thin glossy plastic housing feels weak
The structure of the white plastic housing feels robust
Mechanic scanning sound feels goal oriented
The size feels too big for its weight
The black handle feels robust
The blue Indication light is confusing
The On/off button feels old fashioned

Macro

The product belongs to the product category of Automated microscopes
The functionality can be experienced as:

Use

Surprising as it is easy to learn to work with this high tech device.
Slow because it is not really portable like it should be

Activities

Helpful as it is helping microscopists do their work faster

Functionality

Can feel like an upgrade from using a motorbike to a car; much more speed and reach can be created by using this device

Mechanism

Unfinished feeling through the high amount of noise that is being made by the device.

Need

Indispensable because it is increasing public health

Meta

The product will be brought to areas where it is needed and can save lives. Therefore it can be experienced as a life saving product.

Other people will see the product and perceive it as a high quality product because in the context of local use in Africa there will not be much high quality med tech products

Compared to other products in the context, this product is quite high tech. This can result in admiration for the product.

Trends in rural Africa are that more and more medical products are coming to boost their health. This product can be seen as one of the first products. Maybe it will come across as an intruder; a product from the outside. On the other hand it can be seen as a life saving device.

Three moments of Meaning

Micro

Macro

Meta

Meaning



Technical

The thin glossy plastic housing

All the different parts to take with you to set up a working system

Does not belong to the product category of modern medical devices

Experience

Feels like it breaks easily

Makes you feel slow

Feels like being an amateur using secondhand equipment

Emotion

EMOTION VISION

With the AiDx NTDx I want to support a trusting relationship between human and product. In such a way that the user knows that he can rely on the product

This reliability should be emitted by the product through its robust appearance.

This appearance should 'say' that this device is a professional medical device

Also it should be a product that is easy to use by non-educated people

EMOTIONS DURING PRODUCT INTERACTION

a. emotions of the user before she enters the design context:

Joy because the AiDx NTDx is going to help the user to fulfill his job easier and faster, helping more people.

Eagerness to learn how to work with a technical medical device

Worried if the product is able to withstand the environment

Doubtful because the amount of accessories is big, so it is not portable enough

b. emotions during user-product interaction:

Confusion because it is difficult to understand how to turn the device on

Pride because they are able to use such a complex product

Nervous because they experience the fragility of the device and do not want to break it

Boredom through the little user interaction/aesthetics

Uncomfortable by the amount of sound it makes during use

Empowered through that the machine does the work and that the users still make the decisions

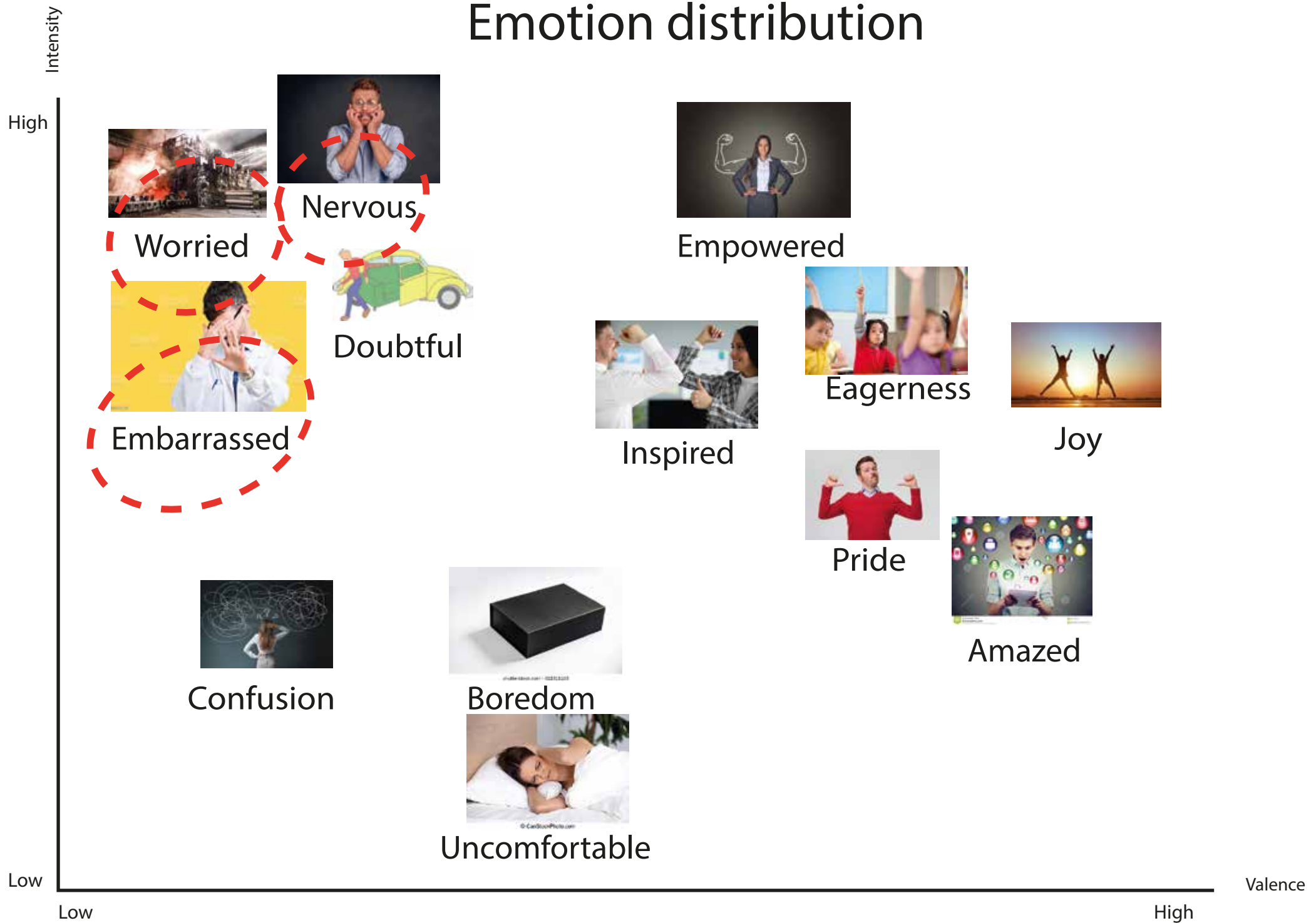
Amazed by the quality of the images and AI

c. emotions that result from the user-product interaction?

Inspired by and enthusiast through the possibilities of monitoring treatment with this device

Embarrassed to other medical personnel because the current product does not look like a medical device

Emotion distribution



Three moments of Emotion

Micro

Macro

Meta

Emotion



Technical

Too many big, open holes

During use, the sound/feeling of the cheap plastic housing when it is touched

The simple rectangle shape

Experience

Worried if the product is able to withstand the environment

Nervous through the feeling of fragility

Embarrassed through the unprofessional looks of the device

Current matrix

Micro

Macro

Meta

Aesthetics



Feels boring



Pride of being a health specialist is taken away



Amature identity

A lot of unity, no variety in materials, shape and colors

No novelty through the rectangle plain box

Autonomy is very low trough the simple shape

Meaning



Feels like it breaks easily



Makes you feel slow



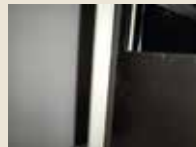
Feels like an amature with secondhands

Thin black glossy plastic housing

The amount of equipment you need to bring with you

Does not fit in the modern medical devices product category

Emotion



Worried about withstanding environment



Nervous by fragility



Embarrassed through unprof-fessional look

Too many big, open holes

Cheap feel of the plastic when touched

Simple rectangle shape that makes the product 'any product'

Envisioned matrix

Micro

Macro

Meta

Aesthetics



Intriguing

Variety in materials, shape and colors
'you want to touch it, feel it, just to explore'



Dedicated

On the device, the necessary functions
should be obvious and stressed



Professional

Add remarkable detail to increase auto-
nomy; white monitor vs dark environment

Meaning



Robust feeling

Obtuse angles, consistent over a longer
surface/area of the product, texture



Portable feeling

The whole system should be designed
with eye to intuitive portability



Modern feeling

A 'clean electronic look' should be inte-
grated in order to be experienced as 'new'

Emotion



Trust

Thick rubber black edges say:
I am designed for accidents



Impenetratable

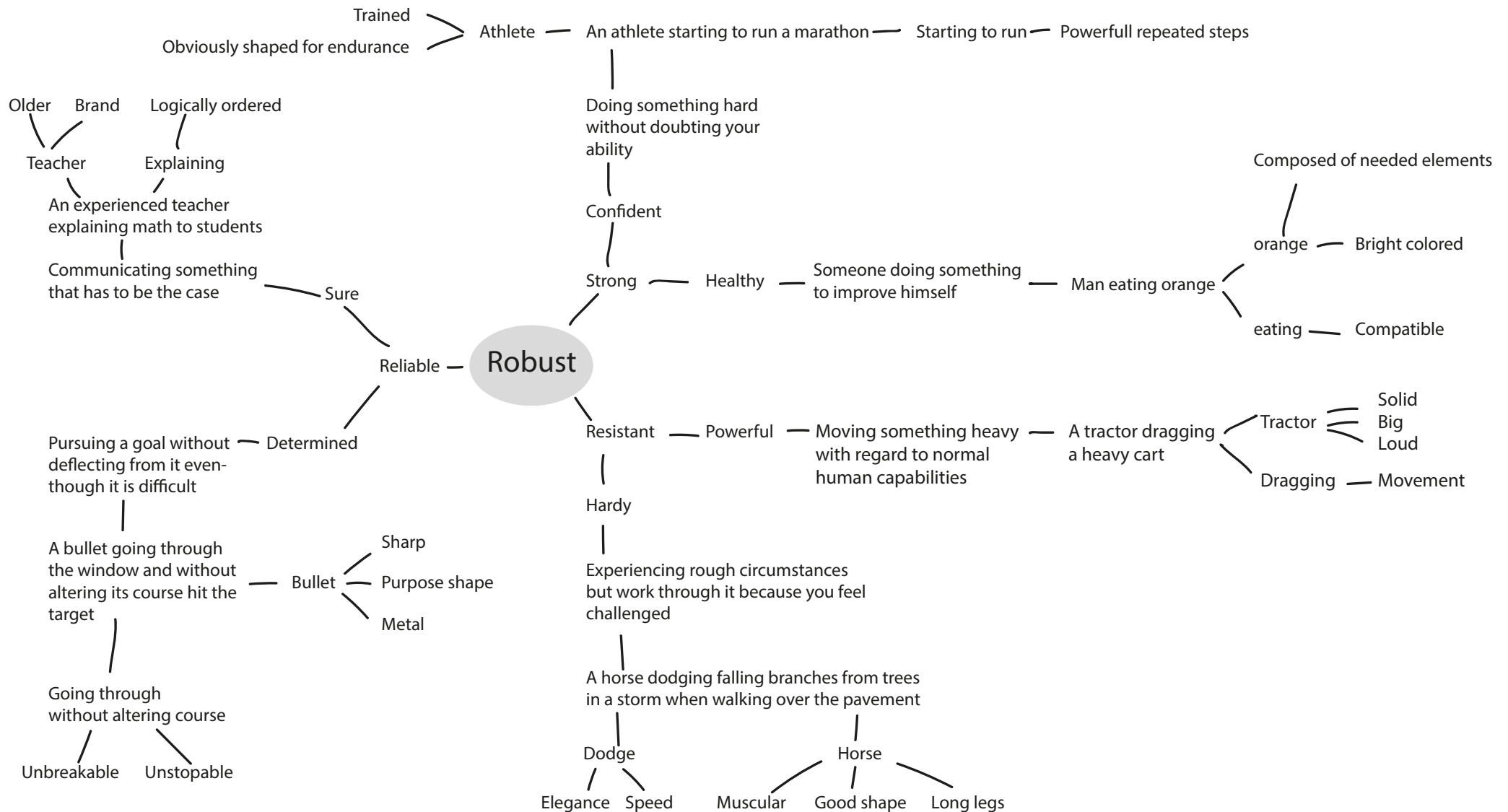
The looks of being made of one piece



Confident
feeling

'I am made for this'. The product should
stand in its environment and 'belong'

Semantic network of product experience: Robustness



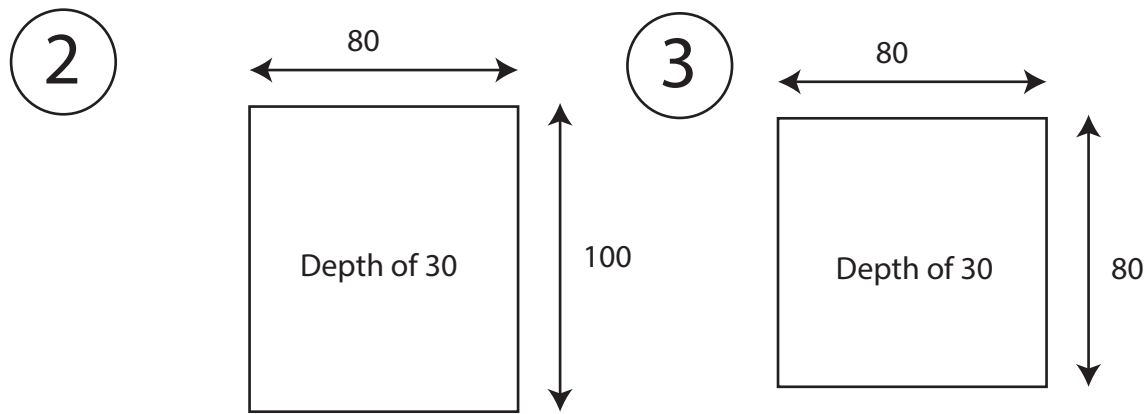
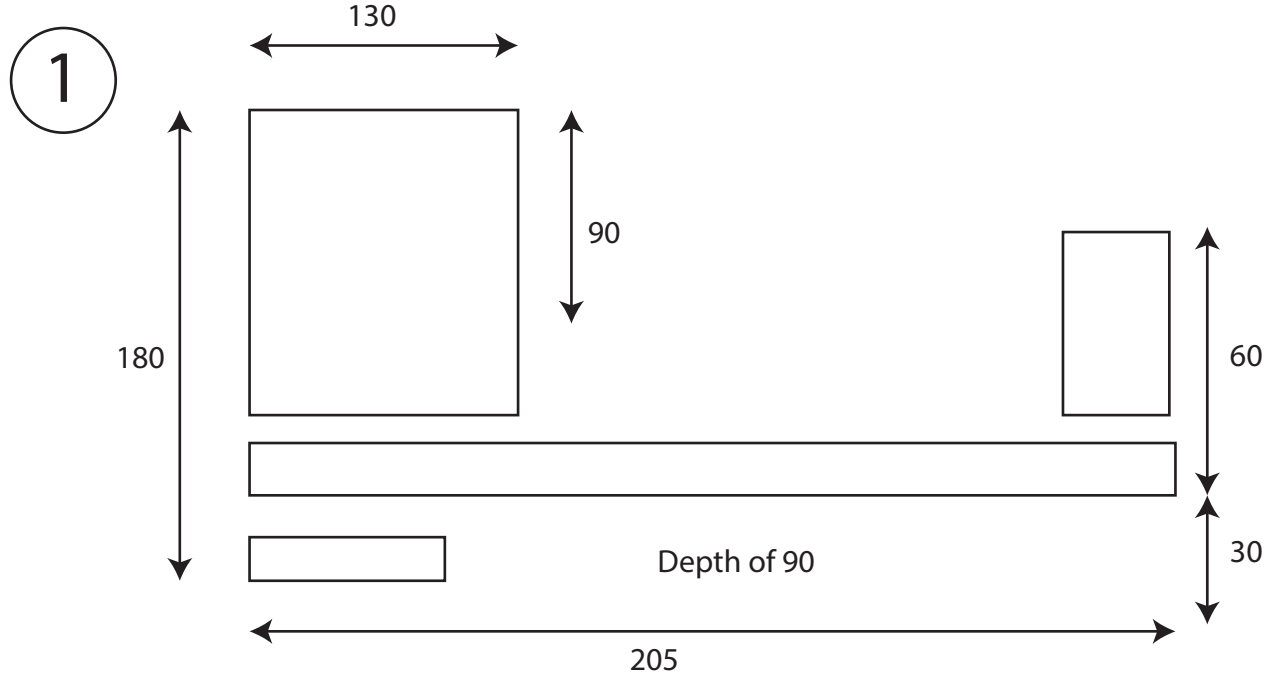
A man with a beard and tattoos, wearing a 'SPARTAN' cap and a backpack, looking thoughtful. The background is a blurred outdoor setting.

Product experience vision

The product should feel like your outdoor sports buddy that can handle everything, therefore intriguing. You really want to know how he 'feels' and how he can handle all that

Confident - Robust- Intriguing

APPENDIX 6 - DESIGN LIMITATIONS



In the future design modules 1 to 3 with the dimensions as seen in the drawings below should be placed.

The first drawing is the mechanism that scans the sample.

The second module is the microcomputer Nano Jetson

The third module is a custom PCB

Next to that the size of the screen plays an important role. The field of view of the optical system is a set size. When decreasing the size of the screen, the size of the cells on the captured image will decrease, making it more difficult to distinguish between the different objects in the image.

On the other side, increasing the size of the screen would result in more expenses and a bigger device.

The screen size on which it is clear enough what is seen on the picture is the screen size we should implement, whereas this is the most important function. To determine this screen size five employees of AiDx Medical are confronted with three (20, 25 and 30 cm in width) printed out 'screens' with the interface of the AiDx assist. The participants were asked which of these screens presented to them had just enough detail to recognize the difference between the objects on the image.

APPENDIX 7 - Interviews

In this appendix, several interviews are reported. Some of the conversations. The information in these interviews is supplemented by Whatsapp conversations I had during my whole project.

1. Nigerian recycling & production company
2. Community healthworker student
3. MLS Iyiola
4. Brice Interaction
5. Brice Concepts
6. Animashaun Introduction
7. Animashaun style

Victor Boyle recycling company Justin Egwudo

10-2-2022

What recycled plastic is available?

PET, HDPE, LDPE. They collect from households and businesses directly.

They also make PP and PS plates of 3, 5 and 20 mm thickness

What are the costs of these plastics?

25 cents per KG approximately Recycled plastic is cheaper than virgin plastic

What facilities are available around them?

Injection molding and thermoforming

Do you know a company that does recycled Aluminum?

They collect and recycle Aluminum cans themselves, however they do not manufacture with Aluminum.

Contact: justin.ek@givo.africa

Goal

The goal of his session is to come up with ideas to tackle certain design challenges together. And I am especially interested in how you would tackle certain issues if these are presented to you.

First questions

Tell me about your background (done via text message in whatsapp group after introducing myself)

Good day 🙏❤️

I'm Student 1, Am also glad meeting you. Am Community Health Practitioner in training and final year student, I use my spare time to watch football 🏈. My opinion about AiDx machine is that I think you should make it smaller than before so that it's will be easy to carry along and you can also make it in solar system form in case there is no electricity so it's can be charged by sun processed..

Good day sir, My name is Student 2. Its nice meeting you, Am Community Health Practitioner in training, and its my final year session. I use my spare time to Read and written story. My opinion about AiDx machine is that you can make it more easier to operate and we can use phone to operate the process not only laptop. And make it smaller not so big like usual. Motivation: I saw a community health worker. I only saw doctors and nurses. This looked reachable for me when I want to help in the community.

Hi 🙌

My name is Student 3, a student of Oyo state college of health science and technology studying diploma in community health In

my spare time I am mostly on my phone watching movies or reading comics

Good evening everyone, my name is Student 4, I am a final year student in the department of community health, Oyo state College of Health science and Technology, Eleyele, Ibadan. In my spare time i watch movie and also reading of books

Aidx is a good machine and it operates well, but I will suggest that manual/hand book should be provided for those that will be making use of it, so that it can serve as a guide for them.

Good evening everyone

I'm Student 5, a final year student of Oyo state college of health science and technology and studying diploma in community health. In my spare time, I listen to music and reading of books.

Aidx is very good but my suggestion is you should make it more portable for it to be easier to carry... Make it a machine everyone will be able to operate.

Good day

I'm Student 6, Am also glad meeting you. Am community health practitioner in training and final year student, I use my spare time to visit music house, My opinion about AiDx machine is that I think you should minimize the size of the machine for easy access and also it should come with inbuilt manual or guides that can be easily accessed by the user also the machine should come in with trade protection. Motivation: I grew up in a village without a health facility. Had to travel a few miles. Wants to save life and rescue her community. Previously she went to some health workers and learned some things. I did that for 3 years. Then she was admitted to school

Interview general:

How often do you use automated microscopes?

We sometimes use it, but these are not devices like the AiDx machine. These machines are big ones based in laboratories and not portable to remote villages

When you are using this or a likewise microscope, did you encounter any challenges?

This AiDx is easy to operate compared to similar microscopes. In other microscopes you need to zoom yourself and find the right position on the glass slide.

Is there anything you wish you could do with the AiDx Assist which is currently not possible?

Reduce the size for easy transport. Also make sure that it can be used without relying on the power grid. You can think about a power supply like an accu or do it via solar. You can use solar through the window, or include two battery packs for separate charging outside.

Interview regarding journey map

Why does the device feel fragile?

Too big for its weight. Color is good, white gets dirty too fast, so make it not entirely white.

What should the interaction of the on-off button be? Where should it be placed?

You connect it and then turn it on. Some people did not know that button was on the back. Front is better. buttons are most of the time bright colored with a contrast color of black.

Why and how should there be a guideline when inserting the slide?

Guide in the pack in the form of a manual. Do not use medical language, but just easy language for the manual. Indication on how to put in the slide. When the device is turned on, the machine should indicate that the device is ready. Also please design an indication that the slide is received correctly, and a warning when this is not done.

In what way does the scanning sound contribute to the experience of operating the device?

Sound was perfectly oke. Sound is not annoying. Sound is bit loud. but I prefer it like that. We multitask. Then we are able to hear that it is working through the sound. Also we like to have a light on the device which indicates if it is running or finished from a distance. This can be a green or a red light.

What techniques makes you feel like an amateur?

Currently the machine does not look like it is able to withstand the rain. People should see that it can not be easily damaged by the rain. Like using an Iphone. Iphone comes waterproof, so the water does not affect the functionality much.

How big should the screen be and how should it be included in the device?

As small as possible. maybe it should be able to beam to your phone. When the slide is inserted you have the whole program on your phone. Everyone knows how to use a phone, but not how to use a screen or a monitor.

Ideating together:

Portability

Would you want to carry it around?

How would you like to carry this device around?

Would you prefer a strap, handle? a suitcase?

I would put it in a backpack if the device is made smaller. Right now it is too difficult. The shape is alright. Take into account back pain, so make it not too heavy. I prefer a handle. The handle should be on the side, because I think the robustness will be better that way.



The handle as present in this image is preferred, because it is obviously present.

Robustness

How can you improve the robustness?

Try making it from metal or superior plastic. Rubber is better. Because it does not add a lot of weight. You can also think about making the bottom from metal. The suitcase to the right was chosen to be the most robust. This was due to the black color and the compact dense shape.



Screen

How to incorporate a screen in the housing?

The screen should be on the front, because other people will be standing around it. In such a scenario, you want to be the 'boss'

of the machine and see what is going on yourself. That is possible when you put the screen on the front. Therefore the screen on the front like is done in the device on the right would be preferable.

Should it be stuck on the device or should you be able to loosen it?

The screen should be able to be taken off the device to carry it around separately. That way it is easy to replace, repair and store it in such a way that it does not damage



How to make sure the screen is not damaged?

Easily attached screen. It can easily be broken, therefore make it next to the device and when you finish using it, you pack it separately in a box.

Professional look

What did you think of the look of the device?

The color is alright. Everything about the shape is excellent

The device on the right is not liked because it does not look balanced.

The device below was how they would imagine the device to look. It touched their imagination. This mainly came because this looked like a small, easily portable medical product to them. The medicality was induced by the rounded edges Also the details are blue, making the device belong in their experience of medical devices.



Ismaila Olaosun

Microscopist

17-2-2022

Introduce yourself?

Medical laboratorist. Parasitology. Teaching parasitology and examiner for 6 years.

What motivates you to do this job?

I was a science student and I liked evidence based thinking. When doing this study, I saw someone working as a parasitologist, I got interested and pursued this career. I like the science part of it, but also the help you can give people when you diagnose them and give them the right treatment.

What were your first thoughts when you saw the AiDx NTDx?

Was excited because this device complements the microscopy work we are doing right now. we will have quicker results with this device. It was very simple and easy to use compared to other microscopes. That is because the process is simple to understand and there are not many different interfaces and steps where you can end up on accident.

Would you be able to set up the whole system yourself (connect keyboard, mouse, monitor)?

quite easy.

Who are future users? How are they schooled?

Should know how to use computers. The primary healthcare workers here understood the device easily within the hour.

What other microscopes or devices do you use? What do you think of their appearance?

A binocular microscope - Microscope is robust and compact.

Did the AiDx assist come across as a microscope?

Yes, however you should work on the size. It should be more portable. weight is good.

What do you think about adding a touch screen instead of mouse monitor and keyboard?

I think that that would be very valuable! We clean the outside of the device with soft tissue paper. The lenses are cleaned by using lens tissue. During use, it is important to be able to clean the lenses.

Do you think a backpack around the machine in which you can store the materials you need is a valuable addition?

Yes, that will make is easier to carry around

Which of these microscopes do you think is the most appealing one?

I like number 8 the most because it looks compact. I also like the green accents.

Brice PhD parasitology at Leiden University

3 years of training to be able to distinguish NTD's and malaria. Current expertise is new diagnostic devices benchmarking; evaluating diagnostic devices in the local context. He is doing this by taking devices to tropical countries like Nigeria and Gabon.

Journey map

So the assignment we get is: go to village x and scan as many people as possible. This results sometimes in five, sometimes in 50 scans a day. It depends on the willingness of people to participate in the scanning. Due to reluctance against medical innovations sometimes they do not want to. Also they have the right to know the results of their test and that was promised by previous groups of medical staff, but they never come back to tell them the results. As a result, people do not trust the medical staff anymore, resulting in less willingness to participate. When being able to scan the samples locally by AiDx the people will get their result directly, eliminating this factor. When people get their result, you just present them with a paper on which you state that they are infected or not. They do not understand the pictures of the cell. Therefore you do not want other people to see what is visible on the screen.

The first thing I would experience when I get the assignment and the equipment is the attractiveness by the looks of it. I do not care if it works or not, just that it looks professional.

Currently it looks a little professional and robust throughout the material and the color of the box. The white color is nice, but the black is not the way to go. Please include some 'blueish' tints instead of the black. And only for the details. I am not impressed by the looks of it. And that is what I want to be. I want to be impressed

by the looks of it. When I take it up, it feels not robust anymore because it feels like a lot of empty space inside. The box is too big for its weight.

Secondly I search where I can turn it on. If I do not see that immediately I get frustrated already. Questions that I ask myself when I see the device is: how does it work? Where to turn it on? How do I get the results?

Currently when going to the field, we always get by bus or by car. We put all our equipment in a big cardboard box and put it on a chair because that is shock absorbing. Then depending on the end location, we arrived with the car, or traveled further by foot, carrying the cardboard box in the hand or head. In this cardboard box we do not have any padding or antishock. If a device looks robust, just put it in the box and we suppose that it will survive.

A bag to put in the device would be nice, however this should not be a handheld bag. This is because then we can carry less by our hands; the other equipment should come with us too. Also this bag should not be big with shock absorbing pads increasing the size. Then the total box we need to carry with us will be increased. We had that once, a bag for a microscope with a lot of padding that we should hold in our hand. We were reluctant to bring it with us. If the bag is on the back with room for accessories it would be perfect.

There should also be a handle on the device but it should not stick out of the device, because it will be difficult to store it or put it in a bag.

When coming to the area where we are scanning we are helped by the households. They provide a table and chairs for us. We prefer to be set up outside in the shadows because it gives a better person interaction outside (except for when it rains).

A surveying day would consist of traveling from the hotel to the village. You arrive at 11, set up everything, try to get participants for the test and start scanning at 1 pm. At the end of the day around 5; m you pack your stuff and go back to the hotel. Sometimes you repeat this for a few days, sometimes you go on a 'test mission' for a few days.

Outside there is most of the case no powersource. Also in these villages, no power is available. So a powersource included in the device should be perfect. This powersource should be able to support a working day. Preferably 8 hours (charge it when you come back to the hotel). This accu should be replaceable to be able to function in a remote area for a few days. In such a scenario you should bring a few accus with you. However there should be an accu included in the device. An auto accu next to the device results in more different parts to bring with you. The device is right now very light, so there is room in weight to include an accu.

Current interactions:

- Are there other interactions that are missing?
- How would you shape these interactions
- Would a light work well enough?

The device is turned on	The indication light turns on, screen turns on
Device is ready to scan	The indication light indicates that the device is ready to scan and sample holder comes out
Device is scanning	The indication light indicates that the device is scanning
Device has finished scanning	The indication light indicates that the scan is done
The device is turned off	The indication light is turned off

For me the main communication should go via the screen. A light will not be very visible outside in the sun. Also it gives me an extra thing to think about; what did the blinking light mean? And then I have to check the manual. When I press the power button, I like to see some light around that, because then I know that I have turned it on.

Action	Interaction
--------	-------------

Perform creative session

Robustness

The box on the right is the best option I think, because it looks dense. I think that the insides of this thing will be robust enough. I do not know why, but this box looks robust to me



Screen

The screen should be visible from the front, because other people should not be able to see the screen. As a medical officer you want to be in charge. The screen could be of phone size, however you should test this. Preferably make it a little bigger. You can also position the screen on the side and make it openable like a camera. Do not make a separate screen module, because it will be stolen, get lost etc. People on the field will just take it with them if you do not pay close attention. Therefore make it fixed to the device. Also make sure that a second screen can be connected to make it easier to use for larger groups. Or still use it when the screen is broken.



The image on the right is a nice positioning of the screen. however the screen is not protected. That is a must in the use scenario. You can put a cover over the screen, or make sure that the screen is on the inside.

Professional look (already addressed)

Portability (already addressed)

Interview Brice

31-3-2022

What do you think about these concepts?

Toolbox

I like that I can get an extra cable if the cables do not work and then connect it and make it work again. A stand of behind the screen works well I think to place the screen somewhere.

The way the sample opening is covered all the time in this design is nice. Because the machine will stand there for hours. It should be closed also if the machine is working.

The handle is not universal. It will not fit people with bigger hands.

Camscreen

I am concerned about the robustness of the mechanism. It looks like sophisticated technology and also fragile. If people are going to use this, they need to read the manual. But ideally you should have a device that you know how to use without a manual. I mean: what happens if someone rotates the screen clockwise instead of anti clockwise. Are the wires breaking? Also people will be worrying about using the device in a wrong way. Of course you can include design cues, but it is not intuitive.

Through this complex mechanism the repairability is very low. People can not easily get special spare parts.

The cord holding the silicone cap for the sample opening is vulnerable to wear, so I would not implement this

This design looks fancy through the curve at the top. It is not a rectangular box as the others. This one is the most aesthetically pleasing. Big black edges of the Toolbox are not nice. A mixture with white, blue and gray is more attractive.

Coverup

Also with the cover of the screen while transportation, the sample opening should be covered. The device will stand in dust for hours, making it possible for dust to come inside.

When you make sure that people understand that they have to open the screen at the front of the device, it will be obvious which step to take next. All the interaction will find place at the front of the device.

Regarding the buttons, use conventional buttons. The power button should be a red button, operating switch with zero and one. This is very informative. The least technical people know how to use such a switch. A round button that you have to press is conventional here because we are used to computers. However, people in LMIC have never seen a computer. They do not know how to use such a button. Therefore I prefer an old fashioned red on off switch.

What do you think about the placing of the screen in the prototype?

Previously I have been working with a device that had a flat screen on the top of the device. People were complaining about neck pain while working with that machine. So a device with a screen as can be seen on the prototype picture would be good.

How waterproof should the housing be?

In a rural village, there might be no inside. You may have no shelter. We stop working when it starts to rain because we can not stain slides anymore then. But we can be surprised on the way back suddenly by a storm. The backpack should be waterproof. But when it is not, we will end up with a soaked backpack. How does the backpack survive and how long does a device last in a soaked backpack?

Should the screen be adjustable?

In the field, in a remote area, we will be working on a table. Most often we use the device standing in these cases. People might not have chairs. When working in a village with more luxury we can find chairs. Then we will be working mostly while sitting. Therefore the screen should be adjustable. It should be easy to work with while sitting, but also while standing.

What do you think about the devices in this selection (encountered collage)?

- Top left: Has a good screen, good orientation of the screen under an angle.
- Middle left: beautiful mixture of blue/sky blue - white
- Middle bottom: Buttons are not clear.
- left bottom: Color blue not attractive. It is too much in your face
- Mostly white not good: We are used to a mixture as microscopists.

What do you think about the devices in this selection (envisioned collage)?

- Blue is a diagnostic color. Green not.
- Touchable surfaces not clear white, because of dirt
- Gray better than black
- Design stands/ rubber foots for stability and vibrations. When going back from a village we sometimes use the device in the back of a bus during traveling. Then the device should be standing very stable.

Animashaun Microscopist

11-2022

Introduce yourself

olawale Animasaun. Lautech University: Advanced degree medical sciences. Masters degree in global health. PHD molecular biology.

How did you perceive the interaction with the AiDx assist?

Easy to use. less than 20 minutes to learn it.

Would you be able to set up the whole system yourself?

People should be schooled on how to use computers. Then I think they know it.

Would other future users be able to do that as well?

Senior scientist to health workers are going to use it. I think that anyone with basic education is able to use the device

Who are future users? How are they schooled?

At least they have basic education and should know how to use computers

What other microscopes or devices do you use? What do you think of their appearance? **He will share pictures.**

Did the AiDx assist come across as a microscope?

In the optical world white and blue are used mostly. Devices are usually white. White appeals to the eyes. The details can be done with blue and black. Blue is better

Where will it be used?

It will be used in very different scenarios. It can be in a laboratory or it can be in a remote village.

What improvements in handling the device can be made?

Moving it to the center was difficult

The device could be smaller in order to be more portable

By the sound you know that the device is working, so keep the sound.

What do you think about adding a touch screen instead of mouse monitor and keyboard?

I think this will give the device a huge advantage in portability.

However the screen size will become smaller this way. I think that anything in between laptop size screen and a notepad is good.

What kind of equipment should be taken with you when going to a remote village in order to use the machine?

Glass slide compartment, microscopic oil

Do you think a backpack around the machine in which you can store the materials you need is a valuable addition?

Yes I think it is nice to have. However the handle on the device itself should not be omitted. Like that it is easy to carry around in the room. However for transportation, it would be nice if we could deliver a backpack for the microscope.

Which of these microscopes did you think is the most appealing one?

Number four is nice because it has one compartment. Three is also nice. Four is cute, whereas three is like a monster. I like the cuteness of four better. Also the color of four is better. Number two is also beautiful.

Animashaun II style interview

Animashaun has experience with microscopy both in villages and hospital labs. He is working from the government side.

Concepts

What do you think about the concepts?

I like that the toolbox concept is quite revolutionair. Also it is easy to take it to the field by the handle. The screen should be covered with transparent Nylon to prevent the screen from direct touch. That way the screen can not get scratched easily and not get dirty by touching it with the hand. I do not have preference for one of the concepts, but I like the handle of the toolbox. Also I like to get an integrated device. Therefore the loose screen as the Toolbox has is not the best solution.

Appearance

What colors do you like?

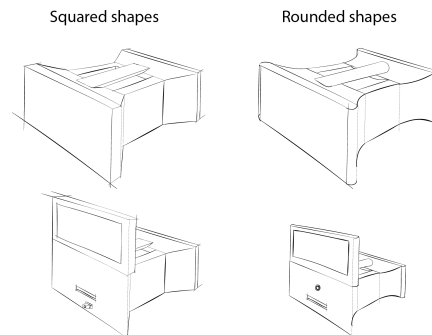
I like white, blue and gray. Blue is the color of a hospital

What material do you like?

This depends on the function. If the device has a lot of functions that are vulnerable, I like the more rugged design. But the more clean white rubber design has a more medical look.

What form language do you like?

I like the rounded edges more because it has a more medical



look. But the form language is not as important as the compactness. If you can make the device more compact by adopting a certain form language, just do it.

Other questions

What kind of on/off button should I use?

A button on a CPU like the round one where you should press in and out to turn on and off the device is nice. However both will be alright. It is important to have a small button. The rounded one is more modern. The switch one is old. The people will understand the round button and you better implement that button, because we are developing modern equipment.



FILN



Do you have experience with trust issues?

It has multiple reasons

- We fight Quakerish microscopy. They have no license to do it. They do not know how certain parasites look like and they will mistreat you.
- Tired people
- A good Giemsa stain can not be made by anyone.
- Sometimes people do not believe the results because they do not feel anything.

Is there a standardized way of showing the results to someone on paper in 1) a remote village 2) in a laboratory

- We give the results back by paper and also we consult them on how to proceed with medication. We are trained in how to do this.
- The results are really easy to understand on paper

- They may choose not to treat, but that is their right. They sometimes say I am healthy, I do not need treatment. but this does not happen frequently
- Especially when you work for a renowned organization. They believe you because they know that you are a professional

APPENDIX 8 - CARDBOARD PROTOTYPING

Introduction

In this section my experimenting and prototyping using cardboard is documented. This phase is done before choosing and iterating the three concepts.

I have been experimenting with the possible positioning of the screen on or next to the device. This is done for screen sizes of 7, 8, 9 and 10 inch. This range is chosen because from my creative session (appendix x) with the students it appeared that they thought a phone size (big phone is almost 7 inch) would be suitable. The upper boundary of 10 inch is chosen because that is the size that would fit the size of the device if the total side surface is used. The 7 inch screen could be positioned anywhere, so I experimented only with the positions for the seven inch screen where the other screens do not fit.

This experimenting is done on a cardboard box I made with the minimal dimensions that the device should have because of its inner components and arrangements. These dimensions are 230x180x12mm.

Also a promising 'screen protecting solution' by using the shape of the device was experimented with.

After this experimenting with the positioning of the screen, I also experimented with several options of closing of the sample insertion opening when traveling to prevent dust from coming in. Lastly, options to create a bigger opening for cleaning purposes of the lenses were tested.

Cardboard prototyping

7 inch screen possibilities

The 7 inch screen can be placed in a lot of different ways. Here the positions that are only suitable for the 7 inch screen is shown.

In figure 1 the basic position can be seen. The hinge around which the screen rotates is positioned in the middle of the device (figure 2).

Advantages:

Protected screen, simple mechanism (one hinge) and easy access to the screen

Disadvantages:

No place for a handle on the top of the device



Figure 1



Figure 2

In figure 3 the basic position can be seen. The hinge around which the screen rotates is positioned on the front (figure 4)

Advantages

Protected screen, simple mechanism (one hinge), place for a handle on top of the device and easy access to the screen

Disadvantages

-



Figure 3



Figure 4

8 inch screen possibilities

Two specially suitable for the 8 inch screen are explained below.

