

A

SECURE TOUCH



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A Secure Touch

Hand-Isolation System for PPE Doffing process

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Keywords

PPE	Personal protection equipment
HCW	Healthcare workers
TO	Trained observers
PAPR	Powered Air-Purifying Respirator
BSL	Biosafety level
Don	to put on or dress in (frequent word: donning process)
Doff	to remove from the body (frequent word: doffing process)

Abstract

Pandemic happens every year, which brings deaths and tragedy to people from all over the world. This diploma shows the possible solution of saving more people's life when an outbreak coming. The project starts from a broad research of the massive pandemic universe in different perspective, and ends up with a series of tools for health care workers. The concept is to isolate the hand using of health care workers in the whole journey of the PPE (personal protection equipment) doffing process, which effectively lower the risk of self-contamination when severe infectious disease happens in near future. The product can be universally used for different type of PPEs.



Photo by John Moore/Getty Images

Getting Started

CONTEXT

My project began as widely as researching within the entire picture of pandemic and epidemic globally. After the big mapping phase, the project scoped down to the area of PPE using for health care workers for a deeper problem-solving phase.

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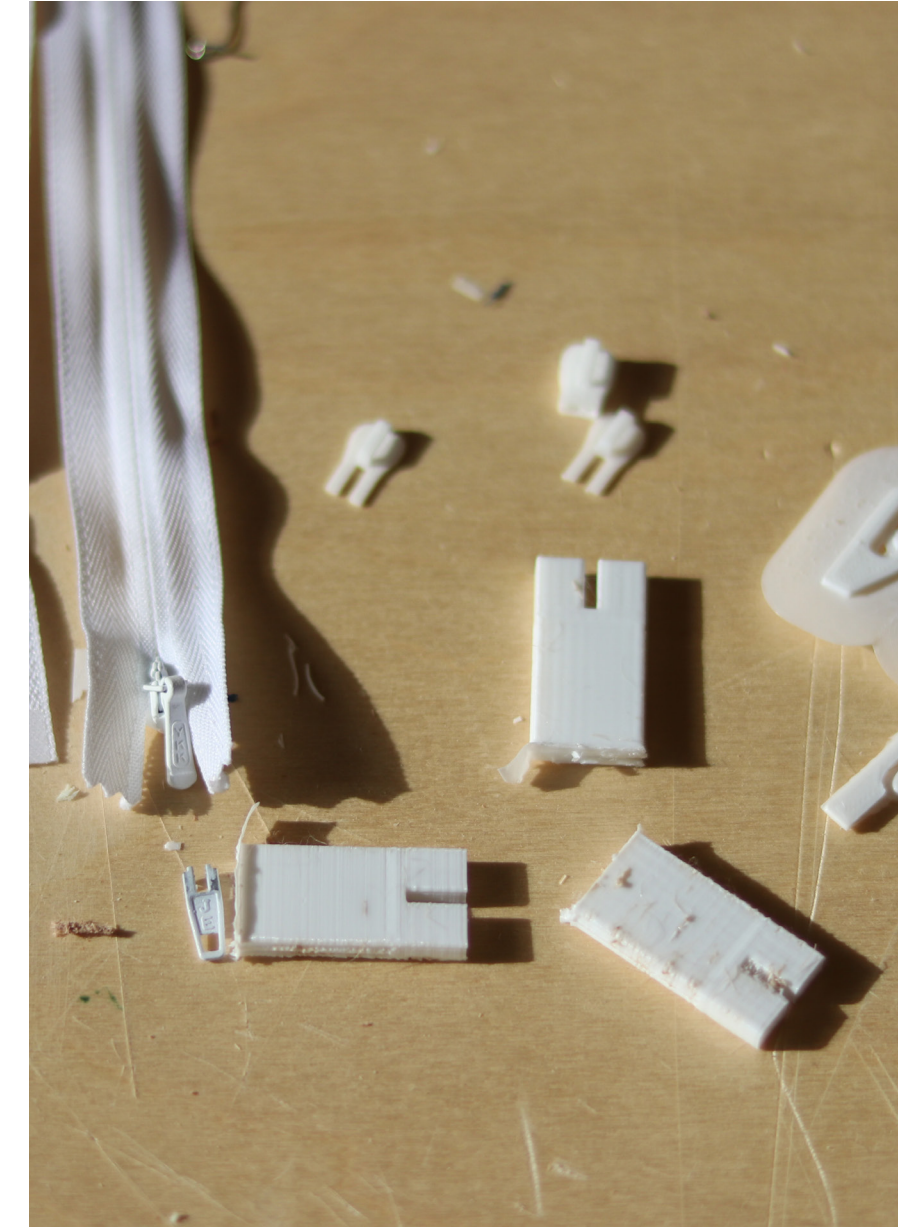
Since the starting point is broad. I would like to be rational and explorative for the big context and try to find the most prioritized area for scoping. I aimed to find the usually ignored but crucial problems that risk people's life and then try to solve them by using design method.

