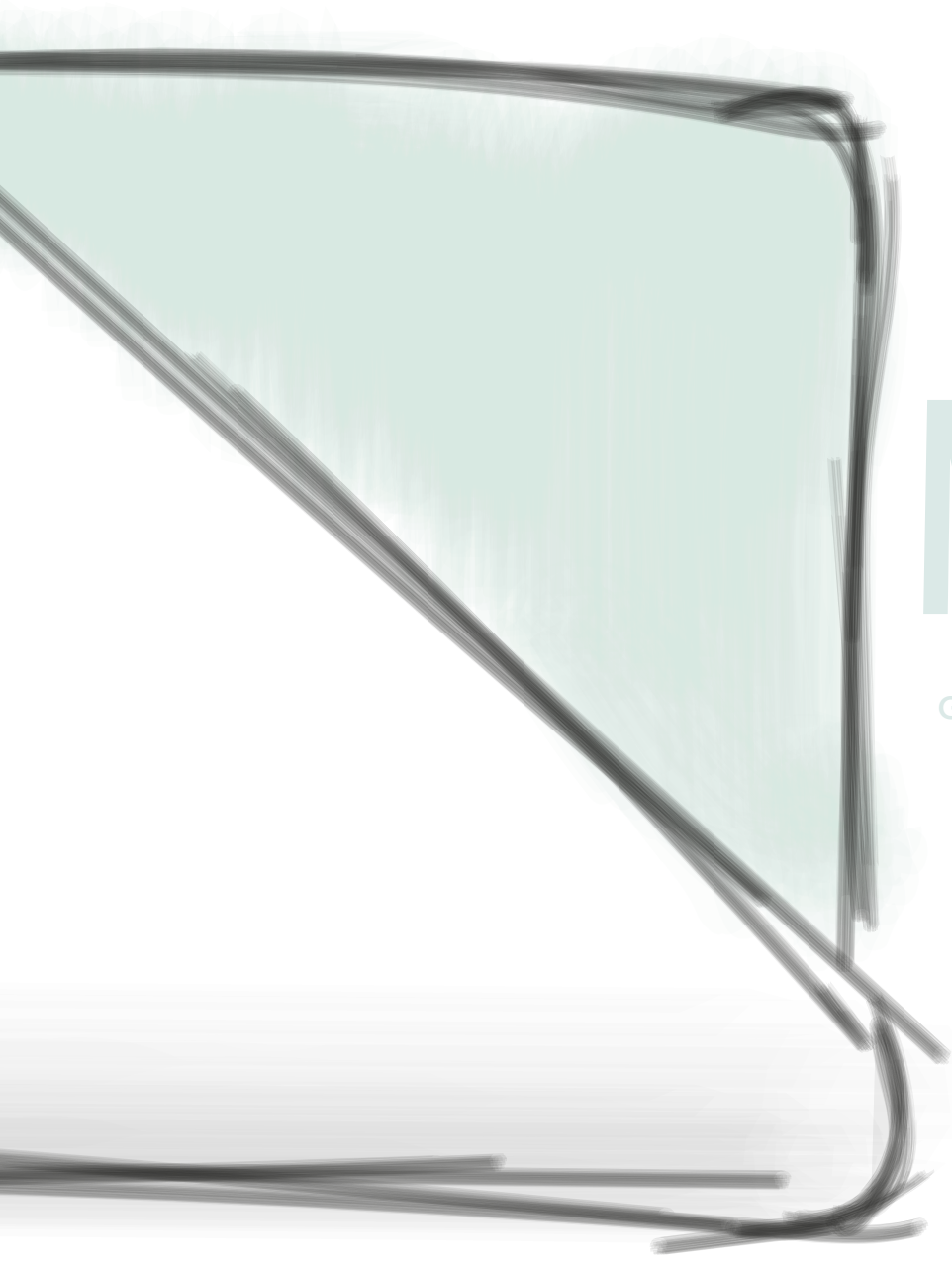

MATE

MEDICINHÅNDTERING DER GØR ARBEJDSFLOWET TRYGT OG EFFEKTIVT

MSC04-ID12 | JUNE 2020

TITLE PAGE

PROJECT TITLE: MATE - Medicinhåndtering der gør arbejdsflowet trygt og effektivt

PROJECT THEME: Reducing medicine related health care errors

PROJECT PERIOD: 03.02.20 - 18.06.20

PROJECT TEAM: MSc04-ID12

MAIN SUPERVISOR: Louise Møller Haase

TECHNICAL SUPERVISOR: Jørgen Kepler

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VIDEOS: 4

THE TEAM

Ill. 1. The team, Sofie, Line and Karina

SOFIE THYLKJÆR ASP LINE LUNDGAARD KARINA RØJKJÆR

PREFASE

This project is made by the group MSc04-ID12 from Industrial Design at Aalborg University. The report shows the process behind the Master thesis of creating a product within the health care sector. The report presents the development of the product from initial research and observations to detailing and creating a business plan.
The project enlightens the high number of medicine related health care errors that occur at the Danish hospitals and it has been a wish to provide the departments with a solution that could possibly reduce this number of health care errors.

A huge acknowledgement, to head nurses Lise Thylkjær, Sidse Lensvelt and Mette Bruhn from Aalborg and Vejle hospital and to all the nurses that has made it possible, to do observations and tests at the hospitals, without that it would not have been possible to create a product like this. Furthermore, an acknowledgement to pharmacist Lecia Møller Nielsen from Aalborg hospital pharmacy. A special thanks to Karsten Winter Johansen and Jens Pauluth for helping and providing knowledge when dealing with assembly and programming of the prototype. Thanks to head supervisor Louise Haase Møller and technical supervisor Jørgen Asbøll Kepler and external supervisor Michael Skipper Andersen for providing guidance throughout the entire project and a special thanks to all our families that has been a mental support and motivation throughout the project.

ABSTRACT

Hvert år sker ca. 10.000 utilsigtede hændelser i forbindelse med medicinering af patienter på de danske hospitaler. Dette tal er kun de indberettede, hvor der foruden dem, også er alle dem som ikke bliver indberettet grundet travlhed og prioriteringer, hvilket betyder at det egentlige tal kan være langt højere.

Dette speciale, udarbejdet af en gruppe Industrielt design studerende viser udviklingen af et produkt, som skal hjælpe sygeplejerskerne når de dispenserer medicin til patienterne. Målet med udviklingen af produktet MATE er, at antallet af utilsigtede hændelser relateret til medicindispensering vil falde. Under specialet arbejdes der med de 5 R'er, som er en betegnelse, der bruges på sygehuset inden for dispensering af medicin. Dette betegner, at den Rigtige patient modtager det Rigtige præparat i den Rigtige form i den Rigtige mængde til den Rigtige tid. MATE vil sikre at disse 5 R'er bliver overholdt under dispenseringen og derved reducere antallet af utilsigtede hændelser.

Under udarbejdelsen af produktet har både sygeplejersker, afdelingssygeplejersker, læger og farmaceuter leveret nyttig viden og feedback på koncepter. Denne kontakt til brugere og interessenter har muliggjort at udarbejde et produkt der kan passe direkte til konteksten og behovet inden for medicindispensering på hospitalet.

EXPLANATION OF IMPORTANT WORDS

Health care errors - Unintended events happening at the hospital that have the potential of hurting or do hurt staff or patients.

5R - The 5R's describes the conditions and attention points at the hospital regarding medicine dispensing in the medicine room. These points help the nurse to ensure that the Right patient gets the Right preparation, in the Right form, in the Right amount, for the Right time.

Promedicin.dk - Is an open digital reference website where both health care personnel and private people can find information regarding a big part of all preparations. Here, the active ingredient, pictures of the medicine, description of it etc. can be seen.

Prescription - When the doctor decides that a given medicine is to be provided to a patient which needs treatment - This is loaded into the program the doctor uses.

Preparation - Type of medicine.

EPJ - The electronic patient journal follows the patient during the hospitalization. The doctor can prescribe medicine and upload it to EPJ. The nurse can access the information provided regarding preparation prescribed, form of medicine, amount and time to receive the medicine.

Dispensing - A description, which is used when the nurses pour medicine for the patients in the medicine room.

Dispensing box - A container that has 4 compartments for pills (morning, noon, evening and night).

Pills - Overall description of types of solid medicine: e.g. pills, tablets, capsules, melt tablets, suppository

Active ingredients - The ingredients that are put into the medicine and affects either pain or the illness. E.g the active ingredient in Ipren is ibuprofen, which helps relieve pain.

Generic substitution - When two preparations contain the same active ingredient. It means that the nurse can safely exchange one preparation with another e.g. Pamol and Panodil where they both have the active ingredient paracetamol.

Analog substitution - When two preparations have the same effect but do not contain the same active ingredient. It means that the two preparations can not replace each other.

Melt - Melt tablets are a type of pill that melts on the tongue. This type is used when the patient can not swallow pills.

IV-fluid - Intravenous medicine is a liquid form that is injected directly into the bloodstream using a drip.

Suppository - A pill which is inserted into rectum.

READING GUIDE

This project is divided into five folders. It is recommended to read the process report first in order to get an understanding the project frame and the design considerations. Each paragraph is provided with an introduction and a sum up, where the sum up is catching up upon the data collected. QR-codes are provided in the implementation, showing videos of the geometry, these can be scanned using a camera. Appendix consists of research that supports the process report and can preferrably be read simoultaneously, these are marked with (WS XX), (Appendix XX) or (Video XX) throughout the process report. Next, the product report presents the final product suggestion and addresses the buyer of the product, where a flyer addressing the user of the product is attached to the product report. Lastly, the techinal drawings can provide an understanding of the considerations regarding production, manufacturing, materials etc.

The report is divided into four phases based on the three Milestones. This has been a natural dividing of phases during the whole project period. Phase one is divided into sub phases; research and framing. Phase two is where the technical aspects and form is investigated. Phase three detailing and phase four with the business aspect. Each phase is marked with a cover, with a small intro to the phase and a process overview, illustrating the process in the respective phase. Whenever a project direction is disregarded the circle in the process overview illustration is toned down.

Along the report there are two icons that need to be attended. One with an exclamation point that indicates a customer need and another with a light bulb that informs the reader of ideas to remember further on in the development of the product. The Harvard method is used when referencing a source in the process report. During the report, valuable insights and customer needs will be presented in a Design brief. The customer needs will be translated to demands in the Design demands.

DISPENSING MEDICINE AT THE HOSPITAL

PROBLEM

Every day, around 5400 nurses, are located in the medicine room when they dipense medicine for the patients at the Danish hospitals. (WS9)

More than 9.800 health care errors related to medicine, were in 2016, reported in the Danish hospitals, this was a result of the medicine being dispensed wrongly in the medicine room or given wrongly to the patient. (Appendix 01).
The consequences of these flaws is that the patient can feel uncomfortable, get an allergic reaction, get side effects or in the worst case it can result in the death of a patient. (WS8)
If a patient is wrongfully medicated it will in average result in the hospitalization being extended by at least two days, resulting in a minimum of 9.600 DKK extra in hospitaliation cost for each medication flaw. If compensation is needed, this typically will be 2-300.000 DKK for each case. [sundhedsdatastyrelsen, n.d]
These many health care errors result in the hospitals investing both time and money in securing the patient better. (WS12)

The real challenge for the nurses is that the medicine boxes in the medicine room often changes looks in terms of design, color or name and that confuses the nurse which can result in the wrong medicine or amount being dispensed.

SCOPE

In order to minimize the medicine related health care errors from happening at the hospitals, the focus of this project is to design a product that can help the nurse raise the patient safety. It is wanted to do that, by ensuring that the right patient, gets the right medicine preparation, in the right form, in the right amount, for the right time (the 5 R's).
It is imagined to be possible to design a product that can assist the nurse by dispensing medicine and in the process ensure the 5 R's.

Currently there are no products on the market which can be implemented at the individual departments at the hospital and help the nurse raise the patient safety by dispensing the pills in a secure and precise way. Therefore, the market gap is discovered and explored with the goal to compete with the existing process for dispensing pills manually, but also to compete with the existing robotic solutions, e.g. Swisslog, on the market that deal with dosage dispensed pills for an entire hospital.

FOCUS

The aim is to assist the nurse when dispensing medicine in order to reduce medicine related health care errors and thereby raise the patient safety.

Health care errors are unintended incidents that happen to patients or staff in the health care sector. These incidents can either be events that have caused harm, or events that have had the potential of causing harm to a patient or staff. The events are not always discovered, but can result in the affected individuals suffering from the incident. [sundhed.dk, 2016 [1]]
This project focuses on dealing with health care errors regarding dispensing medicine namely pills in the medicine rooms at hospitals.

THE TWO MAIN KEY ACTORS ARE SHOWN BELOW.

Ill. 2. Two nurses dispensing medicine at 8Ø

THE NURSE

Ill. 3. A nurse gives the patient medicine

THE PATIENT

MEDICATION ERRORS

As mentioned, more than 9.800 medicine dispensing related health care errors happen at the Danish hospitals every year. It is wanted to point out what can cause these medicine related health care errors. When dispensing the medicine for the patient the nurse has to be aware of many things at the same time. She has to make sure that: The right patient, gets the right medicine, in the right form, in the right amount, for the right time.
Furthermore, it is stated by Julie, nurse at 240 at Vejle hospital (WS3) - "when located in the medicine room, we can be interrupted, resulting in confusion and making medication dispensing errors."

RIGHT PATIENT

In order to ensure the medicine is dispensed to the right patient, the name and social security number on the medicine box need to match the data in the system on the computer. It can happen that the nurse starts dispensing medicine for Jens Jensen but then finds out it has been put into Johan Johansens dispensing box. Then the nurse needs to start the dispensing all over. In worst case scenario the flaw would not have been detected and two people would have been medicated wrongly.

Ill. 4. Patient dispensing boxes

RIGHT MEDICINE

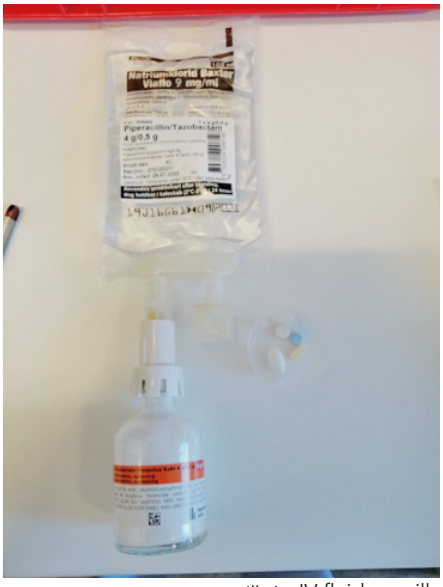
The right medicine is the type of medicine prescribed by the doctor. The observed issue is that often the prescribed medicine is not possible to dispense for the nurses since they do not have the exact medicine preparation on the shelves in the medicine room. This is because changes in the preparations happens often since the hospital has to buy the cheapest medicine available on the market.
This results in the looks, name, brand and the milligrams of the medicine changing a lot and that makes it challenging for the nurse to choose the correct medicine. Preparations can be substituted, which means that medicines can be exchanged as long as they have the same active ingredient. (WS8)

Ill. 5. The different preparations at the shelves

- DIFFICULT TO CHOOSE THE RIGHT PATIENT
- HARD TO CHOOSE THE RIGHT MEDICINE
- INATTENTIVE WHEN SELECTING THE FORM OF THE MEDICINE
- CONFUSION BECAUSE OF CHANGE IN MG
- SOMETIMES THE MEDICINE END UP IN THE WRONG ROOM IN THE DISPENSING BOX

RIGHT FORM

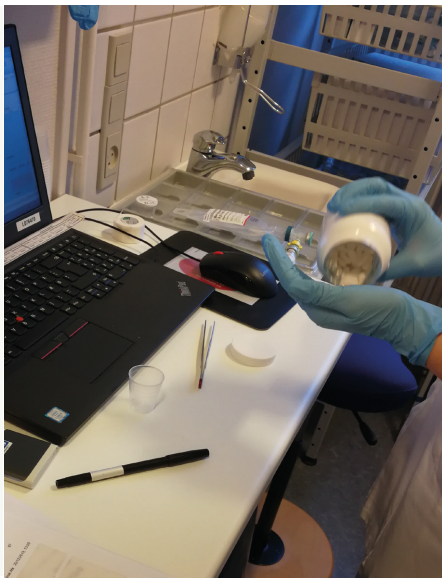
The form is also important to dispense correctly. The form can be an oral pill, IV-fluid, suppository pill, melt tablet etc. Here, it is possible to fail and therefore dispense the wrong form. The error often happens when the patient goes from getting the medicine through IV and the nurse forgets it is changed to pills.
In some cases it can be problematic when the wrong form is given, since there is a difference in the speed and efficiency of the preparations when it enters the body. (WS4)



Ill. 6. IV-fluid vs. pills

RIGHT AMOUNT

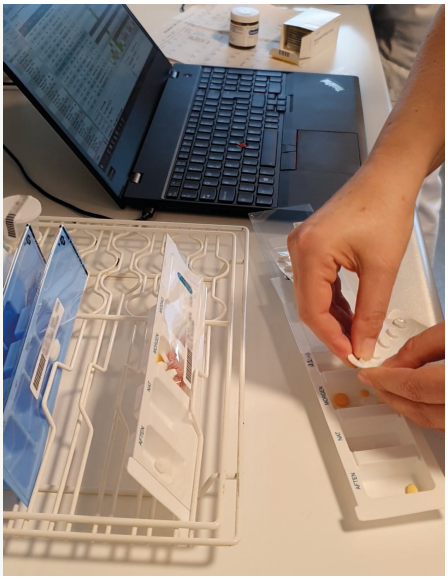
The right amount of medicine is important to ensure when dispensing. But it is hard for the nurse when the medicine, in the medicine room, changes looks and often also the strength of the pills changes. The doctor has no insight of the standard medication there is in the medicine room, so when he prescribes a preparation it is based on the list in the EPJ (electronic patient journal).
This means that the nurse has to be aware if she dispenses the right strength and amount. E.g. Eltroxin 100 mg on the shelves one day and Eltroxin 50 mg the other day. Also, the pills are indicated with either milligrams or pieces which is a potential source of error as well, since it can be read as 5 pcs instead of 5 mg. If not dispensed correctly, it can result in the nurse giving too much or too little medicine to the patient.



Ill. 7. Nurse dispens pills in her hand to ensure the right amount.

RIGHT TIME

The correct time is secured when the pills are dispensed in the correct room in the dispensing box. Often the pills are divided in the box into morning, noon, evening and night. But it can happen that the pills are put into the wrong room in the dispensing box and the patient will then ingest the medicine at the wrong time.
It can be problematic for the patient if the medicine needs to be given at a very precise time at the day.



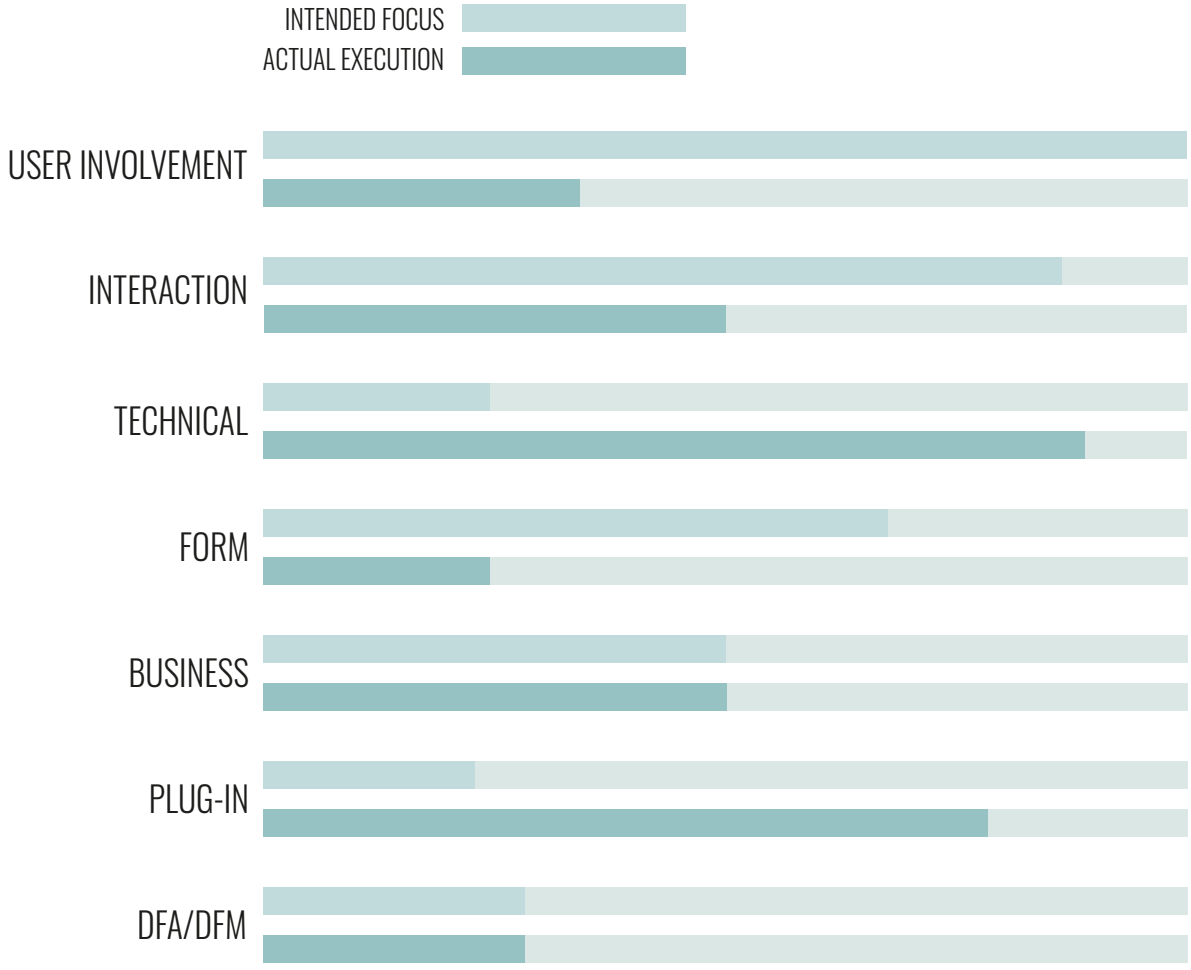
Ill. 8. Nurse dispense pills in the patients dispensing box

FOCUS

In order to understand the intended focus, prioritization and fulfillment of tasks through the project a mapping has been made.
This mapping consists of the seven most important parameters, evaluated by the team, which are individually ranked regarding the focus and workload intended within the project versus the actual workload.
It is described why they have the specified ranking in WS0 and what the gains or losses have been through the project as a result of the change in focus.

The design process has been driven by the design thinking (DT) approach, where an unimagined solution to a given problem was to be found.
During this process, different tools and methods have been used in order to reach the goal. Despite the DT approach, usually focusing a great deal on user involvement, this showed to be challenging to implement to the wanted extent in the project.

The parameters are listed with the intended focus and the actual execution, in the project, in the graph beneath.



Ill. 9. Intended focus vs. actual execution.

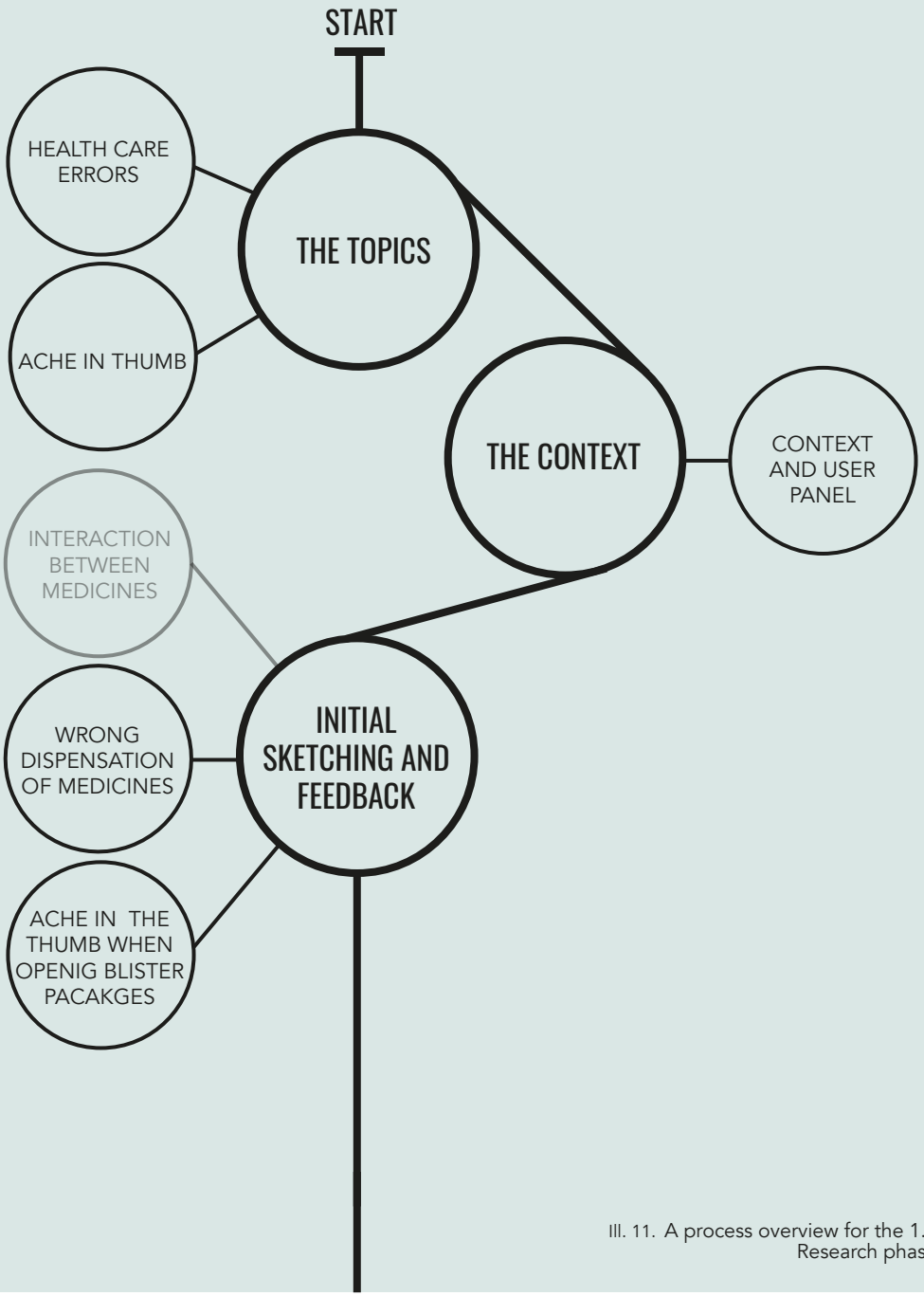
TABLE OF CONTENT

Ill. 10. The team in the medicine room at 8Ø talking with Head nurse Sidse.

1.0 RESEARCH

This phase contains information on the research that enlightens the issue the nurses have regarding medicine dispensing in the hospital. Furthermore, the nurses are presented in this phase and they form the user panel throughout the whole project where they provide knowledge and feedback on the concepts.
Initial sketching on different subjects are done in this phase and sets the foundation of the direction of the project.

PROCESS OVERVIEW



Ill. 11. A process overview for the 1.0 Research phase

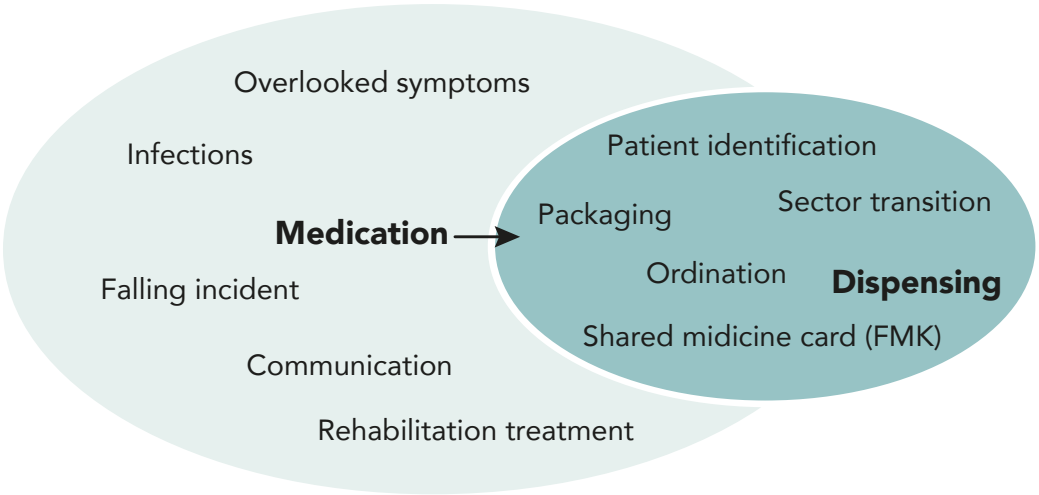
HEALTH CARE ERRORS

In order to understand the challenges within health care errors the issue is looked into. This is specifically regarding errors within the medication dispensing at Danish hospitals, both through research and observations at different departments. It is wanted to look into how patient safety at the Danish hospitals works now and how it is possible to improve it with a physical product. Interviews and observations at different hospital departments are used to validate the project direction and to guide the project.

A health care error is in general an incident that occurs when something in the health care sector goes wrong that potentially could have been prevented. These errors are events that can harm a patient or the staff. Just the risk of harming, is also listed as a health care error.
The error needs to be reported by the health care personnel, but the reported errors are only a fraction of the experienced errors. Furthermore, there also are the unconsciously experienced errors, these errors are incidents the health care personnel are not aware of, and they therefore has no chance of reporting it. [Sundhed.dk, 2016].
The purpose for reporting health care errors is to create attention towards the errors and learn from mistakes in order to prevent these in the future.

Health care errors are a big issue at the Danish hospitals and a great focus is currently attended towards these events.
In 2016, 916 events were reported about errors within the medication, only at Aalborg University Hospital (WS8) and 9.896 events all over Denmark [videnskab.dk, 2020]. Here, dispensing of medicine was the second largest risk of health care errors. When looking at the numbers for 2017, medicine dispensing follows the curve, and is still the second largest reason for errors in the hospitals today (WS8).

TYPES OF HEALTH CARE ERRORS



Ill. 12. A marking of the focus area in the project

TOO MANY MEDICATION RELATED HEALTH CARE ERRORS AT HOSPITALS

REPORTED MEDICINE RELATED HEALTH CARE ERRORS

Every year more than **90.000** medicine related health care errors are reported related to medicine dispensing. In 2016, **9.896** of these errors happened at the Danish hospitals [videnskab.dk, 2020].

EXPERIENCED MEDICINE RELATED HEALTH CARE ERRORS

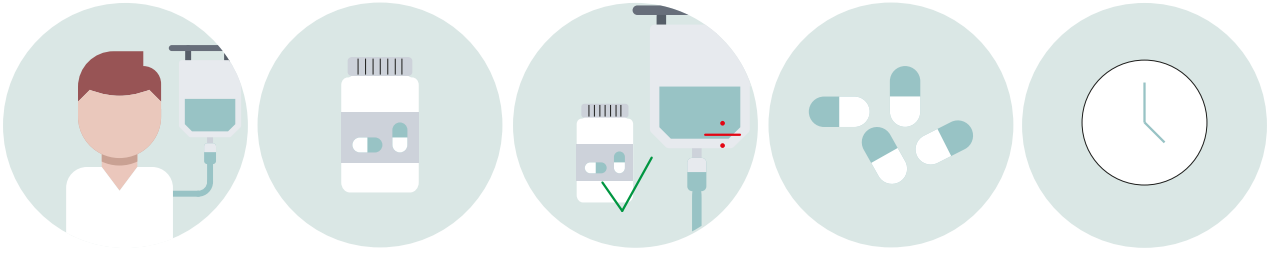
Nurses claim that they experience **a larger amount of health care errors than they report.**
They do not report the majority of the errors since the paperwork is very time consuming and they decide that their time would be used better by alerting the doctor, correcting the error and providing better patient care (WS8).

MEDICINE RELATED HEALTH CARE ERRORS NOT REALIZED FOR THE HEALTH CARE PERSONNEL

It is imagined that the nurses make more errors than they detect and experience.
This can be because some patients are not having a active reaction to the medicine and therefore do not alert the nurses at the department (WS8).

There are a lot of parameters the nurse has to take into consideration when dispensing medicine, and it can be demanding to focus on these simultaneously. This can result in the nurse making a health care error.

The parameters the nurse has to ensure that the right patient gets the right medicine in the right form in the right amount for the right time.

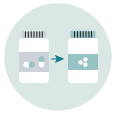


Ill. 13. The 5 R's illustrated

MEDICINE DISPENSING ERROR REASONS

When dispensing medicine at a Danish hospital, the nurse manually grabs the medicine from the shelves in the medicine room, and dispense it directly into the dispensing box for the patient. Many errors can happen when dispensing medicine, and the nurse has to pay attention throughout the whole process in order to secure the patient in the best possible manner. It is wanted to state the found problems with the goal of understanding the challenges the nurse faces when dispensing medicine.

CHANGE IN NAME AND DESIGN



The nurse has to pay attention during the process of dispensing medicine, because many of the medicine boxes frequently change their name, design and color. This is because patents on well known medicine preparations expires and new brands hit the market. The new competitors create a new name and design for the boxes but often the medicine in the pill is generic [minmedicin, 2018]. Therefore, the pills can safely be replaced by the previous preparation that were to be found on the shelf. But it is confusing for the nurses that the boxes looks different (WS4).
The medicine provider Amgros ensures that all regions in Denmark get the cheapest medicine available on the market. Leaving the nurses, with no say in which brand there is on the shelves in the medicine room. (WS8)

***"It is almost every day that new medicine hits the shelves. The design of the boxes becomes more and more alike, because it is cheap to make the boxes white." - Lecia, pharmacist at Aalborg University hospital pharmacy.* (WS8)**

INTERACTIONS BETWEEN MEDICINE

When the doctor is ordinating one type of medication for a patient, it is important to be aware of the possible interactions between preparations. Lecia, a pharmacist at Aalborg univerity hospital stated that the doctor sometimes has limited insights in the other types of medicine, the individual patient gets. This can result in the different preparations potentially interacting unintended with each other. This for example, can happen if a patient has been in multiple departments and has received many different kinds of preparations. Lecia stated that the doctors often has different focuses and little knowledge of the other department and the medicine prescribed. If the preparations are not compatible it can have huge consequences for the patient. (WS8)

CHANGE IN AMOUNT

When the box on the shelf changes, also often the amount of the generic medicine changes (active ingredient). E.g. if ibuprofen 200 mg was on the shelves last week, and this week it is Brufen 400 mg. This requires the nurses to pay attention to what is written on the box and double checking, even though it is generic. Sometimes the nurse can have a hard time to calculate how much medicine is needed when it changes all the time (WS4).

"The doctor prescribes the brand and not the generic medicine. And there can be a difference in the strength. It can be a challenge for the nurses to calculate how much the patient needs. " - Lecia, pharmacist at Aalborg University hospital pharmacy. (WS8)

INTERRUPTIONS

The nurses gets interrupted many times while dispensing medicine. Interruptions can be patients calling for help or needing care, a co-worker that needs help or an emergency situation where the nurse has to leave the medicine room. Many interruptions can result in the nurse losing concentration and getting disoriented when getting back to dispensing medicine. E.g mixing up the patient dispensing boxes (WS8).

"A lot of errors are the result of interruptions from patients and my co-workers that needs my attention." - Anne, Former nurse at Aalborg University hospital. (WS17)

Based upon observations and interviews in the context, there are multiple pitfalls for the nurse to experience when dispensing medicine. This is a potential area where it is possible to create a concept that can help the nurse secure the workflow and increase the patient safety during the dispensing of medicine. The next step is to start idea generating based on the stated problems.

CHANGE IN PREPARATION, BRAND AND DESIGN - HELP TO APPROVE MEDICINE
- HARD TO CHOOSE THE RIGHT MEDICINE
- CONFUSION BECAUSE OF CHANGE IN MG

INTERRUPTIONS WHEN DISPENSING MEDICINE - STANDBY MODE
- INATTENTIVE WHEN SELECTING THE FORM OF THE MEDICINE
- MIXING UP THE PATIENT DISPENSING BOXES

ACHE IN THUMB

Besides having the focus on health care errors, also ache in the thumb as a result of opening blister packages were looked into. The question "Which challenges do you experience in you workday as a nurse" were sent out on social media, in order to hit as many within the focus area as possible. More than half of them, stated that they experience ache in their thumb when dispensing medicine, namely pills from blister packages (WS1). In order to fully understand the challenge of dispensing medicine, research has been done by observing multiple medicine dispensing processes at different departments in hospitals. The research wishes to validate the hypothesis stated by the nurses.

THE PROBLEM

The nurses at the hospitals often experience ache in their thumb when dispensing medicine from blister packages for the patients. Almost all patients at a hospital need medication in the form of pills, and opening blister packages is therefore an ongoing task for the nurses every day. They use a lot of time on dispensing medicine for the patients which can result in an aching thumb throughout the day. Sometimes the foil on the blister packaging can be so hard that the nurses have to use a sharp object in order to get the pills out of the package, making sure they do not break the pill (WS3 and WS4).

"When I only dispense the morning medicine for six patients, it is not so hard, but if I were to dispense all four dosages, morning, noon, evening and night, it would be very hard for my thumb. " - Julie, Nurse at 240 at Vejle Hospital. (WS3)

"We would much rather have the medicine in tubs instead of blister packages, it is much easier to open. " - Sofie, Nurse 8Ø at Aalborg Hospital. (WS4)

MEDICINE PACKAGING

The hospital staff has no influence on which packaging the medicine comes in while it is decided from the companies making the medicine. Amgros is deciding which medicine the Danish hospitals should have in the medicine room and it is therefore not up to the hospital staff to decide (WS8). This problem can have a negative physical effect on the nurses while they are the ones dispensing the medicine on a daily basis.
When working within the health care sector in many years, some nurses can develop arthritis, and it can in worst case get so bad, that they have to stop working as a nurse.

"The ache in the thumbs is the worst. "
- Sidse, Nurse at 8Ø, Aalborg Hospital. (WS4)

Ill. 14. Ache in thumb when dispensing medicine from blister packages

Since it is not possible for the hospital staff to order the medication in tubs, there is seen a potential market for a product that assists the nurse in opening blister packages. From the data gained through observations and interviews, it is clear that the nurses could benefit from a product that assists them in the process. Therefore, the next step is to create solution ideas for the problem.

REMOVE ACHE IN THE THUMB

THE MEDICINE ROOM

To get an understanding of the context the nurses are working in, observations has been made in the medicine room both at Aalborg University Hospital and at Vejle Hospital. The aim is to find out how their working space is build up and what the nurses have in the medicine room. This will be used as a guideline in the concept development regarding interaction, placement, size and form.

AALBORG UNIVERSITY HOSPITAL

Ill. 15. Medicine room and table size at 8Ø and 9Ø

VEJLE HOSPITAL

Ill. 16. Medicine room and table size at 240

From the observations at the two hospitals, it is clear that the medicine rooms are very different as shown in the ill 15 from Aalborg and 16 from Vejle. The medicine room at Aalborg University Hospital is bigger than the one at Vejle Hospital. At Aalborg, three nurses work in the medicine room at the same time and in Vejle only two nurses are working in the medicine room.

What the medicine rooms both have in common, is that they have little counter space. A dispensing station contains a computer, physical paper with a patient list, the patients dispensing boxes and a holder for the boxes.

To make sure that a product will fit into more than one medicine room at a hospital it is necessary to take these observations into consideration when developing the concept. The concepts developed will both be tested at Aalborg University Hospital and Vejle Hospital throughout the project.

FIT INTO THE MEDICINE ROOM

THE NURSES

As mentioned there are two to three nurses working in the medicine room at the same time. The nurses' job is to dispense and distribute the medicine for the patients.
To get an understanding of which challenges there are related to dispensing the medicine and also to be able to test the ideas and concepts in the design process a user panel is set. This user panel consists of three head nurses and three nurses from three different departments, two at Aalborg University Hospital and one at Vejle Hospital.
Where the nurse only has to think about the use of the product, the head nurse can give information and feedback regarding the economy aspect and also which important aspect to consider, in order for the department to invest in a product. Besides the listed nurses, also other nurses at the departments has been giving feedback on shown concepts.
Using different departments with both nurses and head nurses, a broader insight is ensured. In addition, it is possible to see if it is the same aspects and values which are important despite the diffences within the department and hospital.

AALBORG UNIVERSITY HOSPITAL

DEPARTMENT: 9Ø

HEAD NURSE LISE THYLKJÆR

NURSE HELLE BENDTSEN

III. 17. Head nurse and nurse from 9Ø

AALBORG UNIVERSITY HOSPITAL

DEPARTMENT: 8Ø

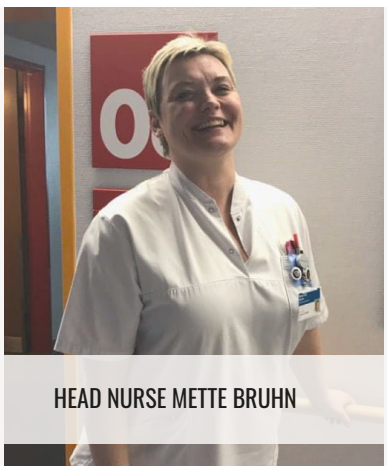
HEAD NURSE SIDSE LENSVELT

NURSE SOFIE ERIKSEN

III. 18. Head nurse and nurse from 8Ø

VEJLE HOSPITAL

DEPARTMENT: 240



HEAD NURSE METTE BRUHN

NURSE JULIE KYNDE

III. 19. Head nurse and nurse from 240

PARADOXES

A lot of data has been collected regarding health care errors within the different departments at the Danish hospitals. Based on the interviews and observations done, (WS3, WS4 and WS8) different paradoxes came of interest. Each of the paradoxes have an effect on the stakeholders who deals with them. The stakeholders are listed, and their dealing with the paradoxes are described. Furthermore, the needed aspects to solve the issues are listed in order to move into the solution space and make it possible to come up with concept ideas.
From specifying the paradoxes and analysing the problems of the stakeholders three directions came of interest: Interaction between medicines, ache in the thumb as a result of opening blister packages and wrong dispensing of medicine.

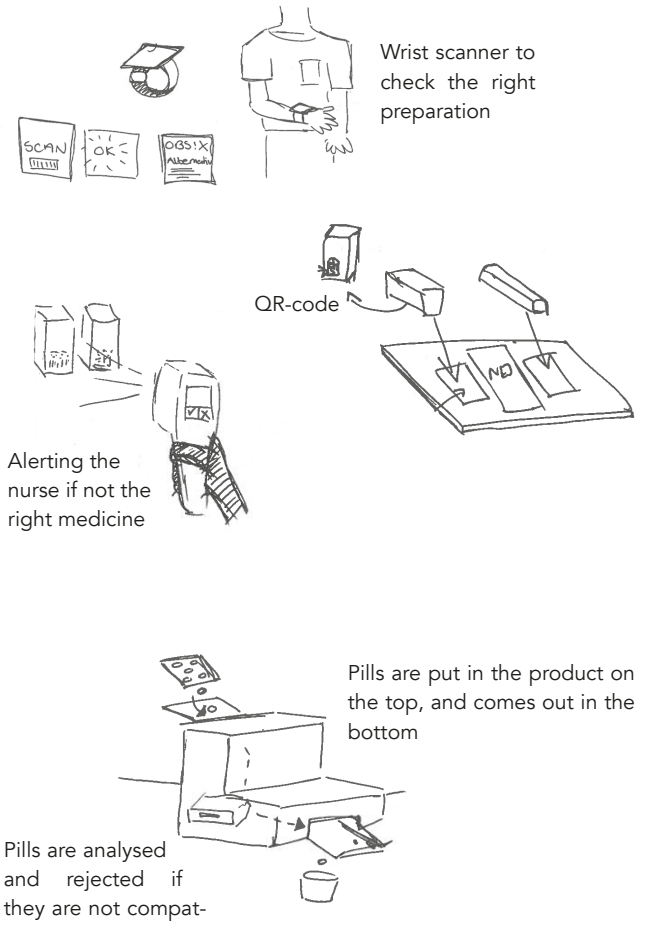
INTERACTION BETWEEN DIFFERENT MEDICINES

It is possible for patients to have multiple illnesses when hospitalized, and therefore the doctors have to be more aware when prescribing the medicine.

"Some medicines can not be given together because they can repeal each other's effect. But the doctors do not look across fields and then health care errors can occur. " - Lecia, pharmacist at Aalborg hospital pharmacy. (WS8)

A potential product should take the role of the pharmaconomist and be able to analyse the medicine preparations effect on each other in order to give the nurse feedback of what is okay to mix.

III. 20. A Nurse, a Doctor, a Patient and a Pharmaconomist



III. 21. Sketches on interaction between different medicines

ACHE IN THUMB

When dispensing medicine the nurses can experience a lot of ache in the thumb. ***"I can already feel the ache in my finger because of the dispensing from blister packages - it is definitely the thumb that is the worst. " - Rikke, Head nurse at Aabybro Nursing home. (WS2)***

When experiencing persistent stress in the thumb it can result in the nurses getting arthritis and needs sick leave.

The nurse's fingers hurt from poking out pills from blister packages.

Ill. 22. A Nurse

A potential product should replace the movement when using the thumbs for poking out pills.

Blister packages are put into the opening.

Ill. 23. Sketches on ache in thumb

WRONG DISPENSING OF MEDICINE

The medicine room is where the most health care errors occur while when dispensing medicine in the medicine room, the nurses frequently get interrupted, even though they are not supposed to.

"Medicine dispensing errors can happen through human mistakes because of interruptions in the medicine room, and it is one of the most common reasons for medicine related health care errors."
- Pia, Pharmacist at Vejle hospital.

A potential product should be able to ensure: Right patient (social security number), right medicine (pharmaceutical), right amount (number of pills), right form (liquid, pill, oral, suppositories), right time (morning, noon, evening, night).

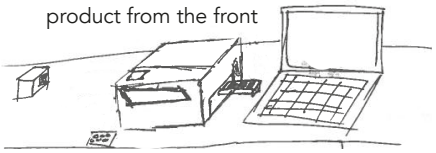
The nurse contacts the doctor when the medicine is already given wrongly and treats the patient.

The doctor helps the nurse if there are any side effects after the wrongly dispensed medicine is given.

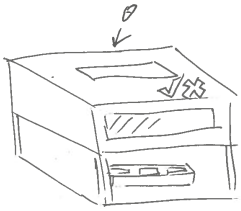
The patient gets side effects or an allergic reaction.
Gets new and correct medicine.

Ill. 24. A Nurse, a Doctor and a Patient

Pills goes inside the product from the front



Pills goes inside the product from the top, and the product can accept or decline the pill



Ill. 25. Sketches on wrong dispensing of medicine

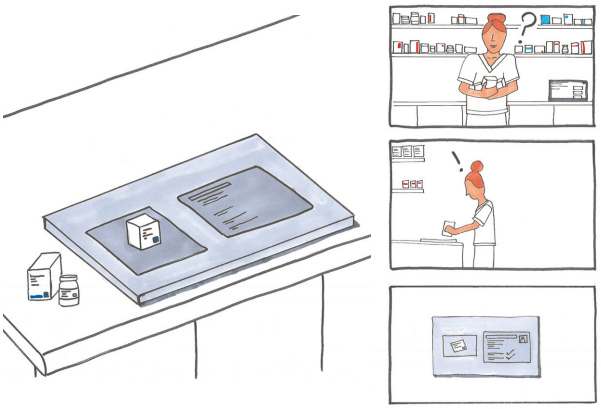
The research and sketching gave an idea of the possible directions the project can go and what to focus on. Feedback on the concepts, regarding the paradoxes, is wanted in order to validate them in the context and by the nurse. Therefore, the next step is to make the concepts more tangible through sketching and specified individually with a user scenario.

GETTING FEEDBACK ON THE CONCEPTS

The concepts were specified further and resulted in seven different product ideas where one for each paradox is shown beneath. To see all concepts, look at (WS11). The concept ideas were shown to different specialists in the health care sector in order to get feedback and to validate a selection round of which values and problem solutions to transfer to the next phase. It was wanted to figure out the most crucial needs from the nurses and to choose a direction from their feedback. The feedback is given by a pharmacist at "Løve apoteket" in Aalborg, nurses in both 8Ø and 9Ø at Aalborg University Hospital and nurses at Vejle Hospital (WS 12, WS13 and WS16).

INTERACTION BETWEEN DIFFERENT MEDICINES

This concept is a plate, that the nurses can use when they dispense medicine. The plate has a scanner, where the nurse can scan the preparation, if she is in doubt of whether the preparations interact with each other. The plate is flat, and can be turned off when not in use, meaning it will be incorporated on the counter, so it does not take up any counter space.



Ill. 26. A plate where the nurse can scan the preparation from the shelves

FEEDBACK ON CONCEPT 1

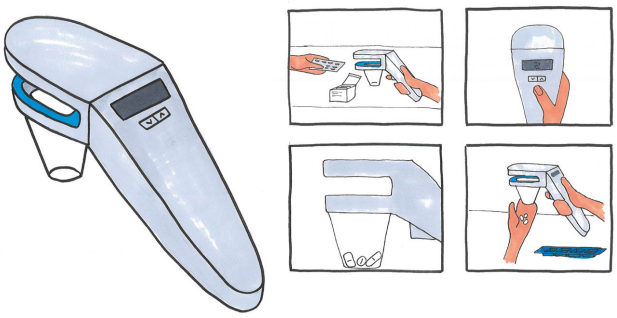
"I have an understanding that when the doctor prescribes some medicine he has checked up on the things he is in doubt of. The doctor prescribes - We dispense" - Sofie, nurse at 8Ø (WS12)

"It happens that the nurse is in doubt, but if so, we will contact the doctor. It does not happen very often and it is the doctors responsibility so we don't look at it". - Helle, nurse at 9Ø (WS12)

"A computer program that can tell if the medicines interact, already exists" - Finn, pharmacist at Løveapoteket Aalborg (WS13)

ACHE IN THUMB

This concept is a hand held device that the nurse can move around in the medicine room. This concept is exclusively a product that can help the nurse poke out pills from a blister package. The pills are collected in a small container underneath the product. It is then possible to release them and place them in the dispensing box for the patient.



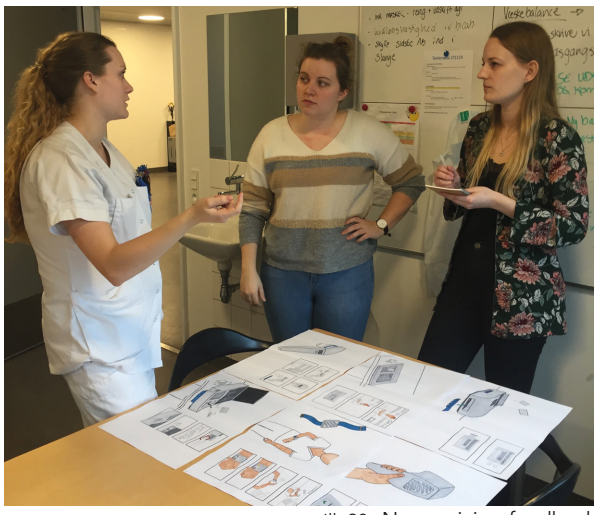
Ill. 27. A hand held device which can help the nurse poke out pills from blister packages.

FEEDBACK ON CONCEPT 2

"It can hurt when poking out the pills from blister packages" - Sofie, nurse at 8Ø (WS12)

"If you can combine it with concept 3 it would be very smart" - Helle, nurse at 9Ø (WS12)

"By using this product we can avoid any contact with the pills which is nice". - Maria, nurse at 9Ø (WS12)

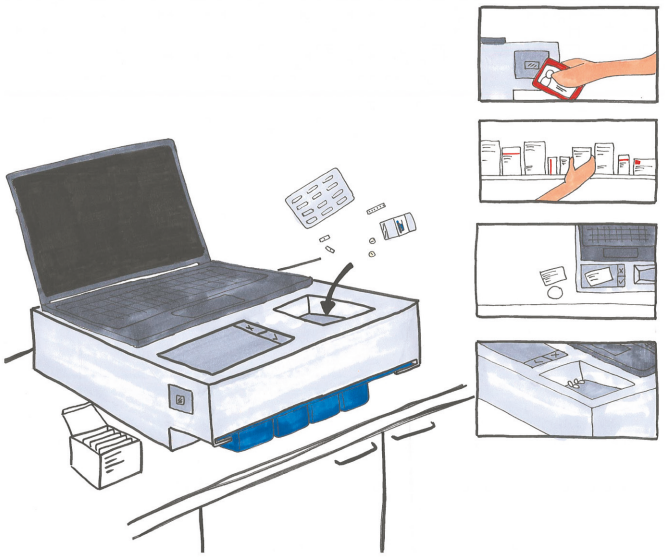


Ill. 28. Nurse giving feedback on the concepts

Ill. 29. Nurses at 9Ø giving feedback on concepts

WRONG DISPENSING OF MEDICINE

This concept is placed underneath the computer, so it does not take up that much space in the medicine room. The concept helps the nurse by dispensing the medicine. All the nurse has to do is to put the pills into the product. The product dispense the medicine in the different rooms in the dispensing box.



Ill. 30. A concept placed under the computer, can help the nurse dispense the right medicine for the patient

FEEDBACK ON CONCEPT 3

"Everything that can raise and optimize patient safety would be fantastic. As long as it won't take more time to use than the time we use now" - Sofie, nurse at 8Ø (WS12)

"It is correctly observed that there is a problem and confusion around the design of the medicine boxes". - Betinna, nurse at 9Ø (WS12)

"I can see the logic in the machine being able to check that I put the correct pills and correct amount of pills in the dispensing box". - Sofie, nurse at 8Ø(WS12)

"We will definitely use it if it raises the patient's safety and if the staff possibly can save time by using the product. It needs to be 'working environment friendly'" - Lise, head nurse at 9Ø (WS12)

Based on feedback gotten, when showing the concepts it is evaluated not to continue with the concept that deals with 'interaction between medicine'. It is disregarded because of the nurses trusting the doctor to double check, but also because the nurses do not feel it is a big problem. Lastly, a pharmacist explained that a computer program for this issue already exists.
The nurses indicated that there was a potential in combining concept two and three. Concept two gave the possibility to open blister packages without having to touch the medicine and getting ache in the thumb. This was seen as a nice feature to add onto concept three, which could raise the patient safety. The next step therefore was to combine these two concepts into a physical model where the user interactions could be tested and initial technical research could be done in order to specify size and structure.

