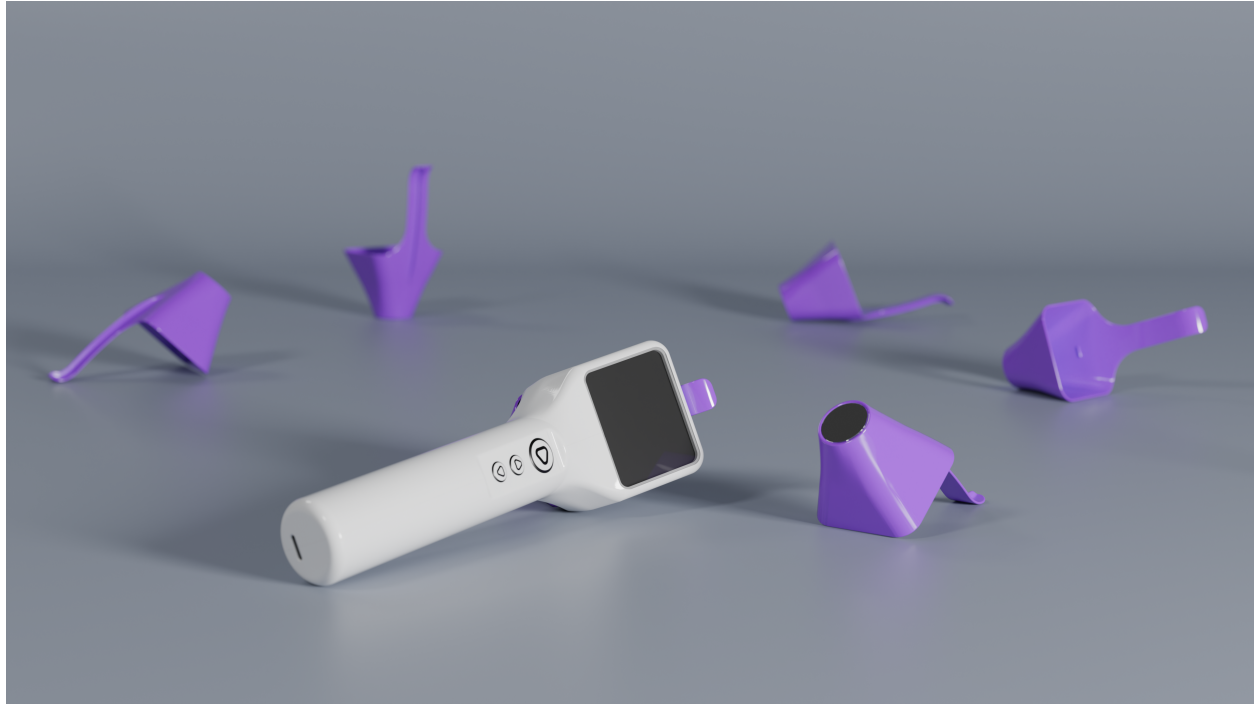




CHALMERS
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Redesigning a Handheld Scanner for Veterinary Care

Improving Usability and Contamination Control Through
Human-Centered Design

Master's thesis in Industrial Design Engineering

Otto Hammarström
Joël van Schoonhoven

DEPARTMENT OF INDUSTRIAL AND MATERIALS SCIENCE

CHALMERS UNIVERSITY OF TECHNOLOGY
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MASTER'S THESIS 2026

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Abstract

As a response to an increase in antimicrobial resistance within veterinary care, Odinwell aims to introduce their bacteria measurement technology as a more effective solution for diagnosing and treatment selection. This thesis explores the redesign of the Odinwell handheld scanner as well as the development of an exchangeable tip solution, for use within veterinary care. With a human-centered design approach, the project features theoretical studies, benchmarking, interviews, observations, and user testing to understand the specific needs within veterinary care.

Based on the findings, the scanner body was redesigned to create a more intuitive and usable product. The redesign features a new grip shape for improved ergonomics as well as a new overall body shape for improved usability. Additionally, a digital interface design combined with a larger screen and redesigned button layout was created, allowing increased functionality and better user interaction. Finally, a single use tip solution was developed, providing the veterinarian with an effective way of preventing cross contamination between patients.

Acknowledgments

First of all a great thank you to the Odinwell team for providing not only this great opportunity, but also an amazing and well-equipped workspace. It was a great pleasure to work with everyone in the team. We would especially like to extend a big thank you to our Odinwell supervisor, Ester Pörtlors, who has been incredibly helpful and has guided us through this project from start to finish. Additionally our gratitude goes out to Lars-Ola, who helped us achieve our goal, through supervising this project. Finally, this project would not have been possible without the help of all the veterinarians who welcomed us into their field and openly answered any questions we had. It was an amazing experience to follow along and get an insight into their daily work.

Otto Hammarström and Joël van Schoonhoven, Gothenburg, June 2026

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1

Introduction

The following section aims to introduce the background of this project by presenting the problems related to overuse of antibiotics within veterinary care. Furthermore, the aim of the project will be described and its general outline will be presented.

1.1 Problem Definition

Within veterinary care, wound treatment and infection prevention occupie a large section of daily activities. A study by Sarah Allen (2020) in the United Kingdom shows over 5% of horses regularly deal with wound problems, over the span of a year, making it one of the most common conditions. During wound treatment, systemic antimicrobials (antibiotics) were administered in approximately 80% of the cases. This reflects the complexity and prolonged duration of the equine wound-healing process, which is associated with an increased risk of bacterial infection (Jorgensen, 2021).

Among small animals, referring to cats and dogs, wounds are not as common. However, roughly 21% of consultations are related to skin infections(Hill et al., 2006). Of these 25% were related to the presence of bacteria (Australian Veterinary Prescribing Guidelines, n.d.). Other cases involve fungal infections. To treat these cases, the correct selection of shampoo is often sufficient. However, antibiotic treatments are often used as well.

During treatment, overuse of antibiotics is not uncommon in veterinary care. This can be caused by multiple factors such as, financial restrictions, response to clients or cautionary action, among other reasons (King et al., 2018). As a result, an increase in antimicrobial resistant bacteria has been found in animal patients. Fortunately, the application of antimicrobial stewardship programs has aided in reducing the use of antibiotics by over 50% over the last decade.

To further decrease the use of antibiotics and to aid veterinarians in their decision making process, Odinwell has developed a scanner which can measure the presence of a biomarker, produced by bacteria. Initially this product was developed for human care. However, this project aims to adapt the product for use within veterinary medicine. This would allow veterinarians to better understand the severity of presented conditions and help determine the correct treatment method, with more certainty.

1.2 Aim

The aim of this project is to explore the handheld scanner which is currently being developed by Odinwell and to identify and address issues related to its ergonomics, usability and hygiene. To achieve this, the exterior shell as well as the interface will be redesigned. Moreover, two separate tip solutions will be designed, to allow the scanner to be used in the specific contexts of both equine clinics, as well as small animal clinics. The main purpose of these tips is to prevent cross-contamination across patients, as well as contamination of the device.

Other general design requirements for the project include looking into manufacturing and material selection. Finally, the existing device architecture, such as electronics and software, had to be taken into consideration to ensure that the housing of all the required internals were taken care of.

The final objective will be to create a representative prototype for the scanner as well as both tip solutions to allow validation through usability and ergonomics testing. Whilst simultaneously considering risk of contamination.

Based on the overall objective of the project, two research questions were formulated:

1. *How can the current Odinwell handheld scanner be adapted for use within veterinary care, and in doing so, aid vets in their decision making process?*
2. *How can the design of a product prevent cross contamination between patients?*

1.3 Thesis Outline

This report is divided into 11 chapters. The following briefly describes the content of each:

1. **Introduction:** Introduces the problem definition, aim and research questions.
2. **Summary of Results:** Gives a brief description of the final result of the project.
3. **Veterinary Theory:** Presents relevant information, found through literature research, related to veterinary care.
4. **Market representation:** Introduces the company with whom the thesis was done as well as their competitors.
5. **Theoretical Framework:** Discusses key concepts related to design for end users
6. **Methods:** Presents an overview of methods used throughout the project
7. **Process:** Describes the general steps and phases throughout the project
8. **Exploration Results:** Presents the results found during the exploration phase.
9. **Concept Development:** Describes the details of the process of developing the final design.
10. **Final design:** Presents the details of the final design and discusses the evaluation of this design
11. **Discussion:** Reflects on the process of the project and its outcome

2

Summary of Results

This master thesis has resulted in increased knowledge about veterinary care in general and has led to an improved understanding of the needs and requirements related to veterinary products. Based on this knowledge, a proposal for a re-design of Odinwell's current handheld scanner has been developed. Additionally, a tip solution has been designed with the purpose of preventing cross contamination between animals and contamination of the device itself.

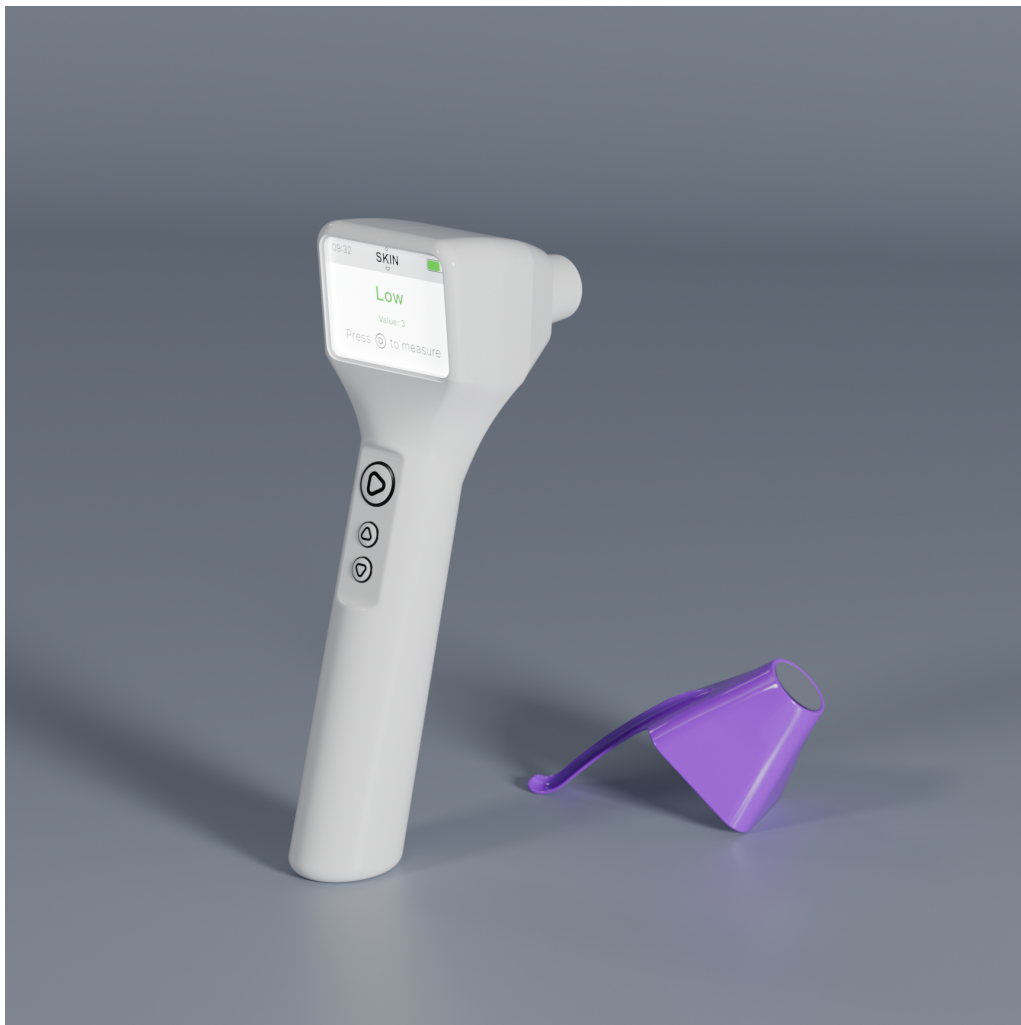


Figure 2.1: Final design for scanner and tip.

2. Summary of Results

The handheld scanner shown in figure 2.1 was re-designed based on feedback from both potential users, veterinary professionals, as well as technical experts that develop the technology within the device. The new design features a more ergonomic body with a cylindrical handle, allowing the user to fully wrap their hand around the device, resulting in a more comfortable and secure grip. Moreover, the screen has been placed at an angle to improve visibility while taking measurements, solving a problem that was highlighted during the testing of the current product. The “head” of the device features a new, larger screen as well as the sensor. The shape of the head has intentionally been interrupted in the front, near the sensor. This decision was made in order to make the product seem exposed without a tip, in order to prevent use without one. At the bottom of the handle there is a USB-C port, which allows for easy charging. The back side of the handle features a recessed area where three buttons are located, buttons which are used to operate the device.

In addition to a re-design of the scanner, a proposal for the digital interface was created. With the adaptation towards veterinary medicine, two different measurement modes have been proposed in order to facilitate use within the most promising application areas. These measuring modes are “Skin” and “Wound” which can be easily toggled between depending on the nature of the next measurement. In addition to the modes, a menu system, which can be seen in figure 2.2, has been added. This allows the user to access measurement history, change language settings and more.



Figure 2.2: Three separate pages of digital interface.

As previously mentioned, a tip solution, presented in figure 2.1 has been developed in order to eliminate the risk of cross contamination when using the device on different patients. The tip design closely resembles the current solution that is used by Odinwell. It is a single-use product that easily snaps on to the front of the device, ensuring that the part contacting the animal is completely sterile. The single use tip not only covers the sensor, it also features a tab that extends to the back of the device, enabling safe and efficient disposal of used tips.

3

Veterinary Theory

In order to create an understanding of the context to which the product will be applied, as well as the process in which the product will be used, some initial theory related to the veterinary and biology field will be presented. First, some common conditions and their associated treatments will be discussed. Next, some information regarding hygiene levels and methods will be presented. Finally, some theory on bacterial autofluorescence and resistance will be presented.

3.1 Common Conditions

The following section will describe several common conditions that veterinarians work with including wounds, skin infection and urine infection.

3.1.1 Wounds

A large part of veterinary work, specifically for horses, involves the treatment of wounds and the prevention of infections. The following section will describe the wound healing process as well as its treatments.

Wound healing process

The process of wound healing is generally divided into three main phases: inflammatory stage, repair stage and remodeling (Winkler, 2024). Each phase executes a specific set of biological and chemical processes. The inflammatory stage starts with the control of bleeding, to supply the area with the correct blood cells as well as to remove any debris. The repair stage is continuous throughout the wound healing process, resulting in the development of a scab. Here, a good blood supply increases resistance against infection (Gottrup, 2002). For the repair stage to be completed correctly, proper humidity levels are vital. In the last phase, remodeling, the tissue restructures as the wound gradually heals. The time it takes for a wound to heal depends on many factors. Wounds that heal quickly are considered acute wounds and generally are less at risk of infection, as there is less time for bacteria to enter the wounds. Chronic wounds need more time to heal, and are at a higher risk of infection as they are exposed for longer. Therefore the treatment method may vary depending on the type of wound (Sandoz, 2022).

Wound Treatment Process

The initial phase of wound treatment, after assessing if the animal is stable, is first aid, focusing on bleeding control. For proper treatment there are three main fundamentals: debridement, infection/inflammation control and moisture balance (Winkler, 2024).

Debridement, cleaning of the wound, serves multiple purposes. First it allows for easier examination of the wound as excess tissue is removed. It can also reduce the bacterial levels in wounds, reducing risk of infection. Lastly, by creating clean wound edges, the closure of a wound can be sped up. Debridement can be done in different ways, with each having their own benefits (*Wound Debridement Options: The 5 Major Methods*, n.d.). A combination of methods is used to treat horse wounds, ranging from surgical removal of tissue to letting the wound clean itself through biological processes, and other methods (Leste-Lasserre, 2022).

Infection or inflammation control is important to maintain throughout the whole process of wound treatment (Textor, 2025). This helps in deciding how the wound should be treated, either open or closed. If the wound is closed too early, the risk of infection might rise, for example if the wound has not been cleaned properly yet. However, exposing the wound for too long risks bacteria entering the wound as well. If done improperly the healing process can get delayed.

A wound is considered infected when an external microbe has entered the wound and overpowered the host's defense system (International Wound Infection Institute, 2022). This generally happens when 10^5 colony forming units of bacteria are present per gram of tissue. Once the bacteria colonize a wound, they create a biofilm, making the bacteria stronger. Maintaining a high level of hygiene and sterility whilst managing a wound is vital as well (Sandoz, 2022). According to several participants from the studies, table 8.4, wounds on small animals generally heal without complications. For horses, however, the process is much slower due to the size of the wound, the environment the horse lives in as well as their relatively thin skin. A large amount of research has been done on horse treatment (Ribeiro, 2024). Treating horse wounds generally requires large amounts of antibiotics as well as aggressive flushing of the wound.

Controlling moisture balance is important to create the ideal conditions for wound repair (Winkler, 2024). Dry wounds often heal slower due to restricted supply of the needed components. However, if a wound is too moist, healthy tissue can start breaking down resulting in complications in the wound healing process. The use of dressing is a great way to maintain the correct moisture levels. There are several types of dressings, some add moisture to a wound while others absorb moisture. Sterile dressings also create a barrier for bacteria to enter the wound (Bishop et al., 2003).

3.1.2 Skin Infection

Among small animals wounds are not as common as with horses. A condition that does present itself regularly is pyoderma or skin infection. These are often secondary to allergic reactions and can occur in different areas of the body. The following section will describe this skin condition and explain its treatment.

General Skin Infection

Pyoderma, referring to bacterial skin infections, are one of the most common reasons for bringing an animal to a veterinary clinic (Hill et al., 2006). Diagnosis of pyoderma can be done in multiple ways, but generally it is diagnosed by performing a clinical evaluation, followed by a cytological evaluation and possibly growing a bacterial culture (Clark, 2025).

The clinical evaluation aims to first determine if any characteristic lesions are present, then confirm the presence of bacteria in order to rule out other common causes (Clark, 2025). The presence of fungi or bacteria is generally determined by, cytology, a direct examination of a skin sample through a microscope. Furthermore growing a culture can help determine more precisely the type of micro organism present, which aids in determining its resistivity to antibiotics. Depending on the infection's location, the sample collection method might vary. Impression smears can be utilized after removing crust or after opening pustules. If the lesion, either is hard to reach with a microscopic slide or is dry or oily, clear adhesive tape can be used. Other methods for sample collection in hard to reach places include using cotton swabs, a micro spatula or a scalpel.

Ear Infection (Otitis Externa)

Otitis externa is generally considered as a form of skin infection and is a common problem for dogs and cats, and refers to an inflammation in the external ear canal (Hoff, 2025). Otitis externa is more common with dogs than cats.

The cause for ear infections can be both primary and secondary and can also be both infectious or noninfectious. Primary causes of otitis externa include allergies, parasites, autoimmune/ endocrine disorders, foreign bodies or fungal/ viral infections. These causes often allow secondary infections to develop due to the altering of the ear environment through inflammation. The secondary causes for otitis externa include, bacteria, yeast, medication reactions and excessive cleaning. Factors such as ear shape, moisture levels and obstruction, systemic disease or prior otitis can increase the risk of developing the inflammation. Clinical signs of otitis externa include head shaking, ear scratching, pain, bad smell, ear discharge, redness and swelling and ulcerations of the ear canal skin.

The treatment process includes cleaning the ear canal with specialized shampoo or sprays and controlling pain and inflammation. Additionally, antibiotics are used for severe infections.