GOAL

For a situation in need of acute attention, my goal is to create a solution which has the potential of being adapted into a real application and near future scenario.

APROACH

I have attempted to be both holistic and exploratory. In research phase, I have touch upon knowledge from different fields such as medical science, epidemiology, physics, material technology. In ideation phase, I learnt, summarized and rebuilt the information by using GIGA map to develop specific conclusions or assumptions. In design period, combined with a series of testing, sketching and mock-up making are my main method to improve the concept. In the meanwhile, I have found and stay in touch with professional coordinators to get the most helpful feedbacks.



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PHASE 1

In this phase I will state why I decided on this topic for my diploma, whereby I have used a set of methods, including my position as a designer in the process.

Motivation

Right before this project started, I was preparing another totally different project, which is about Chinese traditional craft technique. At the same time, Cov-19 outbreaked in China, which forced me to quit the project. When I was struggling thinking about how to start a new project, a crazy idea come up to me: Why not doing an epidemic project to fight back? I told the idea to my supervisor Steinar and Stein and received their strong affirmation.



Purpose

The purpose of this diploma is simple but difficult -- to save more people's life. Since the purpose is too general, I decided to begin with answering two question:

Who to help ?

Small to a family, big to a country, the disaster that a pandemic brings to people is overwhelming. As an industrial design project, it is impossible to take care of all kindsof people. Therefore, it is necessary to figure out which specific groups that need the help and make the decision.

How to save?

As a designer, although I can't save people's life in the front line, by carrying out rich research phase, I am able to get the challenges, find the existing problems that are risking people's life and solve them later by design. Right before the design phase I need to figure out, which challenge is the most relevant one and which problem I am more competent to solve.

Methods

Browsing

Epidemiology is totally a new field for me, in my pursuit to garner a comprehensive and holistic understanding of the topic, I consulted a wide selection of sources by using internet. Luckily, I got a lot of relevant knowledge from the webpages of professional organizations like WHO and CDC. Also, I watched a huge amount of video materials for getting more insight. When it comes to needs of more detailed information, I read lots of academic papers, although it was not that easy to understand all the knowledge, I still acquire many valuable findings from them. At the same time, I have been keeping following the latest news about Cov-19 as the most relevant source.

GIGA mapping

In both broaden and scoping phase, GIGA mapping has played the most important role throughout the diploma. By using GIGA mapping, I learned the new field more efficiently from the beginning, analyzed the information from qualitatively to quantitatively, and eventually developed my original discoveries.

Collaboration

I always try to keep open in ideas and listen to different comments. Before the Cov-2019 outbreak in Norway, I kept contact with different people from China who were suffering from the disease. Also, luckily, I found a medical device company who is willing to help me with the project. After Cov-2019 outbreak in Norway, physical meeting became harder, thus I try to continue the collaboration by using video meeting. The feedbacks out of different people are valuable for the whole stage of my diploma.

Mock-ups

I start building different 1:1 mock-ups instantly when the idea come out. Through building testing models, I can touch and feel the idea physically, by testing the models by myself and target users, many problems have been exposed, which are useful for me to criticize and improve the project.

PHASE 2

The project started with an extreme broad topic, in order to decide on the most valuable direction, I did a lot of research surrounded with the topic of pandemic, which was followed by several more specific choices. Finally a more solid determination was made.