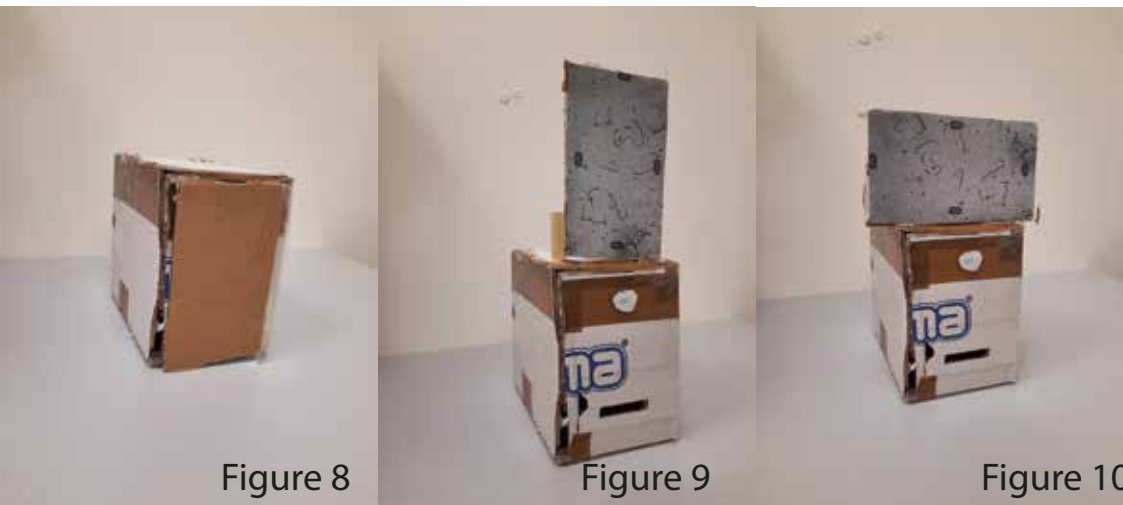
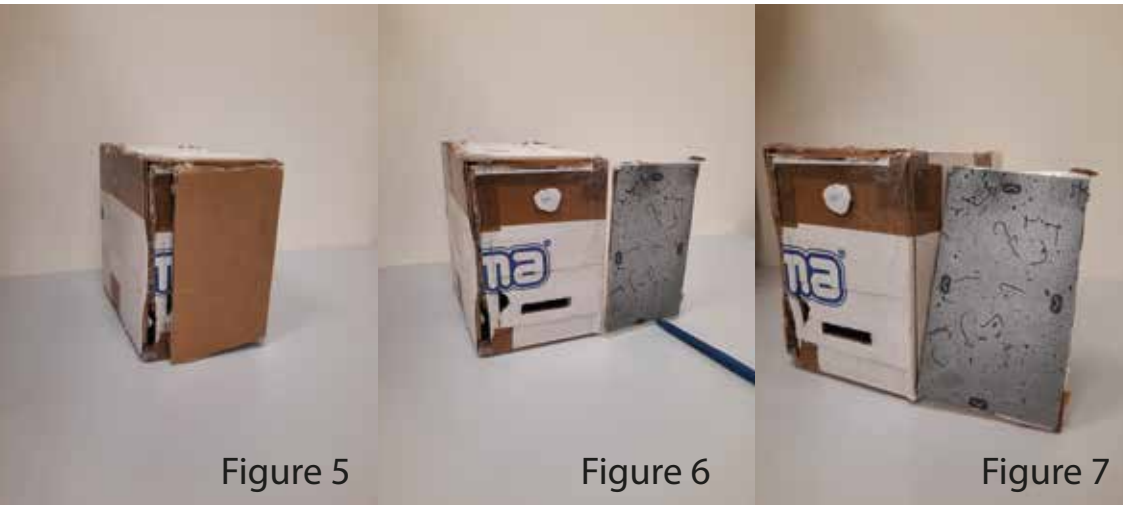
In figure 5 the basic position can be seen. The hinge around which the screen rotates is positioned on the right of the device (figure 6). In figure 7 the screen is rotated around its axis to allow the screen to be turned in such a way that it is easy to use

Advantages:

Protected screen, protects sample insertion from dust during transport

Disadvantages:

Complex mechanism (two 'hinges'), unusual portrait orientation, difficult access to the left part of the screen



In figure 8 the basic position can be seen. The hinge around which the screen rotates is positioned on the front (figure 9). After the screen is opened, the screen can be rotated around its axis (figure 10).

Advantages

Protected screen, protects sample insertion from dust during transport, landscape orientation and easy access to screen.

Disadvantages

Complex mechanism (two 'hinges')



Figure 11



Figure 12



Figure 13

9 inch screen possibility

In figure 11 the basic position can be seen. The hinge around which the screen rotates is positioned on the back of the device (figure 12). At the time the screen is opened, the screen is pushed to the front by means of a spring. In figure 13 the screen is at its end position and is rotated around its axis to allow the screen to be turned in such a way that it is easy to use.

Advantages:
Protected screen

Disadvantages:
Complex mechanism (two 'hinges' and a spring) difficult access to the right part of the screen



Figure 14



Figure 15



Figure 16



Figure 17

9 inch screen possibility

In figure 14 the basic position can be seen. When the screen has to be used, the screen is rotating around its hinge at the front (figure 15). In figure 16, the screen is rotated around its axis to turn the screen towards the 'outside'. After that the screen can be turned in such a way that you get a landscape view of the screen (figure 17).

Advantages:

Protected screen, easy access to the screen

Disadvantages:

Very complicated mechanism, no place for a handle at the top



Figure 18



Figure 19

10 inch screen possibility

In figure 18 the basic position can be seen. The screen is placed in its mount on the side of the device. When the the screen has to be used the screen can be taken out of its mount and positioned next to the device (figure 19). The screen will always be attached to the device by means of wires and an additional cord in order to counter theft and the phenomenon that parts are always disappearing

Advantages:

Protected screen, no mechanism, always good access to the screen

Disadvantages:

Vulnerable cables, prone to theft



Figure 20



Figure 21



Figure 22

Square screen possibility

In figure 20 the basic position can be seen. The screen is attached to the side of the device. When the screen is opened, the screen rotates around a hinge on the top (figure 21). After that, the screen can be tilted until it has a nice position to work with the screen. (figure 22)

Advantages:
Protected screen, good access to screen

Disadvantages:
Complex mechanism



Figure 23



Figure 24



Figure 25

Alternative protecting screen

In figure 23 the basic position is shown. Two diagonal stiff, robust edges are 'wrapped' around the corners of the device. The screen is attached on top of the device, between the 'edges'. If the device is to be used, the screen can be rotated upwards (figure 24) and turned in landscape mode (figure 25)

Advantages:

Protected screen, good access to screen, robust edges, when falling, no impact on screen or hinge of the screen, easy portability through carrying the device on the 'edges'.

Disadvantages:

In this embodiment difficult to implement other functionalities like including an openable part to clean the inner parts.

Drawer tests

To use drawers in the design to create closeable openings in the device was an idea that came up frequently. In this section the use of drawers is researched

In figure 26 the sample insertion opening is closed in order to protect the inside of the machine from dust during transportation. This is done by means of a drawer (figure 27).

Advantages:
Easy mechanism

Disadvantages:
Difficult slide insertion due to the front part of the drawer. It requires space and conductors inside the device

In figure 28 the use of a drawer in order to reach the inner parts for cleaning purposes is discovered. The sample insertion opening was not made in this case on accident but drawn on the image (figure 29).

Advantages
Easy mechanism

Disadvantages
It requires space and conductors inside the device in a place where there is limited space already, it is difficult to reach the inner parts





Figure 30



Figure 31



Figure 32

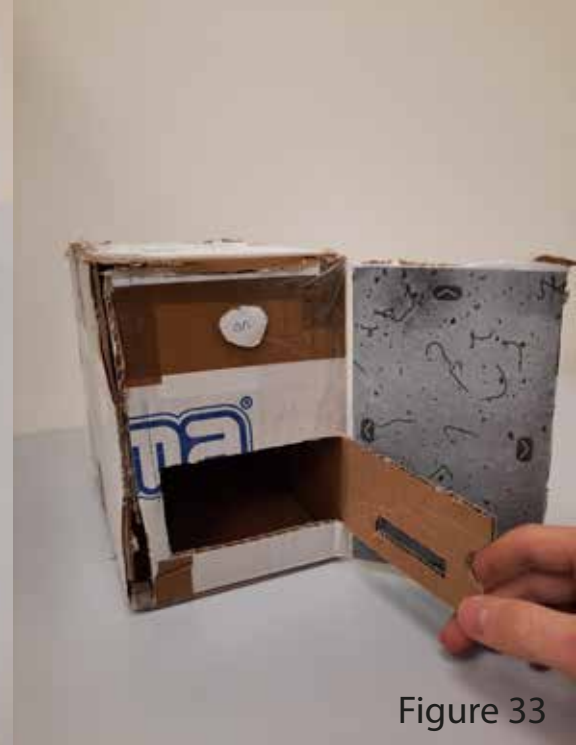


Figure 33

Hinge tests

Using 'doors' in the design to create closeable openings in the device was an idea that came up frequently. In this section the use of these doors or hinges is researched.

In figure 30 a door which opens up to the top (figure 31) is tested in order to discover the use of this mechanism for easy access to clean the inner parts. This test is also done for a door which opens up downwards (figure 32) and to the side (figure 33).

Advantages

Easy mechanism

Disadvantages

Opening upwards: you can not see what you are doing, you have to hold the door with one hand and clean with the other
Opening downwards: high chance of opening automatically
Opening to the side: -

Conclusion & Evaluation

Much can be said about the positioning of the screen. I tried to discover all possible positions, but I am sure that I missed some of them. However doing this helped me a lot in discovering the consequences of placing the screen at certain positions.

Screen positioning

There are broadly three suitable options of implementing the screen I discovered

- Separate from the device, connected through wires
- On front of the device, using a mechanism to position the device for use
- On the side of the device, using a mechanism to position the device for use

I learned that having a separate screen next to the device which can be stored on the side of the device is a very user friendly solution requiring a limited amount of mechanisms.

A screen on front of the device is quite convenient because it covers the sample insertion opening at the same time when it is not in use. However a simple mechanism is needed in order to make the screen intuitive to use. Another advantage of this is that the screen will be positioned at a heightened place. This makes it easier to use the screen because it is closer by the eyes of the user. However when the screen is positioned in such a way, the stability of the device should be looked into.

Lastly there are a lot of different options of positioning the screen on the side of the device. However I experienced that the screen is not easy to use because one side (left or right) will always difficult to reach to because it is attached to the device. Next to that the mechanism for such a positioning of the device tends to become quite complex

Protecting screen by using shape of device

Experimenting with this was a good way of discovering the value of this design. The 'edges' do not only protect the screen, but also the corners of the device itself. Therefore it is a robust solution. However the 'edges' as it is implemented right now limits the possibilities of implementing openings etc. Therefore if to proceed with this, the 'edges' should be made narrower and be removed from the front side of the device.

Closeable openings

Interestingly I discovered that using drawers to make these openings is not a good idea. Drawers make it difficult to reach the parts behind it and they need room inside the device where there is almost no room.

The panels with hinges are a better option for this. Especially a panel opening to the side. Panels opening to the top, will close automatically due to gravity and panels to the bottom will open automatically due to gravity during use. Therefore a panel opening to the side is considered superior.

Also during experimenting I realized that the sample opening only needs protection when the device is not used and transported

APPENDIX 9 - SCREEN SIZE TEST

Objective

Determine the minimum size the screen should have where objects in the image still can be recognized.

Equipment

7, 8, 9 and 10 inch printed 'screens' on which parasites are seen (see appendix 1)

Participants

People with experience with looking at samples through a microscope in order to determine if a sample is infected or not

Method

- Show the participant the four screens (image 1)
- Ask which screen size they prefer in order to determine a infected sample and why
- Ask the participant what the minimal size of screen should be

Results

Software developer: After looking at the enlarged images of the mozaik, microscopists want to see some more details around a specific object. Therefore they need to see a larger area with some detail. So the 7 inch screen is too small. Also for seeing smaller parts than the displayed 'worms' the screen should be bigger than 7 inch. For me, the bigger the screen, the better. However it should be easy to implement. Therefore the 9 inch screen would also do the job.

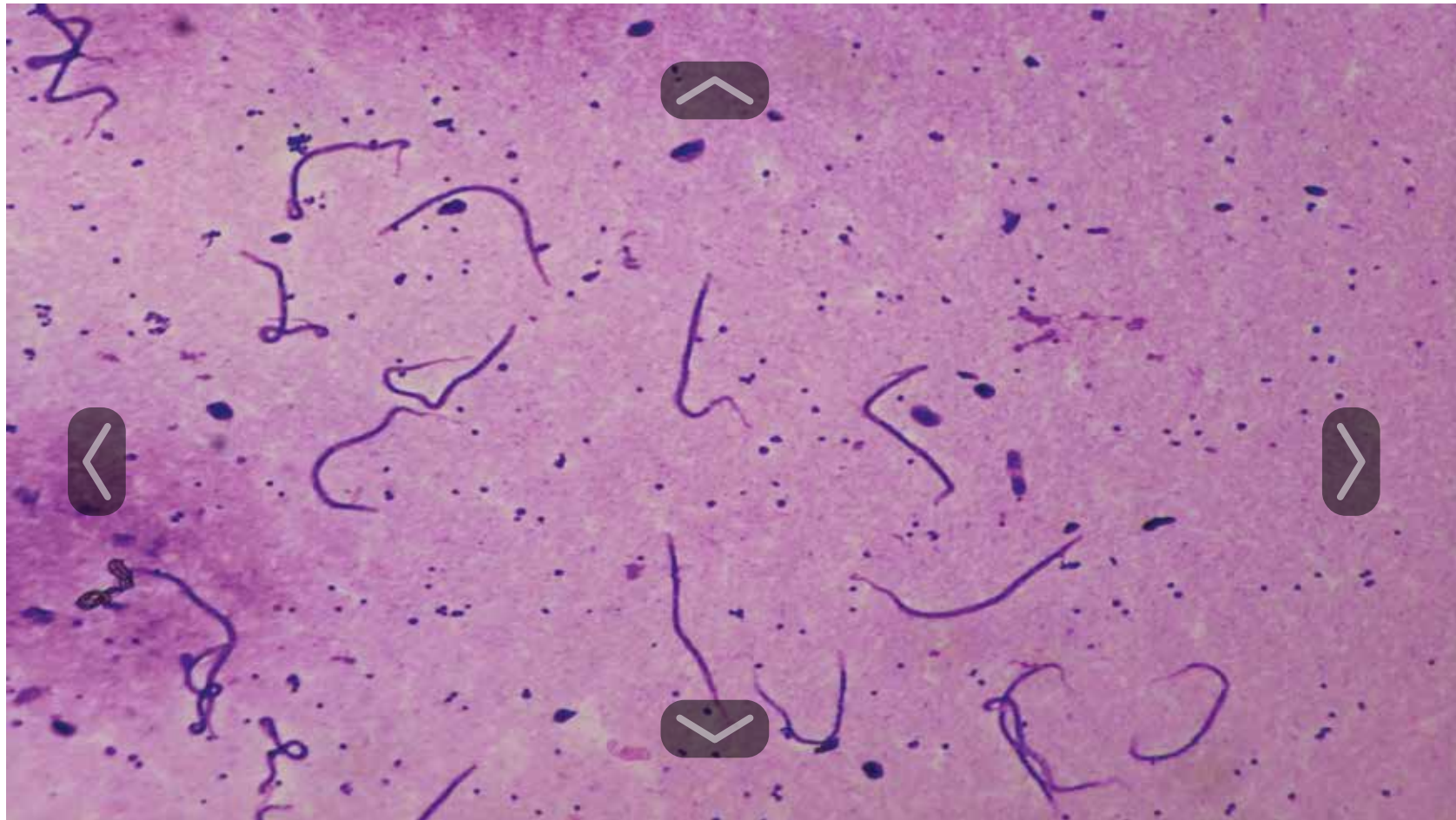
Morrocon Laboratorists:

At the time I wanted to perform the test, Temitope was on a field trip to Morocco for partnering with Moroccan laborotists. I asked him to perform the screen size test in Morocco for me. He printed it out and showed it to two experienced laboratorists with experience on the field. They said that the bigger the screen was, the better. Next to this they said that the 10 inch screen would be good enough.



Image 1: four sizes of screens

Appendix 1



10 inch



7 inch

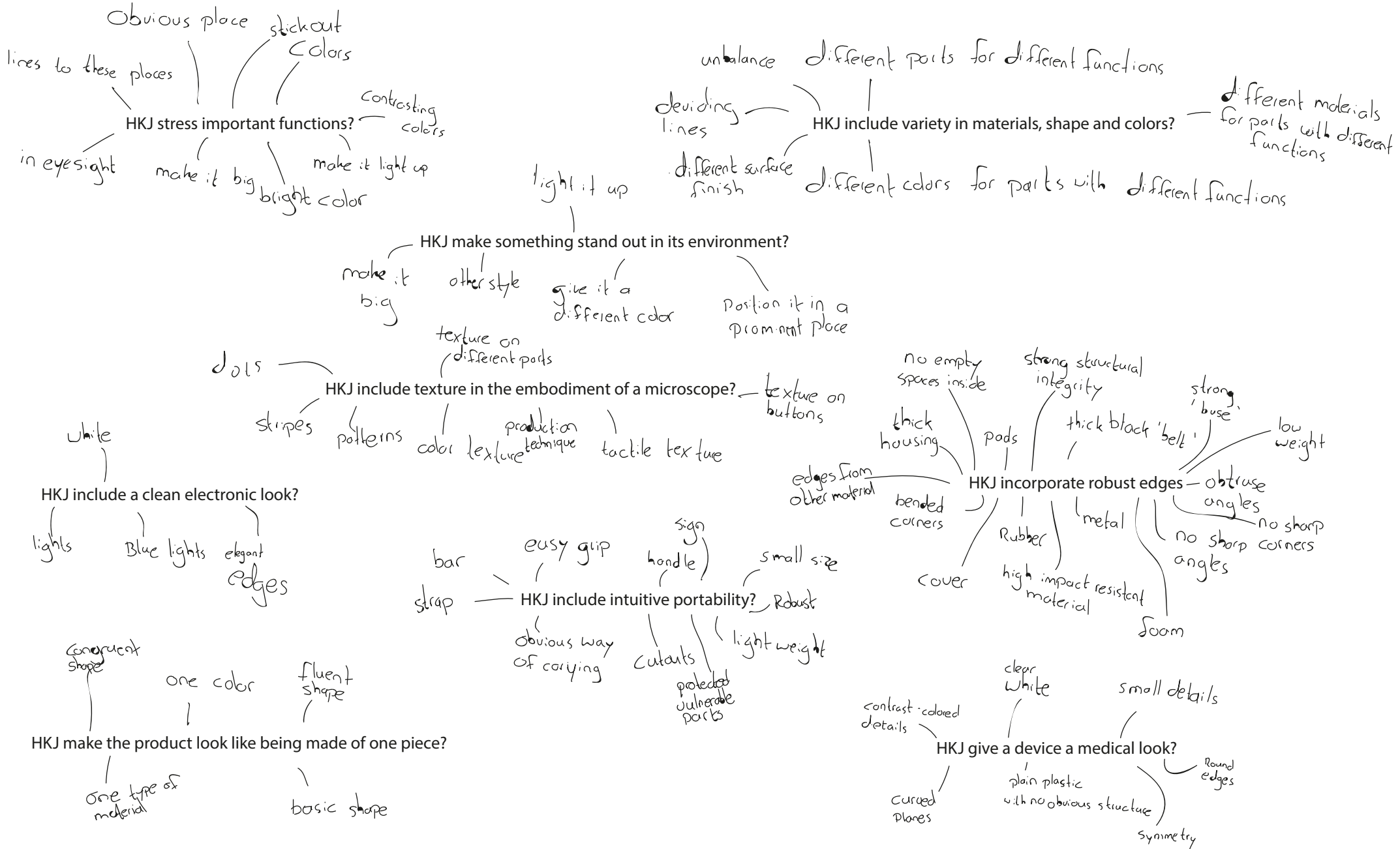


8 inch

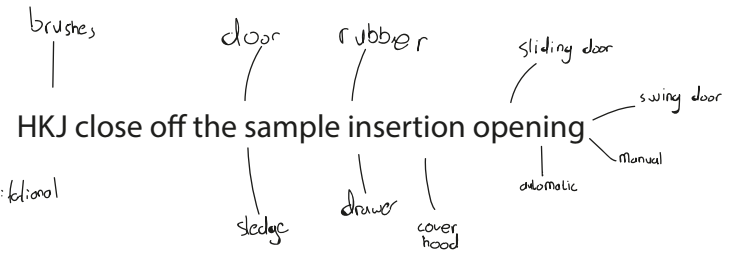
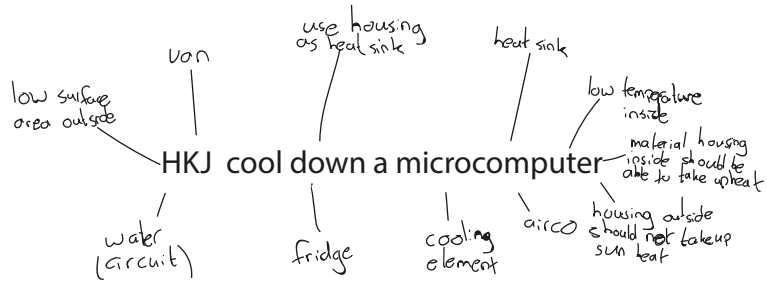


9 inch

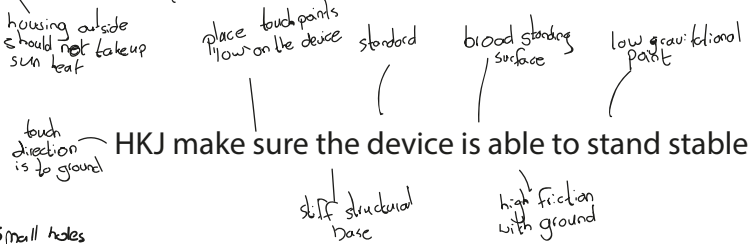
Appearance research HKJ's



Technical HKJ's



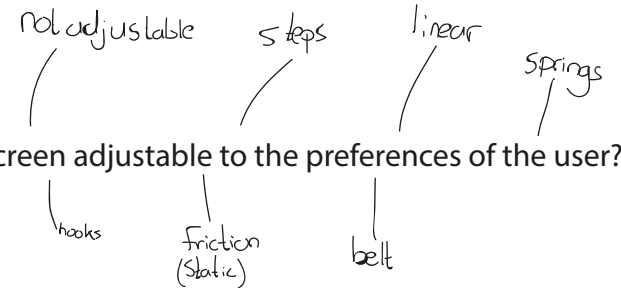
HKJ make sure the device is able to stand stable



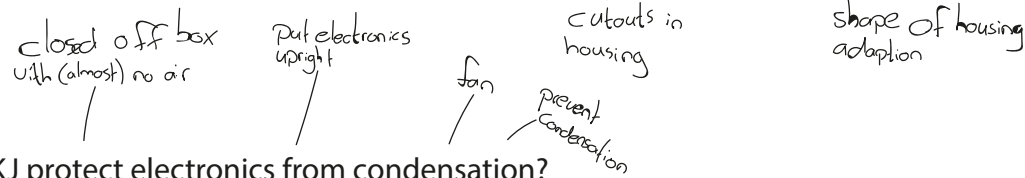
HKJ make the embodiment splash-proof while still have openings?



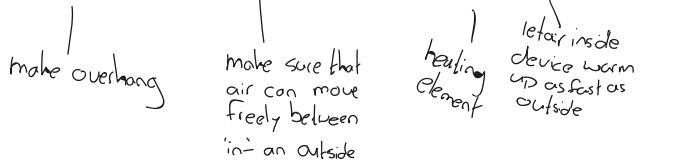
HKJ make the screen adjustable to the preferences of the user?



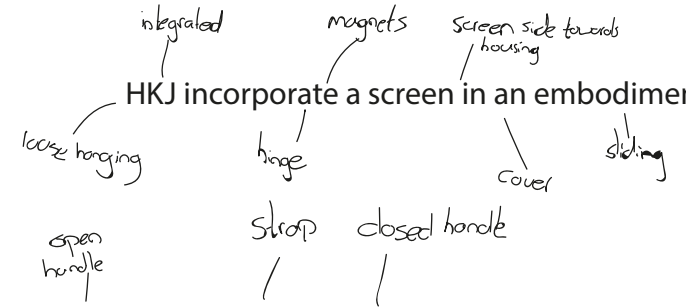
HKJ improve ease of use of the screen?



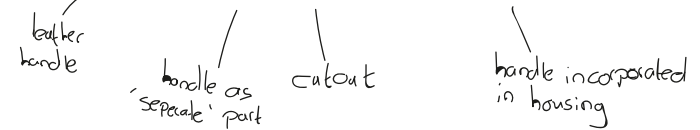
HKJ protect electronics from condensation?



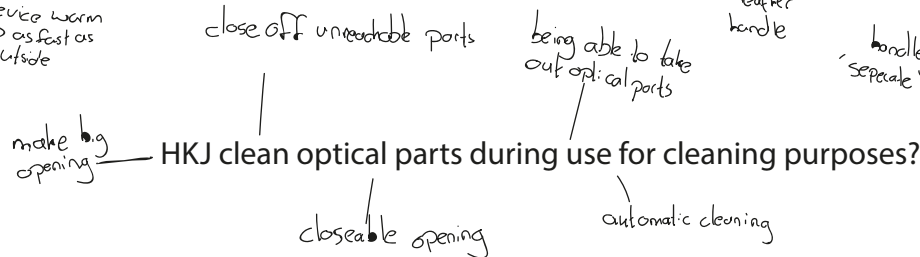
HKJ incorporate a screen in an embodiment?



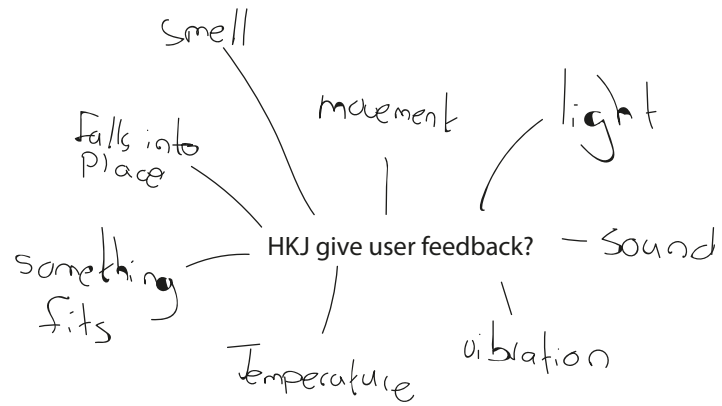
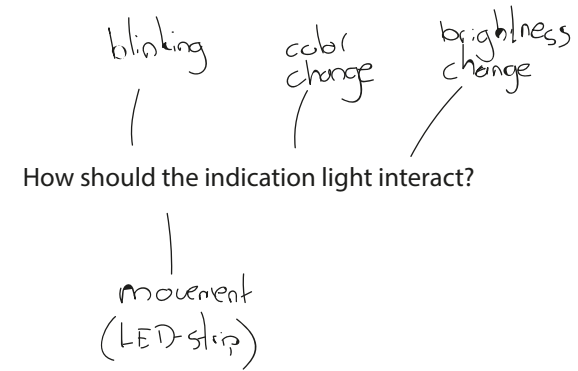
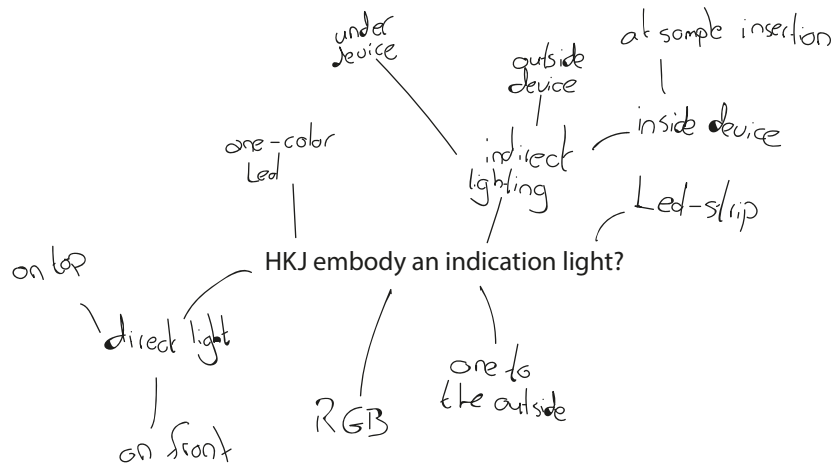
HKJ incorporate a handle in the embodiment



HKJ clean optical parts during use for cleaning purposes?



Interaction HKJ's



HKJ stress important functions?



HKJ include variety in materials, shape and colors?



HKJ make something stand out in its environment?



HKJ include texture in the embodiment of a microscope?



HKJ include a clean electronic look?



HKJ incorporate robust edges



HKJ make the product look like being made of one piece?



HKJ give a device a medical look?



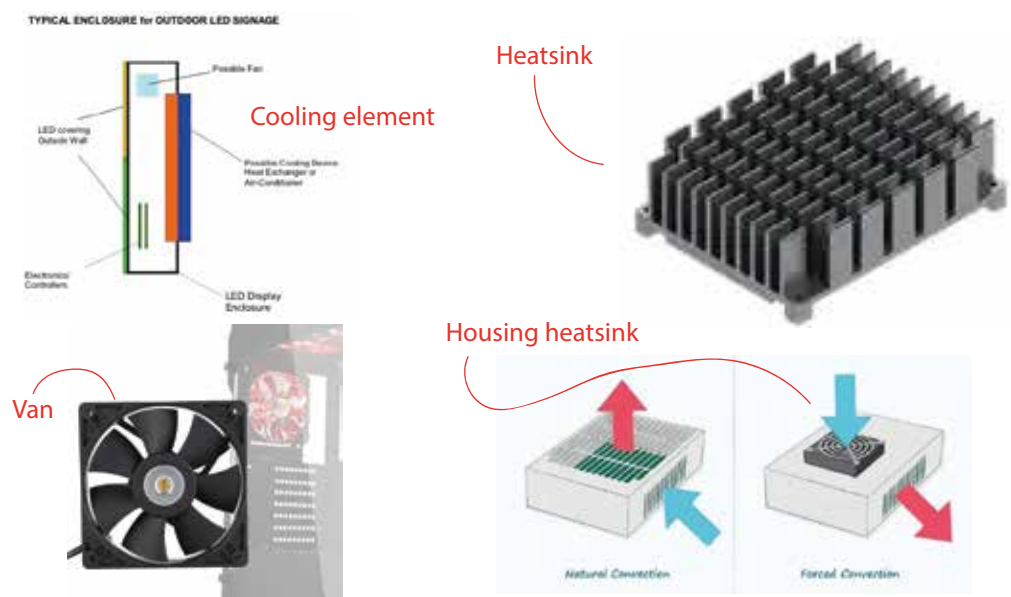
HKJ include intuitive portability?



HKJ close off the sample insertion opening



HKJ cool down a microcomputer



HKJ make sure the device is able to stand stable



HKJ make the embodiment splash-proof and have openings?



HKJ make the screen adjustable to the wishes of the user?



HKJ include improve ease of use of the screen?



HKJ incorporate a screen in an embodiment?



HKJ protect electronics from condensation?



HKJ incorporate a handle in the embodiment




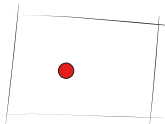
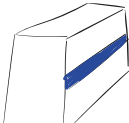
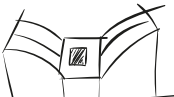

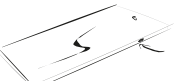

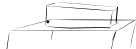



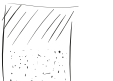










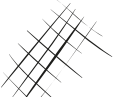
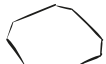


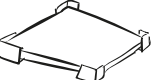


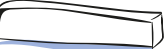




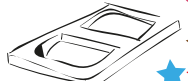


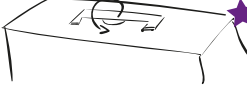






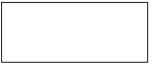



HKJ clean optical parts during use for cleaning purposes?




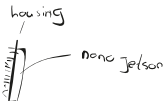









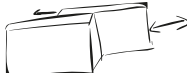



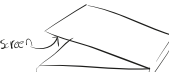

















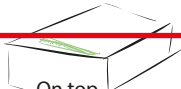




HKJ embody an indication light?



Morphological chart Aesthetics

HKJ stress important functions?	 In eyesight	 Light it	 Contrast in color	 Lines to important part	 Stick out	 Usual place
HKJ make something stand out in its environment?	 Light it	 Make it big	 Unusual style/art	 Remarkable color	 Prominent position	
HKJ include variety in materials, shape and colors?	 Different surface finish	 Different parts	 Unbalance	 (big) pads Deviding lines	 Different materials	 Different colors
HKJ include texture in the embodiment of a microscope?	 Color texture	 Structure texture	 Texture on buttons	 Dots	 Stripes	 Patterns
HKJ incorporate robust edges	 Obtruse angles	 Bumper	 Rubber edges	 (big) pads	 Metal bottom	 Thick superior plastic
HKJ include a clean electronic look?	 (Blue) light	 Elegant edges	 Basic housing color			
HKJ include intuitive portability?	 Bar	 Strap	 Obvious way of carying	 Ergonomic grip	 Handle	 'inside' handle
HKJ make the product look like being made of one piece?	 Fluent shape	 Basic shape	 One color	 One type of material		
HKJ give a device a medical look?	 Symmetry	 Round edges	 Plain (white) plastic	 Contrast-details	 Curved planes	 Blue details

Morphological chart Technical

HKJ cool down a microcomputer? (Not applicable for housing design)	 Heatsink	 Housing as heatsink	 Cooling element	 Fan		
HKJ Make the embodiment splash proof with openings?	 Overhang	 Small holes	 Valve	 Water repellent material	 No open electronics inside	 Raster
HKJ make an adjustable screen?	 Hinge	 Linear	 Friction	 An angle (not adjustable)		
HKJ incorporate a screen in a housing?	 Ergonomic housing	 Screen side towards housing	 Sliding	 Integrated	 Cover over screen	 Separate screen
HKJ close off the sample insertion opening?	 Cover hood	 Door	 Drawer	 Brushes	 Flap	
HKJ protect electronics from condensation? (Not applicable for housing design)	 Electronics upright	 Electronics under overhang	 Closed off box	 Vent		
HKJ clean optical parts during use?	 Take out optical parts	 Close off unreachable parts	 Automatic cleaning	 Closeable opening		
Where KJ embody an indication light? (Single LED or strip)	 Under device	 On top	 Inside device	 At sample insertion	 On the front	 Behind translucent parts

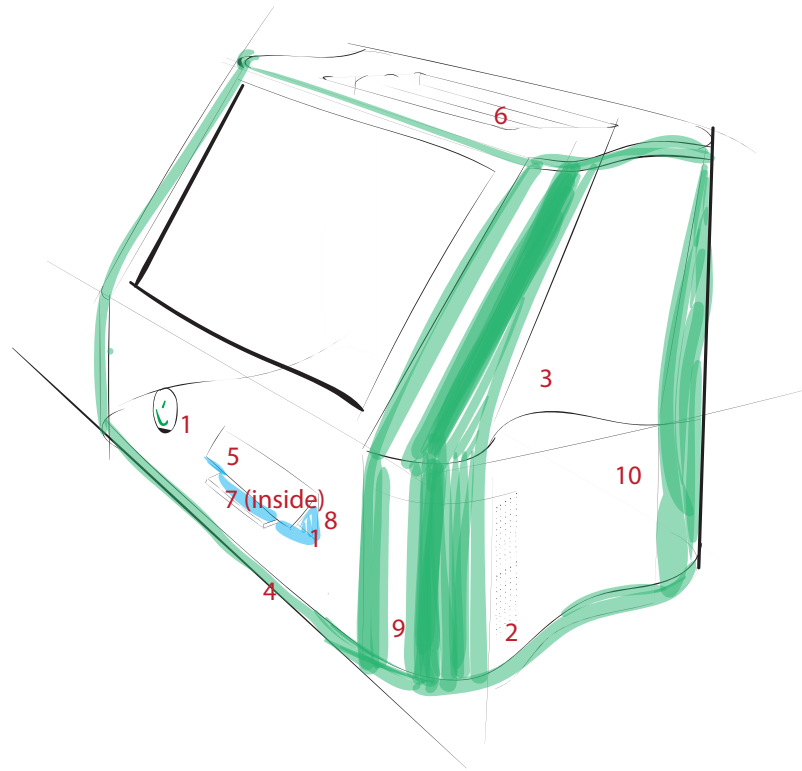


Seperate screen

APPENDIX 11 - 10 IDEA SKETCHES

1 ★

1. Light it
2. Small holes
3. Ergonomic housing
4. Rubber edges
5. Door
6. Handle
7. Close off unreachable parts
8. At sample insertion
9. Round edges
10. Curved planes



Advantages

- Big screen
- 'electronic' look
- Screen same direction as sample insertion

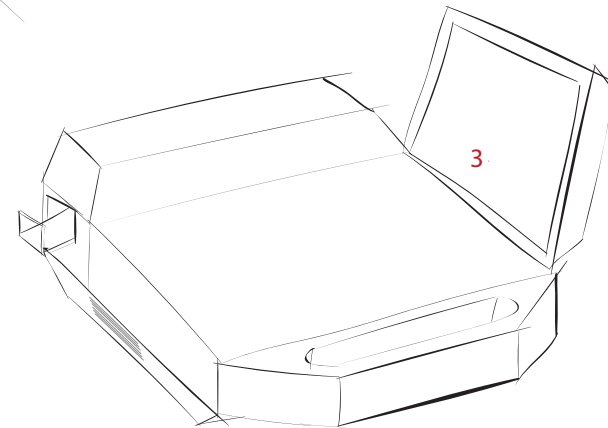
Disadvantages

- The screen is not protected
- The size of the device will be big due to the orientation and size of the screen

2 ★

1. Contrast in color
2. Overhang
3. Screen side towards housing
4. Obtruse angles
5. Drawer
6. Obvious way of carrying
7. Take out optical parts
8. Under device
9. Symmetry

7 (drawer on back)



Advantages

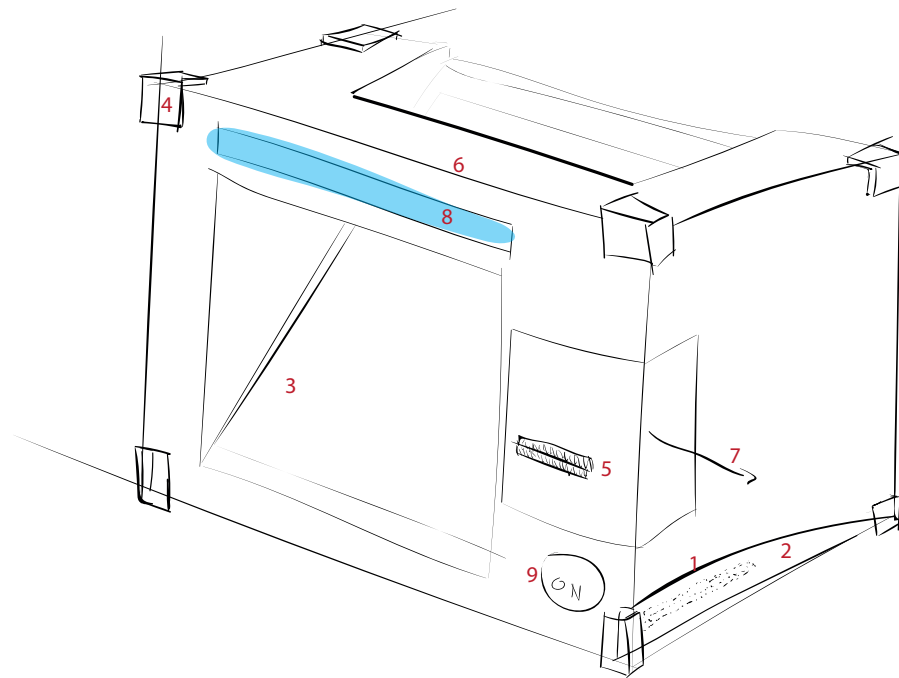
- - Screen same direction as sample insertion
- Protected screen
- Robust look

Disadvantages

- Big size
- Not medical

3 ★

1. Lines to important part
2. Overhang
3. Integrated
4. (big) pads
5. Brushes
6. Bar
7. Closeable opening
8. Behind translucent parts
9. Contrast detail