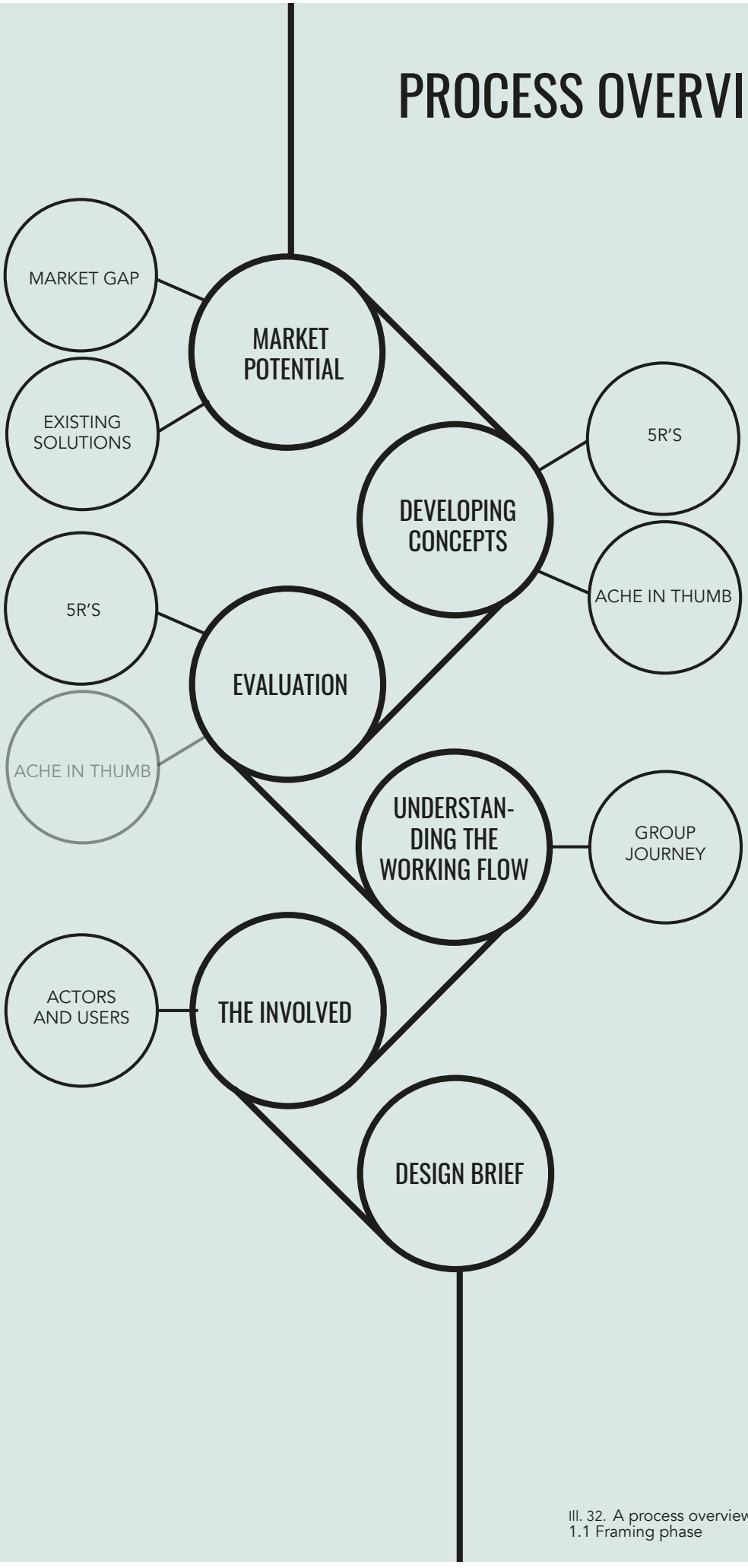
REMOVE ACHE IN THE THUMB
SECURE THE PATIENT BY ENSURING THE 5R'S

Ill. 31. The team sketching on concepts

1.1 FRAMING

The nurses' workflow and the different key actors are introduced in this phase. By looking at existing solutions, a market gap is found where the product potentially can be placed. This phase ends up whith an initial design brief and a sumup of the current direction.

PROCESS OVERVIEW



Ill. 32. A process overview for the 1.1 Framing phase

MARKET POTENTIAL

In order to state the business opportunity and find a potential market gap, it was needed to gain knowledge of potential competing products. A broad perspective on the subject was wanted, therefore both products dealing with a low amount of processes and products dealing with a high amount of processes were looked into. The competing products can be divided into two segments, where one deals with products for individual use and the other deals with dispensing for many people at the time. By listing different types of products dealing with ache in the thumb from opening blister packages and dispensation flaws, it would be possible to get to know the many competing factors on the market and utilize those to the projects advantage. The data gained, has been collected through interviews, observations and desktop research.

EXIXTING PRODUCTS

DOSIS DISPENSING

MEDIMI SMART (TIM)

Placed in the home of a resident where it releases the pills at a predefined time. Helps the resident remembering to take the medicine and ensures the 5 R's. The product is often placed on the kitchen counter and is very compact in size. It is very flexible in terms of placement. Since the machine is filled with pills for 14 days at a time, and releases the medicine in the residents own home, it is only considered as fitting in the homecare sector. (WS6 og WS19). [Medicare, n. d]

Ill. 33. Two Medimi smart products - one closed one open

TOSHO TOPRA 4001CE (STJERNEAPOTEKET)

Dosis dispensing machine located at a pharmacy, where it dosis dispenses pills for citizents. The pills are dispensed in small plastic bags and ordered for 14 days at a time. It ensures the 5R's and in order for the resident to get in consideration for this service, he/she needs to be medicationally stable for three months. This machine has costed the pharmacy many millions of Danish krones to invest in. The resident pay the pharmacy 111 DKK every 14th day for the service. The constellation takes up 20 square meters. It currently dispenses for residents living at home and is not implemented at the hospital. Relates more to the home care sector while it is dispensing for 14 days at a time (WS 10 and WS15). [Tosho, n. d]

Ill. 34. Tosho Topra dispensing medicine at the pharmacy 'Stjerneapoteket'

SWISSLOG (AUH)

Dispenses pills for 450 out of 850 patients each day at Aarhus University hospital (AUH). The pills are prescribed by the doctor before 1 PM and the machine will dispense the pills needed for 24 hours. It ensures the 5R's, but from a conversation with a nurse at Aarhus University hospital it was clear that sometimes changes in the patients medicine can occur and the dispensed pills needs to be corrected by a nurse at the department (WS14 and WS15). This constellation requires around 200 square meters and requres that the hospital has pneumatic tubes installed. [Swisslog, n. d]

Ill. 35. Swisslog for dispensing medicine to the patients at Aarhus University Hospital

OPENING OF BLISTER PACKAGES

PILLOUT (AND SIMILAR PRODUCTS)

Assists the nurse mechanically when dispensing medicine from blister packages. Moves the load away from the thumb by replacing it with another movement in the hand. The product can be operated by one hand and can easily be implemented in all departments at the hospital (WS5). [Nielsen, B, n. d]

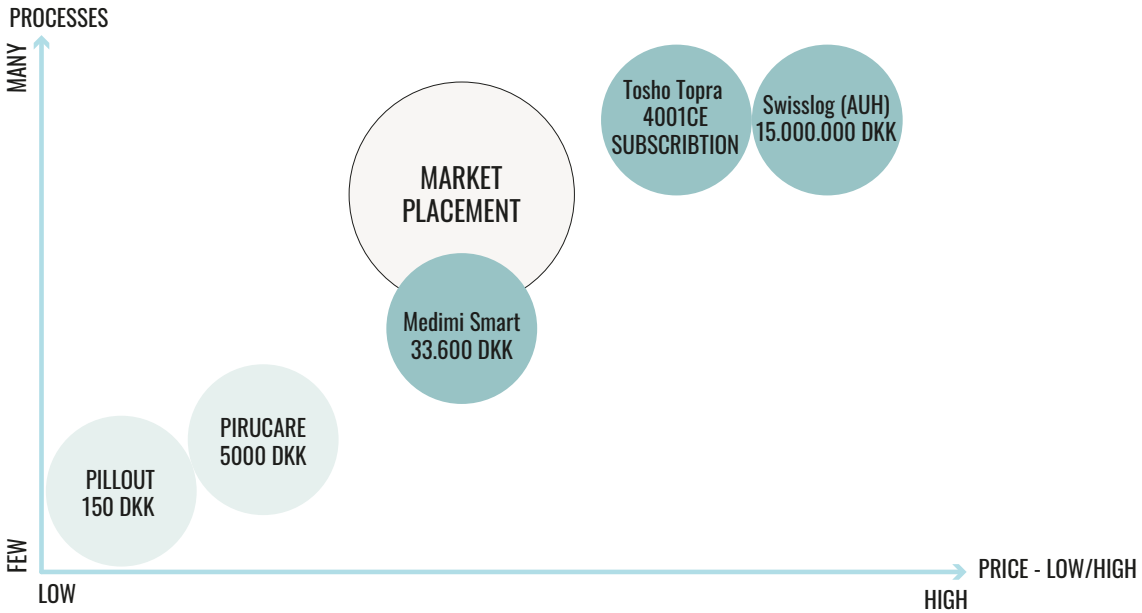
Ill. 36. Manual help for poking out pills from blister packages

PIRUCARE

Assists the nurse electronically when dispensing medicine from blister packages. The load on the thumb and hand is removed completely. It is possible to operate by one hand and is implementable in all departments at the hospital (WS5). [Hjælpemiddelbasen, n. d]

Ill. 37. Electronical help for poking out pills from blister packages

WHERE TO PLACE THE PROJECT?



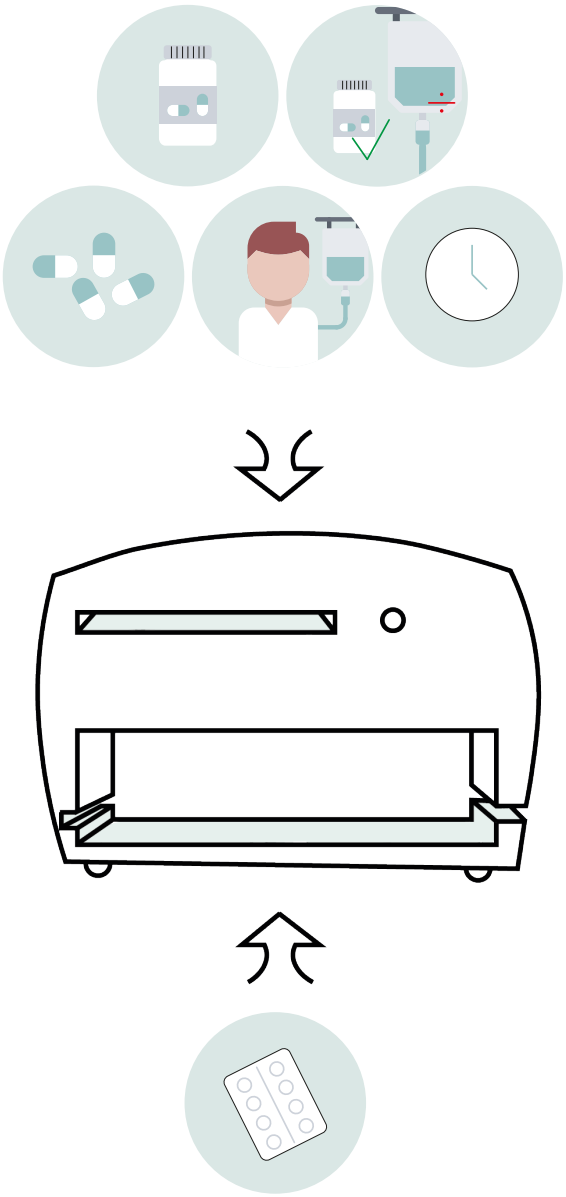
Ill. 38. A graph showing the market placement for the project

Based on research and observations, it is possible to see where there is a gap in the market. It is clear to see that there are no products that can ensure patient safety within the hospital that the nurses can use in the individual departments. Naturally, therefore there is a potential for a new product in the market. The aim of this project is to design a product that handles many processes of ensuring the patient safety like the large robots, Swisslog and Tosho Topra. It is also wanted to open blister packages like Pirucare but all this without having to implement a big product or robot at the hospital that is costly and takes up much space. Medimi smart is seen as a good concept that has potential in the hospital, but it is not possible to use it in the case, since it is not flexible enough in terms of handling many types of pills. This means that it is wanted to have the same value as the big robot Swisslog and the pill poker Pirucare, but with the same accessibility and ease of use that Medimi smart provides. Later in the process it is wanted to figure out how the robot Swisslog works technically in order to get inspiration for the technical aspect of the product. In addition to that combine some of the functions and possibly create a concept that can live up to the important aspect of patient safety. Furthermore it is wanted to state the business opportunity relating to the key actors of the problems.

THE VALUE OF SWISSLOG AND PIRUCARE WITH THE ACCESSIBILITY AS MEDIMI SMART

COMBINATION OF CONCEPTS

It is wanted to figure out what the nurses need from a product in the medicine room when dispensing medicine for the patients. The first step was to try to combine the two concepts "wrong dispensing of medicine" with "ache in the thumb", as the nurses in the last sketching round saw potential in. Here, it was wanted to create a physical model in order to make the process tangible, and to be tested in the context by a nurse and to get feedback. In addition, to get feedback at the milestone regarding considerations about the concept and use the feedback in the further design process.



THE FUNCTIONS

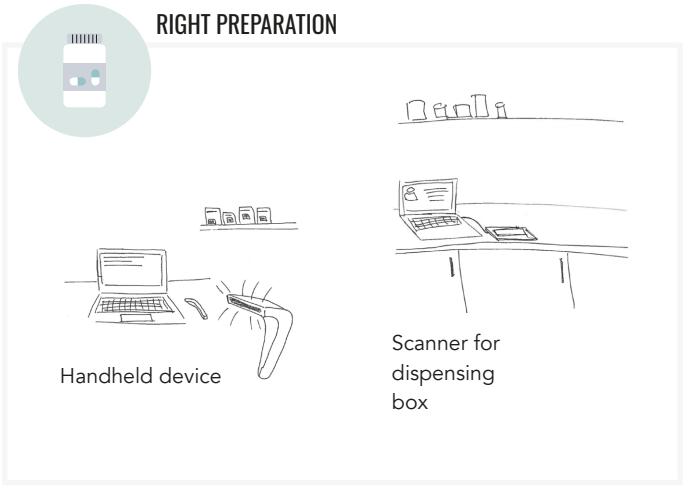
- Scanner for scanning the medicine box/tub - Tell if the preparation is correct, and scanning the bar-code on despensing box.
- Automatically poke out pills from blister packages
- Pushes out blister package when done.
- Count the dispensed pills and make sure the right amount is given.
- Can dispense the pills in the correct room of the patients dispensing box

FEEDBACK

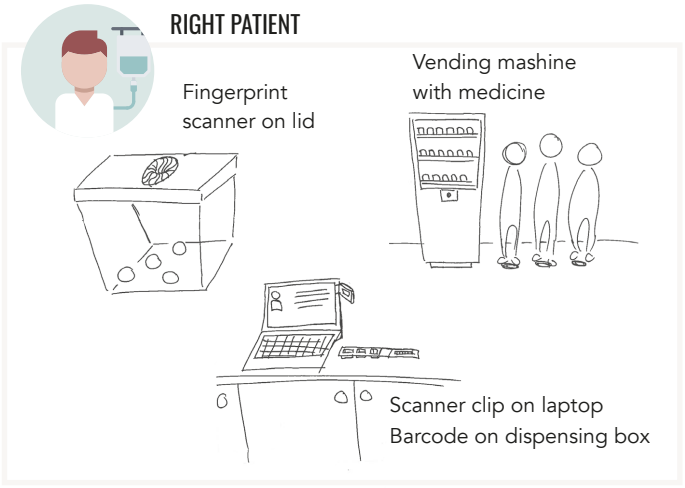
Before showing the concept to the nurses at the hospital, the combined concept was presented at the first milestone.
After the milestone, it became clear that the concept was very complex both in terms of the interaction scenario but also when discussing the technical aspect (WS18). It was therefore assumed that the product would be high in cost, and it was uncertain how much the hospital could actually pay for the product.
In order to probe the market, it was wanted to know, how many functions the nurse actually needed, and how much they would pay for the individual functions.

Ill. 39. A concept combinated of the 5R's and ache in thumb

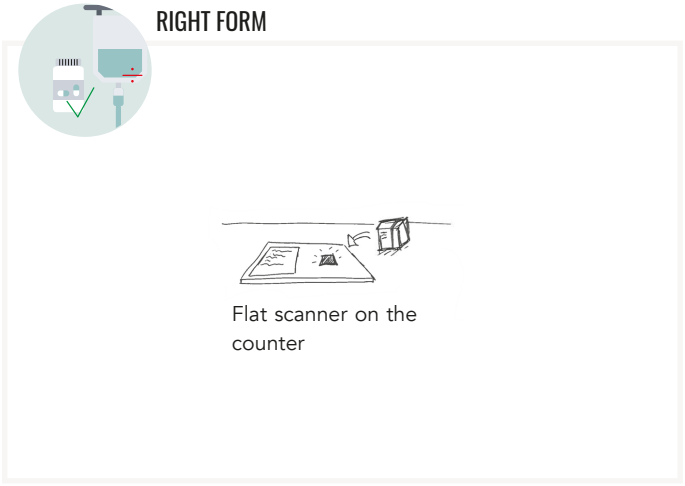
Before figuring out which functions were most important, a sketching round on the two directions "how to individually ensure the 5R's" and "ache in thumb" was done. The sketching round was supposed to base the foundation of a combination round that was tangible for the nurses to provide feedback upon. This was done through systematic sketching were each R and ache in the thumb were individually sketched upon.



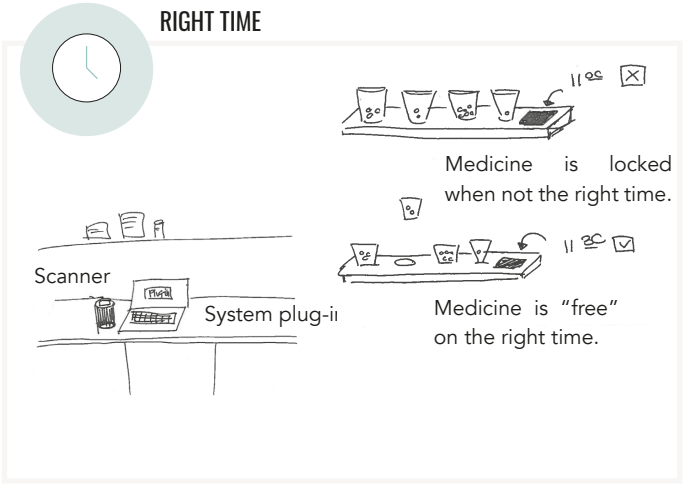
III. 40. Sketches for ensuring the right preparation



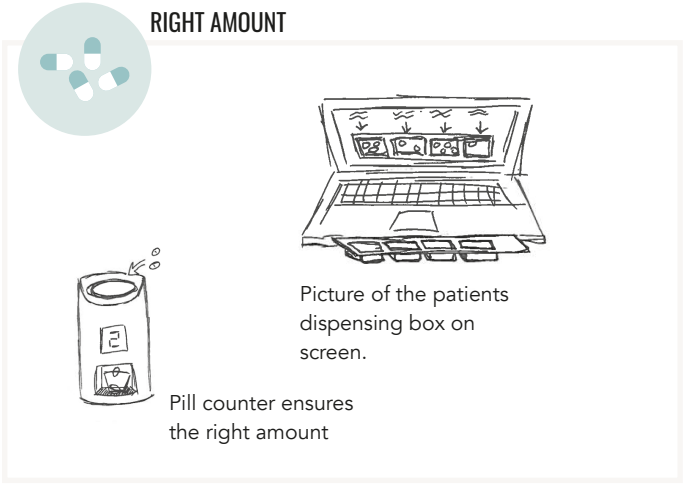
III. 41. Sketches for ensuring the right patient



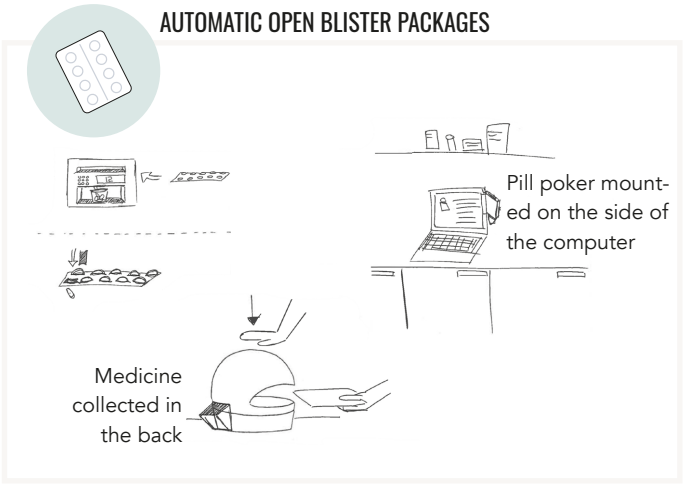
III. 42. Sketches for ensuring the right form



III. 43. Sketches for ensuring the right time



III. 44. Sketches for ensuring the right amount



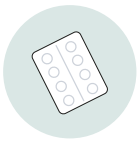
III. 45. Sketches for automatic opening of blister packages

After sketching on the individual subjects it was wanted to combine the sketches into concepts that would be possible to test in the context. This was needed while multiple directions were discussed and it was hard to determine what the biggest needs were in the medicine room. It is known that the hospital will only pay for a product if it fits their specific need which is why research into this was done.

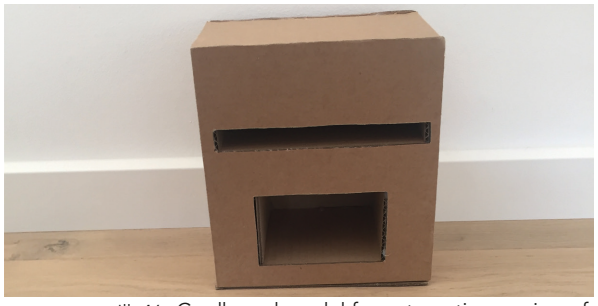
THE THREE CONCEPTS

Since it was hard to know the most needed features considering ache in the thumb and the 5R's, a nurse was contacted regarding this issue. It was wanted to create a product with the minimal needed functions, in order to provide the needed patient safety. From the conversation it became clear that the most challenging areas are to ensure that the right patient gets the right medicine is given in the right amount (WS20). This statement together with previous comments from feedback sessions led to three possible design concepts - Ache in thumb, minimal functions and exclusive - which are shown below. The goal of this develoment and testing of concepts were to narrow the project as much in as possible and to probe the complexity of the product needed.

PILL POKER



The pill poker helps the nurse poke out pills from blister packages. The blister package is inserted in the slit and a dispensing glass is placed in the bigger hole beneath. The nurse will then decide how many pills is needed and make the product poke out the wanted number of pills. The pills can then be dispensed in a dispensing box. This concept relieves ache in the thumb.



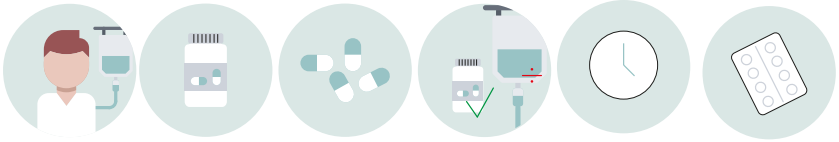
Ill. 46. Cardboard model for automatic opening of blister packages

SCANNER

The scanner helps the nurse ensuring the right patient gets the right preparation in the right amount. It is done through scanning the patient dispensing box and the preparations. Then a plug-in for the scanner can tell the nurse how many pills to dispense manually in the dispensing box. This concept ensures the minimal need of patient safety during dispensing.

Ill. 47. Cardboard model for ensuring the right patient, right perperation and right amount

EXCLUSIVE



The exclusive concept gather many processes regarding manual dispensing of pills by ensuring all the 5 R's and at the same time helps the nurse to open blister packages. It is used by scanning the patient box and medicine preparation on a scanner. The dispensing box is placed in the room and then blister packages or loose pills can be loaded into the system where it is automatically dispensed.

Ill. 48. Cardboard model for ensuring the 5 R's and automatic opening of blister packages

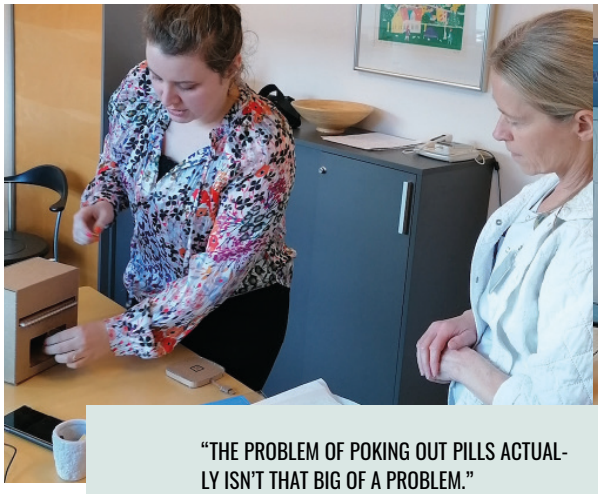
The models are made in cardboard and very simple in order to get the most feedback without having to discuss specific forms or surfaces at this stage.
The next step was to show the concepts and act out the scenarios in order to get feedback from nurses in the context. This is done at department 9Ø at Aalborg University Hospital.

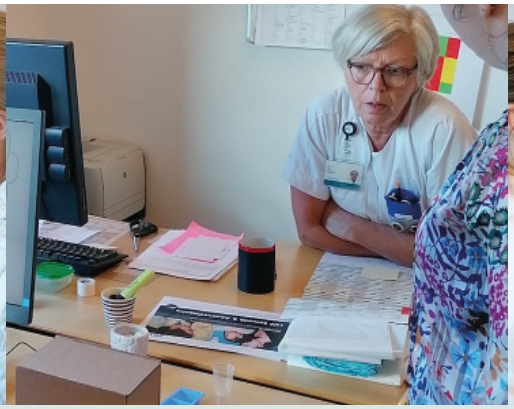
EVALUATION OF THE CONCEPTS

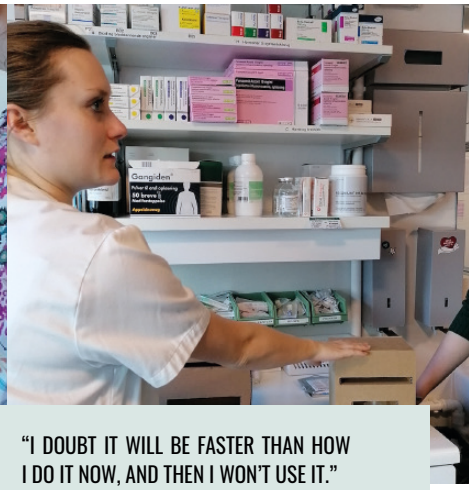
In order to get feedback, the nurses were presented with the functions on the different concepts and furthermore told to act out a dispensing process. In that way it was possible to get concrete feedback to work with when moving forward in the process. The mockups are made of cardboard, so the nurses had to pretend that the concepts were fully functional when acting out.

PILL POKER

The first concept shown was the 'pill poker'. The concept is to be used occasionaly when needed for opening blister packages. (WS21).







"THE PROBLEM OF POKING OUT PILLS ACTUALLY ISN'T THAT BIG OF A PROBLEM."

Helle, nurse at 9Ø at Aalborg University Hospital

"WE HAVE NEVER RESEARCHED ON SOLUTIONS THAT CAN HELP WITH THIS PROBLEM, SO MAYBE THE PROBLEM JUST ISN'T BIG ENOUGH FOR US."

Lise, Head nurse at 9Ø at Aalborg University Hospital

"I DOUBT IT WILL BE FASTER THAN HOW I DO IT NOW, AND THEN I WON'T USE IT."

Sofie, nurse at 8Ø at Aalborg University Hospital

III. 49. Testing and feedback on the pill poker concept at 8Ø and 9Ø

SCANNER

The second concept shown were the scanner for securing the right patient is given the right medicine in the right amount. The product is plugged into the computer's USB-port and can retrieve data about patients through EPJ, which is used in the medicine room.

A plug-in is connected to the product, this can warn the nurse if the wrong medicine is dispensed. If it is the right medicine the plug-in will tell the nurse the amount of pills needed in pieces (WS21).

"I WOULD LIKE TO USE SOME EXTRA TIME WHEN USING IT, IF IT GAINS ME SOMETHING EXTRA"

Helle, nurse at 9Ø at Aalborg University Hospital

"I WANT TO HIGHLIGHT THIS SUGGESTION, BECAUSE PATIENT SAFETY IS VERY IMPORTANT. THIS IS WHERE THE HOSPITAL WILL USE MONEY"

Lise, Head nurse at 9Ø at Aalborg University Hospital

"I ONLY THINK I WILL USE THIS PRODUCT IF I IN SOME WAY ARE IN DOUBT."

Sofie, nurse at 8Ø at Aalborg University Hospital

III. 50. Testing and feedback on the scanner concept at 8Ø and 9Ø

EXCLUSIVE

The third concept shown was the "exclusive" product and is a combination of the patient safety aspect and the pill poker. This concept will help the nurse through the whole process of dispensing pills in the medicine room (WS21).

"I IMAGINE THAT IT WILL BE AN EXPENSIVE PRODUCT. I DON'T SEE THE NECESSITY THAT IT CAN POKE OUT PILLS. I DOUBT WE CAN FIND THE MONEY FOR A PRODUCT THAT IS NOT PERFECTLY FITTED FOR OUR NEED".

Lise, Head nurse at 9Ø at Aalborg University Hospital

"I THINK IT IS SMART, BUT IT NEEDS TO BE VERY FAST, PROBABLY FASTER THAN I CAN DO THE DISPENSING AND CHECKING MANUALLY. I STILL NEED TO LOAD IT WITH THE BLISTER PACKAGE AND THAT TAKES TIME - AND HOW DO I CLEAN THE INSIDE?"

Sofie, nurse at 8Ø at Aalborg University hospital

"SOMETIMES WE ONLY NEED TO DISPENSE A FEW PILLS, THEN I THINK IT MIGHT BE A MORE TIME CONSUMING PROCESS WHEN USING THE PRODUCT"

Helle, nurse at 9Ø at Aalborg University Hospital

III. 51. Testing and feedback on the exclusive concept at 8Ø and 9Ø

It was clear that the issue regarding opening of blister packages was not as big a problem as firstly assumed. At 9Ø, some nurses have worked for over 20 years and have never had a problem when opening the blister packages. And as they said, if it really was a problem they would have looked for a product that could help them a long time ago. The head nurse of the department, Lise, stated that the department would never invest in a product which only could poke out pills from blister packages. Another nurse, Sofie at 8Ø mentioned that she believed it was possible for her to punch the pills out faster herself, than when using the concept. This indicated that speed was more importent, than the ache in the thumb, to her.

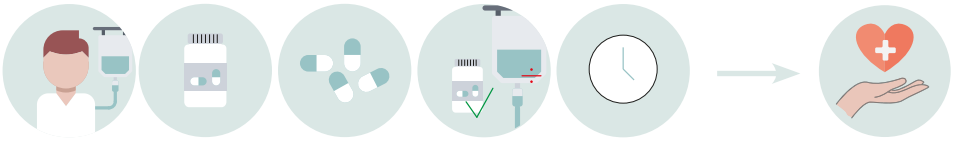
This realisation of the concept showed that the assumption, from previously in the process at Aabybro nursing home was miscalculated, and the nurses probably had a hard time giving feedback before they could act out the scenario (WS2). This is imagined to be because of the differences in the processes. But also the business aspect around the product showed that the department would simply not pay for a product that could only poke out pills.

The aspect of patient safety however had their attention. Lise stated that "Patient safety is where the department will invest" and added that around 100.000 DKK could be used at the department for possibly three products. In order to validate the cost estimation stated by the Head nurse other hospitals could prefferably have been questioned. This means that they could see themselves using the scanner and the dispensing system from the exclusive concept. The nurses thought the scanner would definitely help them dispense the correct pills. And the dispensing system should be able to minimize the chance of making human made errors. Therefore it was decided to work on designing a system that could dispense pills for the nurse by securing the 5R's but without dealing with opening of blister packages. An issue with the exclusive product and the complexity of it, raised the concern of how to clean the product for medicine dust inside of the product. This was because, it would result in a health care error if transferred to a different patient than intended.

NEEDS TO BE POSSIBLE TO CLEAN THE INSIDE OF THE PRODUCT FOR MEDICINE DUST

THE PRODUCT DIRECTION

After the testing of concepts at department 9Ø feedback was gained and it was decided to work on creating a product which were a mix of the scanner and the exclusive product. The product should ensure the 5R's by automatically dispensing pills after the nurse has loaded the pills into the product.



III. 52. Cardboard model from the feedback - Ensuring the 5R's

Now that the product direction was specified the next step in the process was to do research in the medicine room in order to understand the pill flow and how the product should be fitted for the issues it was handling. Furthermore, it was wanted to figure out how the product would affect the different key actors and what could trigger the department, making them invest in the product.

GROUP JOURNEY - IN THE REAL WORLD

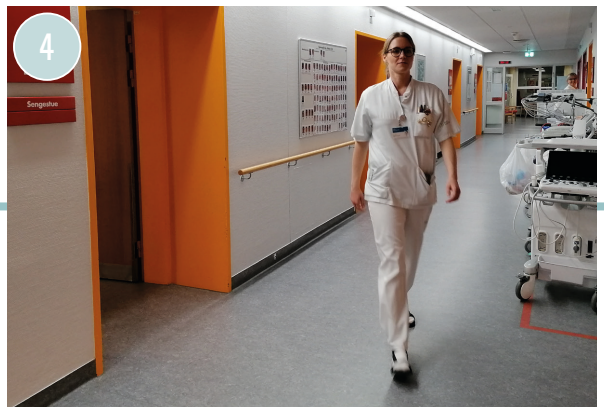
An example of a medicine dispensing related health care error is shown beneath, in order to understand the everyday issues nurses face when being busy and having to pay attention to their surroundings. This research is done, in order to make a potential product fit into the current workflow and surroundings. It has been possible to track this journey through observations, both at Vejle and Aalborg hospitals. The consequences for this problem will be pointed out. In addition the process of dispensing medicine is used in order to know how a physical product can be used in the dispensing process.

A nurse is dispensing the medicine for 6 patients for all hours of the day into a dispensing box. The medicine is prescribed by the doctor and uploaded to the system (EPJ) on the computer. The nurse needs to pay attention when dispensing the pills and keep the 5R's in mind. (Uses around 30 minutes to dispense).

The next morning, another nurse will double check the medicine, before giving the medicine to the patients. (Uses around 45 minutes to double check which is a consuming process). This second nurse also has to keep in mind of the 5R's and make sure that the medicine is dispensed and given correctly.

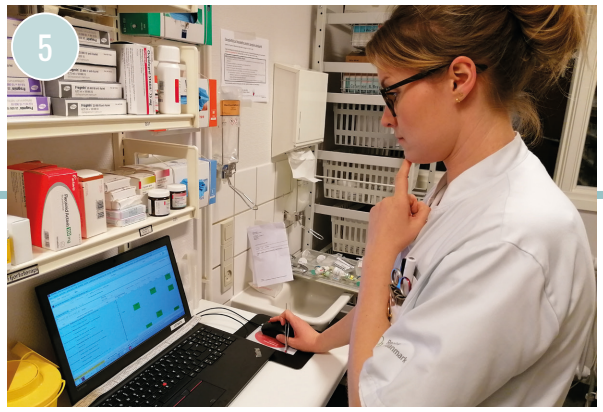
PROJECT FOCUS - IN THE MEDICINE ROOM

After double checking the medicine, it is handed to the patient, and the patient ingests the pills. In the system, the nurse declares the medicine as "given".



Shortly after, the second nurse is in doubt on whether the patient got the correct amount of medicine and therefore goes to the medicine room to check for information on the computer.

USE A LOT OF TIME ON DOUBLE CHECKING - MINIMISE THE NEED TO DOUBLE CHECK



The nurse can see in the system that the prescribed medicine is 2 pcs x 200 mg penomax, which is a penicillin preparation, but the only preparation that is to be found on the shelf in the medicine room is 400 mg. In this case it means that the patient has gotten 800 mg. A wrong dispensing of the medicine has been made.

The nurse will contact the doctor and explain the situation. The nurse is told to keep an eye of the patient, and if anything happens call the doctor again.

The second nurse will then go inform the patient and check the status of the patients health. The patient can experience discomfort or an allergic reaction and can possibly be needing treatment, resulting in a longer hospitalization period.

Ill. 53. Group journey with pictures from 240 at Vejle Hospital

This example shows the need for paying attention to the pitfalls and the need to double check the medicine.

There are different ways to dispense medicine which differs within the departments. Most often the dispensing boxes with 4 compartments - containing rooms for morning, noon, evening and night - are used. But some places they only dispense for one dosage at the time, then they use a dispensing glass and seal it of with a lid and a label with the information on the patient.

The two different types of containers used at hospitals are shown beneath. Size of box (W:60mm, L:215mm, H:14mm) and size of glass (Ø: 38mm, H:40mm)

Ill. 54. A patient dispensing box and a dispensing glass in relation to each other

This mapping of a medicine dispensing related health care error is provided by Lise, Head nurse at 8Ø Aalborg University Hospital, who gave a deeper understanding of a real life situations in the medicine room. Some of the possible pitfalls the nurses can experience, when dispensing medicine is stated in this example. It shows that even though the medicine is double checked, errors can still occur. The walkthrough of the journey validated the need for a product that can help minimise the chance of making dispensing flaws. Furthemore, it gave a deeper understanding of the workflow the nurses have and can help base the foundation of both interactions and functions needed for a physical product later in the process.

By the use of multiple trackings regarding the time used for dispensing medicine for one patient at departments 8Ø and 9Ø at Aalborg University hospital, it was possible to determine the time used in between the handling of pills. Here, the nurses used an average of 19 seconds of putting the medicine back in the box, put the box back on the shelf, finding the new box and unwrapping it, in order to get ready for dispensing the new pills. These 19 seconds base the wish for the designed product to be able to dispense one preparation in this time frame before the next preparation is loaded into the system (WS36).
Besides the nurse as user, there are other actors for the product. These actors can possibly benefit from a product for raising patient safety, therefore it is wanted to enlighten these, before developing the concept further.

THE NURSE SHOULD BE ABLE TO MAKE SIDE DISPENSING
- DISPENSE IN BOTH DISPENSING BOXES AND DISPENSING GLASSES
DISPENSE ONE PREPARATION AS CLOSE TO 19 SECONDS AS POSSIBLE

OVERVIEW OF ACTORS AND USERS

When dealing with the health care sector it is important to get an overview and understanding on which actors and users are affected of the problem. Both in order to understand the user's needs and to get an understanding on which values are needed when buying new products for a department. This listing should help determine needs and initiate the discussion of the business opportunity, here amongst, who will invest in the product and who will benefit from a solution to the problem. The data is optained through several conversations with influenting people within the health care sector and desktop research.

KEY ACTORS

USERS

The region is the big key actor when dealing with the business aspect. Here, important decisions are made, including how much money each hospital has within the region. The board of each hospital decides how the money is divided into each department. The hospital board evaluates which departments that needs more resources and therefore more money than others (WS24).

R
Region

When receiving the money, the department chooses how and what they want to spend the money on. The individual department is of course interested in handling the medicine correctly. They are interested and willing to invest in products that can help increase patient safety regarding medicine dispensing. The product can for example be sold through existing webpages for helping aids. (WS4 and WS37)

D
Department

When dispensing medicine, the nurse has a certain responsibility for the patient. It is often the nurse who makes and detects any flaws that occur regarding medicine dispensing. The nurse at the hospital could benefit from a product that helps secure the patient better. (WS8 and WS7)

N
Nurse

The nurse is the only user of the product. At the moment the nurse is dispensing the medicine to the patient by hand. The five R's are considered when dispensing medicine. A lot of benefits is imagined to meet the nurses, when dispensing with a product. These benefits could possibly raise the patient's safety and save time for the nurse, which they can use on patient care.

The patient is an important link in the process, because it is the patient that receives the medicine. And when given the wrong medicine, the patient can experience discomfort, an allergic reaction and in worst case it can cause death. (WS8)

P
Patient

Investigations have shown that money comes from higher in the system, and in order for the department to invest in a concept it needs to appeal to not only the department but also the region. Every department gets a budget every year that they have to comply. This means that the department cannot buy unlimited amounts of products but instead carefully consider what to invest in. One of the conditions for being able to invest, is that a product creates value and increase and optimize work processes. In addition, it also means that the department have high expectations regarding quality in the products they invest in. In order to have the department and region decide to invest in the product, it is important to state the possible benefits of the product for all the potential actors of the product.

The research done is simplified and listed below. Based on the consequences on the four key actors, it is assessed which benefits a product needs, in order to decrease the numbers of health care errors, and thereby make the product attractive for the listed key actors. This research is done through conversations with the nurses and through desktop research. By asking who will benefit from the product, and what are the benefits, unique selling points are stated. These points creates a good value when discussing the business opportunity.

CONSEQUENCES OF THE PROBLEM

R Region

Longer hospitalization and sometimes needs to provide the patient with money compensation.
[Patienterstatningen, 2018]

D Department

Load on the department because of longer hospitalization time, and the need to redo the error.

N Nurse

Needs to contact the doctor and observe the patient when the wrong medicine is given.
Uses lots of time on double checking.

P Patient

Can experience discomfort or allergic reactions when given the wrong medicine. Will possibly feel insecure throughout the hospitalization.

BENEFITS FROM PRODUCT

R Region

Saves money when having shorter hospitalizations and no need for compensation for patients.

D Department

Ease the load by having shorter hospitalizations.

N Nurse

Uses less time on fixing and reporting health care errors and spend more time on patient care.
Reduce the need for double checking.

P Patient

Securing the patient better considering medicine dispensation.

When creating a product that can increase the patient safety it will have a positive reaction on all key actors. When the department buys a product that can help dispense the medicine, the number of health care errors will decrease. This will have an effect on the patient since the patient will receive the right medicine, and the region will save money when not having longer hospitalizations and no compensations on e.g. serious injuries regarding intake of wrong medicine.
In order to specify the concept further, it is necessary to state the user needs and do research into how they can be solved.

INITIAL DESIGN BRIEF

SCOPE

In order to minimize the medicine related health care errors happening at the hospitals, the focus of this project is to design a product that can help the nurse raise the patient safety. It is wanted to do that, by ensuring that the right patient gets the right medicine preparation, in the right form, in the right amount, at the right time.

THE DIRECTION

The nurse experience ache in the thumb when punching out pills from blister packages.

Many health care errors in relation to medication happens at the Danish hospitals.

FOCUS

The aim of this project is to create a physical product that can raise the patient safety regarding medicine dispensing at the Danish hospitals by assisting the nurse in the dispensing process.

VISION

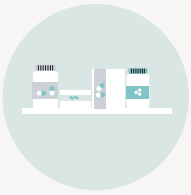
Reduce health care errors in the health care sector, by creating a product that can help the nurses when dispensing medicine for the patients.

BUSINESS ASPECT

This project is considered a startup, where the production is outsourced, but the development, testing and sale happens within the startup. The sale will possibly happen through a webside in collaboration with an already established medico company in order to reach a broad market. Selling through a new and unknown webside it will be hard to get the customers to know the product fast, but also the company will have a hard time competing with the well known companies while the already existing companies have established credibility towards the customers.

SUMMARY OF CURRENT DIRECTION

The nurse is the user.
The region, department, patient and nurse will benefit fom the product and are therefore the key actors.



The product needs to fit into the medicine room where the nurse will use it for dispensing pills for patients at the department.

The solution is imagined to be a machine that can automatically dispense pills after the nurse has put them into the machine.

USER NEEDS AND FEATURES NEEDED

ISSUE NO.	WHAT IS THE ISSUE?	SOURCE (PAGE)
1	There is a huge change in brand and design of the medicine boxes which can make the nurse confused, when dispensing medicine for the patient. If errors are made it can result in the wrong medicine is given.	Medication errors (8)
2	Because the nurse can be inattentive when dispensing medicine, they can overlook the right form of medicine preparation in (EPJ). Meaning that for example if the patient is prescribed a solid form, but the nurse is giving the medicine in a liquid form (IV).	Medication errors (8)
3	The huge change of the medicine boxes in the medicine room, can also result in the milligrams of the preparation being different than usual. These changes can confuse the nurse when dispensing the medicine. If the wrong dosage is given, it can result in side effects.	Medication errors (8)
4	The nurses normally dispense for 5-6 patients each. Sometimes the nurse mixes up the patients dispensing boxes by mistake, which results in a patient ending up with another patient's medicine.	Medication errors (8)
5	When the nurses dispense medicine in the dispensing boxes they sometimes get confused and dispense medicine in the wrong room in the box, which means the patient gets the medicine at the wrong time.	Medication errors (8)
6	If the active ingredient regarding medicine dust ends up in the next patients dispensing box, it can result in a health care error.	Combination of concepts (32)
7	The nurse is often interrupted by colleagues or patients when dispensing the medicine which can result in being unconcentrated and making dispensing errors.	Medication errors (8)
8	The nurse uses a lot of time to double check the medicine before the patient ingest it, this is very time consuming and the time would be beneficial to use elsewhere.	Group journey (34)

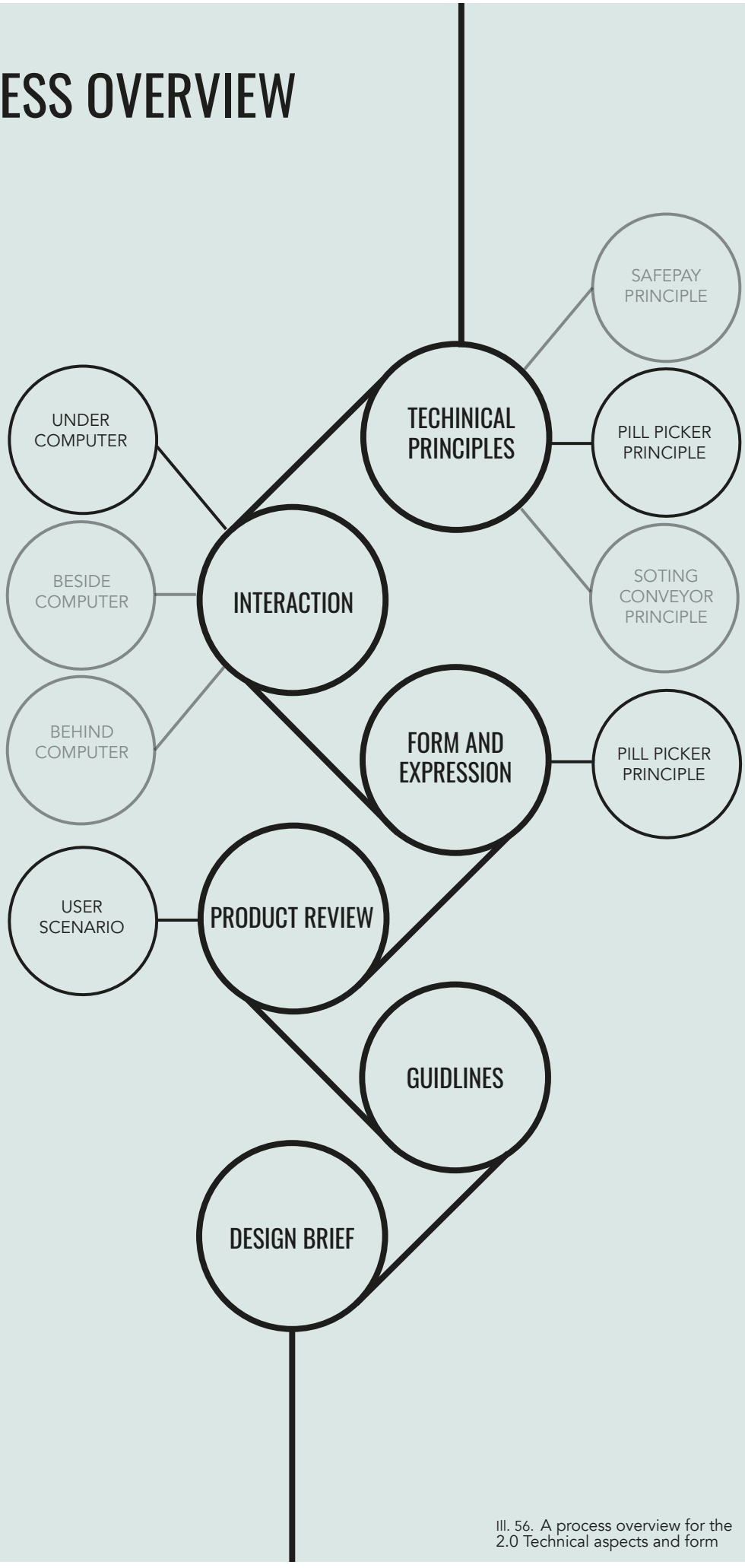
ISSUE NO.	NEED NO	USER NEED	HOW IT IS SOLVED
1	1	Help to approve or disregard a medicine preparation (Recognize the generic substitution)	Create a plug-in for the EPJ and implement a scanner in the product where the QR code on the dispensing box can be scanned. The plug-in can validate if the medicine is right.
2	2	Help to approve or disregard the form of the medicine.	Create a plug-in for the EPJ and implement a scanner in the product where the QR code on the dispensing box can be scanned. The plug-in can validate if it is the right form.
3	3	Help to validate amounts and mg dispensed	Create a plug-in for the EPJ and implement a scanner in the product where the QR code on the dispensing box can be scanned. The plug-in can show the amount in pieces, that the nurse has to dispense.
4	4	Help to select the right patient box	Create a plug-in for the EPJ and implement a scanner in the product where the barcode on the patient's dispensing box can be scanned. The plug-in registers the patient's info and shows the prescription for the patient.
5	5	Help to dispense the medicine for the right time.	The product automatically dispenses the medicine in the patient box, in the right rooms, for the right time.
6	6	Possible to clean for medicine dust where the medicine is in contact with the product	Few and smooth surfaces and edges inside and outside the product.
7	7	Continue dispensing after interruptions without flaws.	Create a Plug-in standby mode, so the nurse can continue the dispensing where it is left off. And the plug-in remembers the status of the dispensation.
8	8	Minimize the need to double check the medicine.	Dispensing of medicine should be close to 100% safe in relation to patient safety by automatizing critical aspects of the dispensing process.
	9	Possible to dispense in the dispensing box and dispensing glass.	The concept should be designed so it is possible to place both dispensing boxes (b: 6 cm x L: 24 cm x h: 2 cm) and dispensing glasses (Ø: 3,4 X H:4) in the dispensing box area.
	10	Possible to dispense faster than the nurse can dispense and double check the medicine for five to six patients .	The concept should minimize the need to double check.

Ill. 55. The team working on the techinal principles

2.0 TECHNICAL ASPECTS AND FORM

This phase considers different technical principles and deals with trying out different interaction scenarios. In this phase it has no longer been possible to go into the real context for testing and getting feedback, which is why tests are done in the homes of nurses and through digital connections. This resulted in the group taking a lot of assumptions during the process.

PROCESS OVERVIEW



Ill. 56. A process overview for the 2.0 Technical aspects and form

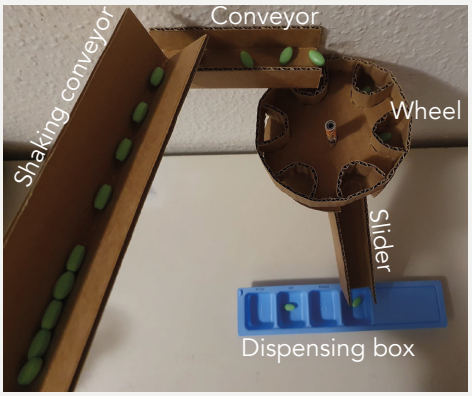
THREE TECHNICAL DIRECTIONS

An inspiration round was made in order to get the most fitting technical and mechanical setup for the concept. The inspiration based the foundation of the three directions described in this section. Models are made in cardboard and are used to act out the scenario in order to state the potential of the individual principles. Models are made with basic knowledge of the technical principles, and after validating and selecting a principal it is to specify the concept further by detailing it (WS25 and WS15).
All principles work with the issue of a nurse loading the product with a handful of pills at once (Louise at Aalborg University hospital states that typically the max amount of identical pills dispensed at once is eight pieces), and the product then needs to divide the pills and dispense them into their respective compartment in the dispensing box for the patient.