3.1.3 Urine Infection (cystitis)

The urinary system, consists of the kidneys, ureters, bladder and urethra (Reece, 2015). It has several functions which are vital to the body. First it excretes waste products from metabolism such as urea or digested toxins. It also regulates the level of body fluids. Infections to any part of this system can negatively affect its functions.

Common Cause

Urinary infections can have multiple causes. However, a common issue is bacterial cystitis (Whitehouse, 2025). This is an infection in the bladder, mainly caused by *E. coli*. However, other bacteria could cause this as well. The infection starts by organisms entering the bladder through the lower urinary tract. If left untreated, the infection can ascend up to the kidneys and cause kidney infections, known as pyelonephritis. This disease mainly occurs among female dogs and cats as well as cats older than 10 years. It is also possible to have bacteria present in urine, without any symptoms of an infection. This is called bacteriuria and is generally left untreated. Some urinary tract infections are caused by fungi instead of bacteria, these are less common however. For fungal infections, antibiotics do not have any effect. It is therefore important to determine the cause of infections beforehand.

Diagnosis and Treatment

In order to diagnose animals with urinary issues several techniques can be applied (Whitbread, 2025b). Urinalysis is the general process of collecting a urine sample, either through manual compression of bladder, use of a catheter or cystocentesis, use of a needle. This sample can then be analyzed using gravity tests and checking the sediment with microscopes. For infections, this method is not sufficient. For example, 25-30% of dogs with a urine infection have bacteria levels below the threshold urinalysis can measure. In these cases growing a bacterial culture is needed to get an accurate reading. Growing the culture can take up to 7 days for results to show. When collecting the sample it is important it is tested within 24 hours. However, as one of the interviewees mentioned many clinics do not have the resources, so it is necessary to ship the sample. In these cases, the sample must be kept refrigerated to prevent spoilage. For the samples considered as significant it must contain more than 10^3 CFU/ml.

Treatment of bacterial cystitis is similar across all mentioned cases including dosing antimicrobials from 3-5 days depending on the severity of the infection and the size of the animal.

3.2 Micro-organism Determination

In order to determine what micro-organisms are present, first a sample must be collected. The method for this varies per use case. As some are superficial, such as skin and ear, they can be collected with ease compared to, for example, urine. The following section will explain the different methods for each case.

In case of small animals, determining the type of bacteria on skin can help determine the required antibiotics treatment, as mentioned by participant 1. According to Moriello (2025) the preferred method for sample collection on skin is through using a sterile culture swab directly on the skin where the tip of the swab would be moistened with the transport medium and then aggressively rubbed against the lesion area, ensuring that the entire tip of the swab is contaminated.

Since impression smears usually only sample the surface and therefore rarely include cells from deeper tissues, their value is limited. However, when performing biopsies they can be of great value before fixation and processing of the tissue sample, since they enable immediate assessment of the cut (Whitbread, 2025a). For urine samples, cystocentesis is generally used (Sanderson, 2025). Here a needle is used to extract urine directly out of the bladder. This method is the most sterile option.

3.2.1 Cytology

A cytological evaluation is performed by analyzing samples with a microscope. After collection the sample material is rolled on to a glass slide. In order to visually analyze the cells, tissue and their components, the sample is stained, which enhances contrast and highlights structures (Gurina & Simms, 2023). When analyzing the stained smears, using multiple different levels of magnification, the veterinarian examines the number of, bacteria, yeast and the white blood cells (Hoff, 2025). Additionally, different types of stain can be used depending on the present micro organisms, enabling a better analysis. The cytological examination aids the veterinarian in choosing the right treatments for the specific case, for example if antibiotics should be used or if other methods are sufficient. If further diagnostics is required, culturing of the samples can be performed.

3.2.2 Bacterial Culturing

As mentioned, clinics generally have the ability to perform simple forms of analyses such as cytology. However, some cases require further investigation involving collecting samples and bacterial culturing. Not all clinics can perform these actions in-house. In these situations, samples are collected and sent to a laboratory. This process is costly, according to participant 2 around 80€, and often takes several days to obtain results. The laboratory receiving the sample will place these on a nutrient base in an incubator to grow the bacteria (Mercer, 2025). This can then be analyzed with specific machinery. Results are then sent back to the clinic, this usually includes a list of the specific species present as well as the amount.

3.3 Bacterial Autofluorescence

As mentioned previously, many forms of infections are caused by the presence of different types of bacteria. There are several species that in the process of creating heme, an essential component for their survival, produce chemical compounds such as porphyrin (Choby & Skaar, 2016). This molecule is fluorescent, meaning it can absorb a specific wavelength of light and emit it at a different wavelength (Badrie et al., 2025). This characteristic can be used to determine the presence of bacteria. The device that Odinwell developed relies on this exact phenomenon. The shine of ultra violet light on the affected area causes the bacteria to fluoresce back at a longer wavelength that can then be measured (Odinwell, n.d.).

3.4 Antimicrobial Resistance

One of the earliest developments of antibiotics was the discovery of penicillin in 1928 according to Hutchings et al. (2019). Since then many more developments have been made, drastically increasing the average life expectancy. However, with the extensive use of these antibiotics, antimicrobial resistance has increased as well. As a result, some infections are currently considered untreatable. Fortunately, a lot of research is being done in developing new antibiotics, which bacteria has not yet adjusted to. Nevertheless, prudent use of antibiotics is essential to reduce the risk of similar issues arising in the future. Meaning not only limiting the use of antibiotics, but also understanding exactly which type to use in which case. One such way is the use of Odinwell's technology. By having a better understanding of the rate of infection in a wound, medical staff can form a better decision around the treatment that is required, thus preventing overuse of antibiotics.

3.5 Sterilization and Decontamination

Hygiene is an important aspect of medical equipment. Any surface that comes in contact with the patient must have a certain level of cleanliness, depending on the situation. For internal sterile tissues proper sterilization of equipment is vital as this reduces the risk of infections. For external organs, such as skin, which are in constant contact with bacterial environments, the level of hygiene is less strict. Here general disinfection can suffice. Since equipment can be made of a large range of materials ranging from metals to plastics, there is a large range of methods for sterilization and disinfection (Centers for Disease Control and Prevention, n.d.).

3.5.1 Levels of Hygiene

Within medical hygiene there are several levels at which this can be maintained. Each is used for different purposes in a clinic (Mohapatra, 2017).

Sterilization

Sterilization is the highest form of cleanliness, meaning all microbial life has been destroyed. This can be achieved by different methods involving temperature, gas or chemicals.

- High temperature: moist and dry heat, is applied to equipment that is heat resistant. The temperatures used usually range from 120°C to 134°C.
- Low temperature: involves the use of different types of gas, such as ethylene oxide, hydrogen peroxide or chlorine dioxide, or a form of radiation. These methods are generally applied to equipment that contains heat-sensitive materials.
- Liquid chemicals: uses different types of chemicals that kill microbes. This targets prions, which are resistant to other sterilization methods. It can be used for equipment that is heat-sensitive, however it should be immersible

Disinfection

With disinfection the majority of micro-organisms are eliminated, depending on the exact type of method used. However, bacterial spores can still remain.

- Heat: Pasteurization is an example of high level disinfection, exposing microorganisms to heat for a period of around 50 min. This will destroy all active forms of micro organisms, and is generally used for heat resistant materials.
- Chemicals: within chemical disinfection there are multiple levels that can be achieved, depending on type of chemical and concentration used.
 - High-level disinfection: higher concentration chemicals, such as hydrogen peroxide. This method is used for heat sensitive equipment.
 - Intermediate-level disinfection: This generally uses chlorine based products
 - Low-level disinfection: Here more diluted solutions are used to remove micro organisms

Cleaning

The process of decontamination involves removing pathogenic microorganisms or visible debris from objects. The amount of microorganisms does reduce, however the amount is minimum. This can be achieved by wiping or flushing with water.

3.6 Key Findings

In conclusion, the literature study resulted in several key findings relevant to the continuation of this project. To start, a good understanding of common conditions among veterinary patients, such as wounds, and a variety of infections was created. In addition to treatment methods, some research was done on how conditions are diagnosed through cytology and bacterial culturing. Some information regarding bacterial autofluorescence was presented, to get a better understanding of how Odinwell's technology works. Moreover, the risk of antimicrobial resistance was described, thus explaining the importance of this project. Finally, several levels of

hygiene were explored. All information gathered during the literature study helped create a better understanding of the context of application. By having a clearer understanding of this, a better product can be developed more accurately solving their needs.

4

Market Representation

The following section aims to present Odinwell, the company for whom the thesis will be conducted. As well as list other companies with similar technologies, who are viewed as the competitors.

4.1 The company

Odinwell is a relatively young med-tech start up, located in Mölnlycke, that was created as a branch of Redsense Medical in 2020. It currently consists of 3 employees and several part time employees and consultants, with their main focus being the development of non-invasive optical sensors to measure bacterial autofluorescence levels in wounds and wound dressings, with the final goal of measuring through the dressing (Odinwell, n.d.). Thus, aiding in the assessment of the state of healing of a wound. With this technology, the company has developed two main products (Odinwell, 2025).

- **Handheld Scanner:** This product, figure 4.1 (a), was designed for health care professionals, HCP, to easily monitor the state of a wound by measuring biomarkers produced by bacteria in the wound or in the dressing. It is also able to measure through transparent dressings, eliminating the need to expose these wounds. The handheld nature of the product simplifies the process for HCP to assess the wounds. As they simply have to place the device on the wound to scan it and receive results. Its small size makes it portable, so it is easy to move from one patient to the next. Moreover, by using exchangeable tips the device can be used across several patients without risk of cross-contamination.
- **Monitoring Device:** Using the same technology, the sensor, figure 4.1 (b), can also be integrated into the dressing of a wound. As it is integrated, the device can continuously send data regarding the presence of bacterial biomarkers in the wound, therefore allowing for remote monitoring. By not having to remove the dressing, the wound has an increased chance of healing without the introduction of infections (Hwang et al., 2024).



(a) Handheld Scanner



(b) Monitoring Device

Figure 4.1: Presentation of the two Odinwell products. *Source:Odinwell (2025)*

As of now Odinwell has a fully functional demo product that is being used to collect data from tests as well as present functions to potential partners. They aim to further develop this product to meet the needs for the veterinary market as well as regulations in order to sell the product as a medical device in the future.

4.2 Competitors

As part of the exploration, the market in which Odinwell is working has been studied. The following section will present some of the competitors within wound monitoring devices. An overview of their products can be viewed in figure 4.2

4.2.1 MolecuLight

MolecuLight is a Canadian based med-tech company that developed a device that aids in wound care by means of visualizing bacteria presence (MolecuLight, 2025). Their initial device, MolecuLight i:X, consisted of a handheld, portable device with a screen. The device emits violet light on the wound area. If over 10^4 CFU are present porphyrin produced by the bacteria will cause the affected area to be displayed as a red area on the screen. The downside of the product is that it has to be used in a dark environment, to not get interference from ambient light.

After this device they created a second model, MolecuLight DX that is slightly larger, with a bigger screen. In addition to measuring bacterial presence this device had added features including: measuring progress of wound size, measuring temperature using infrared camera and a documentation platform to keep track of patients progress.

The MolecuLight technology has been used in several clinical studies and peer reviews (NICE, 2020). They have distributors in a large number of countries across the world.

4.2.2 Kent Imaging

The Canadian med-tech company Kent Imaging focuses on imaging technology within limb preservation and surgical care (Kent Imaging, 2022). The company has two main products, the SnapshotNIR and the SnapshotGLO. Both products have about the same form factor, utilizing a tablet shape where the use is controlled through a touch screen on the front of the device. On the other side of the device, there are lights and a camera sensor and on the sides there are handles to provide good grip for the user. Both products are used in the same way but use two different technologies to determine different things.

SnapshotNIR is used to determine tissue health in a non-invasive manner. By using Near-Infrared (NIR) light to determine the oxygen saturation in the tissue. The weight of the SnapshotNIR is 3,27 kg.

SnapshotGLO uses ultraviolet (UV) light to determine bacterial presence in wounds through bacterial autofluorescence. When capturing an image of the wound, red and cyan fluorescence will indicate both the location of bacterial load as well as the type of biomarker present. The highlighted strength of this device is to provide actionable information early to allow for targeted treatment. The weight of the SnapshotGLO is 1,27 kg. Within the software the user has the ability to not only look at the latest image but also look through previous images that can be stored within the device, there are also multiple automatic features, for example automatic wound detection and automatically generated graphs for monitoring wound trends.

Both devices are marketed as cost-effective, however, no details about the pricing can be found on the company website or in product literature.

4.2.3 Swift Medical

Swift Medical is a company utilizing the high quality and increasing potential in smart phone cameras within wound care and wound assessment (Swift Medical, 2025). Swift's main argument is that technology isn't the solution to better health-care, rather accessible technology is what matters. Swift has developed an AI driven software called Swift Skin & Wound™ 2, that can be used to provide analytics of wounds during the entire healing process. This software can be used in a regular smartphone and utilizes the phone camera. Further, this software can be paired with the swift portal, which gathers all data from the phone and makes it accessible through a computer interface.

Additionally, Swift Medical also sells a product called the Swift Ray, an addon for a smartphone camera that further enhances its capabilities. This product enables thermal imaging and bacterial detection, on screen, through the use of UV-light thanks to multiple light sources and an additional camera lens.

4.2.4 Designs for Vision

Designs for vision is an American based company that has several products that are attached to glasses (*REVEAL FC Autofluorescence Skin Wound Imaging*, n.d.). The use case for these products ranges from dental care to individual optical aid. For our project their medical auto fluorescent imaging line is relevant. The Reveal FC consists of a simple pair of glasses to which a UV lamp is attached. When using the lamp the infected area in a wound will reflect a blue color. The medical staff can then easily see which parts should be removed. This product allows for both hands being free to perform the necessary actions.

4.2.5 Woods Light

The Wood's light technology emits UV-light which is used to detect bacterial infections, fungus and mites. The method of using a wood's light requires the user to, based on what they see, determine what is the cause of the problematic area. Due to the products, size, ruggedness and simplicity the wood's light technology could be suited for use in developing areas of the world where resources are limited (Cardillo et al., 2014).

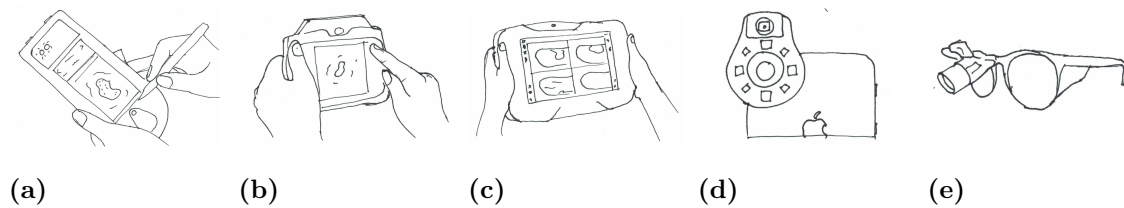


Figure 4.2: Overview of competitor products: (a) MolecuLight i:X, (b) MolecuLight DX, (c) SnapshotGLO, (d) Swift Ray, (e) Reveal FC.

4.3 Key Findings

To summarize, this chapter presented Odinwell as a company and the two main products they are developing. In addition to that, an overview of several competitors was presented, describing the market the product will be applied to. This information created a base understanding of the company, their products and the competitors. As a result, some key requirements such as weight limit key functions were found.

5

Theoretical Framework

The following sections will discuss some theory related to the design of products for end users. It will give definitions for different approaches such as design for usability as well as human centered design. Additionally it will describe some relevant anthropometric data required for this project.

5.1 Design for Usability

The working environment of a veterinarian can be stressful. Having to handle an animal, execute an examination and communicate with the owners all at once requires a large amount of concentration. In order to allow the product to aid this process, rather than interrupt, it is important to ensure a smooth interaction, where the user knows exactly how to use the product and what is happening at what time. To achieve this there is a set of design principles that can be followed(Norman, 2013).

5.1.1 Norman's Design Principles

Affordances

Affordances are the actions that the products allow a user to do. For example a handbag affords to be carried. Norman states that affordances should not be seen as properties, rather as relationships between the product and the user.

Signifiers

Signifiers are the characteristics that signal what actions can be done and where they should happen. These can be deliberate, such as a written sign, or by accident, like a naturally formed trail in a park. It is important that signifiers are seen and easily understood for them to function properly.

Mapping

Mapping is the relationship between the layout of two different groups of elements. This principle is often applied to button layouts. For example having stove top controls match the order of the burners. For mapping to make sense, the order and functions of controls should match the actions they do. This is also known as natural mapping.

Feedback

Feedback relates to the communication of the outcome of actions and is something that we constantly use. For feedback to be effective it is important to have it as immediate and informative as possible. Signals like lights or sound can work counterproductive when they are too distracting, potentially leading to irritation. Similarly, feedback should be limited to the essential, as too much feedback can cause confusion.

Conceptual models

Conceptual models are a general and simplified explanation of how something functions. These models can vary depending on the type of person. Designers might have a different model than users. A form of conceptual models that are shaped in people's minds are mental models. They describe how people see a product and how they want to interact with it.

5.1.2 Human-Centered Design

To ensure these design principles are applied effectively in a project, a human-centered design approach should be used. Human-centered design involves a design process where the end user is seen as the starting point (IDEO, 2009). The process includes three steps starting with collecting data from the user, followed by applying this information to the concept creation, which is done in close collaboration with users. Finally the design is finalized and evaluated before launch. This method ensures users input is applied throughout the whole process.

5.2 Handheld Anthropometrics

The following section aims to present key dimensions related to handheld devices. For this specific case hand breadth, grip diameter and wrist movement will be analyzed.

5.2.1 Hand dimensions

As the product being designed in this project is a handheld device, it is important to consider the ergonomics that relate to this, to ensure a comfortable and usable grip. For this, the ergonomics can be split in two categories: anthropometric and range of motion (Lee & Jung, 2014). The anthropometric have to do with the dimensions of hands, including hand width and grip diameter, figure 5.1. This is important to ensure the handle of the device fits nicely in all hands, to create a secure grip on the product, specifically when animals make sudden movements. According to a study by Garrett (1971) and Rodríguez-Vega and Rodríguez-Vega (2024) the data presented in table 5.1 was collected. These will be used as a baseline for dimensioning the device.

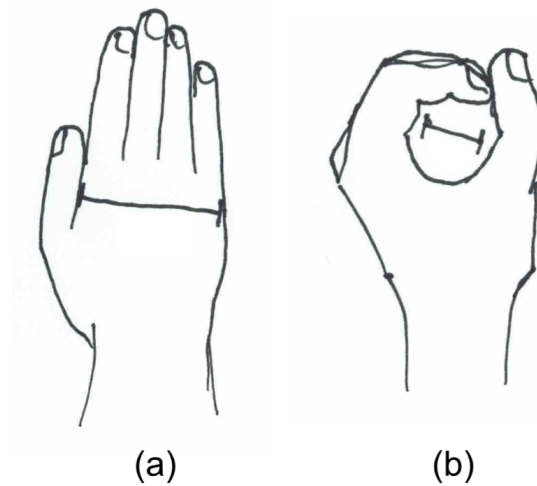


Figure 5.1: Measuring point for (a) hand breadth and (b) grip diameter.

Table 5.1: Anthropometric table for hand sizes.

Dimension	5th percentile (mm)	95th percentile (mm)
Hand breadth (male)	83,31	97,03
Hand breadth (female)	70,61	83,31
Grip diameter (male)	41,80	54,48
Grip diameter (female)	39,49	51,53

5.2.2 Wrist Movement

The movement of the wrist can be split into four directions: wrist flexion, wrist extension, ulnar deviation and radial deviation, presented in figure 5.2. There is also pronation and supination of the hand, however this is achieved by the forearm bones and not the wrist (Bajaj, Spiers, & Dollar, 2015). These motions are important to determine the correct angle for the device when measuring on a surface. To get the range of motion of the wrist, different studies have been done. A study by Ryu et al. (1991) shows the following angles, table 5.2 achieved by the wrist.