Advantages

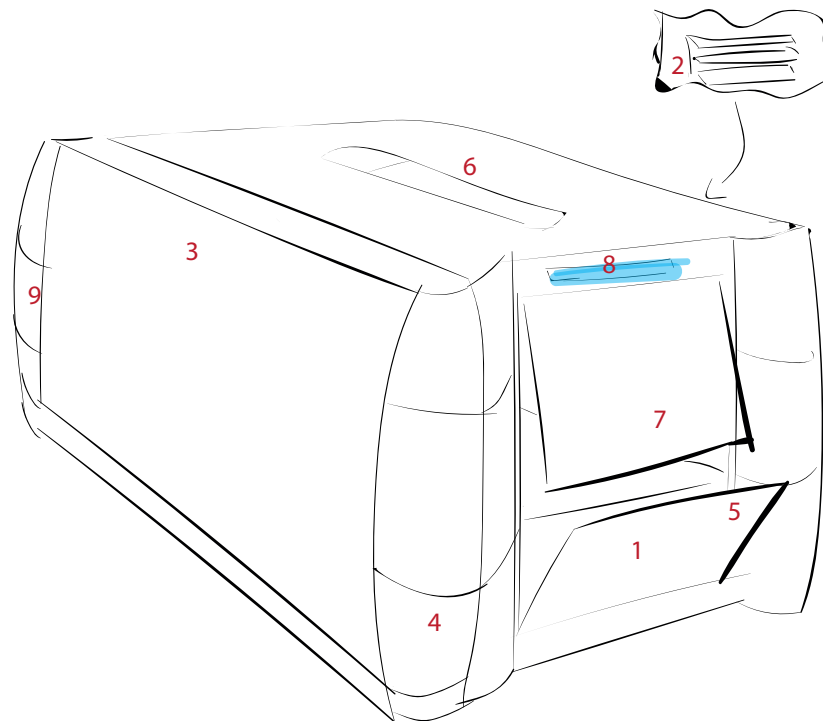
- Big screen
- Robust look
- Screen same direction as sample insertion
- Easy to clean

Disadvantages

- The screen is little protected
- The size of the device will be big due to the orientation and size of the screen
- non medical shape
- non centered handle
- Box design

4 ★

1. In eyesight
2. Small holes
3. Separate screen
4. Bumper
5. Door
6. Obvious way of carrying
7. Closeable opening
8. On the front
9. Curved planes



Advantages

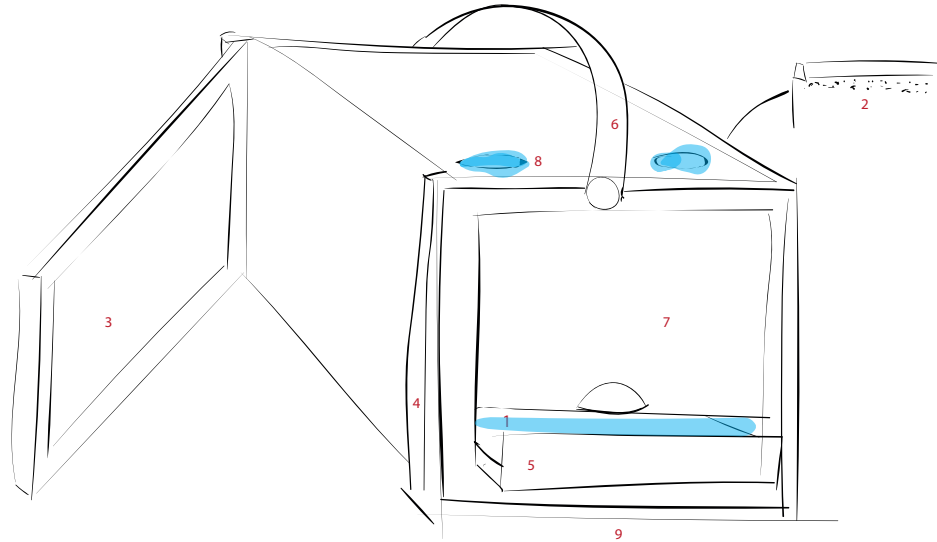
- Protected screen
- Robust look
- Big screen
- Easy to clean

Disadvantages

- Box design
- unbalance due to weight of screen

5 ★

1. Light it
2. Overhang
3. Screen side towards housing
4. Rubber edges
5. Drawer
6. Strap
7. Take out optical parts
8. On top
9. Symmetry

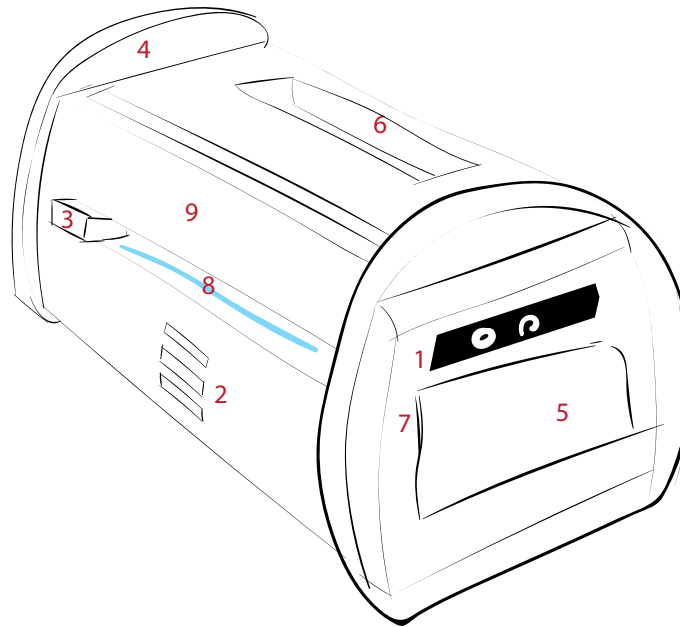


- Advantages
- Big screen
 - Protected screen
 - Easy to clean insides

- Disadvantages
- Strap prone to wear
 - Extra mechanism
 - Box design

6 ★

1. Contrast in color
2. Raster
3. Sliding
4. Bumper
5. Flap
6. Bar
7. Close off unreachable parts
8. Inside device
9. Curved planes

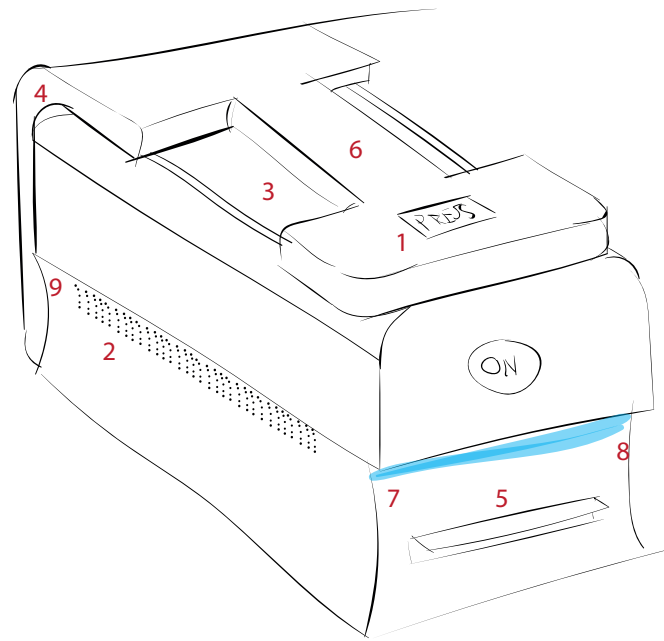


- Advantages
- Robust
 - Protected screen

- Disadvantages
- Increased size due to the screen
 - complex mechanism

7 ★

1. In eyesight
2. Small holes
3. Integrated
4. Rubber edges
5. Door
6. Obvious way of carrying
7. Close off unreachable parts
8. On the front
9. Curved planes

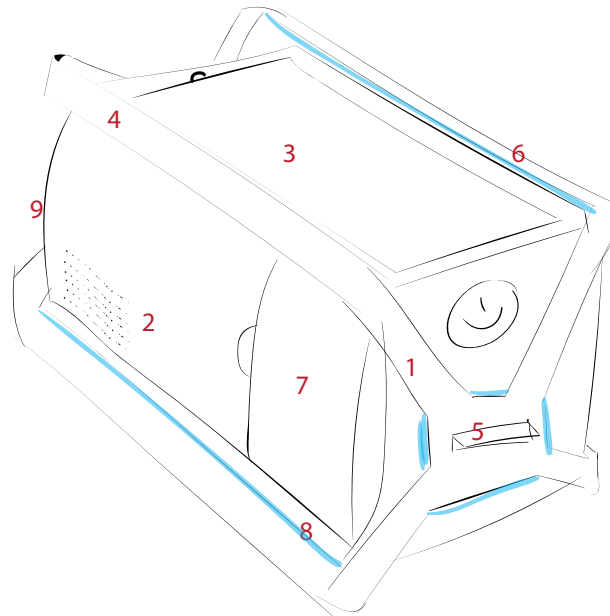


- Advantages
- compact design
 - intriguing design
 - protected screen
 - adjustable screen

- Disadvantages
- small screen

8 ★

1. Lines to important part
2. Small holes
3. Integrated
4. Bumper
5. Door
6. Obvious way of carrying
7. Closeable opening
8. Under device
9. Round edges

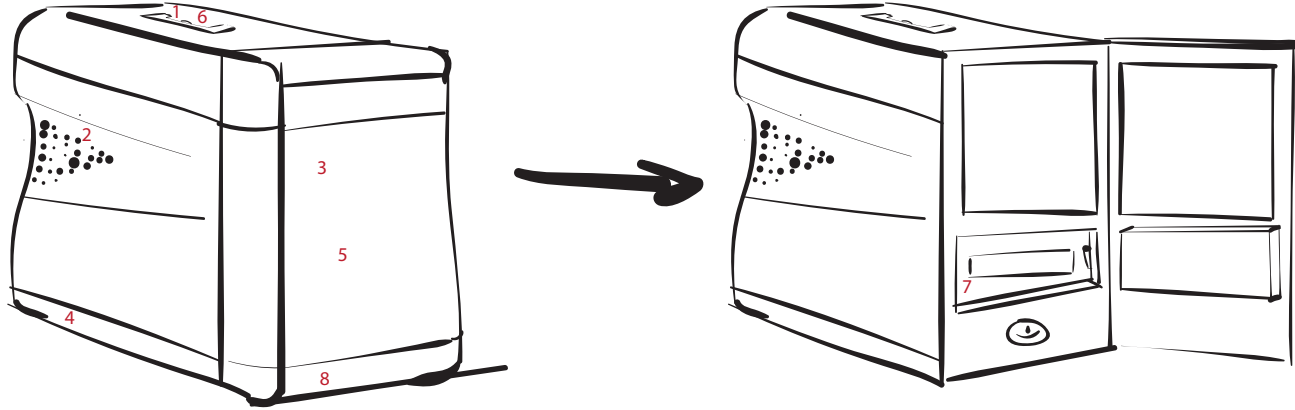


- Advantages
- Robust look
 - Protected screen
 - Compact design
 - adjustable screen

- Disadvantages
- small screen

9 ★

1. In eyesight
2. Overhang
3. Cover over screen
4. Rubber edges
5. Door
6. 'inside' handle
7. Closeable opening
8. Blue details

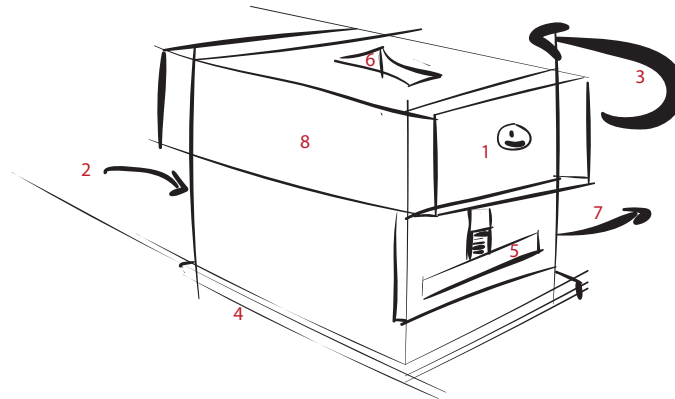


- Advantages
- protected screen
 - protected openings
 - compact design
 - 'electronic' look

- Disadvantages
- small screen or 'two' screens.
 - not adjustable screen

10 ★

1. Stick out
2. Small holes
3. Screen side towards housing
4. Metal bottom
5. Drawer
6. Ergonomic grip
7. Closeable opening
8. Symmetry



- Advantages
- Protected screen
 - compact design

- Disadvantages
- small screen
 - Not medical
 - Heavy design

Conclusions and considerations

In the previous section ten ideas are sketched, after which they are rated on different aspects. Out of these ten ideas, three concepts are chosen. This is done by choosing three ideas which are totally different from each other.

To create concepts the three ideas are combined with several aspects of other ideas. The ideas will be worked out with regard to Aesthetics, interaction, size and materialisation.

The most important selection criteria is the relation of compactness against size of the screen. Idea 1, 2, 3 and 10 fall on this criteria. They have either a screen that is resulting in a housing that is too big or a screen that is too small.

Secondly the robustness is of importance, especially robustness regarding the screen. The screen mechanisms of 6 and 7 are likely to be too fragile through its complexity. Also the screen in 7 is still prone to damage

Idea 8 is interesting to look into because it is a whole other way of protecting the screen or the device from damage. Therefore some of the characteristics of this idea will be translated into one of the concepts.

Idea 4, 5 and 9 will be translated into concepts by adding some characteristics from the other ideas.

Before the ideas are worked out into concepts, I did some cardboard prototyping (appendix 8) in order to discover the best configurations regarding screen positioning and closeable openings.

Idea 4 appears to work quite well in practice. However including a screen mount on the side of the device will result in a bigger device. Also the screen should be attached to the device in such a way that you can not separate these parts. Next to this the wires connecting the device and the screen should be put away smartly when the device is transported in order to mitigate the risk of damaging the cables and connections.

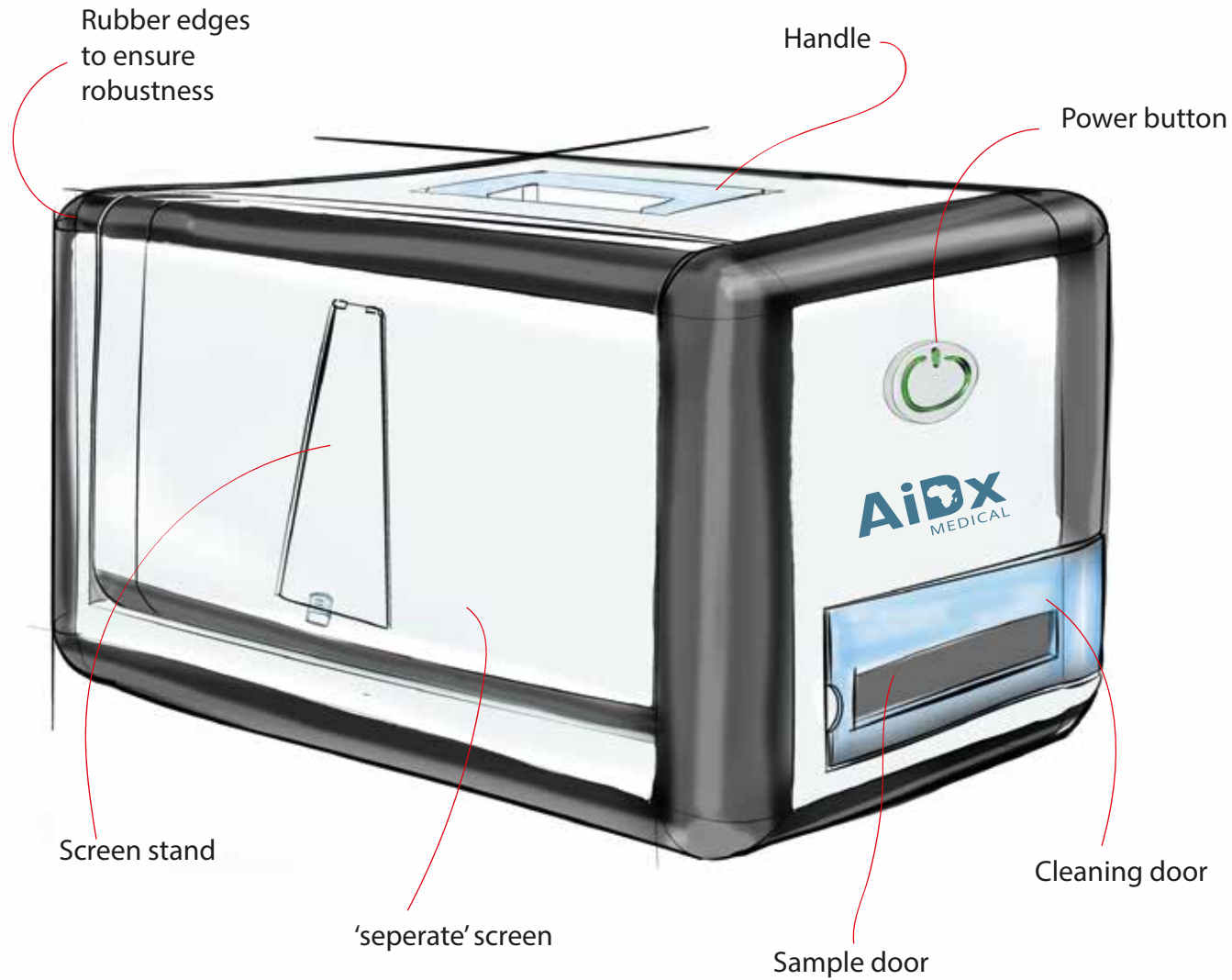
During the prototyping I discovered that having a screen attached on the back of the device is annoying because you cannot reach the right part of the screen easily. Also it can be difficult to see what is on the screen. Therefore the hinge of the screen should be positioned on the front of the device. This results in a mechanism that should open the screen after which it should be able to turn the screen around. Next to that I discovered that the screen should be positioned on the lower part of the side of the housing in order to ensure stability when the screen is smaller than the side of the housing. An advantage of positioning the screen on the side of the housing is that a big screen can be implemented which has a higher height than regular 'tablet' size screens. So the screen on the side can be more squared.

The result of this prototyping on idea 9 was that the screen opening to the side of the device is resulting in a complex system. Also when the only a screen is implemented on the 'door' the orientation of the screen is counter intuitive and the left part of the screen is not easy to reach. Therefore it was chosen to let the front part open towards the top, after which it can be rotated in landscape mode.

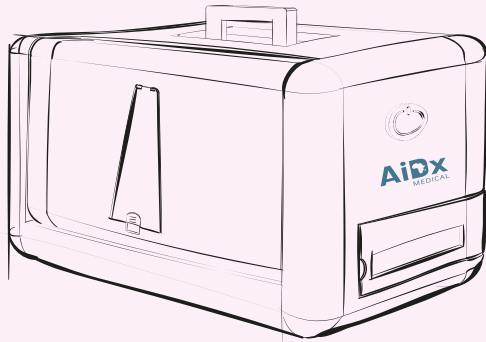
These things are taken into consideration when idea four, five and nine are transformed into concepts. The concepts will be worked out with regard to:

- Considering all HKJ's
- Aesthetics drawing
- Foam model
- Interaction
- Robustness
- Dimensions
- Initial materialisation
- Initial production techniques

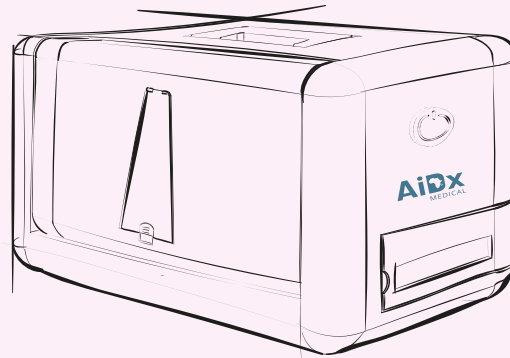
Toolbox



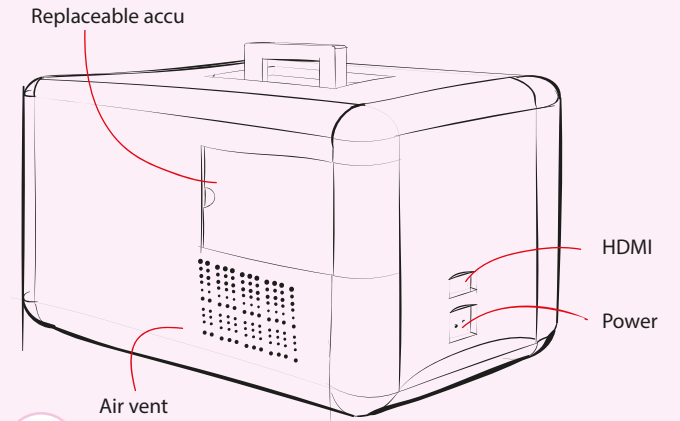
Interaction



1 Travel by using the handle



2 The handle is easily folded in the surface of the top of the device



3 (from the back) Connect the power or use the accu

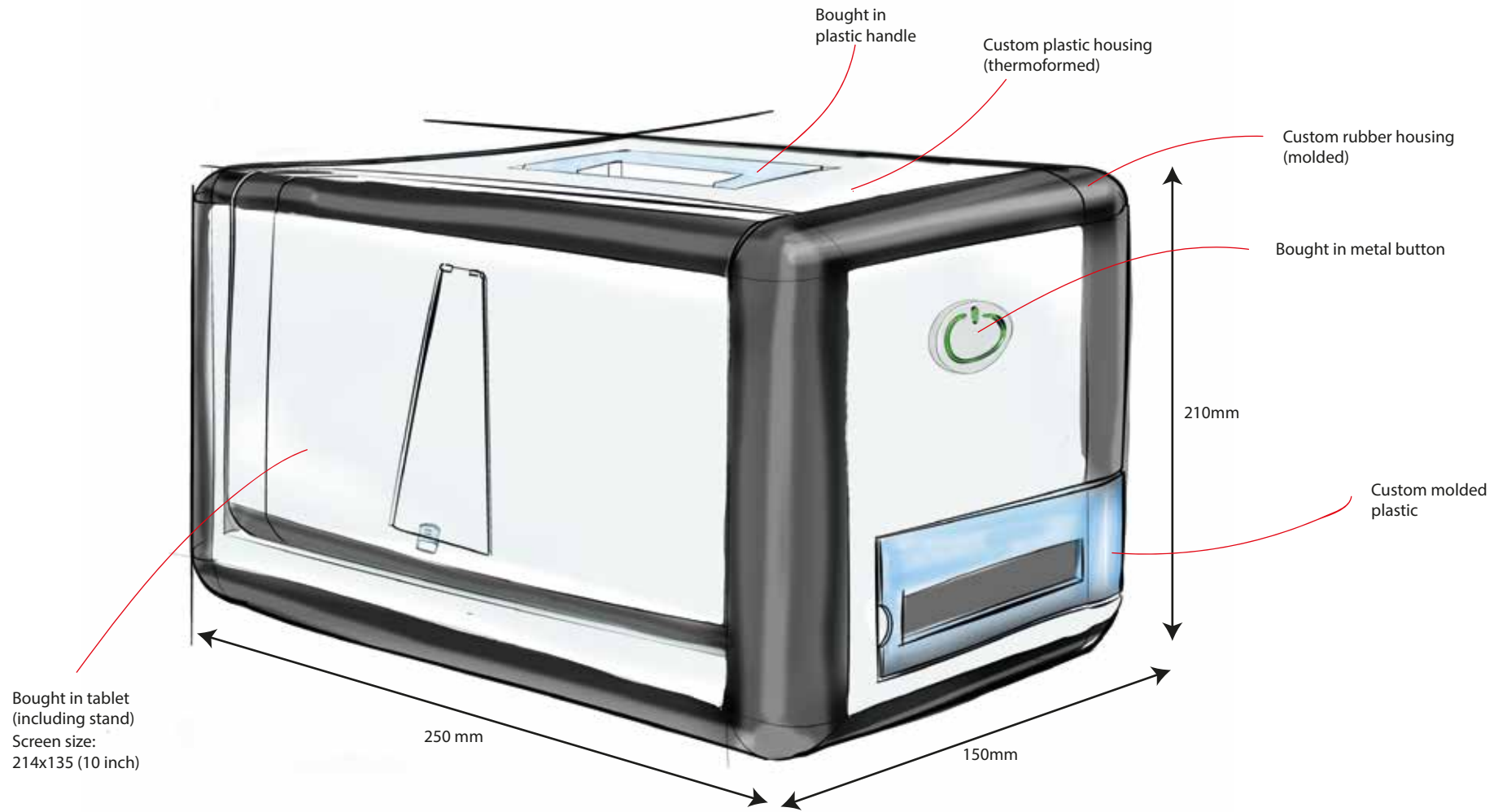


3 Take the screen out the device in order to use the device

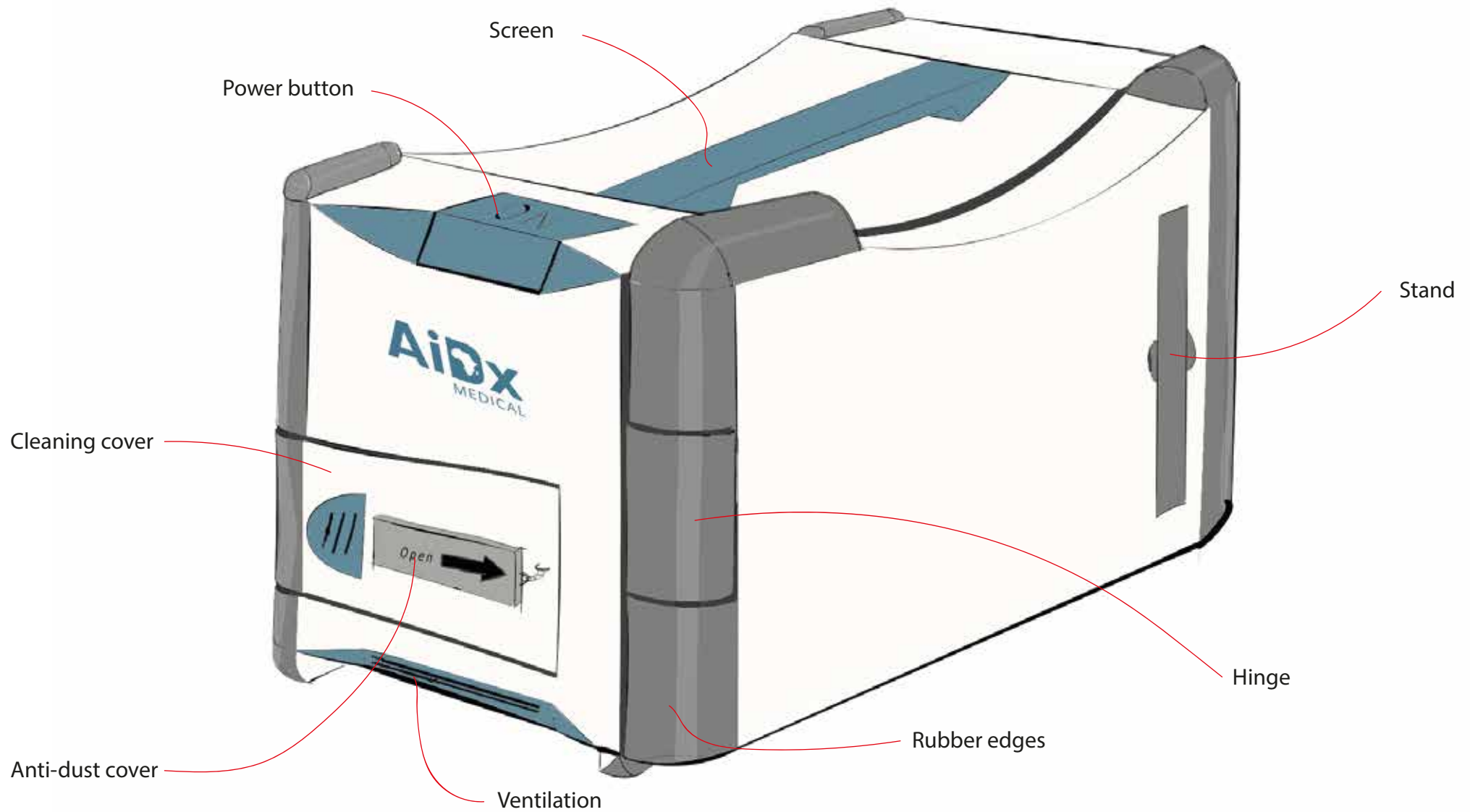
4 When the sample comes out, it pushes the sample door open

5 To clean the lenses, open the cleaning opening

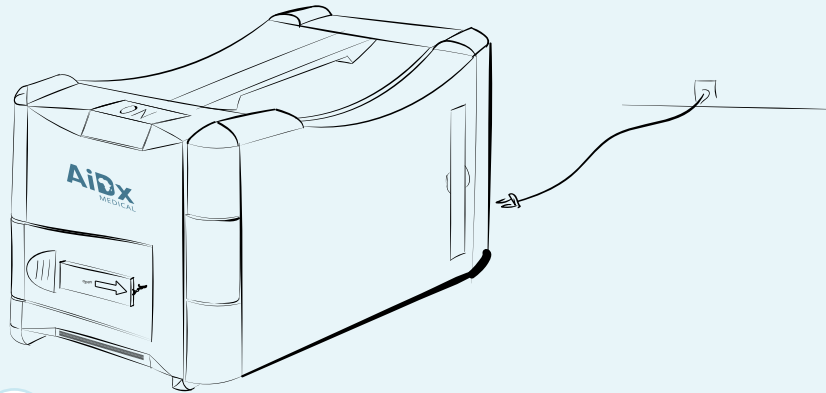
Materialisation



Camscreen



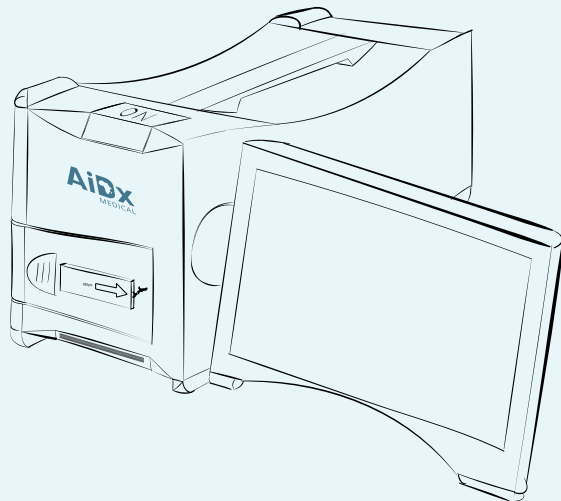
Interaction



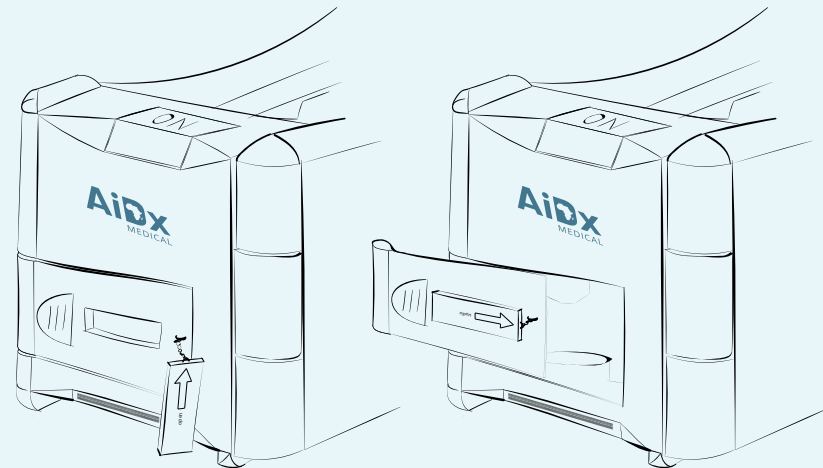
1 Travel by using the handle, connect power or use the accu