Ill. 57. Safepay inside and outside

SAFEPAY PRINCIPLE

The first principle is inspired by a money wheel for sorting coins in shopping malls. This system is called safepay and can count and sort the coins in regards to size and amount. The inspiration is drawn since the system is very safe in terms of accuracy and it can manage different sizes. [Gunnebo, n.d]

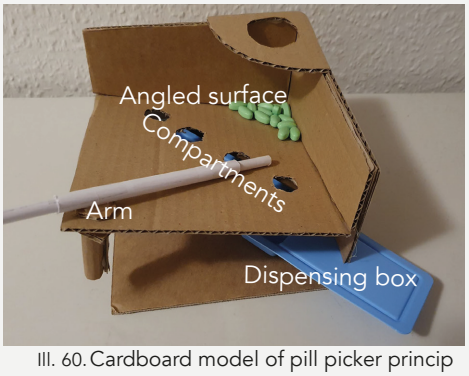


Ill. 58. Cardboard model of safepay princip

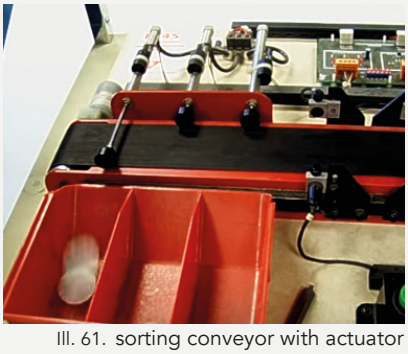
Ill. 59. Swisslog with rubber membran

PILL PICKER PRINCIPLE

This second concept is inspired by the pill picking robot from Swisslog. The robot uses vacuum to suck up a pill from a canister placed inside the system. The robot can pick up all the different types of pills available in the hospital pharmacy. [Swisslog, 2014]



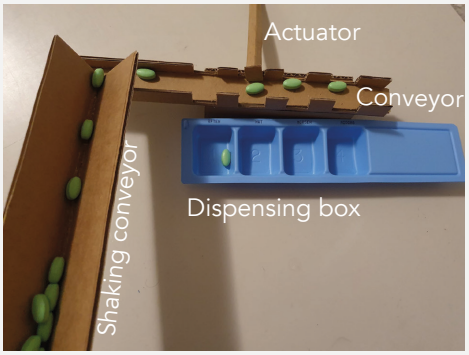
Ill. 60. Cardboard model of pill picker princip



Ill. 61. sorting conveyor with actuator

SORTING CONVEYOR PRINCIPLE

This third principle is a sorting conveyor where an actuator is activated after an item has passed a sensor. This system can function with pills in many different sizes and the individual actuators can be linked up to one compartment each as shown in the picture [PLE Conveyor, 2009].

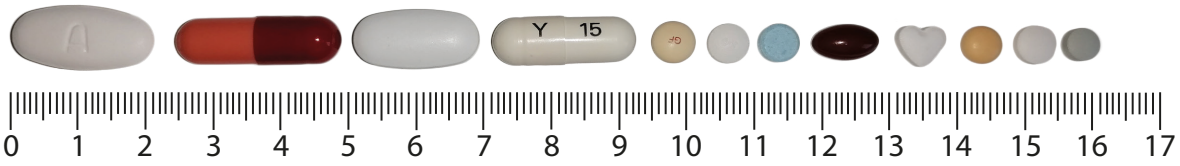


Ill. 62. Cardboard model of conveyor princip

The challenge in finding a technical concept that will work, since the pills in the medicine room are different size and shape.
It is hard to design a system that can be specialised for all types of pills since it is not possible to dispense the pills by measuring the size, which is what most systems for medicine dispensing currently do.

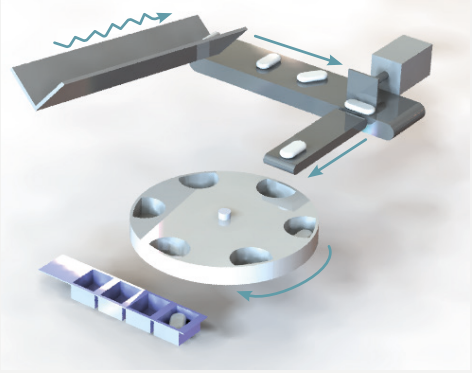
Some different pill sizes shown at the hospital which is illustrated from the smallest to the biggest (xx).

The goal is to design a system that can take all types of pills and therefore also ensure the accuracy of dispensing the pills.



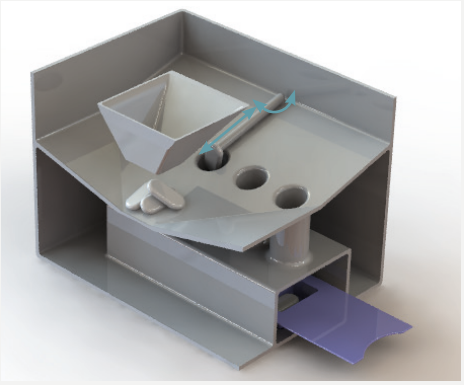
Ill. 66. Size of pills from smallet to biggest

The concept is made with a shaking conveyor that is to be used before the pills individually are loaded into each compartment in the wheel. The shaking conveyor is added in order to separate the pills before loading the wheel. A smaller conveyor will move the pills from the shaking conveyor to the wheel. The wheel will then rotate when one pill is loaded, making it possible to only dispense one pill at a time into the dispensing box for the patient. Then the wheel and a slider will move in regards to what compartment in the dispensing box the pill needs to go into. If too many pills are put into the system by the nurse, the wheel has a fifth position (morning, noon, evening, night, left over tray) where the pills can be collected in a compartment and be emptied. (WS25)



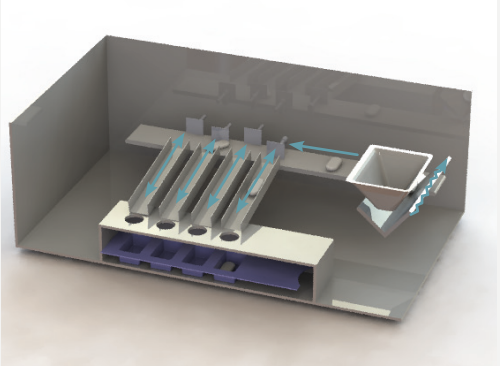
Ill. 63. 3D drawing of the first technical princip

This model utilizes the principle of using vacuum to move the pill and dispensing it into the different compartments in the dispensing box.
The concept needs to consist of a surface that is a specific angle, so the pills will gather into a corner where they wait to be picked up. An arm can then extrude itself towards the pills, create a suction around the pill, then rotate and pull back in order to move the pill into the right compartment. If too many pills are put into the product by the nurse, a small lid will open and drop the extra pills into a compartment where they can be collected. (WS25)



Ill. 64. 3D drawing of the second technical princip

This model uses the actuator principle, but also a shaking conveyor as the first concept since the pills needs to be divided from each other, also in order to make sure that two pills will not be positioned too close to each other and accidentally be dispensed together as one.
The shaking conveyor will drop the pills onto another conveyor where 4 different actuators will be ready to push the pills into their respective compartments in the dispensing box when they pass. If there are put too many pills into the system, the conveyor will continue rolling and move them towards the end of the conveyor into a separate compartment where they can be removed by the nurse (WS25)

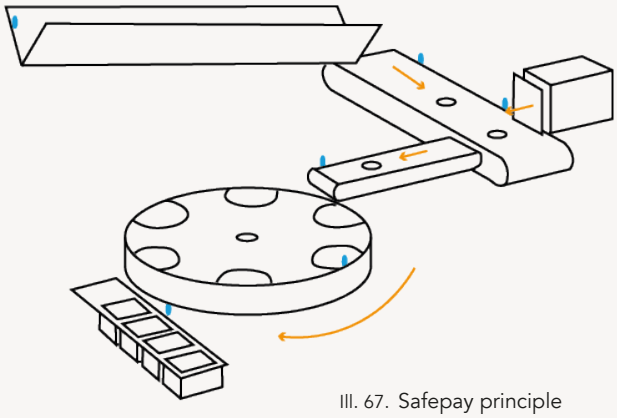


Ill. 65. 3D drawing of the third technical princip

SCENARIOS FOR TECHNICAL PRINCIPLES

In order to select a direction for the technical parts in the concept, pros and cons are listed but also in order to discover possible pitfalls in every concept. An evaluation of the concepts are done with the criterias: how easy it is to clean, how safe and accurate the concept seems to be, how complex it is, how big the price is imagined to be and how big the product is imagined to become. This is done by rating the different concepts using the focus areas. (WS26). The blue dots represent the sensors in the concept and the orange arrows represent the direction of movement. When the technical setup is in place, it is possible to look at the form, overall size and interaction of the concept.
The pros and cons are evaluated from the knowledge within the group and an estimation of the aspects is made. An electro engineer has been looking at the assumptions and validated the listing. If the evalution should have been redone, multiple experts within similar systems could preferrably have been contacted and questioned regarding the aspects and the rating.

SAFEPAY PRINCIPLE



Ill. 67. Safepay principle

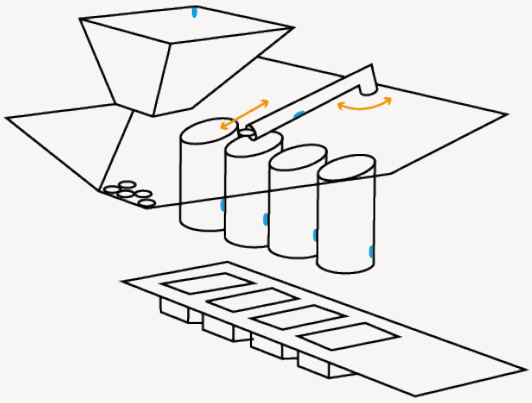
PROS:

The pills are in the system, at the same time and can be moved simultaneously (fast dispensation).

CONS:

- Difficult to clean because the wheel has many curvatures and holes where medicine dust can be collected.
- Many mechanical parts - Larger chance of breaking.
- Not sure if the shaking conveyor can separate the pills enough and whether it is accurate enough.
- The vibration from the shaking conveyor can possibly become noisy.
- If the pill gets stuck in the wheel they can possibly break.
- The components will take up a lot of room in the product, making it hard to minimize the size.

PILL PICKER PRINCIPLE



Ill. 68. Pill picker principle

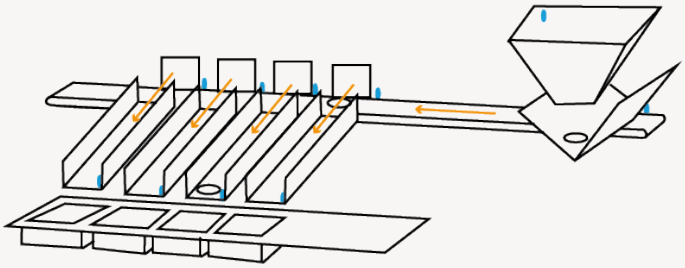
PROS:

- The arm can suck up any medicine dust and can in that way "clean" itself between dispensations of medicine for different patients.
- The rotation arm can be compressed in the system, meaning it will possibly be easier to make the product smaller.
- The vacuum arm is imagined to be accurate since the principle is used in a similar product already.

CONS:

- It has the potential of becoming noisy because of the suction of air.
- It can be very slow if it needs to grab one pill at the time as it is now with only one arm.
- The system is imagined to be expensive to program.

SORTING CONVEYOR PRINCIPLE



Ill. 69. Sorting conveyor principle

PROS:

- Seems to be efficient since all the pills are in the system at the same time and they can be pushed into place simultaneously.
- Can possibly be produced fairly cheap.

CONS:

- Difficult to clean because many different components are in contact with the pills and these components need to be free of medicine dust for the next dispensing.
- Not sure if the shaking conveyor can separate the pills enough and also not sure whether it is accurate enough.
- The vibration from the shaking conveyor can possibly become noisy.
- The shaking conveyor and conveyor will take up a fair amount of space which means that the product will need to take up a lot of space.

SELECTION

In order to be able to choose a technical concept, the nurses have been asked what are the most crucial needs for the product. It was important to know this, since the value of the aspects variates in the different concepts. The five aspects are validated and listed by the users.

THE PRIORITISATION OF THE ASPECTS

All three head nurses Lise, Sidse and Mette, from the different departments at Aalborg University Hospital and Vejle Hospital, had the same belief regarding the top three priorities. The most important aspects was the safety, next up was the cleaning of the product, and as a third prioritising the time aspect. Both Sidse and Mette had the price aspect as the fourth of prioritizing. Where the size of the product was the least important aspect of the concept. Lise had the two last aspects in reverse order.

Since concept two (Pill picker principle) fits best on this listing of the aspects this concept is chosen to work with in the further process.
The concept seems fairly safe in terms of accuracy while the principle already exists in the Swisslog robot. Also, a lot of potential in utilizing the vacuum suction of air for vacuuming the inside of the product is seen. That can help clean the product for medicine dust automatically between every patient. The concept is very flexible in terms of structure, which is why it is possible to move the components around to fit the wanted interaction scenario.
The next step is to look into how this concept can be realised and which specific components need to be used in order to make the product work. Furthermore, it is considered to get in contact with specialists within the field. In that way it is possible to get their point of view on how the components can match each other and how to realize the concept.

USERS LISTING OF ASPECTS

- Safety (correct and accurate dispensing)
- Cleaning of the product (medicine dust)
- Time (the speed of the process)
- Price (Fit their budget - as low as possible)
- Size (as small as possible)

THE PRODUCT SHOULD HAVE A SELFCLEANING PROGRAM WHEN IMPLEMENTING A VACUUM ARM
IT NEEDS TO BE EQUALLY FAST TO USE THE PRODUCT AS DISPENSING MANUALLY

MOCK-UPS AND INTERACTIONS

Now that the technical principle has been chosen, the next step is to investigate how the nurse will interact with the product. The product placement should be decided based on relations to the laptop, since it is providing the nurse with the needed information when dispensing. In order to make these investigations, tests needed to be done in collaboration with a nurse. The opinions and feedback from the nurse will help figure out the most optimal workflow in relation to interactions. The test is done using three cardboard models; one for underneath the computer, one for beside the computer and one for behind the computer. To make sure that the concepts will not affect the nurse's opinion in a certain direction, all three models are made without a scanner, hole for medicine input, or hole for the dispensing box, on them. The nurse should act out a dispensing for a patient, using the models one at a time. In that way it would be possible to get the natural work position and opinion where the different functions are to be placed. Here, the nurse should decide where to interact with the product and therefore place the scanner, hole for dispensing box and hole for medicine input on the models. (WS22) To get the most valid result of this research it is wanted to test it in the real context - the medicine room. But because further meetings and tests at the hospitals were no longer physically possible, another way of testing was necessary. The tests therefore took place at the nurse's home with the remedies which were available.

THE TEST RESULTS

All of the three cardboard models were tested in the same way. The nurse was told to act out how she would use each of the concepts and provide feedback during the test. In this way it was possible to get her first thoughts about the interaction and placement. She was told that she could turn and rotate the concepts as it felt most natural. (See the video no. ***01 - interaction test with Lise***, for the full test)

UNDER THE COMPUTER

This concept is placed under the computer in order to minimize the use of space at the counter in the medicine room. In addition, the concept creates a more optimal working position for the nurse while the computer will be leveled from the table. The nurse mentioned that it worked very well with the product under the computer, because it does not take up that much space at the counter and the working position was better.

PLACEMENT OF INTERACTION

Dispensing box
The nurse stated that the most natural placement was right in front of her, close to where she stands.

Scanner
The nurse takes down a preparation from the shelf and scans it on the right corner on the model. The nurse stated that when taking down the preparation it was natural to move it and scan it on the corner.

Medicine input
Furthermore, she stated that she wanted to place the hole for the pill input close to herself at the right side of the top. She also tried to rotate the concept and placed the hole in front of the computer. But she was concerned that there weren't enough space, which would result in the pills falling beside the hole.

Ill. 70. Under the computer - Test of interaction placement

THE PRODUCT SHOULD BE PLACED UNDERNEATH THE COMPUTER BECAUSE OF LITTLE SPACE ON COUNTER
PRODUCT WIDTH AROUND 38 CM AND DEPTH AROUND 26 CM (PLUS PLACEMENT AF PILL INPUT)

BEHIND THE COMPUTER

The concept is placed behind the computer in order to utilize the unused space at the counter. The nurse stated that this concept would not work at all, because of the placement of the concept. She also stated that the work position is very bad, because she had to reach across the computer in order to interact with the concept.

PLACEMENT OF INTERACTION

Dispensing box
The nurse found it challenging to find the right placement for the dispensing box. It did not feel natural for her to place the box in the concept, but she found a placement for it in the front right corner.

Scanner
The placement of the scanner was found most natural in the right corner, because it was the closest point to her.

Medicine input
The nurse, mentioned that because of the placement of the concept, it was not easy to place the medicine input, she placed it in the middle of the top plate nearest herself - Behind the computer screen.

Ill. 71. Behind the computer - Test of interaction placement

NEXT TO THE COMPUTER

The concept is placed next to the computer because it was wanted to place the concept so close to the nurse as possible, in order for her to reach and interact with the concept. The nurse mentioned that the placement was very good, because the concept did not take up much space while it was very compact.

PLACEMENT OF INTERACTION

Dispensing box
The nurse mentioned that is was clear that she would slide in the dispensing box from the right side of the concept.

Scanner
It was very challenging for the nurse to place the scanner on the concept, because there were multiple areas to place it. She ended up placing the scanner on the top in the right corner furthest away from her.

Medicine input
The nurse stated that the hole for medicine input felt the most natural to place on the top plate as close to her as possible. In that way she does not need to reach over the concept in order to get the medicine in the dispensing hole.

Ill. 72. Next to the computer - Test of interaction placement

Based on the feedback from the nurse Lise, it was clear that the concept behind the computer was not a concept that she would use, because of the bad work position when interacting with the concept. The feedback gotten from the two other concepts was positive, because she could see a potential in both of them. Based on the feedback it was decided to ask more nurses about the interactions. The nurses were shown a video of Lise interacting, where they afterwards gave their opinion and thoughts about the two remaining concepts. Here, it was clear that the concept under the computer was the most optimal, since there would be the most room on the table for other things they needed (WS23). In an optimal setting, the nurses should have had the opportunity to test the concepts physically when providing their feedback. The test set the requirement for the product to be at least around 26 cm in depth and 38 cm in width as a regular 15" laptop. But it may not be deeper than the table which is 60 cm and the width should be as short as possible in regards to the technical components. The next step was to sketch upon the form and interaction based on the given feedback.

Ill. 73. Five pictures used as inspiration board for the form, colour, texture and interaction

INSPIRATION BOARD

In order to figure out how the aesthetics should be for the product, a board is made. Here, items that could help determine the direction for the product was used and some features was transferred onto the concept. The initial thought was that the product should fit into the surroundings of the other hospital equipment that are to be found in the medicine room. Therefore, the pictures for the inspiration board is found with the hospital aesthetichs in mind (WS31). This inspiration board is supposed to create inspiration regarding the form and shape of the product.

1

COLOR

Green, blue and white colors are widely used in the health care sector for helping aids and equipment. This could make the product fit into the context.

2

HIERACHY

All interactions should be gathered on one surface in order to make the product intuitive. This could be done by breaking it up into smaller areas.

3

INTERACTION GUIDLINES

It is important that the user understands how to use the product, therefore feedforward needs to be provided through tactile surfaces. The user will feel and see the elevation in the product and know where to interact with the product.

4

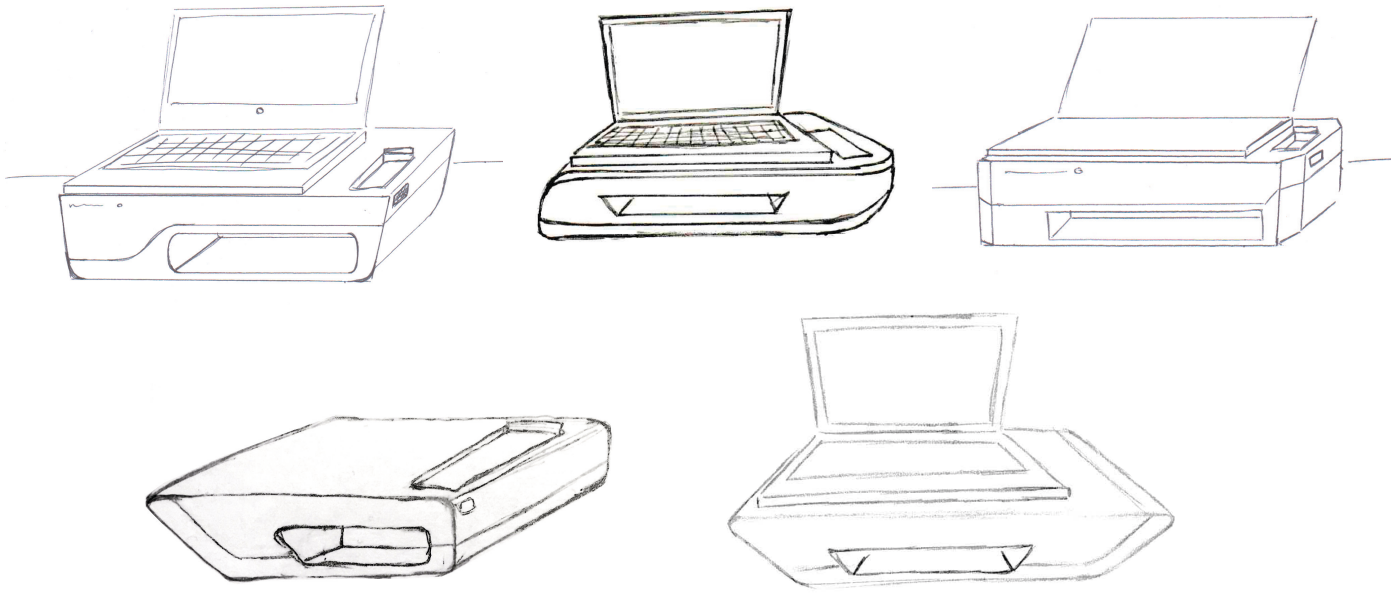
COLOR CHANCE

The product should be divided into sub areas in order to create a hierarchy for the interaction surfaces. This can be done through a color change of the surface, or a surface break.

5

FEEDBACK

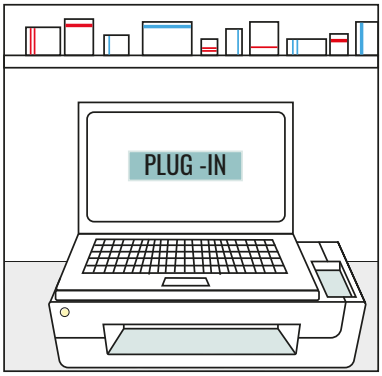
Lighting is used to show the user, when the product is ready to use or if the product is on standby mode.



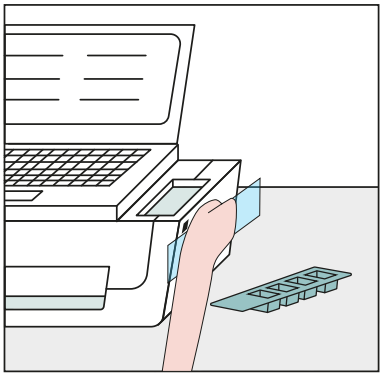
Ill. 74. Sketches on form with inspiration from the inspirations board

UNDERSTAND THE PRODUCT

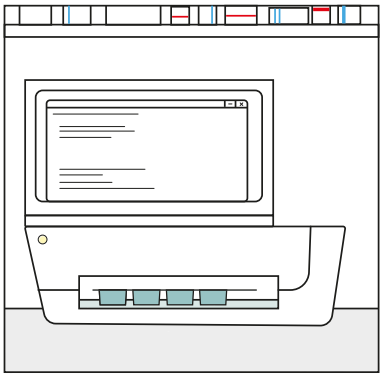
In this section the use of the product is presented. The interactions are based on the previous investigations and tests with the users. The user scenario is made in order to get an indication on how the nurse is going to use the product and to get an understanding of the interaction flow of the product. The product needs to be able to communicate with the data already provided in the electronic patient journal (EPJ) on the computers in the medicine room. The product will communicate through a new plug-in designed for the purpose. The product is physically connected via a USB cabel to the laptop.



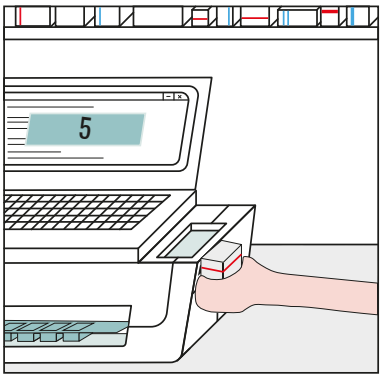
1. The nurse scans the access card she already has and gets access to the EPJ program on the computer and the plug-in starts.



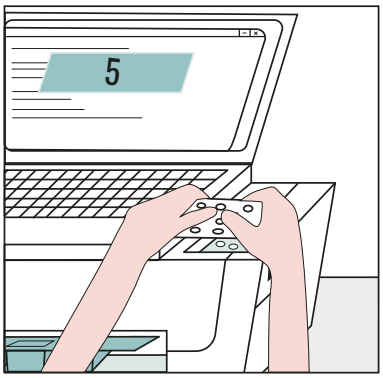
2. The nurse scans the barcode on the lid of the patient's dispensing box on the product. The barcode is linked to the patient data on the computer.



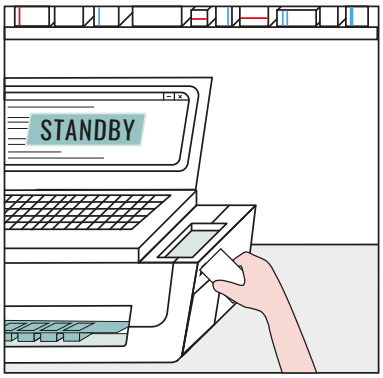
3. The nurse places the dispensing box.



4. The nurse scans the QR code on the medicine preparation on the scanner of the product - The plug-in shows how many pills the nurse needs to dispense into the product. If the wrong preparation is selected and scanned, it will warn the nurse.



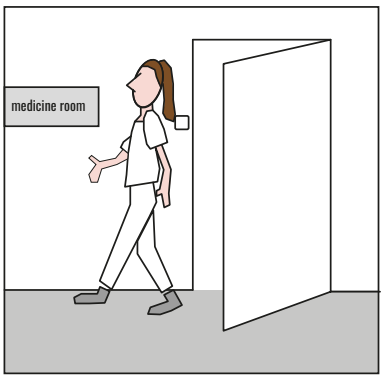
5. The nurse dispense the needed pills into the product. If foil from the blister package is accidentally dispensed with the pills, this is removed before loaded into the product.



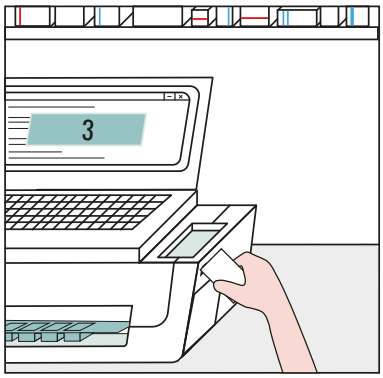
6. The nurse scans the access card while there is an emergency situation that needs attention. The plug-in and product goes on standby. Or, if unattended for more than 60 seconds, it will also automatically go to standby mode.

PLUG-IN WORKS WITH EPJ
STANDBY MODE
FIT THE EXISTING DISPENSING BOXES AND GLASSES
COLLECTION COMPARTMENT FOR WRONGFULLY DISPENSED PILLS
TRAY FOR DISCOVERING FOIL FROM BLISTEPACKAGES BEFORE DISPENSED
QR SCANNER
BARCODE SCANNER
CHIP READER FOR ACCESS CARDS
VACUUM CLEANER INSIDE PRODUCT
POSSIBLE TO OVERWRITE THE SYSTEM

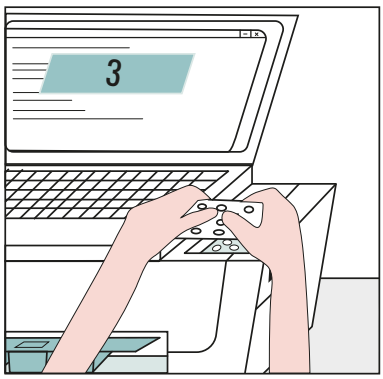
Ill. 75. User scenario in 12 steps



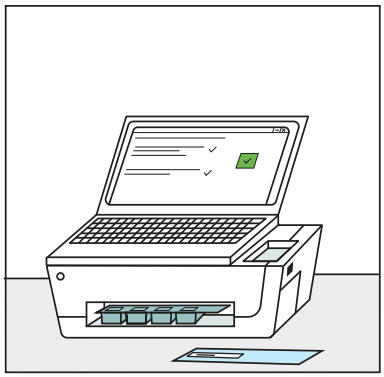
7. The nurse leaves the medicine room.



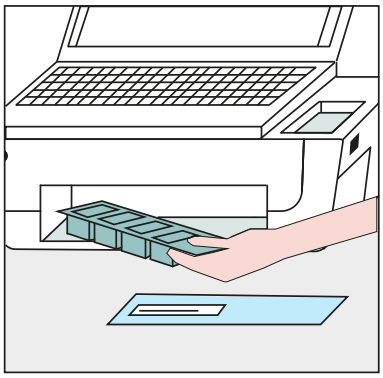
8. The nurse returns to the medicine room and scans the access card to log in. The plug-in remembers and tells the nurse to dispense the remaining pills in the system.



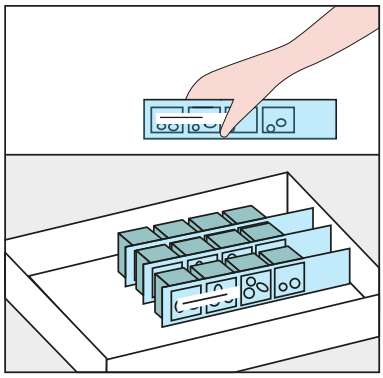
9. The nurse dispense the medicine in the product - If too many pills are dispensed they will be sorted into a collection tray within the product, which can be emptied when needed.



10. The plug-in lights up green and the dispensation is done.



11. The nurse takes the dispensing box out of the product, ends the dispensation by scanning the lid on the scanner and seals the box by closing the lid.



12. The box is placed in the tray. A vacuum cleaner inside the product activates and remove possible leftover medicine dust, before dispensing pills for the next patient.

Besides regular pills for oral ingestion, the product can also handle other medicines as IV fluids, melt pill, suppositories etc. These are scanned like the preparations and then set aside together with the dispensing box. This function makes sure that all medicine can be handled using the product and secures the patient regardless the form of the medicine.
If there is a need for dispensing half pills, they will be dispensed after all the other pills. The plug-in will tell the nurse to scan the preparation box, break the pill and dispense it into the product.
If the product in some way makes a mistake and won't let the nurse dispense a type of medicine it should be possible for the nurse to overwrite the system by scanning the access card and a notification will be sent to a doctor. In this way the nurse still has a last saying in the medicine dispensation process, but any potential errors will still be detected.

This storyboard shows the flow of using the product and can enlighten the need for specific features that need to be in the product in order for it to work. To get the full user scenario, the plug-in for the product also needs to be specified.

UPDATED NEEDS AND FEATURES

The user needs are updated and listed beneath. New issues and needs are marked with *this color*

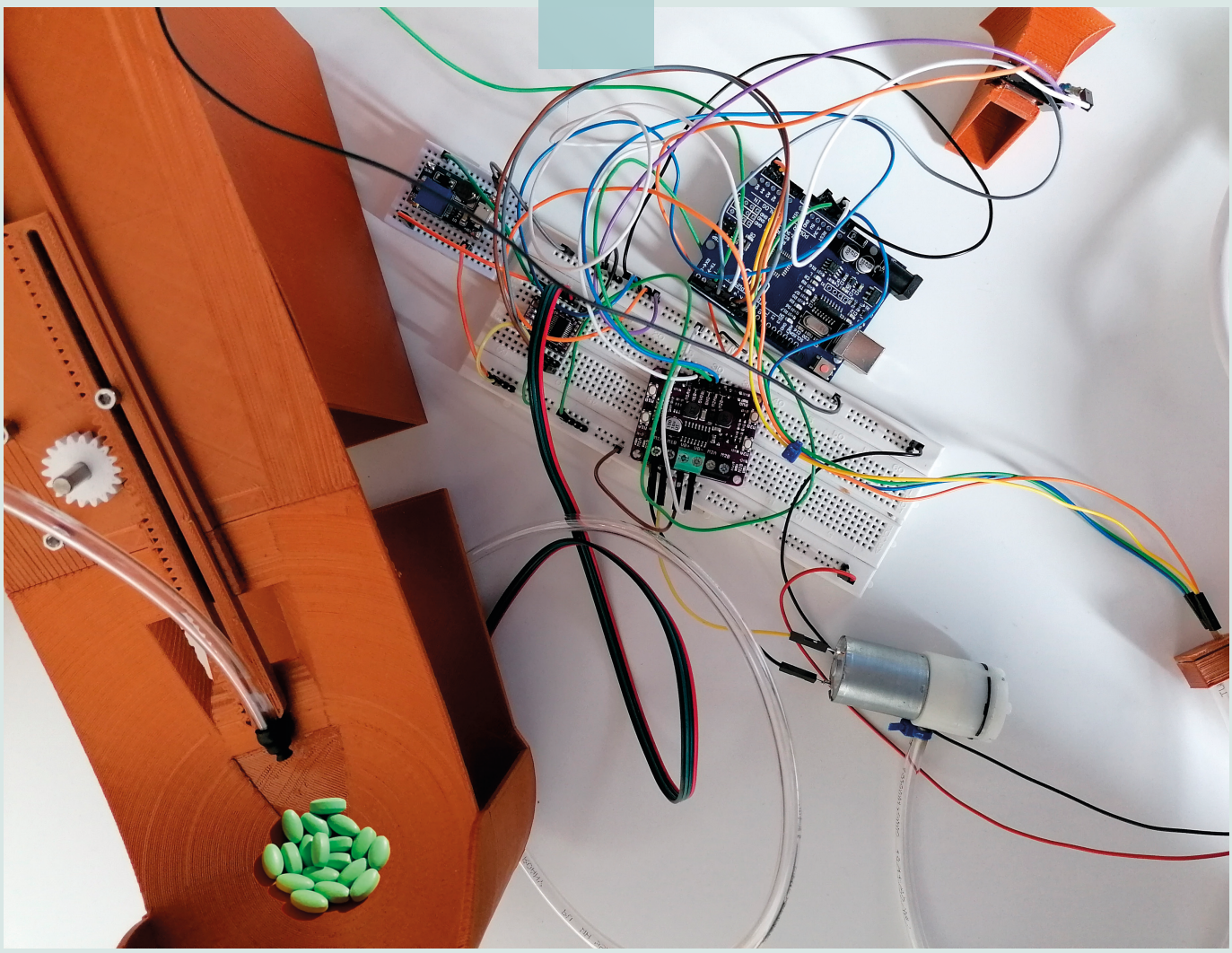
SUMMARY OF CURRENT DIRECTION

The product will be build up by a technical principle that uses vacuum to collect pills.

The product will be placed underneath the computer in the medicine room for the best ergonomics and space

ISSUE NO.	WHAT IS THE ISSUE?	SOURCE (PAGE)
1	There is a change in brand and design of the dispensing boxes which can make the nurse confused, when dispensing medicine for the patient. If errors are made it can result in the wrong medicine is given.	Medication errors (8)
2	Because the nurse can be inattentive when dispensing medicine, they can overlook the right form of medicine preparation in the medicine program (EPJ). Meaning that for example if the patient is prescribed a solid form, but the nurse is giving the medicine in a liquid form.	Medication errors (8)
3	The change of the dispensing boxes in the medicine room, can also result in the milligrams of the preparation being different than usual. These changes can confuse the nurse when dispensing the medicine. If the wrong dosage is given, it can result in side effects.	Medication errors (8)
4	The nurses normally dispense for 5-6 patients each. Sometimes the nurse mixes up the patients dispensing boxes, by mistake, which results in a patient ending up with another patient's medicine.	Medication errors (8)
5	When the nurses dispense medicine in the dispensing boxes they sometimes get confused and dispense medicine in the wrong room in the box, which means the patient gets the medicine at the wrong time.	Medication errors (8)
6	If the active ingredient regarding medicine dust ends up in the next patients dispensing box, it can result in a health care error.	Combination of concepts (32)
7	The nurse is often interrupted by colleagues or patients when dispensing the medicine which can result in being unconcentrated and making dispensing errors.	Medication errors (8)
8	The nurse uses a lot of time to double check the medicine before the patient ingest it, this is time consuming and the time would be beneficial elsewhere.	Group journey (34)
9	***A new prescribtion not updated in the system is available***	Understand the product (50)
10	***Too many or few pills are put into the product which can result in an error in the system.***	Understand the product (50)
11	***The foil from the blister package can damage the function of the product if it gets into the system.***	Understand the product (50)
12	***There is limited room on the counter in the medicine room for dispensing medicine.***	Mock-ups and interactions (46)

NEED NO.	ISSUE NO	USER NEED	HOW IT IS SOLVED
1	1	Help to approve or disregard a medicine preparation (Recognize the generic substitution)	Create a plug-in for the EPJ and implement a scanner in the product/ concept where the QR code on the dispensing box can be scanned. The plug-in can validate if the medicine is right.
2	2	Help to approve or disregard the form of the medicine.	Create a plug-in for the EPJ and implement a scanner in the product/ concept where the QR code on the dispensing box can be scanned. The plug-in can validate if it is the right form.
3	3	Help to validate amounts and mg dispensed	Create a plug-in for the EPJ and implement a scanner in the product/ concept where the QR code on the dispensing box can be scanned. The plug-in can show the amount in pieces that the nurse has to dispense.
4	4	Help to approve the right patient	Create a plug-in for the EPJ and implement a scanner in the product/ concept where the barcode on the patient's dispensing box can be scanned. The plug-in registers the patient's info and shows the prescription for the patient.
5	5	Help to dispense the medicine for the right time.	The product automatically dispenses the medicine in the patient box, in the right rooms, for the right time.
6	6	Possible to clean for medicine dust where the medicine is in contact with the product.	Cleaning program, where the Vacuum suction also functions as a cleaning device inside the product. Few and smooth surfaces/edges on the inside of the product.
7	6	Possible to clean for medicine dust where the medicine is in contact with the product	The materials and surfaces on the outside of the product should be resistant towards sharp cleaning articles and disinfectant alcohol. Few and smooth surfaces and edges on the outside of the product.
8	9	***Possible to overwrite the system***	***Acceptiance through scanning acces card.***
9	10	***If extra pills are put into the product they need to be removed before the next medicine is dispensed.***	***A compartment for wrongfully dispensed pills.***
10	10	***If too few pills are put into the product, the nurse needs to dispense more pills into it.***	***The plug-in needs to tell the nurse that she must dispense more of the same preparation into the product.***
11	11	***Foil from blister packages may not get into the system.***	***Tray for discovering foil from blister packages before loaded into the product.***
12	7	Continue dispensing after interruptions without flaws.	The nurse can shift in between a standby mode and active mode with the access card, by scanning it on a chip reader on the product. The plug-in remembers the status of the dispensation in the standby period.
13	8	Minimize the need to double check the medicine.	Dispensing of medicine should be close to 100% safe in relation to patient safety by automatizing critical aspects of the dispensing process.
14		***Has to be equally fast to use as doing the task manually.***	***Faster dispensation time than the current time used on putting the preparation back on the shelf and finding the next preparation (19 seconds).***
15	12	***Utilize the room on the counter, the best possible way.***	***Product should be placed underneath the computer.***
16		Possible to dispense in the dispensing box and dispensing glass.	The concept should be designed so it is possible to place both dispensing boxes (b: 6 cm x L: 24 cm x h: 2 cm) and dispensing glasses (Ø: 3,4 X H:4) in the dispensing box area.

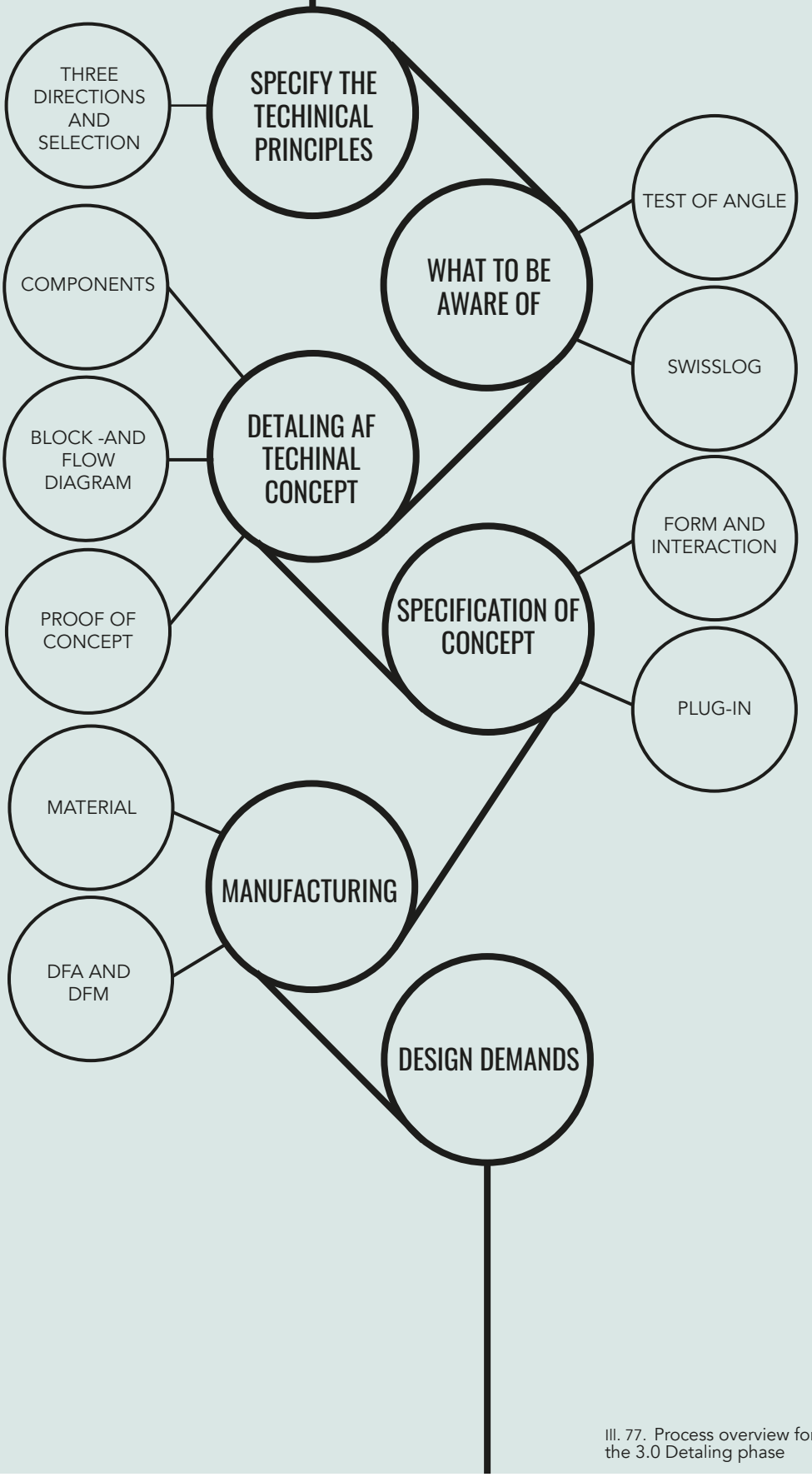


Ill. 76. Proof of concept close up

3.0 DETALING

In this third phase the technical aspects, form and interaction will be detailed where they will be implemented into the concept. In addition, the plug-in, the specific material, manufacturing and production will be specified. In this phase it was still not possible to go into the real context for testing and feedback which is why feedback is provided through digital connections.

PROCESS OVERVIEW



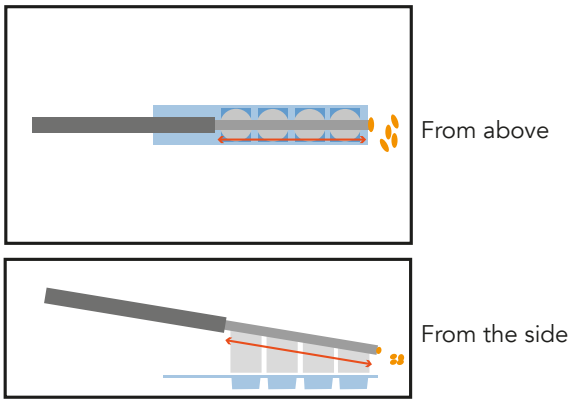
Ill. 77. Process overview for the 3.0 Detaling phase

PILL PICKER PRINCIPLE

Now that the technical principle and initial interaction is specified, the aim is to look into how the concept can be built. Through research regarding how to make the best fit for the hospital, the focus is on accuracy of the product, the ease of cleaning for medicine dust, the speed when using it, the size and price of it. These aspects are already listed by the users and the head nurses at the department in the previous phase. The vacuum concept can possibly solve the removal of medicine dust, since it can vacuum up pill dust, and it is also accurate since it is designed so it only move one pill at the time. Furthermore, it is inspired by the Swisslog at Aarhus University Hospital, which is accurate when dispensing medicine. This section enlightens how the possibilities regarding optimizing the aspects dealing with price, speed and size. Since the first thoughts with an arm both extending and rotating, was too big of a task and got too complicated, other alternatives were researched. Three concepts were created. One that had one arm, the second that had four arms, and a third that has one arm and one moving bottom for the dispensing box. The inspiration for these principle is occurred through supervision.

ONE ARM FOR PICKING UP PILLS

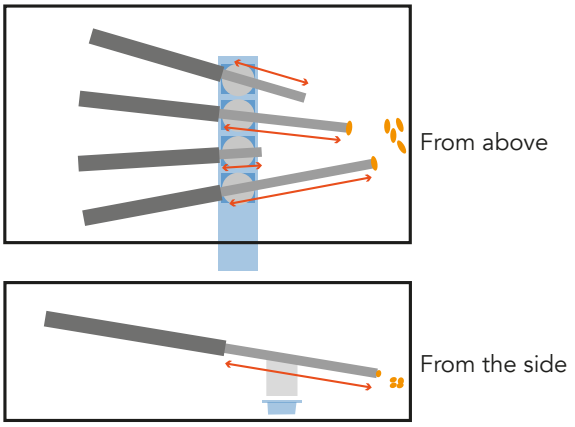
The concept is build up with an arm that can extend itself. The holes for dispensing are placed on one straight path that the arm can reach. The holes will have a closing mechanism in order to secure no pills will fall unintendedly into holes while the pills are moving above other holes in order to be dispensed. With this concept only one pill can be moved at a time, and there is a possibility for errors when moving the pill past other compartments than the intended one.



Ill. 78. One arm for picking up pills

FOUR ARMS FOR PICKING UP PILLS

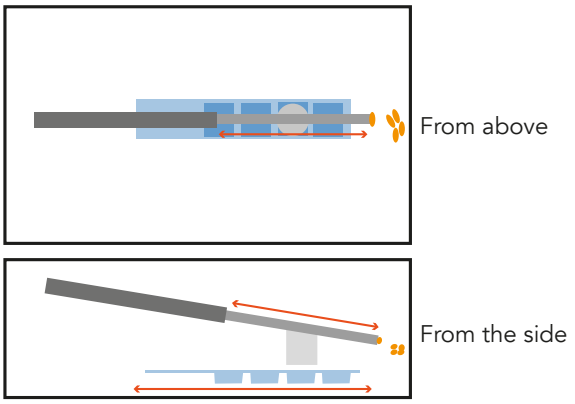
This concept consists of four arms, that extend to reach pills. One arm is linked to a path that moves from the pill drop into the correct dispensing hole. Since the arms are connected to one hole each the safety is higher, because no pills is moved past the other holes when having their own seperate path.
With this concept it is possible to parallelize the arms and therefore move more pills at once, and in that way shorten the dispensing time.



Ill. 79. Four arms for picking up pills

ONE ARM FOR PICKING UP PILLS AND A MOVING BOTTOM

This concept consist of one arm and one moving bottom for the dispensing box. The arm will move as concept one but only towards one hole for dispensing. By moving the bottom underneath the dispensing box, the pill is placed in the correct dispensing room. This concept is the same speed as concept one, since only one pill can be dispensed at a time.



Ill. 80. One arm for picking up pills and moving botton

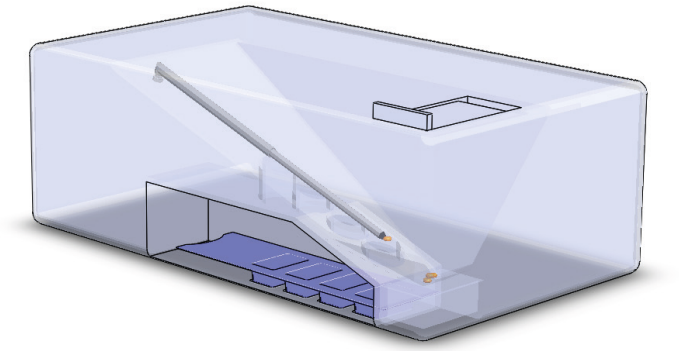
SELECTION

Concept number three has a moving part which the nurse accidentaly can interferre with. This is not seen as acceptable and therefore concept three is disregarded. The two other concepts are researched further and specified with the aim of selecting one concept.
It is wanted to design a product that is as fast as possible to use but at the same time not too expensive to buy. Therefore, components are looked into in order to figure out whether having four arms instead of one can have an impact on the speed of the product and by that adding value to the product. This research can help optimize the product and therefore make sure the hospital will get the best product for the lowest possible cost. (WS27)

1 ARM ACTUATOR

MAIN COMPONENTS:

- 1 high precision actuator
- 4 closing mechanisms for dispensing holes
- 1 vacuum component



III. 81. 3D model with one arm for picking up the pills

PROS:

- Price on programming is lower with one arm than four arms.

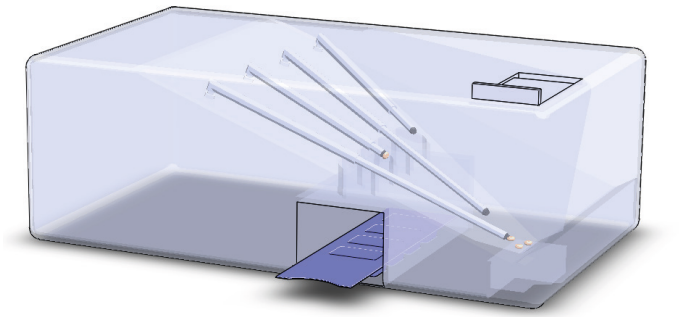
CONS:

- Price of programming is fairly high.
- Low speed, when only moving one pill at the time.
- Pitfall - The arm has to move the pill over other holes when dispensing (many interactions) - can result in dispensing error.
- Needs to have a closing mechanism over each dispensing hole, in order to ensure the pill does not end up in the wrong dispensing hole - making it more complex.
- Complex component structure - Components have to move in respect to each other.

4 ARM ACTUATOR

MAIN COMPONENTS:

- 4 high precision actuators
- 4 vacuum components



III. 82. 3D model with four arms for picking up the pills

PROS:

- Faster while more pills can be moved simultaneously.
- One arm connected to one dispensing hole (one interaction) - low chance of dispensing errors.

CONS:

- Programming is slightly more expensive with four arms than one arm because of parallelizing.
- Expensive components since they have to be very precise.
- Complex component structure - Components have to move in respect to each other.

Since there are more pros when having 4 actuators, it is decided to go with this concept. This is due to the time efficiency of having 4 actuators is increased while more pills can be moved simultaneously, but also that the pills will be moved directly to the respective holes. The product might be a bit more expensive because of more high precision actuators and a bigger task in programming is needed, but it is evaluated that since the time efficiency and safety around the dispensing is more important for the nurses, and the 4 arm concept fulfills that, the price of the product is less important.

WHAT TO BE AWARE OF?

When having chosen the direction for the technical concept of the product it is important to investigate which possible risks there are regarding the technical components and the functions of the product. This risk matrix is created based upon the likelihood of how often the risk occurs, from rare to certain, and the extent of the consequence, is the risk negligible or catastrophic [Pope, 2019] [ScienceDirect, 2016]. Only the high risks are listed and placed in the risk matrix.

THE RISKS

1. MORE THAN ONE PILL AT A TIME ON THE VACUUM SUCTION (OVERDOSE)
MEDIUM

LIKELIHOOD
Possible - The vacuum and the size of the tube is not defined yet. The smallest pills can possibly be sucked onto the tube several at a time.

POTENTIAL CONSEQUENCES
Major - There is a risk of the patient getting an overdose, which can have huge effects. The patient can go into anaphylactic shock or in the worst case die from an overdose.

2. THE VACUUM SUCTION LOSES A PILL BEFORE IT IS DISPENSED
MEDIUM

LIKELIHOOD
Possible - If the vacuum flow is too weak or the pill is in a crooked position, the end of the vacuum tube, cannot get a hold on the pill.

POTENTIAL CONSEQUENCES
Minor - If the suction tube is going back and forth, in order to pick up the lost pill, it can cost valuable time for the nurse in the end.

3. THE SUCTION TUBE CAN NOT FIND THE PILL, BECAUSE THE PILL IS NOT PROPERLY AT THE BOTTOM OF THE AREA.
HIGH

LIKELIHOOD
Likely - The test of the concept (page 42-43) showed that, because of the rough surface and the small angle, not all of the pills would end up at the bottom of the concept, in order to be picked up by the suction tube.