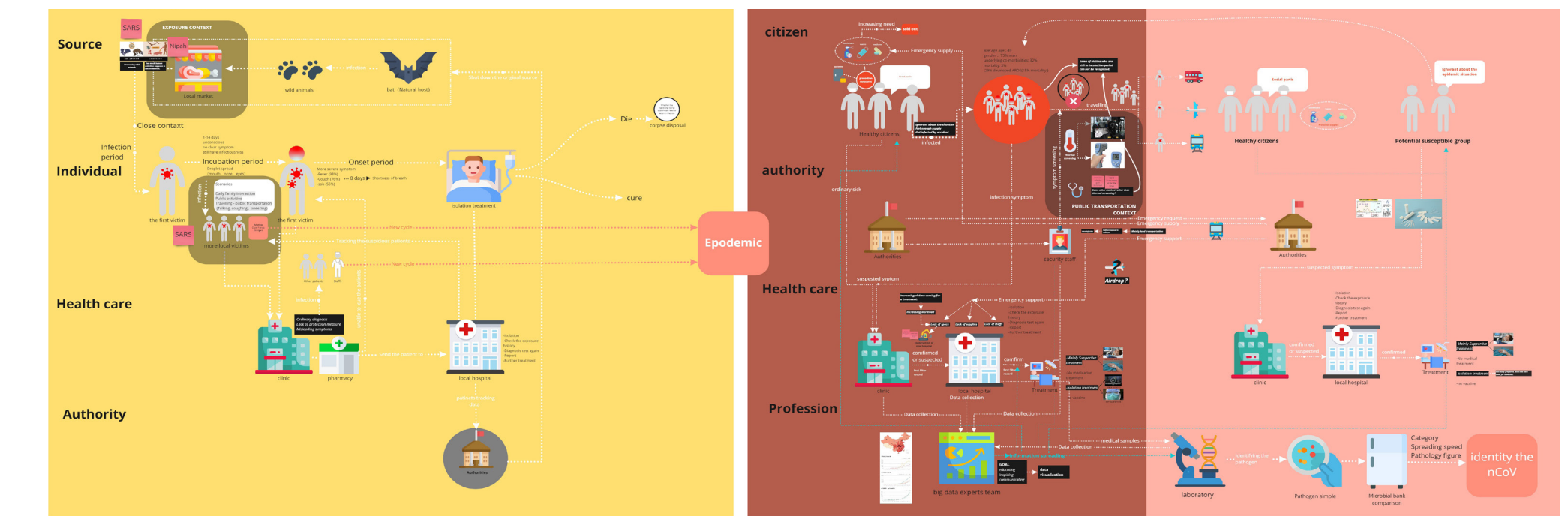
Fumble

In the very beginning, I barely limited perspective on the ongoing cov-2019 pandemic.

By following latest news, searching for different resource materials, as well as carrying out interviews with friends from China and a few numbers of health care workers, I made a conceptual journey of pandemic covid-19 in China and hoped to get some more specific insight.

Nonetheless, I found that just a general journey about the epidemic from China couldn't really reflect a much more complex pandemic scenario – I only showed the tip of an iceberg. The reason is that, I had missed many other more important insights and more immediate needs.

I keep asking myself, how to get a more comprehensive view of pandemic, to know this public enemy of human?



Beginning - source control

Outbreak - spreading control

Knowing the monster

The solution is, I made a much bigger map and tried to cover every severe pandemic that outbreaked in human history. In the meantime, I did in-depth explorations of different views of each pandemic, I read as much resources that I could find as possible to make the map detailed. I listed the all the information scraps on the map, tried to make analysis and comparisons out of it.

I picked HIV/ADS, Ebola, Marburg, Covid-19, SARS-2003, MERS-2012, Spanish Flu and 2019 Flu as vertical research objects, and did horizontal analysis in terms of **source**, **susceptible group**, **transmitting way**, **symptom**, **solutions** and **challenges & problems**. By summarizing and comparing the information, I got the similarities and the characteristics among different pandemics.



Since the amount of the information is huge, I would mainly show the key information that influenced the later-on researches and design decisions, I would put the full map into appendix materials.

Susceptible group

Healthcare workers (HCW)

From the map, i found that health care workers has been frequently put into the list of susceptible groups when a pandemic outbreaks.

-In August 2014, the WHO reported that 10% of the dead were healthcare workers.