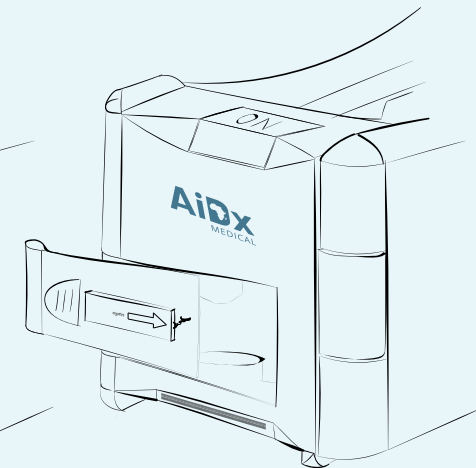
2 To use the device, open the screen



3 Rotate the screen around in order to face the screen from the front

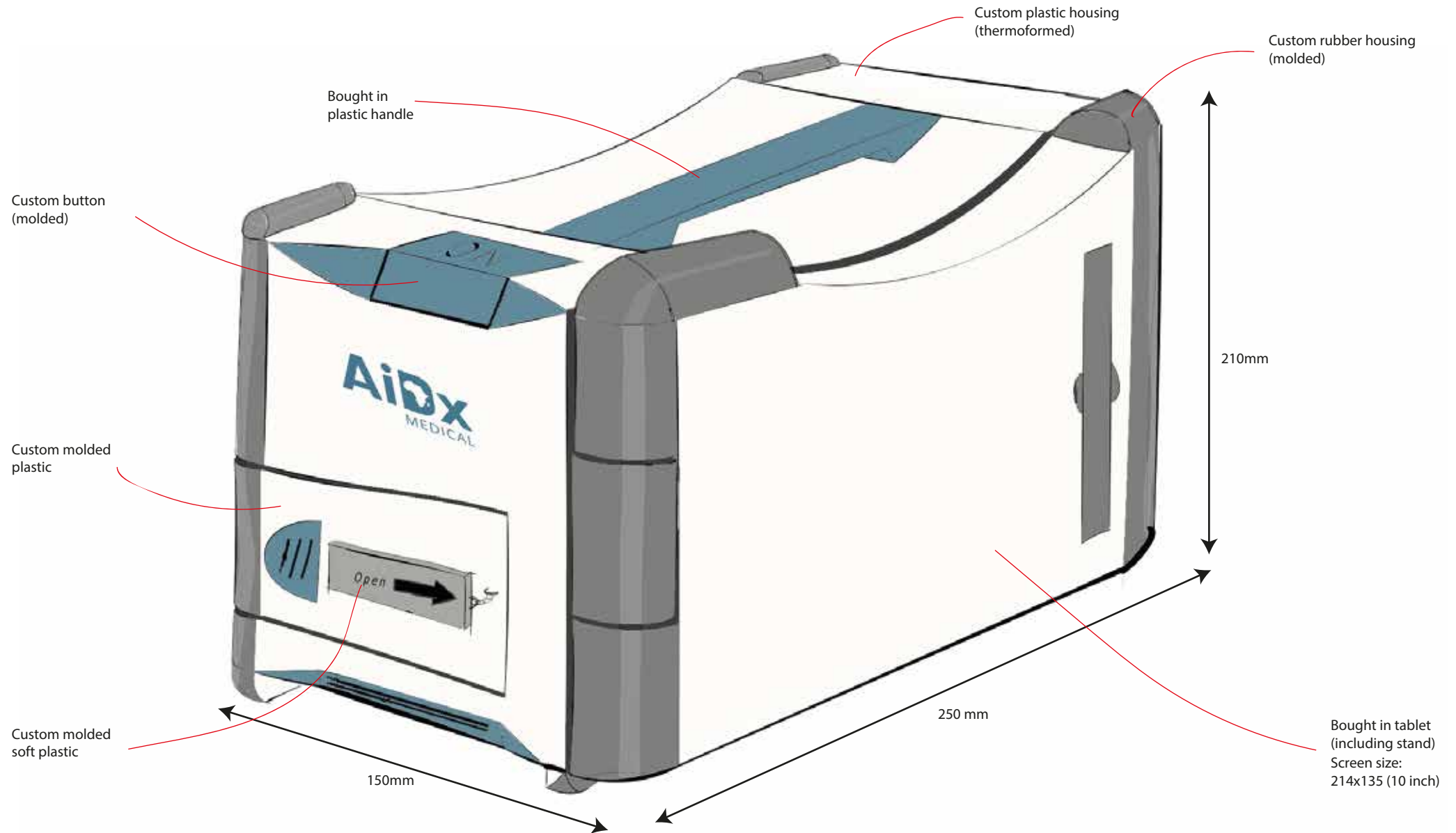


3 To start scanning, remove the anti-dust cover

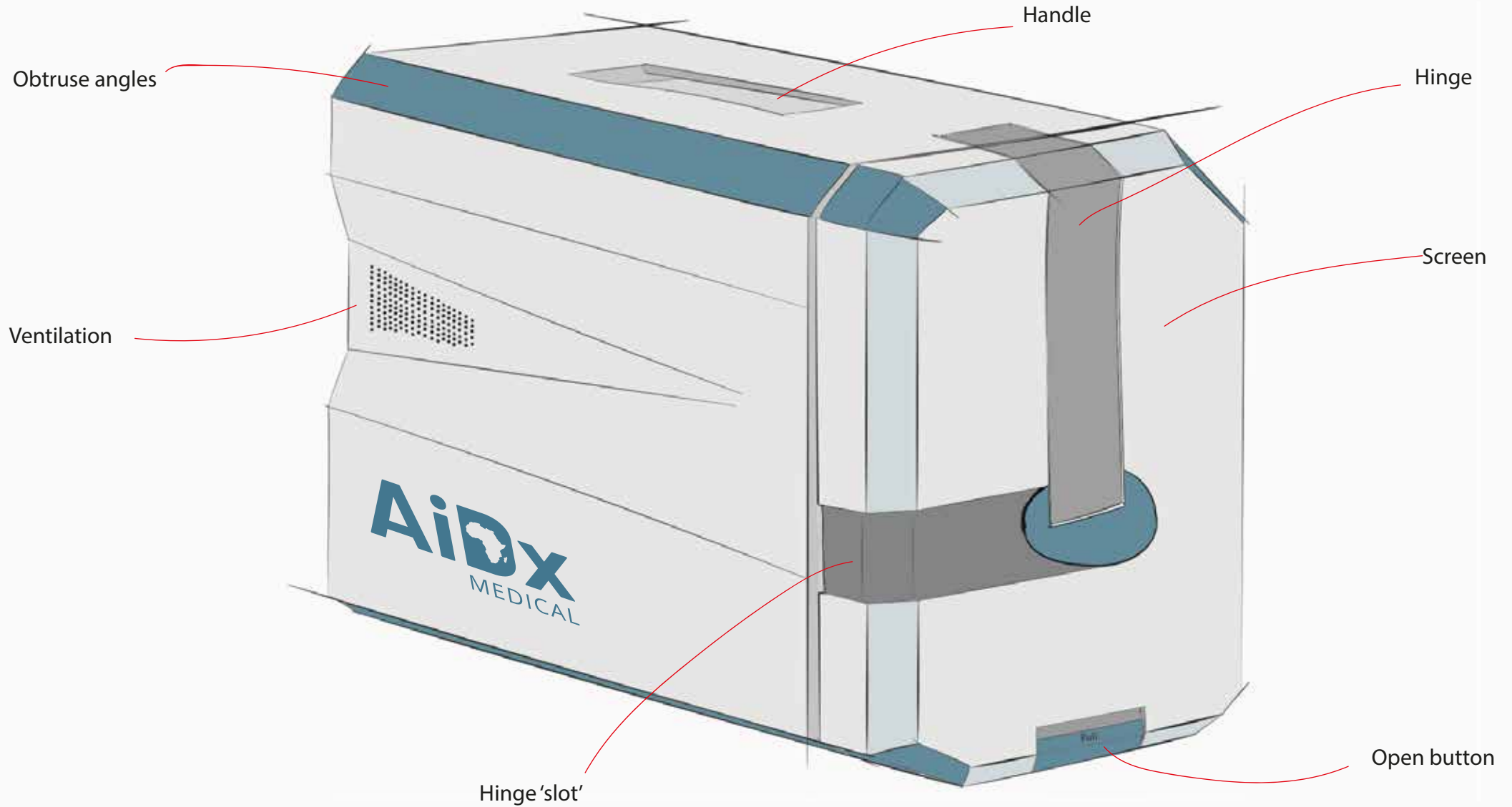


3 To clean the lenses, remove the cleaning cover

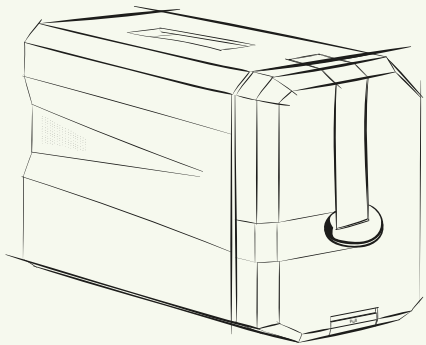
Materialisation



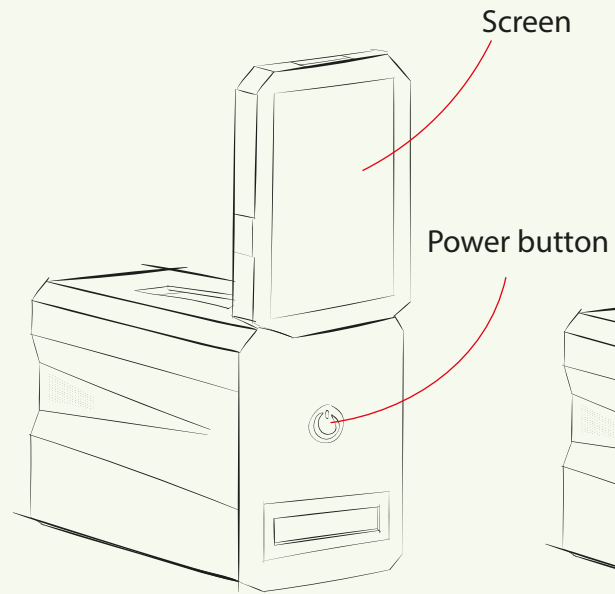
Coverup



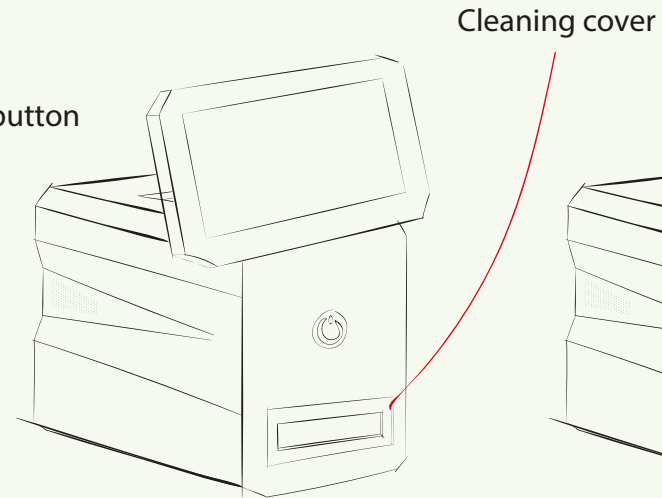
Interaction



1 Travel by using the handle, connect power or use the accu



2 Pull the 'open' button to open the screen

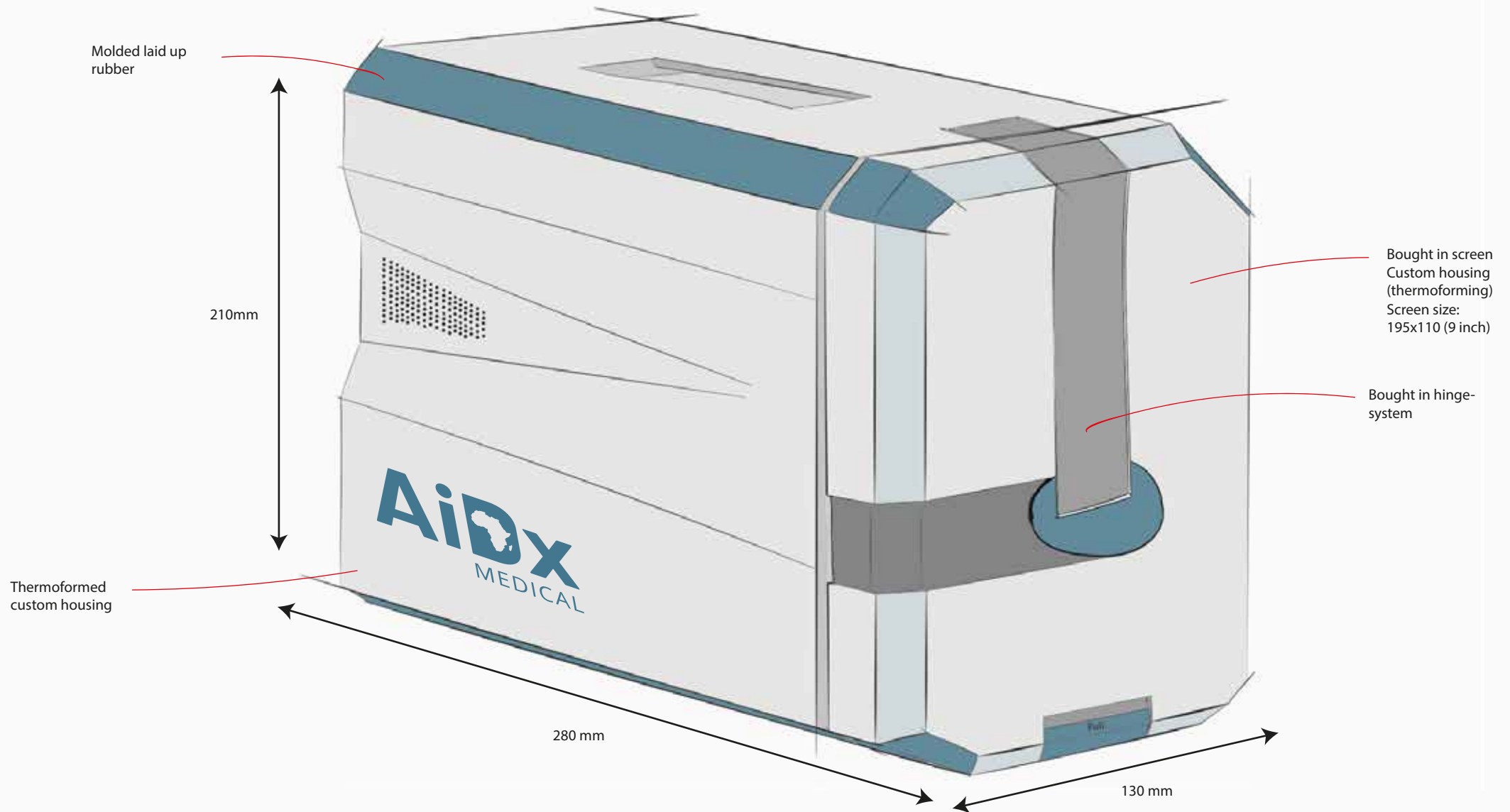


3 Rotate the screen around its axis to retrieve horizontal positioning of the screen. The hinge falls in the 'hinge lock'



4 Open the cleaning cover to clean the lenses

Materialisation



Selection criteria explanation

The concepts will be evaluated on different aspects by using an Harris profile. In this Harris profile, the most important aspect will be positioned at the top and the least important aspect will be positioned at the bottom.

The most important aspect is the portability of the device. During the 'creative session' and the interviews with some laboratorists I discovered that this was the most important concern according to them. Portability is defined as the ease of which it can be transported to distant places. This aspect is directly related to the compactness and weight of the device (interview Brice).

Next to that the actual robustness of the device is important. This because the device should be working in a rough environment and still keep functioning.

Also, the experience of robustness of the device is important. This means that when someone is seeing and touching the device that the person 'knows' or experience that the device is robust enough.

Fourth the size of the screen is a concern. The students from the creative session said that a mobile phone size was big enough. However they do not have the experience on the field as the other microscopists who said that at least 10 inch was needed. Therefore the bigger the screen, the higher 'positive' score on this aspect.

Fifth we consider the aesthetics of the device. When people are confronted with the device for the first time, they want to be intrigued by the design in such a way that they feel that they 'want' to work with it; that they want to be seen with it.

Sixt, the complexity of the screen-mechanism should be as low as possible in order to take as less space as possible. Also, the lesser the complexity is, the easier it will be to create a robust device.

Lastly the 'Intuitivity' of the design should be considered. When the device is shown to the user the user should immediatly know how to use the device, otherwise the person will get frustrated (interview Brice).

Selection criteria

Toolbox

Camscreen

Coverup

-2 -1 +1 +2 -2 -1 +1 +2 -2 -1 +1 +2

Portability

Actual robustness

Perceived robustness

Screen size

Aesthetics

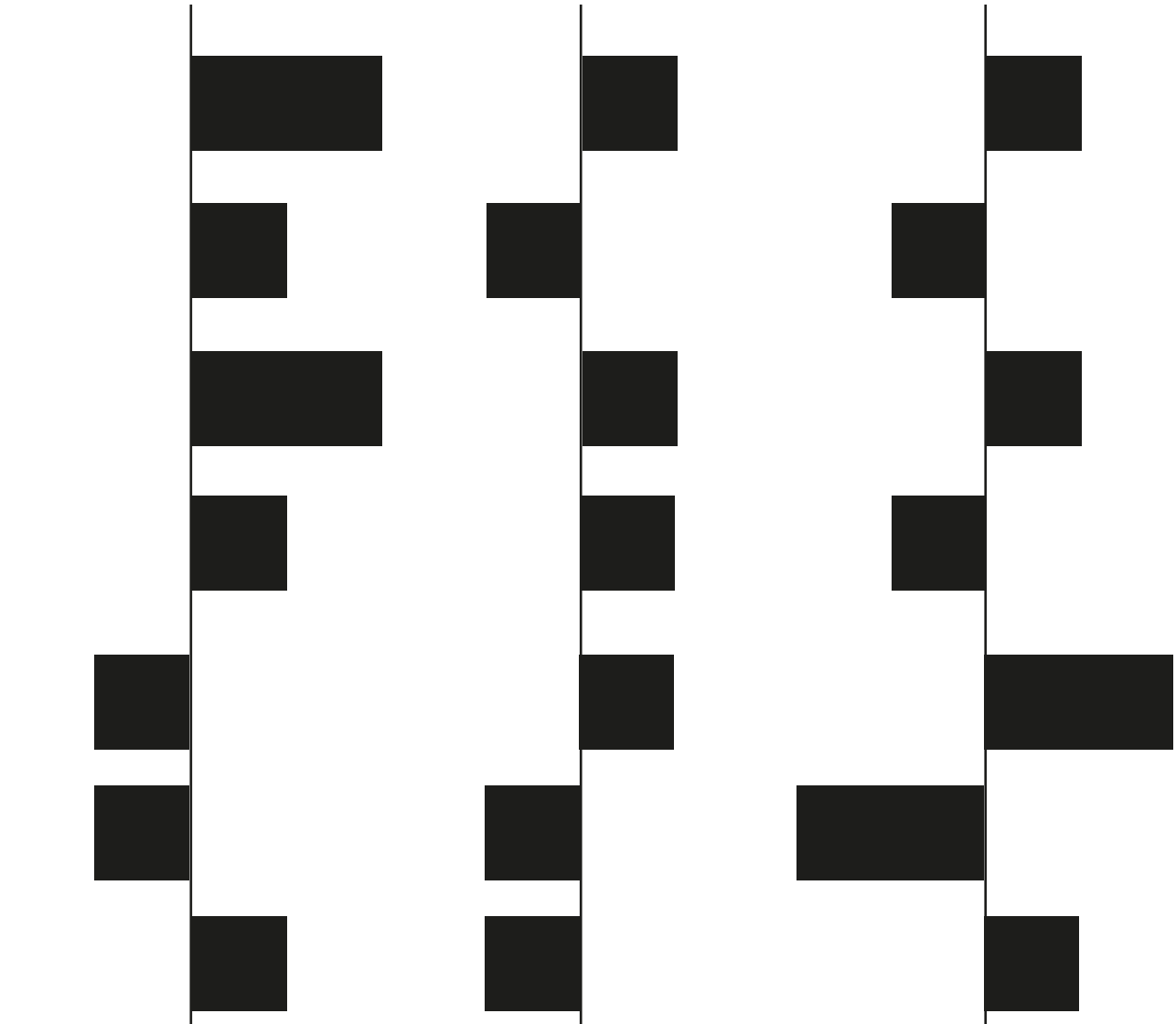
Mechanism complexity

Intuitivity

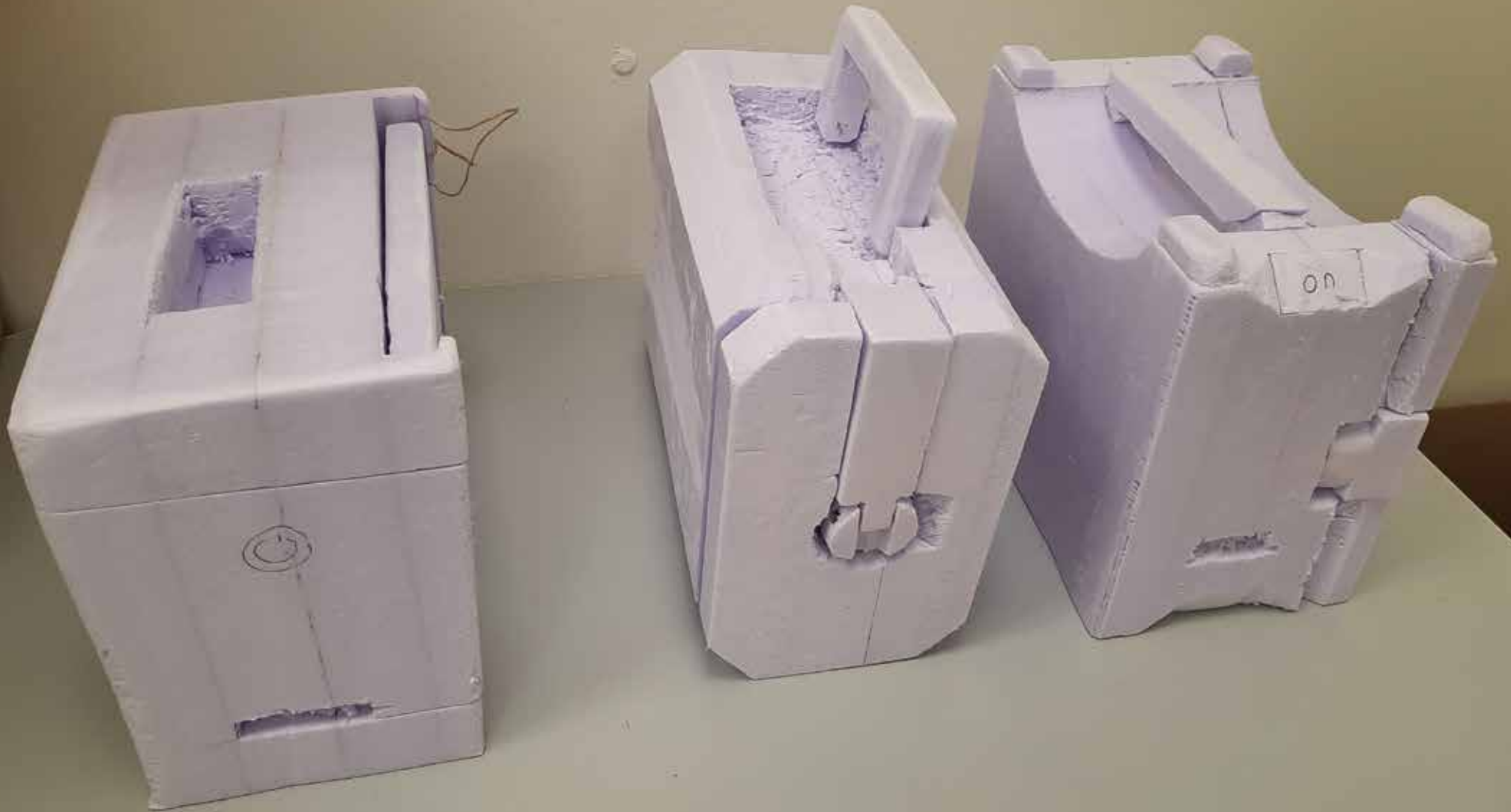
+5

+1

+1



Foam prototyping





Foam Toolbox

Creating the Toolbox out of foam was quite easy. The device is merely a box with a recess for the screen on the side. The screenside is faced inwards in order to protect the screen from damage. The screen has a stand attached to it in order to make it possible to position it next to the device. In order to avoid theft of the device, the screen will be attached by means of an inseparable wire. This can be made from metal for example.

When 'using' the prototype, some drawbacks were discovered. When you are in a haste, and you grab the device, it can be that you did not put the screen in the holder yet. Then you will pull the screen from the table and dangle it on the wire. This will damage the screen very easily.

Also the interaction with the device finds place in two different 'planes' the side and the front plane. This makes the interaction with the device less smooth.

Thirdly the wires connecting the screen with the device undergo a lot of twisting which can easily lead to broken cables.

Fourth, a separate screen gives not the feeling of an integrated device

On the other side, the handle on top of the device is robust and easy to use.

Next to that this device conveys a robust, stable and simple look and feel through the dense shape, and rounded edges.

Foam Camscreen

The Camscreen was the second prototype I made. Therefore I experienced already that I should work with 'big' parts instead of small details. This resulted in quite a big hinge to connect the screen. To make use of the screen it should be opened and turned upside down.

From prototyping this, I learned that to implement such a hinge, you need quite some space. This needed space will result in a smaller screen and a higher width of the device.

Next to that I realized that the wires connecting the screen with the Raspberry Pi will be turned around very often, resulting in broken cables inside. Even screens like this used in video-camera's feel fragile.

Also I learned that the screen should be supported when the device itself has rubber 'feet' for increased stability. Otherwise the screen is hanging loose all the time.

Through the placing of the hinge and the 'rubber' on top of the device, the screen has a nice natural angle to hold itself in place.

Also the screen was easier to reach than expected from the cardboard prototyping. This is probably because the screen is tilted and placed entirely on the front.





Foam Coverup

This concept took the most time to make. This was mainly through the complicated mechanism which requires a lot of designing. Also the shape of this concept took more time to fabricate. For this concept the screen is located on the inside of the front. It has to be opened to the front and then turned into a horizontal position.

A drawback of this design is mainly that it requires a quite complex mechanism in order to position the screen. This mechanism will cost a lot of research and money to produce. Especially when the system has to be robust and intuitive.

Next to this, the location of the handle on top is not centered. This is annoying when picking up the device.

Thirdly, the cables are very vulnerable in this design

An advantage of this design is the covering of all functionalities through the screen, therefore making it a robust design.

Also the thinner, curved shape of this concept makes the design look like a sleek product.

Lastly all the interaction of the device finds place at the front. Therefore it is easy to find all the functionalities.

Mentor & chair meeting

At this point I again had a mentor meeting, during this meeting I had a lot of new information to share. This was because I got out of my comfort zone and interviewed future users. This meeting was in between developing the concepts and creating the foam prototypes. Through this session we discussed the progress and as a result of this new ideas came up:

- The future users prefer a 'normal' design over very futuristisch
- A visual journey map will convey clearer the different user scenario's
- Make a collage of the envisioned appearance of the AiDx
- Include something that people know that they are treated righteous

A few days later I had a meeting with my chair and company mentor. For this meeting I created the mentioned physical concepts out of foam in order to play with it when I presented my concepts. From this meeting we reached the following conclusions:

- Read the paper of the ease of use of the AiDx Assist
- Look into existing mechanisms if you are going to use a mechanism
- Make a fourth concept with a hinge-screen on the front
- Do a field test with screen orientation and ask Tope to perform this test in Nigeria.
- Do this BUT take into account that we are aiming at a quantity of less than 100 devices, so make it simple to produce!

Through this chair meeting, I realized that I had limited myself by considering the small width of the device as a given. Therefore it was good that we had this conversation to open my eyes. **How to prevent this from happening the next time?**

Brice & concepts

These drawings and models are also discussed with Brice. He gave me valuable insights which are partly the same as I heard from my mentor. The most important insights were:

- Make the mechanism so easy that it is easy locally repairable
- Make sure that the mechanism is not very complex, vulnerable or difficult to understand
- The loose screen is the best option of these three. However if a mechanism is easy to make for the Coverup system, I prefer that one: all the interaction finds place at the same time
- I like the curved appearance of the Camscreen. over the box designs of the others
- The sample opening should be covered also during use
- Use a simple red on-off switch. People who are not used to computers might not understand a round power button.

Medical students & concepts

I reached out to the six Nigerian medical students to give their opinion on the concepts I created. Two of them filled in the questionnaire. The exact results can be found in **Appendix XX**. The main results from this enquete were:

- The position of the screen of the Camscreen is better than the of the Toolbox.
- The positioning of the screen of the Coverup is good, but the design of the first and second one is preferred.
- The Toolbox looks most robust.
- The Camscreen looks most aesthetically pleasing
- Device 3 looks most aesthetically pleasing

Due to the low amount of respondents, I should not heavily rely on these results. However I can take some insights from them when selected carefully

Animashaun & concepts

I discussed the concepts and also styling with an experienced microscopist and chairman of the Association of medical laboratory scientists of Nigeria. The main insights are displayed below. More details can be found in [Appendix xx](#).

- I like an integrated device, so the Toolbox is not the best solution
- The screen should be protected during use with a transparent nylon cover to prevent it from damage and dirt
- I like white, blue and gray
- I like curved clean shape language over rugged squared design language
- I like a modern round button like a CPU button over a simple on/off switch because we are developing a modern device here.
- We do not have to deal with trust issues, because we work from a trusted organisation and treat people directly.

Concept conclusion

The foam prototyping was a good step to take. Through this physical prototyping I encountered a lot of physical flaws in the concepts I made. Also it was an easy way to discuss the concepts I had; people could feel and interact with it. Discover the flaws themselves and together we could think of other solutions to develop the concepts in a better way.

Through these discussions we ended up by creating a fourth prototype. Actually this prototype is an iteration on the Coverup with respect to the placement of the screen. However the mechanism is made easier by implementing one hinge. This hinge is placed on the front-top side of the device. This mechanism was chosen because it is the most robust mechanism that is easy to produce with a low quantity of 100 pieces. That is also the reason why the other concepts were not chosen; the mechanism is too complex and vulnerable.

The screen is placed horizontal on the device. This means that the width of the screen is higher than the width of the device. To make sure that the screen is still protected from damage during transport, the front of the device is made wider. [This is illustrated in figure XX](#).

If this change is made in the third concept, the concept will score '+2' on screen size and '+1' on mechanism complexity, '+2' on robustness, resulting in a score of +10.

This third concept, the Coverup, is chosen to proceed with. To summarize the reason of this choice:

- It has the advantage of all interaction on front
- The mechanism for the screen is the most simple
- It directly protects all openings and buttons from being damaged during transport

In order to test what the future users are thinking about this concept, an user test is carried out. The setup and idea of this test is explained in the next chapter. The individual test results can be found in [appendix xx](#)

Alternative Coverup test

The week after I chose to proceed with the alternative Coverup, Tope went to Nigeria to demonstrate our current prototype. This was an opportunity to test the basics of the concept I am developing. Therefore I created the prototype displayed in [figure xx](#). The screen is attached to the current AiDx NTDx, so all the functionalities are included. The screen can be folded to the front and opened to the top by means of a hinge. The screen has a diameter of 10.1 inch. Unfortunately, the edges around the screen also take up a lot of space. Therefore, the whole width of the system is 265 mm whereas the screen only has a width of 216 mm. The screen for this prototype has a resolution of 1280x800 whereas the interface is programmed for 1920x1080 resulting in an interface that did not fit the screen. Together with the software developer we managed to solve this issue.

This system is tested with 10 high profile Nigerian medical practitioners with a range of experience between 15 to 47 years. [Figure ...](#) shows the test setup.

The main results of this experiment are:

- The screen is big enough
- The placement of the screen is ideal
- The sample opening should be covered during and also after use.
- White, grey, black and blue are colors that convey medical appearance in our profession
- A integrated fixed handle is preferred

More detailed results can be found in [appendix xx](#).



Figure ... Prototype to test principle of concept 'Coverup'



Figure ... Test setup in Nigeria

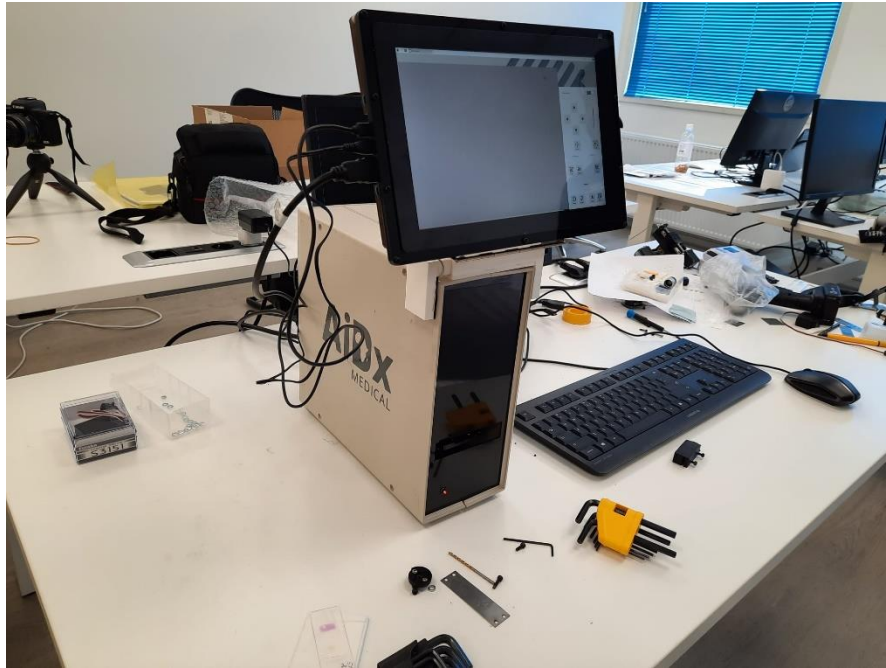
The interaction of the participants was filmed. Some important insights from this interaction are:

- There should be a possibility to print the results of the AiDx NTDx, but it should not be included in the device.
- A battery pack of 8 hours is sufficient
- The touchscreen should be extendable to a monitor for educational purposes
- The size of the AiDx NTDx should preferably be a little smaller.

APPENDIX 13 - Touch screen field experiment

Demonstration date: 29-3-2022

Nigeria



Picture 1: Prototype for this test

Goal

The goal of this experiment is to understand how the future users perceive a 'hinge' screen as is showed on in picture 1. I want to know what the future users think about the placing of the screen, the current interaction and their concerns.

Participants

The participants of this test will be ten experienced Nigerian medical practitioners.

Method

- Sign the informed consent form
- An explanation of the activity is given by the researcher:
 - o This research consists of three parts. First you will have to work with the AiDx Device by using a mouse and monitor. Secondly you will have to work with the machine when using a touchscreen. Lastly you have to fill in a questionnaire about your experiences. **Important: during the interaction with the devices you will be filmed. We ask you to think out loud when working with the devices. Please voice all your positive thoughts, doubts and confusions. (This can be about anything like the robustness, if you can not find a certain feature or a part is not placed well according to you)**
- The AiDx NTDx is connected to power, mouse and screen
- The researcher starts filming

Part 1 (Device 1)

- The participant is asked to:
 - o Turn on the device
 - o Launch the application
 - o Insert a sample
- The manual control is explained by the researcher
- The participant should move the field of view two times to the left and one time to the top

Part 2 (Device 2)

- The researcher attaches the touch screen on the device and turns the screen on
- The researcher explains that this is one of the concepts we are currently considering
- The participant is asked to:

- o Launch the application
- o Insert a sample
- o Move to a field of view until a parasite is found
- The researcher asks several questions about interesting issues regarding the interaction experience of the user that occurred (if participant is not able to recognize parasites, the researcher should help with determining this)

Part 3 – Questionnaire (Please be critical!)

Participant information

What is your name?

What is the name of your organization?

What is your profession?

What is your years of experience?

Interaction with the device

1. What do you think about the placement of the sample insertion opening?
2. What do you think about the screen size of the touchscreen? Can it be smaller, if the buttons are enlarged?
3. What do you think about the inclusion of the touchscreen on the device? What are your positive thoughts and what are your concerns?

4. What do you think about the placement of the touchscreen which is on front-top of the device? Do you prefer it on the top-front or on the top-back? And why?
5. What do you think about the angle the screen is mounted on the device? How far should the screen be able to rotate?
6. What do you think about the operation by means of the touchscreen? How did you manage to use the touchscreen?
7. What do you think about the portability of the AiDx NTDX?

Aesthetics

8. What do you think about the suitability of the colors (black and white) of the AiDx NTDx?

9. Look at the images of medical devices below



Device 1



Device 2



Device 3

To which extent does the AiDx NTDx and these medical devices appeal aesthetically to you? (cross the box which applies) think about shape, colors, type of handle, specific issues.

	1 (not at all)	2	3	4	5 (very much)
Device 1					
Device 2					
Device 3					
AiDx NTDx					

10. Please give one positive and one negative point about the appearance of Device 1

11. Please give one positive and one negative point about the appearance of Device 2

12. Please give one positive and one negative point about the appearance of Device 3

13. Please give one positive and one negative point about the appearance of the AiDx NTDx

Marketing

1. What automated diagnostic device do you have? E.g. GenExpert
2. What is the cost of this device?
3. How and how often do you maintain this device?
4. What is the procurement process of acquiring such a device?
5. Who gives the final approval of the purchase order?
6. Which local supplier do you use for acquiring a diagnostic device?
7. What is the need for an AiDx Device that can perform the following analysis: blood count, sperm cell analysis, Malaria analysis and tuberculosis in your lab?
8. The device will be launched at the end of August, do you want to make a preorder with a discount rate?

Room for other remarks or suggestions

Notes of researcher

Results

The research is performed with 10 participants with experience ranging in between 15 and 47 years as Medical laboratory Scientists.

	Participant 1	Participant 3	Participant 4	Participant 6	Participant 8	Participant 9	Participant 10	Average score
Device 1	4	5	-	1	2	2	5	3,2
Device 2	2	-	5	1	4	4	4	3,3
Device 3	1	-	-	3	3	2	5	2,8
NTDx	-	5	-	5	4	4	5	4,6

Figure xx: Aesthetic score per device per participant

9 of the 10 participants suggested that the sample opening should be covered to prevent dust from getting in the device. Not only when the device was not used, but also when it is doing a scan.

8 out of 10 participants were content with the size of the 10 inch screen. One participant suggested to make the screen a little bigger, while the other participant was content with the size of the screen if it was possible to zoom in.

4 participants stressed that they like the type of handle of 'device 1' over the other handle designs.

3 of the participants requested that the colors of the device should be black and white. Two mentioned that it would be nice to add blue. One participant suggested to make the device as dark as possible to make sure dirt is not seen easily on the device.

3 participants suggested that they would like a printable result format integrated in the device in the 'other remarks' space

2 participants suggested that the screen should be fixed on the device to prevent screen damage

The summary of the findings per participant can be found in appendix 1. The handwritten answers to the questionnaire can be found in [appendix 3](#)

The following results were captured by the filmed interaction with the AiDx NTDx

- There should be a possibility to print the results of the AiDx NTDx, but it should not be included in the device.
- A battery pack of 8 hours is sufficient
- The touchscreen should be extendable to a monitor for educational purposes
- The size of the AiDx NTDx should preferably be a little smaller.

More detail regarding these topics can be found in [appendix 2](#)

Discussion

Only developing the prototype to perform this test taught me some valuable lessons. When ordering a screen, I should be paying attention to the size of the edges of the screen in order to keep the size small. The screen I used can be found via this link: <https://www.robotshop.com/nl/nl/101-1280x800-lcd-scherm-met-hdmi-en-behuizing.html> Secondly, the angle that the screen can be opened is determined by the way the screen is attached to the hinge; if the attachment is too thick, the screen cannot open more than 180 degrees, whereas a screen that is opened a little further would be better. Thirdly, the hinge in this prototype runs very smooth, when closing the screen the screen will smash on the front of the device. This can damage the screen easily. Therefore the hinge of the screen should be made a little stiffer. Lastly, the wires connecting the screen to the machine are connected to

the side of the screen, making these connections vulnerable. It would be better if the wires come from behind the screen.

A few participants suggested that the screen should be fixed under an angle instead of mounted on a hinge. When looking at the discussion about it in the footage, they thought the current set up was quite vulnerable. However when thinking about a hinge as is present in a laptop, they agreed that that will be robust enough.

When the device was brought to Nigeria by plane, some minor issues occurred; a wire was loosened of the PCB and a screw of the lightning module was loosened.

When looking at the results, some participants did not fill in the aesthetic score of the devices. This resulted in six scores per device on average. The score given to the appearance of the AiDx NTDx is better on average than the other designs. I suppose this is due to the physical presence of this device. Next to that in hindsight I see that the competition of the presented alternatives for medical devices were not chosen that good. Therefore I will not rely to heavily on the marks given in this part of the questionnaire

Also due to the long years of experience the participants have, all the devices we produce right now are 'wonderful'. People with almost 50 years' experience have another view on what is attractive as a device than the younger generation. Therefore we should rely more on the feedback of the younger generation to determine the appearance of the AiDx NTDx.

Appendix 1 - Results

Participant 1

Papa Idris. A. Saliyu
Save Blood for Africa Foundation
Medical laboratory Scientist
49 years of experience
idysaliyu@gmail.com

Interaction

- 10 inch screen is a good size. It is very portable right now
- The screen should be on the front
- Rotation of the screen should go as far as a normal laptop
- People will know better how to use a touch screen than a monitor because of experience with their phones.
- I fear that the screen is too vulnerable right now: dust, humidity.
- To younger people it may not be so exciting but I am used to work with big machines. This small machine opens a whole new world.

Appearance

- The color should be dark. The darker the better, because it will not get stained
- Handle of device 1 is nice. I want a device like a Nokia and not as a Samsung Galaxy
- I like that the AiDx NTDx looks like a CPU and that it is nice to look at. Looks like lab equipment.

Marketing

- Elisa equipment, Automated blood grouping equipment
- 7 million Naira upwards

- Make sure that the government puts funding in using specific products in order to increase the amount of the 'same' machines in the country. Then you can establish a repair service
- For the Elisa equipment, we trained local engineers by stripping down the device and building it up again

Participant 2

Chika Ihekuma
Inuse district hospital
Medical laboratory science
15 years experience

Interaction

- The sample insertion opening should be covered because dust could get in
- It should be able to zoom in on the screen, then it does not matter which size the screen is
- Touch screen is user friendly

Participant 3

Col. Felix Abayomi Adhoye (rtd)
Medical laboratory science council of Nigeria
Medical laboratory scientist
36 years

Interaction

- At the moment the screen is vulnerable for rough handling
- Top front is ideal for easy reach
- 90 degrees rotation is good
- The device should be taken to the field with a backpack

Aesthetics

- I am not comfortable with the current color
- Gray or any other color would be better
- Device 1 has an ideal secure handle
- Device 2 appears to be very stable when placed on a surface
- Device 3 does not appear like a medical device

Marketing

- Sysmex, BD facscount
- Daily, quarterly and annually maintenance
- I buy this at a vendor
- Doctor of medicine determines purchase
- Keep in View if I want to buy the AiDx Assist

Participant 4

Oko Patrick
Asokoro district hospital
Medical laboratory science
12 years experience
okopatricketfeanye@gmail.com
08136406810

Interaction

- The sample insertion opening should be closed during use and after use
- 10 inch screen is good
- The screen should be retractable to the side of the device
- 90 to 180 degrees rotation possibility

Aesthetics

- Black and white is good
- Device 1 looks aesthetic, but not rugged enough
- AiDx NTDx looks rugged

Marketing

- Genexpert
- 40000 Dollars
- Annually maintenance
- I acquire this device by directly contact with the manufacturer or country representative
- The General manager gives the final approval
- Our local supplier is: DCL or McRaf
- I would buy this device in august

Participant 5

Nwaneli Cirace N.
Trust Chantos Hospital
Medical Laboratory scientist (lab manager)
20 years experience

Interaction

- The sample opening should be closed because dust will come in
- The screen size is good, but a zoom function should be available
- Make sure that there is a possibility to fix the screen at its desired angle
- The up and down movement will cause the screen to get bad quickly, make the screen fixed at a position

Aesthetic

- The current colors are ok.
- Device 1 looks like a night torch. It is not cool.
- Device 2 looks ergonomic and I like the design
- Device 3 looks bulky, but I like the design
- The AiDx NTDx should be smaller

Marketing

- PCR (Tialong) 96 wells, Epants hematology analyzer
- Costs are around 2000 dollar
- No maintenance needed yet
- Local distribution in place
- The chairman of my hospital approves the purchase order
- Local suppliers: Kingscience and Waves*LTD
- The suggested improvements are very nice for me!
- I want to buy, what could be the price?

Participant 6

Oluseyi Deborah Faturoti

Unique analytical diagnostic laboratory services LTD

Mecial laboratory scientist/public analyst

22 year experience

08065721299

Interaction

- The sample opening should be covered
- The screen should be a little bigger
- Touchscreen is a good addition
- Top-front placement of the screen is preferable, it brings it closer to the operator for better visibility

- The screen-angle should be adjustable

Aesthetics

- Black and white is good coloring, adding color can make it look like a toy
- Device 1: handle is appealing, shape is not appealing
- Device 2: Has no medical look or feel
- Device 3: the front surface is appealing, looks like kitchen equipment (toaster)
- AiDx NTDx: Compact shape, but slide window should be covered

Marketing

- Urine analyzer
- Costs are 250 000
- It came with a trouble shooting manual, therefore we do not have frequent maintenance
- It has to be approved by MD or CEO
- Local supplier depends on availability of the device
- I would buy this

Suggestions

- I suggest that it should be possible to print out the result-report. In that report should be a quantification that is easy to interpret by the end user
- It should be possible to add arrows pointing the MPs on the pictures
- I suggest to set up a post-market surveillance team to be set up for improvement purposes

Participant 7

Godwin Oneliureme Ihimekpen

Association of medical laboratory scientists of Nigeria

Medical laboratory scientist (national secretary)

48 years experience

Interaction

- During operation mode and resting mode the sample opening should be covered
- Touch screen is best on the field device because of space limitations, but also for regular use
- I prefer top front position of the screen
- The screen should be mounted at approximately 120 degrees for proper ergonomics. To prevent damage, the screen should be able to be closed after operation.

Aesthetics

- Black and white is OK, Ash and white could be alternate
- Device 1 looks like a portable light source, screen is too small
- Device 2 looks most appealing, The handle is however in the wrong place according to me. The top would be better
- Device 3 looks most portable, but it looks like a bread toaster
- The NTDx looks like a CPU device

Participant 8

John I Ogbuka

DR Hassan's hospital and diagnostic center Maitama Abuja

Medical laboratory scientist

35 years experience

Interaction

- 10 Inch is ok
- The current screen design is not durable, but a touch screen is good to have
- The top front is preferred location of the screen
- Angle of rotation of 180 degree is ok

Aesthetics

- Colors are alright, blue could also be included
- Device 1: Handle is good, shape looks like a torch
- Device 2: handle and screen position is good
- Device 3: Screen position is good, handle and shape is not good
- NTDx: Size and screen position is good. No handle and looks like a CPU is not good

Marketing

- Mindray Chemistry Haematology analyser
- More than 3 million
- Daily, monthly and yearly maintenance
- The management does the procurement process
- The Lab director should give final approval
- I would buy the device in August

Other remarks

- The insertion opening should be covered
- When scanning is finished the device should alert the user by an alarm or something
- The result of the device should be accompanied with a printed copy for easy interpretation and correlation

Participant 9

Oye Oyetunde B. Akinloye
AMLSN, Oba Mtas laboratory, Baze university
Medical laboratory scientist
31 years experience

Interaction

- The sample opening should be a closed compartment to prevent dust
- The current size of the screen is cost effective design, it fits the purpose.
- Both for fix site and for field, the touch screen is recommended
- Front top is best location
- Current angle of the screen is good

Aesthetics

- Device 1: Looks more like transistor radio
- Device 2: looks mature
- Device 3: looks shimmy
- NTDx: looks compact

Marketing

- Merilyzer, QBC, Haemocoel
- Merilyzer: 652K. QBC: 350K
- Daily maintenance, twice a year big maintenance.
- DLS gives final approval
- Local supplier: Barittomeg Diagnostics
- I would buy this device.