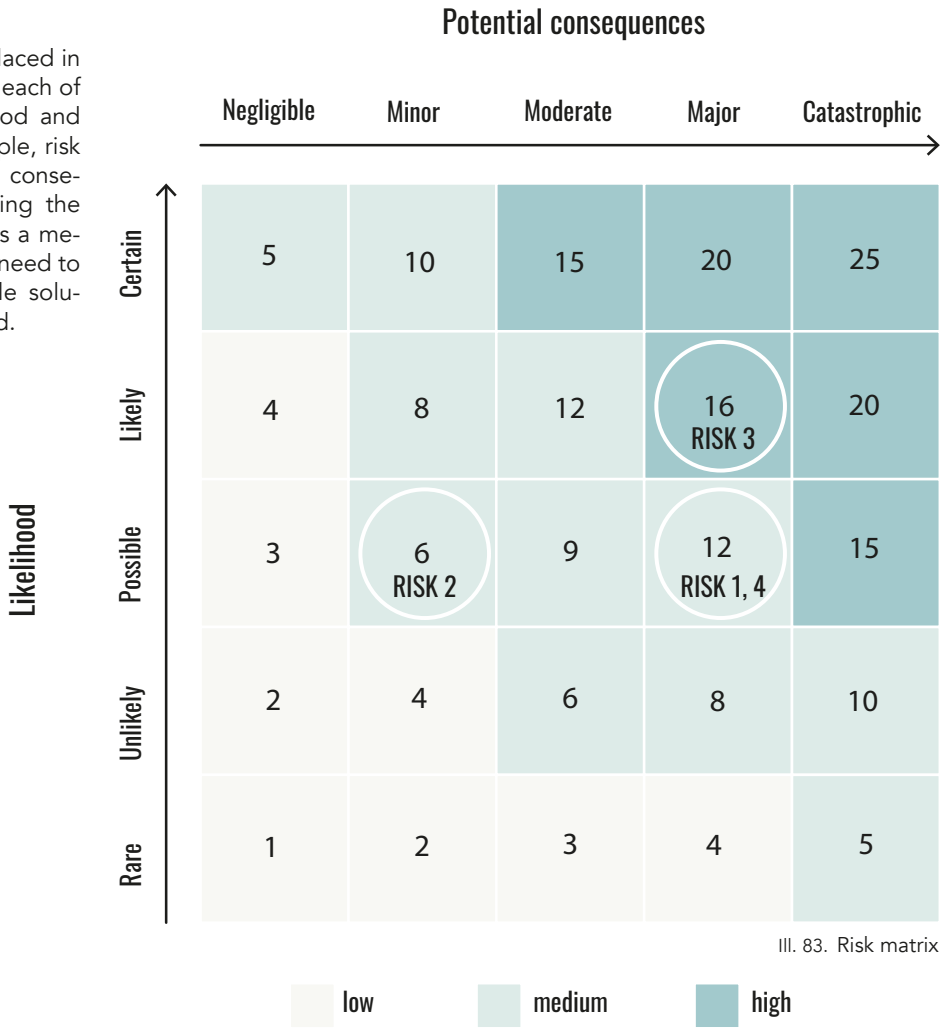
POTENTIAL CONSEQUENCES
Major - If not all the pills end up in the bottom of the concept, the suction tube can not find the pill and dispense it. The product will say it is an error and it will not work.

4. THE PILL CAN BREAK INTO PIECES, IF THE SUCTION TUBE GETS TOO CLOSE AND PUTS PRESSURE ON THE PILL, WHICH WILL RESULT IN MEDICINE DUST INSIDE THE PRODUCT, MAKING IT IMPOSSIBLE FOR THE SUCTION TUBE TO PICK UP THE PILL.
MEDIUM

LIKELIHOOD
Possible - Some pills are more fragile than others, but it is not unlikely that the pill gets squeezed, if the system and suction tube is not flexible and precise enough.

POTENTIAL CONSEQUENCES
Major - The pill can break into pieces and therefore can not be dispensed. This can have a huge effect on the patient, because he/she will not get the proper treatment and this will end up as a health care error. The nurse would need to look for the crushed pill in the product and the lost medicine dust can end up in the next patients dispensing box, which also would be considered a health care error.

The four different risks are placed in the risk matrix by evaluating each of them based on the likelihood and the consequence. For example, risk no. one is possible and the consequence can be major, leaving the risk at a value of 12, which is a medium risk. Therefore the risk need to be evaluated and a possible solution needs to be investigated.



Ill. 83. Risk matrix

THE SOLUTIONS

When the risks are evaluated to be medium or high they need to be adressed. Which means that if a risk is evaluated at a medium value in the risk matrix, a solution needs to be found in order for the product to work and secure the patients safety. The imagined solutions to each risk are listed below.

RISK 1: In order for the product to only pick up one pill at the time and hold it on the suction tube, only the necessary vacuum needed, is provided. This value needs to be calculated using the data from the largest pill to be found.
The size of the smallest pills cross-section defines the size of the opening of the rubber membrane at the end of the suction tube, making it impossible to maintain more than one pill.

RISK 2: A vacuum sensor signals when the vacuum in the tube is correct. This result in the pill not getting moved too early, and making sure the pill is grabbed. When calculating on the suction, a safety factor is incorporated. In that way, the vacuum will only be at the necessary pressure.

RISK 3: The area where the pills ends before they are picked up by the actuators, needs to be funnel shaped and have the right angling and surface smoothness in order for the pills to end up in the bottom of the product. This is to make sure the actuator can always find the pills in the bottom.

RISK 4: A rubber membrane on the suction tube will secure a soft impact with the pills. The vacuum sensor will make sure that, when the pill is on the end of the tube, the actuator will not go any further. A high precision actuator will make sure that the movement is fluent and smooth. The bottom plate also has a trap door, that opens up after each dispensing. If there has been too many pills in the product the nurse can remove these alongside with any medicine dust that may get collected in the process.

These solutions have been reflected upon after creating the risk matrix. It is important that each of them is considered throughout the project while they are either at medium or high risk. Therefore, tests and calculations are to be done in order to come closer to the right solution for the product.

CONTAIN VACUUM SENSOR
FUNNEL SHAPED INTERIOR
SOFT RUBER MEMBRANE WITH SMALL CROSS SECTION

TEST OF ANGLE

A test of the angle is made in order to make sure the pills will end up at the bottom of the product, for the arm to pick them up, as this issue is already stated in the risk matrix. The test is done with a cardboard model with a flexible bottom that can be moved into different angles. The bottom plate is covered with a plastic sheet to make it as realistic as possible when comparing it to the finished product suggestion. In that way, the surface is as smooth as possible for the pills to slide down. The test is done with five different pills. (Big, small, rough surface texture, smooth surface texture and different shapes). (See the video no. *02 - test of angle*, for full test)

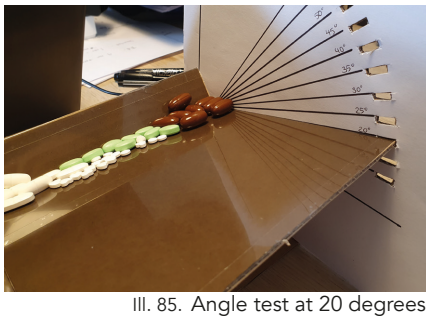
15 DEGREES ANGLE

This angle shows that almost all pills will fall down in the bottom, but as seen in the picture, not all pills fell down correctly. Therefore a bigger angle is necessary.

Ill. 84. Angle test at 15 degrees

20 DEGREES ANGLE

The angle of 20 degrees showed that all pills moved down in the bottom which indicates that 20 degrees can be the correct slope.
Therefore, it is decided that the angle inside the product needs to be 20 degrees.



Ill. 85. Angle test at 20 degrees

PILL PICKER PRINCIPLE AND CALCULATIONS FOR SUCTION

The technical component setup is inspired by the pill picker which is seen in the existing product Swisslog at AUH (WS15). In this section it is wanted to describe what values to take from the Swisslog robot in order to specify how to possibly operate the designed concept. Furthermore, because of the risk of picking two pills with the arm already described in the risk matrix, it is wanted to calculate the needed suction for the arm, making it grab only one pill at the time and move it.

The Swisslog robot moves the pills from canisters using a robot arm which is provided with a vacuum suction function. The vacuum suction and the flexible rubber membrane principle is wanted to transfer into the designed concept. By having a flexible membrane, it is possible to enclose the membrane around the pill and utilize the vacuum efficiently.
By looking at how much the biggest pill to be found at the hospital weights, and how small a surface the smallest pill has, it has been possible to calculate the needed suction to hold and move a pill with the pill picker principle. Here, a negative pressure at 89 kPa is needed (WS28).

Ill. 86. Rubber membrane from Swisslog

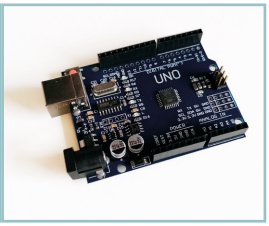
The calculations and test of angle is evaluated to help the product possibly lowering the risks of errors to being rare. The angle test provided a good initial foundation for the technical solution. If done more precisely, test should have been done using the correct material and construction. Since the concept is almost specified, it is wanted to test the implementation of the functions and validating the setup. In order to be able to test the concept, the next step is to find the needed components for the concept and to arrange them so the product becomes time efficient to use, possible to clean and provides a good interaction scenario for the user.

COMPONENTES

In order to get the product to work with the needed functions, different components are investigated. Here, the components are described and it is stated how they fulfill the needs for the product.

MICROCONTROLLER

The microcontroller is the brain in the product, which means that this component is controlling the other components in order for the product to function, and it speaks together with the plug-in. It will send out signals to the individual components when they have to fulfill a task, and it will receive data from sensors. [Trab.dk, n. d [1]]



Ill. 87. Microcontroller

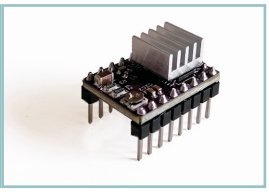
POWER SUPPLY

A power supply will transform the voltage from the power outlet which is 230V to 12V which is what the components needs in order to function. This will provide power for the whole product. (Appendix 2) [RS, n. d [1]]

Ill. 88. Power supply

STEPPER DRIVER

The stepper driver is used to control the actuator. The micro controller cannot provide the necessary energy to drive the actuator fully, which is why the stepper driver is implemented. [DigiKey, n. d [1]] (Appendix 3)



Ill. 89. Stepper driver

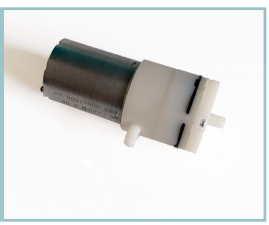
LINEAR ACTUATOR (FOR THE MAIN PRINCIPLE)

A precision actuator will transport the suction tube towards the pills, then pick up one pill and move it back again over a dispensing hole for it to be dispensed into the dispensing box. The actuator needs to have a working stroke around 90 mm, in order to reach the pills and move them to the dispensing holes. The speed of the actuator is 500 mm per second, which is a high speed and sufficient in order to make the product fast at dispensing. (Appendix 4) [RS, no. d [2]]

Ill. 90. Linear actuator

MINI VACUUM AIR PUMP

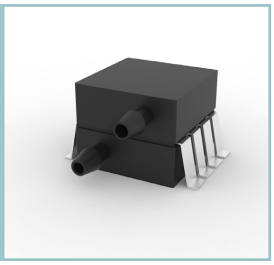
A vacuum pump is needed to create the vacuum inside the tubes. It makes the actuator being able to grab a pill and hold it before dispensing it into the dispensing box. From calculations, it is estimated that 89 kPa is needed for the pump to lift a big pill. [elextra.dk, n. d [2]] (Appendix 5)



Ill. 91. Mini vacuum air pump

DIFFERENTIAL PRESSURE SENSOR

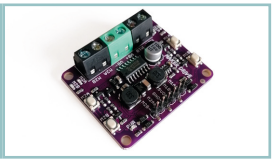
A sensor for measuring the pressure in the vacuum setup is needed, while this sensor will be able to measure when a pill is picked up at the end of the tube because of the change in pressure when a pill blocks the end. When that happens, the microcontroller will know, and it can send a signal to the actuator for it to move towards the correct dispensing hole. (Appendix 6) [RS, n.d [4]]



Ill. 92. Differential pressure sensor

H-BRIDGE

An H-bridge is an electronic circuit that switches the polarity of a voltage applied to a load. The H bridge is used to control the vacuum pump. (Appendix 7) [DigiKey, n. d [2]]



Ill. 93. H-bridge

RUBBER MEMBRANE

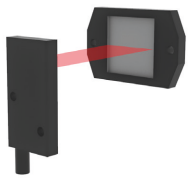
A rubber membrane [RS, n.d [3]] is placed at the end of a rubber tube [elextra.dk n.d [1]] in order to be able to wrap closely around the pill and to be shock absorbing. The membrane size is defined by the smallest pill's cross section. In that way it is possible to ensure that only one pill can be picked up by the actuator at a time.

Ill. 94. Rubber membrane

LASER-GRID SENSOR

A sensor is needed in order to be able to register when a pill has dropped through the dispensing hole and into the dispensing box. This is in order for the product to be able to confirm that the pill is now dispensed, and it will send the data to the plug-in. This functions as an extra check, that the pill has passed.
This sensor works by sending out a laser grid, and if a pill breaks the laser grid, the sensor will detect that a pill has passed. The grid needs to be around 20mm wide and have a detecting distance on 60mm (Appendix 8) [KEYENCE America, n.d]

Ill. 95. Laser-grid sensor



LINEAR ACTUATOR (FOR THE LEFTOVER BOX)

A linear actuator is needed in order to open and close the slider over the "leftover" box. The actuator will move the bottom plate to the side in order for the pills to fall into the "leftover" box. (Appendix 4) [RS, n.d [2]]

Ill. 96. Linear actuator

VACUUM SUCTION (CLEANING)

A cleaning component is needed in order to be able to vacuum up any medicine dust in the bottom of the product after the opening has removed any large pieces of medicine. (WS29-test) [dingadget.dk, n.d]

Ill. 97. Vacuum suction

LASER SENSOR

A laser sensor is placed in the "leftover" box. The sensor will measure when the box is almost full with pills, and communicate to the plug-in when the box needs to be emptied. It is also used for detecting the dispensing box or glass when placed. (Appendix 8) [KEYENCE America, n.d]

Ill. 98. Laser sensor

LED LIGHT

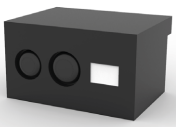
An LED light will give the user an indication on whether the product is on/off or in standby mode. The light will change color when the product is in standby mode. [ELEXTRA.dk, n. d [3]]

Ill. 99. LED light

QR AND BARCODE SCANNER

The small QR and barcode scanner is used to scan the barcode on the patient's dispensing box and the QR code on the preparation boxes. [DY-Scan, n.d]

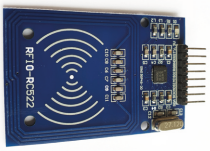
Ill. 100. QR and barcode scanner



RFID TAG READER

The chip reader is placed on the side of the product, and is used when the nurse logs into the plug-in for the product. The chip reader can register when the nurse is scanning her card, and can set the product on and off standby mode. It has a range on 0-50 mm. [DigiKey, n.d [3]]

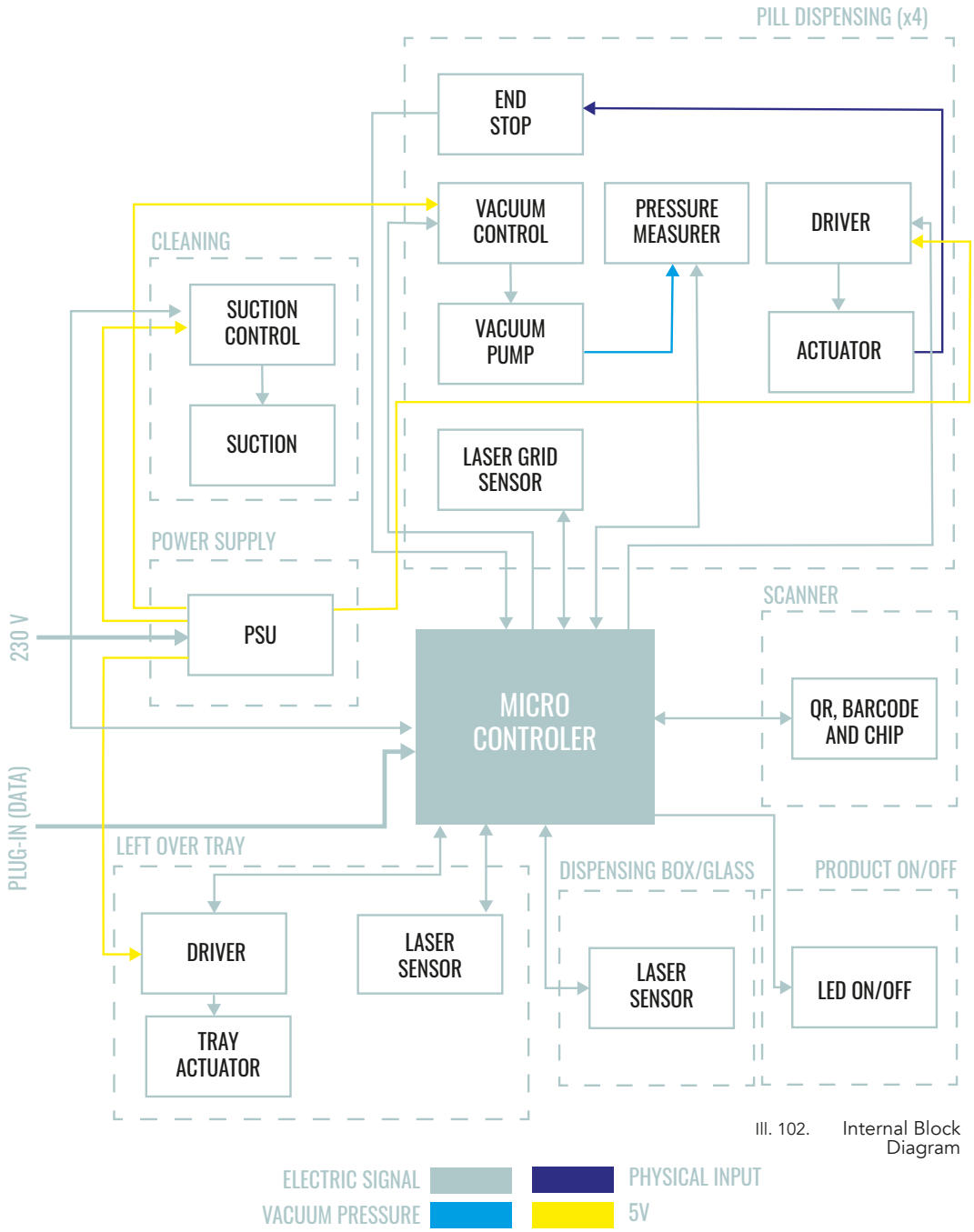
Ill. 101. RFID tag reader



Besides the above described components, also wires, resistors, fuses, supply connections etc. are needed for the product to work, but these are not looked into. Furthermore, the product is connected to the laptop through a USB cable and the concept recives power through an outlet. In order to fully understand the technical flow and the connection between all the components inside the product, it is needed to setup an internal block diagram which is done next.

HOW TO GET THE PRODUCT RUNNING

To get the product working two kinds of Block diagrams are made. The two block diagrams are necessary in order to get an idea of how the the electronic components inside the product work, how they are connected and communicating with each other. The Body Block Diagram (BBD) is an overview on which components are in the concept and how they overall are connected, this can be found in (WS30) The Internal Block Diagram (IBD) is used to get an overview on how the electronic components are sending signals to each other. It should be noticed that the product has four actuators, where four of every component in the area "pill dispensing" is needed, but in the illustration only one is shown in order to simplify the IBD. Both diagrams are simplified, while trying to make them tangible and easy to read.

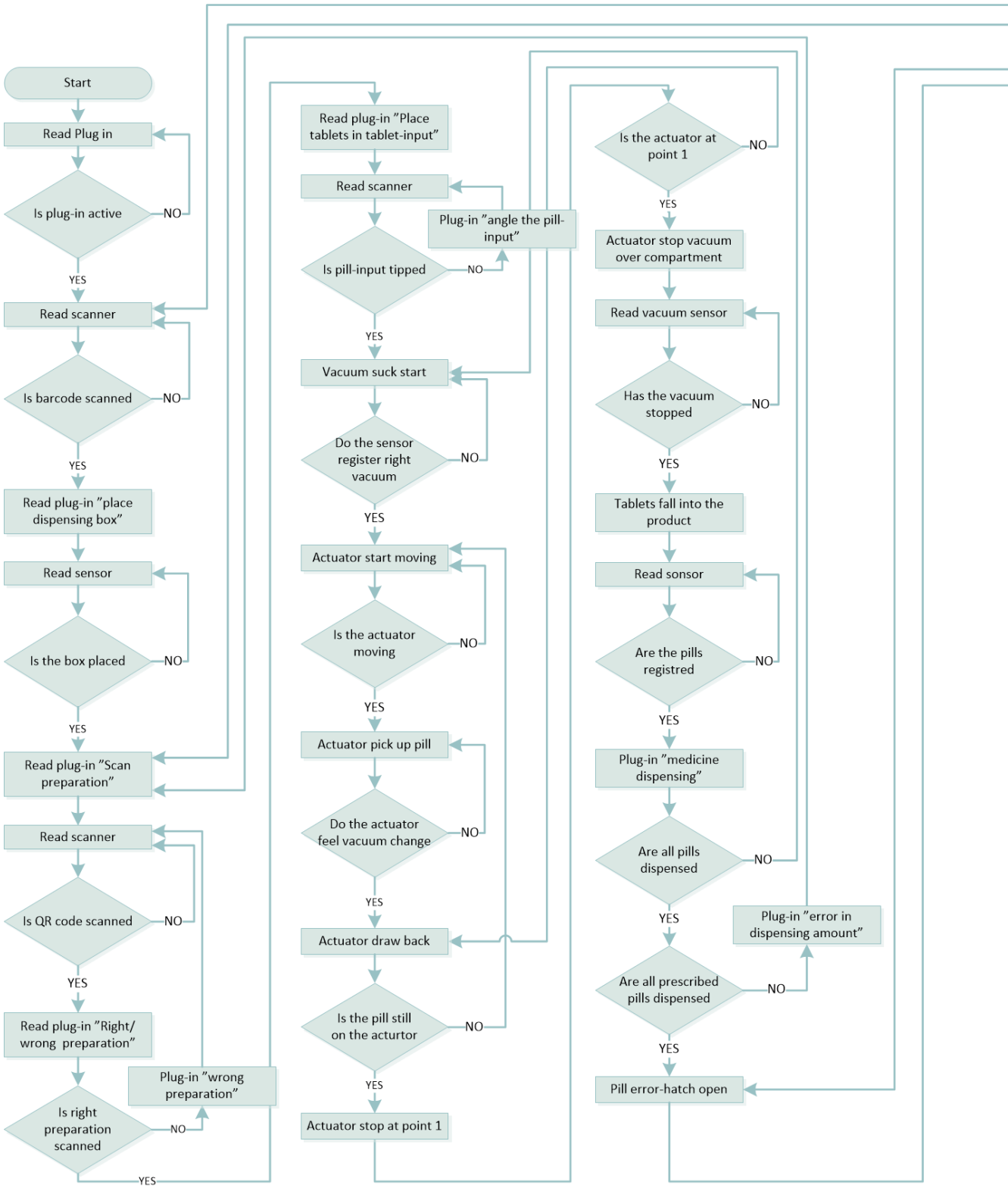


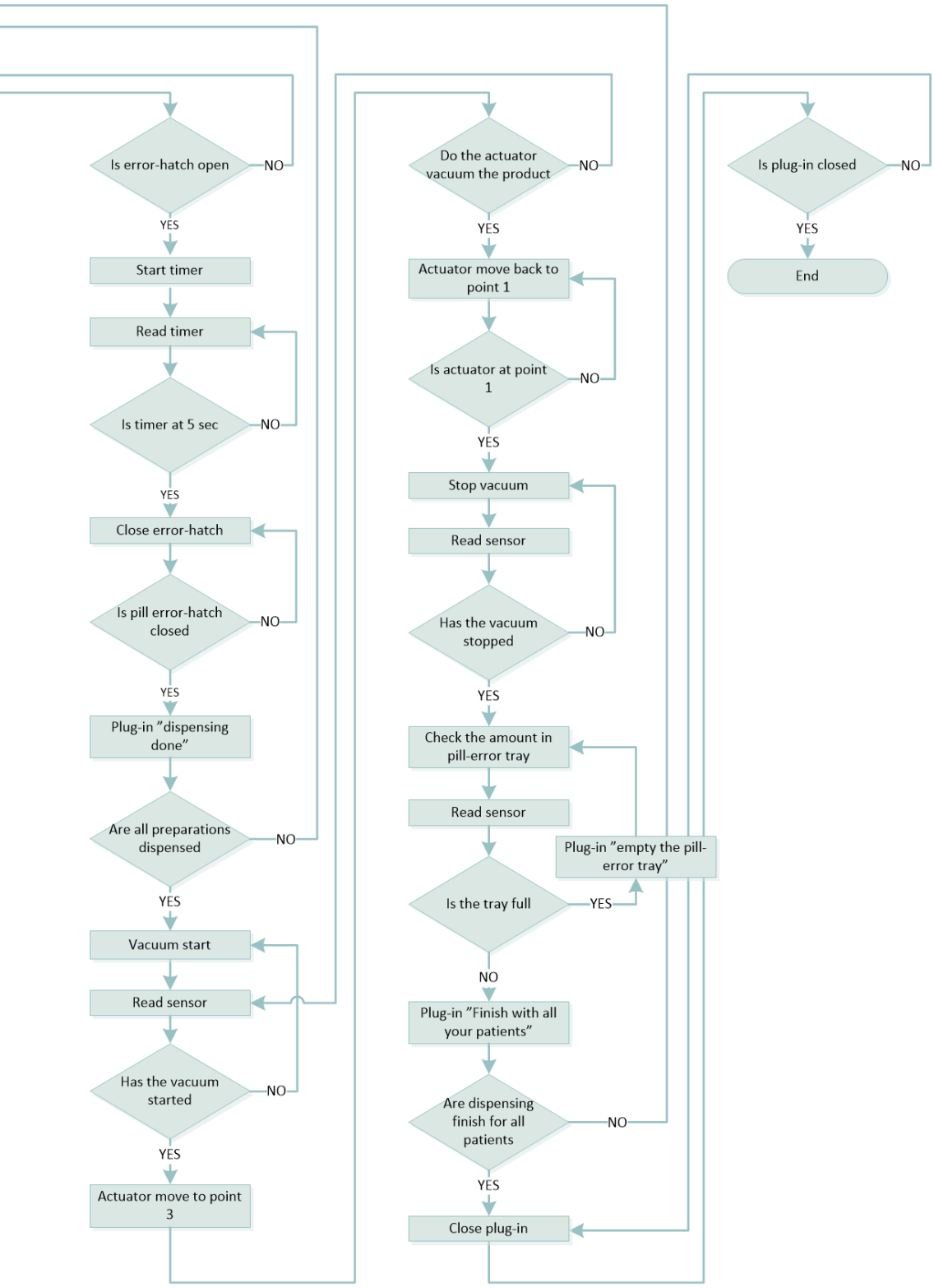
Ill. 102. Internal Block Diagram

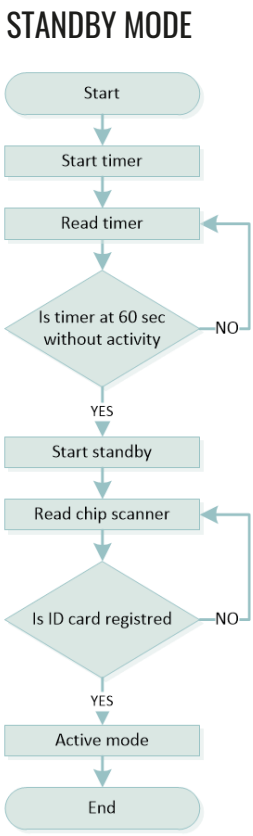
Setting up the diagram gave a broader understandng of the flow within the product and made sure that all components were accounted for. The block diagrams shows the connection between the components that are in the product. This mapping should be used to plan a proof of concept, but also to be able to design the product for assembly regarding the technical components. To get a better understanding of the order of the the electric signals, a flowchart should be made.

THE WORKFLOW

The programming for the product should be outsourced, and in order for the programmers to know how the product works it is necessary to create a flowchart. The flowchart illustrates the workflow of the product, so it is clear which order the different actions should have. The flowchart can be seen as a set of rules that the programmers can use to tell the computer what to do. E.g. a rule could be that the scanner on the side of the product has to check if the barcode on the patient box is scanned - if not, the scanner has to check again until the barcode is scanned. In this flowchart it is only dispensing of pills which is taken into account. The final ideal flowchart for programmers should also show the workflow for dispensing IV fluid, melt pills etc.





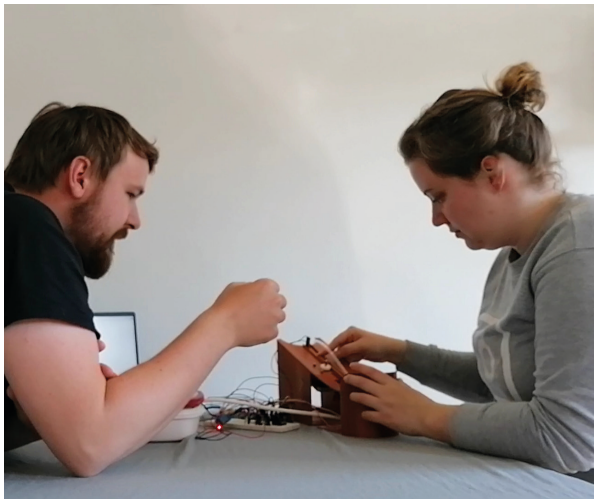


Ill. 103. A Flowchart over the concept process

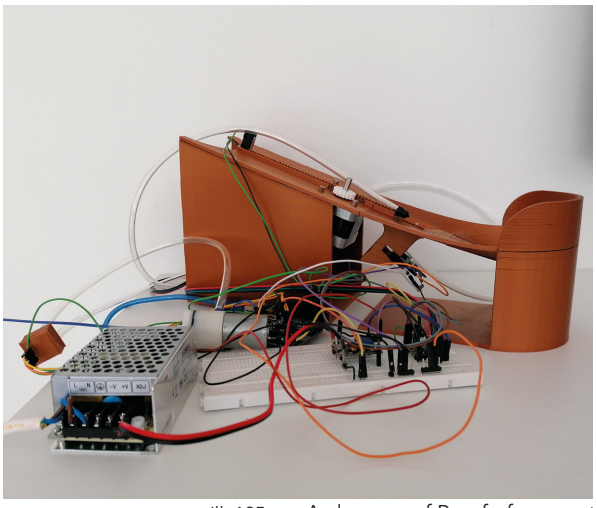
PROOF OF CONCEPT

Now the connection between the different components are defined and the flowchart in place, the next step is to figure out how the concept works in reality.
One of the key aspects within the project has been to ensure the accuracy of the technical construction, and minimize the need to double check the medicine after being dispensed. Here, photo recognition and using weights inside the construction has been discussed.
Through research it has not been possible to determine the total weight of pills, and it is not possible to ensure that all pills of one kind will be the same always because of changes in the preparations in the medicine room constantly happening. Also, different pills can possibly have the same weight and therefore create a source of error e.g. pamol and ipren weighs the same, two pamol and one ipren is needed, but one pamol and two ipren are dispensed. Here, the system will not detect the error and result in a health care error.
Photo recognition is evaluated to be both costly and complex. But also many pills are provided with the same color and shape, which is why it is not possible to always distinguish pills from each other.

Therefore it is wanted to create a proof of concept and figure out how much credibility the product has regarding the current component setup. The proof of concept should validate if the components can dispense all the pills correctly and get as close to 100% secure as wanted. The prototype is built in 3D print, assembled with the needed electrical components already described in the block diagram and afterwards tested with multiple pills in different sizes and shapes in order to validate that it can manage the diverse pills at the hospital.



Ill. 104. Building the Proof of concept



Ill. 105. A close up of Proof of concept

The prototype is used in order to validate if the components can distribute the pills in the cylinder that leads to the dispensing box. Therefore, other aspects of the product are not considered in the test of the prototype. The test is created with a motor attached to an arm, with a rubber tube and rubber membrane at the end. Furthermore, to create the needed vacuum suction, a vacuum pump and a pressure sensor are connected in order to be able to create the needed suction and measure it. (see ill. 105)

The functions and structure of the product is planned and decided by the group during the development of the prototype, but because of safety and lack in experience when assembling electronic components, two electrical engineers have been assisting with assembly and programming of the prototype.

The initial testing with the prototype was done by placing the rubber tubes vertically on one pill to test if the suction was enough. It was possible to move a pill from one point to another, and the sensor which were to register if the pill has been dispensed correctly was working. However, when placing the rubber tube on the arm, where the movement is done by the actuator, it was more challenging. The rubber tube was hard to place correctly, which made it hard for the rubber membrane to reach the pills.

At first it was assumed that it was the vacuum suction that was the problem, therefore another vacuum pump at 12V was implemented instead of the first one on 6V, but that resulted in the the pump taking all the power from the actuator and other components, making the prototype not working. However, the basic principle of moving the pills and dispensing them was working correcty. Adjustments need to be done if working further with the concept could be to e.g. make different positions for the rubber membrane on the arm, so it is possible for it to reach the pills. But also to try out other more flexible rubber membranes to see if that could have an impact.

Ill. 106. Test and building on Proof of concept

In order to figure out whether this concept actually will be faster or slower than the manually way of dispensing as the nurses do now, a small calculation has been done. With the specifications of the chosen components and the distance the pills has to travel in mind, a rough calculation has been done.

Here, one pill is estimated to be dispensed at 12 seconds, four pills at 15 seconds and eight pills (which is the largest load imagined) will take approximately 20 seconds (WS36).

From the tracking of one dispensing in Group journey at page 34-35, it is stated that besides the dispensing time, they also use time on double checking the dispensed medicine.

So when competing with the dispensing time the product will also minimise the need to double check. Therefore, the product initially can compete on time efficiency.

Even though the prototype only has gone through a small amount of testing, the result of the testing was that the component lineup worked as intended. The test with the prototype is only done with one of each component needed, in order to see if the lineup of components and technical concept would fully function. This test has been a low-tech investigation in order to se if a simpified parallel concept could validate the technical direction. In another test, all four actuators should be incorporated to see if they can function together without interferring with one another.
Ideally the testing of components and lineup, should have begun earlier in the design process while multiple tests of more different components would have been possible. This should ensure the concept being optimally accurate and safe. Some of the key components for making the concept accurate, is the rubber membrane that needs to be able to pick up pills, therefore this part needs to be tested further.
It was in the project period, not possible to conclude whether the product was as close to being 100% safe as needed and wished. However, the concept proved to work regarding movement of pills once they were picked up.

The help gained from the electrical engineers proved valuable and helped the understanding of the flow within the proof of concept.

The estimation of needed time respectively on 12, 15 and 20 seconds to dispense a load of pills has been done with the initial knowledge of the components and the setup. A more thorough estimation would be to test a fully functional model by a nurse.

GUIDELINES IN THE MEDICINE ROOM

Regulations in the medicine room are created by the hospital and the State's Serum Institute (SSI). These regulations are made in order to prevent mistakes and secure that the medicine is handled in the correct way. There are many regulations considering medicine, where important and relevant regulations, regarding medicine dispensing and the designed product are listed beneath.

THE GUIDELINES

THERE SHOULD BE NO INTERRUPTIONS DURING DISPENSING OF MEDICINE. IF INTERRUPTED, THE DEPARTMENT SHOULD HAVE ROUTINES THAT SECURE AND CONTROL THE ALREADY DISPENSED MEDICINE.
[Landssygehuset, n. d]

BARCODES MUST BE USED WHERE IT IS TECHNICAL POSSIBLE IN ORDER TO PREVENT ANY MISTRUST BETWEEN PREPARATIONS THAT HAVE DIFFERENT STRENGTH IN THE ACTIVE INGREDIENT.
[Landssygehuset, n. d]

EVERY SURFACE SHOULD BE CLEANABLE AND NOT REFLECT IN RELATION TO LIGHTING.
[Midt, 2019]

LOOSE MEDICINE DUST NEEDS TO BE REMOVED* IN BETWEEN EVERY DISPENSING.
[Region Nordjylland, n. d]

HOW TO ACCOMMODATE THE GUIDELINES

STANDBY-MODE
THE PRODUCT AND PLUG-IN WILL SHIFT TO A STANDBY MODE IF INTERRUPTED. WHEN THE NURSE GETS BACK TO THE DISPENSING IT IS POSSIBLE TO CONTINUE WHERE SHE LEFT OFF.

SCANNER
THE SCANNER ON THE PRODUCT WILL ENSURE THAT THE RIGHT PREPARATION SELECTED BEFORE IT IS DISPENSED.

OUTSIDE MATERIALS
THE PRODUCT NEEDS TO HAVE SMOOTH SURFACES THAT DO NOT REFLECT AND BOTHER THE NURSE.

INSIDE COMPONENTS
A CLEANING PROGRAM IS IMPLEMENTED IN THE PRODUCT, IN ORDER TO REMOVE MEDICINE DUST.

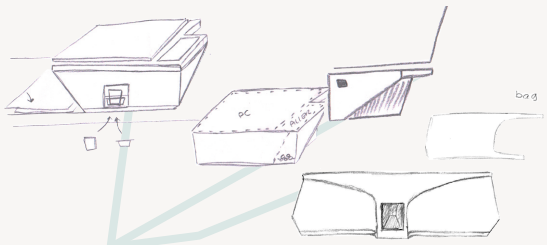
*Based on observations and interviews at Vejle Hospital, Mette, Head nurse at 240, stated that an other medicine device such as a pill divider, the nurses use in the medicine room is cleaned by knocking it on the counter side in order to remove medicine dust. (WS3) In addition, Lise, Head nurse at 9Ø mentioned that removing medicine dust in that way, would be sufficient. (WS12) It can be compared to the product in this project concidering level of cleaning. This means that the cleaning need of the pill divider can be transferred to the final product suggestion.

The list of regulations is guidelines, that needs to be taken into account when designing a concept that helps the nurse dispensing medicine for the patient. The regulations are found through desktop research and interviews with different nurses. These guidelines seeks to be able to set up more requirements for the product and therefore specifiying the needed functions that is to be handled.

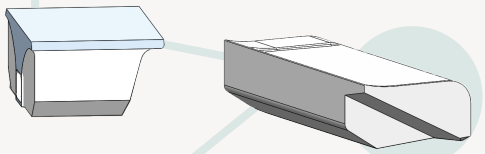
NOT REFLECT LIGHTING IN THE SURFACES
CLEANING PROGRAM FOR MEDICINE DUST

FORM

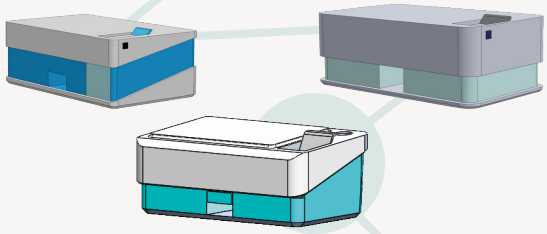
The development of the shape has been done parallel with defining the technical components. The technical components inside the concept resulted in having constraints on the size of the concept, and the test regarding interactions and placement (page 46-47) impacted the dimensions of the concept because the computer needed to have a steady surface to be placed upon. The size of the concept had therefore been specified before beginning the sketching on form which was challenging when dealing with the detailing of the concept. One of the important aspects was that the concept needed to fit into the context, namely the medicine room at the hospital. Besides getting form and aesthetical ideas from the inspiration board (page 48-49), a quick research on different hospital equiptments has been used in the process of designing the final form of the concept (WS31).



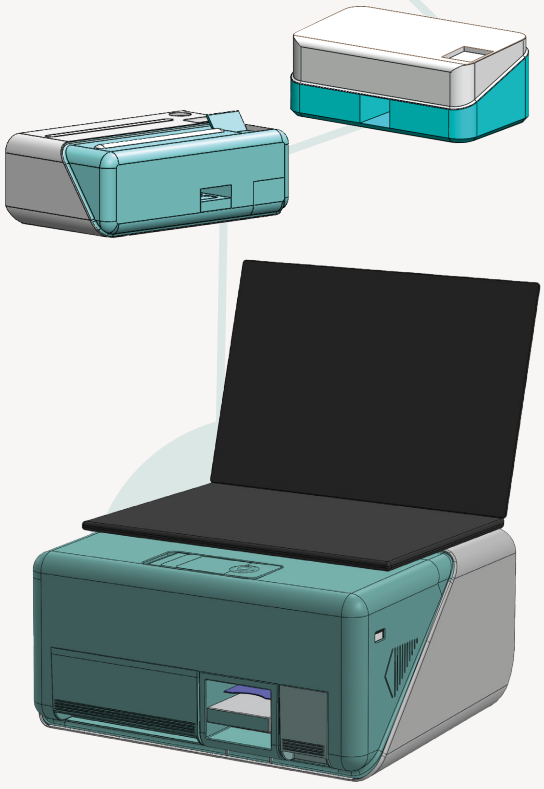
Ideating on the form was initially done by hand on paper, however it was difficult to graphically define the shapes which is why the media quickly changed into 3D CAD modelling in SolidWorks. Because of the technical parts would be centered inside the product, it was possible to experiment with cutting into the form. It was tried to minimize the material use, but also to make the product less squared and give a lighter expression.



It was wanted to create a product that had both organic and geometric shapes but also to give the shape a direction, and lift it from the counter making it less looking like a box. However, the shape and design of the concept did not align with the context expression in the medicine room which is more rigorous and clean.



In another round of 3D modelling, colors were added to the shapes, in order to get a clearer understanding of the interaction surfaces, and it was tried to create a hierarchy. The shape of the concept got fairly neutral in expression, being more squared with rounded corners and edges, creating a rigorous form with a rounded finish.



Ill. 107. The sketching process on the form

The aspect of giving the concept direction was challenging without making it look like a futuristic product. At the same time it was hard to get the interaction areas incorporated into the same surface in order to create a hierarchy. The idea of having some sort of heirachy in the concept was intriguing and different solutions were made in order to get closer to the final form. The initial idea was to have a horizontally oriented diagonal cut, creating the line between the surfaces, but that conflicted towards the interactions, therefore the line was changed to go vertical, splitting the front from the back. The coloured front would indicate where to interact.

The form of the product was very hard to define, while it is a very functional product and the internal component setup needed to be taken into consideration at all time. Since the inside components needed to be defined first the whole process was somehow turned upside down resulting in form and interaction followed the technical aspect. The methods used were very unspecified and unstructured at first, which is imagined to be why it was hard to come up with a good and functional design that fitted the hospital. Therefore, it was wanted to simply it, look at interaction surfaces and create a hierarchy, which made it easier to handle the process and specify the design. Preferrably, the form should have been tested in the real context by the end users in order to validate the expression and functionality of the concept. With the form, interaction and technical principle initially specified, the next step was to figure out how these aspects were linked together.

INTERACTION AND FUNCTIONALITY

The placement of the interactions on the concept has been defined with the help from different nurses earlier in the process (WS23), therefore the placement of the interactions has been an influencing factor when designing the form and shape of the concept. Every interaction is placed on the front area of the concept, and is indicated both with a color change and hierarchy in the surface. The way the user is interacting with the different surfaces is placed in the top and in front of the computer. In the previous phase the medicine input was placed on the side of the computer, but it was wanted to create more room on the side of the product which was an important need from the users. Furthermore, the technical components could be placed more central in the product if the overall shell of the product could be squared rather than rectangular. The new interaction therefore aligned better with the technical setup. In order to be able to clean the product properly, some of the parts can be removed and put into the dishwasher at the hospital. There should be two of each part so there will always be one clean part available in order to use the product. It was hard to know how interaction surfaces with function, therefore it was wanted to test one af the parts considering tactility and functionality - here a 3D print of the pill input was created. The pill input was chosen here because of the complexity of interactions were it was needed to test out the tactility and the understanding thereof. The test was conducted on own body, but also a female nurse and a man gave their insights regarding the interactions. This research validated the interaction surfaces which is why, they are transferred to the other parts whitin the concept. The test showed that minor changes would be preferrable to the hight of the bumps. (WS38)

MEDICINE INPUT

The tray where the nurse dispenses the medicine is placed on the top of the product in front of the computer. The handle for the medicine input tray can be flipped and is lowered into the surface in order to make the top surface smooth, when the product is not in use, but also to close off the top in order to minimize dust in the pill input. This part will be pushed and pop up where it is afterwards possible to turn it around. A structured surface is added onto the grip which makes it comfortable and intuitive to handle. This design should result in the nurse knowing how to grab the tray handle and load the medicine into the product.

DRAWER

In order to utilize the whole shell of the product, a drawer for extra equipment is added. Extra inserts for the product can be placed here, but also e.g. dispensing glasses can be stored in the drawer. The handle is visualised by the grooves that indicate the interaction surface. It is hidden in the bottom, in order to create a smooth surface on the product front but also in order to minimize the possibility of collecting dust.

DISPENSING BOX INPUT

It should be possible to both dispense into a dispensing box with four holes for the four times at the day and a dispensing glass. Since the two are different in height an insert is needed. The insert has two positions fitting the two different containers, it can be flipped around and match the need the nurse has. The insert can only be oriented correctly because of the shape of it, but also a grib surface indicate the orientation of the insert.

LEFTOVER MEDICINE TRAY

The leftover tray is used for wrong dispensed pills and can be emptied when being full. Also here, the handle is visualised by the grooves that indicate the interaction surface. The tray is made in transparent plastic in order to provide feedback when the tray is full.

Ill. 108. The final form and interactions

The function for pop up the pill input in order to turn it, will use the same mechanical solution as already known from kitchen cabinet doors where, if pressed they will pop out so it is possible to open them. It has been challenging to find a specific component that match this function in the small scale that is needed in this project. A parallel will be drawn to how SD cards are inserted and ejected from the SD card reader.

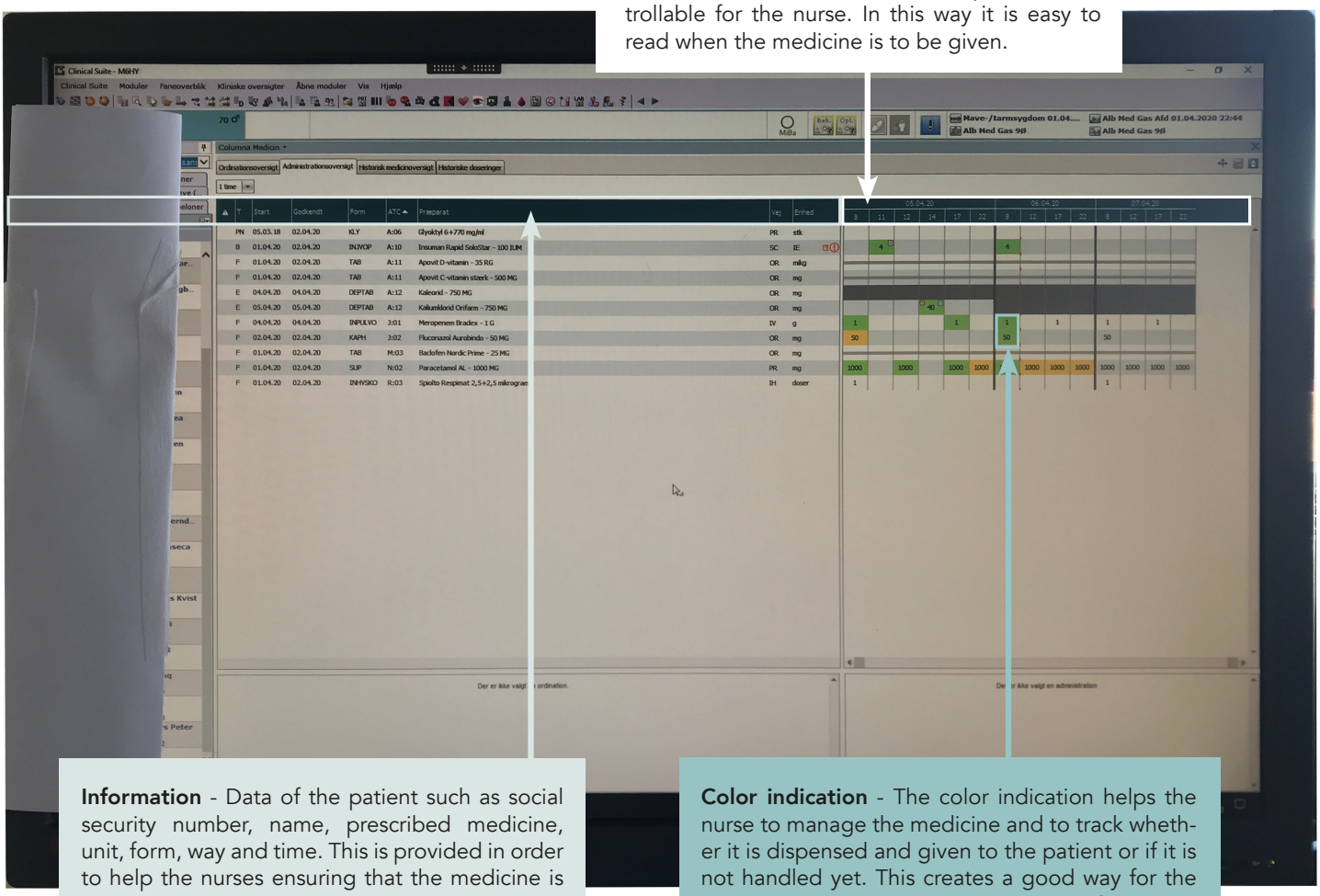
A plug-in should create the link between what the technical components do and give digital feedback according to the users interaction. Furthermore, the plug-in should retrieve the data needed from the computer in order to get all the patient information needed. The interactions on the concept will be further described and visualised in the implementation phase.

TACTILE INTERACTION SURFACE FOR GRIPPING AND FEED FORWARD

PLUG-IN

In order to get the product connected to EPJ, it is necessary to create a plug-in for the computer. This plug-in must go through the EPJ, when the nurse dispenses the medicine for the patient. Furthermore the plug-in will collect data from pro.medicin which hold data regarding generic and analog medicine in order to validate a substitution made by the nurse. It is needed to sketch on the plug-in in order to figure out what the plug-in should look like and how it should bring information for the nurses. The first step is to research EPJ that the nurses use currently. This is done in order to figure out which functions and informations needs to be transferred into the new plug-in when designing it.
There will exclusively be looked at the graphic aspects of the plug-in, which frames to appear on the computer screen and in which order. The programming part of the plug-in will not be looked into in this project.

A schedule with the time - This is to make it clear for the nurse for which time at the day the patient is to be given the medicine. It is put into a schedule in order to make it simple and controllable for the nurse. In this way it is easy to read when the medicine is to be given.



Information - Data of the patient such as social security number, name, prescribed medicine, unit, form, way and time. This is provided in order to help the nurses ensuring that the medicine is given correctly with considerations to the 5R's.

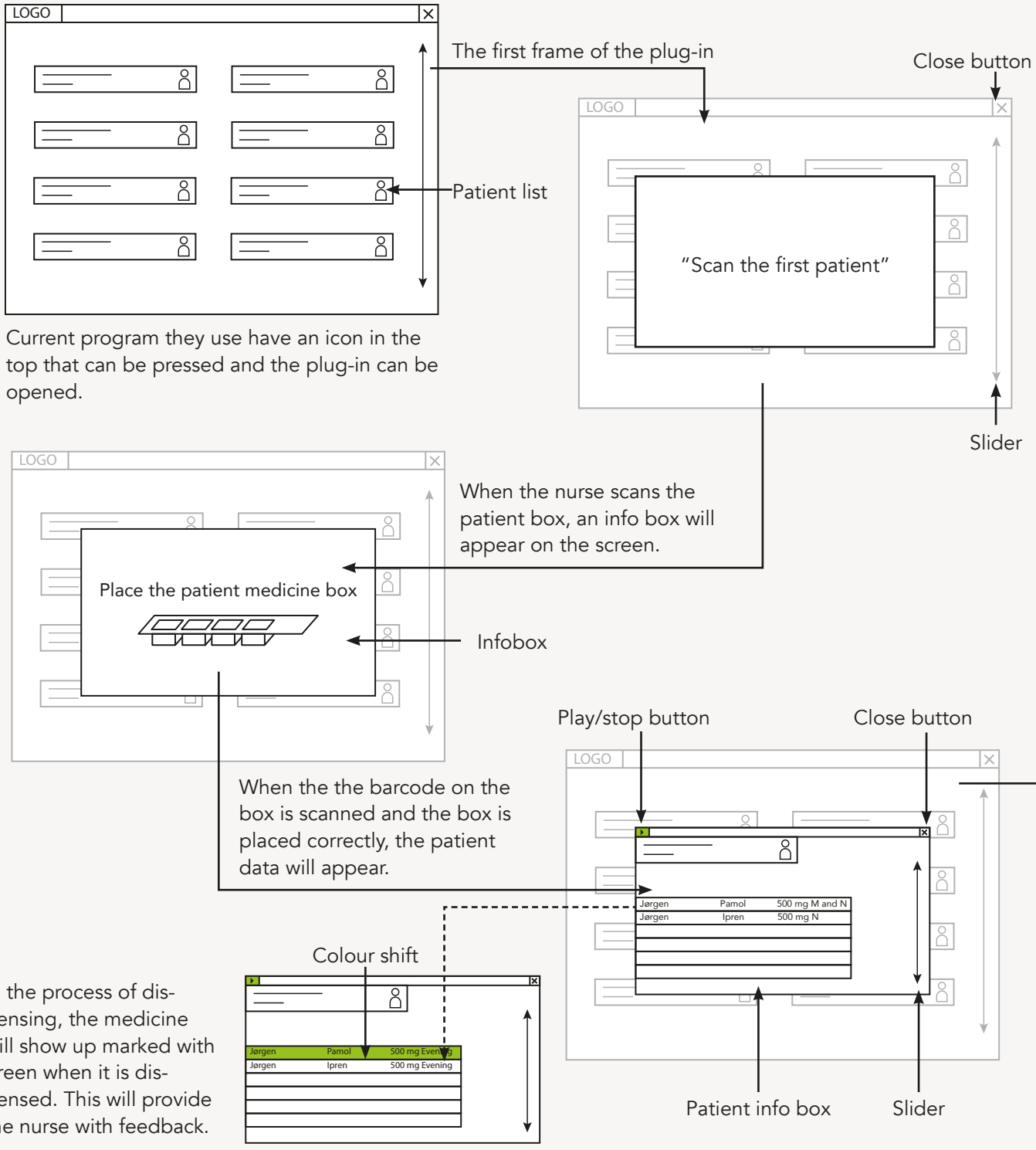
Color indication - The color indication helps the nurse to manage the medicine and to track whether it is dispensed and given to the patient or if it is not handled yet. This creates a good way for the nurse to quickly check up on the status of the medicine chart.