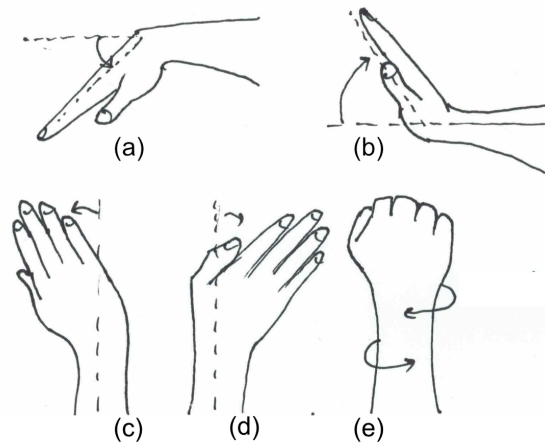


Figure 5.2: Wrist movement: (a) Flexion, (b) Extension, (c) Radial Deviation, (d) Ulnar Deviation, (e) Pronation and Supination

Table 5.2: Wrist range of motion.

Movement direction	Angle
Extension	68,9°
Flexion	68,4°
Ulnar Deviation	42,7°
Radial deviation	16,6°

5.3 Key Findings

To conclude, this chapter studied different aspects related to the design of hand-held products. First, Norman's design principles and human centered design were studied to discover key requirements for well functioning products. Additionally, research was done on hand dimensions and wrist mobility to find key dimensions for a handheld product. These findings were added to the list of requirements, to form a base for the concept development phase as well as create accurate data to use in the evaluation of the final design.

6

Methods

Several methods were applied throughout the different phases of the project. The following section will describe these methods. How these methods were applied, will be discussed later in the report.

6.1 Benchmarking

Benchmarking is a process where different competitor products or companies are analyzed and evaluated in order to make better decisions (Aela, 2021). Benchmarking can be used either when entering a new market or when re-designing a current product. By comparing competitors, their strengths and weaknesses can be found, as well as potential gaps in the market, providing valuable information of what areas to focus on for your own product.

6.2 User Studies

To understand different needs of the users, several methods can be applied. The following section will describe two of these methods.

6.2.1 Interviews

To gain an understanding of how a user thinks and reasons, interviews can be conducted, which is the most fundamental method for collecting user information (Bligård & Simonsen, 2015). This method can be used for exploration as well as evaluation. An interview involves engaging in a conversation with a user in order to develop an understanding of the subject being studied. The questions asked during the interview can be prepared in advance to create a clear structure and ensure that the areas of interest are discussed. This type of interview is referred to as a structured interview, as it follows a predetermined format, and is considered the most advantageous form for collecting quantitative data. Interviews can also be conducted without a predetermined structure, allowing for a more open and free-flowing discussion with the user. This form is known as an unstructured interview and is well suited for collecting qualitative data. Additionally, interviews can be semi-structured, representing a combination of the two approaches. Here, interviews are conducted based on a predetermined structure with defined topic areas, while still allowing the discussion to flow freely within each.

Mediating objects are used in interviews to facilitate communication and support participants in expressing their thoughts (Sanders & Stappers, 2012). These may consist of, for example, images or physical artifacts and function as a shared reference point in the conversation.

6.2.2 Observations

Observations involve directly watching a user perform a task and can help provide insight into what users actually do, rather than what they say they do (Bligård & Simonsen, 2015). Observations can be conducted in two different settings: in the field or in a laboratory environment. Field observations take place in a real-world context, where the user performs an actual task in their natural environment. In contrast, laboratory observations are conducted in a predetermined and controlled setting, where the user performs a specified task. This type of observation can be advantageous for understanding how a specific solution functions for a particular task, as the controlled environment allows external factors influencing the situation to be managed.

6.3 Analysis

The data gathered throughout the project was systematically structured and analyzed in order to maximize understanding and support the development of subsequent studies. The main objective of the user studies was to develop an understanding of the tasks and goals of veterinarians in order to identify how and when the bacterial scanner could be implemented. KJ analysis, Hierarchical Task Analysis (HTA) and Link Analysis were used to analyze the qualitative data gathered through the user studies.

6.3.1 KJ-analysis

In order to analyze the information gathered from the initial interviews with veterinarians, the KJ-analysis was used. The method is used in order to summarize and divide big amounts of data, to get a better overview (Bligård & Simonsen, 2015). The strength of this method is thanks to it being a “bottom-up” strategy, where details are the starting point that evolves into an overview. The method works by writing all the information that could be of interest on separate pieces of paper, where every paper only contains one unit of data. Then, based on the theme of information of each note, they are divided into categories after which these categories are given a title.

6.3.2 Hierarchical Task Analysis

Hierarchical Task Analysis (HTA) is a method used to describe a specific task and its goal by identifying the steps required by the user (Bligård & Simonsen, 2015). Each step performed by the user to achieve the final goal is identified and divided into subordinate tasks. This process is repeated until the desired level of detail is reached.

6.3.3 Link Analysis

A link analysis is a method used to analyze a system, and specifically the movements within the system during a task (Stanton & Young, 2005). Spatial diagrams are created, showcasing the physical movements and movements of the attentional gaze performed during the task, allowing for a broad understanding of the environment within the system.

6.3.4 Physical Ergonomics Product Assessment

A Physical Ergonomics Product Assessment (PEPA) aims at evaluating the physical strain of a product in a specific use-case (Belin and Bligård, 2022). This use-case is typically analyzed through the creation of a HTA or a link analysis in order to establish clear steps. PEPA can be used in order to identify the most and least straining parts, highlighting potential target areas for design improvements.

Seven different aspects are considered for each step of the task, these are; Handling, Strength, Precision, Endurance, Grip, Body Load and External Factors. The tasks are rated in each aspect and get a value of Low, Medium or High, except in the first and last aspects. Handling is evaluated by noting the action, the options are Hold, Move, Impulse force and Catch. In the final aspect the external factor is noted in text.

6.3.5 Persona

A persona describes a typical user of the designed product. This description is highly detailed to bring a fictional person into reality (Bligård & Simonsen, 2015). This creates a more concrete and personal profile to help understand user needs and the contexts they work in. This method can be used both to define the actual user as well as the intended user.

6.4 Concept Creation

Concepts can be created with the help of multiple different methods that can be used separately or in combination with each other. The following section will explain two separate methods.

6.4.1 Ideation

Brainstorming and brainwriting are methods used in group settings to generate as many ideas as possible for potential solutions to a given problem (Österlin, 2010). The primary difference between the two methods is that brainstorming involves continuous discussion throughout the process, whereas brainwriting is initially performed individually and discussed collectively only after a certain period of time.

During brainstorming, participants present their ideas to the group immediately, enabling ongoing discussion intended to stimulate further ideas. In brainwriting, however, participants write or draw their ideas individually instead of sharing them directly, thereby reducing the risk of influencing one another. After a set amount of time, the participants present and discuss their ideas together.

Typological design splits the product into several basic geometric shapes such as cubes, cylinders and spheres (Muller, 2001). The connection, relation and orientation of these basic shapes can be adjusted to create a larger variety of initial designs. The topological order changes the direction a product can have by changing the positioning in space.

6.4.2 Prototyping

An important aspect of the product development process is the creation of prototypes. These can be virtual, physical, or, as is often used in current practice, a combination of both (Kent, Snider, Gopsill, et al., 2021). Prototypes are an initial representation of the final product, and are used to evaluate different aspects of the design (Hallgrímsson, 2012). They are created with a question in mind that is meant to be answered by analyzing the prototype. The initial phase of mock-ups is rough and general. As the project progresses, prototypes become more detailed. The materials used can include cardboard, foam or additive manufacturing.

3D modeling is a commonly used tool in the creation process and can be split into different areas, including solid modeling, surface modeling and parametric modeling (Borrmann & Berkhahn, 2018). Solid modeling represents an object as closed volumes where geometry and typology is defined while surface modeling describes the object's outer surfaces. Different types of 3D modeling have different strengths and should be adapted to the task at hand.

Additive manufacturing, also referred to as 3D printing, is a manufacturing method where 3D models are created as physical objects by printing it layer by layer (Kruth, 1998). By using this technology, designers can quickly and easily assess form, fit and functionality early in the process, which is a method called rapid prototyping. Depending on the required level of accuracy, production time and mechanical capabilities different methods of additive manufacturing can be used, the selection should be based on the objectives of the prototype. The most common method within additive manufacturing is called Fused Deposition Modeling (FDM), where a thermoplastic filament thread is fed through a heated nozzle and is then stacked

in layers to create a physical component (Ahn, Montero, Odell, Roundy, & Wright, 2002). FDM is a cost effective, quick and widely accessible technology which has led to its popularity.

6.5 Concept Evaluation

Concepts can be evaluated with the use of multiple methods, the following section explains the theory behind Diary Studies and Cognitive Walkthrough.

6.5.1 Diary Studies

A diary study is a method in which participants note down their experience as they use the product over a set period (*Diary Studies: A Step-by-Step Guide for UX Researchers*, n.d.). It can be used throughout several phases in the product development process, exploration, validation or optimization, to gather user needs, identify issues or evaluate the design. This method is often combined with interviews or usability testing to create a more specific understanding of the product's usability.

6.5.2 Cognitive Walkthrough

A Cognitive Walkthrough (CW) is a method for the evaluator to understand how the interaction between the user and a product will take place by simulating the user's thought process. It is based on humans' need for learning by trial and error (Bligård & Simonsen, 2015). This method is used in order to determine the users ability to perform the task sequence in the "correct" order, by utilizing a structured questioning process.

6.6 Key Findings

To summarize, this chapter presented a large variety of methods to be used in the process of this project. Different methods for benchmarking, user studies, analysis, concept creation, concept evaluation were discussed. Each of these will be applied in their specific phase in the project. The following chapters will describe how exactly they have been applied

7

Process

The general approach used within this project can be described as human centered design. As mentioned previously, this method involves having the user as the starting point of the design and constantly be present throughout the process (IDEO, 2009). This was achieved by continuously gathering user inputs to create a base for the design as well as to evaluate the solutions. The project was split into three main phases visualized in figure 7.1: exploration, concept development and evaluation. Each phase included multiple iteration cycles. Here the double diamond approach of diverging and subsequently converging concept variations was followed in each cycle (Cross, 2024). The exploration phase aimed to expand the solution space. During the concept development this space was continuously narrowed down, by applying different methods within design evaluation, such as cognitive walkthrough and user studies. Additionally detailed solutions were expanded further, by creating design iterations, till a final design was created. For ease of understanding, the phases will be described as individual phases in a linear order. However, during the project the phases were executed more in parallel.

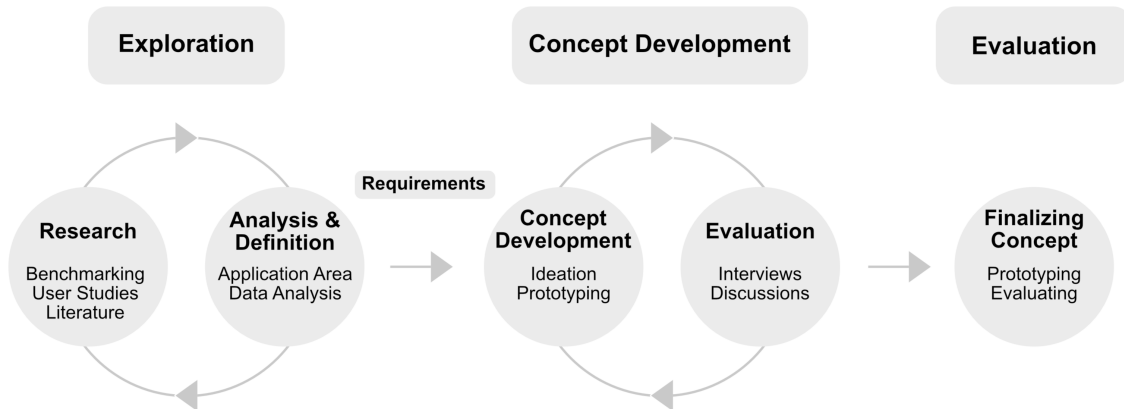


Figure 7.1: Overview of the process.

7.1 Exploration

As with many design processes, this project started with an exploration phase in which a combination of theoretical research, observations and interviews helped create an understanding of the users needs and their working environment. Multiple methods were applied to analyze the results, leading to a set of personas with each

their own HTA. Additionally, benchmarking and product analysis helped define the current weaknesses of the product and set a baseline to evaluate the final design. The results of all of this combined formed the foundation of the requirements list, which served as the main guide throughout the whole concept development.

7.2 Concept Development

The concept development phase consisted of multiple iterative cycles, each of which started by increasing the variety of solutions and ending in an evaluation round to narrow down the solution space. The final phase was spent defining details. In these phases the grip and tip will be presented separately. The goal was to create a single scanner that could be used in different contexts, by changing modes in the device. A single tip will be designed for both contexts in this project. However, future development could allow development of context specific tips to further expand the use cases of the scanner.

Throughout the concept development phase, multiple ideation methods were used, however, most were variations of brainstorming and brainwriting. The majority of the ideation sessions were based on different forms of brainwriting. Ideas were not only written down on paper, but also explored through the creation of prototypes and mock-ups. In some cases, ideas were communicated by presenting external products or solutions to different problems in order to illustrate a concept. Nevertheless, the main principle of brainwriting, where participants work individually before later discussing the results collectively, was consistently followed.

7.2.1 Crazy Week

The initial week was described as the crazy phase, which involved unrestricted exploration of ideas and solutions, both for the overall shape of the device as well as tip solutions, resulting in a large variety of ideas. Throughout this phase typological design was applied in order to challenge the existing solutions and explore other ways of connecting the vital parts of the product. With the initial phase completed, the requirement list was used to eliminate the unrealistic designs, thus narrowing down the solution space.

7.2.2 Grip Categories

The next phase focused on the general shape of the device. Solutions were created for different grip types and different context scenarios. Exploration was mainly done by creating foam prototypes, in combination with some rough sketching. Part of this phase involved a co-creation workshop with the employees at Odinwell. This was done to allow more creative input from multiple people with different backgrounds. The result of this phase was a set of grip solution categories with variations within each. Before continuing to the next phase, a selection of grip categories was made, to further define the design direction. This selection was done based on user feedback as well as a voting and evaluation round with everyone at the company.

7.2.3 Selection of General Body

With a set of grip solutions, this phase aimed to create variations within the chosen categories. Moreover, additional variations of the original design were created. Once a large number of variations was formed, the models were categorized and discussed with the Odinwell team to evaluate feasibility. Based on this discussion a selection was made to continue with and create the details. Throughout this section a slow transition was made from prototyping with foam into using 3D-modeling and 3D-printing in order to make the prototypes more realistic.

7.2.4 Focus on Tip Exploration

Having a clear understanding of what the final product would look like enabled a shift of focus towards the tip. Though its design has been kept in mind throughout the whole process, it would now be the main focus. This phase followed a similar pattern as previous design steps, involving sketching and multiple iterations of prototypes to create a final result.

7.2.5 Final Details

Once the general design was complete, final details such as interface, dimensions and manufacturing methods were explored.

7.3 Evaluation

As mentioned, a form of evaluation was done in each cycle of the concept development. The goal was to do the majority of this with end-users, however due to complications with communication, this could not always be achieved. For the initial cycles the designs were evaluated by colleagues at Odinwell. The variety in background helped select products that could be produced, and fit the company's wishes. Later, prototypes were sent to multiple veterinarians to allow for final evaluation by an end user.

7.4 Summary

To summarize, a description of the general process of this project was given. All phases have been presented and explained in detail. The following chapters will describe the exact steps taken throughout this process and how the findings have been used to create the final design.

8

Exploration Results

The results found in the exploration phase can be split into two categories: context specific exploration and product specific exploration. The first examines the environments in which veterinarians work and the tasks they commonly perform. The product specifics explore the current device, competitor products and similar products in the market.

8.1 Context Specific

In order to understand the veterinary environment and the context in which the device will be used, multiple methods of data collection and analysis were used. This section explains how these methods were applied and the results gathered.

8.1.1 Veterinary Environment

Based on the data collected through research and observations, two potential application contexts were discovered. The first being a horse clinic and the second a clinic focusing on small animals. The following section will describe these contexts and explain how the veterinarians work in each environment, what equipment is used and how instruments are stored.

8.1.2 Horse Clinic Context

To create an understanding of the layout and functions of horse clinics, two different clinics were analyzed. Additionally, some information was gathered through interviews. The environments in which horses are treated can vary. If a horse is treated at a clinic, it is led into a special room with all required equipment. Depending on the treatment, the horse can be placed in stocks, figure 8.1, a special restriction box, in order to ensure the safety of the veterinarian. The material for the stocks varies from steel to wood. The room has a concrete floor, which can be easily rinsed and cleaned after treatments. All sterile equipment is stored in specific drawers, usually in an adjacent room with a higher level of sterility. It is also common for veterinarians to visit horses at their home stable. This is mainly done for simpler treatments as the environments are less controlled and generally not very hygienic.



Figure 8.1: Two examples of stocks.

8.1.3 Small Animals Clinic

The second area of interest is a clinic specialized in small animals, typically referring to cats and dogs. Patients are commonly brought in for general assessments, therapeutic interventions, and routine health examinations. For the analysis, two clinics were observed. A comparison was done between a large animal hospital and a smaller local clinic. The majority of the equipment and layout for both of these was very similar.

Both clinics comprised several examination rooms designated for general clinical assessments, in addition to specialized rooms serving specific diagnostic and therapeutic purposes. These included a radiography (X-ray) suite, an ultrasonography room, multiple operating rooms of varying size and sterility level, storage rooms for medical consumables, separate recovery rooms for cats and dogs, and a small in-house laboratory. The main difference was that the equipment at the larger animal hospital was more varied and specialized than in the smaller clinic, figure 8.2.



Figure 8.2: Cytology setup in small clinic (a) and local hospital (b).

Within small animal clinics the dermatology room is of most interest. As mentioned in section 3.1.2, skin conditions are a common issue in small animals. Therefore, this is where the product is believed to have the most potential. This room provides a clean, consistent and controlled environment for the vet to perform the complete assessment and treatment. According to participant 3, a dermatologist, the most used tools were, a chip scanner, an otoscope and a microscope with a staining station, all equipment is usually accessible in a general examination room.

8.1.4 Interviews

In total, six veterinarians were interviewed during the initial phase of the project. They represented a range of experience levels, professional backgrounds, areas of expertise, and were based in two different countries, Sweden and the Netherlands.

Table 8.1: Overview of Participants.

Participant	Field of Expertise	Workplace
1	Small Animal Clinic Owner	Animal Clinic
2	Veterinary Teacher	Veterinary School
3	Dermatologist	Research Hospital
4	Surgeon	Animal Hospital
5	Ambulant Veterinarian	Remote clinic
6	Surgeon	Animal Hospital
7	Dermatologist	Animal Hospital
8	Dermatology Nurse	Animal Hospital
9	Horse Veterinarian	Horse Clinic
10	Horse Veterinarian	Horse Clinic

Most of the interviews were conducted in a semi-structured manner. A predefined set of questions was used to guide the discussion, while allowing flexibility for participants to provide more detailed and elaborated responses. An overview of the questions can be viewed in appendix E. Follow-up questions were frequently asked, often taking precedence over the original question order, in order to maintain a natural and coherent flow of conversation.