Participant 10

Iseimokumo Christopher Peletiri
National hospital Abuja
Medical laboratory science
25 years

Interaction

- The sample insertion should be covered
- The 10 inch screen is good size
- The top- front placement of the screen is just okay

Marketing

- Malaria automated Parasight machine
- We acquire this machine via the government procurement procedures
- The chief medical director determines this
- We use the registered suppliers of our national hospital Abuja

Other remarks

- A printable result format would be a highly boost to this wonderful scientific piece
- A finer adjusted output (result) on the screen would be nice

Appendix 2 – Insights filmed interaction

From the videos that were taken, I could follow a discussion about the need for a printable result format from the device. There are very much fake RDT tests on the market through the broker. Therefore in city, very much mistrust is present for these fake tests. What they do now is: crop the malaria parasite from the picture and print it and snap it to the result with a comment that you are positive, here is the proof that you have malaria. The conclusion of this discussion was that it should be an option to print out the result, but that our customers should have the printer separately and not included in the device.

Through a discussion with Tope, I learned that most of the people in the room that day were working in the private lab industry. The clients of these hospitals are educated people, who ask questions and sometimes do not trust the test result. On the other hand you have the clients at the public hospitals. People going there are delivered to the 'mercy' of the hospital. They go, because they really feel sick and they want to get treated. If the hospital says they have malaria or another disease, they believe it.

Researchers like Brice on the other side do have trust issues. They collect samples in order to research them and take them for training purposes. They collect samples and disappear to their laboratory to see the results without treating the people. These researchers are not the target customers of AiDx. The private and public hospitals and NGO's who are actively fighting parasites e.d. are. NGO's treat people directly on the spot, so they do not have trust issues as well

So the trust issue is present in private hospitals, where they already have a printer to print out the result. Also with researchers, but they are not our target customer. The NGO's and public hospitals do not have trust

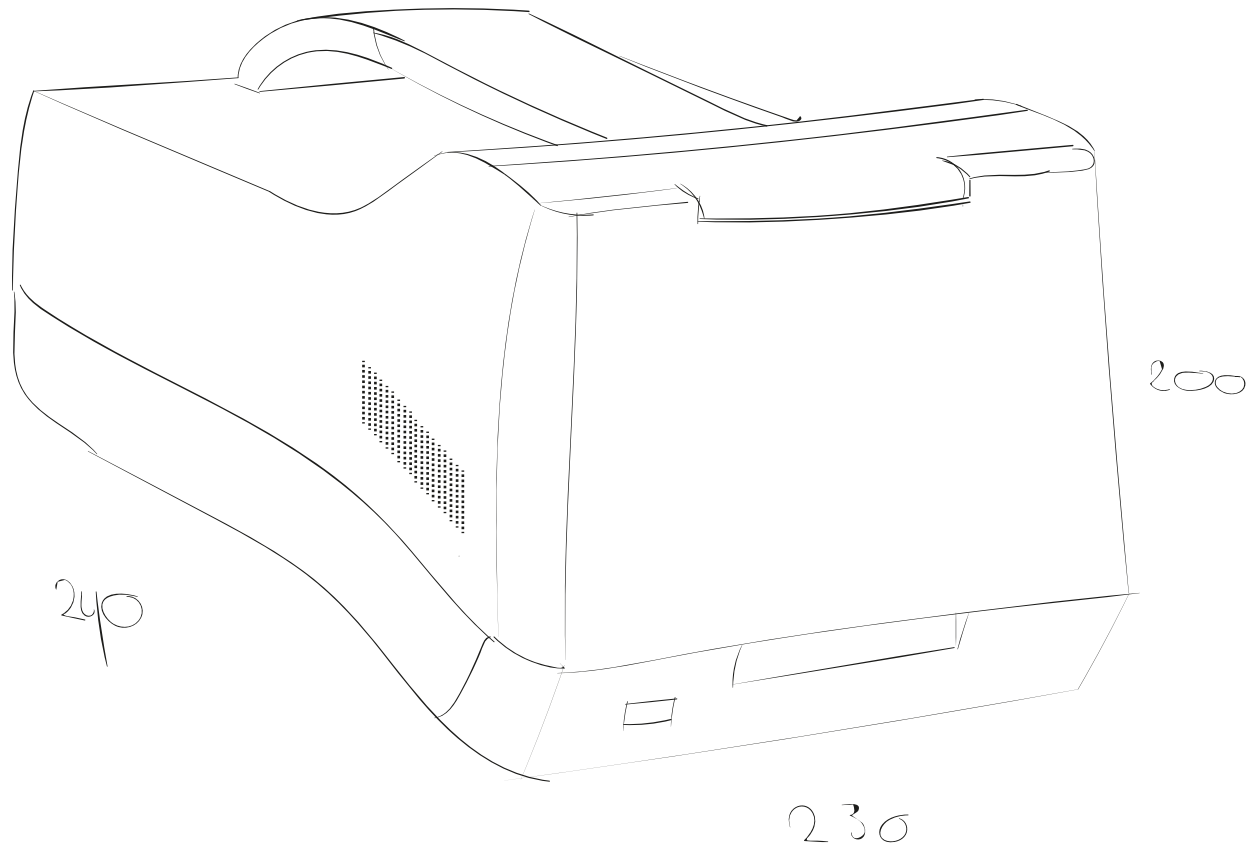
issues because they treat people. As a conclusion of this, we do not need to include a small printer in the device.

Secondly from the video I learned that they would want a battery back included of 8 hours.

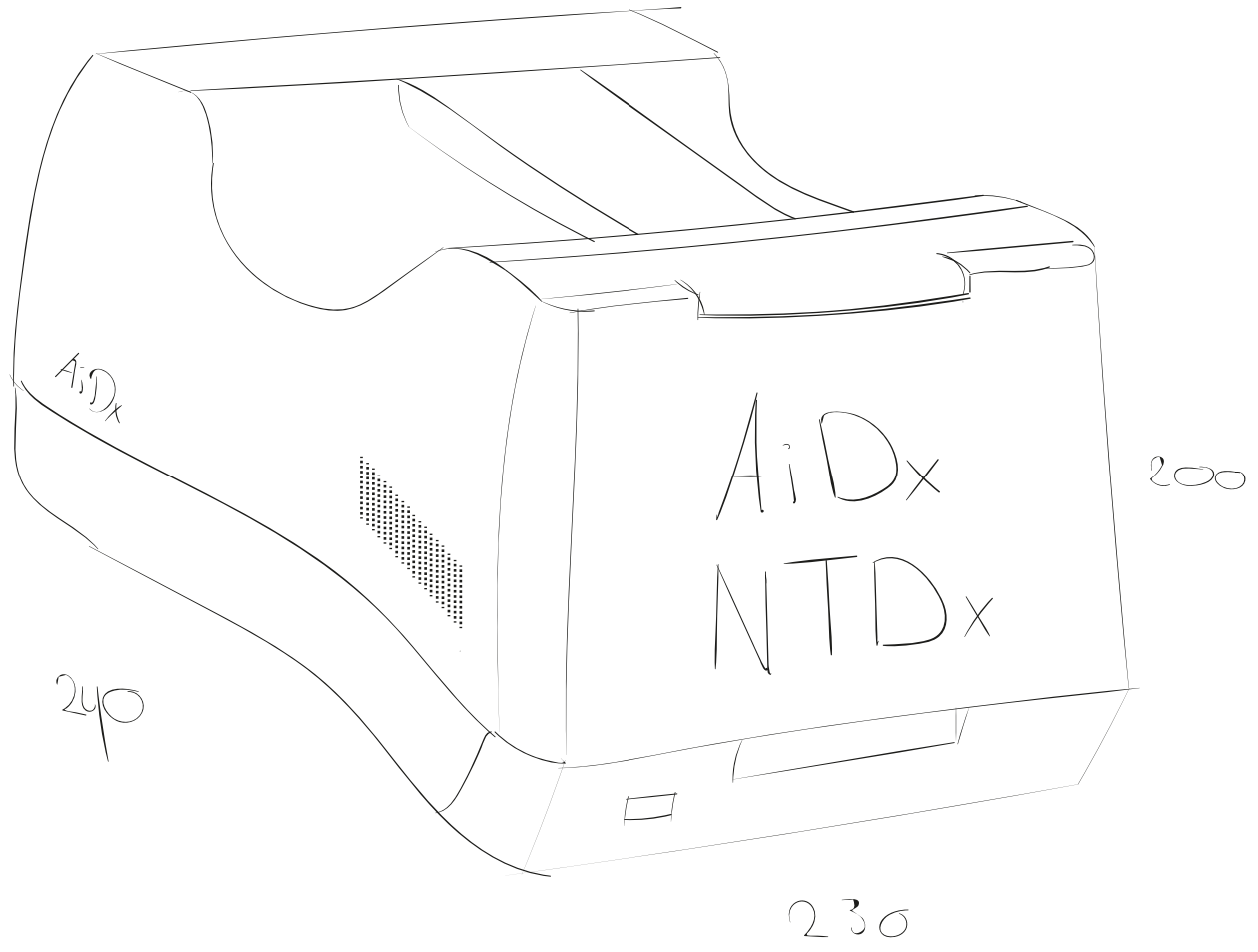
Thirdly they wanted the screen of the AiDx NTDx extendable to a monitor for educational purposes

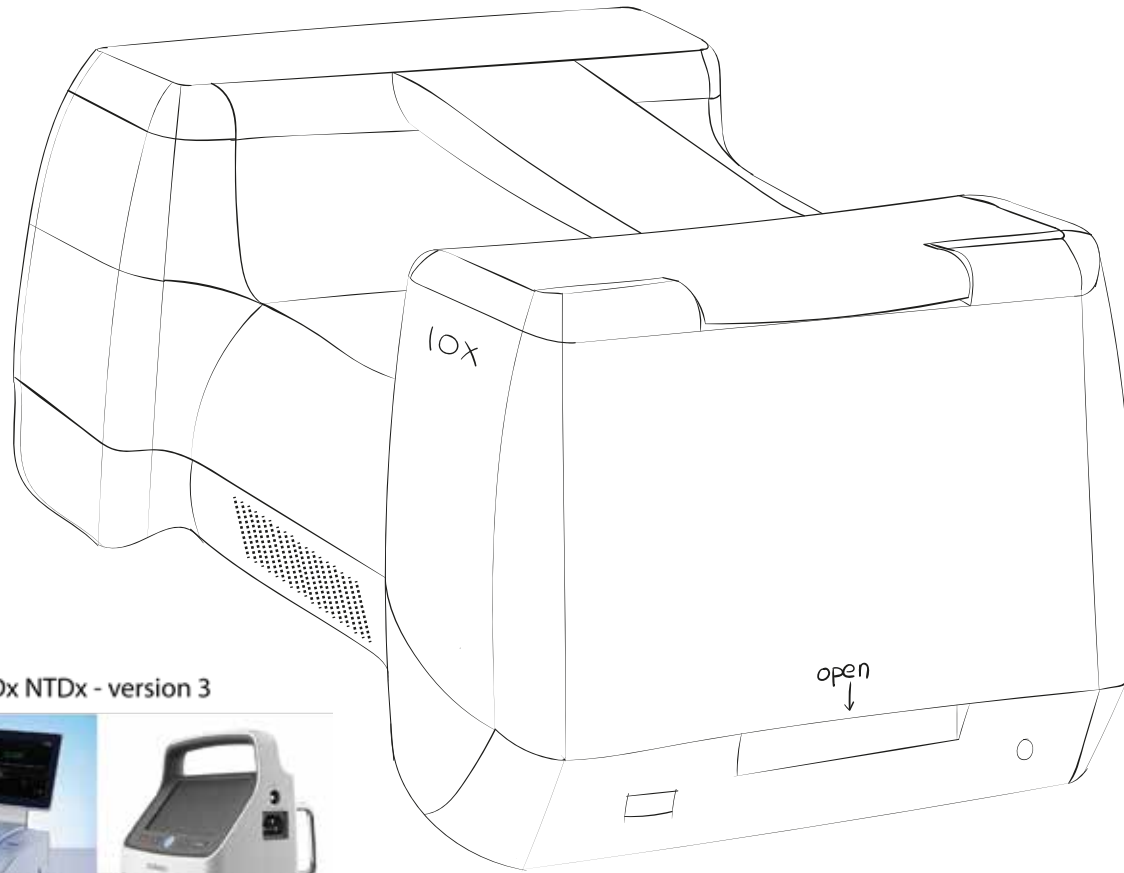
Lastly they mentioned that they want the AiDx NTDx as small as possible. The current size is good, but preferably a little smaller.

APPENDIX 14 - HANDLE IDEAS





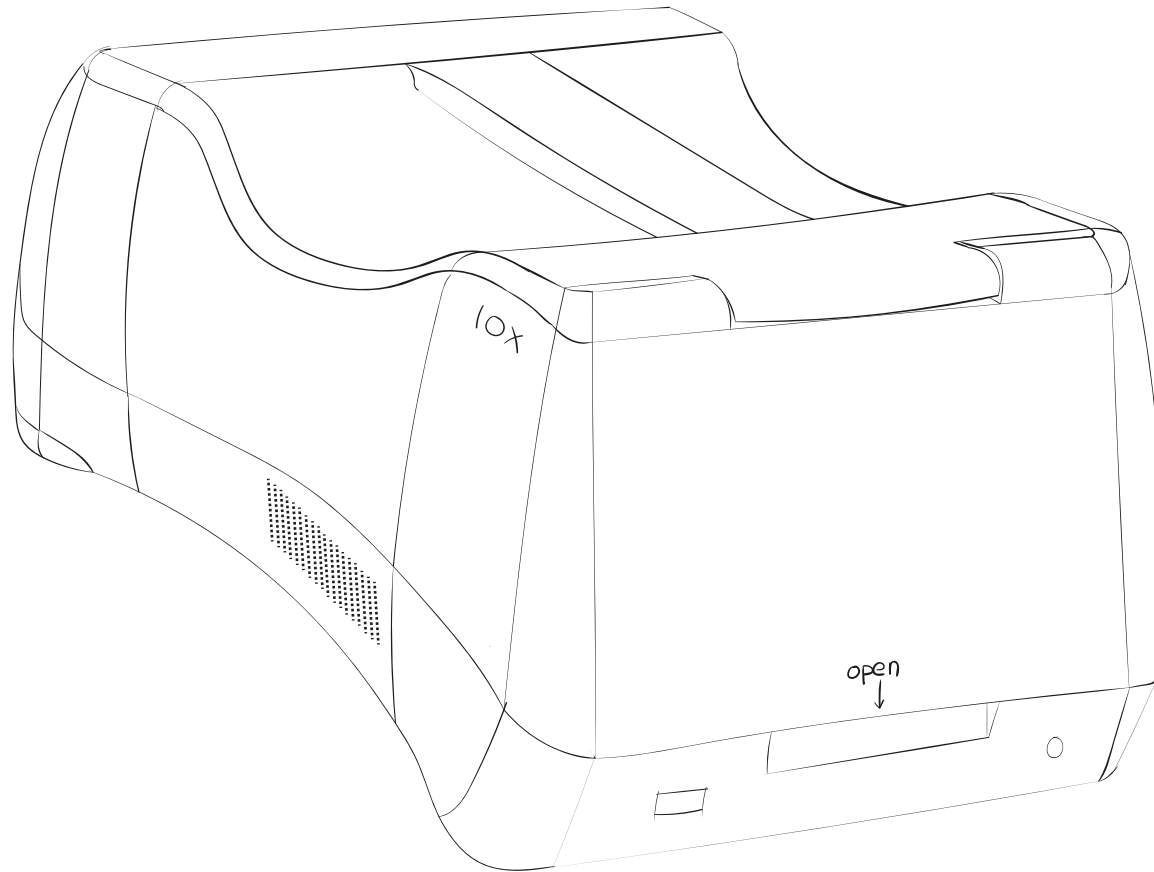


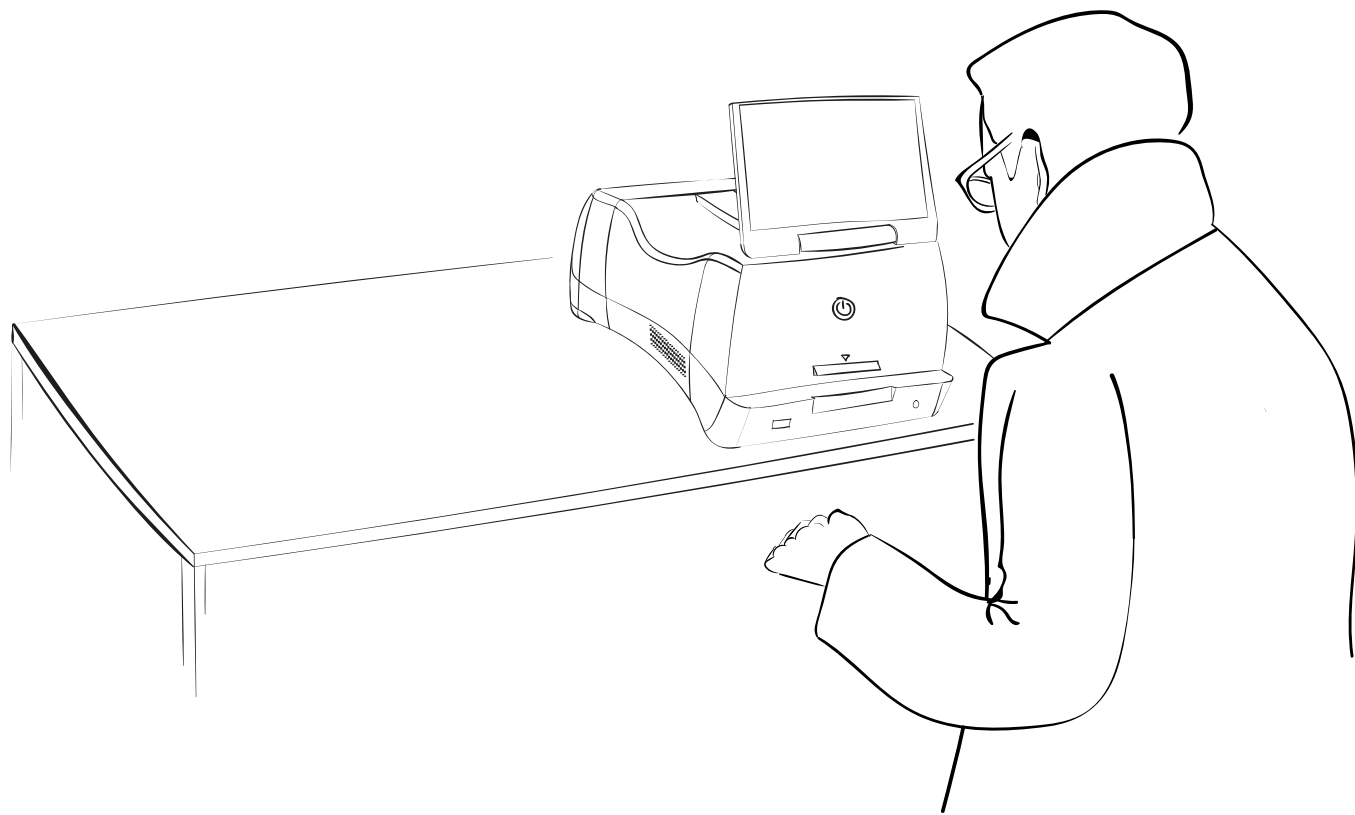


Collage with envisioned style for the AiDx NTDx - version 3

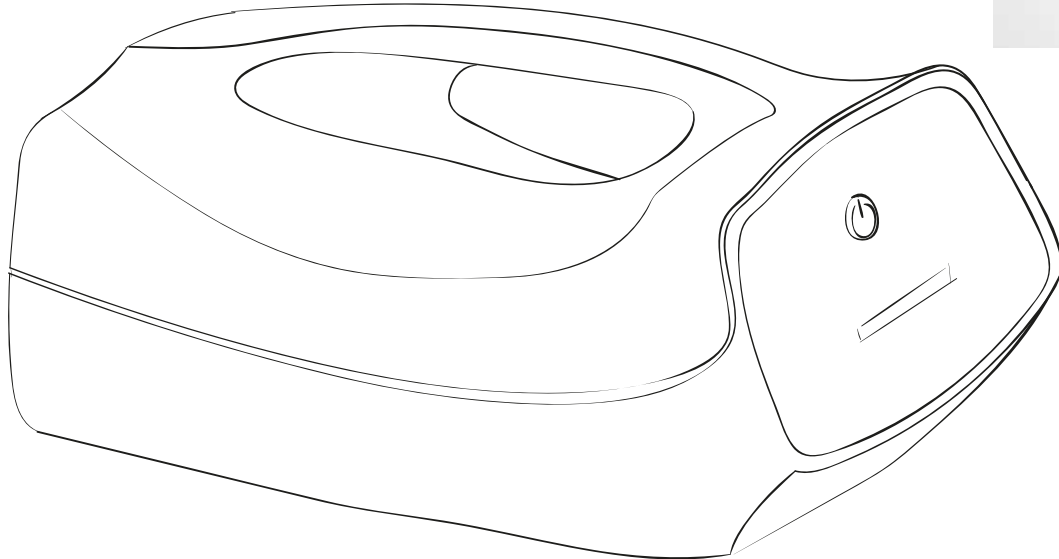
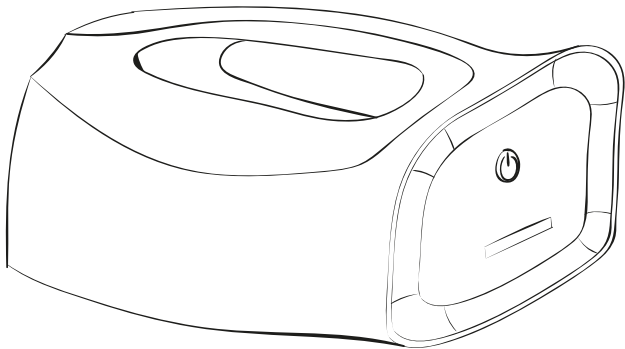
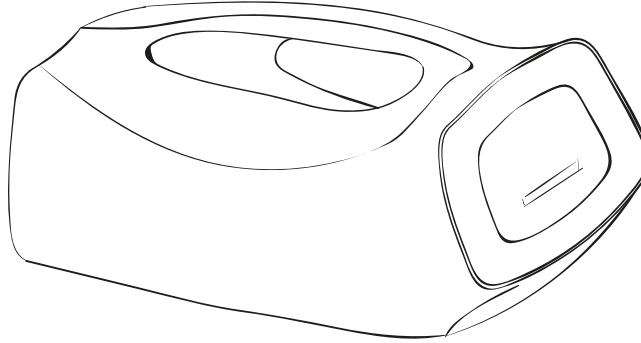
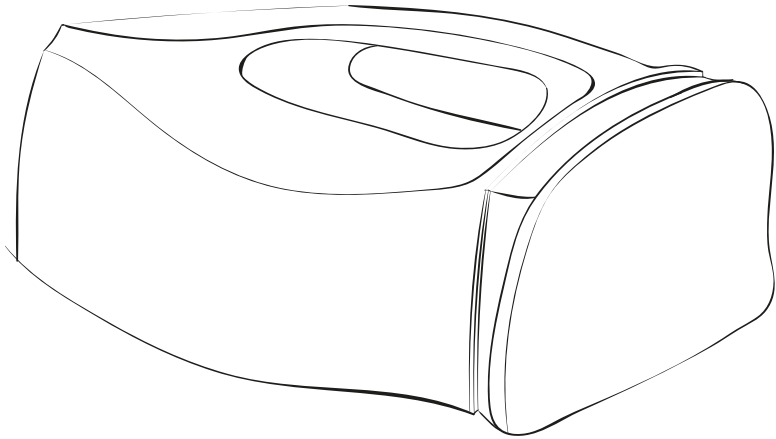


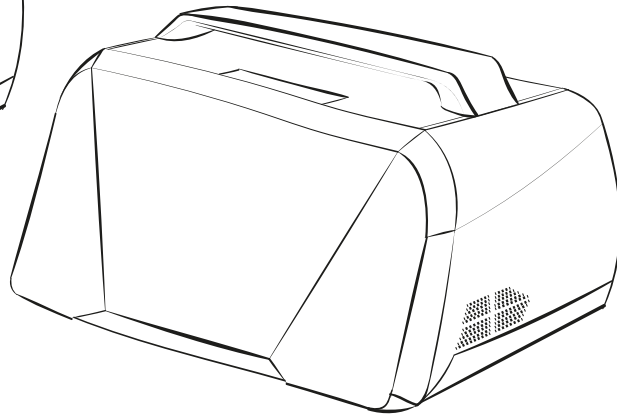
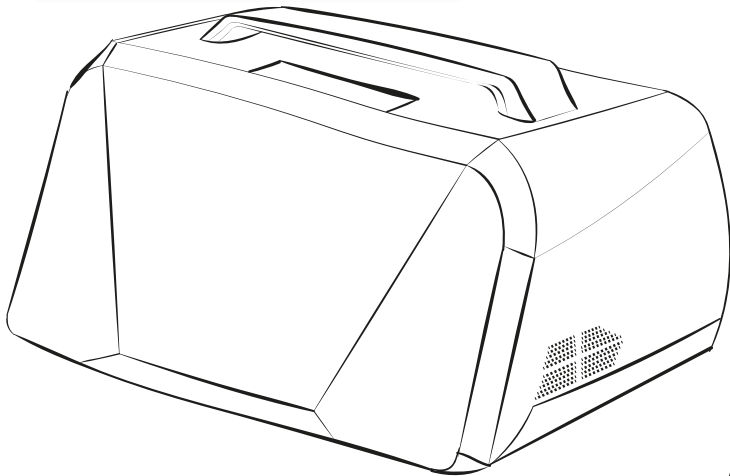
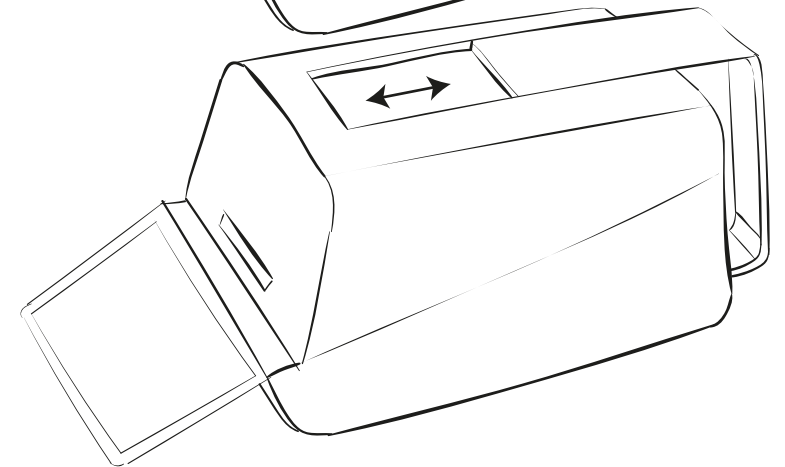
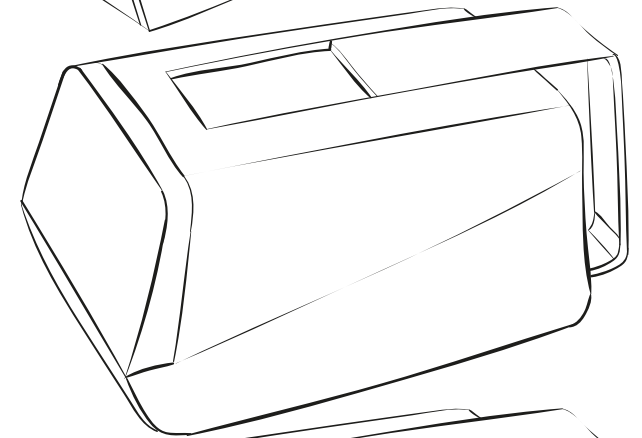
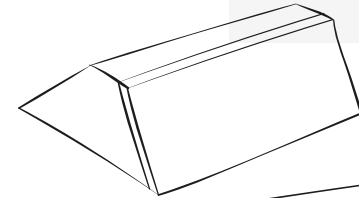
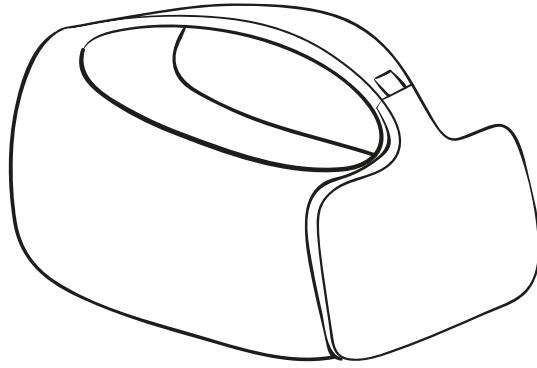
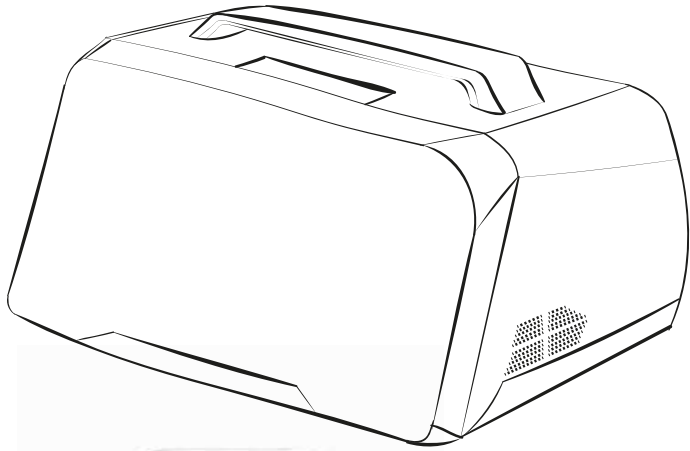


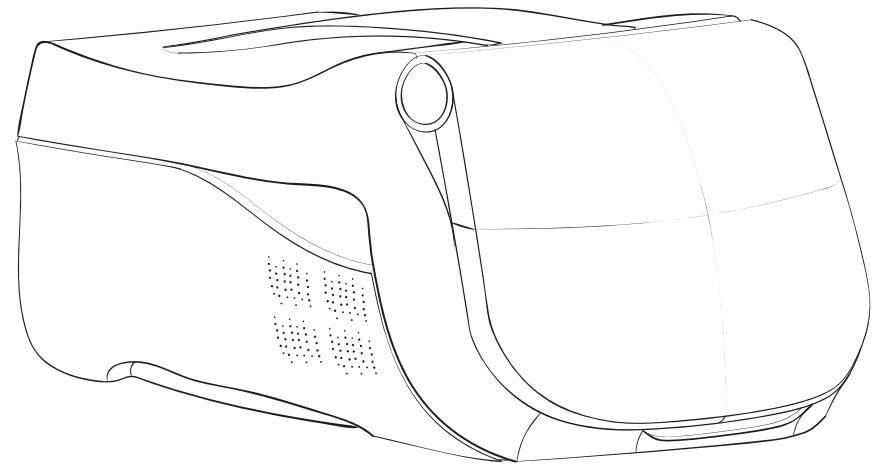
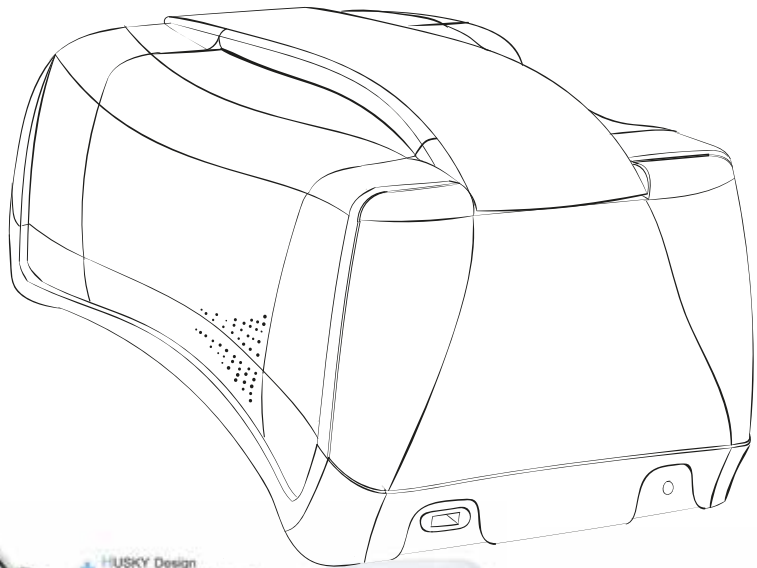




APPENDIX 15 - PRE-CONCEPTS

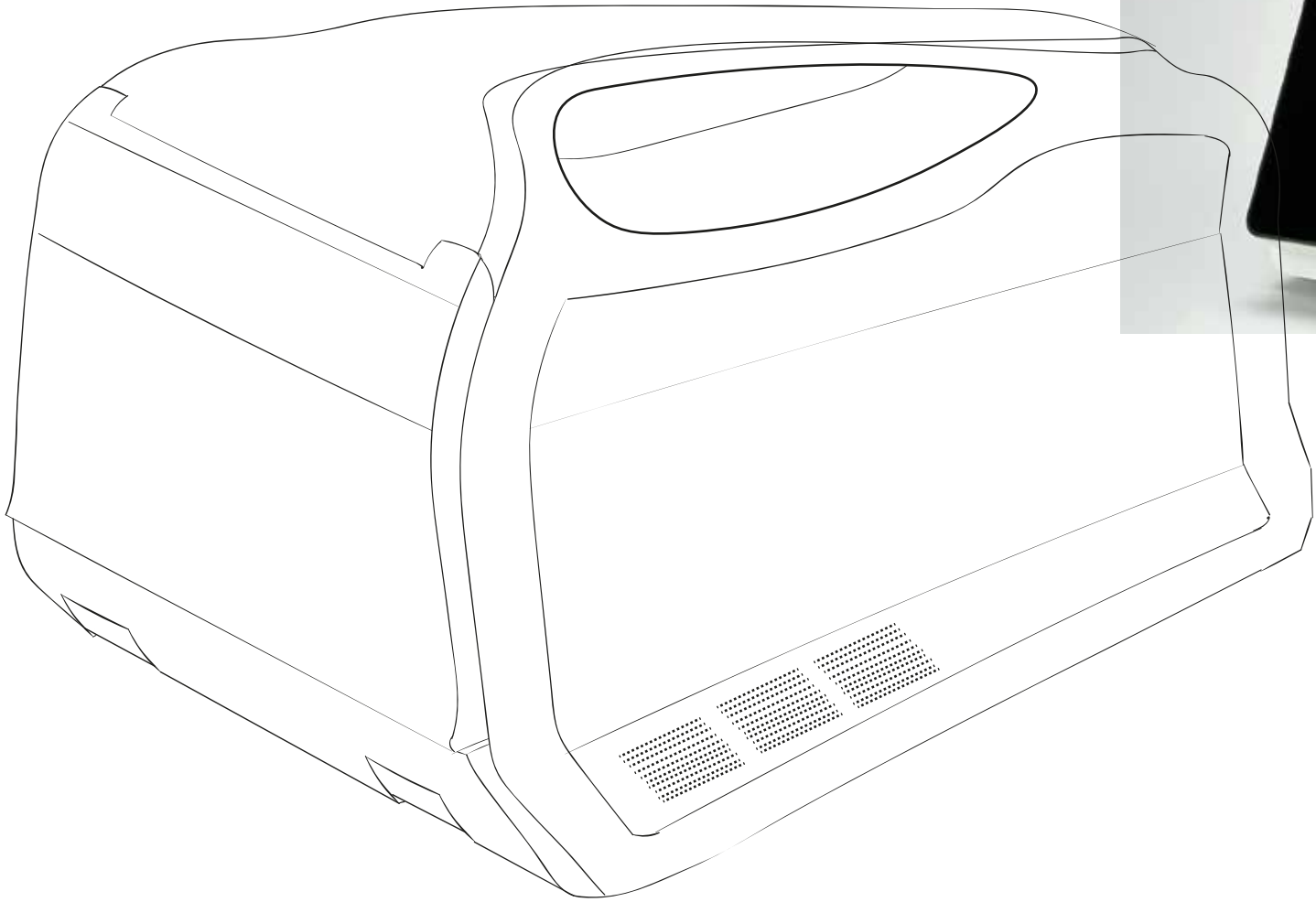


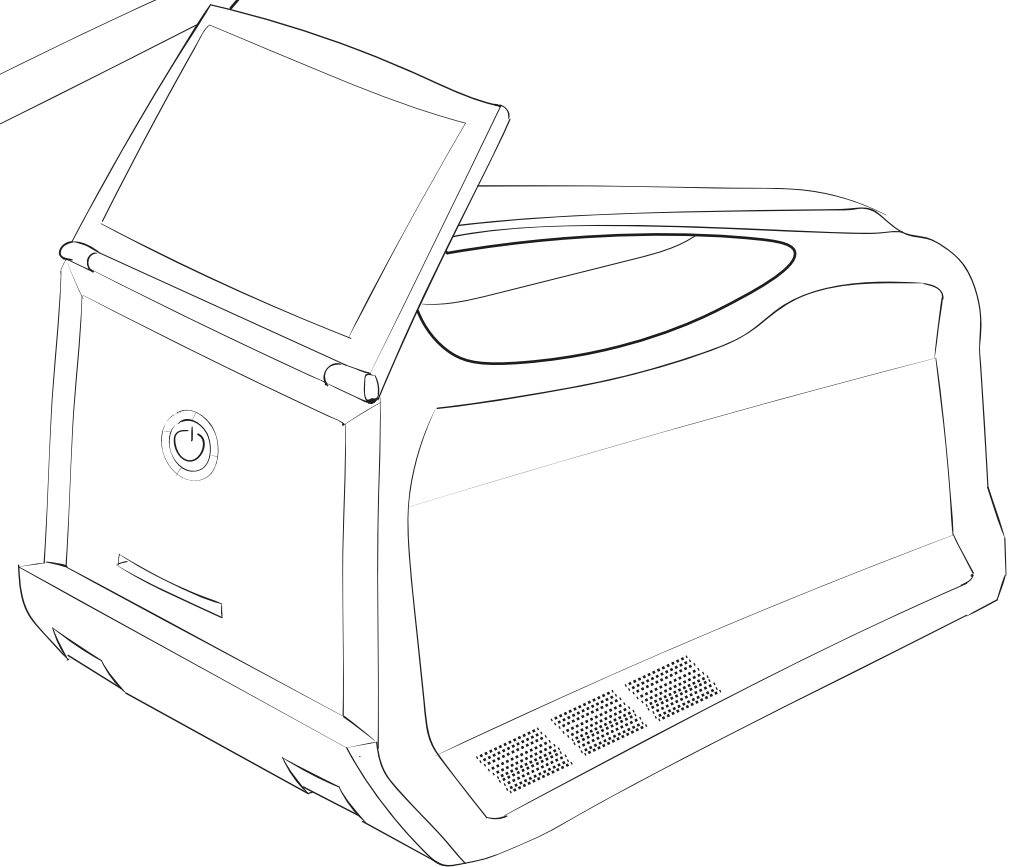
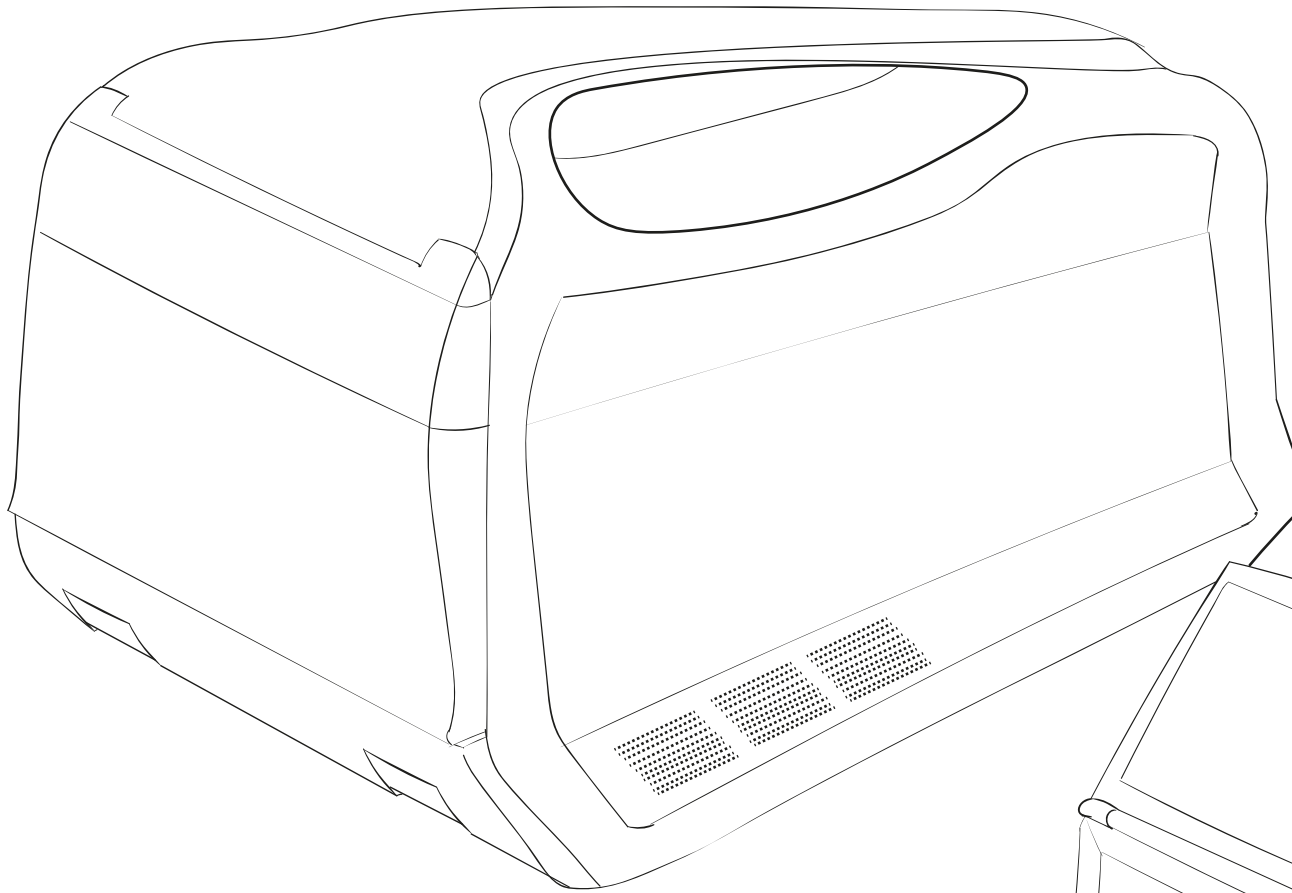