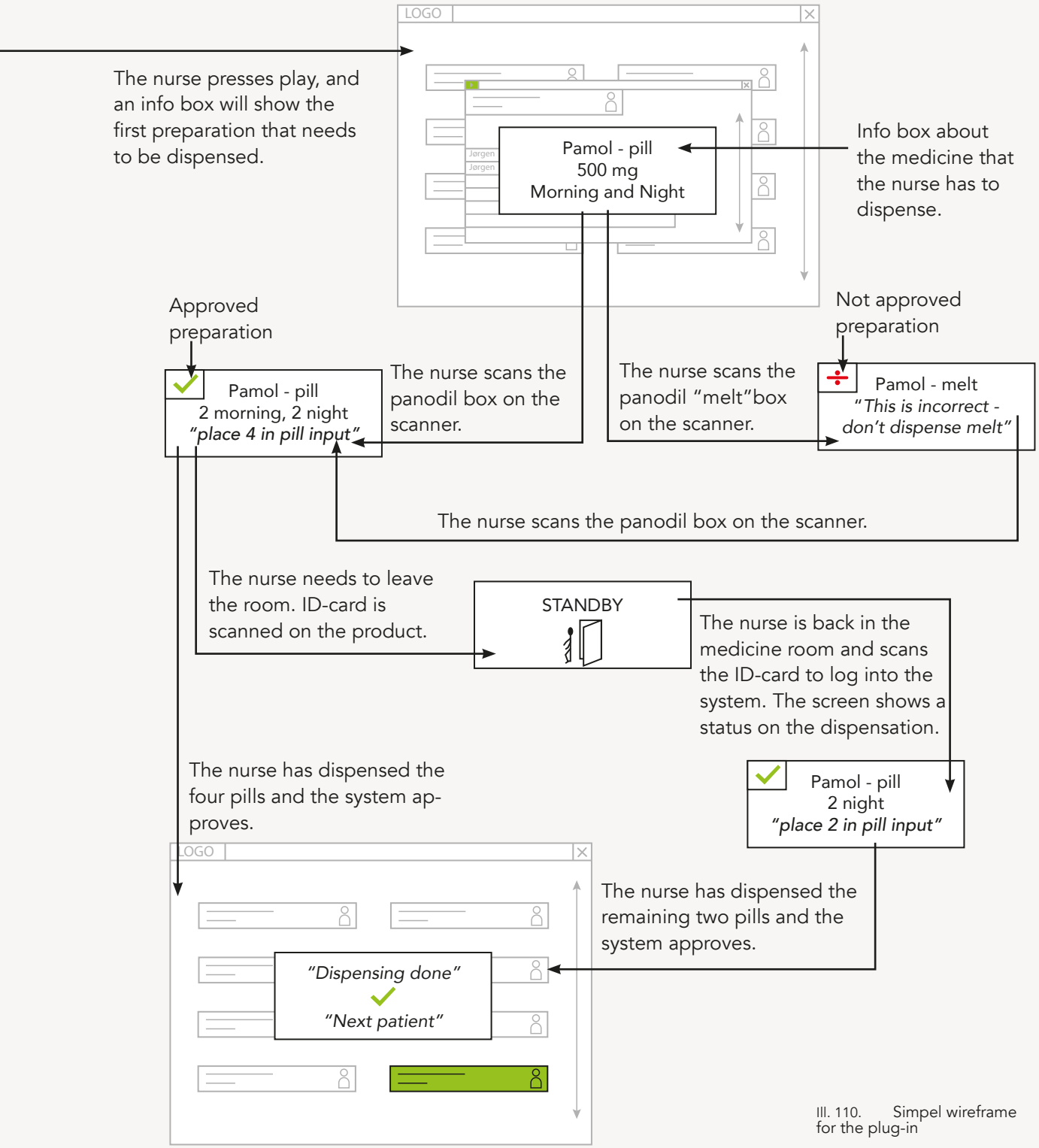
Ill. 109. EPJ screenshot

TRANSFER DATA FROM THE EPJ

THE PROCESS

The found features to transfer from the EPJ program to the plug-in will in this step be incorporated. In order to figure out how the plug-in should be designed and which steps and frames it needs to have included, a simplified wireframe is made. Here informaion design is looked into in order to decide the needed data for each frame, and what needs focus. The navigation is looked into regarding how to move from a frame to the next and how to move through the interface intuitively and simple. The interface is looked into regarding the needed functions, and how they are placed on the frame. This method is chosen in order to make sure data, function, placement and interactions are considered for each frame. [redWEB, 2020]





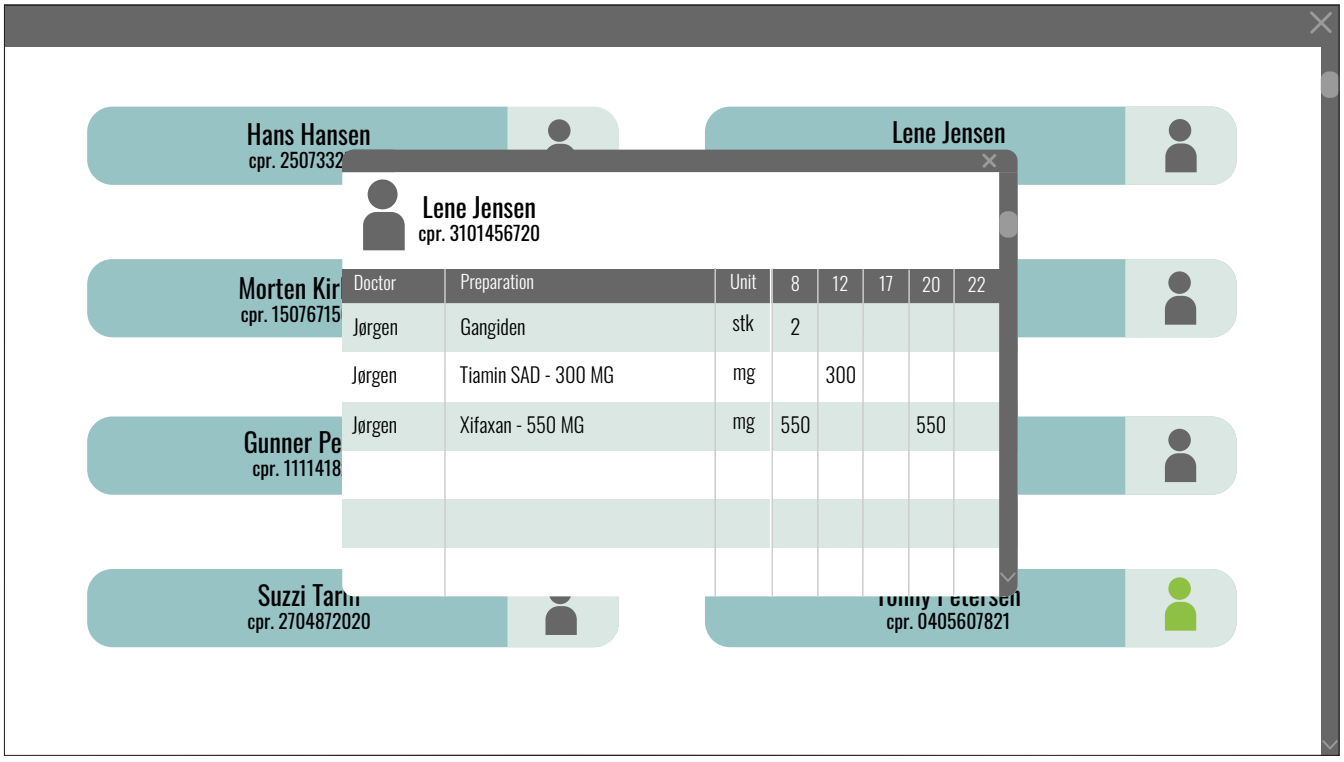
Ill. 110. Simpel wireframe for the plug-in

If the wrong preparation is selected the plug-in will alert the nurse. But when for example, ipren is being replaced with ibuprofen it is okay since they have the same active ingredient. The plug-in will then approve and calculate the dosis needed of the new preparation.

All data is retrieved from Pro.medicin, because it has a complete register of which types of medicines that can substitute each other and which ones it can not.
Pro.medicin will therefore speak together with the designed plug-in.

In order to make the interface visual and understandable, two different design suggestions are made. These suggestions draw inspiration from EPJ that the nurses know and uses every day. The final plug-in suggestion can be seen in the product report.

When designing an interface it is important to consider colors applied in order to ensure the correct contrast ratio. It is also important to ensure the font that is used is appropriate and possible for all to read.



III. 111. Two suggestions in the process for designing the final plug-in

DESIGN FOR MANUFACTURING AND ASSEMBLY

It is important to take into consideration which production methods and materials are most fitting for a product before specifying the shape and the overall construction. This section will focus on how to select a fitting production method and how to implement thoughts about design for assembly and design for manufacturing into the product design.
The goal of this segment is to specify the detailing of the product and give an understanding of the overall construction and material use (WS32).

MATERIAL

Polyphenylsulfone (PPSU) is already used in a wide variety of products for the hospital and meets the criteria of being food grade, which is an important aspect when dealing with medicine being in contact with the product, which the patients later ingest.

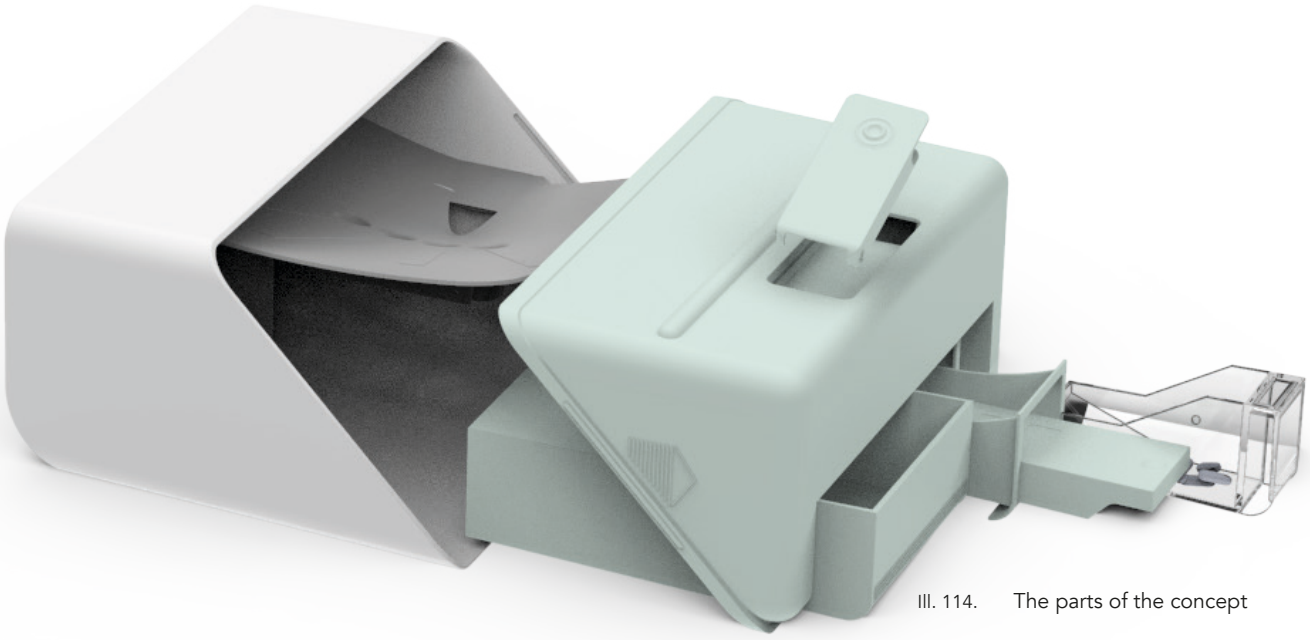
In the medicine room the product will be exposed to a lot of different hands every day, and therefore needs to be cleaned frequently. PPSU is very resistant towards the chemicals in cleaning articles and hand sanitizer. In addition, the material has a high tolerance for high temperatures, which means that detachable parts of the product can be cleaned in a dishwasher. In that way it is possible to ensure that there are no bacteria on the product. The material is used throughout the whole product. [Lefteri. C, 2013 [1]] The material however has a low UV-resistance, but this is a minor problem since the UV radiation from the sun is not strong enough through glass windows to have an effect on the material. It only affects the lack of possibility of cleaning the product using UV lighting. [PPSU - Holm & Holm A/S, no date]

Ill. 112. Hospital product made of PPSU

Ill. 113. Chemical structure for PPSU

PRODUCTION

The construction of the product has been specified through an iterative process where many functions have been crucial to incorporate in order to get the wanted product construction and functionality. Since many parts per product is needed, and having a high complexity of each part, it has been hard to make the investment cost on tooling for the production low. It is evaluated that the production method for all components will be injection molding, except for the dispensing box insert that will be rotation molding because of its geometry of being hollow (See all parts, their geometry and production method in the technical drawings).
Injection molding is most fitted when producing a high number of units as in this project where an estimation of at least 5.000 products are needed (WS9). -
[Lefteri. C, 2012 [2]] Injection mold tooling will be a big investment, but will allow the needed complexity of the parts designed. See the considerations done on different production methods in (WS33). The construction of the shell and the actuator plate and back shell should allow all electronic components to be fastened onto it and will therefore function as the base of the product.

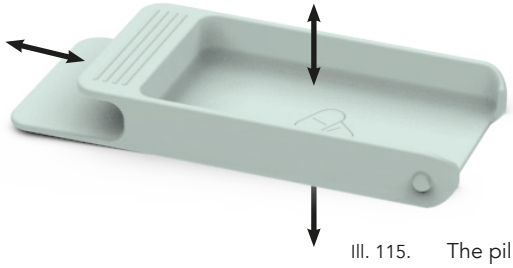


Ill. 114. The parts of the concept

DESIGN FOR MANUFACTURING

In order for the product to be produced using injection moulding and rotational moulding, draft angles are crucial in order to release the parts from the molds when formed - the draft angles in this case are one degree. Also, injection molding sets requirements for the overall construction in order to be able to create the part geometry with the least amount of plastic material and having a uniform wall thickness throughout the product.

Some of the parts will need to have a more complex mold for injection molding with more pull directions, since for example holes in the front shell for the pill input, the scanners and the grooves in the side of it, can not be done in the molding process without additional pulls.
Another example of a part like this can be the pill input tray which need three pull directions.



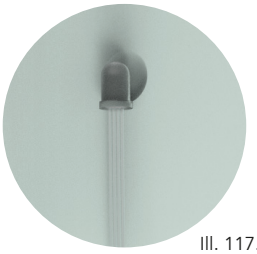
Ill. 115. The pill input

DESIGN FOR ASSEMBLY

The project aims at creating a product inspired by circular economy, where no gluing or mix of materials are used in order to secure the possibility of the reuse of materials and components. Therefore, for assembling the electrical components to the main shell, screws are used. This makes it possible to fast assemble the components but also easily replace parts or components when the product breaks or ends its life cycle.
Walls for fastening electrical components and strength are added on the shell component.

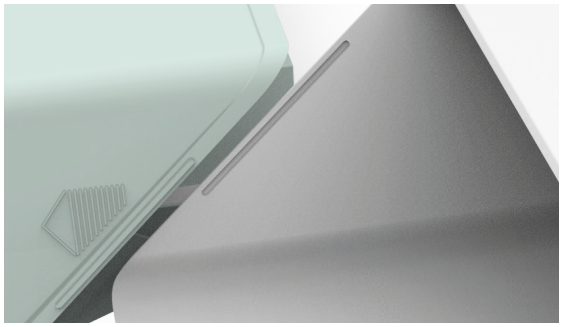
Ill. 116. The back shell

It is wanted to transilluminate the shell where the LED will indicate what status the product is in (On/Off/Standby). It needs to be very thin at the area where the LED needs to be visible.



Ill. 117. The LED ligth

After the assembly process, it should be possible for the nurse to open up the product and clean the inside of the product where the pills are in contact with the product. The front and back shell closes off the entire product and is pressed together with a click-mechanism as shown on the right.



Ill. 118. The assemble of the front and back shell

Throughout the designing of the individual parts, design for assembly has been taken into consideration in order to be able to assemble and disassemble the product easily with the goal of being able to replace parts or recycling old parts in the product.
Problems occurred during the process, while many parts needed to fit together and many interaction surfaces were in play, they therefore all needed attention in order to work. It was not possible to create a solution for the slots that the medicine input moves in, since it would not be possible to assemble the parts using screws. This part is glued onto the shell, therefore it is wanted to look more into the design of it before the exam and try to come up with a solution where is it possible to detach the part and make it possible to put it in the dishwasher for cleaning. The next step was to implement all the parts and the electrical components in relation to the block diagram from page 63.

DESIGN DEMANDS

DEMANDS

NO.	METRIC	UNIT	MARGINAL VALUE	IDEAL VALUE	SOURCE (PAGE)
1	Cross section of rubber membrane hole	mm^2	Ø: 2	Ø: 2	Calculation for suction (60)
2	Soft rubber membrane	binary	-	-	Calculation for suction (60)
3	Actuator stroke	mm	100	97	Technical drawing (detail drawing) NO. 10
4	Actuator speed	m/s	0,5	> 0,18	Group journey (35)
5	Vacuum suction	kPa	220	83	Calculation for suction (60)
6	Plate angle	deg.	20	20	Test of angle (60)
7	Plug-in connect to EPJ	binary	-	-	Understand the product (50)
8	Plug-in connect to Pro.medicin	binary	-	-	Plug-in (72)
9	QR scanner distance	mm	500	> 20	Components (62)
10	Barcode scanner distance	mm	500	> 20	Components (62)
11	RFID tag reader distance	mm	0-50	< 80	Components (62)
12	Vacuum cleaner	binary	-	-	Components (62)
13	Power supply	Volt	12	12	Components (61)
14	Activation waiting time for standby mode	sec	60	60	Understand the product (50)
15	Time the hatch for extra pills is open	sec	5	5	The workflow (64)
16	Product memorize dispensing status	binary	-	-	Understand the product (50)
17	Dispensing time for eight pills	sec	20	19	Proof of concept (67)
18	Food grade material	type	PPSU	PPSU	Material (76)
19	Non reflecting material	type	PPSU	PPSU	Guidelines in the medicine room (68)
20	Possible to desinfect product	type	PPSU	PPSU	Guidelines in the medicine room (68)
21	Removable front (cleaning)	binary	-	-	DFM and DFA (77)
22	Overall size of product	mm	W:425, H:200, D:360	> W:380, D:260 > D:600	Mock ups and interactions (46)
23	Pill input size	mm	W:95, H:17, D:55	> W:50, D:50	Mock ups and interactions (46)
24	Room for dispensing box size	mm	W:76, H:64, D:243	> W:60, H:14, D:215	Group journey (35)
25	Room for dispensing glass size	mm	W:76, H:64, D:243	> Ø:38, H:40	Group journey (35)

WISHES

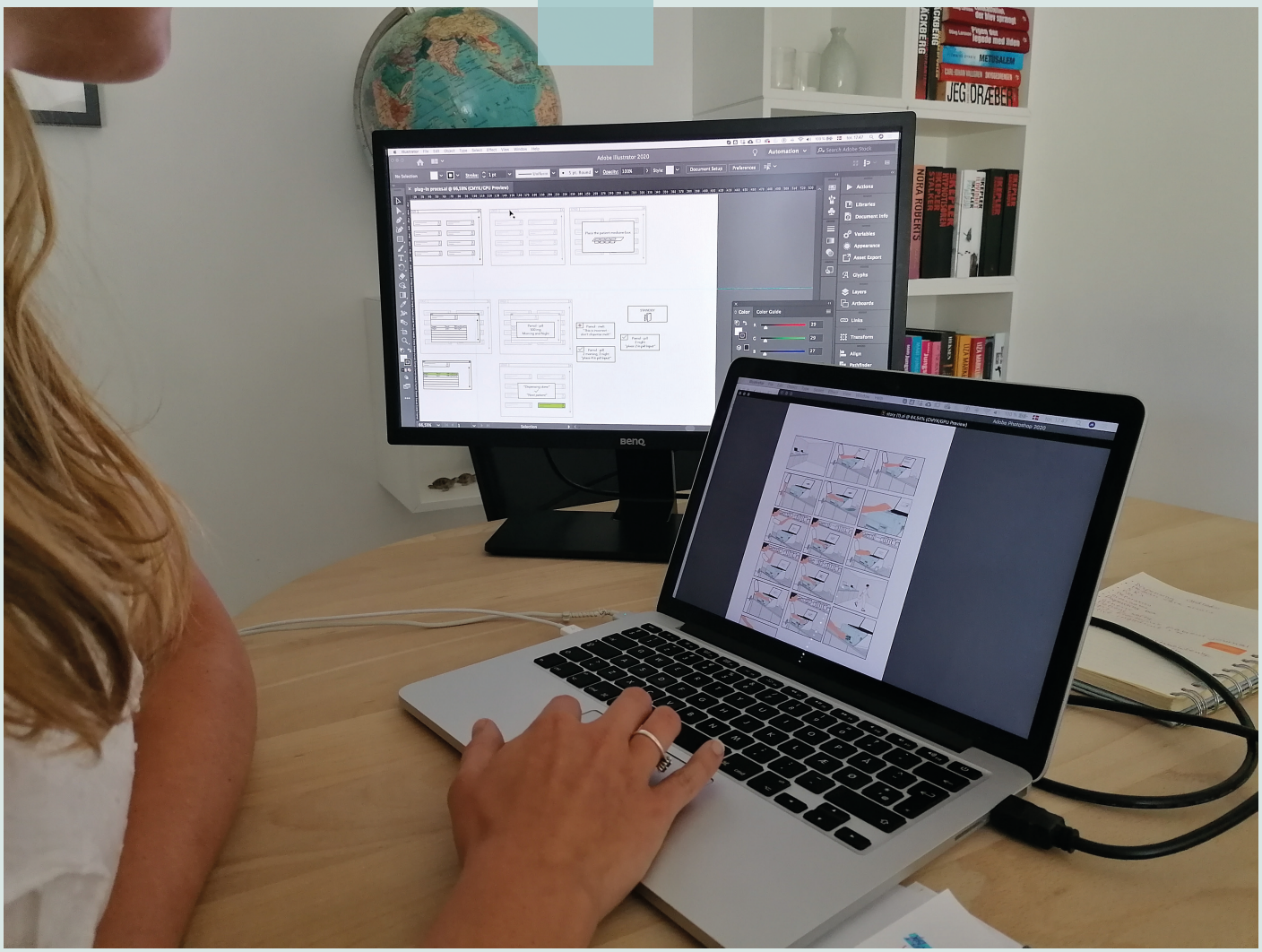
NO.	METRIC	UNIT	MARGINAL VALUE	IDEAL VALUE	SOURCE
1	Product placed under computer	binary	-	-	Mock ups and interactions (46)
2	Nurse can overwrite the plug-in if necessary	binary	-	-	Understand the product (50)
3	Possible to turn pill input (dust)	binary	-	-	Form (69)
4	Tactile surfaces at gripping areas	binary	-	-	Interaction and functionality (70)
5	Placement of pill input centered in top/front	binary	-	-	Form (69)

SUMMARY OF THE PROJECT

The product would primarily be used and cleaned by the nurse

The product will help the nurse by ensuring the 5R's, and dispense medicine in the patient's dispensing box.

The product will be placed in the medicine room, where only the nurses will have access.

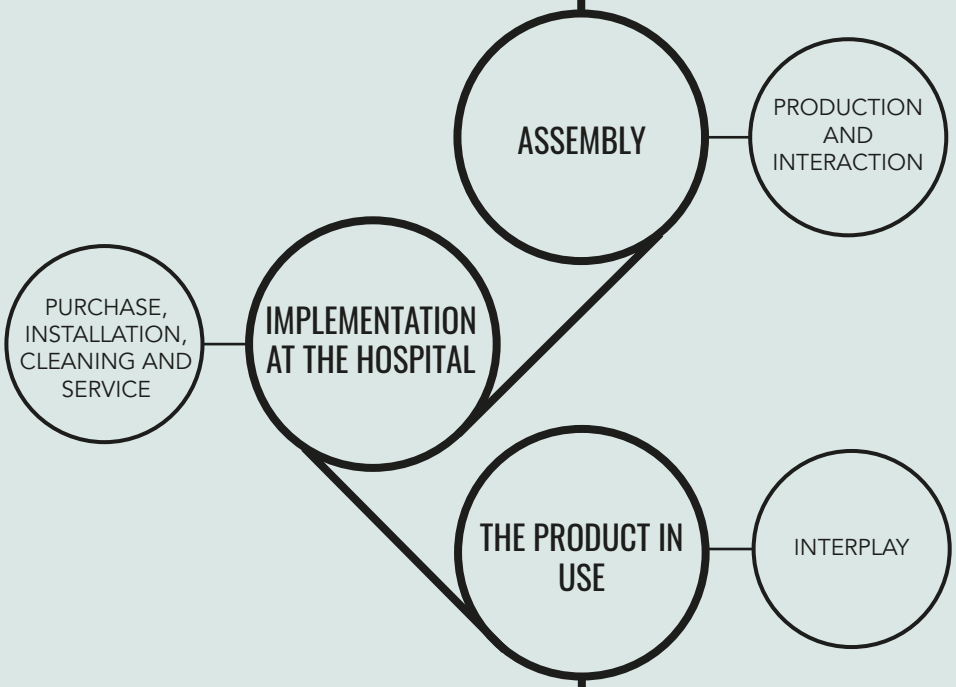


Ill. 119. Team member working on the interplay

3.1 IMPLEMENTATION

Now that the product is detailed this phase will take a look at the implementation of the product. How the product is build regarding the produced parts, the chosen electrical components, the interactions needed and the programming of both the product and the interface for the plug-in.

PROCESS OVERVIEW



Ill. 120. Process overview for the 3.1 Implementering Phase

IMPLEMENTATION

COMPONENTS, PRODUCTION AND INTERACTION

The implementation of electrical components, produced parts, and interactions are gathered in this section. On the picture below, the shell and the plate for installment of actuators are shown. On the parts, almost all electrical components are fasened. Also, the interactions are highlighted in this section, where they are shown in relation to each other. In order to see how the product fully functions regarding technical aspect, see video 03 -implementation - technical.

VACUUM PUMP

The vacuum pump creates the needed vacuum in the tube which is conected to an actuator. It is fastened with screws onto the back shell. One for each actuator arm is needed.

ACTUATOR

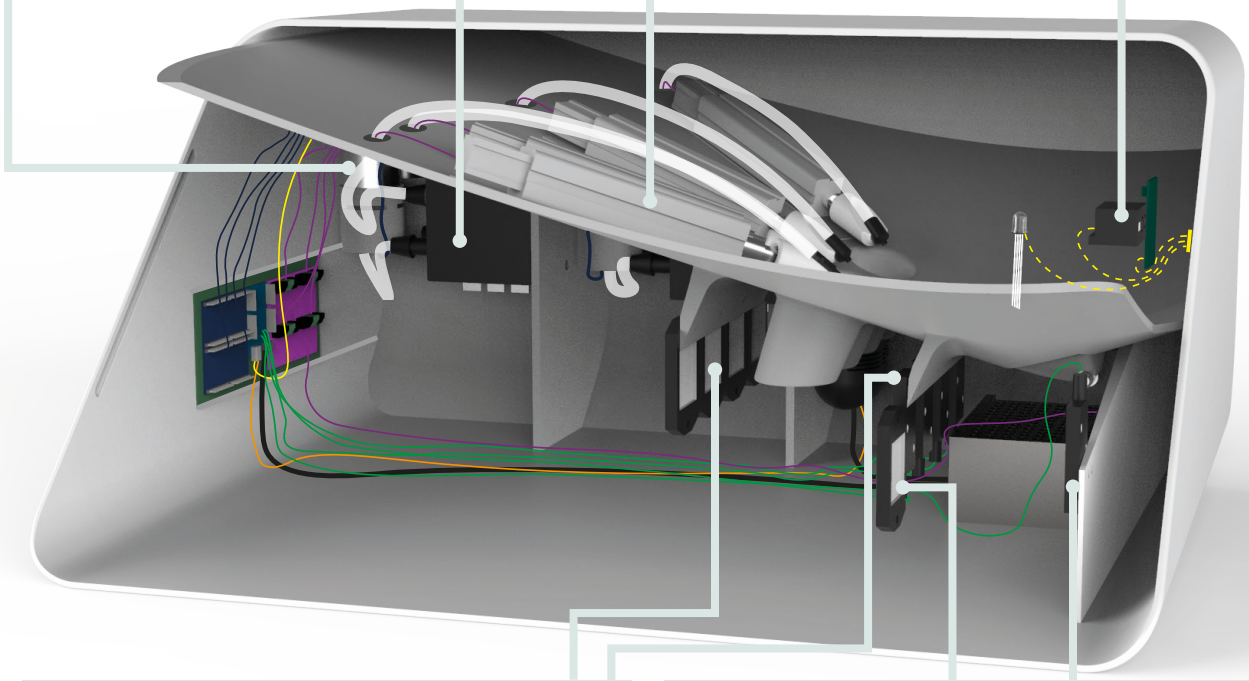
The actuators are placed on top of the funnel shaped actuator plate and fastened with screws from beneath. Each actuator is oriented in a way so the four actuators will not collide when operating.

PRESSURE SENSOR

The pressure sensor for measuring the vacuum suction is placed next to the vacuum pump also using screws. One for each vacuum pump is needed.

QR, BARCODE AND RFID TAG READER

The QR and barcode scanner, and the RFID tag reader is placed on the upper corner of the product. The user has easy accessibility when scanning the personal ID card, the patient box and the medicine boxes. Power wil be supplied through magnetic conduction.



LASER-GRID SENSOR

The laser-grid sensor detects if a pill is dropped into the compartment in the dispensing box. It is a two part component with a laser sensor and a reflecter, which are both mounted onto the actuator plate using screws.

LASER SENSOR

The sensor measures whether the leftover tray is almost full. A sensor is placed on one side of the tray and a reflecter on the other side in order to send the laser through the hole of the tray. When the sensor detect the pills, it needs to be emptied.

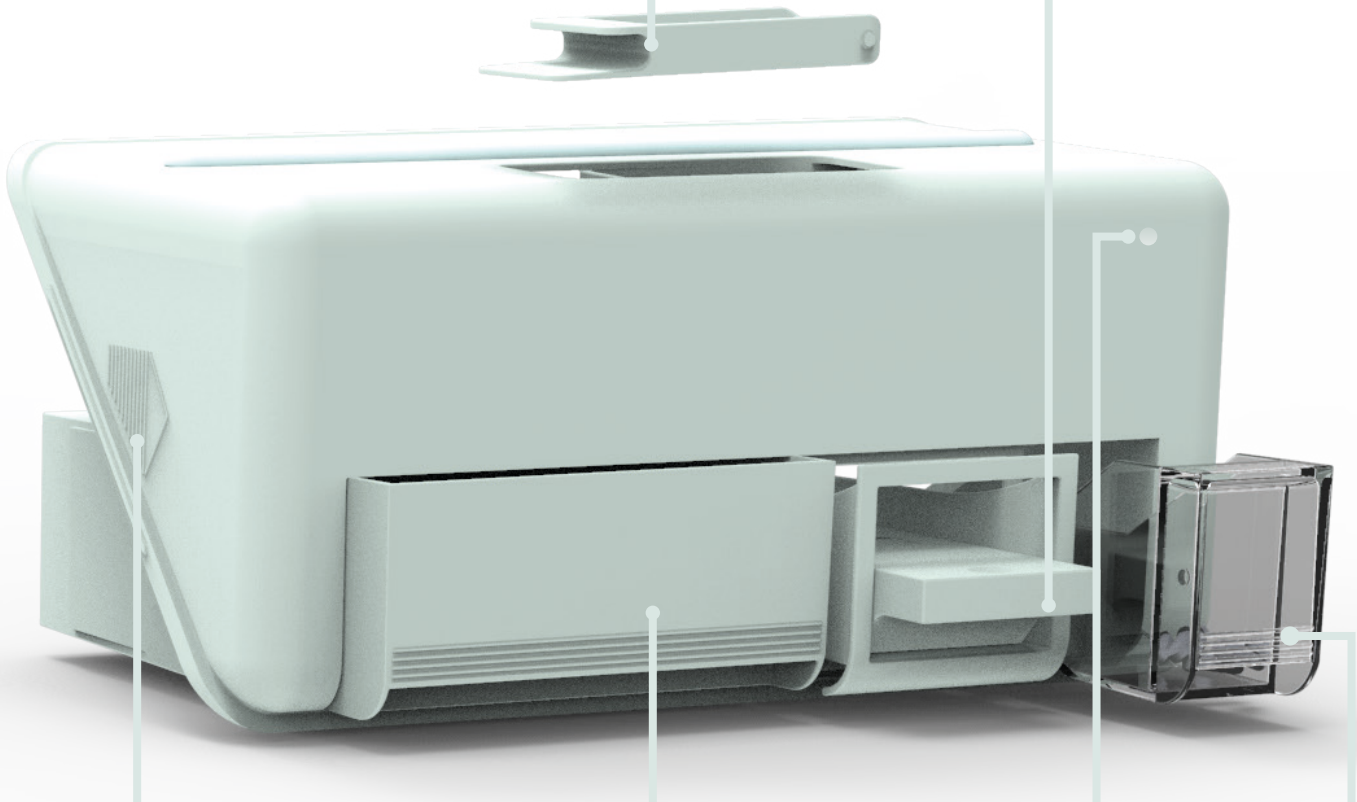
Ill. 121. The back shell with the electronic components

MEDICINE INPUT TRAY

The tray for medicine input has two positions. When the product is not in use, the bottom of the tray works like a lid, leaving the surface smooth with no holes where dust can enter. When pressing the circle in the tray, it will pop up, and it can be turned around and work as the medicine input. An ingravement showing two pills indicate the placement of the medicine.
When the user has inserted the pills and checked for any foil pieces, the tray is lifted to an angle and the pills fall into the product. On the left end of the tray is the handle that the user interacts with. The handle is provided with grooves to show where to grab.

INSERT FOR DISPENSING BOX AND GLASS

The insert has two positions, which means that it can hold a dispensing box on one surface and a dispensing glass on the opposite surface. The insert can only be placed with the gripping handle pointing outwards and therefore ensures it is always oriented the right way. It has a dent in the surface, which indicates where the user should grab when turning it around. When the insert is put into place it will make a click, and the nurse will get feedback, knowing the insert is in place.



Ill. 122. The front shell with the interactions arears

TACTILE GRIPPING FOR OPENING THE SHELL

On each side of the front shell, interaction areas are placed. When the product needs cleaning, the user can place the hands on the grooves and press slighly towards the center of the product in order to release the front from the back. The grooves indicates the direction of pull.

LIGHT

On the upper right corner on the front of the product, there is a small light transilluminating the material, which indicates when the product is on or in standby mode. This provides feedback for the user.

TRAY FOR INSERTS

The tray is for any extra clean parts for the product. The tray can also be used for extra storage for other things in the medicine room related to dispensing medicine. e.g. dispensing glasses and lids. The tray has a handle on the lower front where the user can interact with. It is indicated with grooves creating a good grib for the user.

LEFTOVER TRAY

The leftover tray is clear in the material, which makes it possible for the user to see through it. If any medicine should end up here, the user can see it and empty the tray. This tray also has a handle on the lower area of the front and grooves which indicates that it is possible to interact with the tray.

In order to see how the product fully functions regarding interactions, see video 04 -implementation - interaction. With the components and interactions in place, the next step in the process is to define and get an understanding on what happens in the product and plug-in, when the user is interacting with the concept. Furthermore, it is wanted to specify how to clean the product and to install it in the medicine room.

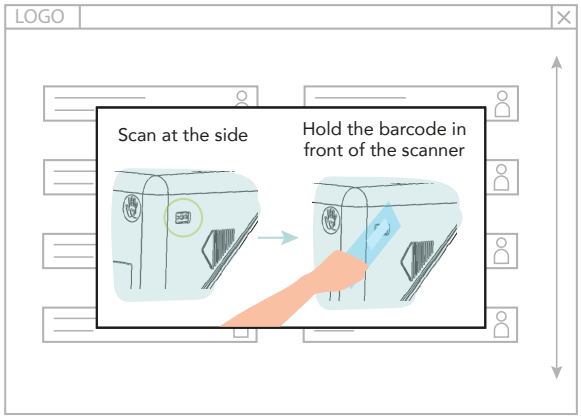
THE PRODUCT IN THE REAL CONTEXT

Now it is clear how the technical aspects is implemented in the product, the next step is to investigate on how the product can be implemented on the individual departments, where the product will be used. From desktop research [Region Nordjylland, n. d] and interviews with different nurses it was possible to set the needs for cleaning of the concept (WS3 and WS12). Furthermore, Head nurse Lise at 9Ø provided a contact to the economist for the department, in order to provide understanding regarding buying and installing clinical products at the department (WS34).

BUY AND INSTALLING THE PRODUCT

When the head nurse decides to buy the product for the department, the order must go through the clinical manager and the economist for the department, to make sure that there is enough money in the budget. Next, the order is sent to the department of purchasing, where the employees handles the order. (WS34 and WS35)
When the product arrives to the hospital, a technician from the technical department in the hospital deliver the product to the medicine room. In addition, the technician will make sure that the plug-in is installed on the computer and that it is correctly connected to the product. - In order for them to install it properly, there is a user manual in the package.

When the nurse is going to use the product, it must provide the user security. Therefore, when using the product the first time there will be a thorough guide through the interface of the plug-in.
E.g. when the nurse is to scan the patient's dispensing box, the plug-in will show where the scanner is placed and a hand scanning the barcode on the patient box' lid. see ill. xx



Ill. 123. Plug-in showing the process for the first time scanning the barcode

If the nurse wishes to go through the guide another time, it is possible to go through it again. In addition, the interface will inform the nurse, every time dispensing, exactly which step the nurse should take in the process. In order for the nurse to feel secure regarding the information that is given during the dispensing, the plug-in will collect data from Pro.medicin. which is the database that is already used in the hospital.

CLEANING OF THE PRODUCT

As described before, it should be possible to clean the product. A small vacuum cleaner is implemented onto one of the actuators in order to be able to clean the inside for medicine dust.
As described in the flowchart, the vacuum cleaner will clean the product from possible medicine dust after each dispensing. Furthermore, the hatch for removing medicine dust will open and secure that any remaining pills, will disappear.
The parts being in contact with pills can be removed and put into the dishwasher. Here extra parts are provided in order to enable using the concept at all times.
Also, it will be possible to clean the product with disinfecting alcohol. It is a conscious choice to elliminate any sharp corners and edges inside and outside the product, to make sure that the nurse can get easy access to when cleaning it.

ERRORS REGARDING THE PRODUCT

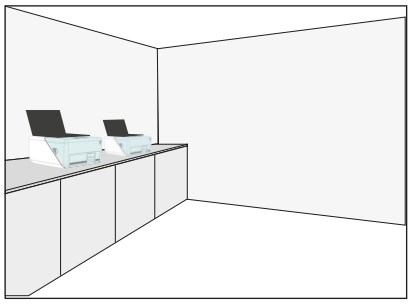
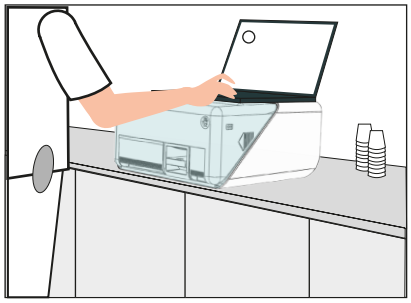
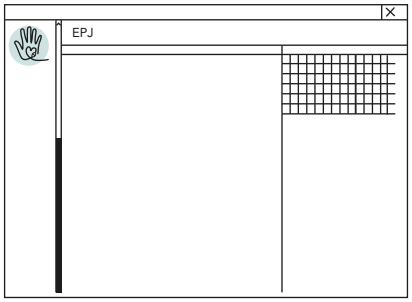
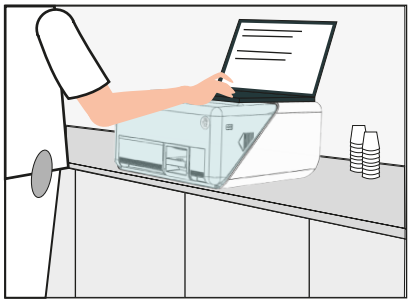
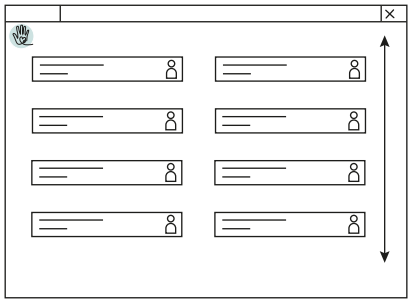
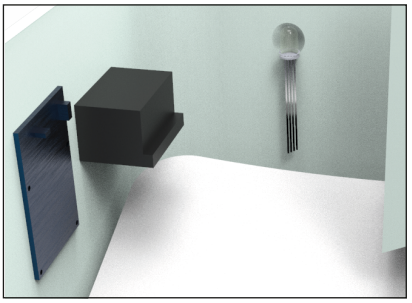
Any product on the market can at some point signal errors or break. Because of that, it is necessary that the nurse can contact the technical department in the hospital in order for them to fix the possible problems. The technical department therefore will get to know how to fix it.

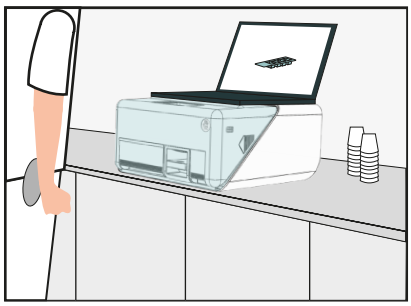
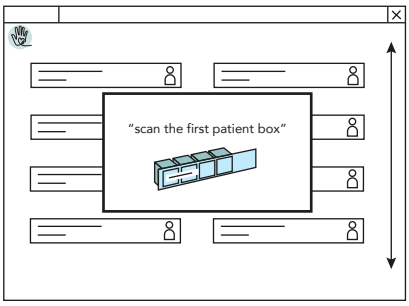
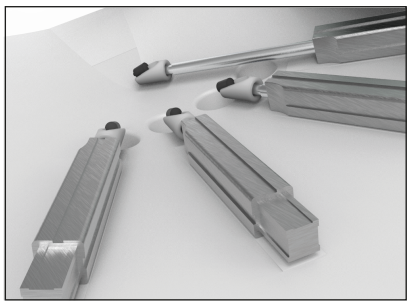
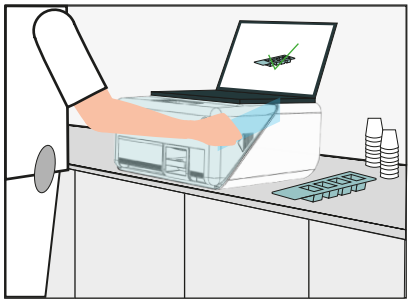
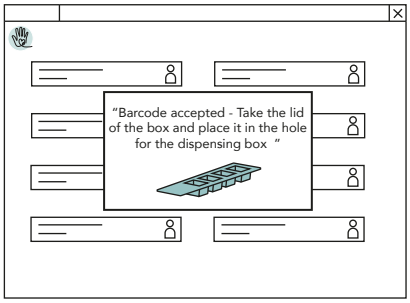
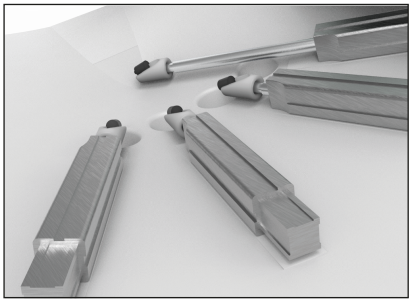
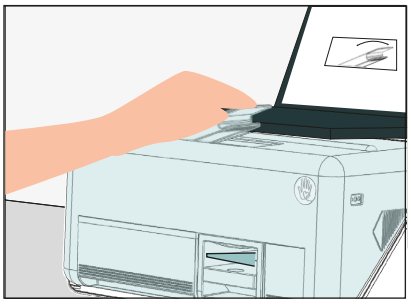
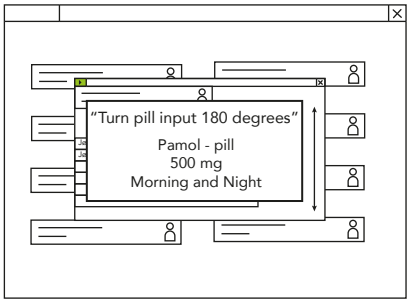
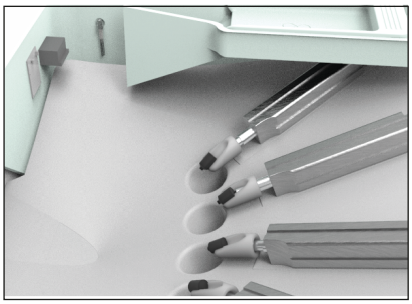
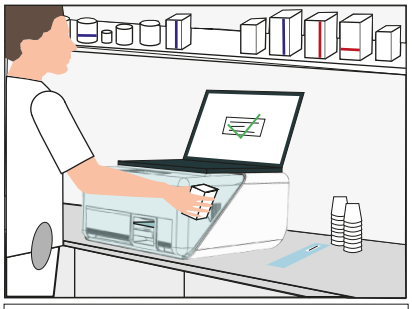
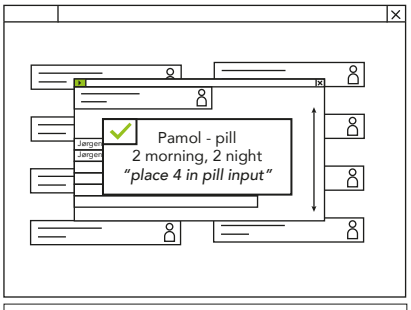
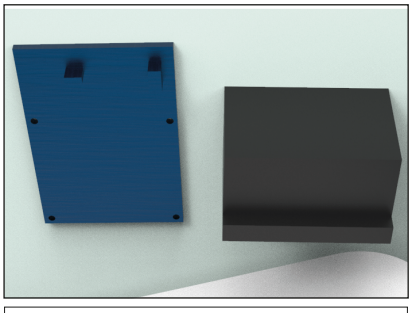
There are a lot of aspects that can effect the implementation of the product on the department and for the nurse to use the product. In order to get a more clear view on which interplay's there are between the userscenario, the interface and the product, the next step is to research the interplay further.

Ill. 124. The Clinical manager, Head nurse and Technician

INTERPLAY

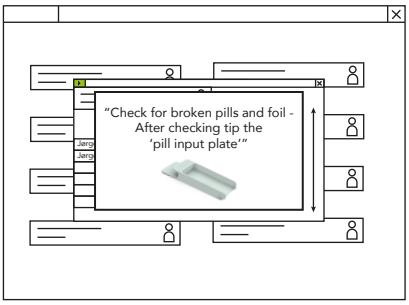
In order to get an understanding of the flow through the product and the interplay between the user scenario, the interface in plug-in and the technical functions in the product a mapping is done. This mapping has been developed with the interplay in mind and seeks to clear up any functions that may have been lost in the process.

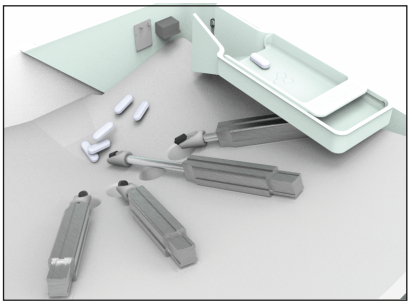
	USER SCENARIO	INTERFACE	THE PRODUCT
1			
	Computer and product is placed in the medicine room and the nurse is entering the room because of the need to dispense medicine for patients.		
2			
	The nurse enters, and logs on to the computer, in order to begin the dispensation process.	EPJ which the nurse use shows on the computer and the plug-in for the product can be seen in the top of the screen.	
3			
	The nurse press the plug-in in order to begin the dispensation of medcine for the patients.	The interface shows a list of all the patients that needs dispensed medicine.	A LED will light up in the product and indicate that the product is turned on and ready for inputs.

	USER SCENARIO	INTERFACE	THE PRODUCT
4			
	The nurse is ready to dispense the medicine and looks on the screen in order to see what the interface tells.	The interface informs the nurse that the first patient box needs to be scanned using the barcode on the lid of the box.	Actuators inside the product turns on, and one actuator moves towards the pill drop position and vacuums it, making it ready for dispensing medicine, namely pills.
5			
	The first patient box is scanned and the nurse reads the interface for next step.	The interface informs the nurse that the barcode and patient box is approved and it is time to place the patient box in the dispensing box hole in the product.	The actuator finishes the vacuuming and is ready for pills to be dispensed. The barcode scanner registers the barcode and sends signals to the plug-in to approve.
6			
	The box is placed and the next step is to turn the pill input by pressing the groove so it pops up and the input is flipped around. The product is ready to recieve pills.	The interface approves the placement of the box, tells the nurse to flip the pill input, and shows the name and strength of the preparation to dispense.	The scanner awaits any input when a preparation is scanned. The actuators awaits signal to start dispense.
7			
	The nurse takes down the first preparation corresponding to the prescribed preparation from the shelf and scans it on the side of the product.	The interface accepts the preparation and tells the nurse how many tablets to put into the pill input.	The QR scanner reads the QR code on the preparation and sends a signal to the plug-in.

USER SCENARIO | INTERFACE | THE PRODUCT

8



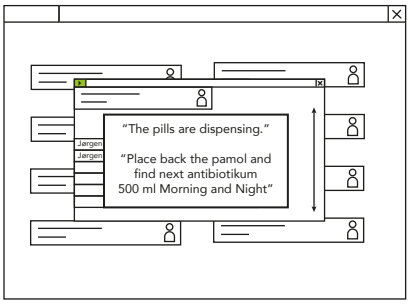


The needed pills is dispensed into the pill input. After checking for foil from blister packages and similar, the nurse can angle the pill input so the pills are loaded into the product

The interface tells the nurse to check for broken pills or foil from blister packages in the pill input before loading the pills into the product by tipping the pill input.

After the scanning of the preparation, the product starts moving the actuators towards the pill drop and next the dispensing holes.

9

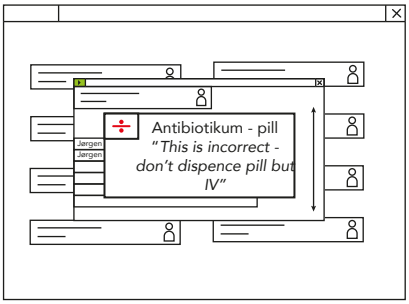


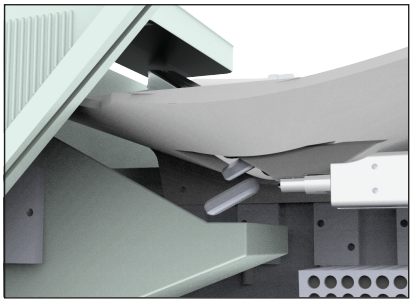
While the product dispenses the pills, the nurse can put the preparation back on the shelf and find the next preparation to dispense. In average this takes 19 seconds.

The interface tells the nurse that the pills are being dispensed and that the preparation can be placed back on the shelf and the next can be found.

The actuators moves alternately, and picks up pills using vacuum suction before dropped into the holes. The pills are registered when they fall into the patient box.

10



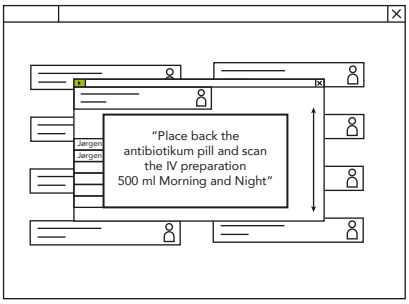


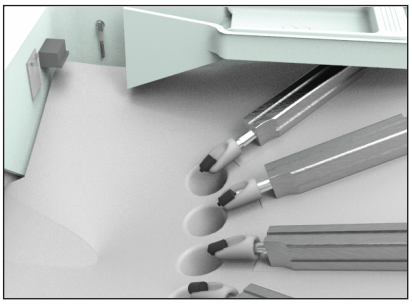
It is time to dispense the next preparation and the nurse will take it down from the shelf and scan it on the QR scanner.

The interface will tell the nurse that it is the wrong preparation, and it needs to be IV and not pills.

The door for wrong dispensed pills will open in order to remove any extra pills before the next preparation is dispensed. The scanner reads the QR code and signals the plug-in.