In addition to questions, a selection of mediating objects was used to improve communication and to support conveying thoughts and ideas. For the mediating objects, existing products in Odinwell’s portfolio were primarily used to explain the technology and the product. However, for some of the interviews, foam or 3D printed prototypes of new designs were used.

The first three interviews were conducted remotely via video calls, as in-person meetings were not feasible. The primary focus of these interviews was intentionally broad, aiming to develop an overall understanding of current veterinary practices and to explore how Odinwell’s technology could be integrated into daily clinical work. In addition, questions regarding other commonly used veterinary products were included to identify which products are considered effective and to better understand the factors contributing to their perceived quality. The first two interviews were conducted with highly experienced veterinarians with broad professional backgrounds. These interviews provided a clear overview of the veterinary profession in general, as well as identified areas in which Odinwell’s technology could potentially be implemented. In particular, participant 1 highlighted urinary tract infections as a common issue in both cats and dogs, an area that was explored further, through literature studies, during the exploration phase. The interview with participant 3 involved a veterinarian with a specialization in dermatology and teaching, which

provided valuable insights into cytology and its practical applications. Again, this formed a topic for theoretical research during the exploration phase.

The fourth interview was conducted on-site at a local veterinary clinic. Due to time constraints, a slightly condensed version of the interview guide was used. During the interview, an existing Odinwell product, figure 8.3 was used as a mediating object, allowing the veterinarian to test it to gain a clearer understanding of the technology. Following the interview, a tour of the clinic was conducted, during which additional questions were asked and answered as different areas of the facility were presented. This visit proved valuable in confirming the information gathered from previous interviews. Observing the clinic environment also contributed to a more comprehensive understanding of how veterinary clinics are structured and how their different functional areas are interconnected.



Figure 8.3: Odinwell's scanner as mediation object.

The interviews with participant 5 and 6 were carried out at Odinwell's office, which provided additional opportunities for interaction. Although the overall interview structure remained consistent, the office setting enabled a more comprehensive presentation of the product. This facilitated a clearer understanding of potential future use scenarios for the participating veterinarians. Furthermore, some prototypes, from section 9.1.3 were introduced as mediating objects, allowing for more detailed feedback. Participant 5 worked as an ambulant vet, which proved useful in providing an understanding of how a level of sterility is kept in a constantly changing outdoors environment, compared to the controlled environment of a veterinary clinic.

All information gathered for each interview was documented. After concluding the interview, the notes were reviewed and summarized and the main takeaways were noted down. These documents were later used in the KJ-analysis, presented in the following section, to create a better overview of the required data and to discover topics that required more research.

8.1.5 KJ-analysis

The KJ-analysis was based on the previously mentioned interview results. After each interview, notes and recordings were summarized in a document. These documents later became the foundation for the KJ-analysis. In total, 77 pieces of paper containing one unit of data each were used in the analysis. After a few rounds of discussing and organizing the pieces of information included in the KJ-analysis, twelve categories of data were established, these can be viewed in table 8.2. A more detailed representation of the results can be seen in appendix B.

Most of the categories proved to be in line with the already established image of the researched subject. However the analysis provided confirmation of this. Some categories, however, provided new insights. For example environment and use cases aided in developing a clearer understanding of the differences and similarities between different fields of application for the technology. This supported the decision later in the project to create a universal scanner that can be adapted to specific scenarios by changing modes. Initially these contexts included: horse wounds, skin conditions, ear infections, urine infections and surgery. Throughout the project, mainly based on the available clinics for observation, these contexts were narrowed down to horse clinics and dermatology for small animals. The requirement category also helped in understanding what actually is important for a product and was used as a base when creating the list of requirements.

Table 8.2: Data categories KJ-analysis.

Environment: Provided an understanding of where the product will be used and how this might vary between different use cases. Especially, the storage of the device depends largely on the environment and what type of clinic it is used on or the type of user.	First Assessment: Provided an understanding of the time frame and how much time could be allocated towards using the product.
Documentation: Could be an opportunity for Odinwell to collaborate with a journal system company to directly store the data in the system.	The veterinarian: Mainly confirmed the suspicion that the veterinarian might not be the main user of the device, it would rather be used by the nurse who in a lot of cases perform sample collection and look at cytology.
Common diseases: Increased the understanding of the most common reasons for visits, providing an understanding of where to implement the device in order to help the vet the most.	Culturing and Samples Provided an understanding of what the bacterial scanner can replace and what needs to stay. This category also highlighted the need to perform further research and studies of how the process of collecting and testing samples are performed and in what situations it is needed.
Methods: The methods category further increased the understanding of how the current practice works and therefore, greater insights towards how the new product can fit into the current practice.	Requirements: The requirements category provided a good overview of what would be required from the device and was the foundation for the list of requirements.
Animal facts: Further increased the understanding of the use case and how it might vary depending on what animal is being assessed.	Use cases: Provided a further understanding of how different use cases provide different requirements, which resulted in the three research categories for this project, Lab environment, horse clinics and general assessment.
Current Equipment: Provided a broader understanding of what equipment is currently used and what these products do.	Cost: Confirmed that the budget of veterinarians can be limited and that product price should be minimized.

8.1.6 Observations

In total, three rounds of observations were conducted across two different application areas. These observations aimed to study veterinarians and veterinary nurses in order to further strengthen the understanding developed during the interviews, as well as to identify any discrepancies between reported practices and actual behavior in real clinical settings. In addition to performing their routine tasks, the participants also tested Odinwell's existing handheld scanner. This provided an opportunity to observe how the product was used in practice and to identify potential areas for further development. All observation sessions were conducted as field observations, the veterinarians worked under normal conditions with real patients. The only change was the addition of taking measurements with the scanner between treatment steps. Since the technology in the scanner is still under development, the measurements were only taken to gather data for the company and did not provide the veterinarian with any information that altered their decision making.

One observation was conducted at a local animal hospital for small animals, where a dermatologist and nurse were observed over the course of a half workday, including several patient assessments. During this session, examinations and treatments were performed as usual, with the addition of using the handheld scanner to measure bacterial levels in each sample collected for cytological analysis. For this the scanner was used to measure values on a glass slide as seen in figure 8.4. This observation provided a clear understanding of how dermatologists work and highlighted the importance of cytology in the diagnostic process, as it was performed on all patients and served as the primary basis for treatment decisions. It was also noted that a significant portion of the dermatologist's work involved communication with the animal owner, explaining each step of the process, the observations made, and their implications. Moreover, it presented usability issues with the current device, such as angle of screen and difficulty of holding the device. Overall, this study offered valuable insights into where in the clinical workflow the scanner could be implemented most effectively, without significantly disrupting existing practices. Following the visit, key findings were synthesized in two link analyses, see section 8.1.8.



Figure 8.4: Using the scanner in a dermatology context.

The remaining two observations were conducted at two different equine veterinary clinics, where the treatment process of wounds on horses was examined. At the first clinic, the treatment of two horses was observed, both presenting with wounds of varying size and location on the body. The process of cleaning and dressing the wound was observed closely. At the second clinic, the treatment of one horse with a similar condition was observed. As in the animal hospital setting, the veterinarian incorporated the handheld scanner into the process, as can be seen in figure 8.5, without altering the overall workflow. However, in contrast to the dermatology context, the scanner was applied directly to the wound on the animal rather than being used on collected samples. This distinction provided valuable insights into how the use of the technology differs in a more variable and less controlled environment with additional influencing factors.



Figure 8.5: Scanning wound using current Odinwell scanner.

For example, the veterinarian needed to maintain a heightened awareness of the surroundings, as the horse, despite sedation, could make sudden and unpredictable movements. Another notable observation concerned how sterility and hygiene were

maintained, despite the procedures taking place in a relatively unclean stable environment. The veterinarian demonstrated a high level of thoroughness in ensuring the sterility of all tools and materials that came into contact with the wound. This highlighted the importance of strict hygiene requirements for the handheld scanner, particularly when used in direct contact with the wound.

The results of the observations were again documented and reviewed. The findings were used to update the requirement list, as well as to form a base for new concepts.

8.1.7 Hierarchical Task Analysis

Hierarchical Task Analysis, HTA, was used to analyze the two target contexts. The information for this was taken directly from what was observed during the visits to the different clinics, in combination with information gathered from interviews. These analyses were used to develop an understanding of the final use case for the handheld scanner. Two separate detailed HTA were conducted for the general tasks performed by a veterinarian in the two different scenarios:

- The collection and analysis of samples from the animal.
- Inspecting horse wounds.

Figure 8.6 and 8.7 show the overview of both HTA. Although the final goal for both of these is the same, determining the bacterial presence with the Odinwell device, the steps taken to reach this goal vary. The main difference is the surface on which the measurement is taken. For horses, the device is placed directly on the animal. This might result in the veterinarian having to take an awkward stance to reach the area whilst staying safe. For skin samples, the measurement was taken on a microscopic slide. This involved extra steps to collect the sample from the animal and place it on the slide. Here, the challenge was to place the device correctly without causing ambient light to leak through to the sensor.

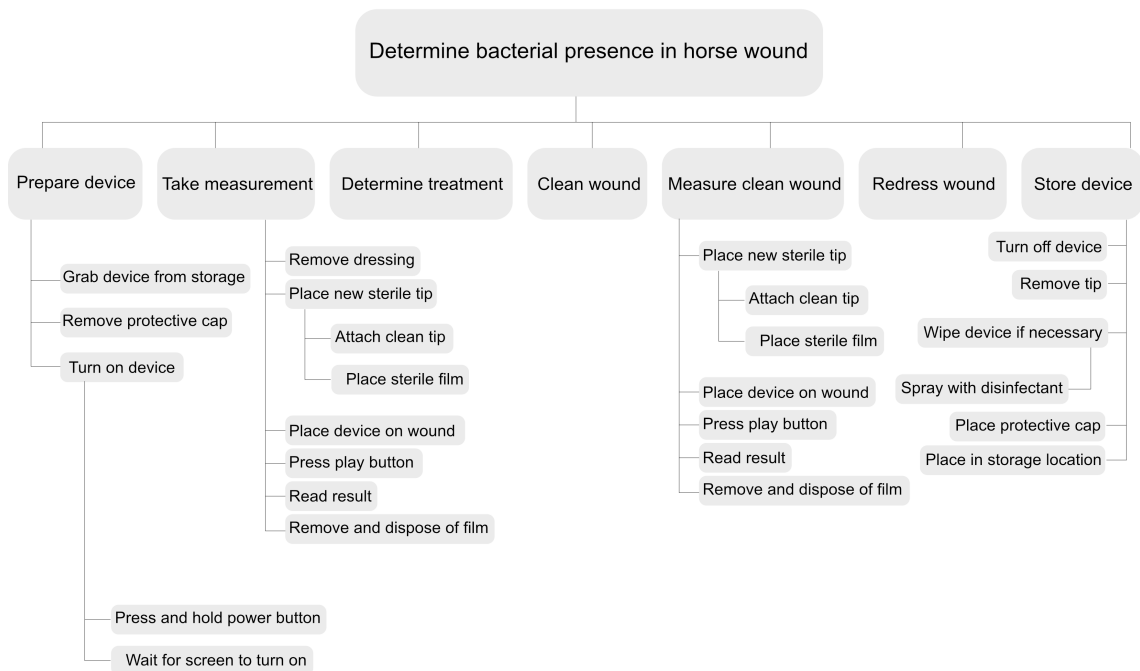


Figure 8.6: HTA measuring on horse wound.

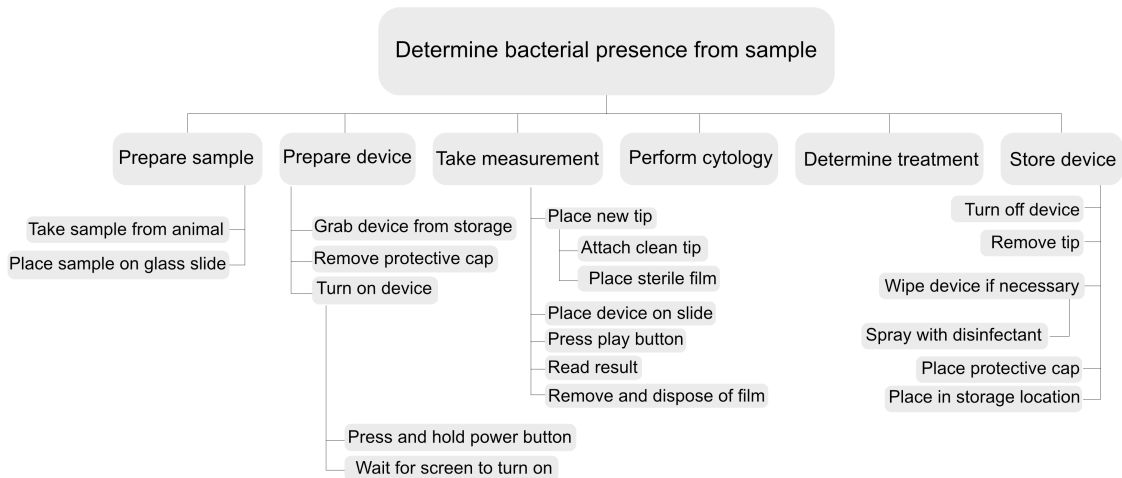


Figure 8.7: HTA measuring on glass slide.

For both contexts, the exact setup was different than intended. Instead of using specific tips, sterility was achieved by using single use sterile films. This was done to prevent any contamination by using incomplete tips. This resulted in additional steps in the HTA, which will be ignored later in the design process, during evaluation of the new design.

Additionally, two other tasks were analyzed, based on the intended use of the current device: connecting the device to a charger and charging it, and placing the device in storage. These tasks are relatively simple and can be considered straightforward.

However, there is potential for them to be modified or even combined. Both of these tasks were not developed in detail during this project. However, they are still worth considering and did influence some design decisions.

8.1.8 Link-analysis

A link-analysis was conducted after visiting a dermatologist at a local animal hospital. Two different tasks were analyzed, the task of using the current product in order to take a measurement on a small animal. This was analyzed from a top view of the room in order to visualize how much the vet moves around in the room. The map was based on the specific dermatology room at the hospital. The second analysis was based on the task of performing cytology on a freshly collected sample. This task was analyzed using a frontal map of the work bench, allowing for analysis in vertical and horizontal movements performed during the task. Since the analysis was based on the observation at the animal hospital, the process might vary depending on the clinic and the veterinarian. No link-analysis was performed for the equine clinic as less time was spent in this context. However, the interaction with equine patients closely resembles the link-analysis for measuring on animals. The veterinarian moves around the animal as the nurse supplies the required tools. Only one area will be measured, as the wound is generally only in one location.

Measuring on Animal

During a typical examination, the dermatology veterinarian primarily moves between the workbench and the examination table, which was also observed in the first task that was analyzed, see figure 8.8. For this analysis, the steps of collecting samples were replaced by using the device to take measurements. The process for both of these are very similar. All preparations take place at the workbench, step 1.1-1.3, and once the device is ready, the veterinarian moves to the examination table to perform measurements on the animal, 3.1-3.3. Multiple measurements may be taken at this stage if needed.

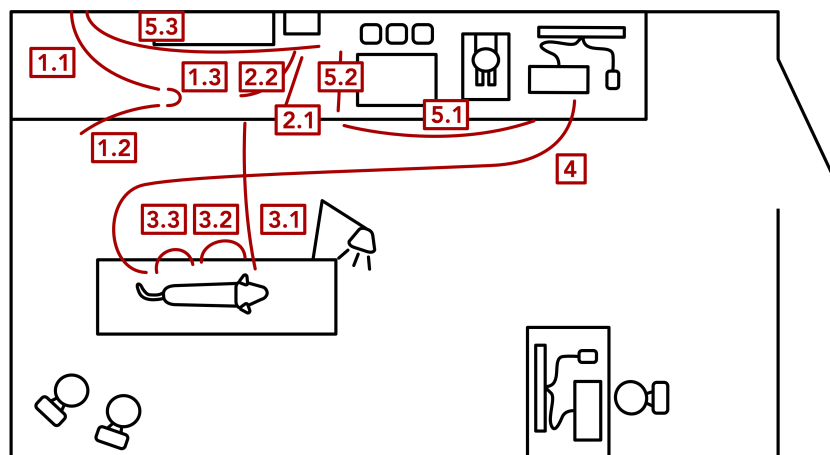
In the analyzed case, the veterinarian wipes the tip of the device between measurement points instead of replacing it. As a result, the entire measurement procedure can be carried out at the examination table. However, if the tip were to be replaced between measurements, the veterinarian would need to move back and forth between the workbench and the examination table, leading to a less streamlined process.

After completing all measurements, the veterinarian returns to the workbench to record the results, step 4, although this task could alternatively be carried out by a nurse. If no nurse is available and multiple measurements are taken, there may be a need to move between the computer at the workbench and the examination table during the process.

Once the results have been documented, the veterinarian resets the device by disposing of the tip and, if necessary, cleaning the unit before placing it back into storage, which is all done at the workbench, 5.1-5.3.

Table 8.3: Link analysis steps for measuring on animal

Step	Action
1.1	Grab product from storage
1.2	Grab exchangeable tip
1.3	Attach tip to device
2.1	Grab gloves
2.2	Put on gloves
3.1	Measure ear
3.2	Measure paw
3.3	Measure skin
4	Document result in computer
5.1	Detach tip
5.2	Dispose of used tip
5.3	Place device in storage

**Figure 8.8:** Link analysis for measuring on an animal.

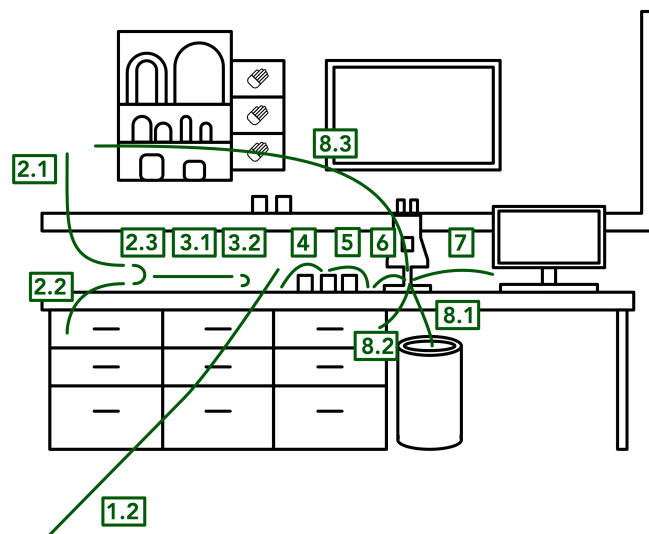
Cytology Process

The second task that was analyzed involved examining a sample using cytology, see figure 8.9. The starting point was defined as the moment when the veterinarian has collected the sample from the animal at the examination table and returns to the workbench, 1.2, as the remainder of the process is carried out entirely at the workbench.

The analysis shows that this task is well developed, as the layout of the workbench supports a streamlined workflow. The sample is prepared at one end and then moves sequentially through the different steps: staining, drying, examination under a microscope, and finally documentation in the computer. Cytology is performed by the dermatologist in almost every session, making it one of the main tasks, which is the reason that the work area is developed and organized the way it is.