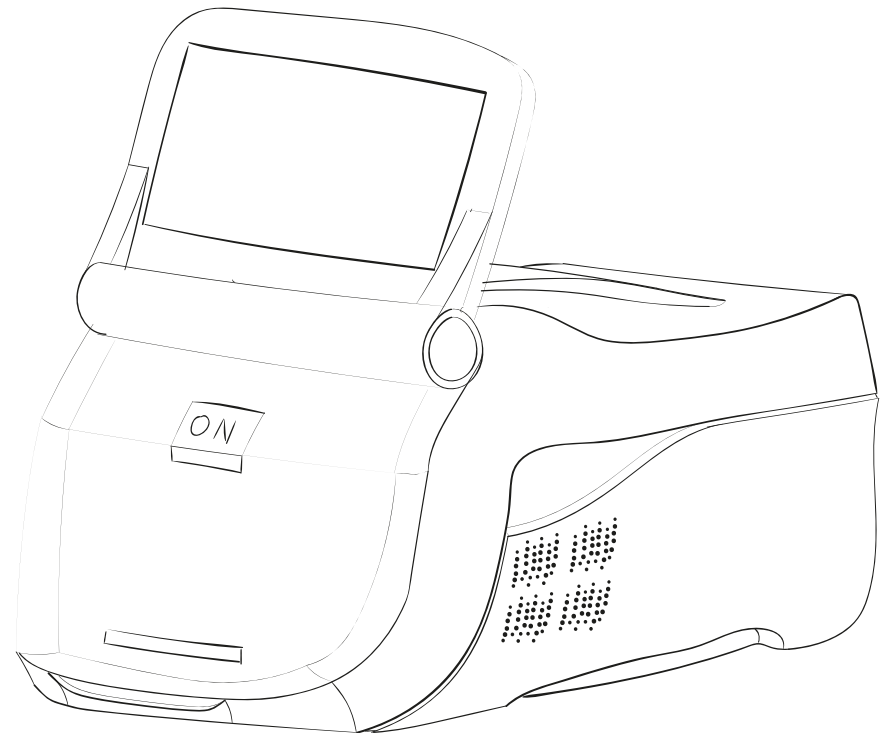
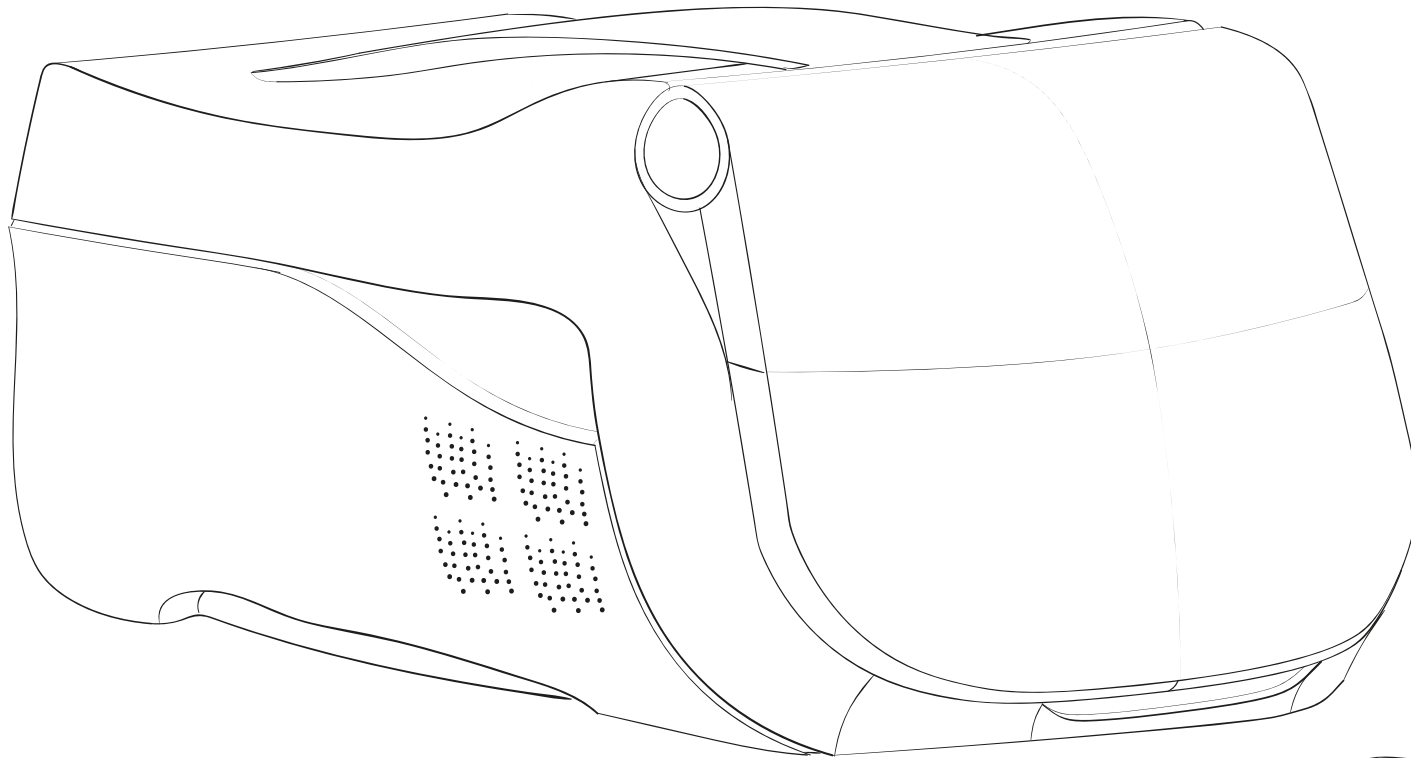


+ HUSKY Design
high potential therapeutic equipment

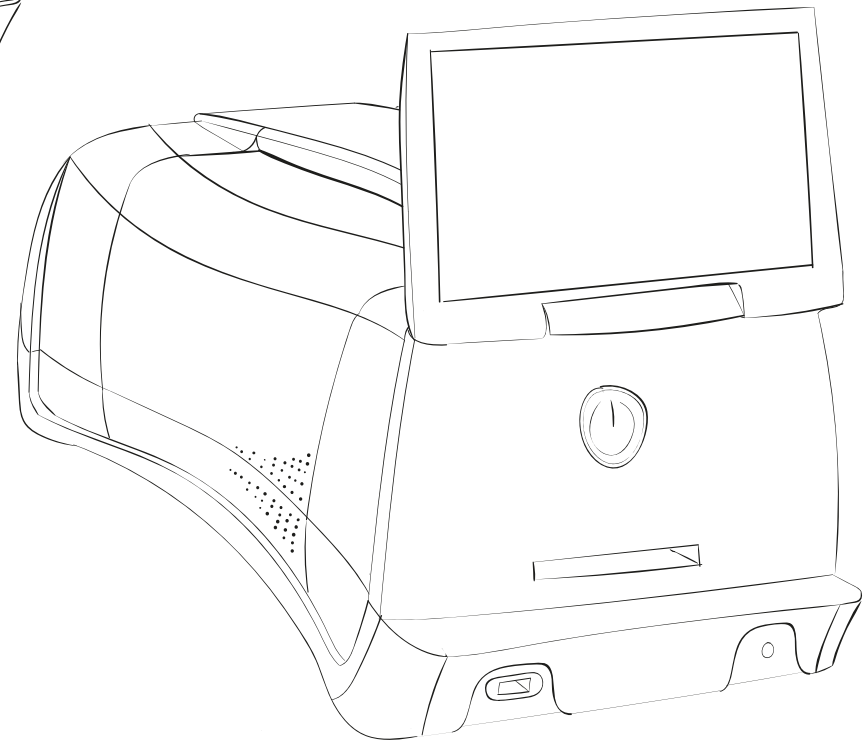
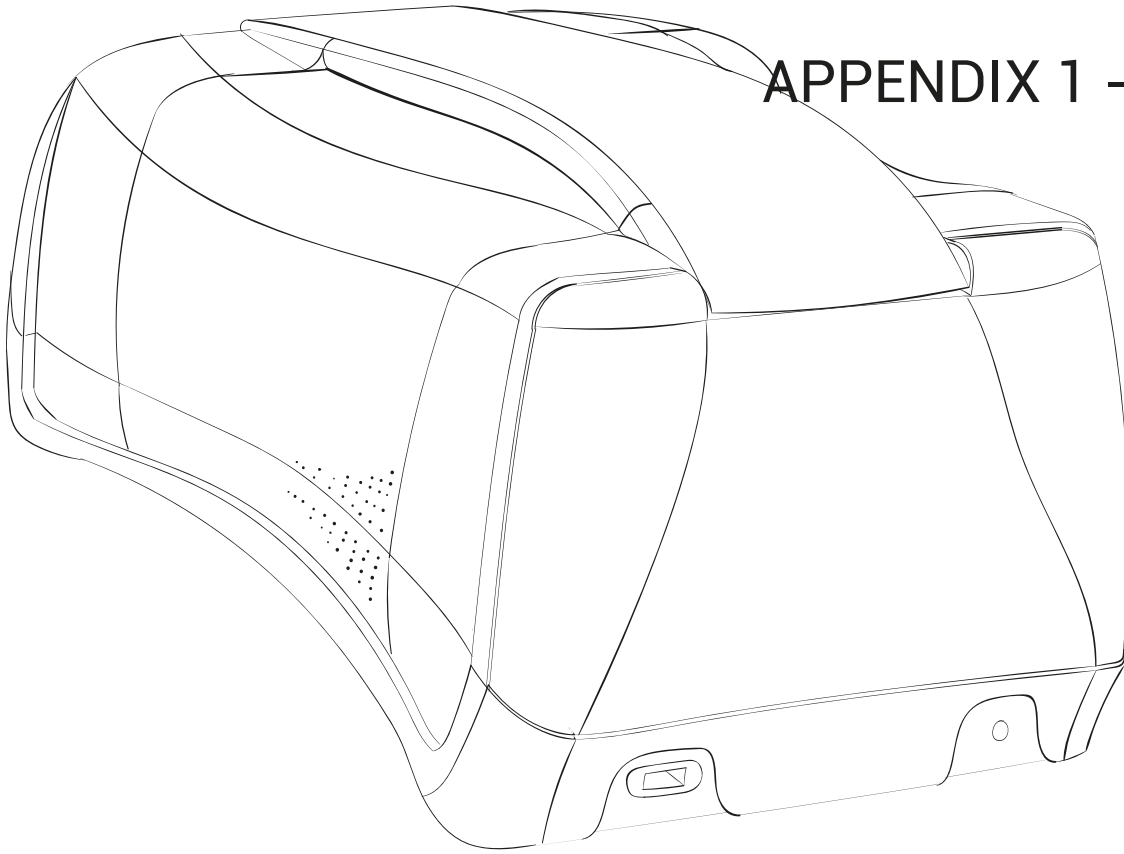


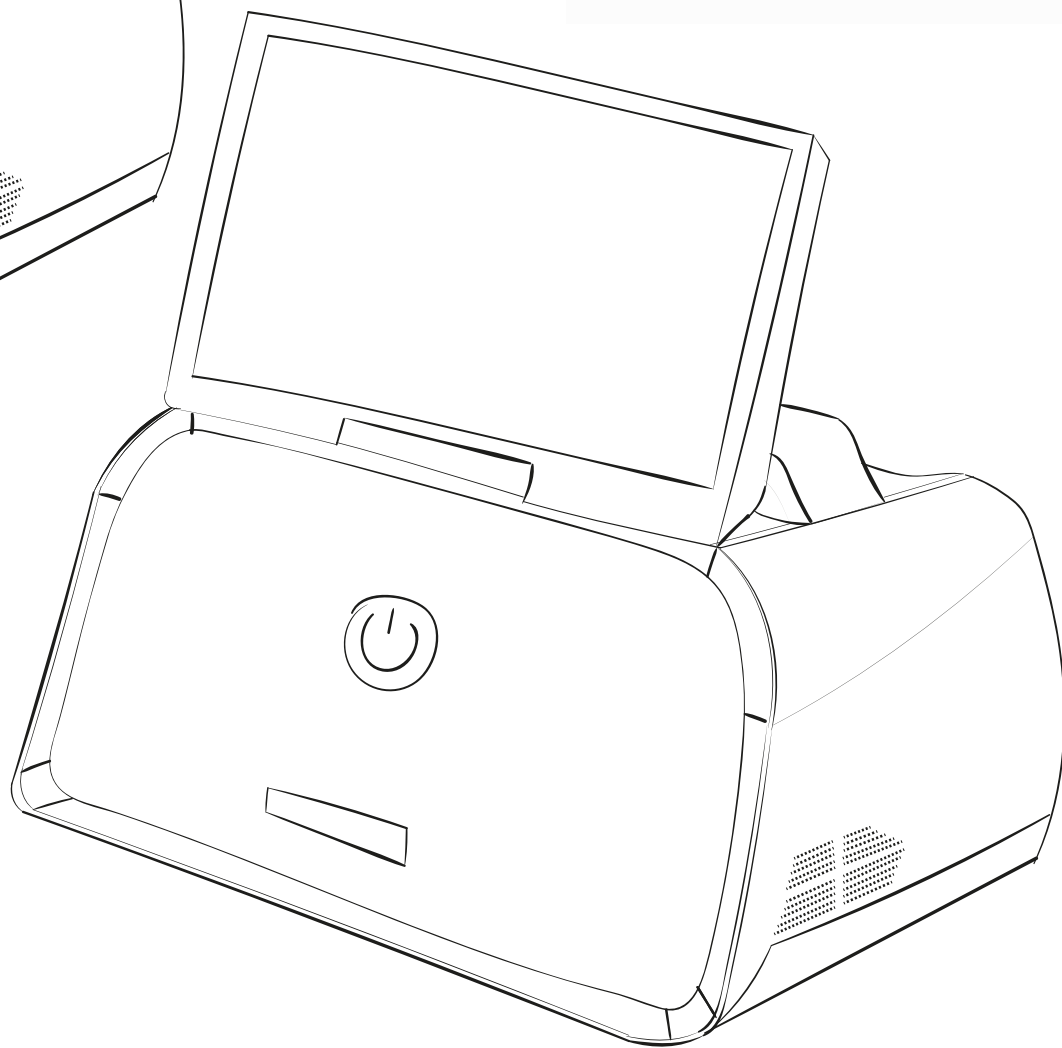
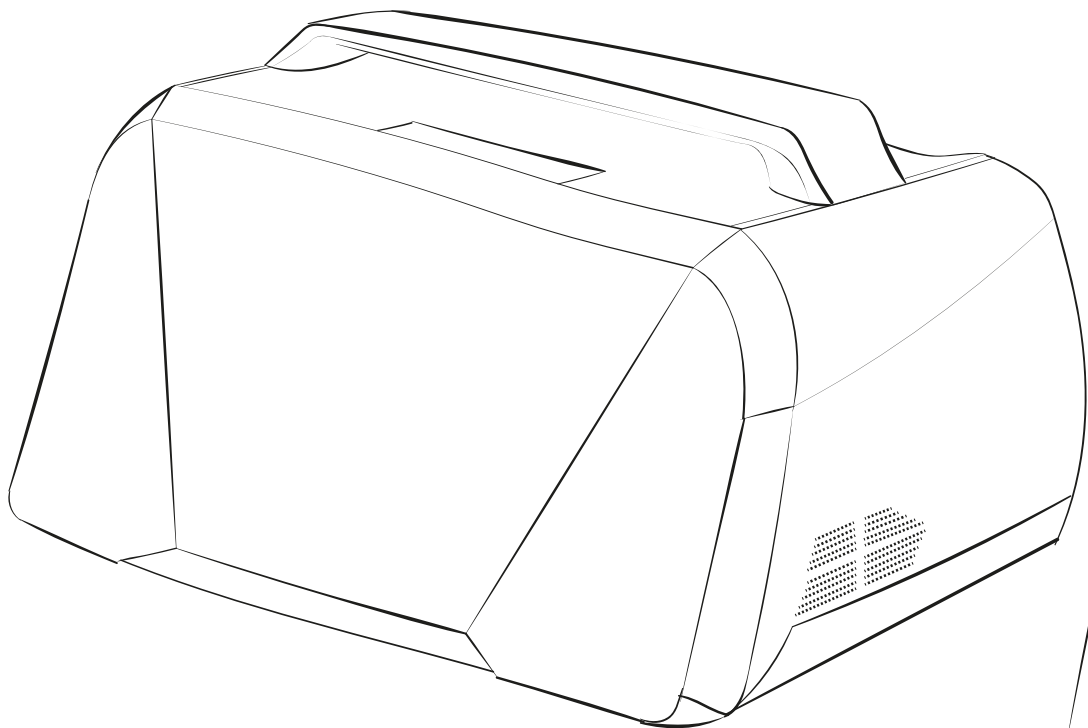




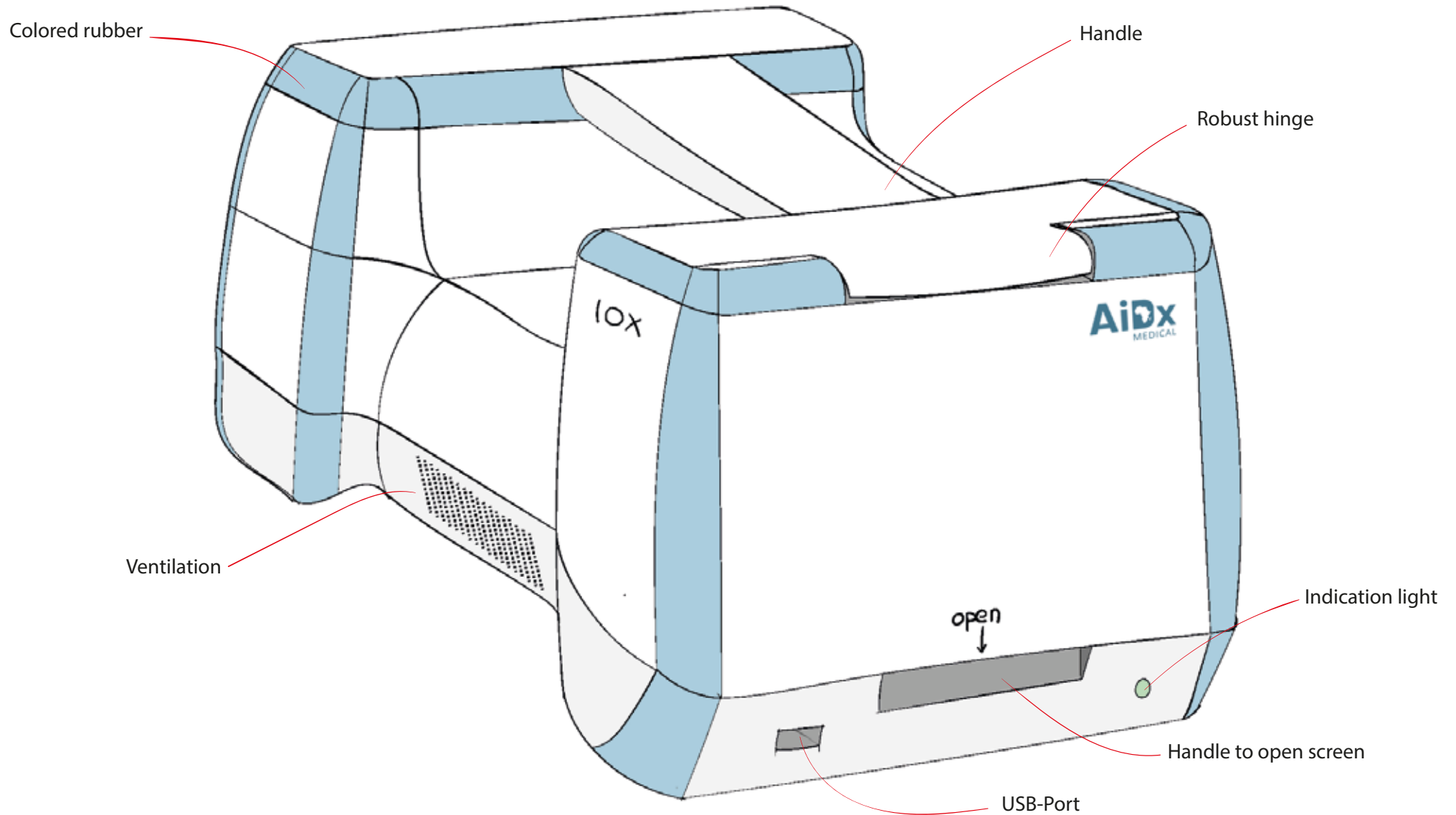


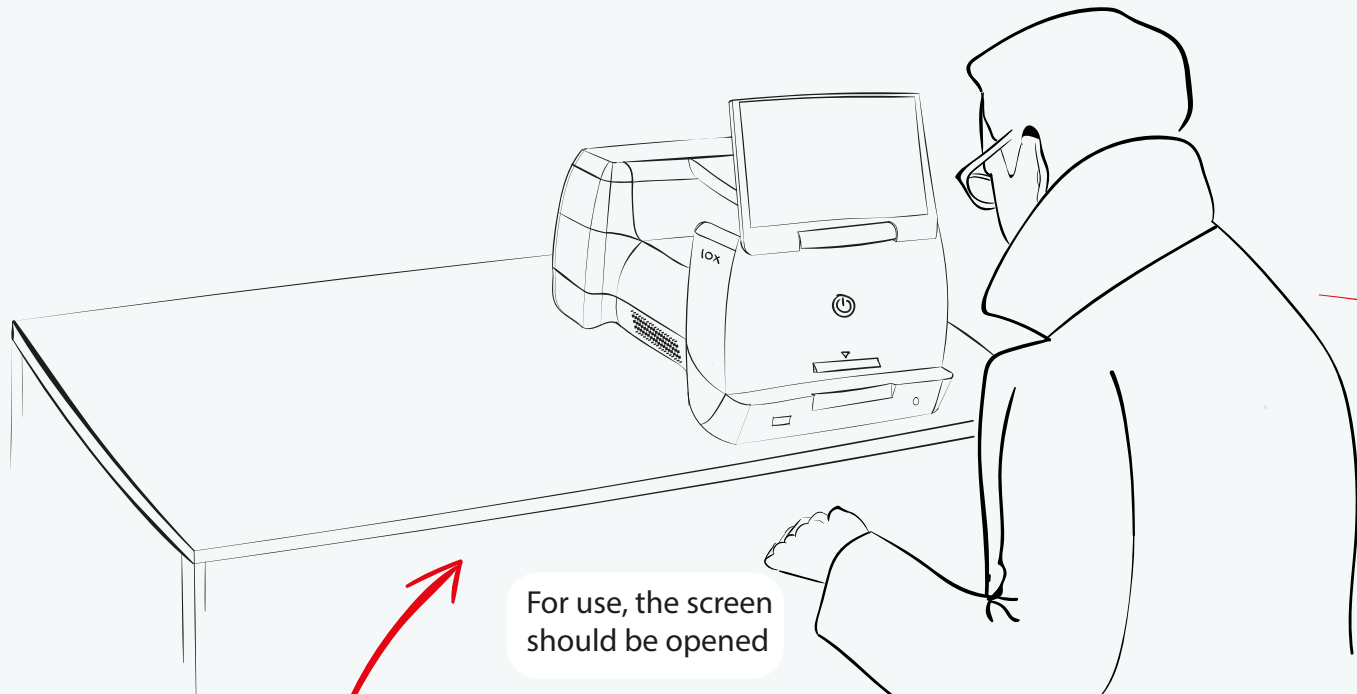
APPENDIX 1 - PLANNING





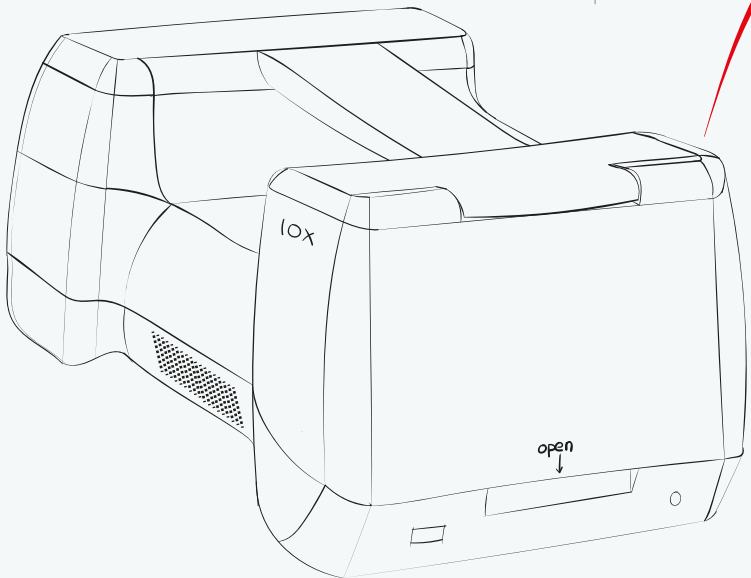
U-Shape



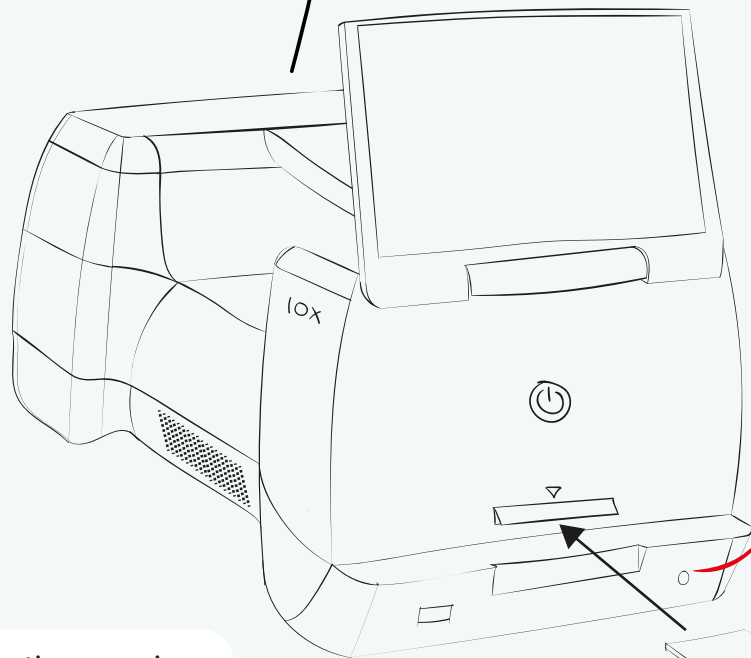


Easily transported by the handle

For use, the screen should be opened



The glass slide insertion opening is only opened when the slide has to be put in or taken out



After inserting the slide, the scan can be started

Battery status communication

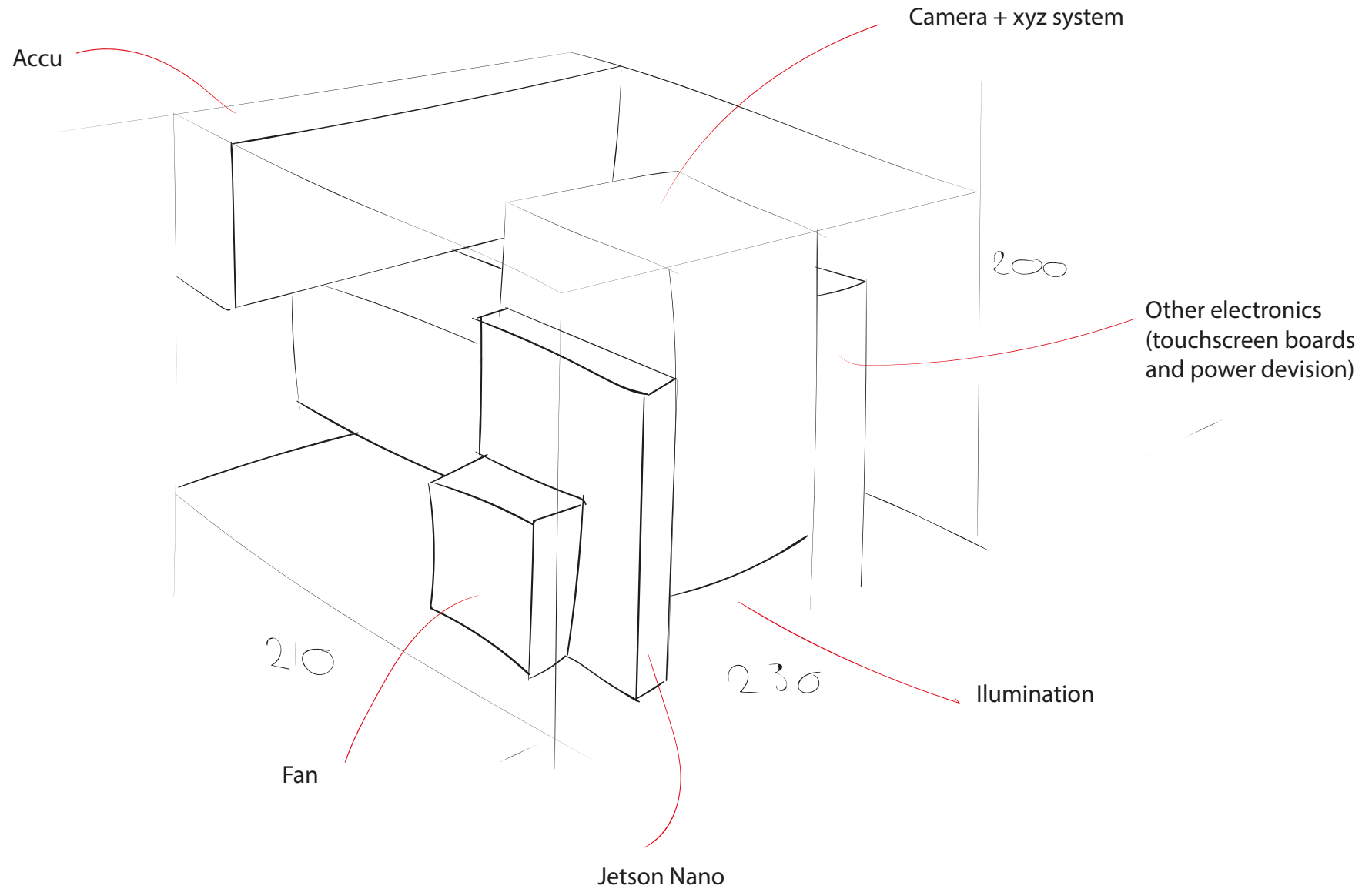
- → 100% Battery
- → 50% Battery
- → 10% Battery

Battery status can also be read from screen

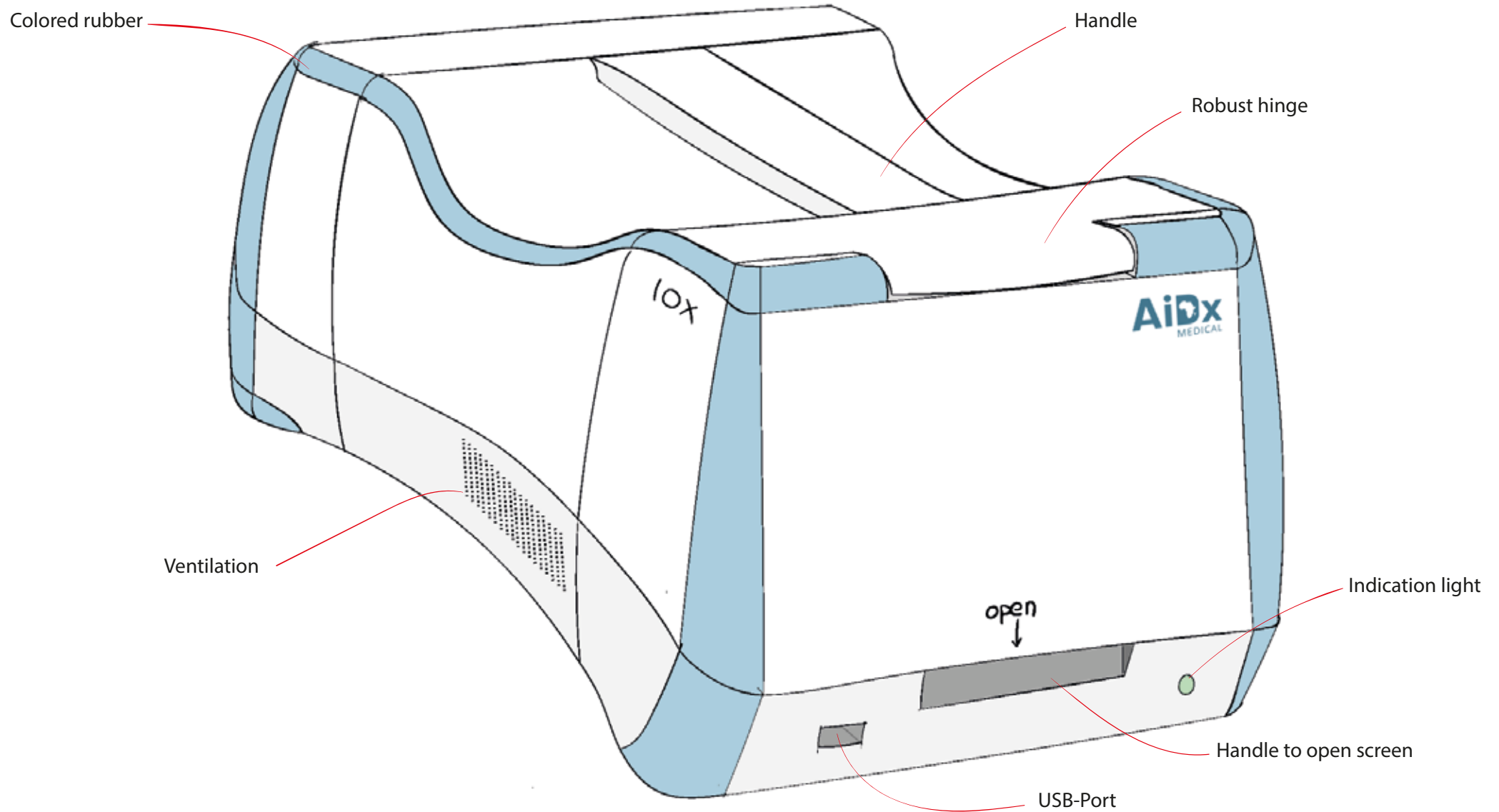
The interaction below will be executed with a color depending on the battery status