11

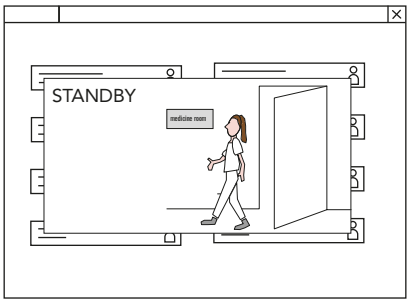
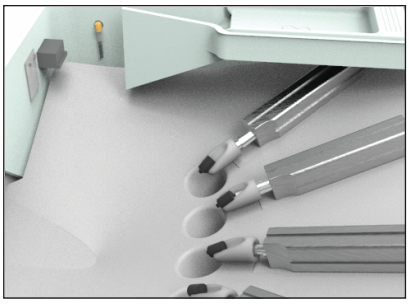
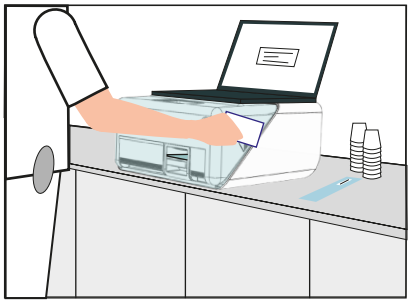
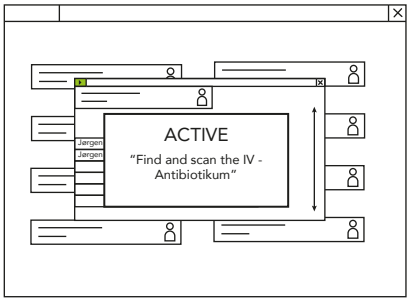
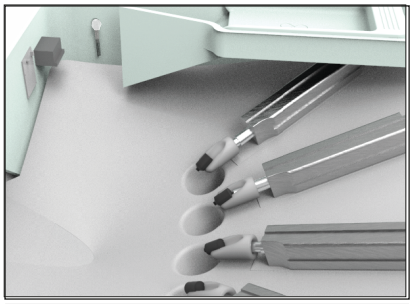
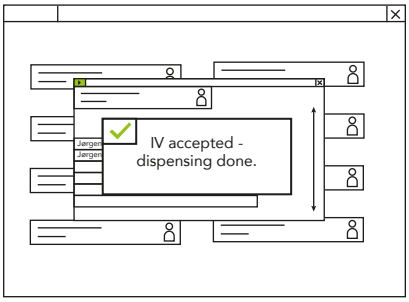
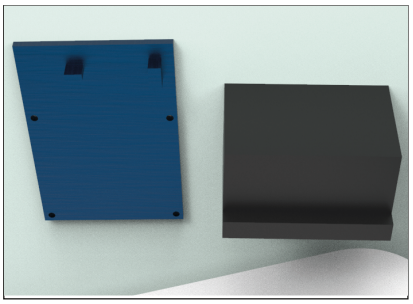
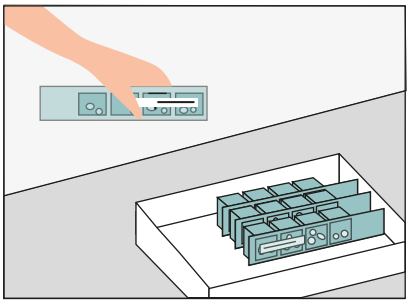
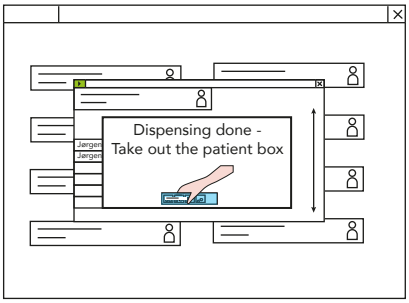
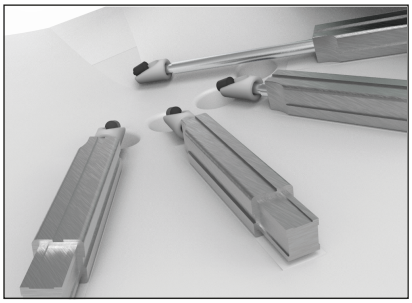




The nurse looks at the interface which tells it is the wrong preparation. The plug-in says to dispense IV in stead of pills, and the pills should be placed back on the shelf.

The interface tells the nurse to scan the correct preparation and that it is IV which is the correct preparation.

The scanner awaits the next QR code. Also, the actuator awaits commands for moving and using vacuum to move pills.

	USER SCENARIO	INTERFACE	THE PRODUCT
12			
	Before the nurse can find the IV, the phone rings and the nurse needs to leave the medicine room to take care of a situation. The ID card is scanned on the product for standby.	The interface goes into standby mode and shows a person leaving the room. This will tell other nurses that this product and computer is already in use.	The RFID tag reader reads the ID card and signals the plug-in. The RFID reader awaits a scan for login. The LED lights orange to visualise the standby mode.
13			
	The nurses gets back in the medicine room to continue the dispensation. She scans the ID card again to log onto the product.	The interface tells that it is active and it remembers the next step for the dispensation, namely finding the IV and scanning it on the QR scanner.	The RFID reader registers the login. The scanner and actuators awaits input. The LED will light up white to show the product is active.
14			
	The nurse finds the IV and scans it on the QR scanner. The IV is put next to the other pills until it is to be delivered to the patient later the same day.	The interface tells the nurse to make it ready for the patient, and remember to register when it is delivered to the patient. The plug-in accepts the scanning and dispensing is done	The QR scanner reads the QR code and sends the signal to the plug-in.
15			
	The nurse reads the interface and sees that the dispensing is done. The patient box is removed from the product, the lid is put back on and the barcode is lastly scanned.	The interface tells that the patient box can be removed and to scan the lid on the scanner to finish and seal the box before storing it with the other patient boxes.	The door for wrong dispensed pills will open and one actuator will vacuum the bottom for medicine dust, in order to make it ready for the next use. The LED turns off.

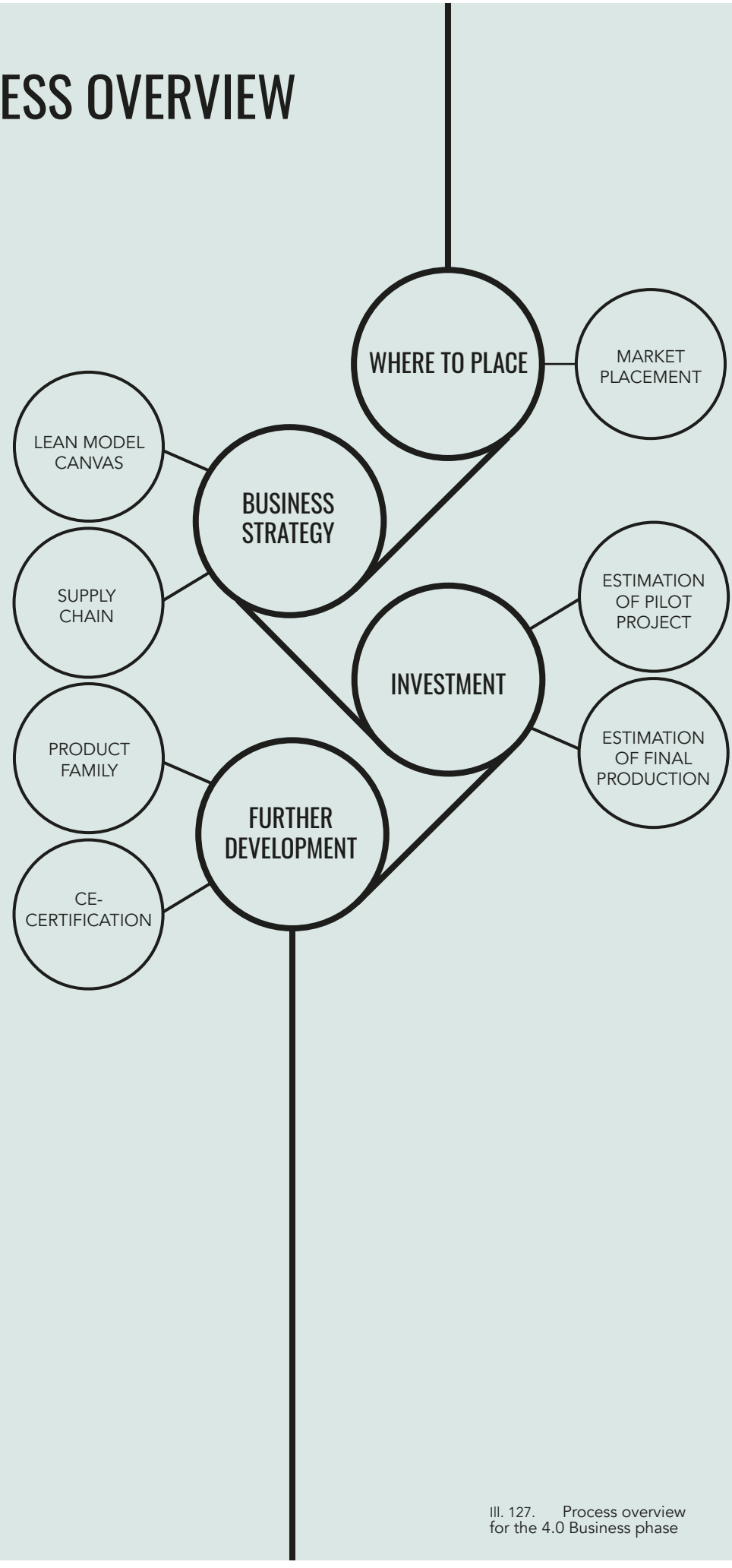
Ill. 125. 15 steps in the Interplay, between the user scenario, plug-in and product inside

Ill. 126. Team members working on the business plan

4.0 BUSINESS

With the functions and detailing of the product in place, the next natural step is to investigate how the product will provide an income and mature the product in order to get it ready to be sold. If a company should have success, it is important to have a business plan. When having defined which key partners there are in the project, a budget can be made on the expenses and income, and from that create a break even analysis. Further development of the company and the placement of the market is also specified in this phase.

PROCESS OVERVIEW



Ill. 127. Process overview for the 4.0 Business phase

MARKET PLACEMENT

Research has already been done on existing solutions at the market, which is why it is wanted to specify where the new product differs and creates a better market position for itself. This is done through a comparison with the hightech robot solution Swisslog which is considered the biggest competitor to the product suggestion. The goal is to verify the need for the product and to state the positive competitive aspect the product provides.

THE PRODUCT SUGGESTION

The product suggestion aims at ensuring that the right patient gets the right medicine preparation, in the right form, in the right amount, for the right time as the Swisslog robot claims to do. It should help nurses in their workflow when dispensing medicine in the medicine room and ease the workload when always having to pay extra attention in an already stressful workday. It should not be necessary to double check the dispensed pills because of the imagined high accuracy and safety of the product and it will thereby release time for the nurse. When buying the product, it is a low investment compared to Swisslog, and it is placed inside the medicine room where it can be used when needed.

Ill. 128. The concept in context at 9Ø

SWISSLOG

Swisslog dispenses pills for oral ingestion in plastic bags at an external building at the hospital. The medicine can only be ordered at noon and sent through the hospital using a pneumatic tube system. The robot dispenses the pills, therefore the nurses do not need to use time on that, but it is still necessary to add suppositories, melt pill, IV fluids etc. Therefore the nurses still uses time in the medicine room. Also, if a change is made in the medicine prescription by a doctor, the nurse has to manually dispense the new pills for the patient meaning that patient safety is lowered. The pills needs to be double checked to make sure all pills are provided in the delivery. (WS14)

Ill. 129. Swisslog at AUH

When comparing the product suggestion to Swisslog, it is clear that there is a big difference in the flexibility of usage, investment and implementation need.
Swisslog demands an investment of around 15 million, takes up 200 square meters, needs an installment of pneumatic tubes and demands the nurses to use around 60 minutes at each department on checking if everything is received in order to dispense medicine for the 450 patients that the robot has the capacity for.
With the new design suggestion it is possible to implement a dispensing product at the individual departments without having to do big investments or make big changes to the hospital interior. Furthermore, it is not always possible to install a big robot as Swisslog at a hospital while a certain area and hospital capacity is needed in order to validate such a big installment. The design suggestion will also make it possible to make side dispensings, check IV, melt pills, suppositories etc. which Swisslog is not capable of. Businesswise the design solution is low in investment cost compared to competing solutions, and can be installed without making changes to the hospital structure.
Since is has not been possible to test the full interaction of the design suggestion in the real context, it was hard to validate the approriateness of the concept regarding the specified interactions and the whether it fitted the context fully. After the validation of the business opportunity for the product, it was wanted to specify the business strategy and how to manage the development and production of the product.

BUILDING BLOCKS FOR THE PROJECT

The Lean Model Canvas (LMC) is used in start ups to get an overview over the stakeholders and aspects of the business part that are important and affect the project. This LMC is illustrated with building blocks and the lineup is an interpretation of the original LMC [Medium, 2016]. The goal of this setup is to specify the direction of the project and to list the initial thoughts of the business case.

CUSTOMER SEGMENT

Either the individual department at the hospital will be the customer, or the region if they decide that every department should have the product.

EARLY ADAPTORS

There will be a pilot period to test the product in order to get feedback, and give the possibility to make adjustments. The test persons will be the nurses at different departments.

PROBLEM

The nurses experiences a lot of health care errors regarding the dispensing of medicine which directly affect the patient and indirectly affect the region.

EXISTING SOLUTIONS

Swisslog at AUH handles medicine dispensations, however the installation is big, requires many m2 and is expensive.

SOLUTION

The department who is the investor, should benefit from a good investment when securing the patients better and keeping the cost of hospitalization and compensation down.

The nurse who is the user, is meant to experience ease when dispensing medicine, which will result in extra time available for taking care of the patient.

UNIQUE VALUE PROPOSITIONS

Raising the patient safety by assisting the nurse dispensing medicine at the individual department.

Easing the workflow for the nurse when dispensing medicine for the patient.

No need for the nurse to double check the dispensed medicine before giving it to the patient.

COST STRUCTURE

After the development of the product, money will be used on milling prototypes for pilot testing and initial programming of the plug-in and the product. After pilot testing changes will be made, and final forms for injection moulding will be ordered. Programming and tooling will be fixed costs.

Variable costs will be the electrical components, plastic material for injection moulding and salary.

REVENUE STREAMS

The source of the cashflow will be the customer who is either the region or the individual department at the hospital.
They will be offered a product.
After break even there will be developed a variability of products in terms of the need by the individual customer.
The product will be sold directly to the customer.

CHANNELS

Physical meetings when setting up the product.
Possibly create own website for the product where the department can find information and buy the product.
Customer support and service both online and physical.

KEY METRICS

The best way to monitor the performance is to see if there are any changes in the numbers of reported health care errors. In that way it is possible to conclude that the product is working.

UNFAIR ADVANTAGES

Raises the safety of the patient regarding medicine in the individual department without havig to do big investments or do big rebuilds of the hospital.

Ill. 130. Lean Model Canvas

The Lean Model Canvas has given an indication of how to set up the business potential and that the product is wanted from both potential customers, namely the region and the individual department at the hospital. The value created by the product is highly requested by both customer segments and therefore it is wanted to specify the price estimation and probe whether they are actually willing to invest in the product.

SUPPLY CHAIN

The supply chain is providing insight on the different links between the project and the key partners that are a part of the development and production team. The development phase of the project is excluded in the supply chain because it is done by the design company. Two different supply chains has been made in this project, one for a pilot project and one for the final product when launching it into the market. The pilot project will be a 00 series where testing of the product can be done in the real context and feedback can be provided by the nurses when testing it before the actual production. In this way it is possible to spot possible risks regarding the product and adjust any potential flaws before launching the final product.

The part of the supply chain at the left side illustrates the flow in the pilot project. The products for pilot testing are produced by CNC milling while it is a method that can give the wanted geometry and surface finish. Also, 3D printing has been considered.
It is imagined that around 50-100 products are needed for the pilot testing. It is possible to test the product and see if any adjustments are needed before specifying the concept further and investing in tooling for a bigger production.

SOFTWARE ENGINEER

When testing the product in the context, the coding of the plug-in and the components should be fully functional and done by an external company like PREVAS.

CNC MILLING

In order to keep the investment costs down when running the pilot project, the first production on 50-100 units of the products is CNC milled by Duch Group.

ELECTRICAL COMPONENTS

Electrical standard parts will be provided from multiple different companies. These components can be revised for the real production if necessary.

ASSEMBLY

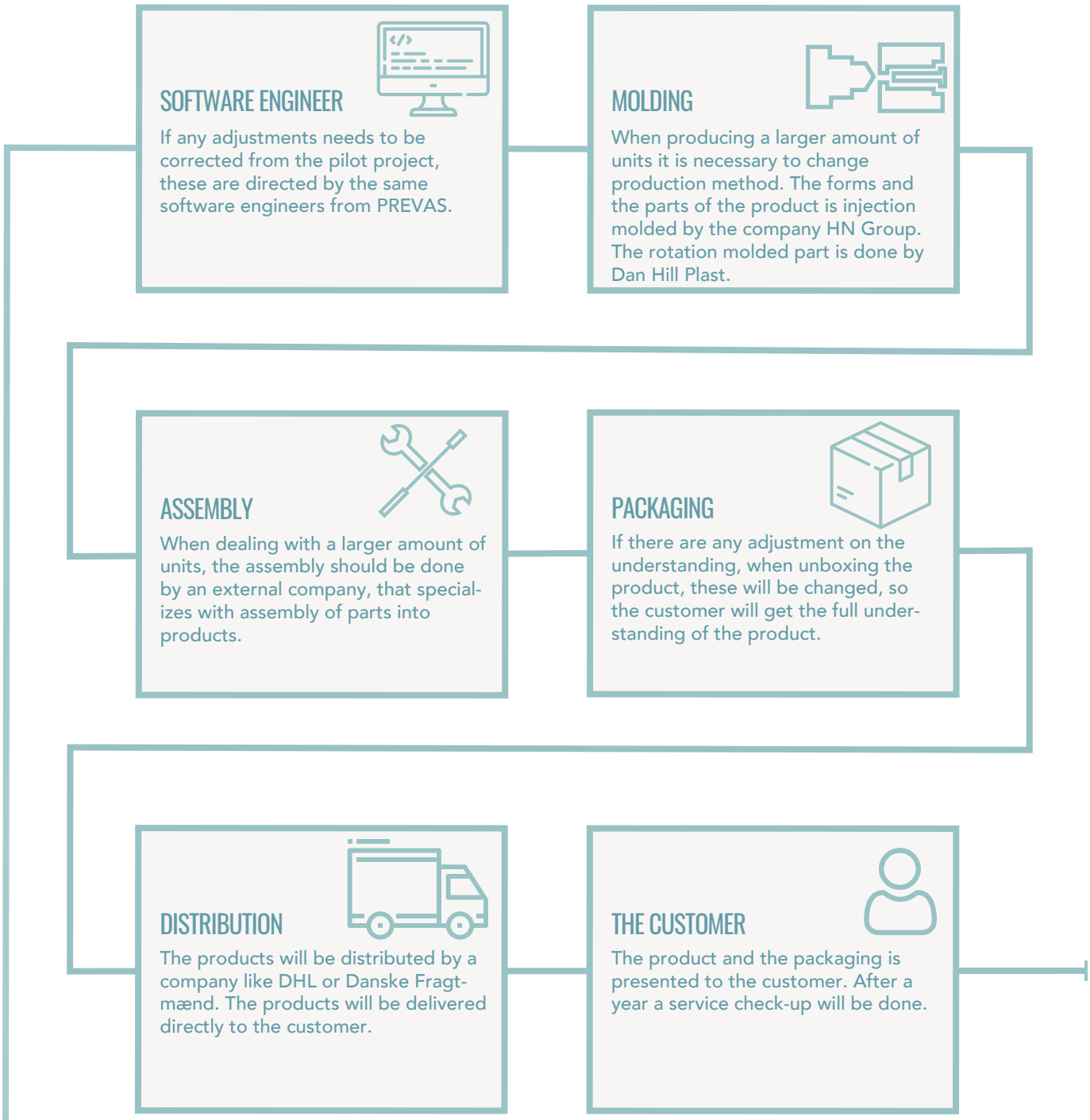
The assembly is done by the design company and internal electrical engineers, this way the costs of assembly is kept to a minimum.

PACKAGING

The packaging of the product, should be done by an external company like Smurfit Kappa. There will be an amount of consultancy hours with the company with design and packaging.

TESTING WITH THE USER

The product and the packaging is presented to the customer. The nurses are testing the product and giving feedback on any adjustments that needs to be changed if there are any. The test periode is evaluated to be minimum two years.



Ill. 131. Supply chain for the pilot project and fianl product

After the creation of the supply chain it became clear that a long timeframe for the pilot testing was needed. Here, it is estimated to designate at least two years for the pilot project phase. The pilot project will as mentioned, happen in collaboration with the nurses and the department at the hospital. In order to make the supply chain, many experts regarding production has been contacted. These also helped provide prices for production which should make it possible to make a price estimation of the product.
It is wanted to research how to get in contact with the different departments and establish an agreement regarding the testing period. Therefore, the next step is to figure out how to establish this contact and how the whole economy around the testing period can happen. In order to make the supply chain, many experts regarding production has been contacted.

THE BEGINING OF THE SUCCESS

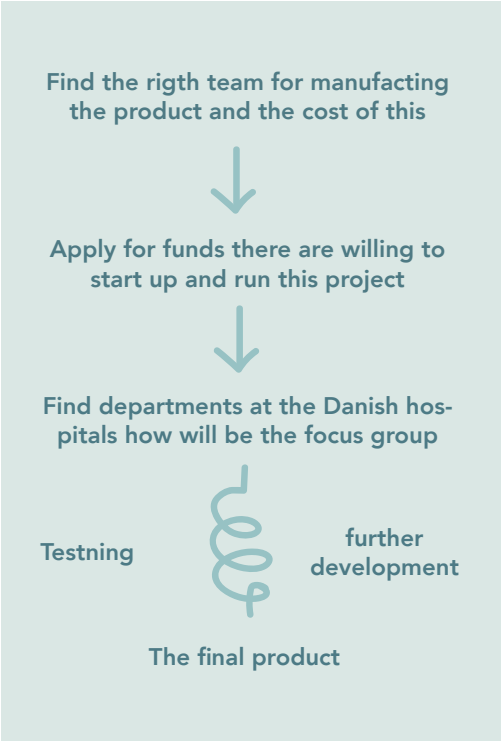
In order to make sure the product will be ready to be sold on the market, it needs to be tested in the real context by the real users over a longer period of time - called a pilot project.
The pilot project is to establish the validity and confirm the effect of the product. This project is imagined to be conducted at different hospitals with around 50-100 participating departments. Here amongst the goal is to get approved to get at CE certification.

The first step will be to set up meetings with production and software firms to find out the cost for manufacturing the product series 00 (pilot project) - This is calculated beneath. (WS37).

Because the company is not yet established, in order to finance the pilot project, fundings are to be sought. This could eg. be Nordea-fonden (supporting projects about the good life regarding health), Trygfonden (supporting amongst others the security in Denmark) and Novo nordisk fonden (supporting amongst others challenges regarding health and technology).

The third step will be to find departments at the Danish hospitals that will be interested in being a part of the pilot project when testing the product. The team will visit the departments, tell them about the project and hand out flyers about the product.
A meeting with the clinic manager and the head nurse regarding the project and the guidelines for the project will be set.

The departments already used for providing feedback in the development phase can preferably be a part of the pilot project as well, since they are interested in collaborating and are well into the process. Another way to find departments which are interested in the pilot project could be going through Idéklinikken, which can help to find a way into the hospitals in Nordjylland.



III. 132. A smiplyfied process from start to final product

PILOT PROJECT

Task	Hours	Salary external	Cost (Each product)	Cost for all 100 pieces
Software engineer (900 DKK pr. hour)	500	450.000,00 DKK		450.000,00 DKK
CNC milling prototypes (incl. salary & material)			10.740,56 DKK	1.074.056,00 DKK
Electrical components			19.312,00 DKK	1.931.200,00 DKK
Design of plug-in	200			- DKK
Assembly				- DKK
Packaging development (900 DKK pr. hour)	16	14.400,00 DKK		14.400,00 DKK
Packaging pr. item			32,00 DKK	3.200,00 DKK
Testing				- DKK
Consultant CE certification (2000 DKK pr. hour)	200	400.000,00 DKK		400.000,00 DKK
Total cost				3.872.858,00 DKK

III. 133. Investment for Pilot project

As seen above, the pilot project will cost around 3,9 million DKK and it is estimated that the pilot project will last for around 2 years since many tests and changes to the product needs to be done in this phase. It is imagined that after the pilot project, the real production can be initiated and real sales can happen immediately after the product is produced and hit the market. Since it is a startup company and no income will happen during the first two years, the salary for the employees at the company will be bootstrapped until the break even has been reached. Possibly the employees can get fundings or other unemployment benefits from the government during that time.

SALES

Calculations of the real production have been done and a sales price of 32.599 DKK has been estimated. From a conversation with the head nurse at 9Ø it was clear that they were possibly able to pay around 100.000 DKK each department for products that could ensure the patient better. From this estimation it is possible to place the optimal number of three products at each department, since they usually are two or three nurses dispensing medicine at the same time.

It is estimated to sell around 750 products the first year since the company is new and unknown to the customers (WS9 and WS37). The years after the number of units is imagined to increase, and within a short time frame the product will possibly expand to the rest of Scandinavia, next europe and when time, to the rest of the world.

In order to get money for the investment it is wanted to find investors that have an interest in getting products into the health care sector that can make the field better and safer. It has also been discussed that a possibility is to sell the idea to an already established company and get royalties. But it is evaluated that the need for the product is fairly large, and a potential business can grow very big. Therefore it is initially not wanted to sell the company and leave the rights of the project.

An estimated production cost of 15.425 DKK will with a contribution for the design company of 10.654 DKK mean that the product sales price will be 32.599 DKK. The investment for the product and the calculated sales price is used to calculate the break even point which can be seen below. (WS37).

Prices of producing injection molded and rotation molded parts has been calculated through help from the company HN Group.

BREAK EVEN ANALYSIS

Timeframe	Year 1	Year 2	Year 3	Year 4	Year 5
Units	-	-	750	1000	1700
Sales price	-	-	32.599,00 DKK	32.599,00 DKK	32.599,00 DKK
Production cost	-	-	15.425,00 DKK	15.425,00 DKK	15.425,00 DKK
Income that year	-	-	24.449.250,00 DKK	32.599.000,00 DKK	55.418.300,00 DKK
Investment in total	3.872.858,00 DKK	3.872.858,00 DKK	9.185.358,00 DKK	1.194.708,00 DKK	-
Contribution	-	-	7.990.650,00 DKK	10.654.200,00 DKK	18.112.140,00 DKK
Remaining	- 3.872.858,00 DKK	- 3.872.858,00 DKK	- 1.194.708,00 DKK	9.459.492,00 DKK	27.571.632,00 DKK

SALES PRICE FOR ONE PRODUCT

Sales price incl. VAT	32.599,00 DKK
Sales price excl. VAT	26.079,20 DKK
Contribution design company	10.654,20 DKK
Production cost	15.425,00 DKK

NUMBERS OF UNITS TO BE SOLD TO BREAK EVEN

Investment	9.185.358,00 DKK
Product cost contribution	10.654,20 DKK
Numbers of units needed to be sold	862 pieces

Ill. 134. Break even analysis for the fianl product

As seen in the break even analysis, 862 products needs to be sold in order to break even. This break even will according to the estimations happen in the beginning of year 4, where the sales possibly will increase and create a steady cash flow making it possible for the company to expand their product portfolio and create a product family.
As mentioned earlier, it costs the hospital a minimum of 9.600 DKK for each medication errors at the hospital, which means that only 4 medicine errors (32.599 DKK/9.600DKK = 3,4 medicine errors ≈ 4 medicine errors) that leads to longer hospitalizations, needs to be averted by the product in order to earn in the money invested in the product.

THE PRODUCT FAMILY

As a further development, when the first product has ensured a profit, it is wanted to initiate a product family. The reason why it is wanted to build up a product family is because it is desired to hit a wider target group on the market and expand the business. This will make sure to help as many nurses in their workflow as possible at different departments and places (homecare, accommodation centers, treatment centers). In the long run it will ensure a higher profit. As the product is designed right now it can be used at all departments at the Danish hospitals, where the nurses are dispensing in patients dispensing boxes, with four rooms, (morning, noon, evening, night) but also in the dispensing glasses. In addition, the product can also be used other places, where the same dispensing method with the patients dispensing box and the small pill glasses are used.
An advantage when expanding is that the whole system already exists and the programming is made. Therefore, it will be much cheaper to develop a new product for the product family.

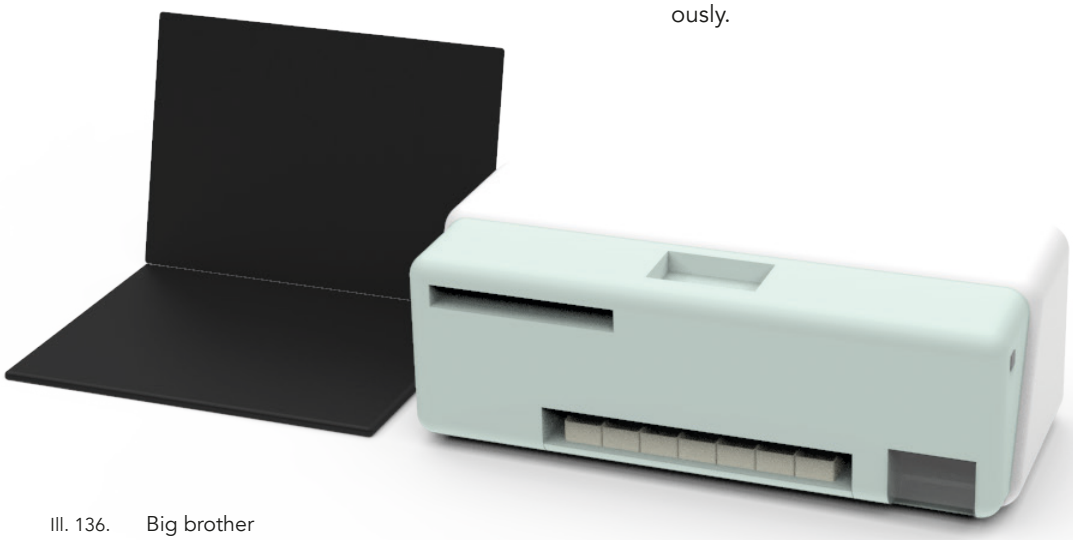
Ill. 135. Little sister

LITTLE SISTER

The "little sister" to the designed product will be a smaller product but with the same functionalities as the original concept. It is only possible to dispense into the small pill glasses that are used at the hospital. This product will fit into the departments that only make one dispensation at the time, but also at depatments where they use Swisslog and side dispensations are needed. It will only be provided with one actuator and is therefore also seen as the budget version in the product family.

BIG BROTHER

A "big brother" to the designed product will be designed for eg. nursing homes where the nurses dispense in dispensing boxes with four rooms with morning, noon, evening and night. Different from the hospitals, they dispense for two weeks at a time. The product will therefore as the initial product be designed with four actuators, but also with a moving bottom, in order for the product to move the dispensing boxes inside the product and allow more boxes to be filled simultaneously.



Ill. 136. Big brother

To make sure that the product family fits into the context where it belongs a deep research and analysis of these have to be done. This is an internal look into what could be interesting to work further on. It could be imagined that in order to make it cheaper in terms of investment when starting the production of more products, moulds and component setup could be designed in a was so most parts can be transferred directly onto the new design.

CE - CERTIFICATION

In order to get a product approved for sale in all countries within the EU, the product needs to be CE certificated. The certification shows that the product is approved and is equal to the general requirements in order for a person to use the product. The requirements are valid in all of the EU. The process of getting a product CE approved is long, and is often initiated during the pilot project.

For a product getting the CE certification, there are multiple requirements that need to be complied. (WS35) In order to get clarification regarding the CE certification on medical equipment [Medicinsk udstyr - 93/42/EØF - Dansk Standard, 2020], a research has been made on both Sikkerhedsstyrelsen, [Sikkerhedsstyrelsen, n.d.] Retsmedicin, [Retsinformation, n.d.] lægemiddelstyrelsen [CE-mærkning, n.d.] and in addition, personal contact has been made to Agnete, who is employed at Danske standarder [Harmoniserede standarder - Dansk Standard, n.d.], in order to find concrete requirements when CE certifying a product. According to Agnete; "... You cannot just CE certificate your product in a couple of days. It takes a lot of time, just to get an idea on which product category one's product is within. A lot of start ups or companies often contact consultancies that work with CE certification, to make sure that nothing is forgotten in the process.."

According to Agnete there are two clear requirements that always need to be complied in order for a product to get the CE certification mark:

RISK OF SQUEEZING

Because the product has multiple trays and inserts the user can interact with.

RISK OF ELECTRIC SHOCK

Because the product needs power to function, it needs to be secured so the user does not get electrocuted.

These two common requirements have to be complied as a minimum, amongst others.

Because the product requires a lot of testing in order for it to get a CE certification, it is necessary to get in contact with a company that handles CE certifications, e.g. DELTA [DELTA DK, 2019]. The company will handle the test of the product and make sure that it complies with the requirements there are when getting a CE certification on a product. Agnete informed that since it is a long process and requires a great amount of work, it can be a good idea to hire another consultancy that handles this aspect of the certification process.
During the testing, also application forms needs to be processed in order to achieve the CE certification. The internal company at DELTA, Force Technology is responsible for the paper work [Force Technology, 2020]. The company can provide security in order to get every aspect implemented when getting a product approved for the CE certification, in order to be sold in Denmark and the rest of the EU.

Ill. 137. CE-mark

FINAL SUM-UP

This master thesis sought to create a solution for the nurses at the Danish hospitals that could help them increse the patint safety by safely dispensing medicine, and by that, improve the workflow and efficiency at the department. Great knowledge and insight has been gained throughout the project, regarding the mentality and understanding of the process behind dispensing medicine to a patient. Interviews and conversations with the head-nurses and nurses resulted in getting an understanding on which challenges the nurses face everyday. The user involvement and research during the project made clear that a product which could provide a higher security regarding medicine dispensing at the individual departments was highly requested.

Around 1800 departments at Danish hospitals need to dispense medication every day. All these departments have the need for a product that can lower the risk of making a health care error while the errors are not only bad for the patient, but they can also affect the economy for the whole hospital and the region.
The market potential is therefore large, and the possibility to expand the product to other countries and customer segments is high.

Through a reasoning process and feedback from the user segment, it was possible to create product suggestion. A product that assists the nurses at the Danish hospitals when manually dispensing medicine for the patients. The everyday workflow in the medicine room has been taken into consideration when designing, and it has been possible to fit the new product into the already existing working environment by adding a low amount of extra processes and utilizing the equipment already available.

The foregoing business plan behind the product suggestion is to conduct a thorough minimum two year period with a pilot project with testing the product in use in the medicine room before having it ready for production and later sales. All, in order to ensure the accuracy, usability and quality of the product. It is estimated that 862 products needs to be sold before gaining a profit within the company. This number of sold products is estimated to happen in the beginning of year two after

REFLECTION

REFRAMING IN THE PROCESS

In the beginning of the project a clear intention was to develop a product that could ease the nurses workflow, however the focus in the beginning was to develop a product that could open blister packages for the nurses. The focus originated at a visit at Aabybro nursing home, but when investigating the marked, it became clear that there already were a lot of products for helping the problem, therefore it was needed to reframe the project at an early stage and the focus was changed to handle medicine dispensing with the focus on the 5R's.

PROJECT MANAGER (PM)

The project has been managed by one group member for two weeks at a time with the role as project manager (PM). By switching the role as PM, each group member has had the opportunity to evolve one's competences. Fundamentally this solution has been good for the project while it has created structure throughout the whole project. However, there has been challenges regarding setting up deadlines and having to deal with them when not complied, which has resulted in frustration by the PM.

COMMUNICATION

Because of the lock down situation in Denmark during the time of the project, basically all communication has been conducted on Skype. It has been hard to communicate ideas and suggestions regarding shape and interactions of the product, which has led to frustration and the process slowing down. The weekly supervision has been a big support and kept up the motivation despite the challenges created by the situation.

USER-GROUP

It has been a wish to involve the user group throughout the whole process when developing the product suggestion, while it is important that the product fits into the medicine room and that the user understands the interaction surfaces. However, it has not been possible, from primo march, to visit and involve the user group at the hospitals, as much as intended. This resulted in the functions, interactions, size, ect. to not have been tested to the preferred extent. It has led the group members to make assumptions where user testing has not been possible, resulting in possibly creating a design that would not fit the target group perfectly. If possible, the product should have been tested continuously throughout the project in the real context by the primary users in order to get the feedback on the experience of using the product by the user group. The users feedback, considerations and aspects were taken into consideration when designing the different parts of the product to the extent possible. Furthermore, it could have shown to be beneficial to question nurses at more hospitals than Aalborg and Vejle in order to get a larger diversity of users and spot differences within the hospitals.

THE TECHNICAL ASPECTS

The technical aspects have been the primary part of this project and have been controlling the process from an early stage when developing it. It was important to design a product that would work in the context in the given situation, but also to create it within the given time available of the project. It has been challenging to balance the design, interactions and size when the technical aspect was taking much focus, but also to probe whether the technical validation is accurate because of many assumptions made.

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LIST OF ILLUSTRATIONS

Ill. 1-32: Own illustrations

Ill. 33: MedicCare, n.d. MediSmart Tim. Available at: http://www.mediccare.dk/folder.php (Accessed: 31 May 2020).

Ill. 34: Own illustrations

Ill. 35: Swisslog, 2014, PillPick Automated Packaging and Dispensing System - YouTube. Available at: https://www.youtube.com/watch?v=sXBWB1wQm20&fbclid=IwAR3pxnlJr_I2lpCQJghFXEVBGWdnJfovxyR1b6LHjCfkpwcnb6Fn8nY-zdg0 (Accessed: 14 May 2020).

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Ill. 37: Hjælpemiddelbasen, n.d. Pirucare - Pilleudtrykkeren. Available at: https://hmi-basen.dk/r11x.asp?linkinfo=22068 (Accessed: 31 May 2020).

Ill. 38-58: Own ilustrations

Ill. 59:Swisslog, 2014, PillPick Automated Packaging and Dispensing System - YouTube. Available at: https://www.youtube.com/watch?v=sXBWB1wQm20&fbclid=IwAR3pxnlJr_I2lpCQJghFXEVBGWdnJfovxyR1b6LHjCfkpwcnb6Fn8nY-zdg0 (Accessed: 14 May 2020).

Ill. 60: Own illustrations

Ill. 61: PLC Conveyor Sorter, 2009. Youtube. Available at: https://www.youtube.com/watch?v=9PvhJngelug&fbclid=IwAR2EDxR-WGIyH5W-IcLFL9gwqh5uaMmPCyG48ym7QCFnxBKjJI9n3hffYtow (Accessed: 14 May 2020).

Ill. 62-72: Own illustrations

Ill. 73:

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3: Own

4-5: Own illustrations

Ill. 74-85: Own illustrations

Ill. 86: Swisslog, 2014, PillPick Automated Packaging and Dispensing System - YouTube. Available at: https://www.youtube.com/watch?v=sXBWB1wQm20&fbclid=IwAR3pxnlJr_I2lpCQJghFXEVBGWdnJfovxyR1b6LHjCfkpwcnb6Fn8nY-zdg0 (Accessed: 14 May 2020).

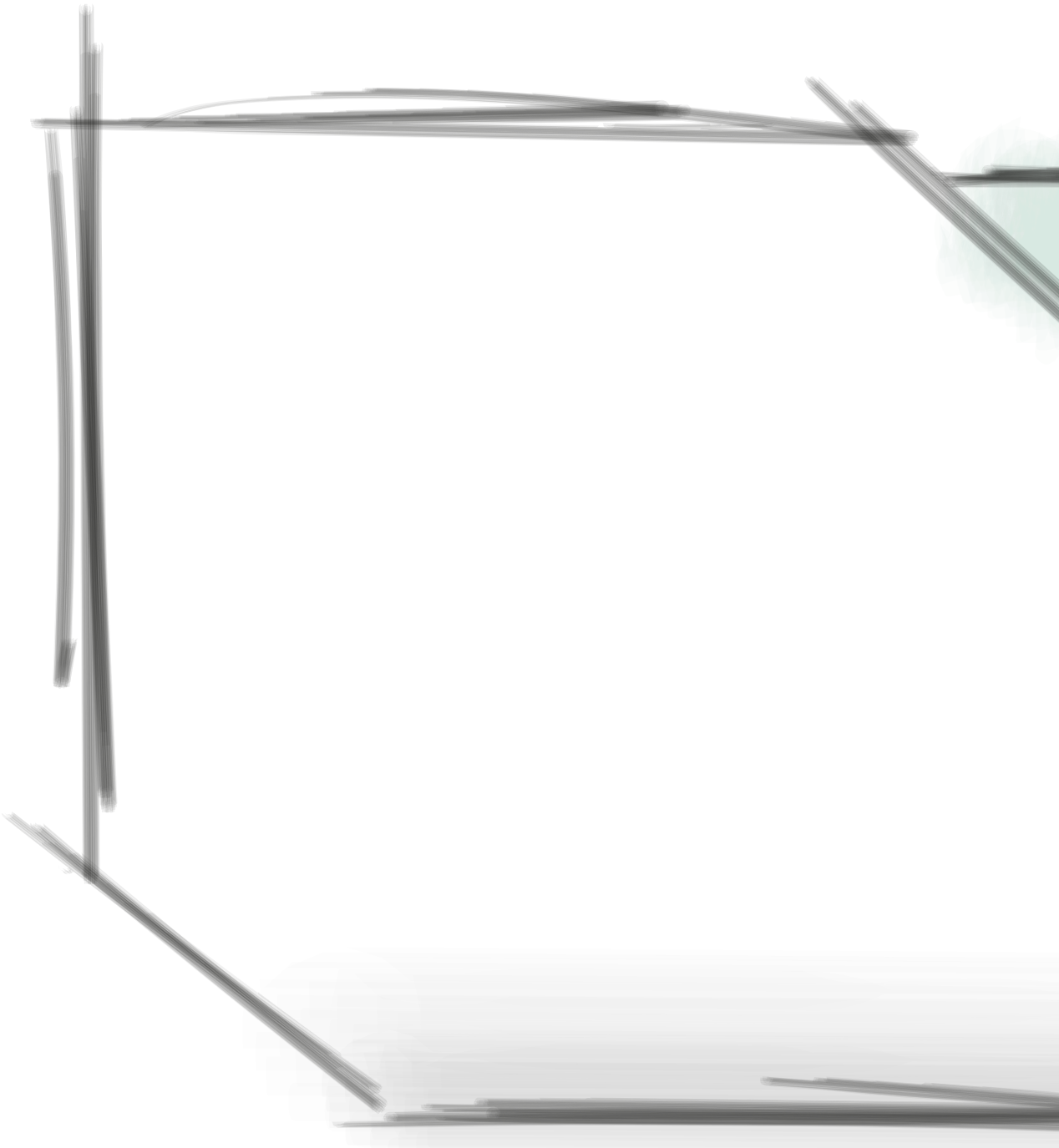
Ill. 87-111: Own illustrations

Ill. 112: Lefteri. C, 2013, Materials for design, Laurence King Publishing, London

Ill. 113-129: Own illustrations

Ill 130: Swisslog, 2014, PillPick Automated Packaging and Dispensing System - YouTube. Available at: https://www.youtube.com/watch?v=sXBWB1wQm20&fbclid=IwAR3pxnlJr_I2lpCQJghFXEVBGWdnJfovxyR1b6LHjCfkpwcnb6Fn8nY-zdg0 (Accessed: 14 May 2020).

Ill 131-138: Own illustrations.

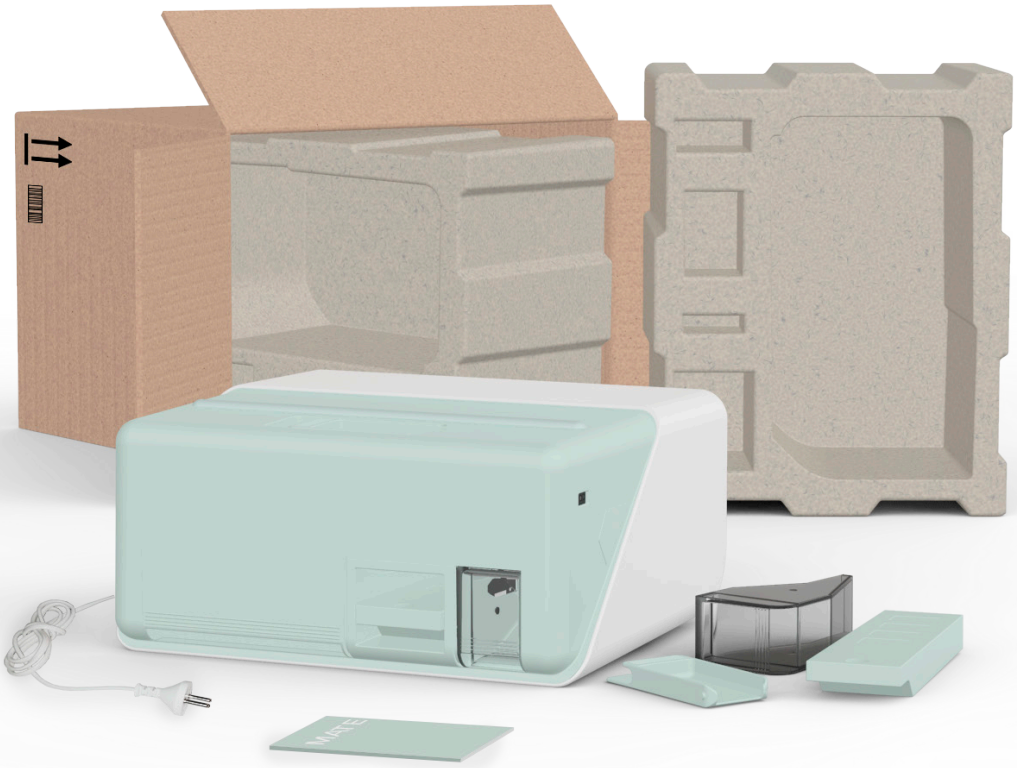


MATE

MEDICINHÅNDTERING DER GØR ARBEJDSFLOWET TRYGT OG EFFEKTIVT

MS04 ID | JUNE 2020

WHAT'S INSIDE



TITLE PAGE

PROJECT TITLE: MATE - Medicinhåndtering der gør arbejdsflowet trygt og effektivt

PROJECT THEME: Reducing medicine related health care errors

PROJECT PERIOD: 03.02.20 - 18.06.20

PROJECT TEAM: MSc04-ID12

NUMBER OF PAGES: 25

MAIN SUPERVISOR: Louise Møller Haase

TECHNICAL SUPERVISOR: Jørgen Kepler

NUMBER OF REPORTS: 6

NUMBER OF PAGES: 25

In addition, a belonging flyer addresses the department when promoting the pilot project

ABSTRACT

Hvert år sker ca. 10.000 utilsigtede hændelser i forbindelse med medicinering af patienter på de danske hospitaler. Dette tal er kun de indberettede, hvor der foruden dem, også er alle dem som ikke bliver indberettet grundet travlhed og prioriteringer, hvilket betyder at det egentlige tal kan være langt højere.

Dette speciale, udarbejdet af en gruppe Industrielt design studerende viser udviklingen af et produkt, som skal hjælpe sygeplejerskerne når de dispenserer medicin til patienterne. Målet med udviklingen af produktet MATE er, at antallet af utilsigtede hændelser relateret til medicindispensering vil falde. Under specialet arbejdes der med de 5 R'er, som er en betegnelse, der bruges på sygehuset inden for dispensering af medicin. Dette betegner, at den Rigtige patient modtager det Rigtige præparat i den Rigtige form i den Rigtige mængde til den Rigtige tid. MATE vil sikre at disse 5 R'er bliver overholdt under dispenseringen og derved reducere antallet af utilsigtede hændelser.

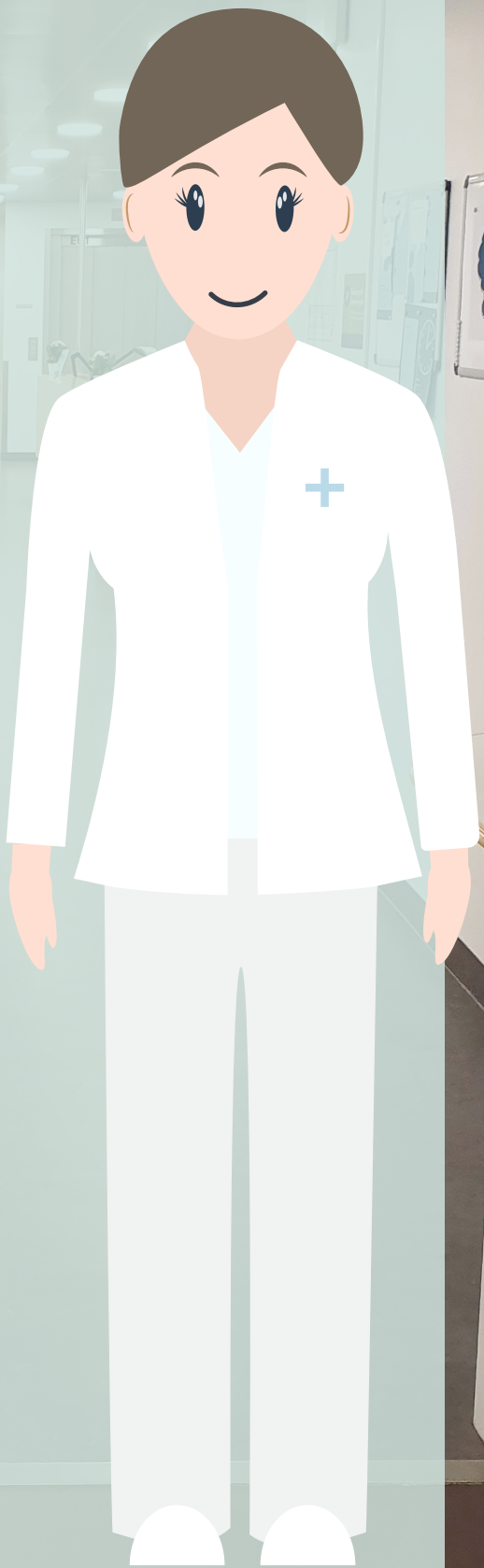
Under udarbejdelsen af produktet har både sygeplejersker, afdelingssygeplejersker, læger og farmaceuter leveret nyttig viden og feedback på koncepter. Denne kontakt til brugere og interessenter har muliggjort at udarbejde et produkt der kan passe direkte til konteksten og behovet inden for medicindispensering på hospitalet.

SOFIE THYLKJÆR ASP LINE LUNDGAARD KARINA RØJKJÆR

WHAT TO EXPECT

HEALTH CARE ERRORS

Medicine related health care errors affect the whole health care sector and there are many of them. Around 10.000 medicine related health care errors are reported at the Danish hospital every year, and the nurses strive to decrease these.



R

The region has to handle the financial aspect of a medicine related health care error, while e.g. a longer hospitalization of two days will cost at least 9200 DKK and a possible applied compensation can cost around 2-300.000 DKK.

D

The department has to handle and correct these medicine related health care errors from happening forward. The errors which result in the patients getting hospitalized for a longer period of time, takes resources in the form of hospital beds and the nurses time, this time could have been used more productively on patient care.

N

The nurse handles the dispensation process of the medicine. This task demands concentration and attention during the workflow, since many possible sources of errors can happen. It is difficult for the nurse, while the medicine changes look and design very often and disturbances from patients or co-workers happen frequently.

P

The patient is directly affected by a medicine related health care error. The wrong dispensed medicine can result in the patient getting an allergic reaction, having side effects or in worst case it can result in the death of the patient. Often a health care error also means that the patient will be hospitalized for a longer period of time than first needed.


Hans Hansen
cpr.: 2507332517
Morten Kirke
cpr.: 1507675565
Gunner Peder
cpr.: 1111418756 9
Suzzi Tarm
cpr.: 2704872020
Lene Jensen
cpr.: 3101456705
Lene Kirke
Cpr.: 3107525117
Gunner Peder
cpr.: 1111418569 7
Tonny Petersen
cpr.: 0405807021

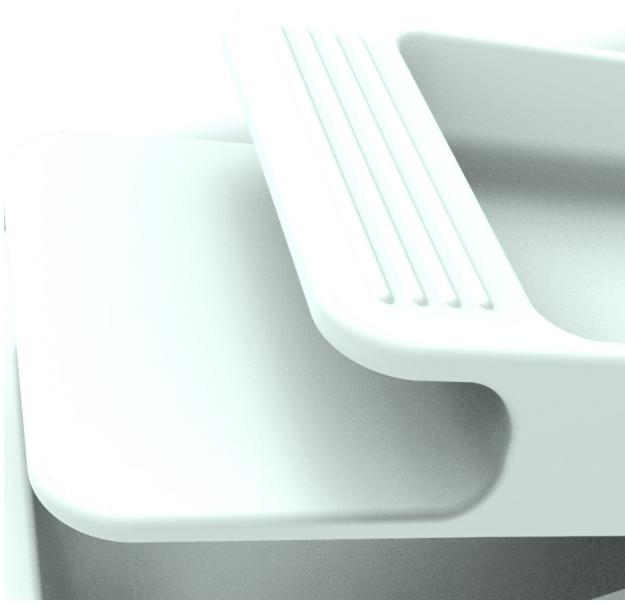
MATE

With the help from MATE, every individual department at the hospital can increase the safety when dispensing medicine for the patients. MATE is easy and fast to implement in the medicine room in the individual department, and requires little change in the already established workflow of the nurse.

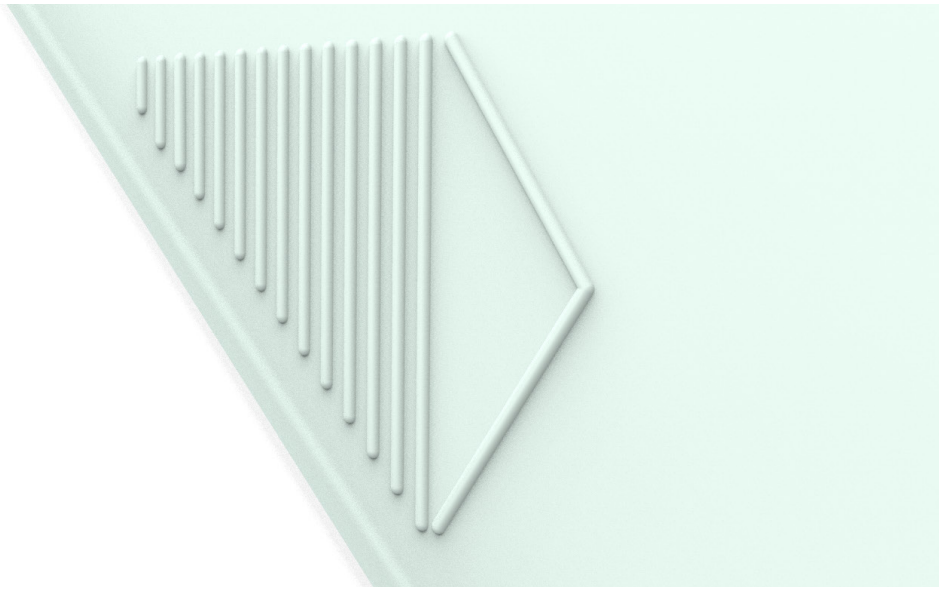
The goal with the construction of MATE is to guarantee that the safety when dispensing medicine is as close to 100% as possible. This means that the time currently used on double checking e.g. possibly can be usen on better patient care.