-Health workers are between 21 and 32 times more likely to be infected with Ebola than people in the general adult population

-During the SARS epidemic,18.13% of the infection case were healthcare workers.

-Health workers caring for persons who are sick with 2019-nCoV are at higher risk and must protect themselves with appropriate infection prevention and control procedures.

Table 1. Baseline Characteristics of Patients Infected With 2019-nCoV

	No. (%)			P Value ^a
	Total (N = 138)	ICU (n = 36)	Non-ICU (n = 102)	
Age, median (IQR), y	56 (42-68)	66 (57-78)	51 (37-62)	<.001
Sex				
Female	63 (45.7)	14 (38.9)	51 (37-62)	.34
Male	75 (54.3)	22 (61.1)	53 (52.0)	
Huanan Seafood Wholesale Market exposure	12 (8.7)	5 (13.9)	7 (6.9)	.30
Infected				
Hospitalized patients	17 (12.3)	9 (25.0)	8 (7.8)	.02
Medical staff	40 (29)	1 (2.8)	39 (38.2)	<.001

Transmission and BSL

By listing the transmission way and the required BSL (biosafety level) for each disease, I could clearly find the most dangerous disease and the scenarios which are corresponding to.

DISEASE	TRANSMISSION WAY	BSL
HIV/AIDS	Body fluid (blood, breast milk, semen and vaginal secretions), mother to baby	Level 2
Ebola virus	Body fluid (blood, secretions, organs or other bodily fluids) close contact	Level 4
Marburg virus	Body fluid (blood, secretions, organs or other bodily fluids) close contact	Level 4
MERS-2012	respiratory droplets more specific way is not fully understood	Level 3
SARS-2003	respiratory droplets through eyes, nose, mouth	Level 3
Covid-19	respiratory droplets eyes, nose, mouth	Level 3
Spanish flu	respiratory droplets more specific way is not fully understood	Level 3
2019 flu	respiratory droplets nose, mouth	Level 3



A biosafety level (BSL), or Pathogen/Protection level, is a set of biocontainment precautions required to isolate dangerous biological agents in an enclosed laboratory facility. The levels of containment range from the lowest biosafety level 1 (BSL-1) to the highest at level 4 (BSL-4).

Prevention measures

Individual

For healthy individuals, from all the resources that I have found, **hand hygiene** is always the most important measure, washing your hand, this daily routine has been considered the most efficient way to avoid getting infected. Besides, if people need to have a closer contact with confirmed or suspected patients, they need some more extra protection such as gloves, respirator goggles etc.

Public

Public sectors like governments, communities also play a crucial role in prevention actions. Firstly, they should ensure that the population is well informed about the nature of the disease and about necessary outbreak containment measures by using public media; Secondly, many countries performed physical measures such as **symptom diagnostic screening** (rapid thermal screening, rapid laboratory tests etc.). Also, they should also maintain a clean and safe public environment.

Healthcare setting

/Hand hygiene

Every health care worker should constantly disinfect their hand during the treatment and nursing mission.

/PPE (personal protection equipment)

Health care workers are always equipped with PPE to avoid getting infected during the missions.

/Waste disposal

PPE should be disposed after the mission for avoiding contaminating other people and the environment.

Medication & treatment

I find that, when a new disease outbreaks, in most occasions, there are not neither any vaccine for protecting people nor any proven treatment available to save people's life. (Ebola, Marburg, covid-19, MERS, SARS, Spanish flu, 2009 Flu)

The only way to cope with the diseases is to perform **supportive treatment** to relieve the symptoms.