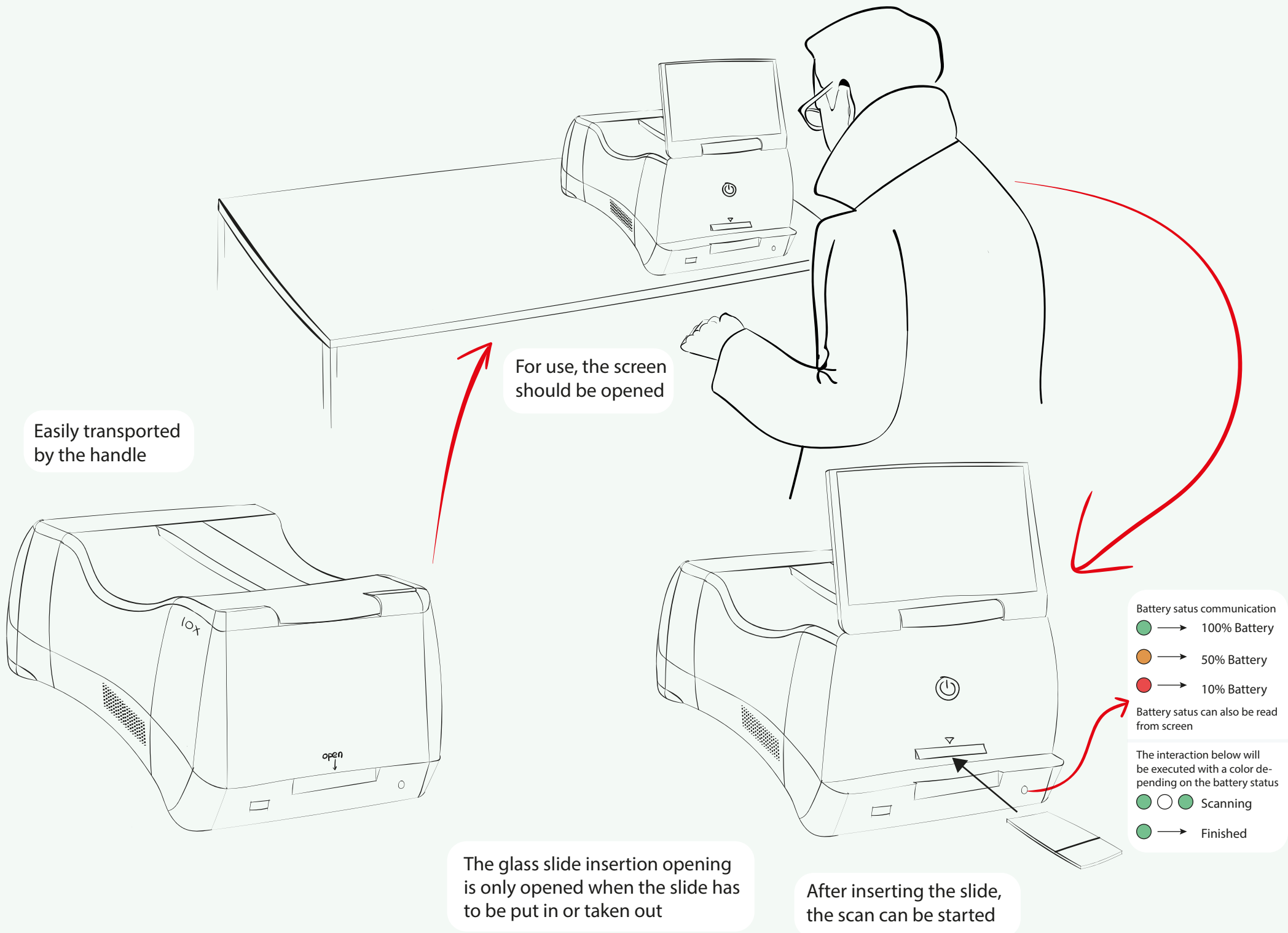
- ○ ● Scanning
- → Finished

INNER PARTS

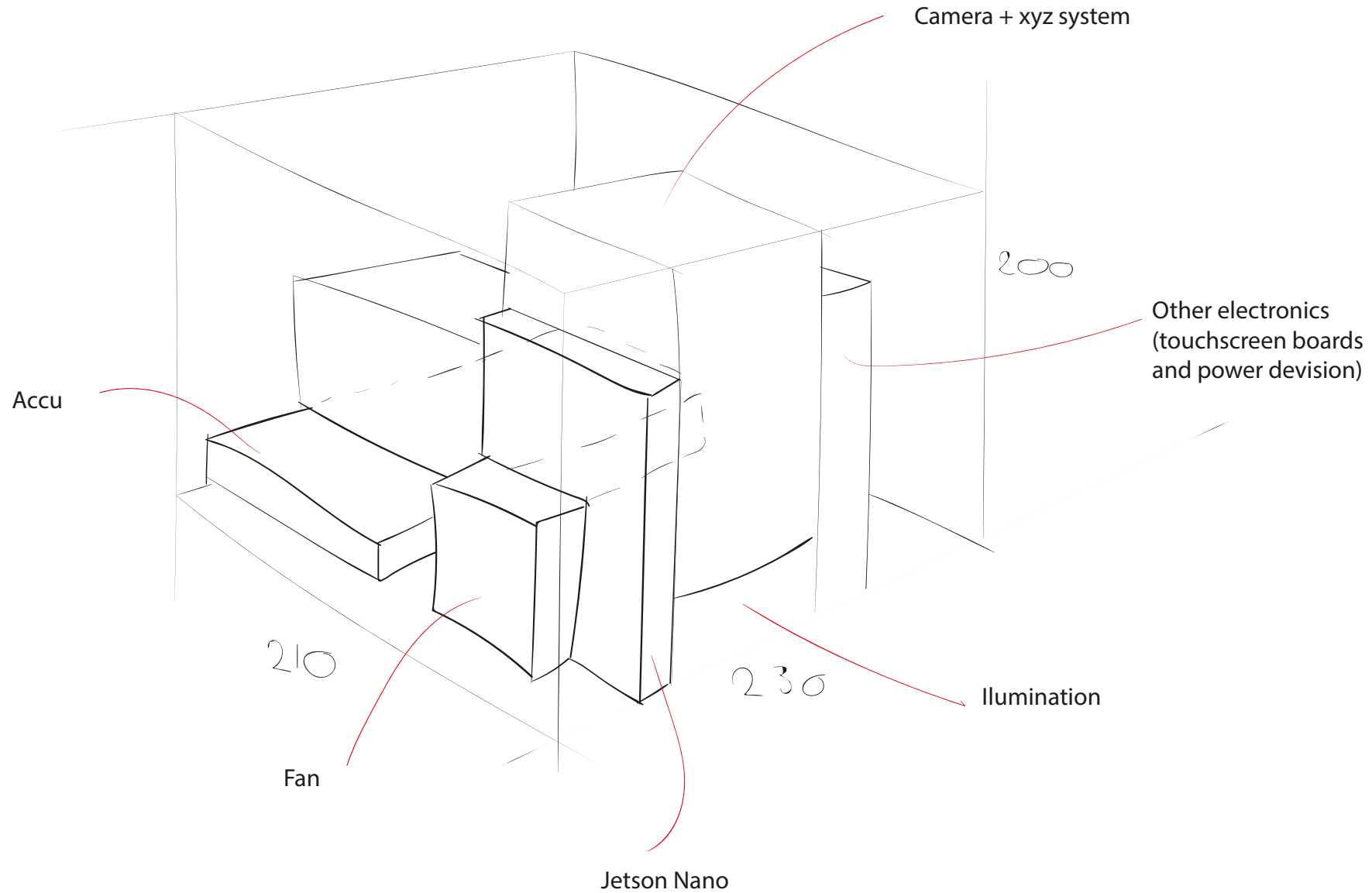


FLUENT BEND





INNER PARTS



Feedback

APPENDIX 1 - PLANNING

After presenting these designs, anonymously Brice, Animashaun and Iyilona went for the fluent bend design. That design looked more attractive to them. However they liked the presence of blue on the U-shaped more than on the fluent bend concept, because the blue in the bended shape was a little to less.

The bended shape was liked more especially when looking at the side view. As I concluded before, harmony and symmetry are quite important for my target group and should be represented in the product. When looking at the side view of the U-shaped, you see different compartments, whereas you look at the side view of the fluent bend design, you see one coherent whole. I think that is the underlying factor of determining that they like the fluent bend design more

Conclusion

With this knowledge I will choose the fluent bend as my starting position to prototype.

APPENDIX 17 - STYLE COLLAGE

Finding the right style - Collage

The AiDx NTDx will be used in Sub-Saharan Africa and mainly in Nigeria at first. The appearance of the device should be conform the appearances of laboratoric devices the people in Sub-Saharan Africa are used to. In order to discover the style that the device should be, I have to talk to them and let them tell me what they like. This because the western view on aesthetics of medical devices can be a lot different than the view of Nigerian medical experts.

Collage 1

The first collage are devices that I encountered in a laboratory in Leiden. This is combined with diagnostic devices that Temitope has seen in Moroccan labs

Collage 2

Based on the first collage, I developed a collage with more different types of devices. Also I included devices that looked to me like an aesthetically pleasing microscopic device.

Collage 3

After discussing the second collage with Brice, I developed this third collage. The input Brice gave can be seen in Appendix 7. I omitted some designs who were mainly white and I added some devices that have more blue accents. Also I added some detailed pictures about different structures and textures. This collage is developed mainly to get to know the preferences of future users with regard to structures, textures and the preferred 'shape-language' (e.g. curved or sharp edges)

Collage 4

The third collage was presented to an experienced microscopist in Nigeria in order to develop the final collage. For more detail see Appendix 7. With regard to the previous collage, this collage presents more curved designs, omitted black, omitted shiny white plastic and included mat colored white plastic.

Diagnostic devices present at Lab in Leiden University and Marrocon Lab



Collage with envisioned style for the AiDx NTDx - version 1



Collage with envisioned style for the AiDx NTDx - version 2



Collage with envisioned style for the AiDx NTDx - version 3



Collage analysis

Colors

- White
- Blue details
- Gray parts are allowed
- Limited to three different colors

Shape

- Fluent shape
- Curved edges & planes
- Elegant bulky design
- Rounded
- Symmetry
- No thin protrusions
- No sharp edges

Materials

- Main part matt appearance
- Shiny details
- Plastic materials
- Little texture is allowed

Focus



Shape



Colors



Handle

Symmetry



Shape

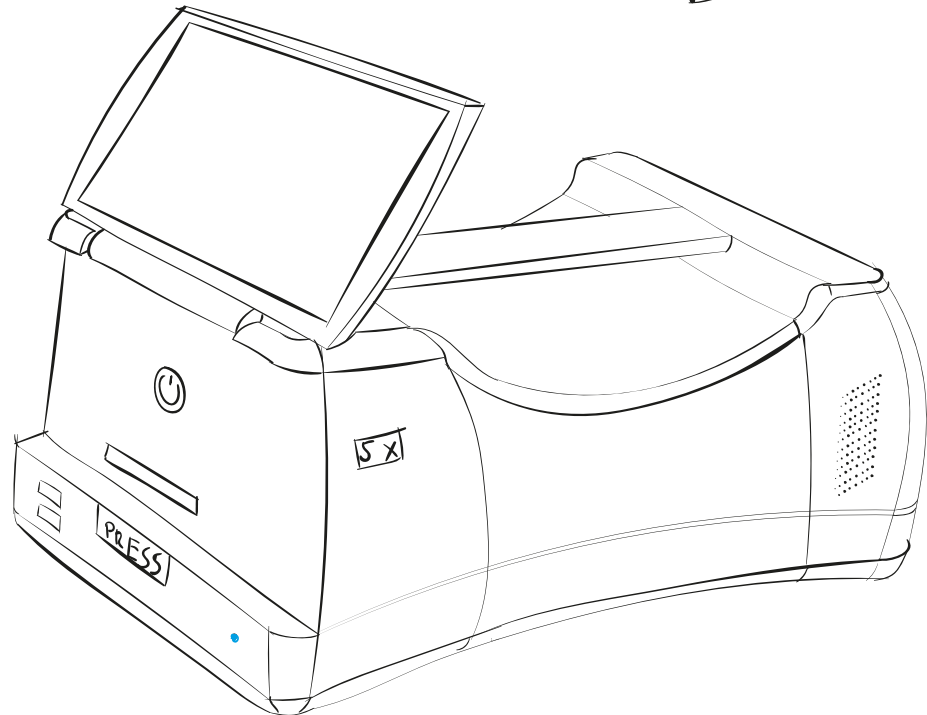
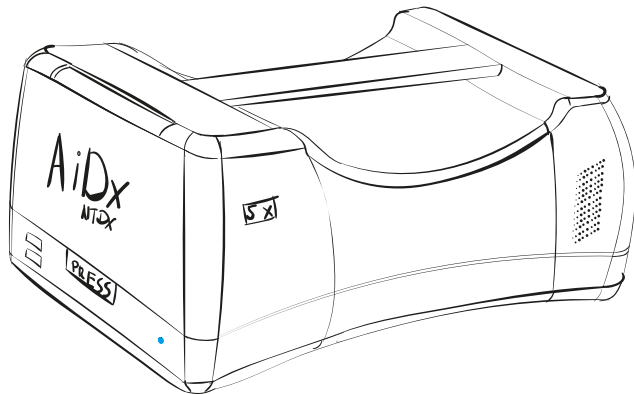
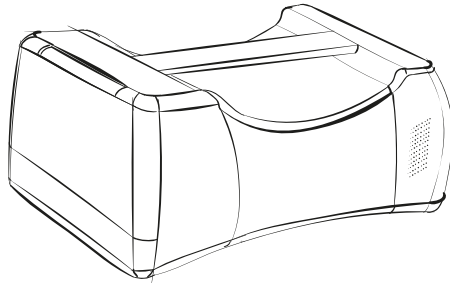
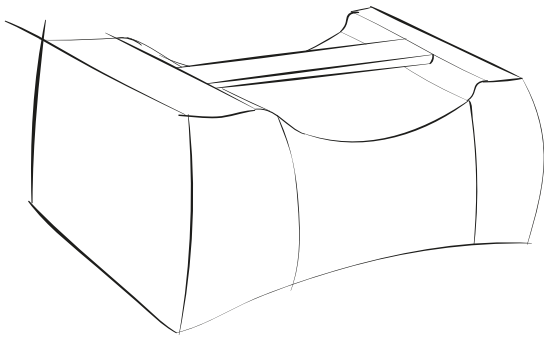
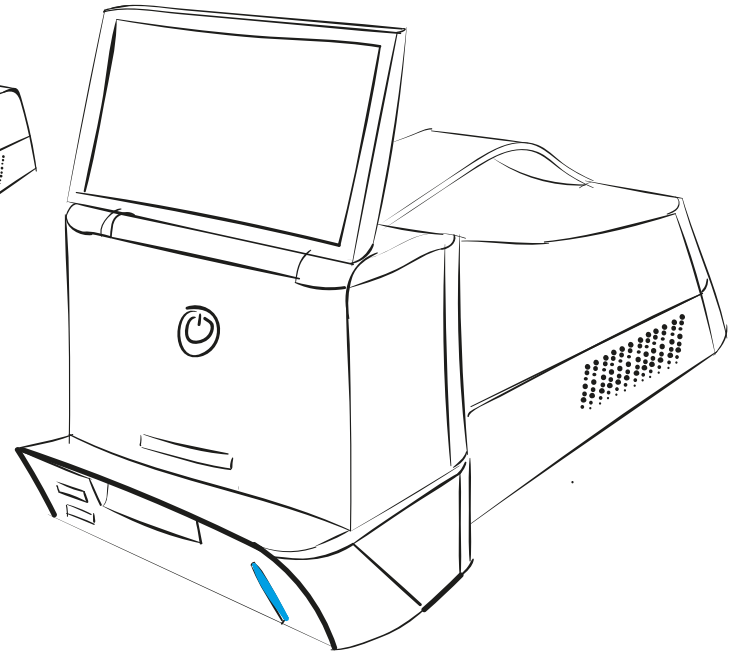
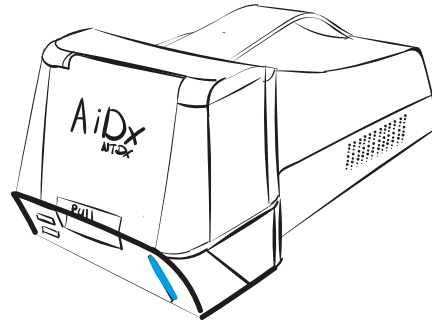
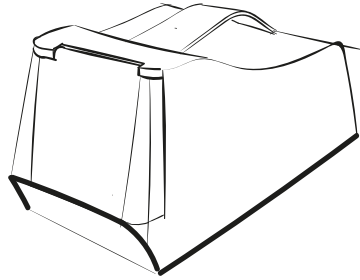
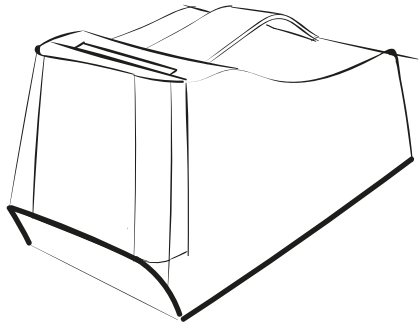


Colors

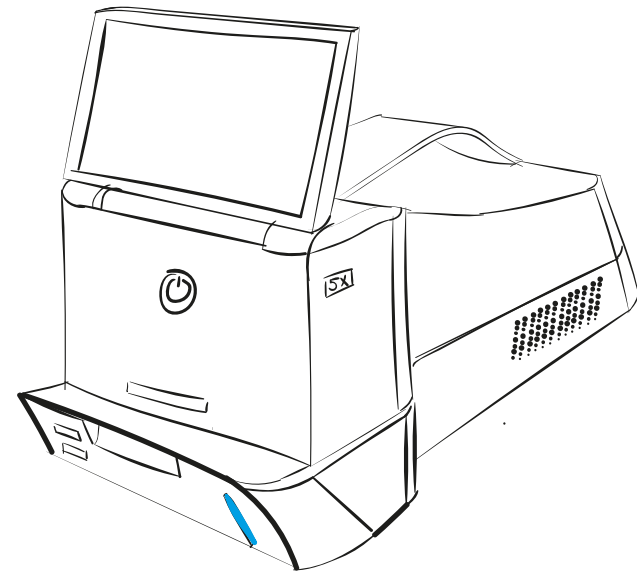
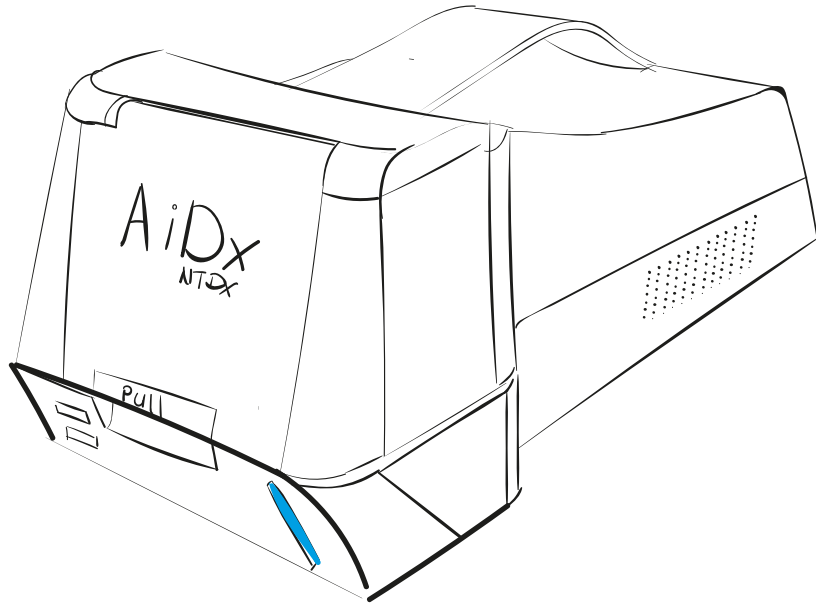


Handle

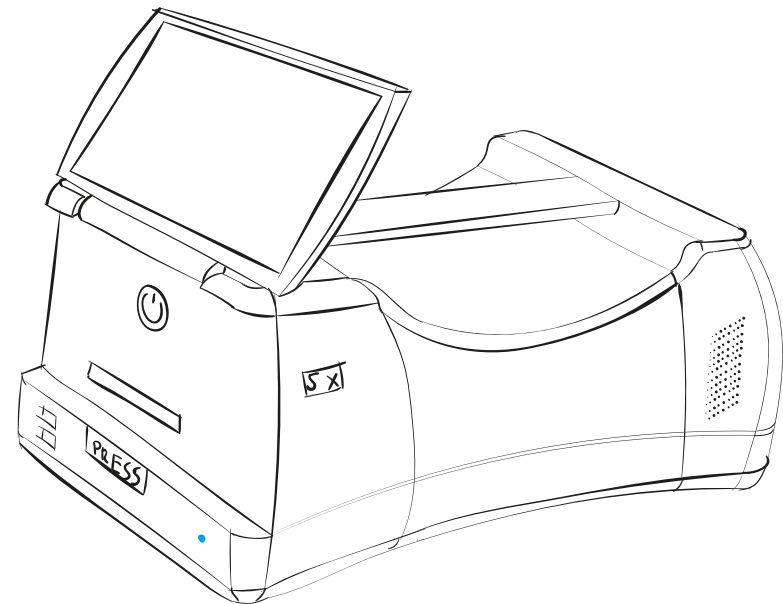
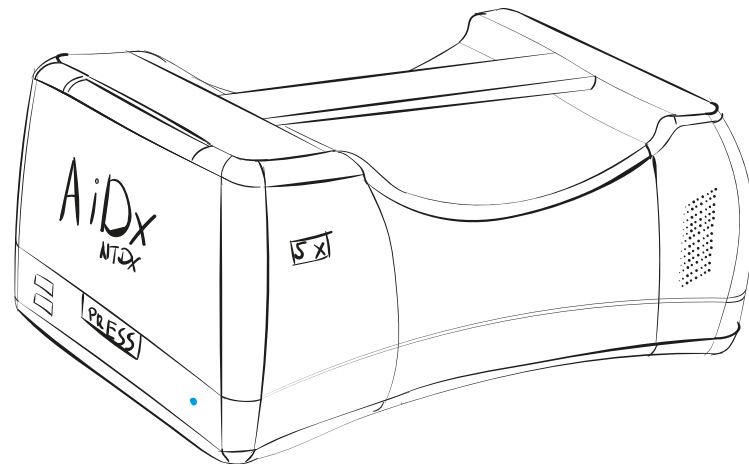
Sketches based on collage & analysis



One sided



Symmetry



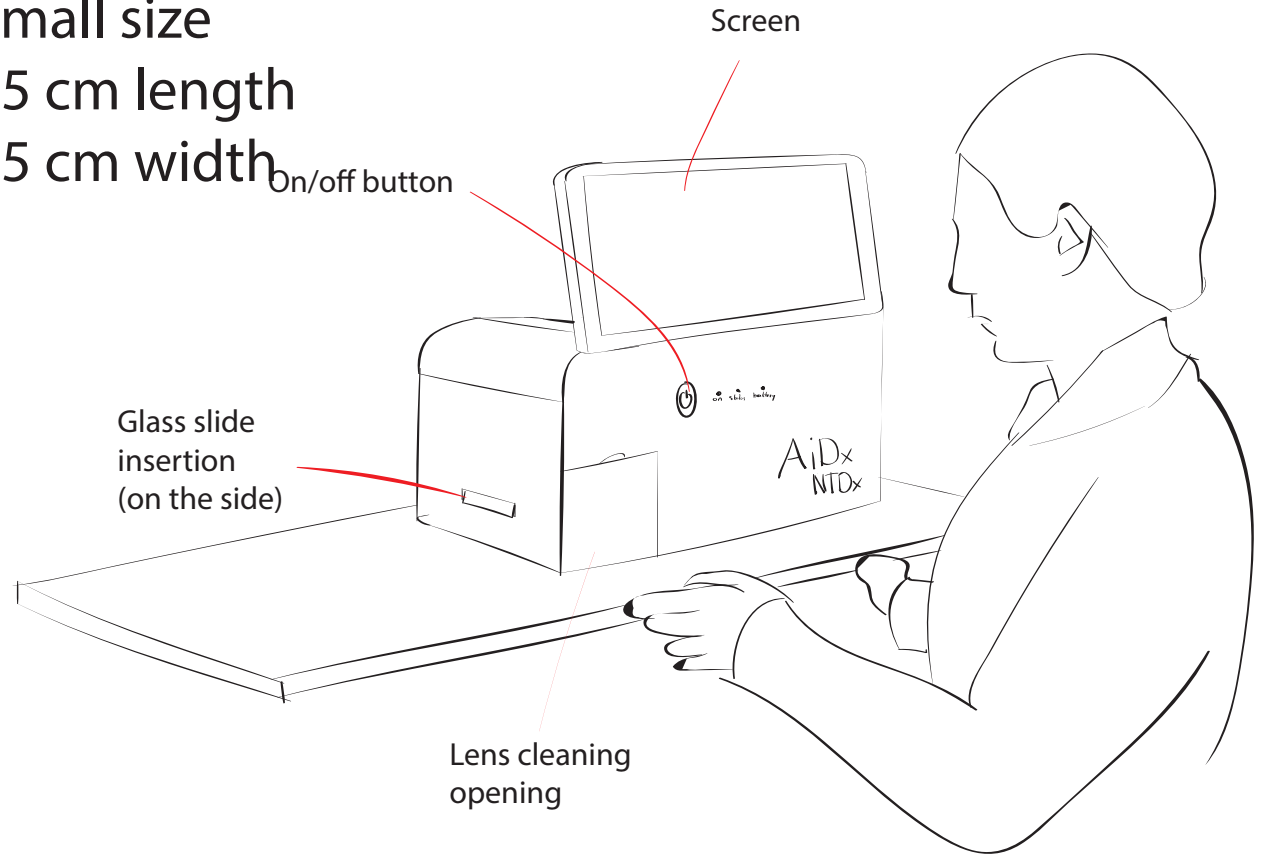
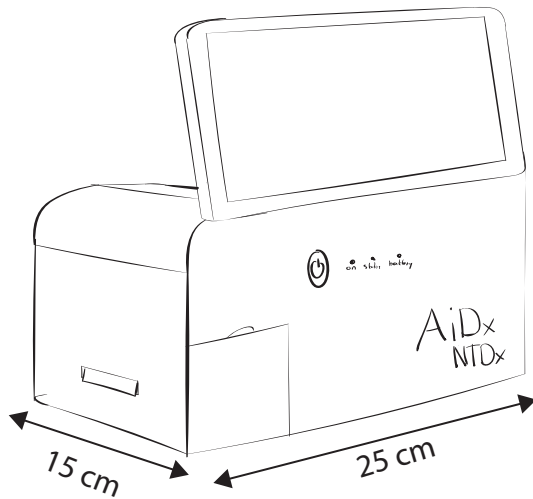
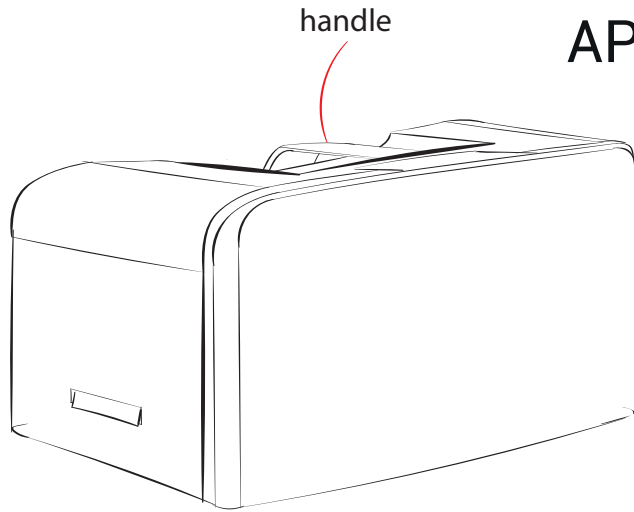
APPENDIX 18 - SIZE EXPLORATION

Glass slide insertion and screen on different sides

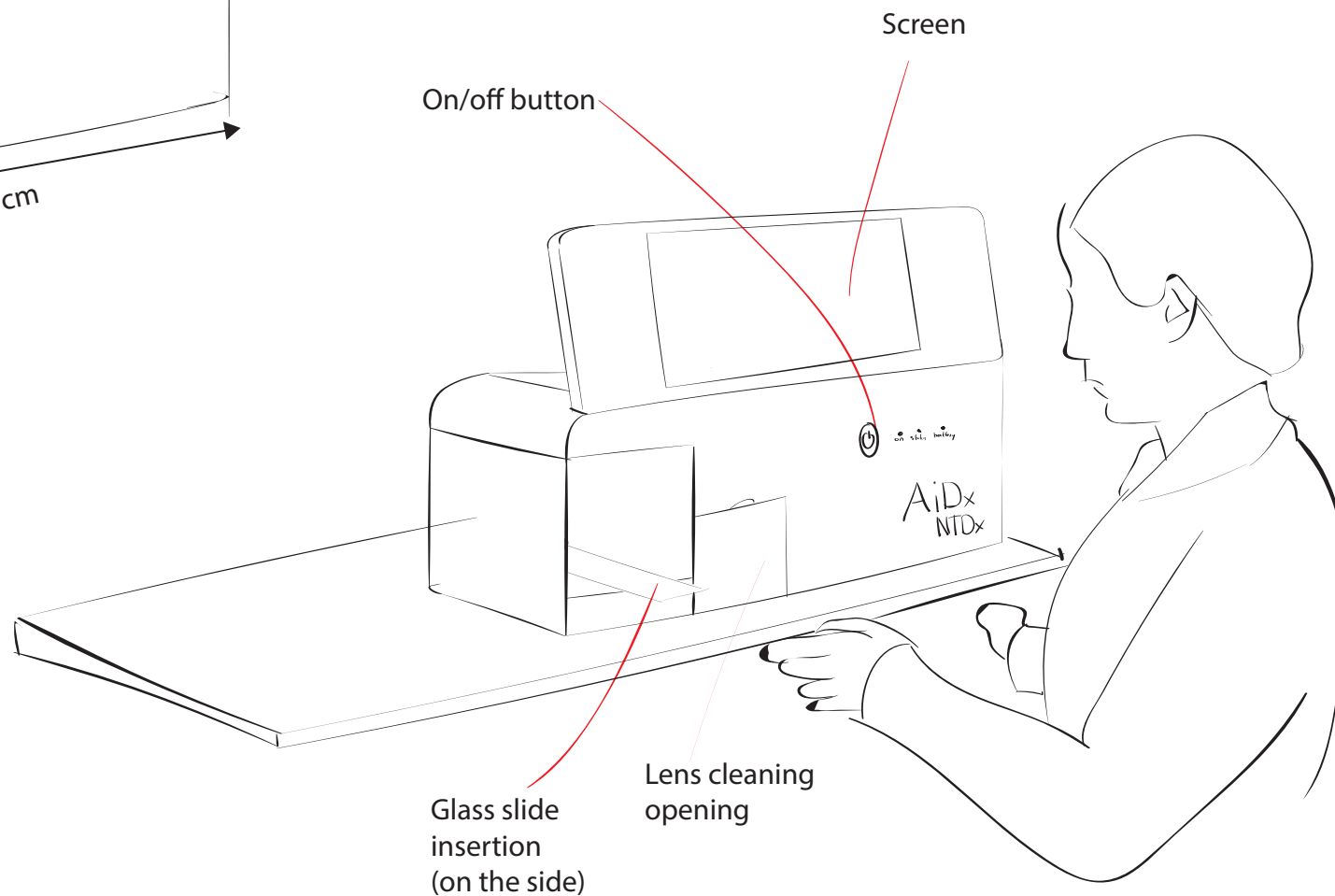
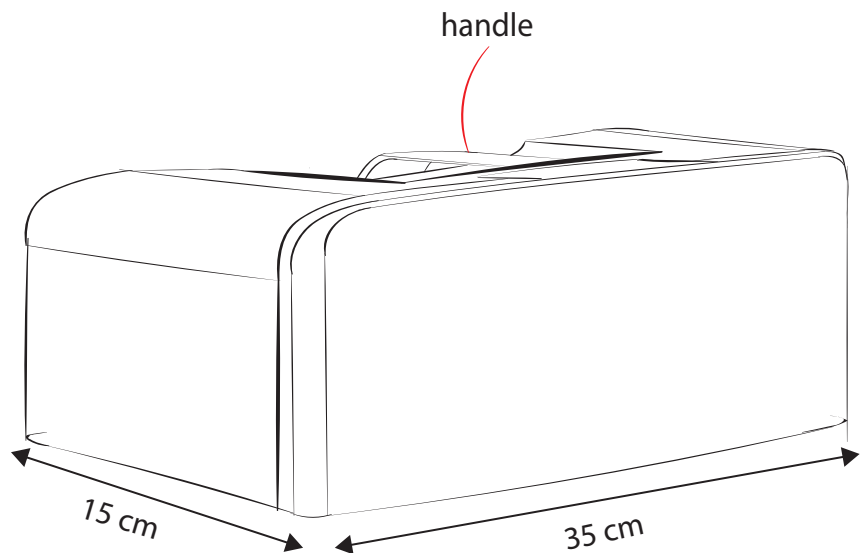
Small size

25 cm length

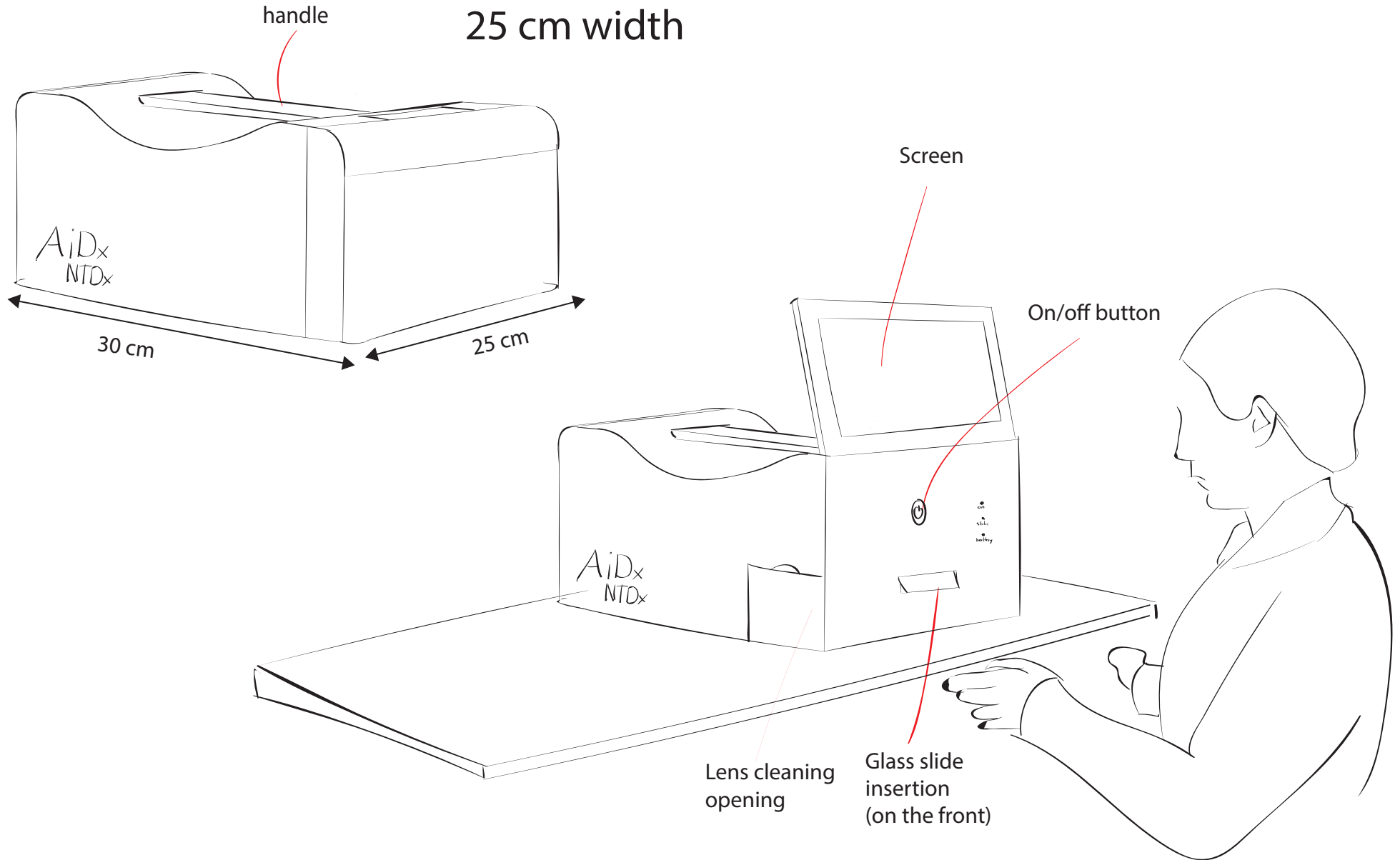
15 cm width



Glass slide insertion on the same side
Big size
35 cm length
15 cm width



Glass slide insertion and screen on the same side
Big size
30 cm length
25 cm width



Feedback

Brice

Design 3 is best because 'sample insertion window and screen on same side.. Also prefer to have a screen on the smaller side than the longer''The one with both sample window and screen on different sides is not really going to be an option. Just for convenience of work it will be nice to have it on same'
After talking with him, I came to the conclusion that the convenience of having the interaction on one side of the device is more important advantage than the disadvantage of the increase of size.

Animashaun

He prefers the third option as well, because:

- 1) the glass slide insertion is more convenient and looks finer at the front
- 2)Screen well positioned
- 3) Symmetrical

He also thinks that the ease of operation is more important than the smaller size.

Iyiona

'I prefer the first one because of it's size but not the side of the insertion of slide, the same side with the screen will be better. The second one is also desirable but the size is an issue. The third one is too big but the side for slide is more better than the second one'. He prefers a smaller device over the ease of use of the device.

Conclusion

This test showed that both it is important to have all the interaction at one side and to have a small device.

Having the interaction at one side of the device is according to the interviewed people slightly more important than a smaller device.

Option one is the smallest device. It will be easy to design, however the ease of use of the device will be low. Also the stability of this device is a concern. The interaction with the touchscreen in this direction can cause the device to fall. Therefore this option should not be pursued.

Option two has both characteristics but at the same time none. To make it possible to insert the slide from the side in the device, the device is made bigger. At the same time a lot of re-engineering has to be done in order to make the slide insertion intuitive like that. Therefore option two is not the best option.

By means of good design, design three can be made quite small. Maybe even smaller than expected. The glass slide insertion and the screen is on the same side, providing good access to both of them.

Therefore option three is the best design to proceed with. With the note that the size of the design should be as small as possible to increase the portability.

APPENDIX 19 – PRODUCTION TECHNIQUE CONSIDERATION

Technique	Typical quantity	Materials	Material thickness (mm)	Complexity	Size (mm)	Surface finish	Costs
Vacuum casting	25	ABS, PE, PP, HDPR, PA	1,5-?		Up to 1900x900x750	Smooth	low
Compression molding	high	PPS, PEEK, PE, PU, HDPE		No deep draws	Up to Very large, small parts are easy to prototype	Smooth	Medium
Injection molding	Very high	PMMA, ABS, PA, PC, PE, POM, PP, PS		high	Very large gets difficult	Smooth	High
Vacuum forming	Low	PMMA, ABS, PC, PE, PETG, PP, PS, PVC	Up to 12,7 mm	Medium		Smooth	Low

Vacuum casting:

<https://www.3erp.com/services/vacuum-casting/>
https://www.youtube.com/watch?v=zIBM3zAl5gY&ab_channel=LPELtd

Compression molding

https://www.youtube.com/watch?v=pOGpXZ-UMfo&ab_channel=EngineeringChemistry
<https://formlabs.com/eu/blog/compression-molding/>

Injection molding

https://www.pcbway.com/blog/InjectionMolding/Injection_molding_

[Vs Vacuum casting how to choose.html](#)

Vacuum forming

<https://formlabs.com/eu/blog/introduction-to-vacuum-forming/>

The conclusion of this research is that using vacuum casting and vacuum forming are very good possibilities to mold the product I designed. Vacuum forming is more suitable for the outer housing because that part is quite big. However, a big disadvantage of vacuum forming is that thicker smaller features can not be formed. For these parts that have to be rigid, with a more complex shape, vacuum casting will be used.

APPENDIX 20 – PROTOTYPING DOCUMENT

In this document, all the iterations I made before I assembled the whole device are displayed. The used parts in the prototype are not included in this appendix. The main iterations are explained from version to version.



Connection ring. (1) the edges were too thin (2) the edge of the housing parts did not fit (3) male model for the molded connection ring



Bottom housing. (1) the recesses for the feet were not formed clearly (2) The right size



Inside front housing. (1) The screen did not fit in the hole (2) the assembly for the hinges was too difficult (3) The thickness of the part was increased (4) the part was made out of one part for the first time, the screen did not fit (5) The mounting position of the hinges was changed.



Side housing. (1) the handle was too difficult to thermoform (2) the recess did not thermoform (3) The depth of the part was too low.



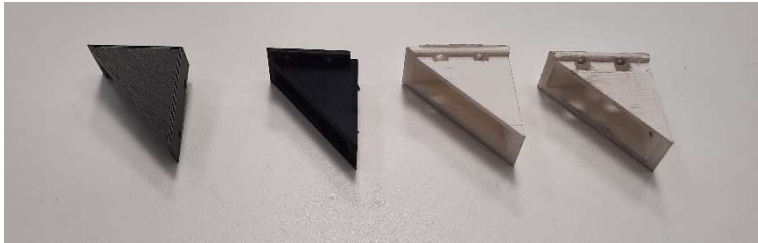
Front housing. The part was too high. The mounting mechanism on the front was not aesthetically pleasing



Housing molds. All the molds that were used to create the final prototype.