MATE ensures the 5R's – namely, the Right patient receives the Right preparation in the Right form in the Right amount for the Right time. The nurse still has to use time on dispensing, but the goal is to increase patient safety. It will be possible to implement this safety at the individual departments at the hospital, and the product will be able to not only handle pills, but also to assist the nurse when handling IV, melt tablets, suppositories etc.

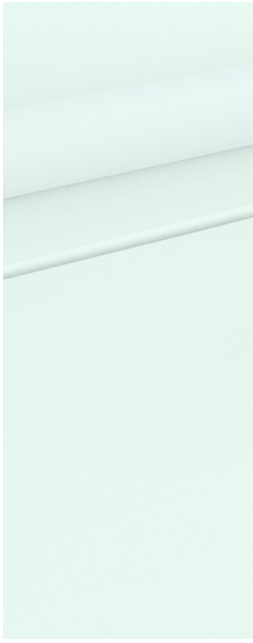
ACTIVE PILL INPUT



INTERACTION LINES

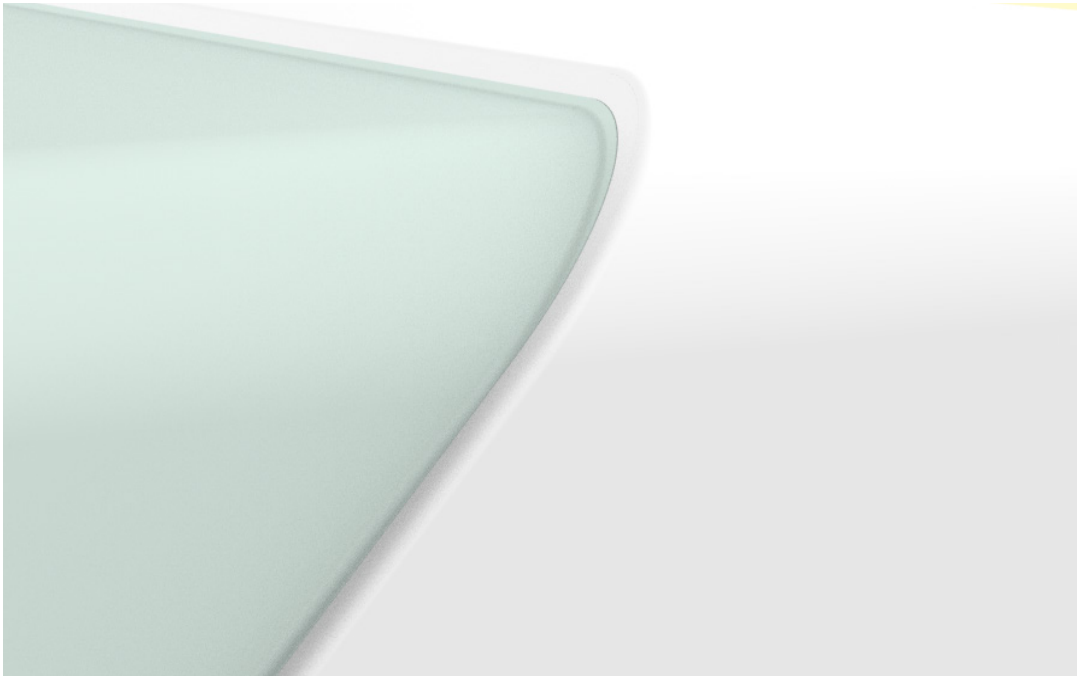


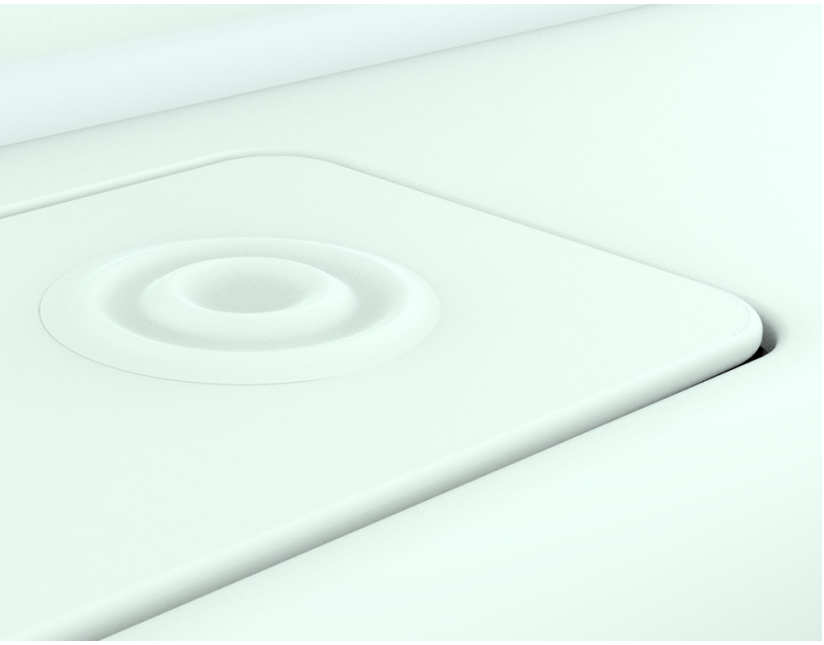
INACTIVE PILL INPUT



TRAY FOR EXTRA PARTS

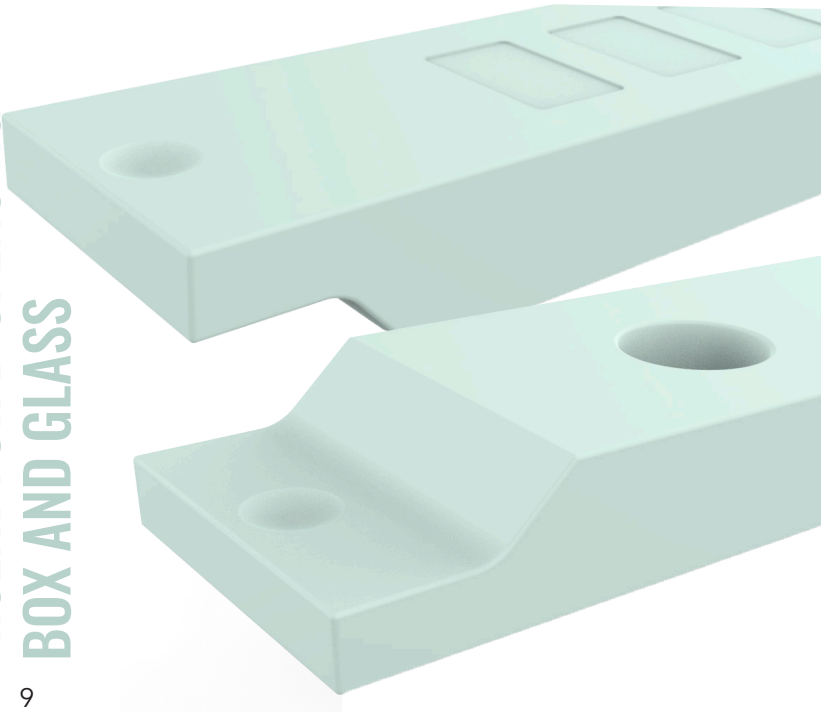
HIERARCHY



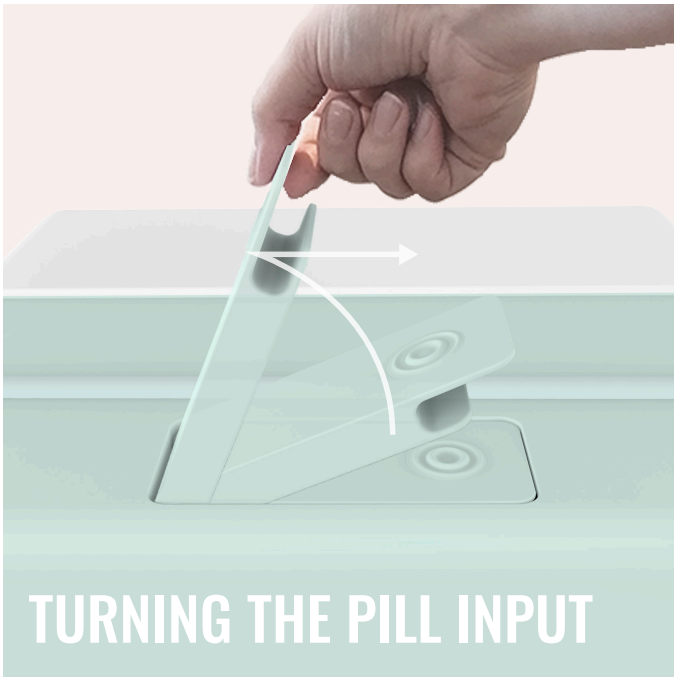


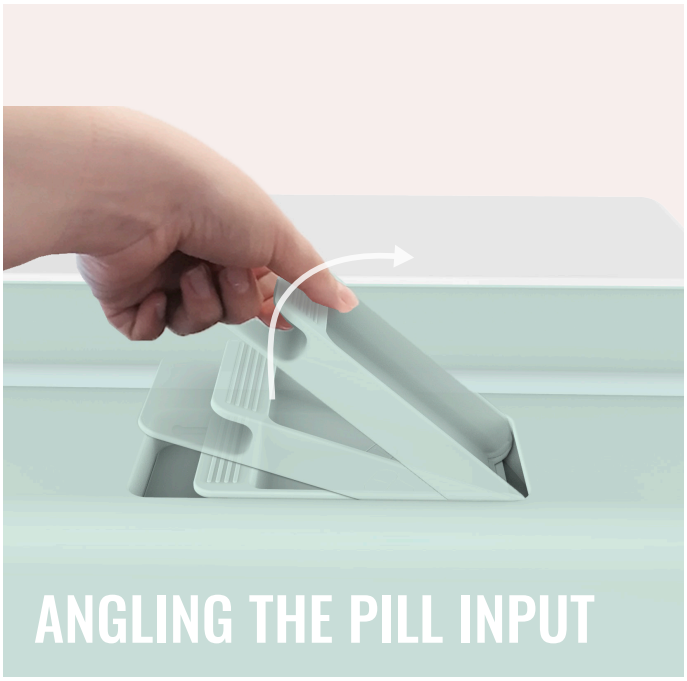
LOGO WITH LIGHT

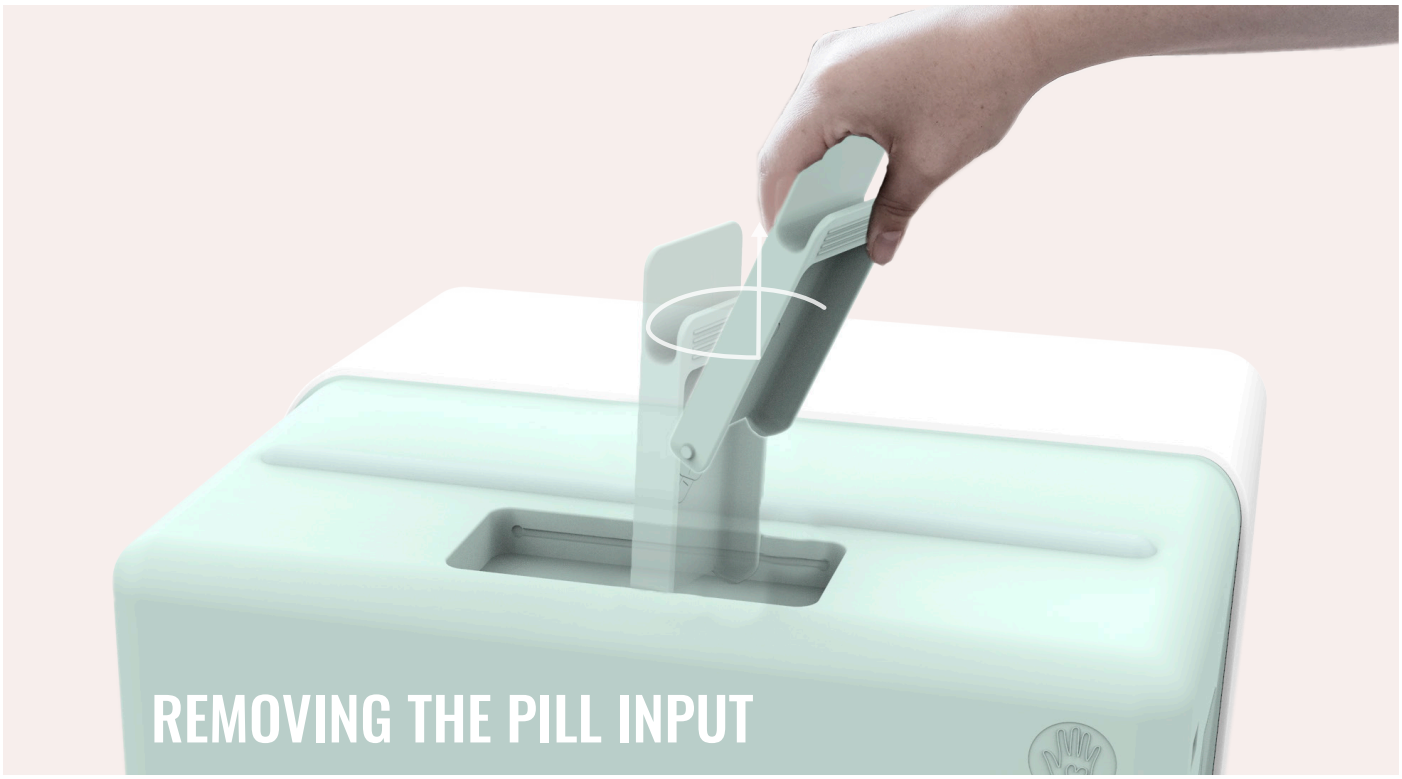
INSERT FOR DISPENSING BOX AND GLASS



HOW TO INTERACT





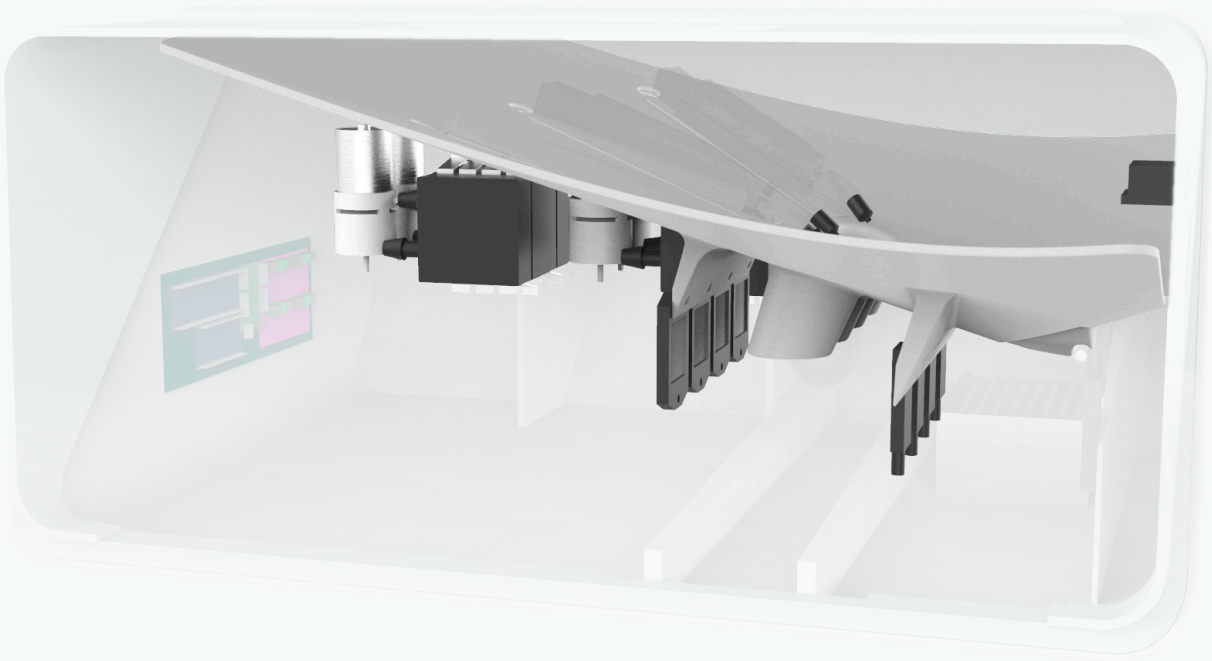


INSERT FOR DISPENSING BOX CAN BE TURNED

INDICATION OF GRIP ON TRAY FOR EXTRA PARTS

SCANNING CARD, DISPENSING BOX OR MEDICINE

HOW IS IT SAFE



In order to achieve the most accurate and safe product as possible, a vacuum suction principle is implemented in order to catch pills and dispense them into the respective compartments in the dispensing box.

BARCODE AND QR

Scanners esnures that the nurse dispenses the right medicine for the right patient in the right form.

ANGLE

An angle ensures that all the parts are positioned in the right angle and that the pills end up in the right position of the plate.

SENSOR

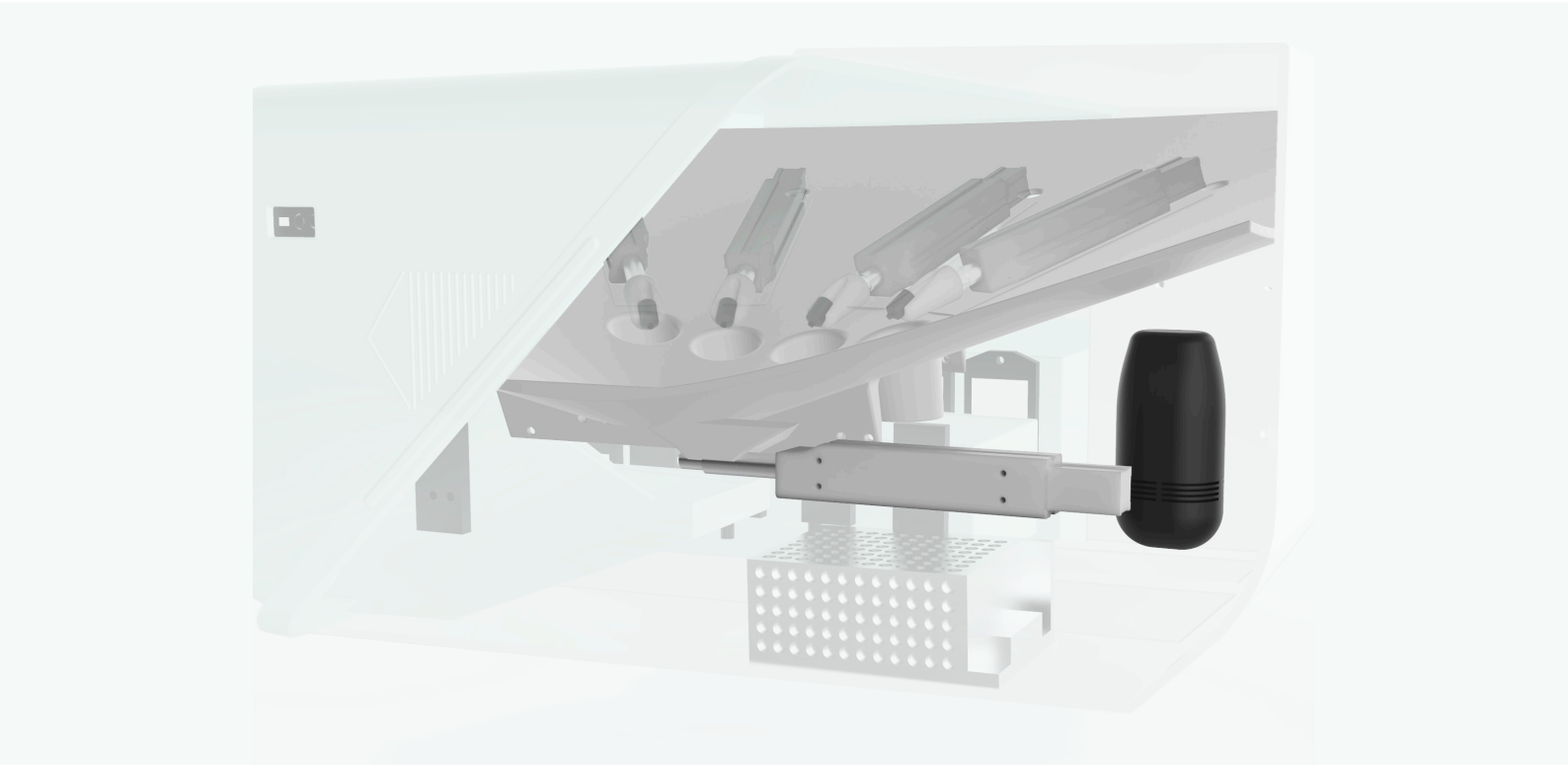
Sensors double check the placement of the pills and ensures the right amount.

VACUUM SENSOR

Vacuum sensors ensures the correct and needed vacuum for collecting pills.

MEMBRANE

A flexible membrane with the correct cross section ensures only one pill is moved at a time.



Medicine dust and potentially extra pills in the system will be safely removed regularly from MATE in order to make sure no dust or pills will be transferred to the next patient's dispensing and thereby cause a health care error.

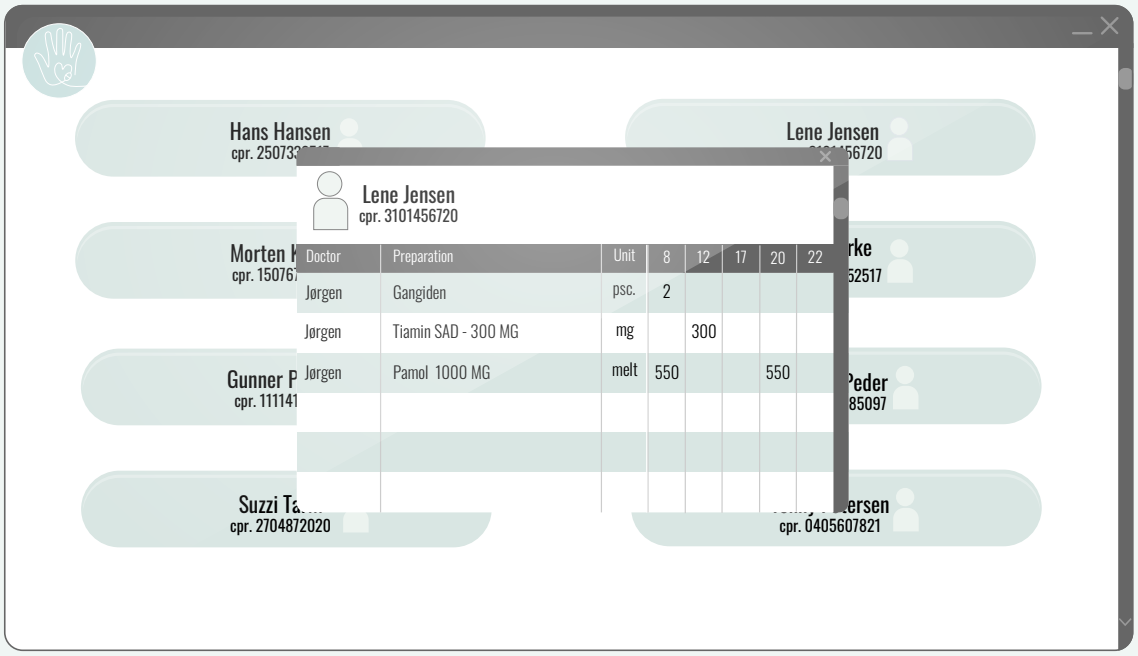
TRAY AND HATCH

A leftover tray and hatch ensures extra pills will be removed from the system.

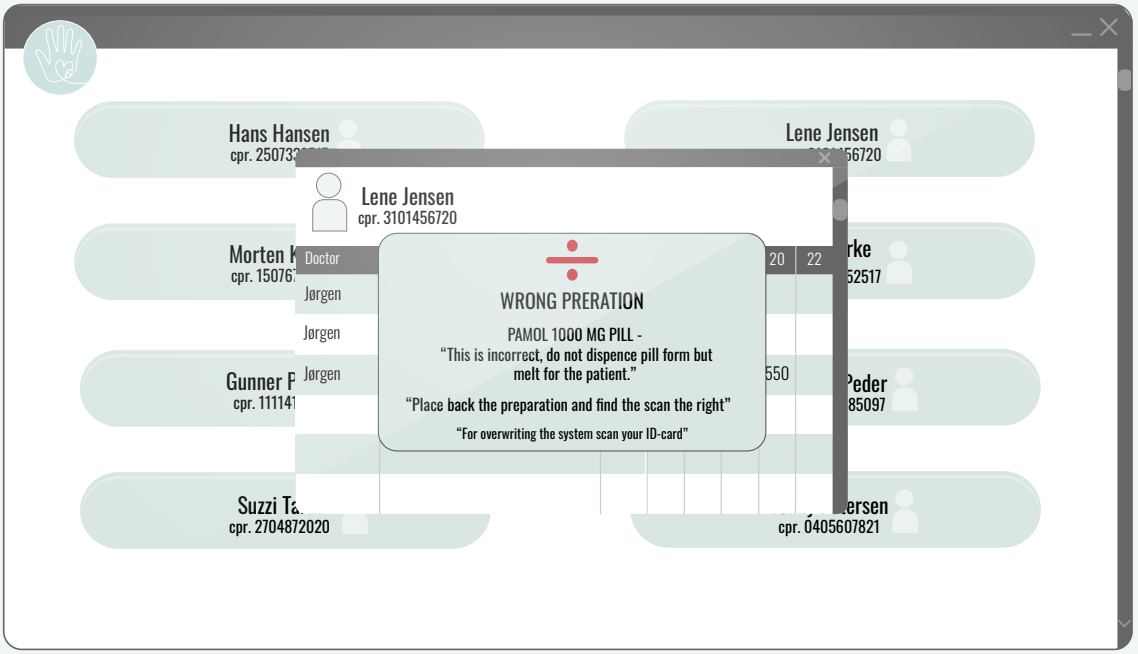
VACUUM CLEANER

A vacuum cleaner ensures no medicine dust is transferred to the next patient's dispensing.

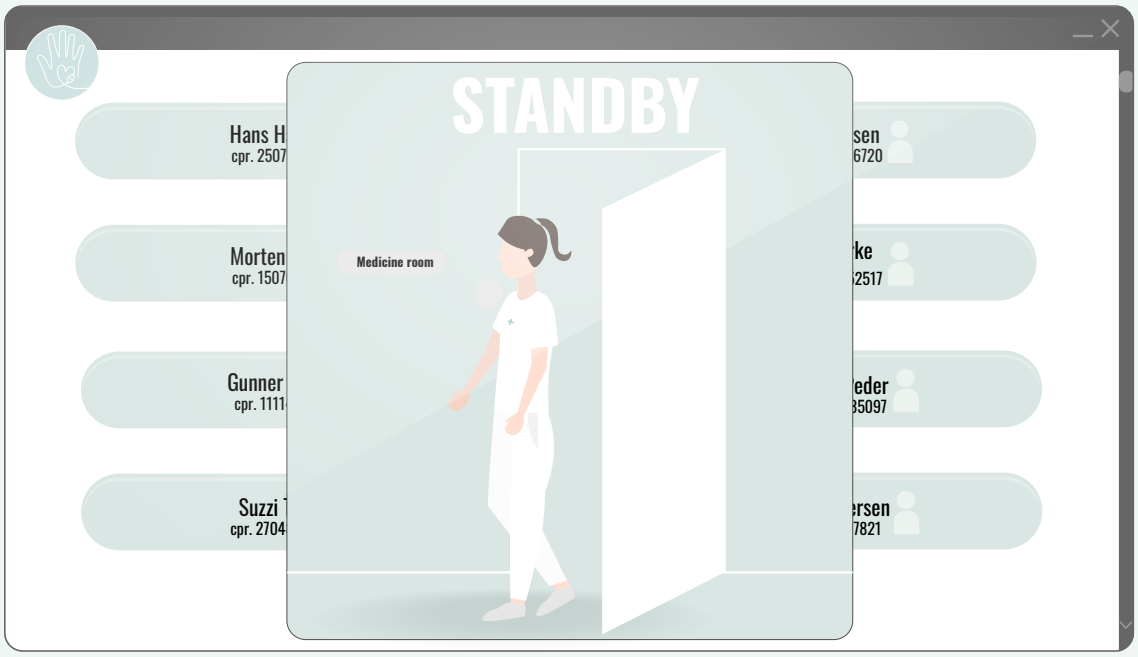
PLUG-IN



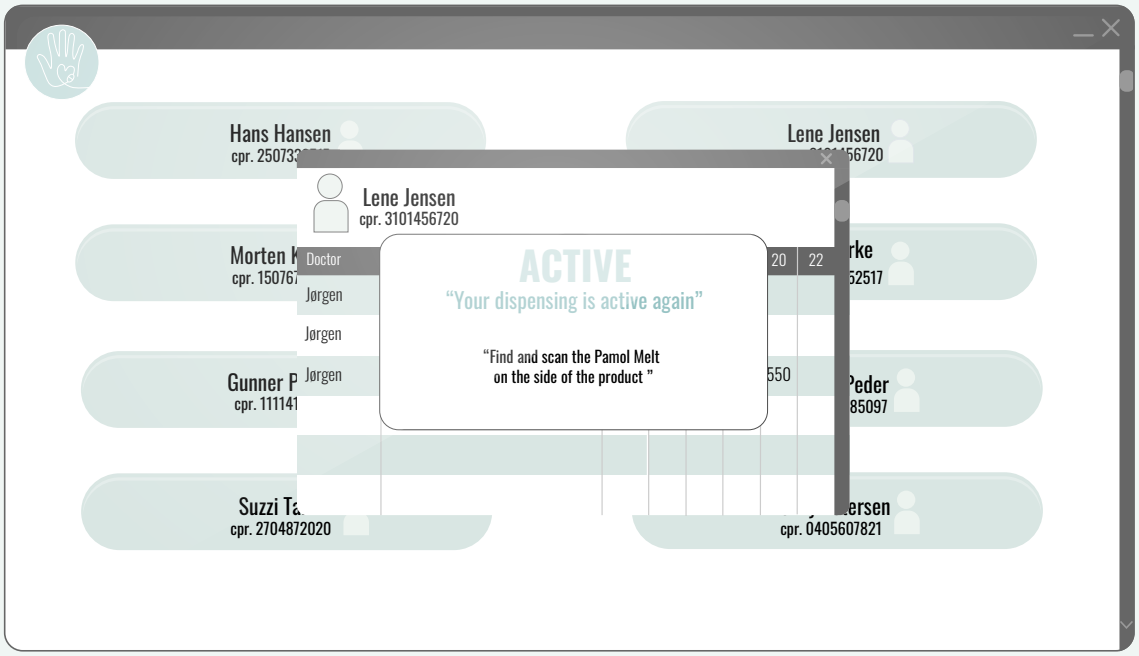
The plug-in for MATE assists the nurse when dispensing medicine. It draws the data from the Electronic Patient Journal already available for the nurse and informs if the action done is correct or not. At the interface, the nurse can see the patient list, the prescribed medicine for the patients, when the medicine is to be given and which form and dosage it should be given in.



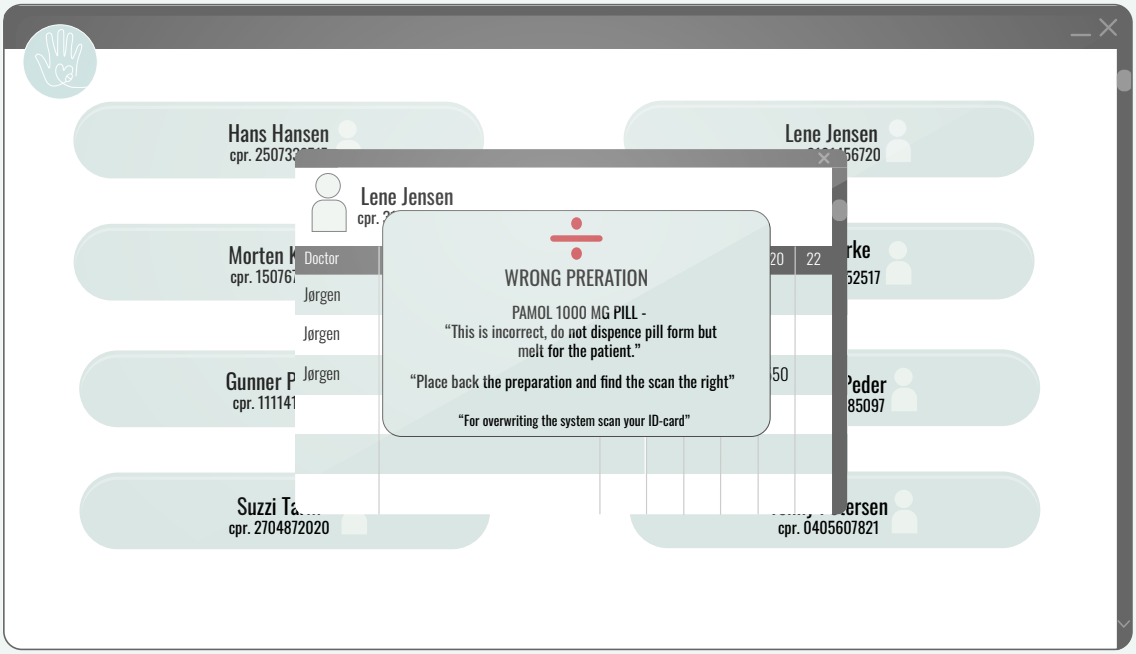
If an error happens, the plug-in alerts the nurse right away, and enlightens what needs to be done in order to correct it. In the shown case, the patient needs the pill as melt instead of a regular pill.



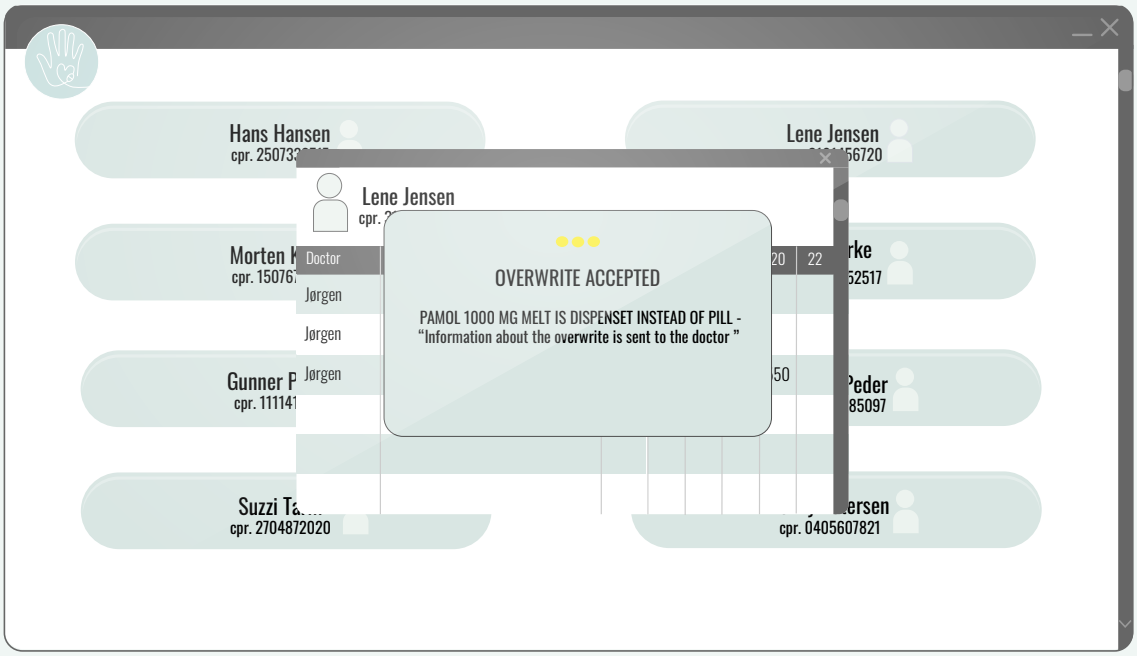
Sometimes the nurse has to leave the medicine room and take care of patients or help colleagues. Here, the plug-in will be put on standby, either actively done by the nurse when scanning the access card on the chip reader, or after the product has been inactive for 60 seconds. This function freeze the dispensation and ensures that no unintentional acts can be done before scanned back into the system.



When the nurse is back and has scanned the access card once more, the plug-in will remember the exact spot the nurse left off, and no errors will happen because of the interruption.



If the nurse needs to dispense another kind of medicine since a new medicine is prescribed, but not updated in the EPJ it is necessary to overwrite the system. The plug-in will warn the nurse, when a mistake is about to occur, and the nurse can use the ID-card to make MATE approve.



The medicine can be dispensed without having a doctor check it before hand. The plug-in will send a notification to the doctor of the preparations exchanged and which nurse that has overwritten the plug-in.

MANUAL CLEANING

MATE needs to be cleaned frequently because of the high need for patient safety and removal of bacteria. Therefore, it is designed in a way that makes it possible to take off the parts that are in direct touch of pills, and wash them in the autoclave at the hospital. Furthermore, the product needs to be possible to open in order to wipe the inside with disinfectants.

The nurse removes the laptop from MATE and places it on the counter top.

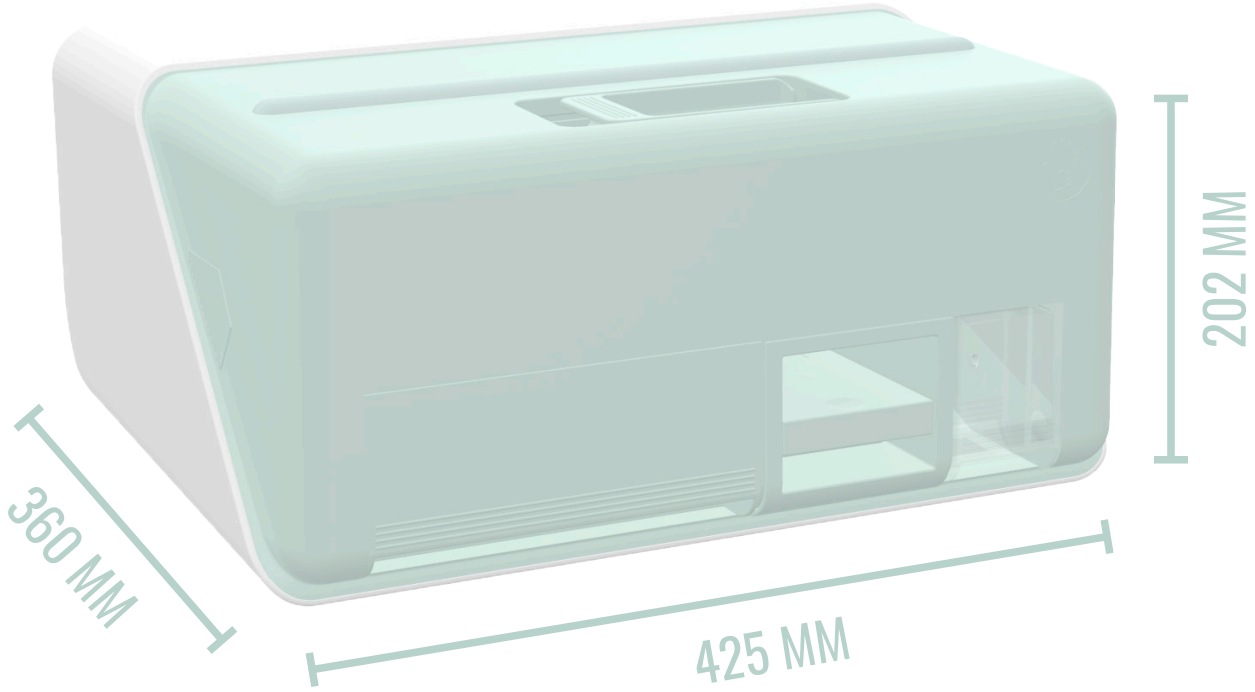
The pill input, insert for the dispensing box and glass, and the tray for leftover pills are removed and carried to the autoclave for cleaning.

The front shell is removed from MATE, and the inside components are disposed for cleaning.

A wet wipe with disinfectant is used to clean the plate where the pills have been in contact with it.

The front is placed back on the shell and the extra inserts are taken from the insert tray and placed into the front.

SPECIFICATIONS

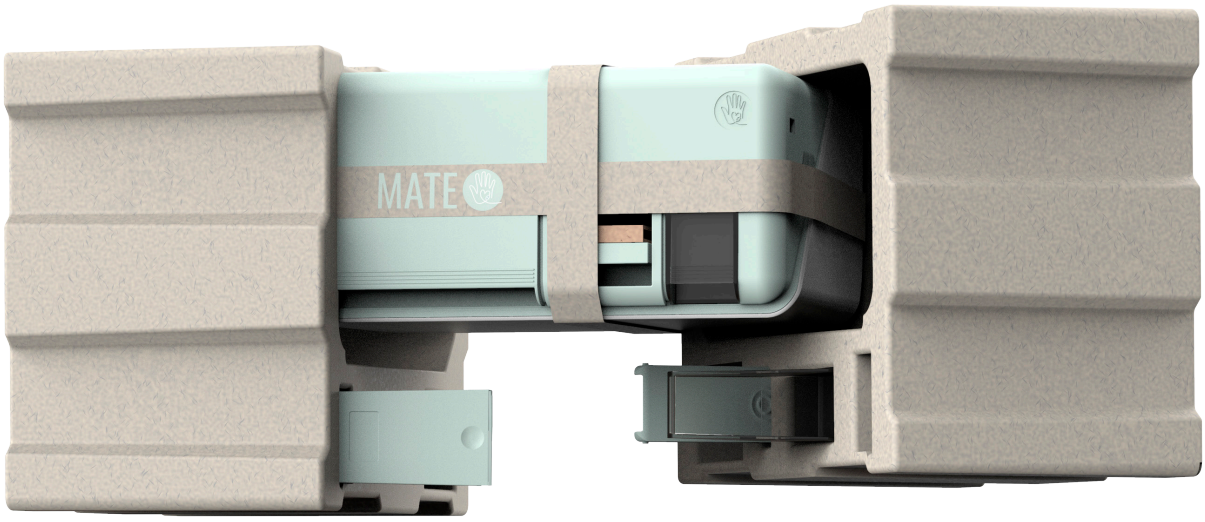


MATERIAL: PPSU

FIT LAPTOP SIZE: 15”

PLACEMENT: MEDICINE ROOM

SAFE TRANSPORTATION



TECHNICAL SUPPORT

The product will be installed in the medicine room by the technician at the hospital. If a problem occurs, the hospital department can contact the technical department at the hospital in order to get service and help with MATE.

If further help is needed, considering support, or the need to order new parts for MATE, it is possible to contact the design company.

With MATE the goal is to reduce medicine related health care errors, and optimize the workflow for the nurses in the medicine room.

Considering the price of extra hospitalization days at minimum 9600 DKK for each case, and a price of MATE at **32.599 DKK**, it will have earned its value back after having prevented four medicine related health care errors.
If speaking of a patient applying for compensation as a result of being wrongfully mediciated, it can cost between 2-300.000 DKK. Here, MATE would have been a much cheaper choice.

With a lower amount of health care errors, not only the patient and region will benefit from MATE. Also, the nurse will be able to use the time on better patient care and the department will utilize their resources better.

MINI MATE

If being a hospital with dosis dispensing solution already implemented at the hospital, where the patient safety is already in focus, MATE can seem unnecessary.

> *MINI MATE will provide the already covered department with an extra opportunity to do side dispensations and correct changed medicine dispensings.*

It will be possible to dispense one dose of medicine at a time in the standard dispensing glass and will be a much cheaper choice than MATE while it needs less functions and components. MINI MATE will also be possible to use at the departments where the nurses only dispense medicine for one dosis at the time.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MATE

Every department at the hospital will benefit from the help of MATE when dispensing medicine, while the chances of making a medicine related health care error will be reduced when using it, and insure that the right patient gets the right medicine in the right form in the right amount for the right time.

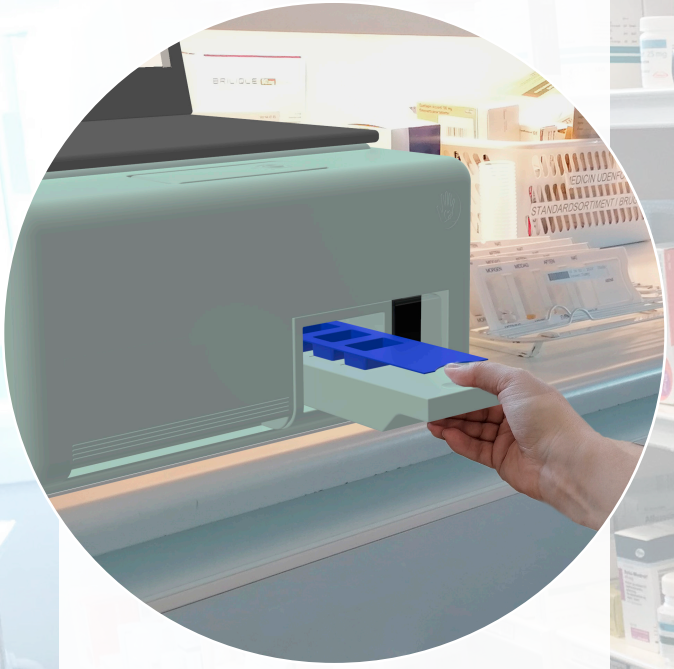
With the construction of precision actuators it is the goal to guarantee that MATE is as close to a 100% as possible.

It is now possible to implement patient safety regarding medicine dispensing at the individual departments within the hospital, without demanding big rebuilds of the hospital or huge investments.

MATE

Medicinhåndtering der gør
arbejdsflowet trygt og effektivt

MATE A/S
Co-directors: Sofie Thylkjær, Line Lundgaard, Karina Røjkjær
Contact: info@MATE.dk - Phone: +45 28 22 15 55



After scanning the patient's dispensing box, it is placed inside MATE where the system ensures that the pills are dispensed in the right amount for the right time.
The patient's dispensing box is placed on an insert that has two positions that has two orientations, one for the dispensing box and one for the dispensing glass.

Both the patient's medicine box and preparation box can be scanned in order to make sure that the right patient gets the right medicine in the right form.

MATE ensures that no medicine dust or leftover pills will be transferred to the next patient's dispensing, since a cleaning program will be activated between usages.

Specific parts being in direct contact with pills can be removed and cleaned in the autoclave.

TECHNICAL DRAWINGS
MATE

MSc04-ID12 I June 2020

TITLE PAGE

PROJECT TITLE: MATE - Medicinhåndtering der gør arbejdsf owet trygt og effektivt

PROJECT THEME: Redusing medicine related health care errors

PROJECT PERIOD: 03.02.20 - 18.06.20

PROJECT TEAM: MSc04-ID12

MAIN SUPERVISOR: Louise Møller Haase

TECHNICAL SUPERVISOR: Jørgen Kepler

NUMBER OF PAGES: 10

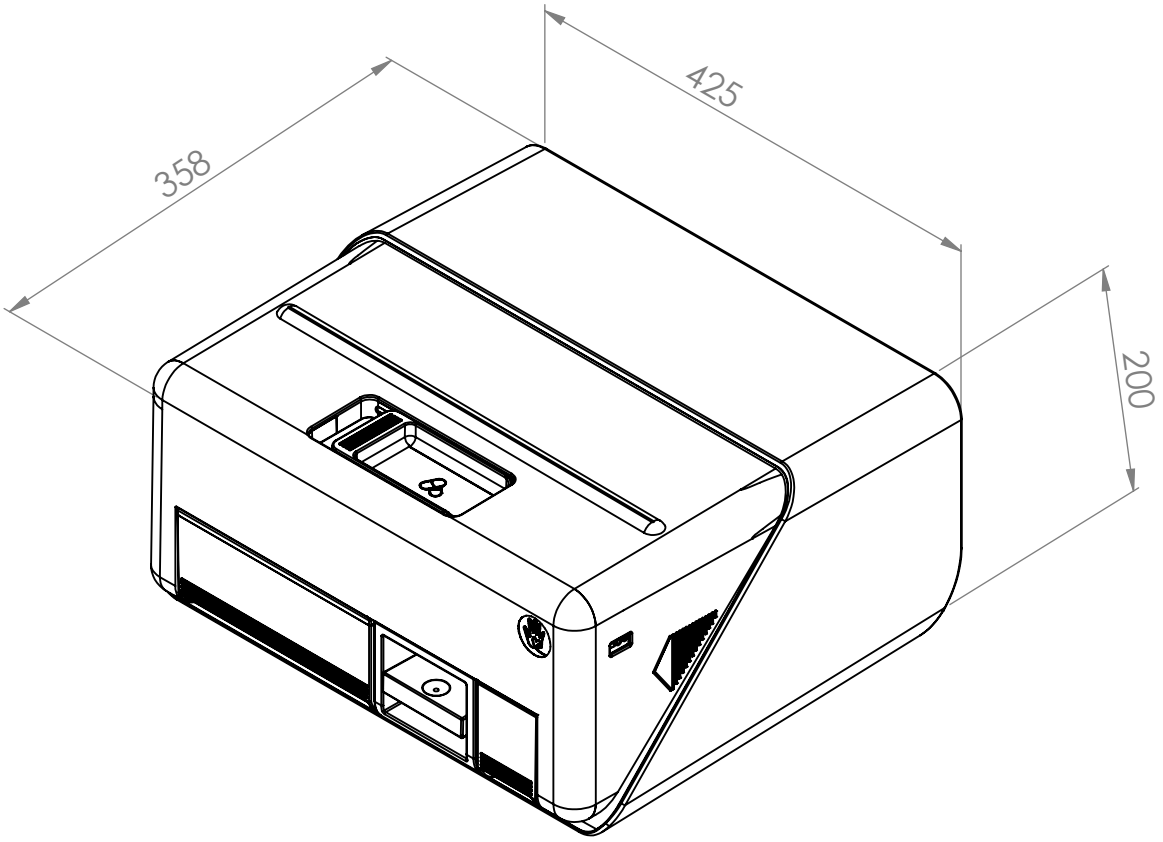
THE TEAM

SOFIE THYLKJÆR ASP

LINE LUNDGAARRD

KARINA RØJKJÆR

CONTENT



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	NAME	SIGNATURE	DATE			TITLE:	
DRAWN	MATE		30.05.20			Entire product	
CHK'D							
APPV'D							
MFG							
Q.A				MATERIAL:		DWG NO.	A4
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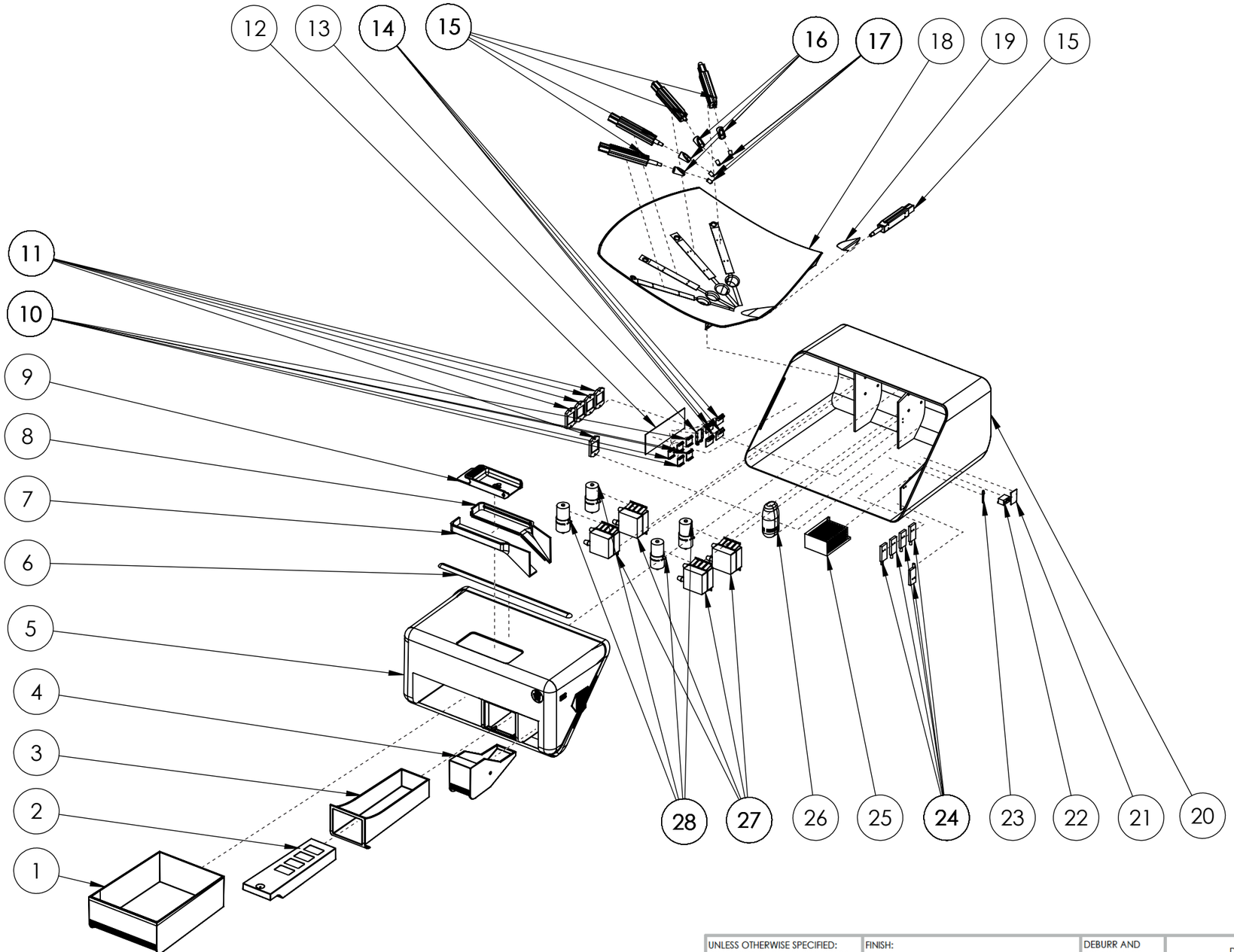
				WEIGHT: 4722g		SCALE 1:5	SHEET 1 OF 1

SOLIDWORKS Educational Product. For Instructional Use Only.