Table 8.4: Link analysis steps for measuring on a sample

Step	Action
1.1	Smear sample on slide
2.1	Grab device from storage
2.2	Grab tip
2.3	Attach tip
3.1	Place device on slide
3.2	Take measurement
4	Color samples
5	Let slide dry
6	Analyze in microscope
7	Log results
8.1	Dispose of slide
8.2	Dispose of tip
8.3	Place device in storage

**Figure 8.9:** Link analysis for measuring on sample.

8.1.9 Persona

Based on the results of the previous analysis, a good understanding of the users was created. This understanding was presented in the form of two personas to get an overview of the needs and environment for each target context. These two contexts include horse vet and dermatologist. Figure 8.10 presents an overview of both personas. As can be seen, an overview of common tasks, needs and behavior is given to understand in what environment the product will be used and what tasks it might support. For the horse environment it was important that the device is sturdy and easy to hold, as the veterinarians work in a more robust and varying environment. Moreover, hygiene in the room is not as critical. However, for all equipment that

touches the wound, hygiene should be maximized. For dermatologists, taking samples is an important task for determining the issues. Moreover, all examination and treatment steps are clearly explained to the owner as they are executed. This meant the scanner should be able to help the veterinarian study samples as well as communicate with the owners of the patients.

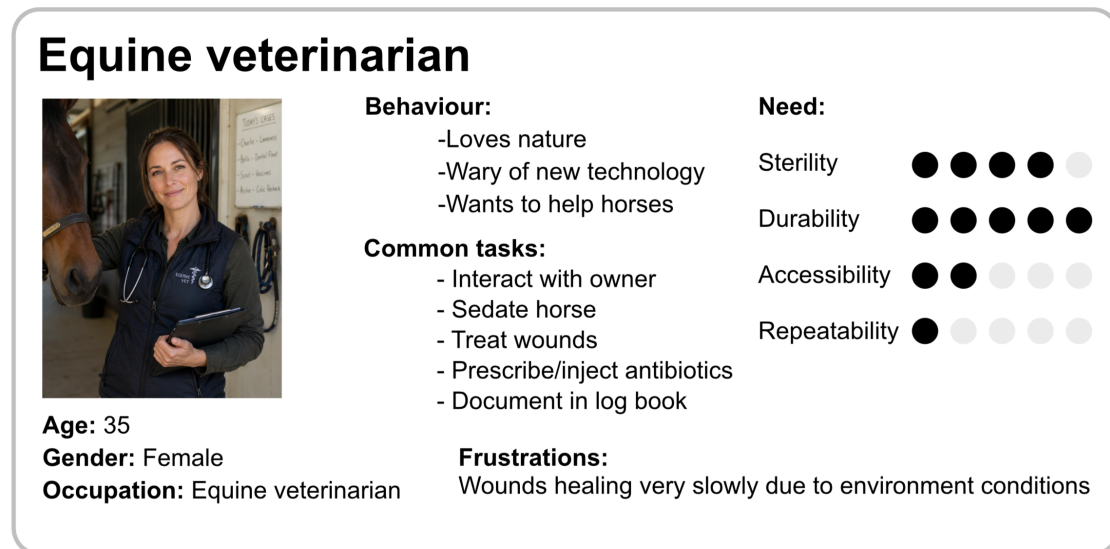


Figure 8.10: Equine veterinarian Persona. *Image created by OpenAI, 2026*

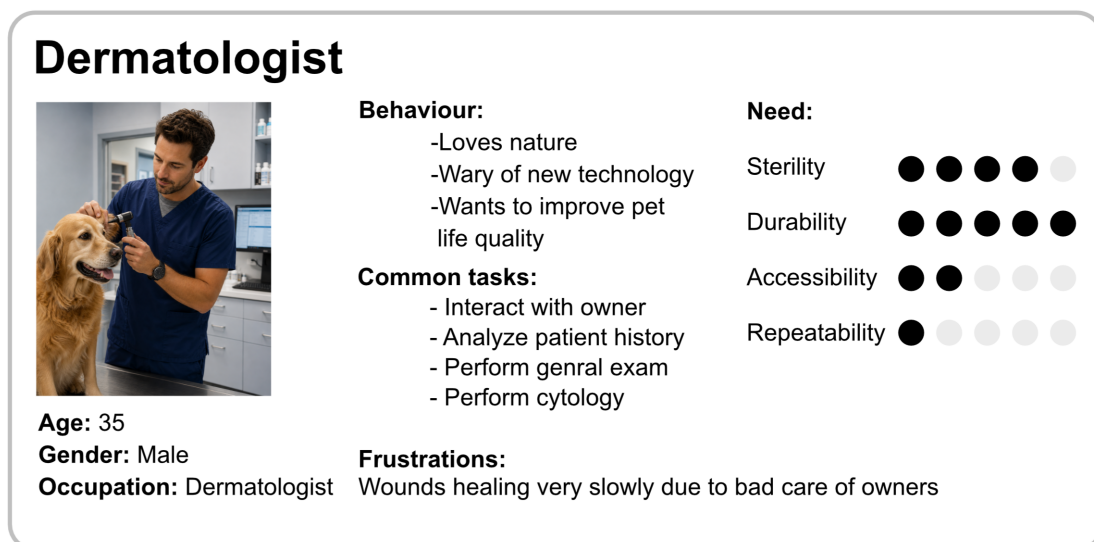


Figure 8.11: Dermatologist Persona. *Image created by OpenAI, 2026*

8.2 Product Specific

This section will present the results from the exploration of competitor products and similar products on the market. Additionally the results from the evaluation of the current handheld scanner will be presented.

8.2.1 Market Research

To get an overview of the competitors and how they compare to Odinwell's scanner, a comparison matrix was made. This matrix summarizes the information previously discussed in chapter 4, and provides a clear overview on similarities and differences between the competitor products. Figure 8.12 shows an overview of these product. Each was analyzed based on several aspects including weight, portability and risk of contamination, among others. By doing this a clear understanding of what certain products strengths and weaknesses could be made, providing inspiration for what areas to focus on for the re-design of Odinwell's device. A detailed overview can be seen in appendix F. A key point of interest was the relationship between weight and usability. The most usable product had a weight around 400 grams. This is easily holdable, but still gives a feel of quality. Some products had an excessive weight of over 3 kg, which reduced usability. Additionally, most of the devices worked with non-contact technology, something Odinwell does not have. To make up for this, the technology Odinwell uses can take more accurate measurements. However, it will be more important to create correct designs to prevent cross contamination in this case.

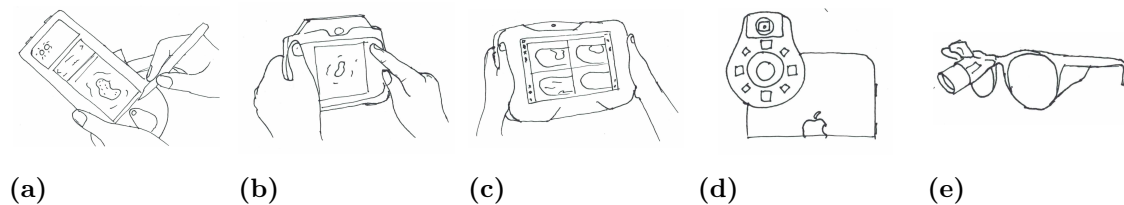


Figure 8.12: Overview of competitor products: (a) MolecuLight i:X, (b) MolecuLight DX, (c) SnapshotGLO, (d) Swift Ray, (e) Reveal FC.

In addition to this a product comparison matrix was created to compare Odinwell's scanner to a larger variety of handheld veterinary products, appendix D. Each product was given a grade based on several variables: professional feel, ergonomics, intuitiveness, ease of cleaning and robustness. The grading was based on observation only and was used more as a reference and inspiration for our design process than a scientific overview. The full table can be viewed in appendix D. This comparison helped create an understanding of how shape affect the feel of a product. For example, the more angular designs felt more professional. Material selection had a large influence on this as well, where metal products felt more high end. When it came to cleaning, it was clear that minimizing gaps and having a polished light colored surface finish improved the sense of cleanliness.

8.2.2 PEPA - Physical Ergonomics Product Assessment

A PEPA-analysis was performed in order to compare the physical strain of the current product compared to the physical strain of the redesign, later in the process, when performing the same task. Two tasks were analyzed, these were to take a measurement on a sample as well as taking a measurement on an animal. The values were estimated based on the observations from both the animal hospital as well as the two horse clinics that had been visited. A table of the results can be viewed in appendix C.

In both of the analyzed tasks, the PEPA analysis indicates that the physical workload is generally low. Due to the device's light weight and the relatively short duration of the tasks, the overall physical strain is considered low across most criteria. In a few categories, however, a medium rating was assigned, reflecting slightly higher demands compared to the rest, primarily related to grip.

In the first three steps of both tasks, grip load is rated as medium, as these steps involve either an impulse force or a movement. Precision is also rated as medium in step one and three of both tasks. In the task involving measurement on a sample, precision is rated as high in step two ("place device on sample"), since achieving the correct angle is critical to block out ambient light that could otherwise affect the measurement results. This higher rating applies only to the sample measurement task and not to measurements performed on an animal, as in that case the softer surface adapts to the device and helps block out ambient light.

The strain on the neck and back was also rated as medium during the third step for measuring on a sample. This is because the angle of the screen is naturally directed away from the user during measurement. Although it is possible to perform the measurement without looking at the screen, the observed veterinarian preferred to do so, resulting in a less ergonomic posture with a bent neck and back. For measuring on a horse, the wound could be in an awkward position, resulting in the user having to bend down or stand in awkward positions. Therefore, the strain on the majority of the body was set as medium.

In the first task, no external factors were identified as influencing the outcome. In contrast, such factors do arise in the second task. Since the measurements are performed directly on animals, movement from the animal can introduce challenges. This increases the demand for precision and may also act as a distraction during the measurement process. Additionally, the measurement angle can vary significantly depending on where on the animal the measurement is taken. However, this factor was not included in the evaluation, as it varies from patient to patient.

8.2.3 Product Usability Analysis

As part of exploring Odinwell's existing design, an evaluation was done based on Norman's (2013) design for usability principles, explained in section 5.1.1. The product received positive and negative comments for each principle. For this analysis,

the product was evaluated as a whole, both tip and scanner. This resulted in a list of strengths and possible improvements for the design.

Table 8.5: Usability Analysis Results.

Conceptual Model	
+	-
Exchangeable tip tab helps orient the device	Shape of tip ejection tab is similar to bottom profile of device, resulting in placing the tip upside down
Location of charging port is similar to commonly used products	
Shape of tip shows where and how to aim device for measuring	
Visibility	
+	-
High contrast screen	Angle of screen is not easily visible when taking measurement
Clear large button icons	The screen has a low resolution
Clear light indicators	
Hand is not covering information when using device	
Mapping	
+	-
Placement of measuring button matches natural rest point of fingers	Power button and measure button are very similar, creating confusion
Feedback	
+	-
Screen readout is clear	Haptic feedback when pressing buttons is minimal
	Unclear when measurement failed
Affordances/Limitations	
+	-
The tip point creates good understanding of where to take measurements	Placing the tip only 1 way can cause confusion, as the shape seems like it fits upside down as well
Shape of tip ensures it can only be placed such that the tab is on top	Angle of tab signals the user to push in the wrong direction when ejecting tip
Shape of tab sticking out indicates ejection function	

8.3 List of Requirements

Based on all of the information gathered from the exploration phase, a list of requirements was created. The purpose of this list was to be the foundation for all the decisions made throughout the concept development phase. The list was continuously updated and reshaped throughout the entire phase. The final version of the list consists of four categories which are: Device, Usability, General and Tip. The items in the list are either requirements or guidelines, which is clearly specified in the list. The key requirements can be viewed in table 8.6 and the final list can be viewed in its entirety in appendix A.

Table 8.6: Key requirements from the list of requirements.

ID	Requirement	Type
1.1	Device should allow for a secure grip for all hands (5th percentile female to 95th percentile male).	G
1.3	Device must maintain a distance of 30mm between hand and measuring surface.	R
1.4	Device should be easy to clean.	G
1.5	Shell should fit all necessary electronics.	R
2.1	Device should encourage user to use tip.	G
2.3	All buttons should be reachable without shifting grip or using second hand.	R
2.7	User should get feedback through screen for every interaction with device (taking measurement, charging, changing modes, etc.).	R
2.9	User should be able to differentiate between buttons by feel.	G
3.3	Device should be usable in different scenarios (In horse clinic, in dermatology assessment).	G
3.6	Device should aid the vet in their decision making process.	G
4.5	Tip should provide sufficient protection from the device getting contaminated.	R

9

Concept Development

As mentioned, the concept development phase consisted of multiple iteration cycles, each exploring a large variety of solutions that slowly narrowed down to the final design. This section will present the results of the scanner design and the tip design separately. However, during the project this was done simultaneously.

9.1 Scanner Body

The development of a redesigned version of the scanner body, adapted for use within veterinary care, was carried out through multiple design rounds. This section will describe each round and present the results in chronological order.

9.1.1 Round 0: Crazy Phase

Since much was still unclear at the beginning of the project, the initial brainstorming sessions were conducted completely unrestricted. This allowed for free exploration of the solution space and resulted in questions that could be asked during the interviews. In addition to free sketching, largely inspired by previous market research, see figure 9.1, some guided sketching was done as well. A topological approach, as shown in figure 9.2, was used. This enabled the creation of different shapes and orientations.

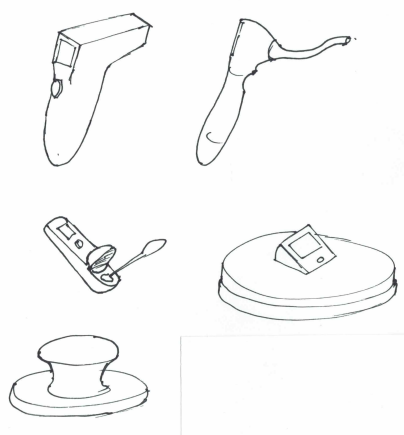


Figure 9.1: Example sketches based on market research.

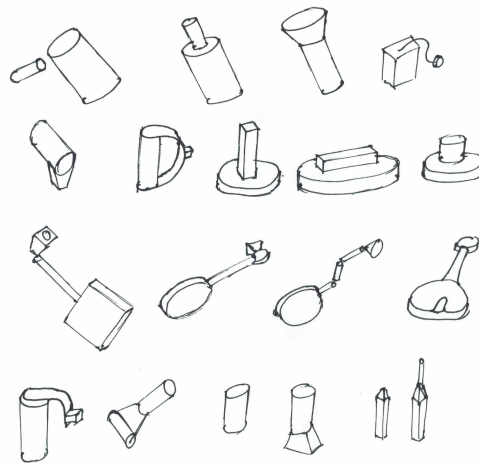


Figure 9.2: Example of topological sketches.

To further discover different possibilities for device shapes and function, foam prototypes were created, using XPS insulation foam. A variety of tools, including saws, knives and sandpaper were used to create different shapes. Some of the ideas included a scanning device with a rolling film to prevent contamination, a pen design for delicate probing, a device with a similar grip to a brass knuckle and an otoscope-like device with an adjustable head, some of which are presented in figures 9.5 and 9.8. Many of these were eliminated before continuing to the next phase of prototyping. However, they functioned as a great warm-up to get familiar with the prototyping media and formed a base of inspiration for further designs.

9.1.2 Round 1: Grip Categories

Once the crazy phase was completed and a further understanding of the product was formed, the design approach became more targeted. Initially, the general shape of the handle was explored, focusing on the grip type and its relation to the ease of taking measurements. Again, a large variety of foam prototypes were created to evaluate different ideas.

To increase the variety of ideas and to gain input from people with different backgrounds, a prototyping workshop was held with several employees at Odinwell. A group of 5 participants with varying backgrounds was involved. The assignment was to come up with their preferred shape and function of the device. All participants were aware of how the current device was used. However, no further input was provided to prevent influencing the solutions they would create. The workshop started with the participants making rough sketches of their designs, after which each selected a foam block to create their design in 3D. Figure 9.3 shows the process of this workshop. These designs were discussed as a group and consequently added to the initial set of concepts.



Figure 9.3: Prototyping workshop at Odinwell.

Since the design process followed a trend of creating a prototype, evaluating the design to then create a new variety, several distinct categories naturally appeared. The designs in this stage still targeted a wide range of contexts. At the end of the first design round, all prototypes were grouped into categories to create a better overview. The following categories were found:

Trigger Grip

The trigger grip, figure 9.4, was favored as it felt very natural to hold and intuitive to use. It is a very recognizable design, the use of which matches its conceptual model. For this design, it was important to consider the angle in relation to the grip to prevent strain in the wrist when taking measurements. Another thing to consider is the tolerance required for the movement of the trigger. Any gaps could result in the accumulation of debris.



Figure 9.4: Trigger grip variations.

Pencil Grip

The pencil grip, figure 9.5, also had a very intuitive feel. Another advantage of this grip is its delicate nature. Since the grip is very fine, it allows the user to take very precise and gentle measurements. Things to consider for this design were the shape of the device in relation to the size of the hand and placement of the buttons for left- and right-hand users. Due to its small size, installation of a screen and other electronics could prove difficult.



Figure 9.5: Pencil grip variations.

Thumb Grip

The thumb grip, figure 9.6, involved wrapping the handle with the fingers and using the thumb to press buttons, similar to the original device. A variation of this was to hold the device from above and use the index finger to press buttons. The preference for this variation was often correlated with the generation of the user. Giving the product a narrower rounder handle ensured a more secure grip. However, some issues arose regarding the maintenance of a sufficient distance between the hand and the patient. Moreover, depending on the angle of the handle, taking measurements could put strain on the wrist.



Figure 9.6: Thumb grip variations.

Probe Grip

Similarly to the pencil grip, the probe grip, figure 9.7, allowed for very accurate and controlled handling. In the designs created, the measuring area was larger, making it suitable for a scanning function rather than a single measurement. Again, location of the screen proved difficult. A solution for this could be to use a separate monitor.



Figure 9.7: Probe grip variations.

Miscellaneous

Some of the prototypes did not fit a specific category, figure 9.8, several of these solutions arose from the crazy phase. The grip types in this area ranged from scrolling to stabbing and punching. Many of these were either not realistic to produce or created a more aggressive measurement experience. Therefore, these designs were eliminated.



Figure 9.8: Miscellaneous grip variations.

9.1.3 Round 2: Creating Variations

Categorizing the prototypes clearly showed which areas were lacking in variety and could be explored further. Based on this, the pencil grip and probe grip were chosen to explore more to further expand the variety within the category. Some more designs were created for the other models as well. However, here the focus shifted to more details, such as screens and buttons.

Additionally, 4 different handle shapes were 3D printed using an FDM printer, in order to better understand their feel in hard plastic instead of soft foam, figure 9.9. Their designs varied from straight handles with a hexagonal cross-section to more round and organic handles. The goal was mainly to test whether the angular shapes in the handle would feel sharp or uncomfortable. This was not the case.

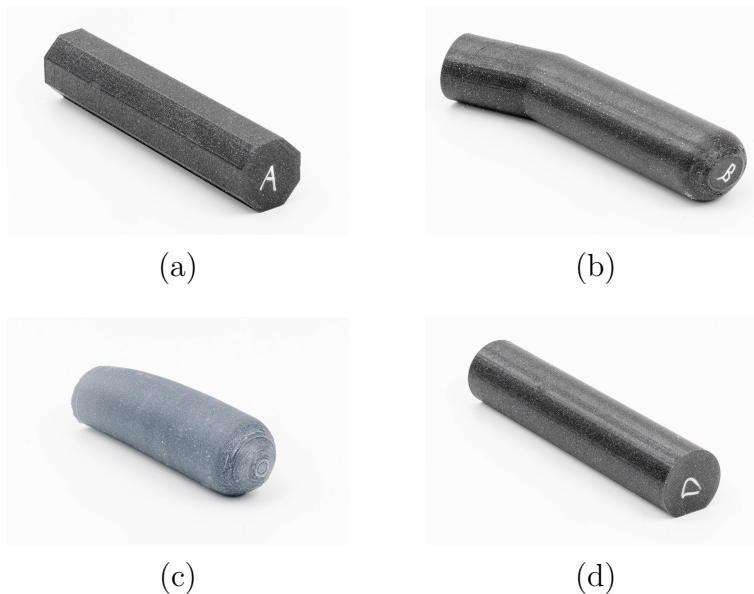


Figure 9.9: 3D prints of four different grip shapes: (a) Hexagon, (b) Bent Oval, (c) Organic, (d) Flat cylinder.