Handle. (1) the preferred thickness of the handle was researched with wooden shapes (2) the handle was printed out of two parts (3) The height of the handle did not allow the screen to open when mounted.



Screen bracket. (1) the bracket was too fragile (2) the space in between the two supports was too little to mount it to the mounting plate (3) the depth of recess for the nuts was too small. (4) It did not fit the mounting plate because of one of the supports; it collided with the focus mechanism.



Spacer. Used to close off the opening on the top of the inside housing when attached. More prototyping should be done to get it to fit.



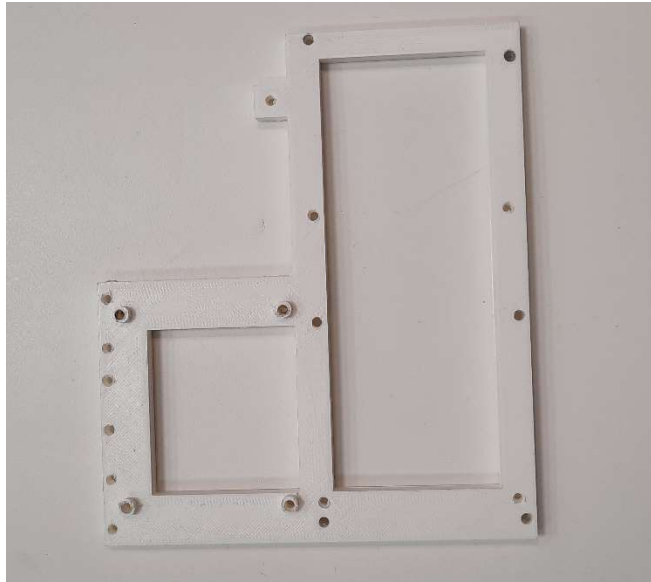
Button plate. The hole for the power button is too wide, so it does not hold the button in place.



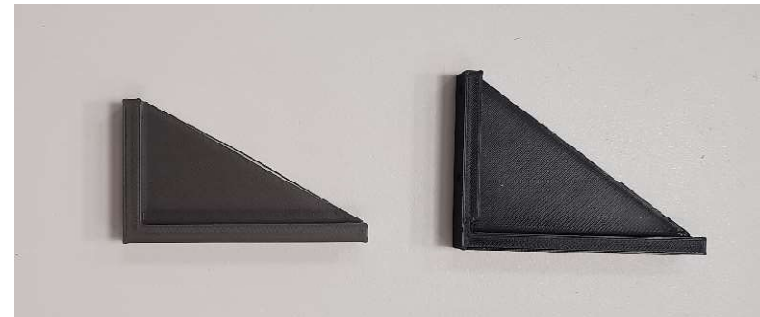
Handle holder. The holes were misplaced.



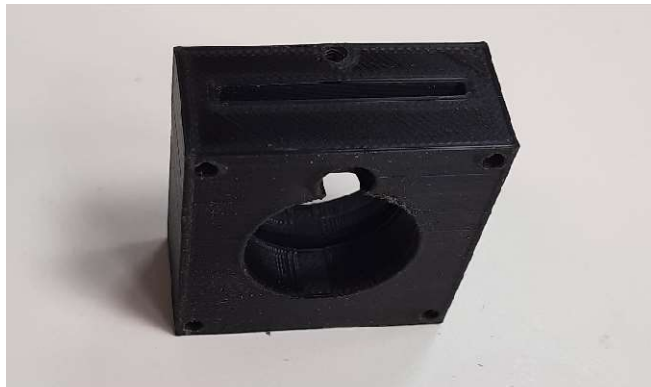
Screen plate. (1) too much was cut off. (2) the holes were drilled on the wrong place.



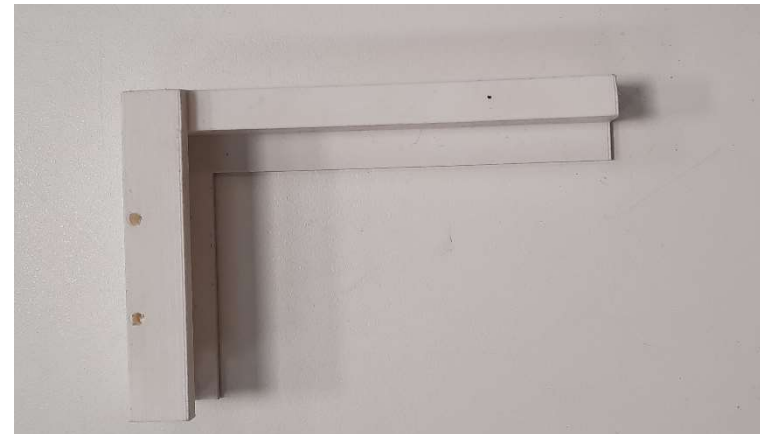
The spacers which were included on the print (left) did not work out right as they damaged too fast.



Mounting plate bracket. (1) the holes were placed in such a way that only one side could be attached (2) not enough place for the bolts and it collided with the buttons.



Illumination base. The height was too big so it did not fit in its place.



Battery holder. The width was too small as the battery wires go out on the side of the pack.

APPENDIX 21 – ELECTRONICS EVALUATION

A few requirements:

- Must be compatible with raspberry pi and Jetson nano
- At least 1280x800 resolution in order to make the parasites etc visible
- The screen should be 10.1 inch, 9 out of 10 of the field experts in Nigeria liked the size.

Screen choice

Price (dollar)	Resolution	Technique	Panel size (cm)	Power consumption	Link
145.99	1280 X800	IPS	9.2*29.7*20.8	4W (12V/1.5A)	https://www.amazon.com/Raspberry-Inch-Touch-Screen-Touchscreen/dp/B0776VNW9C
80.75	1280 x800	IPS	218.56*137.2	(12V, 2A)	https://nl.aliexpress.com/item/4000880766079.html?spm=a2g0o.detail.1000013.2.739efa80BHGZrj&gps-id=pcDetailBottomMoreThisSeller&scm=1007.13339.274681.0&scm_id=1007.13339.274681.0&scm-url=1007.13339.274681.0&pvid=38c7ee11-7943-49ce-b046-99b8dbe38770&t=gps-id:pcDetailBottomMoreThisSeller,scm-url:1007.13339.274681.0,pvid:38c7ee11-7943-49ce-b046-99b8dbe38770,tpp_buckets:668%232846%238111%231996&pdp_ext_f=%257B%2522sku_id%2522%253A%252210000010290382486%2522%252C%2522scenelid%2522%253A%25223339%2522%257D&pdp_pi=-1%253B38.06%253B-1%253B-1%2540salePrice%253BEUR%253Brecommend-recommend

Table 1: The most important requirement is the power consumption with regard to the price. It is also important that the screen should not have a casing or big edge around the screen. That limits the possibility of including the screen in my design in a space-efficient way. Therefore the second screen of 80,75 euro is chosen. There were almost no screens available at the time of ordering, only these two were available at the time of ordering.

Power consumption calculation

	W	V	A	Amount	Link
LED	0.09	3	0.03	3	https://www.pcbay.com/product/25478---text=Eact%20RGB%20LED%20draw%20approximate%20V%20mA%20when%20in%20as%20much%20as%201%20A
Jetson nano	10	5	4	1	https://forums.developer.nvidia.com/t/power-supply-considerations-for-jetson-nano-developer-kit/71637
MG995R servo	5.2	5	? (1.2 max)	4	https://components101.com/motors/mg995-servo-motor
Touch screen	?	12	2	1	https://nl.aliexpress.com/item/4000880766079.html?gatewayAdapt=igto2nid&spm=a2gbo.order_list.0.0.21ef79d2mV2x5H

Table 2: Power consumption per electronic part in the NTDx

5,4 watt power consumption at 7 inch

7,4 watt power consumption at 13 inch

10 watt for jetson nano

0.09 Watt voor 3 LED (neglectable)

$1,2 \text{ A stall current} * 5\text{V} * 4 = 24 \text{ watt}$ (on average they use 0.1 A, so 2,4 watt)

I do not know the exact power consumption of the screen before I bought it, so I made an estimation by making an educated guess based on the power consumption of other touch screens. I ended up using 7,6 Watt for the screen for this calculation (using 2,4 watt for the servos as these servos will not come to its stall current)

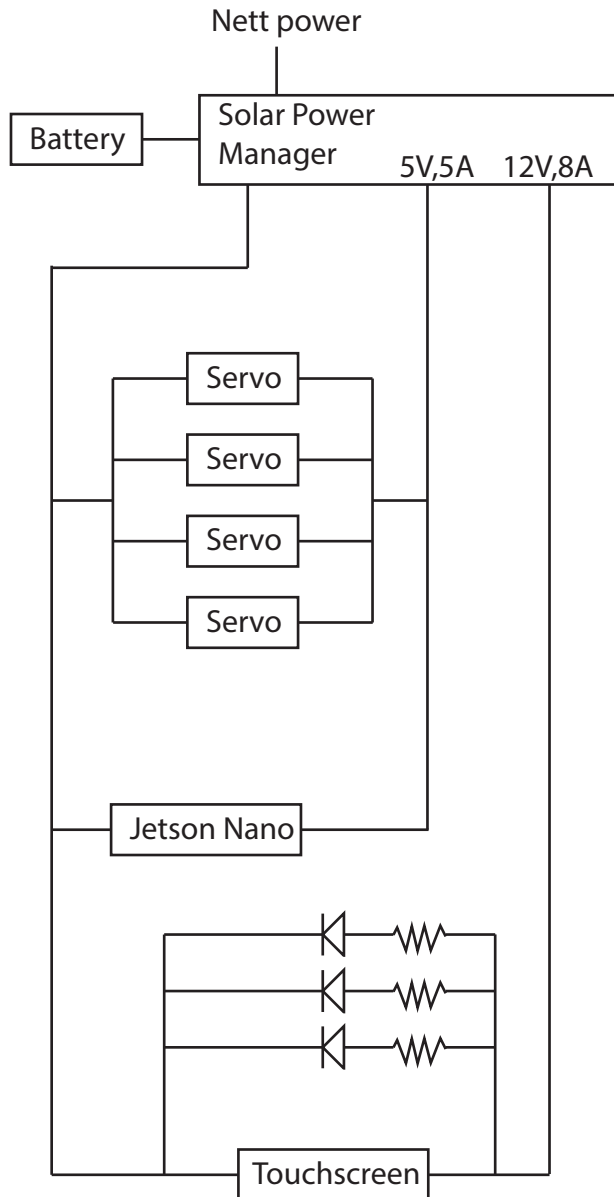
$0,9(\text{battery}) * 0,9(\text{Solar power manager}) = 0,8 \text{ efficiency}$ (0,9 is the efficiency I estimate)

10 Watt for Jetson Nano + 2,4 Watt for Servo's= 12,4 watt at 5V for 6 hours

$12,4 * 6 / 5 = 14,88 \text{ Ah}$

7,6 Watt for touchscreen at 12V for 6 hours

$7,6 * 6 / 12 = 3,8 \text{ Ah}$



Version 3

The power circuit as displayed in version 2 needs a lot of different chips, which makes it complex and costly. Therefore I was searching for a power manager chip that could do everything in one.

This was difficult to find, because most of these chips work with a voltage of 5V instead of the needed 12V and work with currents of max 2A. I have considered transferring 12V of the battery to 5V of a power manager after which I transfer it back to 12V for the screen. However this would result in a lot of losses in energy decreasing the amount of uptime. In this configuration you would also need multiple power managers in parallel to get the needed current of 4A for the Jetson Nano.

After searching for more than a day I found a chip that can do all in one: the Solar Power Manager.

30Ah, 12V Battery

<https://nl.grandado.com/products/6s2p-24v-8ah-18650-batterij-lithium-batterij-25-2v-8000mah-elektrische-fiets-bromfiets-elektrische-li-ion-batterij-met-bms?variant=UHVjZHVjdFZhcmlhbnQ6MzI5NTA1MjM>

2A, 12V Touchscreen

https://nl.aliexpress.com/item/4000880766079.html?spm=a2g0o-detail.1000013.2.739efa80BHGZrj&gps-id=pcDetailBottomMoreThisSeller&scm=1007.13339.274681.0&scm-url=1007.13339.274681.0&pvid=38c7ee11-7943-49ce-b046-99b8dbe38770&t=gps-id:pcDetailBottomMoreThisSeller,scm-url:1007.13339.274681.0,pvid:38c7ee11-7943-49ce-b046-99b8dbe38770,tpp_buckets:668%232846%238111%231996&pdp_ext_f=%257B%2522sku_id%2522%253A%252210000010290382486%2522%252C%2522sceneld%2522%253A%2523339%2522%257D&pdp_pi=-1%253B38.06%253B-1%253B-1%2540salePrice%253BEUR%253BRecommend-recommend

1.2A(stall), 5V Servo MG966R

<https://components101.com/motors/mg995-servo-motor>

4A, 5V Jetson Nano

<https://forums.developer.nvidia.com/t/power-supply-considerations-for-jetson-nano-developer-kit/71637>

Resistor value

$(12V-3.4V)/(0.010A \times 3) = 290 \text{ ohms}$.

Solar Power Manager

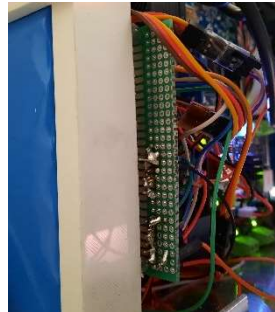
<https://www.dfrobot.com/product-1795.html>

Monitor	amazon.de	ASIN: B08KP1P98T	107,58	1	€ 107,58	
Mouse	amazon.de	ASIN: B0039TYBQ	6,29	1	€ 6,29	
Power entry module			7,03	1	€ 7,03	
Panel mounted indicator LED 6mm	farnell.nl	2431249	0,65	1	€ 0,65	
ribbon cable 20-way 1.27 mm pitch, price per 30m	farnell.nl	2628347	36,11	0,0167	€ 0,60	
resistors 1k S50R_330R through hole	farnell.nl		0,03	10	€ 0,30	
Servo MG995	Otronc		8,99	4	€ 35,96	https://www.otronic.nl/a-64574083/servos/servo-mg995-180-graden/?gclid=Cj0KCQwrs2XBhDARISAHVym54SaLma6F6m022x0AlptCxlNroPetdGNHEDH2EcorpctCV3B0bQaAJ9EALw_wcB
Wires			0,001	20	€ 0,02	
Connectors			0,001	40	€ 0,04	
Shrink tube			0,001	40	€ 0,04	
128GB Micro SDHC Kaart	Bol.com		36,99	1	€ 36,99	https://www.bol.com/nl/nl/p/lexar-microsdhc-card-128gb-high-performance-1066x-uhs-i-u3/93000002242959/?bthg=rvf5O20F0FKMeoz9MVJxQ_4_14.15.ProductTitle
capacitors 100uF+, 16V	farnell.nl		0,25	2	€ 0,50	
Other	€ 125,85					
Achromatic doublet	Thorlabs	AC254-125-A	77,77	1	€ 77,77	https://www.thorlabs.com/thorproduct.cfm?partnumber=AC254-125-A
Fresnel lens condenser	AliExpress		2,65	1	€ 2,65	https://www.aliexpress.com/item/1005001940782109.html?spm=a2g0s.12269583.0.0.67983b2aXOMq48
Condens lens (google cardboard 25mm dia F40)	AliExpress		0,2144	1	€ 0,21	https://www.aliexpress.com/shot/0.html?spm=a2g0s.9042647.0.0.5be54c4dMe4L6B&orderId=8139828865768317&productId=32532429720
Achromatic lens holder	Thorlabs	CP33T/M	22,76	1	€ 22,76	https://www.thorlabs.com/thorproduct.cfm?partnumber=CP33T/M
Adapter with external SM1 thread	Thorlabs	SM1A3	16,82	1	€ 16,82	https://www.thorlabs.com/thorproduct.cfm?partnumber=SM1A3
Microscope objective 10x	AliExpress		4,53	1	€ 4,53	https://www.aliexpress.com/shot/0.html?spm=a2g0s.9042647.6.2.7e694c4dmsvcB&orderId=8139597764018317&productId=1005002840443950
Magnet round 5x5mm	Magneetgigant	MKSA-5x5-Ni-N45	0,37	3	€ 1,11	https://www.magneetgigant.nl/Neodymium-magneten/Schijfmagneten/5x5-mm-vernikkeld
Housing	€ 61,14					
Handle			12,39	1	€ 12,39	https://nl.grandado.com/products/152mm-zwart-plastic-handvat-grip-voor-gitaar-case-ervanging-koffer-does-bagage-handvat-grip?variant=UHVZHVjdfZhcmlhbnQ6MT11OTYwMDE&gclid=CjwKCAJwDkXhBPEiWA2bmObaxQWxmaK8xDNDuLFSzC4d-RTebzWH7C32rBhg8PvYwWTEJfVBlwoCA4sQAVD_BwE
Enclosure (www.distrelec.nl)	pactec DM-4	1-610-361-4200 (DM-4)	46,15	1	€ 46,15	
Front housing			1,23	1	€ 1,23	
Back housing			1,37	1	€ 1,37	
Milling	€ 377,60					(Eastmaster manufacturing LTD)
Main breadboard Aluminum			35,1	1	€ 35,10	
Servo plate Magnetic steel			35,1	1	€ 35,10	
Servo plate brackets Aluminum			26,3	2	€ 52,60	
Glass slide holder Aluminum			31,5	1	€ 31,50	
Glass slide spring Aluminum			33,3	1	€ 33,30	
Horn small Aluminum			8,4	2	€ 16,80	
Horn big Aluminum			10,2	1	€ 10,20	
Beam small Aluminum			9,9	2	€ 19,80	
Beam big Aluminum			10,3	1	€ 10,30	
Lens holder connector Steel			3,5	3	€ 10,50	
Camera holder Aluminum			16,7	1	€ 16,70	
Cam Steel			9,6	1	€ 9,60	
Focus base Aluminum			24,6	1	€ 24,60	
Focus servo holder Aluminum			16,7	1	€ 16,70	
Focus springs Spring steel			14,9	2	€ 29,80	
Spring connector Aluminum			25	1	€ 25,00	
3D print	€ 4,58	price/hour	hour			
Raspberry Pi holder			0,0053	2	€ 0,01	
Fan holder			0,0053	1	€ 0,01	
HDMI holder			0,0053	1	€ 0,01	
PCB Holder			0,0053	4	€ 0,02	
Illumination base (3parts)			0,0053	7	€ 0,04	
PLA (200gr)			22,5	0,2	€ 4,50	
					€ 950,94	

APPENDIX 24 – ASSEMBLING DOCUMENTATION

Before proceeding with assembling, make sure that you have all the parts as listed in the cost price calculation appendix. Next to that, before assembling the hardware and the housing parts do the following steps:

- Solder electrical wires and a 100 ohm resistor on a perfboard in order to create the needed 5V and GND connections for the Servos, Power button and illumination. The circuit can be found in this thesis
- Make sure that all these cables can be connected to another cable that connects to an electrical part. Do not solder a wire that connects to a electrical part directly to this perfboard.



- Solder wires to the electrical parts with connectors on the other side. Prevent circuit failure by placing shrinking tube around the soldered points.

For all the steps it is important to use locknuts and spring washers where possible in order to increase robustness.

Screen assembly

1. Paste double sided tape on the edges of the Inside front housing



2. Put the screen in the opening



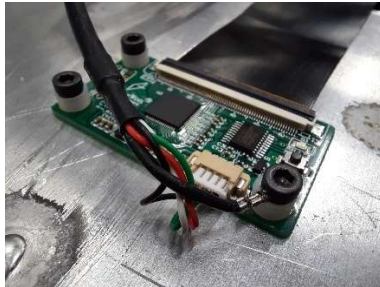
3. Attach the hinges to the Inside front housing, spacers and Screen plate



4. Mount the Screen plate to the Inside Housing



5. Fasten the driver boards of the screen to the Screen plate

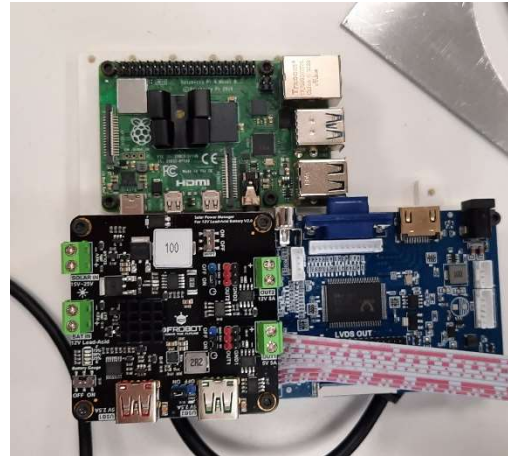


6. Attach the Front housing to the Inside Housing (make sure that the cables are coming out of the top of the sub-assembly)

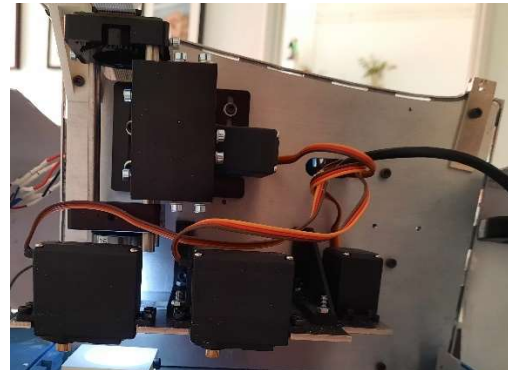


Main assembly

1. Assemble XY-mechanism
2. Assemble Z-mechanism
3. Assemble electronics holder



4. Mount XY-mechanism, Z-mechanism and electronics holder on the mounting plate



5. Connect Power and HDMI(normal) and HDMI(panel) cables to the Raspberry
6. Connect HDMI(normal) to the screen driver board
7. Connect the other side of the Power cable to the Solar Power Manager (port 2).
8. Mount two Brackets to the mounting plate



9. Mount two Hinge brackets to the mounting plate



10. Mount the handle holder plates to the mounting plate



11. Connect the screen power cable to the screen driver board and the 12V output of the Solar power manager.
12. Attach the Fan and Perfboard to the Battery holder
13. Mount the Battery holder to the mounting plate. Before tightening it too much, make sure the cables of the battery are in their designated place (on top, through the groove in the battery holder).



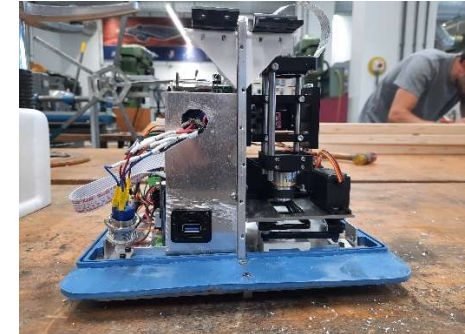
14. Connect/solder/make the electrical circuit as displayed in this thesis
15. Mount 6 brackets on the baseplate

16. Mount the connection ring to these six brackets (only attach the connection ring to the brackets on the left and right side).
17. Mount the illumination module on the base plate

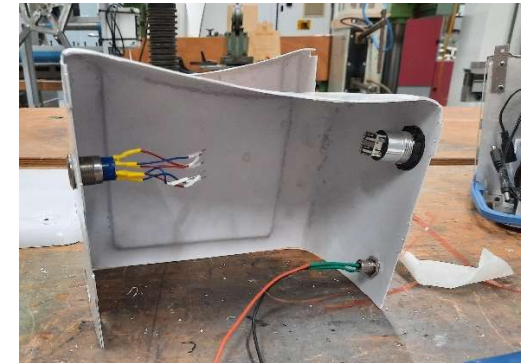


18. Mount the single USB port panel to the button plate and connect the USB port to the Pi.
19. Pull the button cables through the top hole of the Button plate
20. Mount the Button plate to the front bracket that is attached to the mounting plate
21. Put the Mounting plate between the Base plate and the Connection plate and attach the Mounting plate brackets to the Base plate

22. Screw the connection ring in the mounting plate

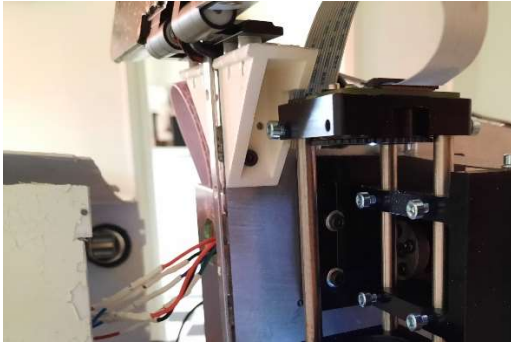


23. Screw the Power button, the AC/DC output and the Double USB output in the left side of the housing



24. Connect the Power button, the AC/DC output and the double USB cables.
25. Screw the HDMI(panel) on the right side of the housing
26. Connect the screen by screwing the hinges on top of the Hinge brackets.

27. Attach the Touchscreen USB to the Pi and the Display cables to the Screen driver board



28. Connect the Battery cable to the Battery in port on the Solar Power Manager
29. Pull the LED through the hole in the Base plate and push it in the middle hole of the illumination position on the Base plate.
30. **Test if everything works**
31. Close the left side of the housing by means of screwing it into the mounting plate
32. Close the right side of the housing by means of screwing it into the mounting plate

33. Place the Bottom housing on the connection ring



34. Screw the Bottom housing to the base plate by means of the rubber feet. (make sure that the device is balanced by adjusting the height of the rubber feet)



35. Attach the handle on top of the device



36. Paste the stickers

APPENDIX 25 – MATERIAL CONSIDERATION

In the table below plastics that can be thermoformed are displayed in order to make a good decision on which material the final housing should be made of.

	UV resistant	Impact resistant	Environmental impact	Other
ABS	--	++	--	
HIPS	-	+	+	Easy flammable
HDPE	++	+	+	
PVC	++	+	--	Health hazard when burned
PET	++	-	-	
PETG	++	+	+	

In the table below plastics that can be Vacuum casting are displayed in order to make a good decision on which material the final vacuum molded parts should be made of.

	UV	Impact resistant	Environmental impact	Other
ABS	--	++	--	
PP	--	+	+	
PC	++	++	+	
PU	-	+	+	Flammable

Based on the simplified comparison of the materials in the tables above. The housing will be thermoformed of HDPE and the other vacuum casted parts will be made from PC.

APPENDIX 27 – Interaction research

Goal

The goal of this research is to find out if the use cues on the AiDx NTDx are clear enough to understand how to use the device on first sight without having to read instructions. I want to test if the participants know how to relocate, turn it on, insert a USB stick, insert a glass slide or charge the device. How the participants are using the interface is not included in this research as I have not developed the interface during my graduation.

Method

1. The participants are presented with a closed AiDx NTDx standing on a table
2. They get the following instructions:
 - a. Pick up the device and place it on the next table where a glass slide is placed.
 - b. Power on the device (tap twice on the left side of the screen to power on the screen)
 - c. Insert a USB stick
 - d. Charge the device
 - e. Insert a glass slide
3. The participants are asked to say what they think and experience during these steps
4. Afterwards the following questions are asked:
 - a. How did you experience the interaction?
 - b. What did you not understand?
 - c. Do you have any additional remarks

Participants

The participants are random students at the IDE faculty that have no specific experience with microscopes or microscopy. 5 participants performed the test. Next to that one test was performed by the PHD expert I have been talking to in the research phase. He however had never seen the device before.

Results

Results of the participants

Actions	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	PHD'er
a	4	8	4	7	3	4
b	5	3	6	7	5	5
c	15	14	10	19	10	12
d	13	23	6	15	7	7
e	17 (1)	5	23 (3)	17 (1)	10	5

The fields in the table are filled with two numbers. The first number is the time in seconds that the participant needed in seconds to perform the task. The number in brackets is the amount of hints that I needed to give in order to let them complete the assignment.

The most important quotes during the speaking out loud interaction:

- It is as heavy as I expected
- The device is not that heavy
- Glass slide insertion is quite difficult
- Is the glass slide inserted deep enough?
- The material around the charging port is a bit soft
- I can not open the screen from the middle, but has to do grab it by the side.

The most important observations I made were:

- It was immediately clear how to carry the device. Only one of the participants picked the device up with two hands and held it before her body.
- The USB port on front is not very obvious. Only 3 of the six participants inserted the USB on the front
- The device is easy to use when seated. When standing, the screen can not be rotated enough. Two of the five participants did immediately sit down when using the device.
- The power button is placed obviously

Conclusion

The amount of time needed for each action is approximately equal over the participants. The device is almost self-explanatory as almost no hints had to be given. Only the glass slide insertion was difficult without explanation. Especially the orientation of the glass slide.

Discussion

It can be said that the overall interaction with the device was clear. But I learned the following things about for the next iteration of the device

- Make the screen be openable from the bottom by creating a recess.
- Place the USB port a bit higher in order to show it more
- Make it possible to rotate the screen further.

APPENDIX 27. Raw aesthetics test results

Respondent	To which extend do the following devices look like a medical device to you? You may think or know that a certain device is a medical device, but does it also look like that? The latter is what I am researching. [Device 1]	To which extend do the following devices look like a medical device to you? You may think or know that a certain device is a medical device, but does it also look like that? The latter is what I am researching. [Device 2]	To which extend do the following devices look like a medical device to you? You may think or know that a certain device is a medical device, but does it also look like that? The latter is what I am researching. [Device 3]	To which extend do the following devices look like a medical device to you? You may think or know that a certain device is a medical device, but does it also look like that? The latter is what I am researching. [Device 4]	To which extend do the devices above look beautiful to your opinion? [Device 1]	To which extend do the devices above look beautiful to your opinion? [Device 2]	To which extend do the devices above look beautiful to your opinion? [Device 3]	To which extend do the devices above look beautiful to your opinion? [Device 4]
1 Yes	3	3	4	4	3	4	5 (very beautiful)	4
2 No	1 (not at all)	2	3	4	2	3	4	3
3 No	2	3	1 (not at all)	3	3	3	2	3
4 No	4	1 (not at all)	3	3	4	1 (not beautiful)	3	1 (not beautiful)
5 No	2	2	1 (not at all)	3	1 (not beautiful)	3	4	1 (not beautiful)
6 No	5 (Entirely)	2	2	4	2	2	5 (very beautiful)	2
7 No	3	4	1 (not at all)	5 (Entirely)	1 (not beautiful)	4	5 (very beautiful)	3
8 Yes	1 (not at all)	2	5 (Entirely)	5 (Entirely)	3	5 (very beautiful)	4	5 (very beautiful)
9 Yes	5 (Entirely)	2	3	5 (Entirely)	3	5 (very beautiful)	5	5 (very beautiful)
10 Yes	4	1 (not at all)	2	2	1 (not beautiful)	5	3	5 (very beautiful)
To which extend does this device look like a beautiful in your opinion?	To which extend does this device make you want to interact with it?	To which extend does this device give you the feeling that it is robust?	To which extend do you feel confident enough about the design of this device between other medical devices?	To which extend do the following devices look like a medical device to you?	To which extend do the following devices look beautiful to your opinion?	To which extend does this device make you want to interact with it?	To which extend does this device give you the feeling that it is robust?	To which extend do you feel confident enough about the design of this device between other medical devices?
4	5	5	5	5	5	5	5	5
5	3	2	5	4	3	5	3	4
3	4	4	4	4	3	4	3	5
5	4	3	3	5	4	4	2	5
2	3	2	4	4	3	5	3	4
4	3	2	5	4	2	3	3	4
2	4	2	4	4	4	5	4	3
5	5	5	5	5	4	3	3	3
5	4	3	4	5	5	5	5	5
1	1	5	1	3	5	4	4	4

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

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Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy". Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !



family name _____
 initials _____ given name _____
 student number _____
 street & no. _____
 zipcode & city _____
 country _____
 phone _____
 email _____

Your master programme (only select the options that apply to you):

IDE master(s): IPD Dfl SPD

2nd non-IDE master: _____

individual programme: - - - (give date of approval)

honours programme:

specialisation / annotation:

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair _____ dept. / section: _____
 ** mentor _____ dept. / section: _____
 2nd mentor _____
 organisation: _____
 city: _____ country: _____

comments
(optional)
 :
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! Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

! Second mentor only applies in case the assignment is hosted by an external organisation.

! Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair _____ date ____ - ____ - ____ signature _____



CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair. The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: _____ EC

YES all 1st year master courses passed

Of which, taking the conditional requirements into account, can be part of the exam programme _____ EC

NO missing 1st year master courses are:

List of electives obtained before the third semester without approval of the BoE

name _____ date ____ - ____ - ____ signature _____

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **. Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: APPROVED NOT APPROVED

Procedure: APPROVED NOT APPROVED

comments

name _____ date ____ - ____ - ____ signature _____

introduction (continued): space for images

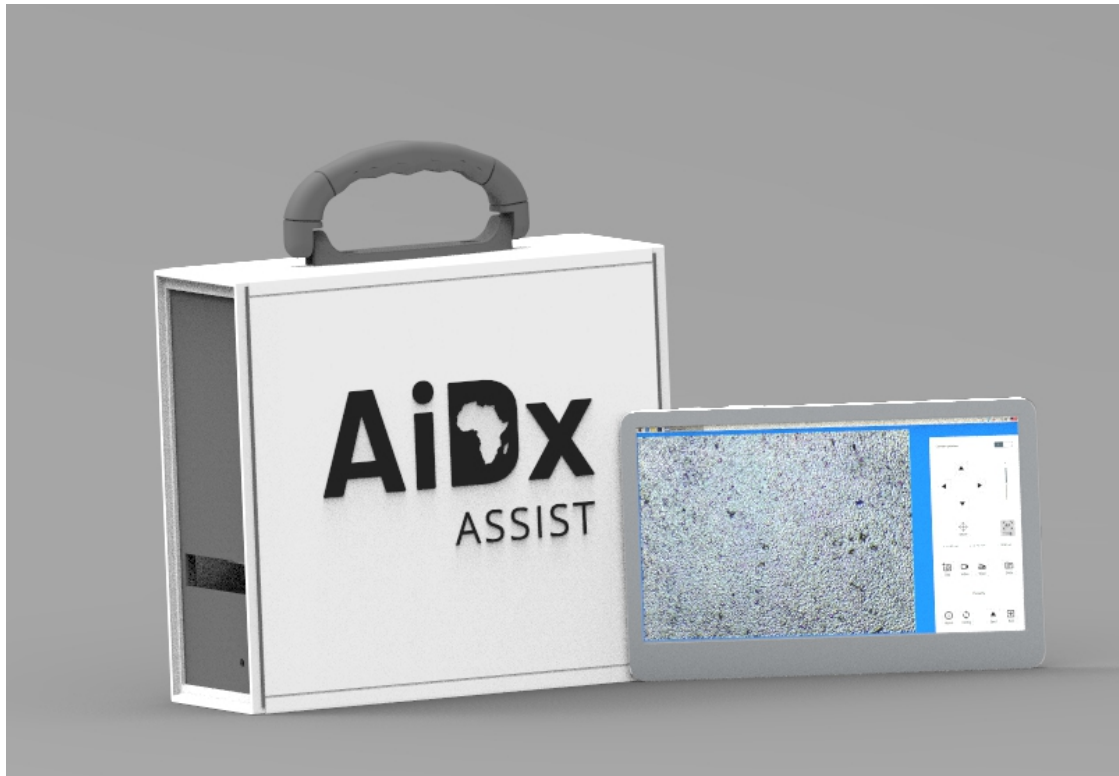


image / figure 1:

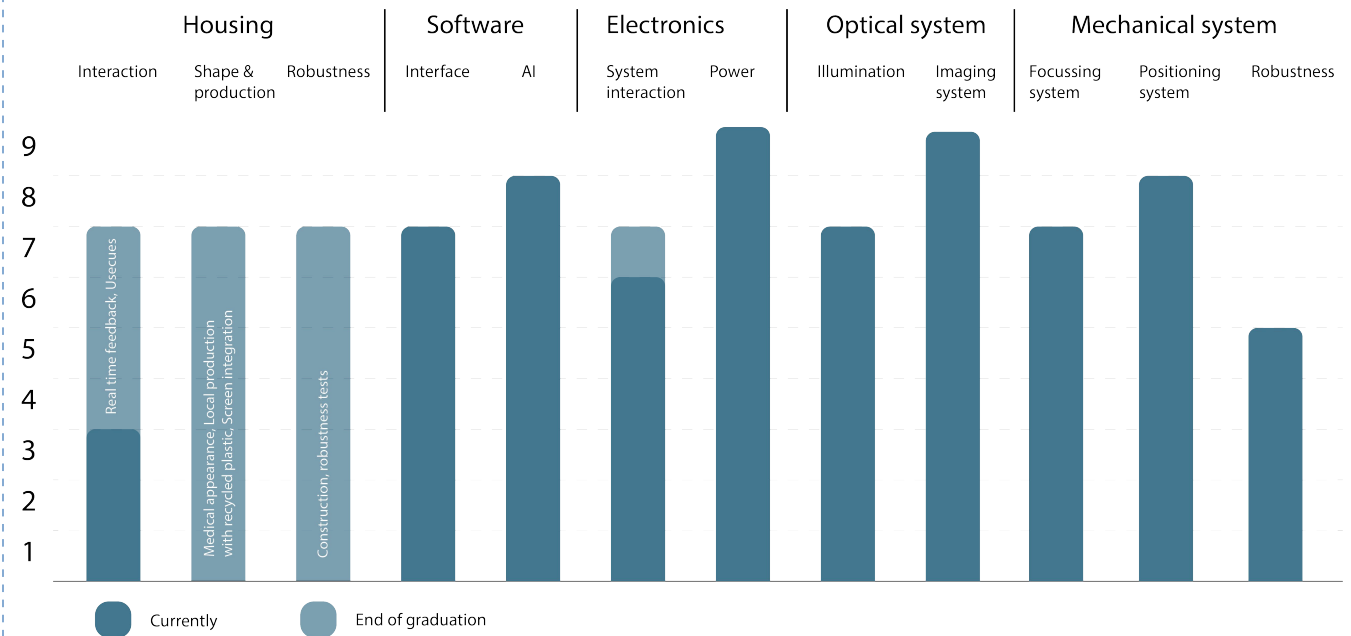
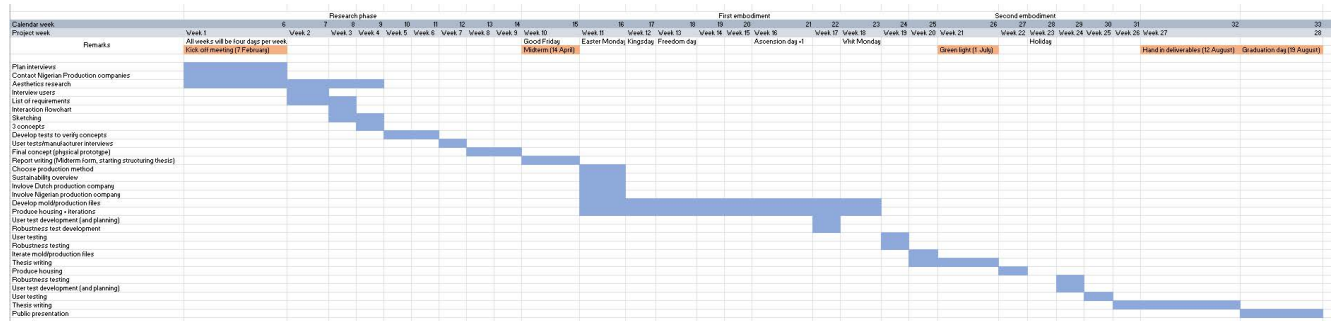


image / figure 2:

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date _____ end date _____



MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, Stick to no more than five ambitions.

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FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

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