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	NAME	SIGNATURE	DATE			TITLE:	
DRAWN	MATE		30.05.20			Exploded view	
CHK'D							
APPV'D							
MFG							
Q.A				MATERIAL:		DWG NO.	A3
						NO. 2	
				WEIGHT: 4722g		SCALE:1:5	SHEET 1 OF 2

SOLIDWORKS Educational Product. For Instructional Use Only.

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Tray for inserts	PPSU	1
2	Insert for dispensing box and dispensing glass	PPSU	1
3	Frame for dispensing box hole	PPSU	1
4	Tray for extra pills	PPSU	1
5	Front	PPSU	1
6	Silicone list	Silicone	1
7	Pill input - left holder	PPSU	1
8	Pill input - right holder	PPSU	1
9	Pill input	PPSU	1
10	Driver for actuator	Power Management	5
11	Laser sensor reflector	Etro reflective LV-S/LV-N series	6
12	Print board	50mm x 140mm	1
13	Microcontroller	5V	1
14	Driver for vacuum pump	2.5 ~ 9.5VDC	4
15	Actuator	Stroke 100mm Speed 0,5m/s	5
16	Holder for membrane	PPSU	4
17	Membrane	NBR rubber - 2 mm	4
18	Angled plate	PPSU	1
19	Hatch	PPSU	1
20	Back	PPSU	1
21	RFID tag reader	Read Only 125kHz	1
22	QR and Barcode scanner	21.4mm x 12.0mm x 16.0mm	1
23	LED	5mm RGB - LED	1
24	Laser sensor sender	Laser head LV-S/LV-N series	6
25	Power supply	SGS25-12 V	1
26	Mini vacuum cleaner	80mm x 30mm x 40mm	1
27	Pressure sensor	Difference pressure sensor 10 kPa	4
28	Vacuum pump	12 V DC	4
29	Screws	Steel	36

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
DRAFT ANGLE: 1 degree:

FINISH:

DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN	MATE		30.05.20
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:

Bill of materials

MATERIAL:

DWG NO.

NO. 3

A4

WEIGHT:

SHEET 2 OF 2

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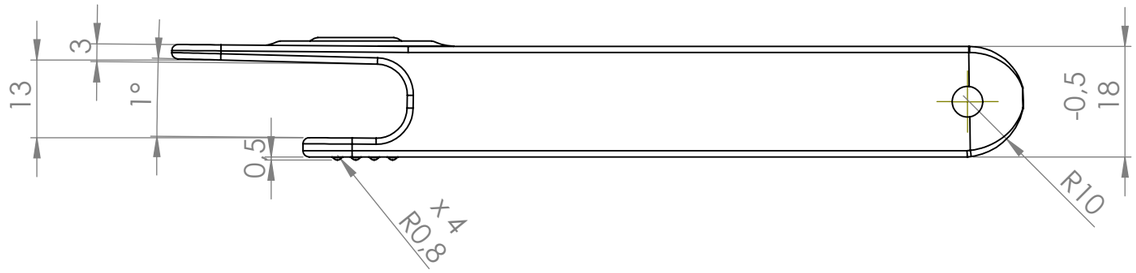
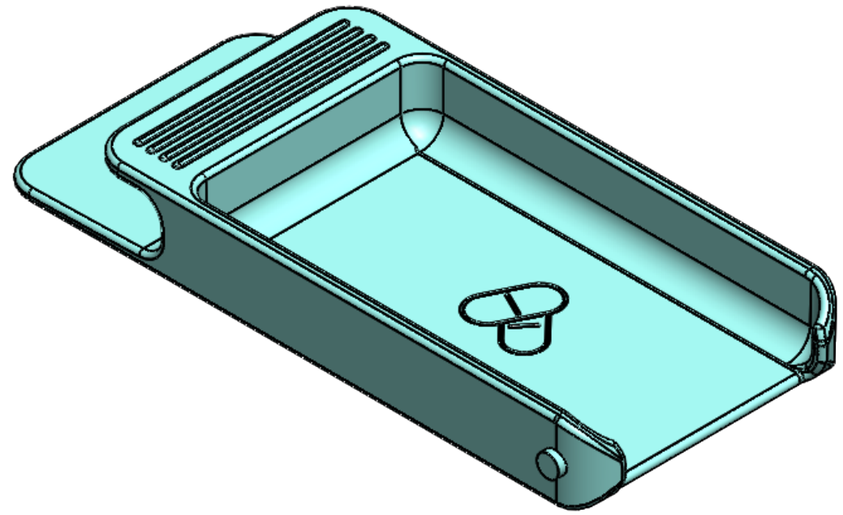
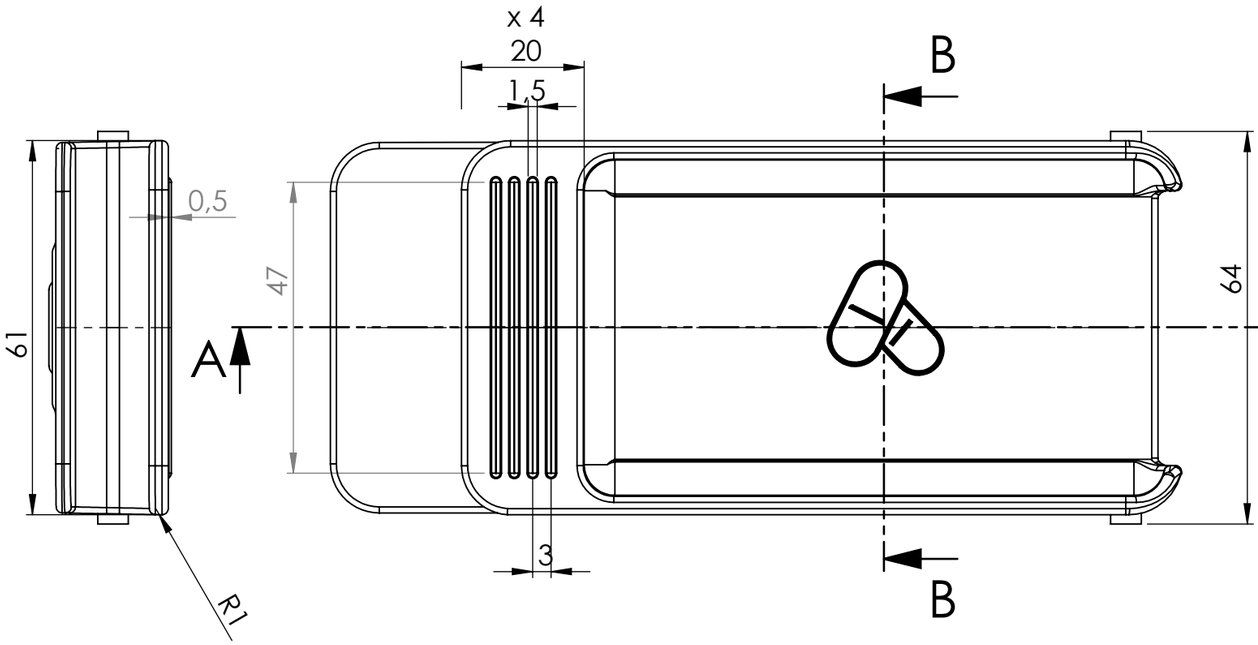
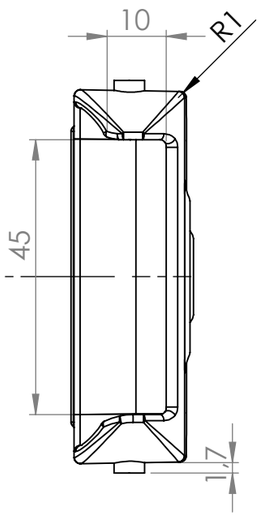
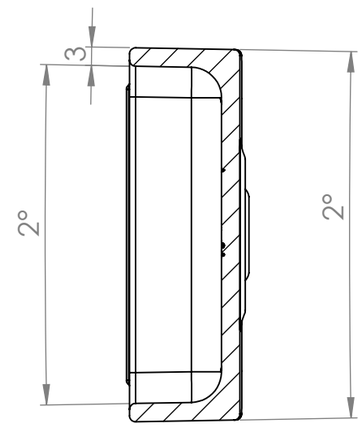


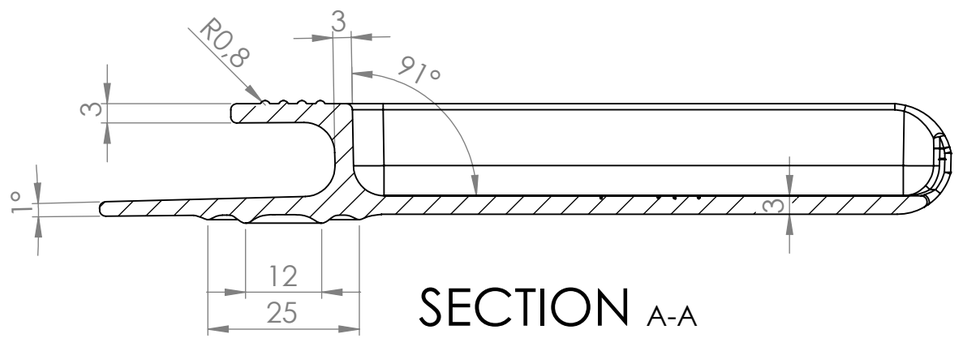








SECTION B-B



SECTION A-A

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: N5 TOLERANCES: DIN ISO 2768 DRAFT ANGLE: 1 DEGREE		PRODUCTION METHOD: Injection molding UNLESS OTHERWISE SPECIFIED: FILLETS ARE 1mm Mold consists of three pull directions			DEBURR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION
	NAME	SIGNATURE	DATE			TITLE: Pil input	
DRAWN	MATE		30.05.20				
CHK'D							
APPV'D							
MFG							
Q.A				MATERIAL: PPSU		DWG NO. NO. 4	A3
				WEIGHT: 40g		SCALE:1:1	SHEET 1 OF 1

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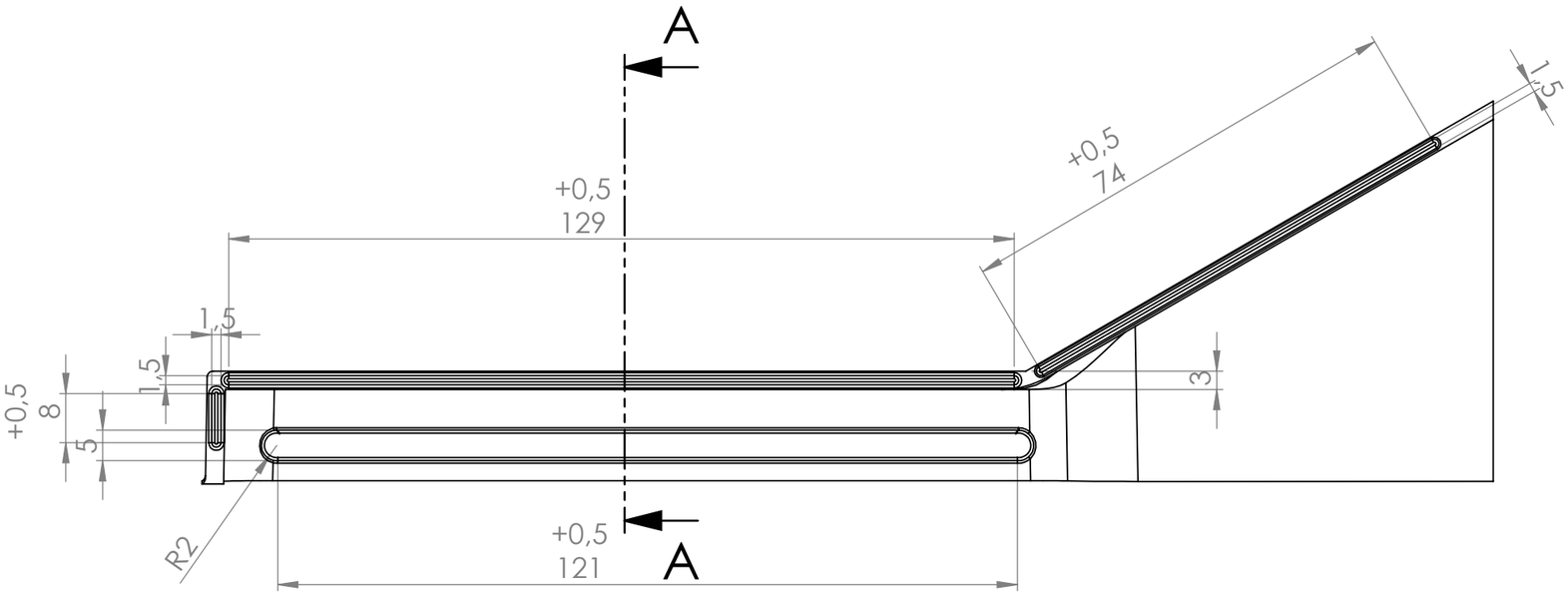

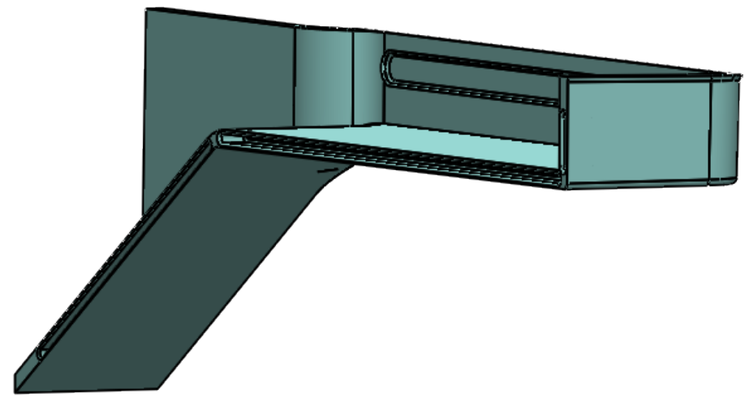

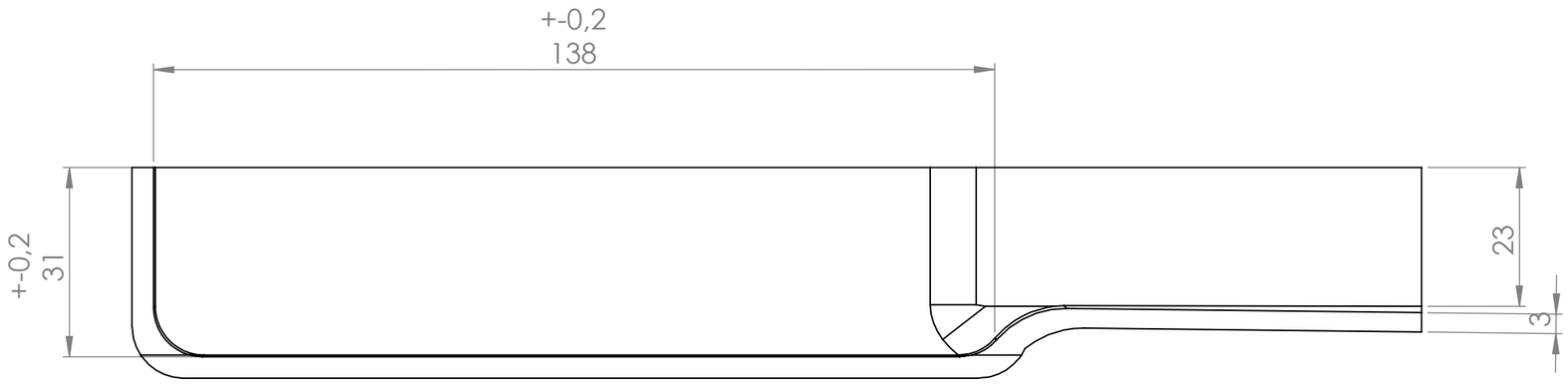

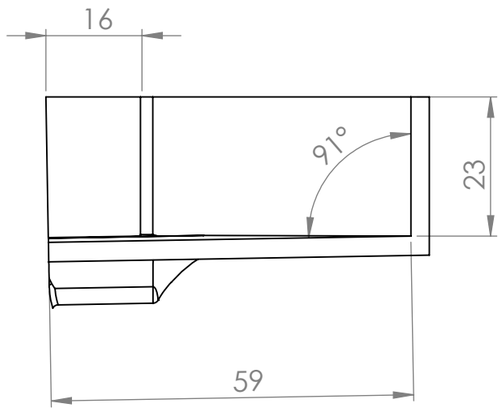

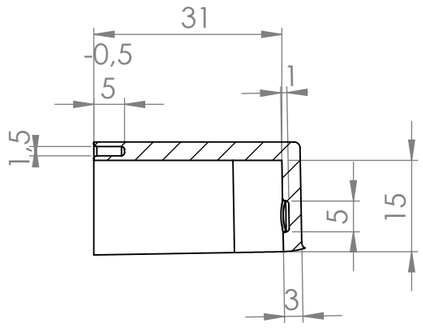

SECTION A-A

SCALE 1 : 1

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: N5 TOLERANCES: DIN ISO 2768 DRAFT ANGLES: 1 degree		PRODUCTION METHOD: Injection molding UNLESS OTHERWISE SPECIFIED: FILLETS ARE 1mm Mold consists of two pull directions		DEBURR AND BREAK SHARP EDGES		DO NOT SCALE DRAWING	REVISION
	NAME	SIGNATURE	DATE			TITLE: Left input holder	
DRAWN	MATE		31.05.20				
CHK'D							
APPV'D							
MFG							
Q.A				MATERIAL: PPSU		DWG NO. NO. 5	A3
				WEIGHT: 37g		SCALE: 1:1	SHEET 1 OF 1

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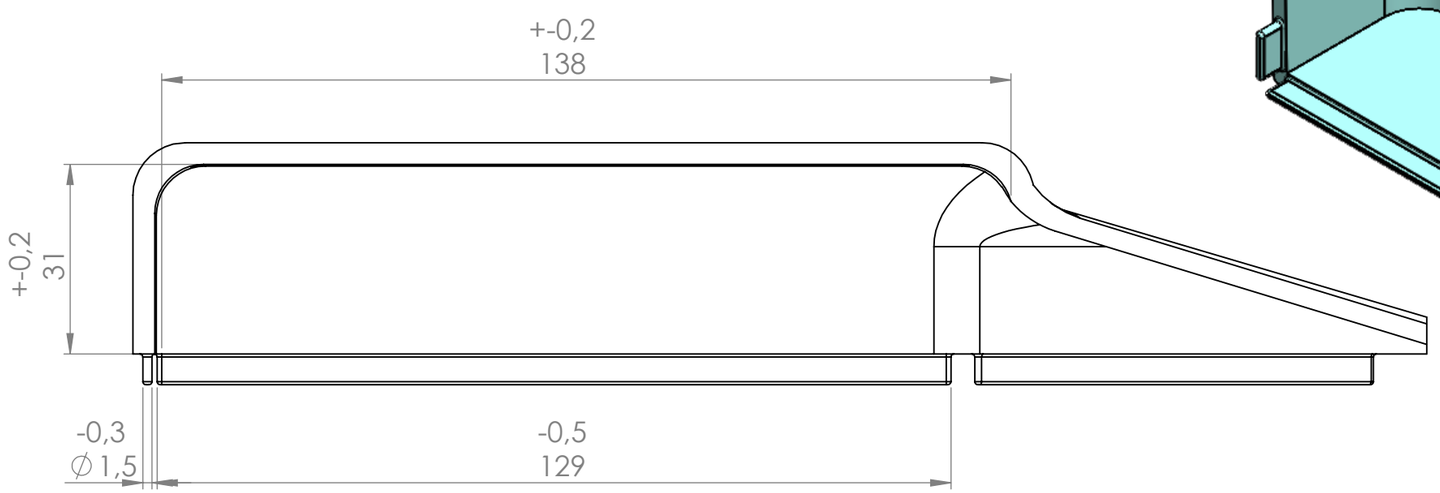

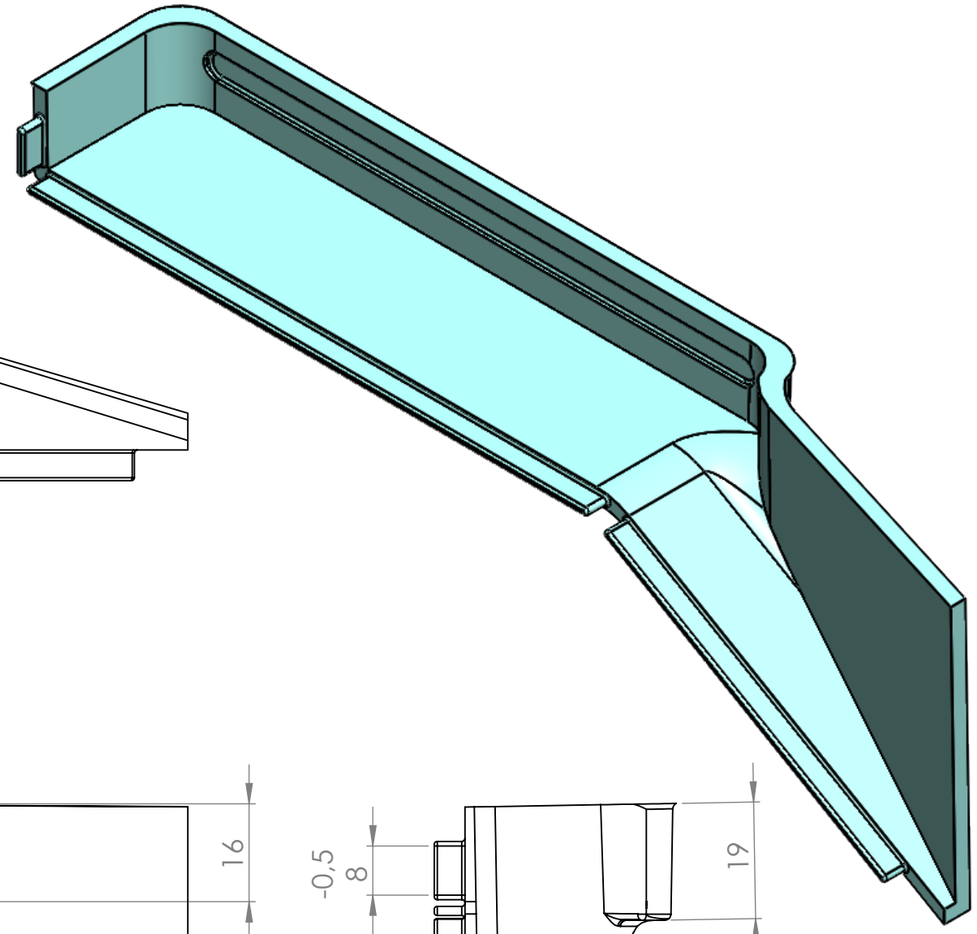

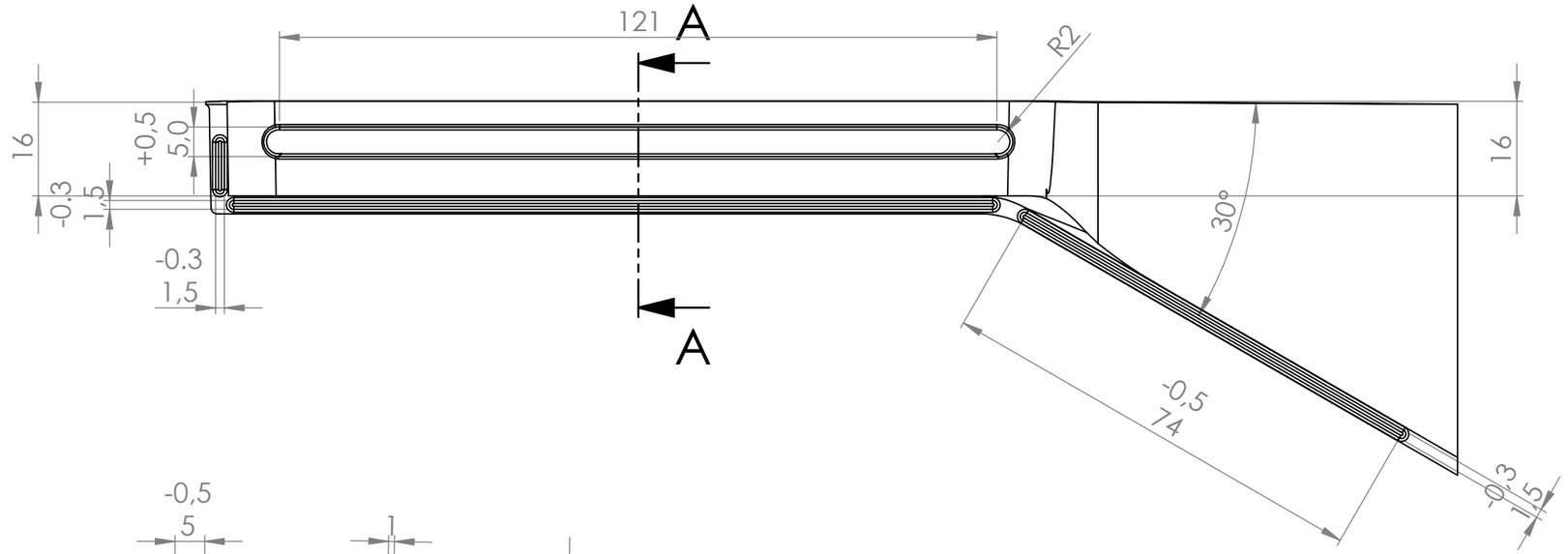

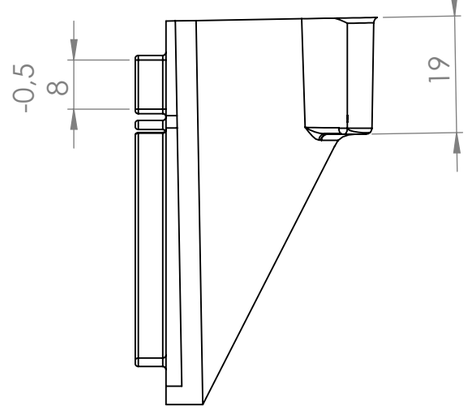

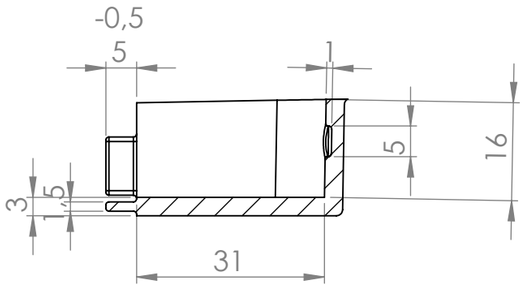

SECTION A-A

SCALE 1 : 1

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: N5 TOLERANCES: DIN ISO 2768 DRAFT ANGLE: 1 degree		PRODUCTION METHOD: Injection molding UNLESS OTHERWISE SPECIFIED: FILLETS ARE 1mm Mold consists of two pull directions		DEBURR AND BREAK SHARP EDGES		DO NOT SCALE DRAWING	REVISION
	NAME	SIGNATURE	DATE			TITLE: Right input holder	
DRAWN	MATE		31.05.20				
CHK'D							
APPV'D							
MFG							
Q.A				MATERIAL: PPSU		DWG NO. NO. 6	A3
				WEIGHT: 37g		SCALE:1:1	SHEET 1 OF 1

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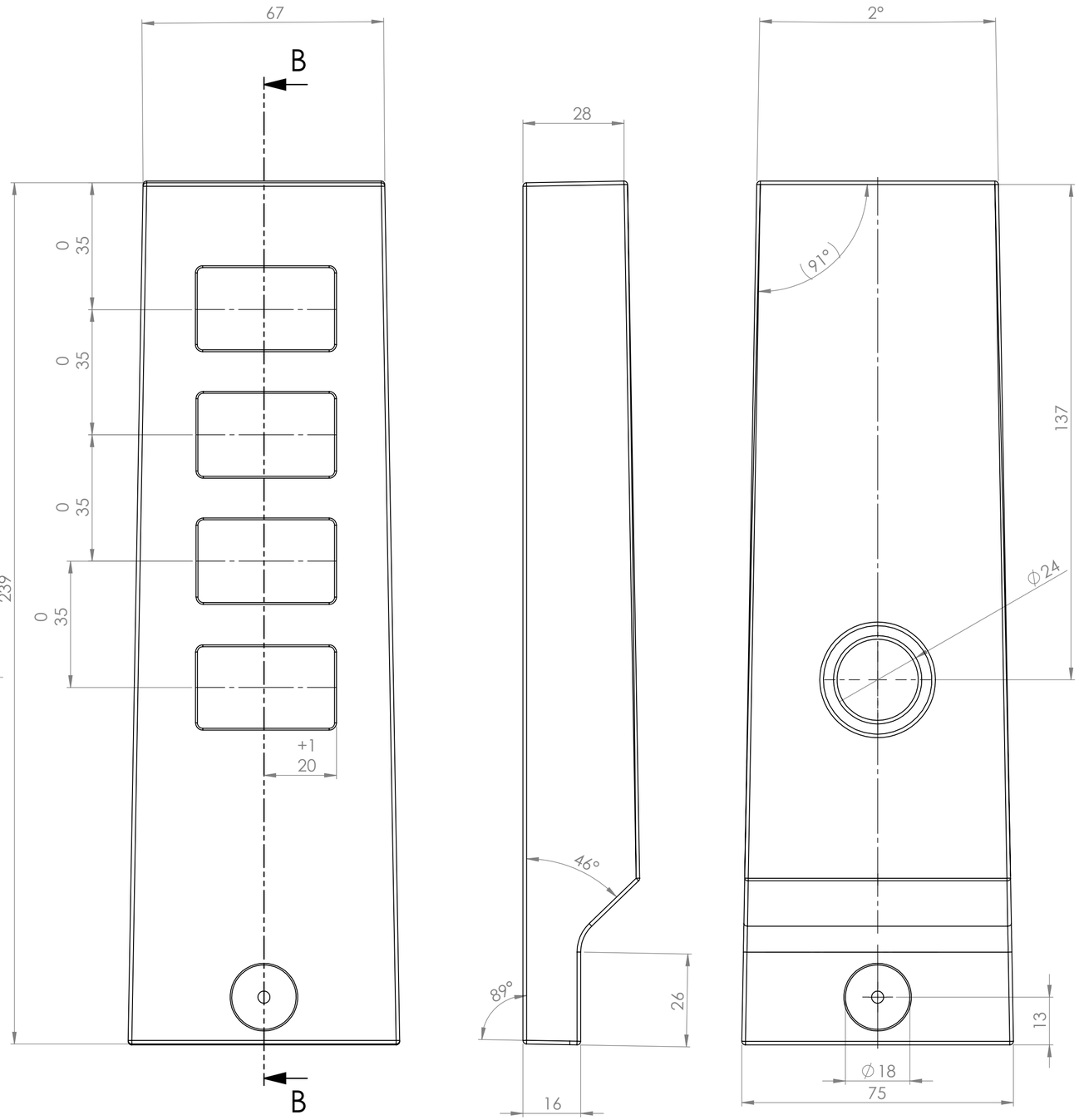
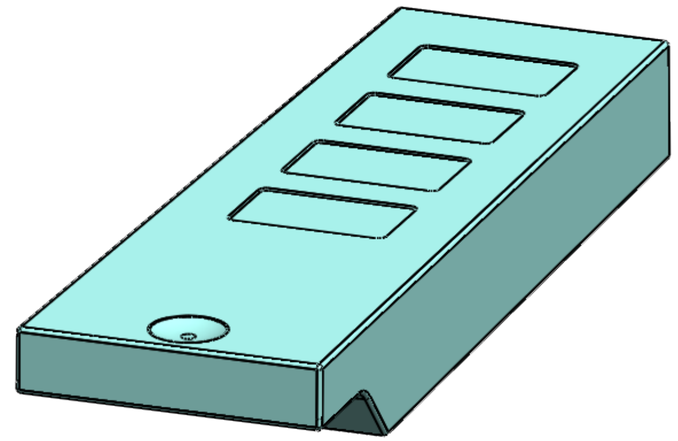
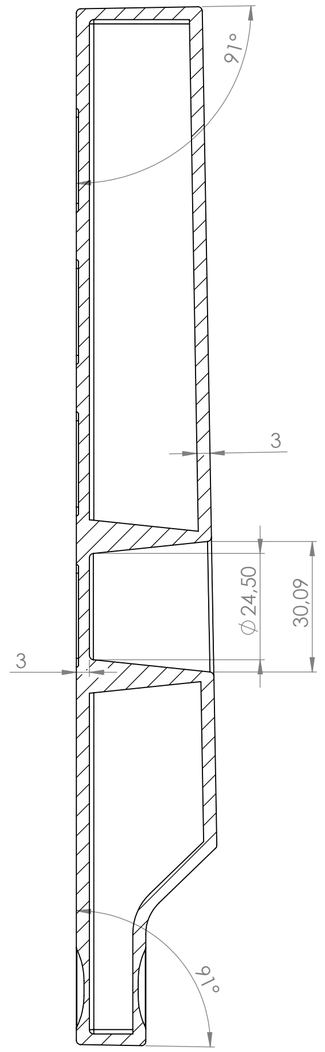
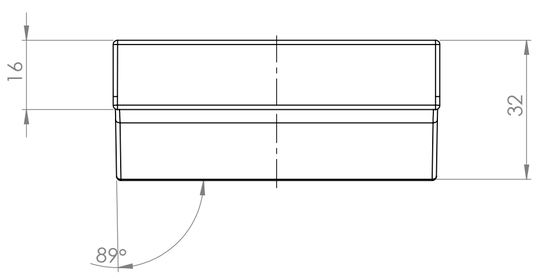






SECTION B-B



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: N5 TOLERANCES: DIN ISO 2768 DRAFT ANGLE: 1 degree	PRODUCTION METHOD: Rotational molding UNLESS OTHERWISE SPECIFIED: FILLETS ARE 1mm	DEBURR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION		
	NAME	SIGNATURE	DATE	TITLE: Insert, dispensing glass and box		
DRAWN	MATE		31.05.20			
CHK'D						
APPV'D						
MFG						
Q.A				MATERIAL: PPSU	DWG NO. NO. 7	A2
				WEIGHT: 154g	SCALE:1:1	SHEET 1 OF 1

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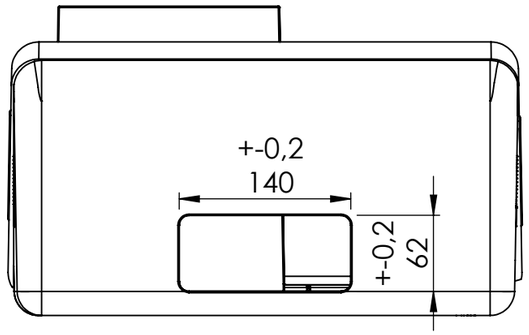

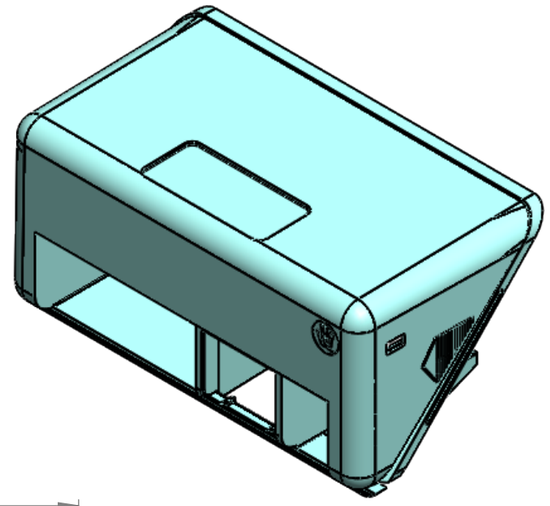

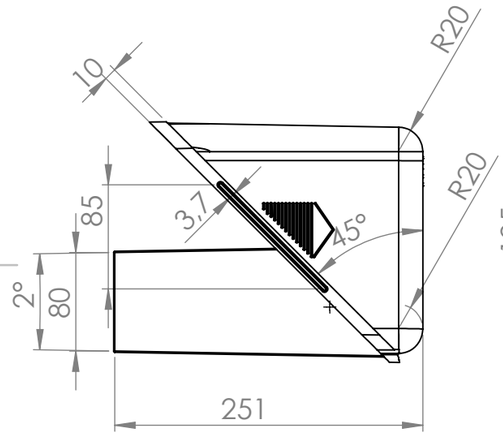

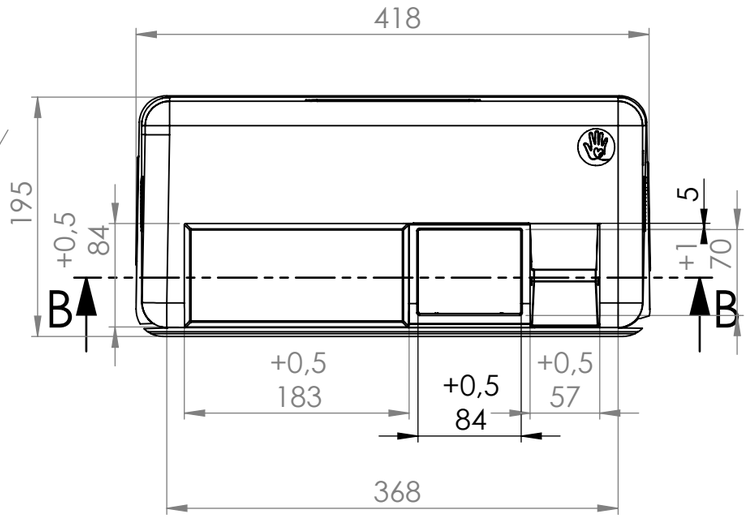

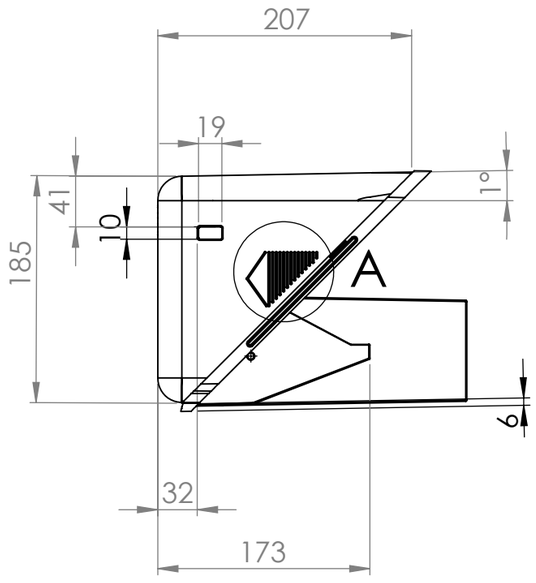

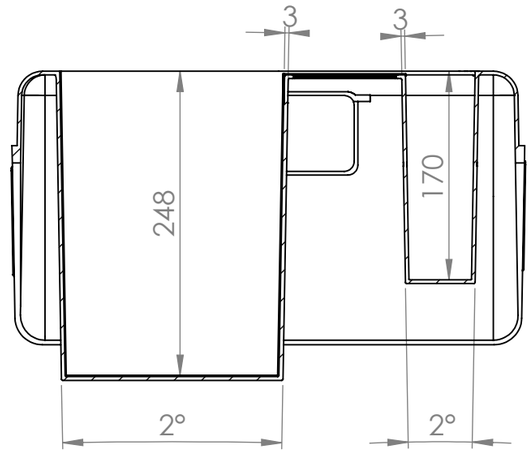

SECTION B-B

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: N5 TOLERANCES: DIN ISO 2768 DRAFT ANGLE: 1 degree	PRODUCTION METHOD: Injection molding UNLESS OTHERWISE SPECIFIED: FILLETS ARE 1mm Mold consists of five pull directions	DEBURR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION			
	NAME	SIGNATURE	DATE				TITLE: Front
DRAWN	MATE		31.05.20				
CHK'D							
APPV'D							
MFG							
Q.A				MATERIAL: PPSU			DWG NO. NO. 8
							A3
				WEIGHT: 1082g		SCALE:1:5	SHEET 1 OF 1

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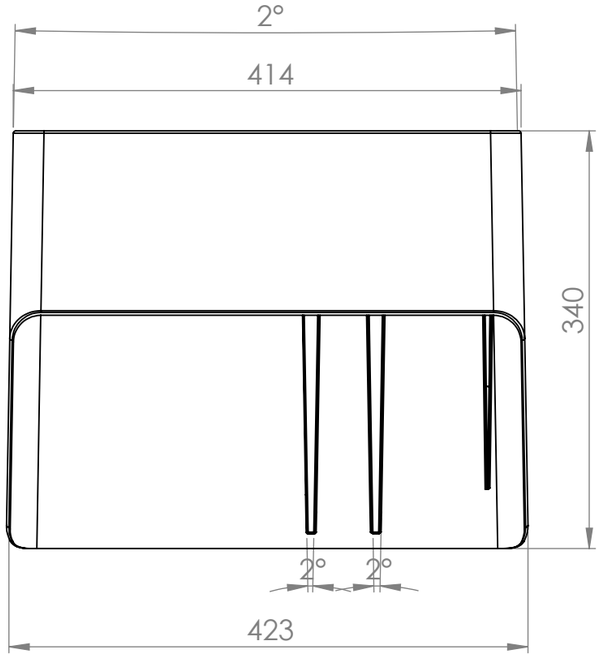
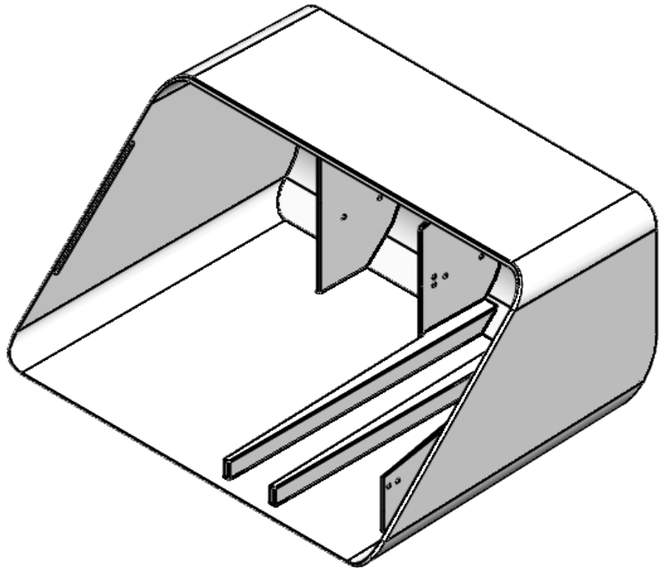
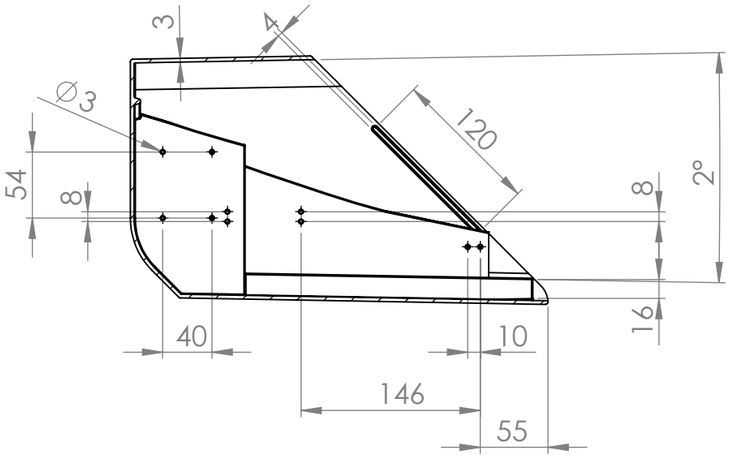
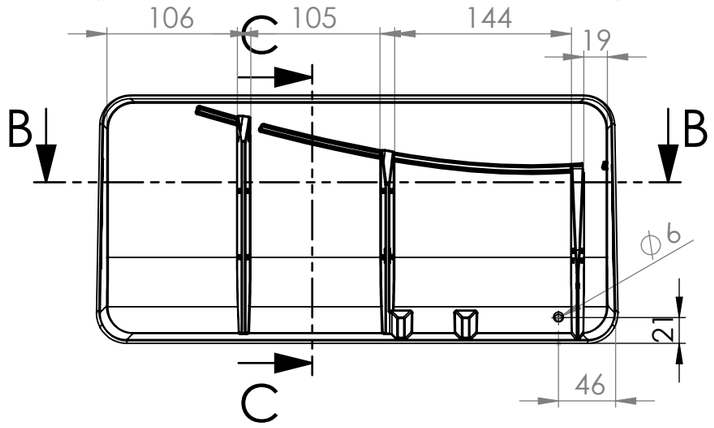
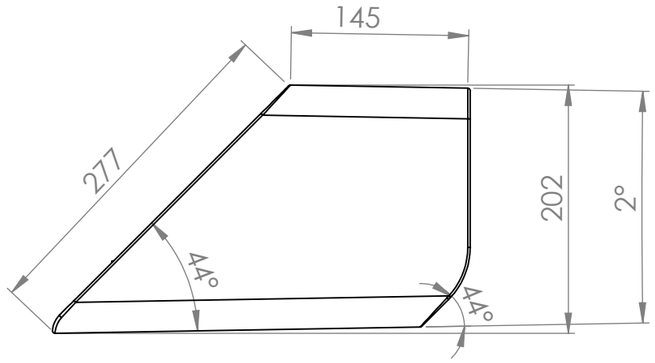


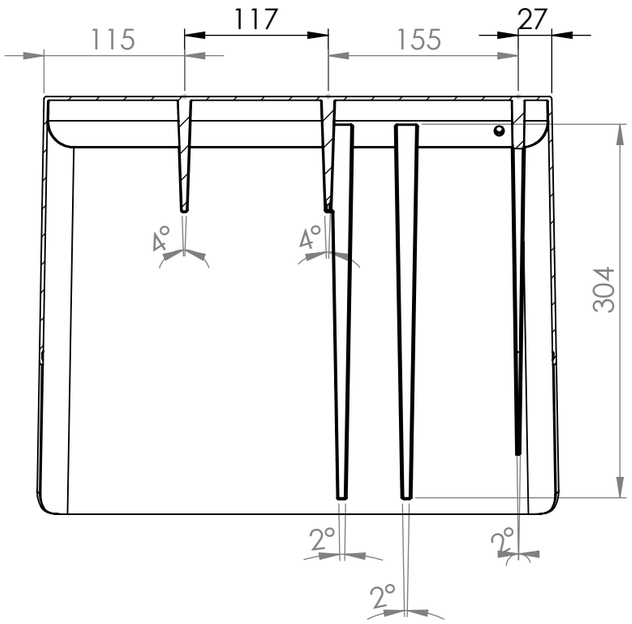




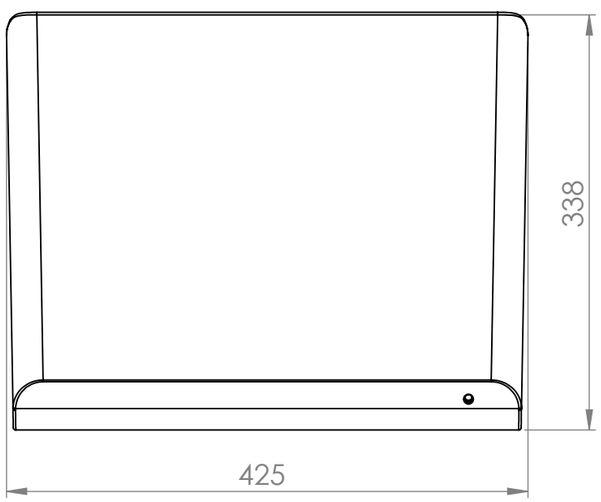
SECTION C-C







SECTION B-B



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: N5 TOLERANCES: DIN ISO 2768 DRAFT ANGLE: 1 degree	PRODUCTION METHOD: Injection molding UNLESS OTHERWISE SPECIFIED: FILLETS ARE 1mm Mold consists of two pull directions	DEBURR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION			
	NAME	SIGNATURE	DATE				TITLE: Back
DRAWN	MATE		31.05.20				
CHK'D							
APPV'D							
MFG							
Q.A				MATERIAL: PPSU			DWG NO. NO. 9
							A3
				WEIGHT: 1535 g			SCALE:1:5
							SHEET 1 OF 1

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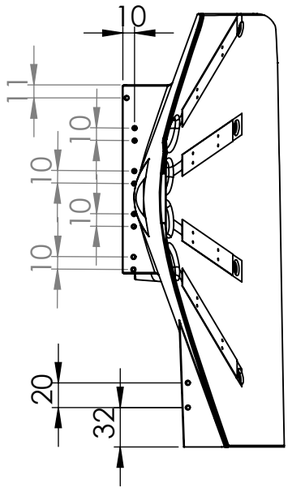

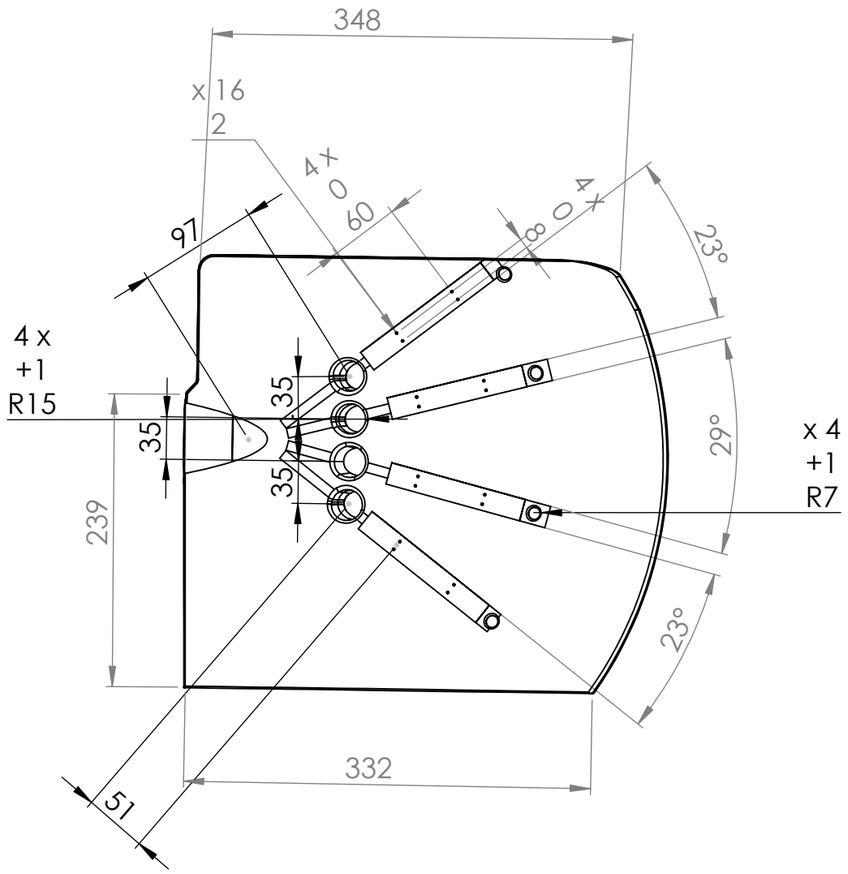

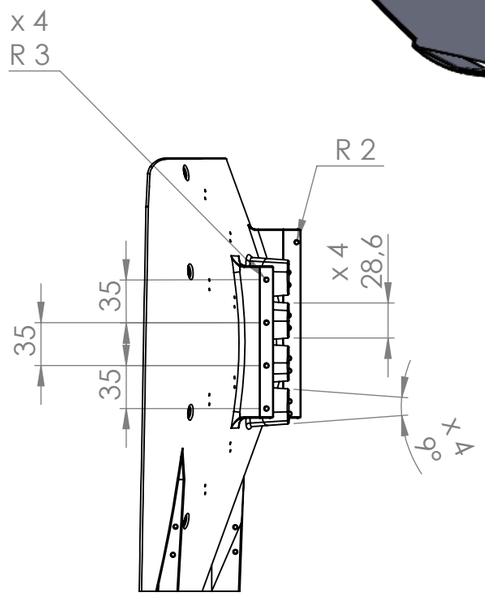

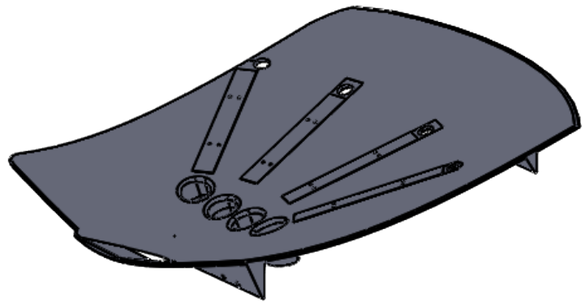

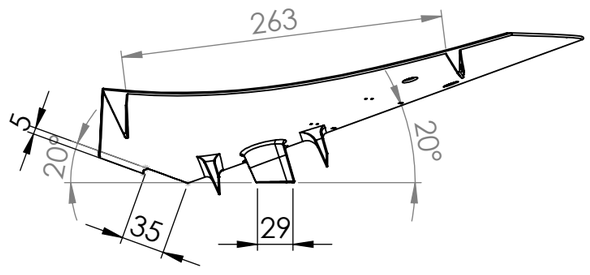

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: N3 TOLERANCES: DIN ISO 2768 DRAFT ANGLES: 1 degree	PRODUCTION METHOD: Injection molding UNLESS OTHERWISE SPECIFIED: FILLETS ARE 1mm Mold consists of two pull directions		DEBURR AND BREAK SHARP EDGES		DO NOT SCALE DRAWING	REVISION	
	NAME	SIGNATURE	DATE		TITLE:		
DRAWN	MATE		01.06.20		Plate for actuators		
CHK'D							
APPV'D							
MFG							
Q.A				MATERIAL:	DWG NO.		A3
				PPSU	NO. 10		
				WEIGHT: 1200 g	SCALE:1:5	SHEET 1 OF 1	

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