With an even larger set of prototypes, the next step was to narrow down the solution space. Although several prototypes had been discussed with veterinarians, it was not possible to set up an evaluation of the entire set. Instead, a voting set-up was made at the office with all Odinwell employees. This allowed for feedback from people with different backgrounds and helped in the decision making process. For this, all 25 prototypes were laid out and numbered as seen in figure 9.10. The 3D printed handles from figure 9.9 were included separately. All participants received pieces of paper to note down their top three prototypes. This was executed individually in their own time to prevent the participants from influencing each other. Finally, all votes were gathered and a discussion was held to discover why certain prototypes were preferred.



Figure 9.10: Prototypes prepared for voting.

Based on the voting, there was a clear winner, with 5 votes. This was prototype number 7. The participants appreciated the shape of the handle, as the flat area on top created a nice space for the thumb to rest. The head had enough space for a screen as well as all the necessary electronics. The transition between the handle and the head felt aesthetically pleasing according to multiple participants. Some other shared aspects across other leading prototypes were the use of a trigger button in prototypes 9, 11, 15, 16 and 21 as well as the angle of the screen in prototypes 8 and 15. In the end, 12 prototypes received votes. These were grouped into 4 categories: otoscope-like, trigger, original design and organic grip.

9.1.4 Round 3: Creating Final Categories

The four categories, resulting from the voting, created a starting point for the next design round. One discovery at this point was that very few variations of Odinwell's original design had been created. So, this became the first focus. Multiple iterations were shaped based on the original design, resulting in three varieties in this category. The other categories were explored further as well. More details, such as buttons and screens, were added to enable specific evaluation of the products. Some handles received finger indents as well, as this was something the participant 5 liked about previous prototypes. In the end, each category had between 4 and 5 variations, which can be seen in figure 9.11. Additionally, the concept development approach changed, as the decision was made to create a single scanner that could be used in different contexts by changing the measurement mode.



(a) Otoscope-like concepts.



(b) Trigger concepts.



(c) Original design concepts.



(d) Organic concepts.

Figure 9.11: Overview of the four different concept categories.

The initial plan was to set up a test at the local animal hospital, to have multiple veterinarians evaluate the prototypes and comment on features they enjoyed, similar to the voting round at the office. However, due to personal issues with the main contact person, this was delayed and eventually canceled. Instead, the categories were discussed in detail with the CEO, electrical engineer and design lead at Odinwell. The goal of this discussion was both to evaluate if the product fit the company's goal, as well as to analyze its feasibility, mainly relating to manufacturing and fitment of the internal technology. The discussion led to the selection of the otoscope-like category as the design direction. These devices had sufficient space for screens and electronics, they fit the purpose of the technology and seemed producible. Since the trigger was still seen as a valuable feature, it was added to the chosen category.

9.1.5 Round 4: Final Selection

Until now, the majority of the prototypes had been made in foam. With a more detailed selection, the new designs could be created in CAD for 3D printing, as this allowed for evaluation of designs more closely resembling a final product. Several prints are presented in figure 9.12. In this stage a 3D modeling software for solid modeling was used together with an FDM 3D printer, which allowed for efficient prototyping. For this process, the device was split into 4 sections: head shape, handle shape, button design and transition between handle and head.



Figure 9.12: Printing first otoscope variations.

Several variations were created for each section. In order to test the designs, 3 prototypes, presented in figure 9.13 were printed using a mix and match approach of all variations across sections. These prints were sent to a veterinarian, participant 3, along with the original design to allow for an online evaluation.



Figure 9.13: Three prototypes with varying shape, handles and buttons (a,b,c left to right).

During the evaluation participant 3 mentioned several interesting points. First, the trigger could result in difficulties with cleaning the device and did not add much in the user experience. The device that was most similar to an otoscope felt the most intuitive to use, as this is what they were familiar with. The narrow transition between the handle and the head in figure 9.13 prototype B was also mentioned as a concerning weak point.

In the end, the head of prototype A was chosen in combination with the handle and button placement of prototype C. The exact order of the buttons was explored once more to determine whether the scanning button should be placed in the middle

or on top. The original button placement of prototype C proved to be the most effective. These features were then combined in a new design and the final shape was completed. This will be presented in chapter 10.1.

9.2 Tip Design

Throughout the project, multiple veterinary contexts were considered as target use cases. As mentioned the decision was made to create a uniform scanner to be used across several contexts. From the initial interviews several use cases arose, these were: surgery, horse wounds, skin conditions, ear infections and urine infections. Initially, designs were created for all contexts. However later in the process the contexts were narrowed down as more information was gathered. Of these, surgery was neglected as this was only a small margin of the veterinary work. Horse wounds seemed to have a large potential, the same could be said for skin conditions. Urine infections and ear infections were grouped under sample evaluation, as it is not possible to reach the infected area with the device. In the final phase a solution was created for horse wounds and skin conditions, both involving measurements directly on the animal.

9.2.1 Contact Tip

In order to safely use Odinwell's handheld scanner in direct contact with, for example a wound on an animal, it is of great importance that the contact point is completely sterile. As a solution to this problem, Odinwell created a detachable tip that acts as a sterile cover for the contact point of the device. As part of this project, this solution was analyzed and alternatives were explored in order to find the most optimal way of eliminating contamination between patients.

Throughout the exploration phase of the project, the exchangeable tip was an area of interest. The veterinarians that were interviewed were questioned regarding issues related to cross contamination between patients. Furthermore, feedback was collected for the original Odinwell solution. From this it was determined that an exchangeable part covering the contact point would be sufficient to avoid contamination. Moreover, a reoccurring opinion was that re-usable products were preferred. So, single use products should be avoided.

Additionally, the interviews showed that all products used by veterinarians are not necessarily used as intended. The most common example of this is that single use products often get cleaned and reused in order to minimize clinical expenses. This was also considered during the design of the product.

Round 1: Free exploration

The first round of exploration of the tip design had a wide focus and aimed to find solutions that differed from the current exchangeable tip. Different materials, shapes, attachment and detachment mechanisms as well as manufacturing methods

were explored, see figure 9.14. A variety of methods of ensuring the correct behavior were also explored during this phase. Initially, designs involved hindering the veterinarian from reusing a contaminated tip by, for example, having the tip break when it is being detached. However, the concept of restricting certain actions was discarded due to the possibility of causing irritation among end users. Moreover, the assumption was made that veterinarians are highly skilled and experienced and are able to determine the risk involved with re-using a single-use product.

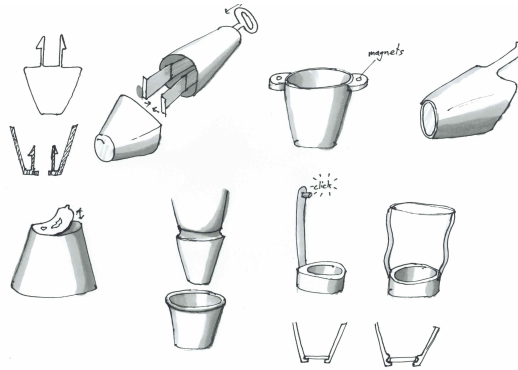


Figure 9.14: Initial ideation for tip attachment solutions.

Round 2: Material Exploration

After the initial round of free exploration, it became clear that the material selection would play a vital role in the design of the tip and the decision regarding creating single use or re-usable products. For the product to be reusable, it was important that it could withstand the required cleaning process. Additionally, the manufacturing methods would determine the costs of the part. Therefore, the second round aimed to explore potential materials in order to understand their manufacturing possibilities and their resistance to sterilization and cleaning. As part of the selection process, some different manufacturing methods were explored as well. Figure 9.15 shows some experiments done using vacuum forming.



Figure 9.15: Vacuum forming experiments for tip manufacturing.

As mentioned the main focus was towards finding a material that could withstand cleaning processes, such as autoclaving or use of chemicals, while maintaining its properties. Three main options were explored, these were silicon, glass and clear

hard plastics with high melting points. All of these materials are used in the veterinary industry and can withstand being autoclaved to some extent. However, each has its limitations. Silicon is easy to produce and is relatively easy to clean. However, there is great uncertainty how the material would hold up after multiple uses and how degradation of the material over time, such as scratches, would affect the measurements of the device. Since silicon is soft, there is the added risk that the material in front of the sensor can stretch and move, leading to inconsistent measurements. Moreover, the transparency of silicone is not as high as other materials. The same strengths were found using hard plastics. However, there were still uncertainties of how aging and wear on the material would affect the measurement. The final option considered was glass, a material commonly used in veterinary clinics, due to its ability to withstand the cleaning process without any degradation. This material seemed to be a superior option as it would allow for consistent measurement conditions. Nonetheless, shaping glass into precise shapes can be challenging and costly.

During this material phase, an additional limitation was discovered. This was the need for the tip to completely block out ambient light in order to not affect the measurements. This meant that the tip could not be made exclusively of a clear material. Therefore, a multi material tip was required to allow measuring through a clear and consistent material while simultaneously blocking out ambient light from the sides. This restriction left two options based on the limitations of materials. The first option was to have glass as the transparent material in front of the sensor and a hard plastic shell to block out light and to protect the device from contamination. The second option was to have the whole tip made out of plastic, similar to the previous option but with transparent plastic instead of glass. After further research it became apparent that plastic options would slowly degrade over multiple autoclave cycles. Resulting in a product that would have a limited number of use-cycles where consistent measurements could be guaranteed. This issue was discussed with a veterinarian who stated it would be hard to keep track of cleaning cycles and the benefits of having a re-usable product would be lost when having a small amount of usage. This realization moved the focus from a re-usable tip to a single use alternative despite the initial goal for design a reusable product.

Round 3: Reshaping Original Tip

After the realization that a single-use solution would be the best option for the contacting tip, efforts were once again shifted towards shape and usage. Some exploration was done regarding the amount of area the tip would cover, figure 9.16. Of these, 9.16b seemed to be the best option, as it minimized material use, whilst maintaining sufficient protection. After further ideation combined with revisiting initial ideas, the conclusion was made to continue with Odinwell's original tip design. The design was optimized by creating variations for different elements of the design.



Figure 9.16: Three variations for tip designs.

In order to find the most optimal ejection solution, a prototype consisting of multiple different placements for the ejection tab was created, see figure 10.8. This prototype was created to fit the, at the time, latest concept of the scanner instead of on the current Odinwell scanner. This provided the opportunity to simulate the type of grip and hand position that the final design would allow. These different placements for the ejection mechanism were tested with multiple people with varying hand sizes as well as with a veterinarian in order to find the best option.



Figure 9.17: Three locations of ejection tab.

Based on these tests, the tab at the bottom, meant to allow ejection with the index finger, was determined as the least optimal solution. Ejecting the tab required the user to apply force in an unnatural way, which put strain on the fingers. The side ejection points proved to be effective. It was also discovered that the most optimal side, left or right, differed depending on the hand size and how the device was gripped. The ejection point at the top of the device was also preferred over the one at the bottom. Compared to the side placements, the top placement required the user to change their grip of the device in order to reach the top, especially for users with smaller hands. However, the top placement was still determined to be the best option, due to other problems with the side placements. The side placement would require two tabs in order to facilitate users with different hand sizes as well as both left- and right-handed users, meaning that more material would be used compared to only having one tab. Additionally, the side placement could lead to confusion as the orientation of attaching the tip would be less obvious to the user. This problem could also apply to the top placement, especially with a first time user. However, the top tab gives a clearer indication of orientation, as well as improves memorability. In the end, the top tab was selected.

Before moving to the final stage, two more prototypes with varying tab length were created, figure 9.18. This was to test the difference between having a flush tab and one sticking out. In the end, the extended tab was selected. With these conclusions on the optimal design of the tip, focus could be shifted to determining the final shape and manufacturing methods which will be further described in chapter 10.1.

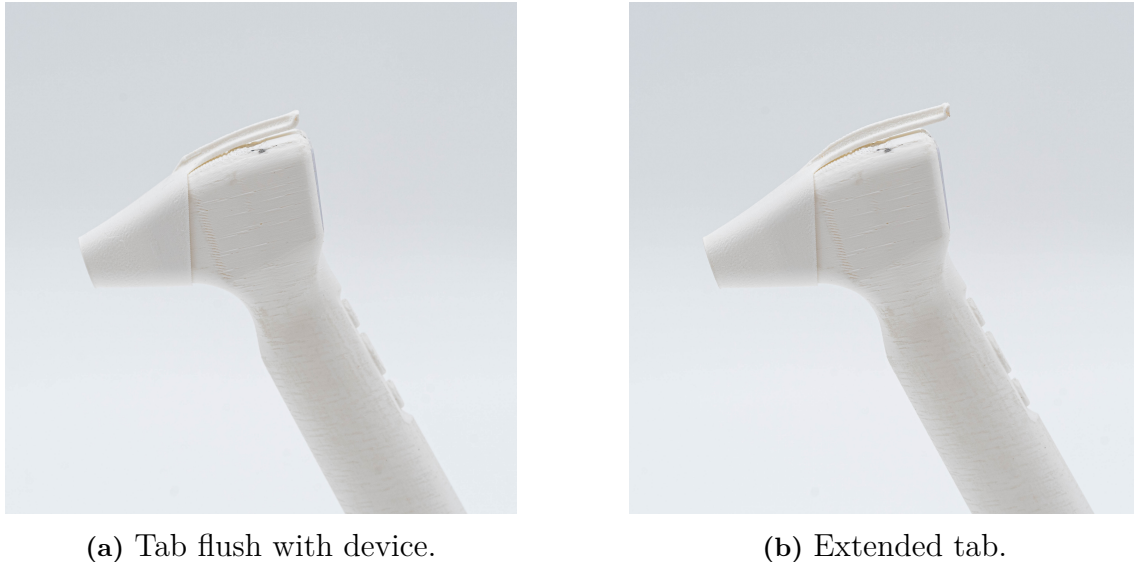


Figure 9.18: Two options for tab length.

9.3 User Interface

With the final design of the main body completed the focus could shift to the user interface. In order to determine the exact button placement, it was important to decide what the screen would read out and what functions were required. Multiple screen layouts were created and discussed with the Odinwell team to ensure a future proof device, as the goal is to create a device that could easily be used in areas not researched yet without needing redesign.

A 3D printed model was created with all possible button placements on a single device, to easily compare their usability, figure 9.19. The combination of the print and screen layouts lead to the decision that 3 buttons would suffice: an up button, down button and select/scan button. The screen would have different modes to scroll through, depending on the context in which the device would be used. For the selection of button types, a meeting was held with OEM electronics to discuss possibilities for using a button overlay in the final design. This would reduce gaps and thereby simplify the cleaning process.



Figure 9.19: Prototype with multiple button layout options.

9.4 User Error Prevention

Part of the design process was aimed towards preventing the end users from making errors. This was applied to multiple aspects of the product.

First, the main issue of importance is using the device without a tip. This could both damage the device as well as cause problems with cross contamination between patients. To solve this issue, multiple ideas were considered. Solutions ranged from complex ideas such as creating tips with integrated Near Field Communication, NFC, chips so the device could read when a tip was attached or not, to more simple designs, for example, printing a dotted line on the scanner to indicate that the tip is missing. In the end, a designed was chosen where the scanner would feel incomplete without a tip. The sensor area was design such that it resembles an internal part of the product. Once a tip is placed, the head shape becomes more complete. This is a non-intrusive solution that easily reminds the user to place the tip. This solution was discussed with a veterinarian during the final evaluation and was perceived as a good solution. Additionally solutions regarding incorrect reuse of tips were considered as well. By reusing contaminated tips, risk of cross-contamination would increase. Some intrusive solutions were considered, such as the tip breaking after use. However, these solutions were considered as too constricting. After discussing with participant 6, the decision was made to place the responsibility with the users, as they have the knowledge required to determine the risk of reuse.

Another problem that could damage the device, was related to how it would be stored. Originally the handle had a flat, perpendicular bottom surface. This created an signifier for users to store the product upright. This position, however, was not stable, creating a high risk for the scanner to fall over and get damaged. As a solution, the bottom surface was cut at an angle. Now the product had to be placed

flat when stored. Moreover, the design of the scanner prevents users from placing the device on a surface such that it is resting on the sensor. The weight distribution causes the device to naturally roll over to its side, thus protecting the sensor.

9.5 Summary

As this chapter has shown, the concept development phase was a large part of this thesis, where a lot of ideas were explored. With a wide focus at the start, a large amount of concepts were created. As the project progressed, the focus got narrower and concepts got eliminated based on user inputs and theoretical studies, until only the final concepts remained. This result will be presented in the next chapter, which explains in detail the final design for the scanner body as well as the interchangeable tip.

10

Final Design

With the exploration and concept development completed, the final design could be defined. The following chapter will present the final solution for the scanner as well as the exchangeable tip. All aspects will be described in detail, including usage and manufacturing. Consequently, a final evaluation will be done, comparing the new concept to the original product. This will clarify the improvements made and determine if the goal has been achieved.

10.1 Design Presentation

In the following section, the final design will be presented in its entirety. The redesign of the scanner body and the interface, as well as the development of a tip solution will be explained. Details such as material choices and manufacturing for future development will also be addressed.

10.1.1 Scanner Body

As mentioned at the end of section 9.1.5 a final design was created by combining the preferred head shape, handle shape, transition and button layout, based on the feedback from participant 3 . Figure 10.1 shows the result of this combination.



Figure 10.1: Prototype of final design.

The final design greatly resembles the traditional otoscope shape, allowing the end user to easily understand the interaction with the product. The straight handle has an oval cross section with a diameter slightly smaller than the 5th percentile female, see figure 5.1, to allow for a secure grip. Moreover, the handle has a flat section on which a button overlay can be placed. This ensures a surface that is easy to clean, with no gaps around the buttons. The transition between handle and head creates a robust feel for the product, whilst simultaneously allowing for an area to naturally place fingers. For this area, focus on flow resulted in a more aesthetic shape.

When it comes to the head design, sufficient space was created for a larger screen and internal electronic components. Additionally, all corners were rounded, based on a suggestion from a participant 5, to reduce potential damage and simplify wiping. Moreover, the area close to the sensor is designed such to feel exposed and incomplete without a tip attached, to remind the user to not use the device without a tip, figure 10.2 .

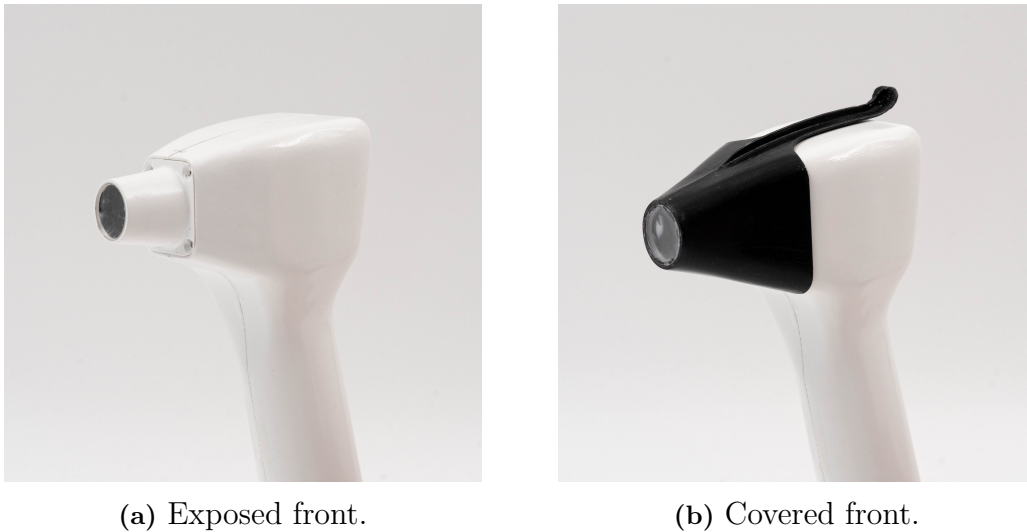


Figure 10.2: Representation of exposed front with and without tip.

When it comes to the power supply, the decision was made to use a rechargeable battery rather than replaceable AA batteries. The reason for this being simpler maintenance of the device. In order to charge the battery, a USB-C port was added at the bottom of the device, figure 10.3. USB-C was chosen based on that is it the regulatory standard for most handheld devices, because of the Radio Equipment Directive (RED) (The EU Common Charger, n.d.). For storage the device will simply be placed in a drawer or on a desk surface. The bottom of the handle, where the charging port is located, is cut at an angle to prevent users from placing the device upright on a surface, creating a risk for the product to fall and get damaged. Additionally, a version of the contact tip, which is completely closed and slightly thicker, can be placed over the sensor as a protective cover, more on this in section 10.1.4. Throughout the project, several storage solutions, such as desk stands or wall mounts had been considered. Though the veterinarians appreciated these solutions, it was decided to prioritize the development of scanner and tips instead. For future development, it would be preferable to include a stand with a charging function. This ensures a clear storage points for users to place the device when not in use and prevents the risk of the device getting lost. By including a charging function, the device will always be charging when not in use. Preventing the problem of grabbing the scanner with an empty battery.

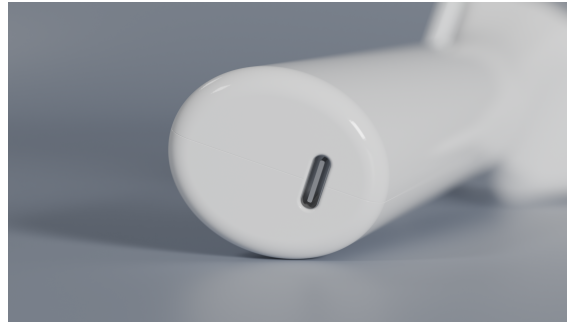


Figure 10.3: Render of charging port location.

For the scanner, several manufacturing methods were considered. After discussing with a manufacturing expert, additive manufacturing for polymers or injection molding seemed to be the best solution. Since the initial production batch will be limited to several hundreds, investing in a mold could be too costly, especially if the design changes. Because of this, additive manufacturing would be the best solution. However, the final design is created such that it involves a suggestion for injection molding as well. As injection molding has more limitations than additive manufacturing, these were included in the design. Doing this, enables Odinwell to make a swift transition from additive manufacturing to injection molding, once they decide to do so.



Figure 10.4: Product components for manufacturing.

The part is split into three components, to halves of the general body and one tip section, figure 10.4. The two halves of the body will snap together and will be held in place by two screws, hidden below the button overlay. Moreover, the tip section will screw into place, thus further strengthening the connection. The internal structure has specific slots for the electronic components to fit into, holding them in place. This method allows for easy manufacturing and assembly.

10.1.2 Interface

In addition to the general scanner body, development was also done to the interface of the device. The final result of this can be seen in appendix G where the entire interface is displayed. As previously mentioned, the new design hosts a screen that is significantly larger than in the current version. This was done in order to allow for a more advanced and developed interface, allowing for more functionality of the device. Firstly, the addition of different measuring modes puts increased demand on the interface, since the user has to be able to change mode and at the same time get a clear indication of which mode is selected. These modes have been added as a way of preparing the device for further development, since testing has shown that the device setup might have to adapt depending on the measurement surface. Additionally, functions such as measurement history and language settings were added.



Figure 10.5: Scanner interface, showcasing buttons and screen.

The goal of the interface was to add all the required functionality for the device to work while keeping the user interaction as simple as possible. This was made possible by having three buttons on the front of the device that control the entire interface, see figure 10.6. The top button is the so-called action button, which is larger than the other buttons to clearly differentiate between them. The action button is indicated by its play symbol. The two buttons below are the navigation buttons, which have up and down arrows on them. These buttons are part of a tactile overlay that will be produced by an external company. The overlay is produced as one piece, without gaps, to simplify cleaning and can be mounted into a slot of the device casing, using its sticky back side.



Figure 10.6: Scanner interface, showcasing interaction.

In order to start the device, the user simply presses any of the three buttons, as presented and the device will wake up. When started, the device will have one of the different measuring modes selected, which is indicated in the top of the screen. In order to move between the different modes, the user presses the up or down button, depending on which mode they intend to use. Which button to press is also indicated on the top of the screen where the next mode in the list is displayed with the symbol of the correct button to press next to it, see item 1 in figure 10.7. The list of modes available does not go in a loop and instead has a top and a bottom, in order to limit confusion for the user. When either the top or bottom option is selected, the arrow indicating which button to press for the next item on the list is transformed from an arrow to a circle, indicating that the top or bottom of the list has been reached.

When the user has the intended mode selected, there is a text, displayed as item 2 in figure 10.7, indicating that the action button can be used in order to take a measurement. When the measurement has been taken, the result is displayed on the screen. The result is displayed in two ways, firstly a general result that says if the measurement is “Low”, “Medium” or “High” to give the user a vague but easily understandable result, see item 3 in figure 10.7. Secondly, the result will also be displayed as a number on a scale of 1 to 100, which can be seen as item 4 in figure 10.7, in order to give a more exact result that can be tracked over time. The scale of 1 to 100 is displayed as whole numbers to indicate that it is a number on a scale and not a value with a unit which a result with decimals might indicate.

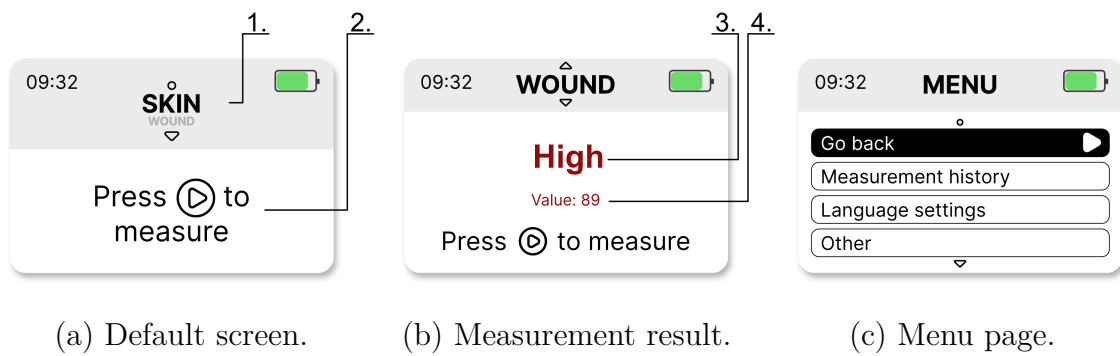


Figure 10.7: Three pages from the digital interface with highlighted functionality.

The final option in the list of modes is a menu option, here the action button is used as a selection button, which is indicated in the same way as before with instructional text on the screen. When the menu option has been selected the text in the top bar is changed from a list with options to a static text, indicating which menu page is selected. When entering the menu, the rest of the screen hosts the menu structure, where options are listed in a vertical menu, see image (c) in figure 10.7. Above and below the list of menu items there are arrows, indicating which buttons to use in order to navigate the menu. When the top or bottom of the menu has been reached the adjacent arrow will turn into a circle, indicating that the top or bottom has been reached, which can be seen in image (c) of figure 10.7. The top option of the menu says “Go Back” and takes the user back to the previous page. From this point the whole menu system works by moving up and down with the navigation buttons and then pressing the action button to choose the selected option.

As mentioned before, the device is turned on by clicking any button, which was chosen instead of having a specific power button, which means that there is no button to turn the device off. Instead, the device automatically turns itself off after having been inactive for 60 seconds, as is commonly done with similar products.

10.1.3 Contact Tip

In order to minimize risk of cross contamination between patients when the device is used directly on the animal, a tip was developed to be attached to the scanner. Based on the decision explained in section 9.2.1, the final design of the sterile tip will be a single use product, closely resembling the current Odinwell tip solution.

The main feature of the tip follows the contours of the front of the scanner and covers the sensor area and the intentionally seemingly exposed front section of the head of the scanner. Covering a significant part of the scanner, close to the sensor area, prevents contact between the animal and the device itself. Thus, ensuring that the device can be used in direct contact with patients without the risk of cross contamination. The size of the area that the tip covers has been chosen after discussions and observations and is determined to be significant enough to avoid contamination of the device itself, whilst simultaneously minimizing material.



Figure 10.8: Three views of tip design.

The sterile tip easily clicks on to the device, made possible by indentations on the device into which extrusion on the tip can latch on to, figure 10.8b . In order to allow for a safe and easy disposal of the tip, a tab extending from the tip to the top of the device was added. This tab is supported by a rib, to help it withstand the forces figure 10.8a. This tab allows the user to push the tip off of the device without having to change their grip and without touching the contaminated part of the tip, therefore not contaminating themselves, figure 10.9 . The tab extends a few millimeters out from the device, creating space to press on the tab. The location is in the middle of the device, right above the screen which makes it reachable for both left and right handed users. When the user applies force to the tab, the plastic of the tip bends which creates a gap between the top of the device and the inside of the tip. This gap means that the click fit loses its grip and the tip comes off the device. The indentations that allow the tip to click on to the device are located at the top and bottom which is in line with the tab. This was decided to be the best location, based on trials with multiple prototypes. Compared to the existing solution on the current Odinwell device, the pressing point on the ejection tab on the new design has a different angle, both making it more comfortable to press while also indicating in which direction the force should be applied.



Figure 10.9: Action of removing the tip.

As mentioned in the design process, material selection and manufacturing had a large influence on the design decisions. The final concept will consist of two materials, an opaque plastic for the general area of the tip and a clear plastic for the area in front of the sensor, presented in figure 10.8c. Two methods of manufacturing were considered. First, an approach more applicable to a small scale startup, the general tip shape and the clear section can be produced separately, using injection molding. Once formed, these can be assembled using a simple press fit. Though this process can be done in a sterile environment, there is a slight risk of liquids leaking past the clear plastic into the tip. A more expensive, yet more controlled solution would be to use over molding to create a single multi material tip. Here no gaps are present, however the process might be too complicated. Both options are viable, however, further development by an experienced manufacturer will be needed to create the best solution, based on Odinwell's wishes.

10.1.4 Protective Cover

In addition to the tip solution, a second design was made to function as a protective cover for the device when not in use. As limited time was spent on developing a secure storage solution for the scanner, use of a protective cover functioned as a replacement for this. The design of this is an adaptation to the contact tip, having the same design and ejection tab. However, the area covering the sensor, which is transparent for the contact tip, is replaced by an opaque material, see figure 10.10. As a result, the tip can be produced in single material, eliminating the need for over-molding or assembly. Additionally, the wall thickness will increase slightly, to increase durability of the cover.



Figure 10.10: Scanner interface, showcasing buttons and screen.

10.2 Evaluation of Final Design

The following section aims to evaluate the final design, by comparing the new design to the original Odinwell scanner. Both the scanner and tip design will be discussed based on how they meet specific requirements as well as general feedback received by participants. Initially the plan was to perform an evaluation with multiple participants to reach a clear understanding of whether the project goal was met. However, due to illness among the participants, this was hindered. Fortunately, a discussion could be held with participant 5 to review the final design. During this review, usability and hygiene were the main focus points. Additionally, the final design was discussed with the electrical engineer at Odinwell to evaluate the product's feasibility.

10.2.1 Usability

The general function of the device has not changed significantly. As the internal technology was not developed as part of this project, the method of taking a measurement remained the same. The device continues to use a scanning button to take a snapshot measurement of the present biomarker, which is then read out on a screen.

However, when it comes to the usability of the device, and the physical attributes related to this, some clear improvements have been made. Initially, users experienced difficulty creating a firm grip on the original scanner whilst taking measurements. To improve this, a cylindrical handle, matching the correct anthropometric dimensions was created. Participant 5 instantly confirmed a more comfortable and secure grip when holding the device. This meets requirement 1.1 and 2.3, ensuring a firm grip and using only one hand to interact with the device. Additionally, the angle of the screen has been improved, so users do not need to strain their neck to read the screen when taking measurements. This allows the design to meet requirement 2.7 where the user must be able to receive necessary feedback through the screen.

The interface has received changes as well. Though the original central button layout functioned sufficiently, an extra button was added to support the improved screen functions, such as changing modes, presenting battery level and changing settings, allowing for requirement 1.3.1 to be fulfilled. By varying the size of action and navigation buttons, users can clearly differentiate between them, requirement 2.9, an improvement over the original design. The screen functions, however, have not undergone adequate testing with users. Though, this way of scrolling through functions and settings seems to be a functional solution, further development and evaluation is required. The current solution should be viewed as a visualization of how the intended functionality can be implemented in to the scanner. However, exact details should be adapted along with future development to correctly match user needs.

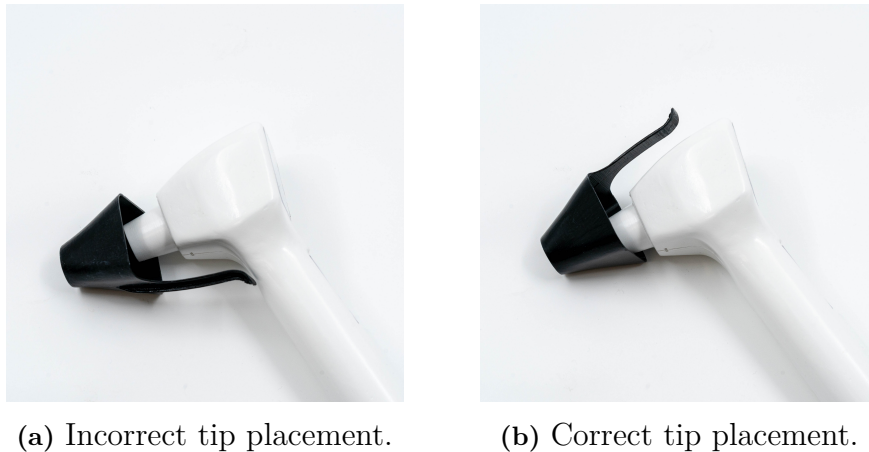


Figure 10.11: Representation of tab shape in relation to connection errors.

As mentioned, the original tip design created by Odinwell formed the base of the final contact tip. This design already fulfilled several of the requirements relating to tip design. Originally, some user error was observed when placing the tip on the scanner. To solve this, the shape of the new tip design has been changed to more clearly differentiate top from bottom, figure 10.11. Participant 5 also mentioned the extruding tab, once placed on the scanner, forms a clear reminder of how to place the tip, as well as not to forget to place it. Additionally, the angle of the pressing area, to eject the tab, created an easier removal of the tab.

10.2.2 Hygiene

As part of the research questions, the goal was to prevent the product from getting contaminated, and therefore causing cross contamination. Several improvements have been made to both the scanner, as well as the tip. Cleaning methods were discussed with participant 5 to see if a sufficient level of hygiene could be maintained.

When it comes to the scanner the main consideration taken into account was the location of gaps and split lines. During the evaluation with participant 3 early in the project, it was concluded that it would be preferable to move split lines to the area close to the sensor, as this will be covered by a tip when in use. Therefore, minimizing exposed split lines, fulfilling requirement 1.5.1. However, they also mentioned to avoid split lines around the area of the handle that should be gripped, as debris from hands could collect here. This was not possible due to manufacturing restrictions. Additionally, the use of a button overlay avoids the need for any gaps around the buttons, thus simplifying cleaning. This ensured device could be wiped clean according to requirement 1.5.3, which was also confirmed by participant 5.

The tip serves the main purpose of improving the sterility of the device. The decision to shift from multi-use contact tips to single use, ensured a higher level of sterility. During the evaluation participant 5 mentioned that veterinarians will still reuse single use tips when they find it suitable. Though this could cause issues, the assumption was made that the veterinarians will have adequate knowledge of when

this can be possible in a safe way. Having the sensor area exposed, however, was viewed as a good solution to remind the user to attach a tip, and not use the scanner without one.

10.2.3 Manufacturing

Though manufacturing was not a main goal for the project, some guidelines have been followed to create the final design. An evaluation was held with Odinwell's electrical engineer to review if the product could fit all electronic components. This was confirmed to be feasible, fulfilling requirement 1.6. For the final manufacturing of the scanner, the product was designed for injection molding. It is important to note that the current internal design is only a suggestion, further development with manufacturing experts is required.

11

Discussion

This chapter aims to present a discussion around multiple aspects of the project. The purpose and objective will be discussed with a focus on the research questions that were established at the start of the project. Additionally, this chapter will discuss the choice of process and the overall approach of the project. Moreover, some ethical and sustainability aspects that have been taken into consideration throughout the project will be addressed. Finally, recommendations for future work will be discussed.

11.1 Purpose and Objective

Considering the first of the two research questions “How can the current Odinwell handheld scanner be adapted for use within veterinary care, and in doing so, aid vets in their decision making process?”, several reflections can be made.

The redesign of the handheld scanner explained in chapter 9 provides a clear answer to the first part of the question. The redesign was performed through the approach of human centered design which included theoretical research and gathering inputs from discussions and testing with potential users. This approach ensures that the final product was adapted to the intended user and their specific needs. However, the second part of the question that targets the device’s potential in aiding the veterinarian in their decision making process can still be up for discussion in some contexts.

With the introduction of the technology to veterinary medicine, the users will have access to a quick method of indicating bacterial presence in the measured area. This information will enable veterinarians to quickly rule out certain causes for the patient’s issue. Additionally, it will provide the possibility of keeping track of the infection trend over time and could help with providing higher certainty in debridement processes. For equine contexts, no such solution currently exists. Therefore, this technology provides an effective solution that removes any uncertainty regarding cleanliness of wounds.

For dermatology contexts, it can provide a clear indicator when explaining a patient’s condition to the animal owners, in addition to the previously mentioned benefits. However, current limitations in the technology and in the information it provides restrict the design from replacing steps in the current practice. Differentiating be-

tween different types of bacteria and fungi is an important part when diagnosing skin infections. This information can not yet be provided by the handheld scanner. Therefore, the current method of cytology is still required. Based on this, the introduction of the technology to the veterinary field can aid the vet in certain ways. However, in its current stage it can not replace current practice and might not be as effective to the veterinarian as it potentially could be in the future.

The second research question “How can the design of a product prevent cross contamination between patients?” has also been addressed and answered through the redesign of the scanner as well as through the introduction of the tip concept. Certain decisions made for the final design of the scanner, explained in section 9.1.5, resulted in better cleaning of the device which in turn aids in preventing cross contamination. However, the single use tip solutions play the biggest role in preventing cross contamination. This tip provides the veterinarian with an efficient way of ensuring that the part in contact with the animal is sterile and removes the labor required to clean and sterilize the contacting part of the device.

The final solution created in this project provides the user with the means to minimize the risk of cross contamination. However, it does not remove the responsibility regarding correct behavior. Removing restrictive design aspects, as discussed in 9.4 was beneficial to the user, as it minimized irritation. Despite the fact that veterinarians often use the products in non-intended ways, when they can ensure that it is safe to do so. The assumption was made that some responsibility could be left in the hands of the user in order to avoid frustration. As veterinarians are highly trained in what they do and their main goal is to improve the health of the animals. Instead, certain design decisions were made to help encourage correct use. Looking back at the research question, it can be determined that great efforts have been put towards preventing cross contamination and that the final design provides a solution to the problem.

11.2 Process

The following section aims to reflect on the general process of this project. As mentioned, the aim of developing a product to answer the two research questions has been achieved. However, little reflection has been given on the process itself.

Whilst planning the project, several specific phases were set to ensure each aspect of the project could be developed sufficiently. The approach of creating an exploration, concept development and evaluation phase proved very effective. By having iterative cycles within these phases, large amounts of ideas could be created. Additionally, new insights could be applied to previous designs through each iteration. Unfortunately, the evaluation phase was inadequate, more on this later.

To start, the project goal was fairly well defined. The original device served as a clear starting point for the design. However, the exact application area still had to be discovered. Therefore, the project started with a large amount of exploration,

both through theoretical research as well as interviews and observations. Getting in contact with veterinarians came with relative ease. Many were excited to participate and open to share information about their work. This created great opportunities for learning.

Once development started, prototyping proved to be the most effective method. Early on, rough mock-ups were made to discuss ideas and present concepts to participants as well as colleagues at Odinwell. Fortunately, there were sufficient resources available at Odinwell to enable this exploration method. Later in the process, as concepts became more defined. FDM printing served as a great solution to create detailed prototypes, closely resembling the final design. This allowed for more accurate evaluation in each iteration round within the concept development.

Though evaluation within the iteration rounds went well, a small setback later in the process resulted in some delay. Unfortunately the main participant in this project became unavailable due to personal issues. Since this was not communicated late, several weeks were spent working without a clear direction on how to proceed. As a result, the final phase of the project could not be completed with proper evaluation. Though the final design was discussed with another participant, detailed evaluation was lacking.

11.3 Ethics

As was briefly mentioned in the introduction to this chapter, several ethical aspects have been taken in to consideration. This following section will address these aspects and discuss their effect on the project. The ethical areas that will be discussed are Inclusivity, Reliance on Technology and Ethical User Research.

11.3.1 Inclusivity

To ensure that the final concept would be successful and usable, it was designed with inclusivity in mind. As the product is a handheld device, specific design considerations were required to ensure its use by as many users as possible. First and foremost, the product accommodated users with varying hand sizes. This was achieved by researching hand sizes and using mean dimensions for the grip diameter and length. Additionally, design prototypes were evaluated by end users on this subject. To add, it was essential that the product would be equally usable for both left- and right-handed users. To achieve this, the product was designed symmetrically, with all buttons placed in the middle of the device. The selection of colors for symbols, buttons, and other interface elements was also an important consideration, in order to ensure usability for users with color vision deficiencies. Here high contrast and brightness was applied.

11.3.2 Reliance on Technology

The main goal of the product is for veterinary staff to get an idea of the bacterial growth and risk of infection in a wound. For this, Odinwell has developed an amazing technology that can accurately read bacterial levels in wounds, enabling veterinarians to monitor patients with ease. With this, however, it was vital to ensure staff would not overly rely on the technology. To ensure this, the screen interface and readout was designed to give an indication, and not a diagnosis. The value of high, medium, low, still ensures the vet decides whether the wound is infected. Additionally, for dermatologists, the device was designed as an addition to cytology, so it would not be the final decision maker.

11.3.3 Ethical User Research

Throughout the duration of the project, several user tests were conducted. When conducting these tests, several ethical aspects were kept in mind. First off there was an agreement with the company to not disclose any sensitive information. This not only applied to the tests, but also over the duration of the project. When conducting the test it was important participants were aware of what they would be doing at the test and what would happen with the results, this is part of informed consent and transparency (Mortensen, 2025). This was achieved by verbal explanation at the start of every study. Moreover, the required forms were presented at the beginning of the tests to ensure participants' agreement with storing of information. All happened according to Odinwell's GDPR guidelines. Also, none of the tests harmed participants nor patients and an overall level of respect was maintained. No testing with animals will be done without the consent from the owner.

11.4 Sustainability

Though not the main focus of this project, sustainability was kept in mind throughout the whole process. Initially the goal for the tip design was to create a reusable product to meet the UN goal number 12 (United Nations, 2025): Responsible consumption and production. Unfortunately, the product had to become single use, due to degradation through cleaning processes. To compensate for this, efforts were made to minimize material usage in the part, to still reduce consumption.

Another UN goal this project aims to contribute to is number 3: Good health and well-being. As mentioned, the technology developed by Odinwell, is meant to reduce incorrect use of antibiotics in veterinary care. By minimizing this, steps are taken to combat antimicrobial resistance. Thus contributing to the improvement of overall health and well being. Additionally, in the future, the product can be adapted to medical care, to improve the diagnosis and treatment of wounds and other conditions. Once again, adding to the improvement of overall health care.

11.4.1 Future Work

As mentioned in section 10.2, the final concepts still need some work until they can be fully functional and sold. Firstly, additional testing of the final designs will be required. The designs have been evaluated with two participants from the study, indicating that the new design is an improvement over the current handheld scanner. However, further evaluation should be preformed with more participants to verify the design and to highlight areas of potential improvements. These tests should also include participants that have not seen or used the previous device, since that might affect their thoughts on the new design.

Before further testing of the device, the internal components should be adapted and fitted in to the new design so that the prototype can be fully functional. This would make the tests more realistic and thereby ensure the best results. This would also enable usability testing of the digital interface, which was not possible due to the timer restrictions of this project.

When further usability testing has been preformed with a functional prototype of the new design the final shape can be determined. This should then be followed by further exploration of possible methods for manufacturing and material choices. This project briefly touched upon this area; however, the final choices will vary a lot with respect to batch sizes, budget, manufacturing company, and more.

12

Conclusion

This thesis project delivered a redesign, fulfilling the aim of adapting Odinwell's current handheld scanner, the NovaQS, towards use within veterinary care. Additionally, a tip solution was developed to prevent cross-contamination between patients.

Due to the limited amount of evaluation of the final designs, it can not be ensured that the design is the optimal solution. However, looking back at the feedback gathered during the exploration phase that resulted in the list of requirements, it is clear that the final solution, including both scanner and tip, provides a better solution for use within veterinary care.

Though the final design concept can be considered a success, there is still much work that has to be done before the concept can become an actual product and then be implemented within veterinary care. Material choices and manufacturing methods have only been briefly studied and will require more research before a decision can be made. The project's exploration phase also proved that the technology does have a promising future within veterinary care. However, in its current state the technology can not fully replace any of the processes used, making its potential benefits limited. With this said, with further development of the technology it shows great promise and could greatly improve the future of animal care. This development can happen in parallel to establishing the final details of the handheld scanner.

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A

List of Requirements

The following section presents a detailed overview of the list of requirements that have been formed during the exploration phase of the project.

Notation: (R) denotes a Requirement and (G) denotes a Guideline.

1. Device

- 1.1. Device should allow for a secure grip for all hands (5th percentile female to 95th percentile male). (G)
 - 1.1.1. Handle length should exceed 97mm from measurement button. (R)
 - 1.1.2. Handle diameter should not exceed 39.5mm. (R)
 - 1.1.3. Grip should not be negatively affected by wearing latex gloves. (G)
- 1.2. Device must have a screen. (R)
 - 1.2.1. Screen should read out battery level, result, modes, settings and history. (R)
- 1.3. Device must maintain a distance of 30mm between hand and measuring surface. (R)
- 1.4. Device should be easy to clean. (G)
 - 1.4.1. Minimize exposed split lines. (G)
 - 1.4.2. Device should have a smooth surface finish. (G)
 - 1.4.3. Device should be wiped clean within 10 second. (R)
 - 1.4.4. Device should have a light color to easily detect dirt. (R)
- 1.5. Shell should fit all necessary electronics. (R)
 - 1.5.1. Device should fit critical component of roughly 20*30*15mm. (R)
 - 1.5.2. Critical component should be in line with sensor area. (R)
 - 1.5.3. Shell should accommodate a screen of approximately 35x45 mm. (R)
 - 1.5.4. Device should fit rechargeable battery. (R)
- 1.6. Device should have a language setting. (R)
- 1.7. Diameter of device tip area should be minimum 16mm to fit sensor. (R)
- 1.8. Device should allow for storing measurements. (R)

2. Usability

- 2.1. Device should encourage user to use tip. (G)
 - 2.1.1. User should be able to clearly see when tip is missing. (G)

- 2.2. Device should be rechargeable. (R)
 - 2.2.1. Device should read out battery level. (R)
 - 2.2.2. Device should communicate status when charging. (R)
 - 2.2.3. Device should charge when being stored. (R)
- 2.3. All buttons should be reachable without shifting grip or using second hand. (R)
- 2.4. Time between grabbing device and reading first measurement value should take less than 5 min. (R)
- 2.5. Taking a measurement should require a maximum of 4 clicks. (R)
- 2.6. Button function should still work when wearing gloves. (R)
- 2.7. User should get feedback through screen for every interaction with device (taking measurement, charging, changing modes, etc.). (R)
- 2.8. Screen should provide sufficient contrast. (G)
- 2.9. User should be able to differentiate between buttons by feel. (G)
- 2.10. Measurement readout should be easy to understand. (G)
 - 2.10.1. Read out value should have a specific scale with clear start and end values. (G)
 - 2.10.2. Measurement readout should be sufficiently detailed. (G)

3. General

- 3.1. Device should come with storage solution. (R)
 - 3.1.1. Device should be easily accessible when stored. (G)
 - 3.1.2. Device should not interfere with work area. (G)
 - 3.1.3. Storage should prevent damage to sensor. (G)
- 3.2. Device should withstand dropping from 1m. (R)
- 3.3. Device should be usable in different scenarios (In horse clinic, in dermatology assessment). (G)
 - 3.3.1. Solution should prevent ambient light from interfering with measurement. (R)
- 3.4. Part that comes in contact with animal should be sterile. (R)
- 3.5. Chosen materials should withstand cleaning process. (R)
 - 3.5.1. Device material should withstand cleaning products used. (R)
- 3.6. Device should aid the vet in their decision making process. (G)
- 3.7. Device should help vet communicate problem to owner. (G)

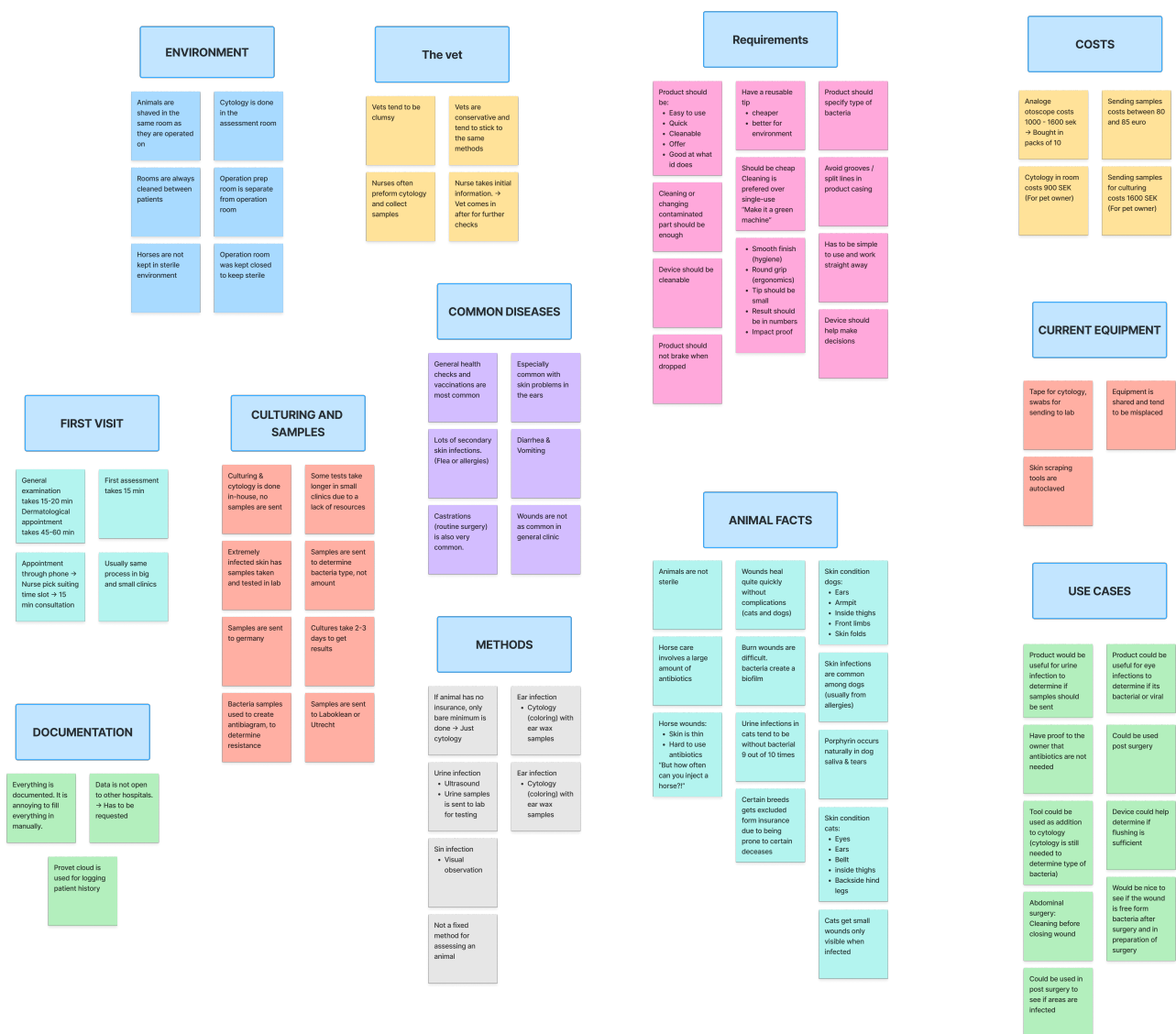
4. Tip

- 4.1. Tip should block out all ambient light. (R)
- 4.2. Tip should ensure a consistent predetermined distance between sensor and measured area. (R)
- 4.3. Tip material in front of sensor should be transparent. (R)
- 4.4. Tip should prevent sensor from getting contaminated. (R)
- 4.5. Tip should provide sufficient protection from the device getting contaminated. (R)

B

KJ-Analysis

The following figure presents an overview of the KJ-analysis. This analysis summarizes the data collected during the interviews.



C

PEPA results tables

The following two tables present the PEPA analysis done for both taking a measurement on a horse and taking a measurement on a sample. These results were collected during an observation at a horse clinic and at a animal hospital.

Table C.1: PEPA taking measurement on a horse.

Physical Ergonomics Product Assessment (PEPA)	Step 1	Step 2	Step 3	Step 4
	Turn on device	Place device on Animal	Press measurement button	Read measurement
(1) Handling(Hold, Move, Impuls, Catch)	Impuls	Move	Impuls	Hold
(2) Strength	L	L	L	L
(3) Precision	M	L	M	L
(4) Endurance	L	L	L	L
(5) Grip	M	M	M	L
(6a) Neck	L	M	L	L
(6b) Shoulders	L	M	L	L
(6c) Arm/elbow	L	M	L	L
(6d) Hand/wrist	L	M	L	L
(6e) Fingers	L	L	L	L
(6f) Back	L	M	L	L
(6g) Legs/knee	L	M	L	L
(6h) Foot	L	L	L	L
(7) External factors	-	Be aware of animal if it starts to move	Be aware of animal if it starts to move	-

Table C.2: PEPA taking measurement on a sample.

Physical Ergonomics Product Assessment (PEPA)	Step 1	Step 2	Step 3	Step 4
	Turn on device	Place device on sample	Press measurement button	Read measurement
(1) Handling(Hold, Move, Impuls, Catch)	Impuls	Move	Impuls	Hold
(2) Strength	L	L	L	L
(3) Precision	M	H	M	L
(4) Endurance	L	L	L	L
(5) Grip	M	M	M	L
(6a) Neck	L	L	M	L
(6b) Shoulders	L	L	L	L
(6c) Arm/elbow	L	L	L	L
(6d) Hand/wrist	L	L	M	L
(6e) Fingers	L	L	M	L
(6f) Back	L	L	M	L
(6g) Legs/knee	L	L	L	L
(6h) Foot	L	L	L	L
(7) External factors	-	-	-	-

D

Product Comparison Matrix

The following table presents a scoring board resulting from a product comparison study. The handheld scanner is Odinwell's original product. This was compared to a large variety of veterinary and medical devices.

Device	Professional	Ergonomic	Intuitive	Easy to clean	Robust	Total
Trimmer	8	4	6	5	8	31
Trimmer	3	7	9	5	6	30
Cast Cutter	9	6	7	6	9	37
Pliers	10	8	9	8	9	44
Blood saturation meter	7	6	7	4	6	30
Thermometer	5	7	8	8	6	34
Portable Ultrasound	9	5	3	7	7	31
Bar code Scanner	7	8	9	3	6	33
Odinwell Handheld Scanner	6	6	8	7	6	33
Chip Scanner	6	6	8	6	6	32
Otoscope	9	6	8	6	8	37

E

Interview Questions

The following list shows a detailed representation of the questions used during the interviews. They formed the base of the structure. However, exact questions were adapted to the responses received.

1 Personal information:

- 1.1 Years of experience
- 1.2 Field of expertise
- 1.3 Country

2 General veterinary questions

- 2.1 Describe your work/ work environment
- 2.2 Describe the process of assessing an animal (HTA)
- 2.3 Most common reason bringing in animals
- 2.4 To what degree can you help an animal in a regular clinic and when is more advanced care needed?
- 2.5 How much is done in house, blood test etc.
- 2.6 How do you document/log assessment
- 2.7 How often will vets prescribe further studies?
- 2.8 Where do most skin conditions occur?

3 Infection and bacterial related questions

- 3.1 How do you determine bacterial presence now (how do you assess the severity)?
- 3.2 What equipment do you use
- 3.3 How important is hygiene in an animal clinic?
- 3.4 Can you describe the process of sterilization in the clinic?

4 Product specific questions

- 4.1 Where do you think this device would be most applicable? (wounds vs skin infection)
- 4.2 Urine infection, eye infection, ear infection, skin condition
- 4.3 Describe how you would use it
- 4.4 When you buy new equipment, what factors do you consider?
- 4.5 What do you think is the most important to focus on for this product?
- 4.6 What are products you use everyday?

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Competitor Comparison Matrix

The following table presents the Odinwell scanner relative to the products of the competitors. Each product was scored based on several different variables. This was done to create an understanding of the strengths and weaknesses of Odinwell's device.

Device	Ease of Use	Weight (kg)	Measurement	Portability	Risk of Cross-contamination
MolecuLight i:X	7	0.4	Biomarker Presence	8	Low
MolecuLight DX	5	-	Biomarker Presence	5	Low/Medium*
Snapshot NIR	4	3.27	Tissue oxygen	2	Low
Snapshot GLO	4	1.27	Biomarker Presence	4	Low
Odinwell Scanner	8	0.1	Biomarker Presence	9	Low/Medium**
Design For Vision	10	-	Biomarker Presence	8	Low
Swift Ray	7	-	Thermal Imaging	10	Low
Woods Light	9	-	Micro-organism Estimation	8	Low

* A drape is used to cover the measuring area, this comes in contact with the patient and could increase risk of contamination when misused.

** Due to the product contacting the measuring area, risk of contamination increases if product is misused.

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Digital Interface

The following figure shows an overview of the digital interface created in Figma. Each rectangle represents one frame in the interface and can be toggled between using the buttons on the device.



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