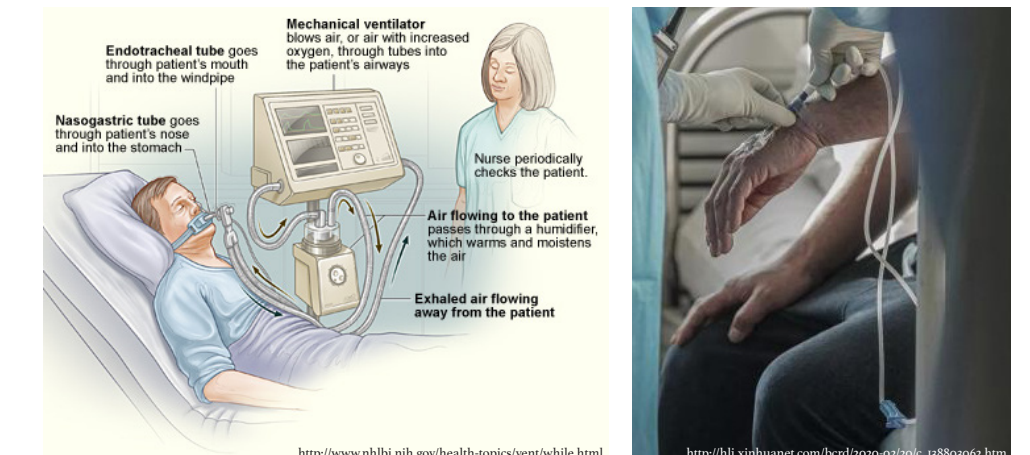
Supportive treatment

Supportive treatment means cares that are given to improve the quality of life of patients who are having a serious or life-threatening disease. The goal of supportive care is to prevent or treat as early as possible the symptoms of a disease, side effects caused by treatment of a disease, and psychological, social, and spiritual problems related to a disease or its treatment. It is also called comfort care, palliative care, and symptom management.

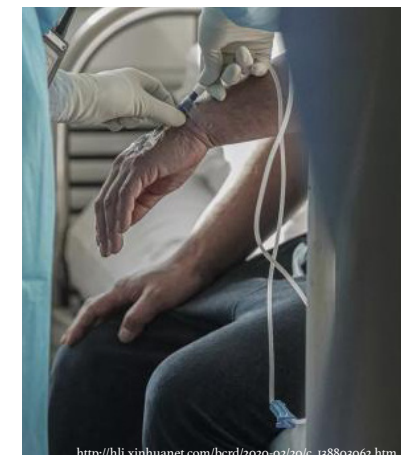
The most common supportive treatments that has been put into practice are **ventilatory support**, **fluid support**, **supportive medicine** and the **treatment of other infections**.



During Ebola pandemic, additional medication are used to support blood pressure, reduce vomiting and diarrhea and to manage fever and pain.



The illustration shows a standard setup for a mechanical ventilator in a hospital room. The ventilator pushes warm, moist air (or air with extra oxygen) to the patient through a breathing tube (also called an endotracheal tube) or a tightly fitting mask.



Providing fluids and electrolytes (body salts) through infusion into the vein (intravenously).

Isolation setting

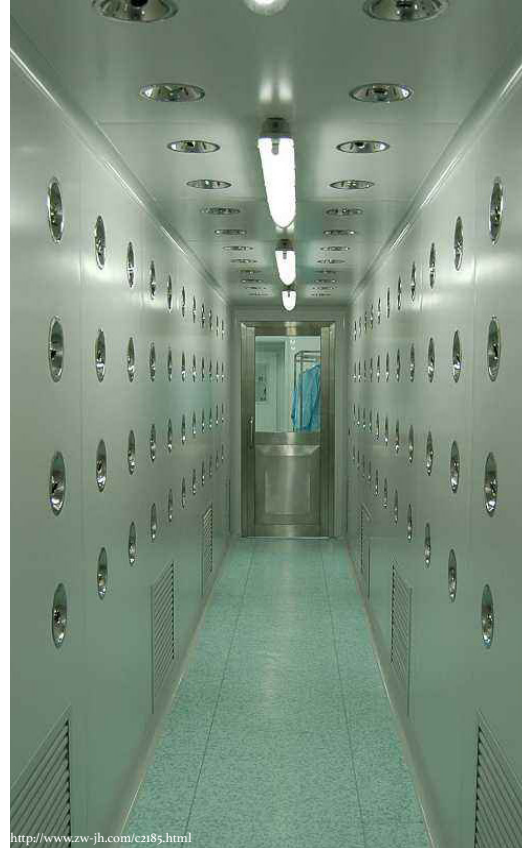
All treatment should be performed in a strict **isolation environment**. The most standard isolation environment is supposed to be a combination of dressing areas, contaminated/potentially contaminated area, air filtered rooms, ultraviolet room and treatment area.



Health care workers are performing donning process in dressing room.



View of contaminated area.



Air filtered room and ultraviolet room are the rooms for disinfection.

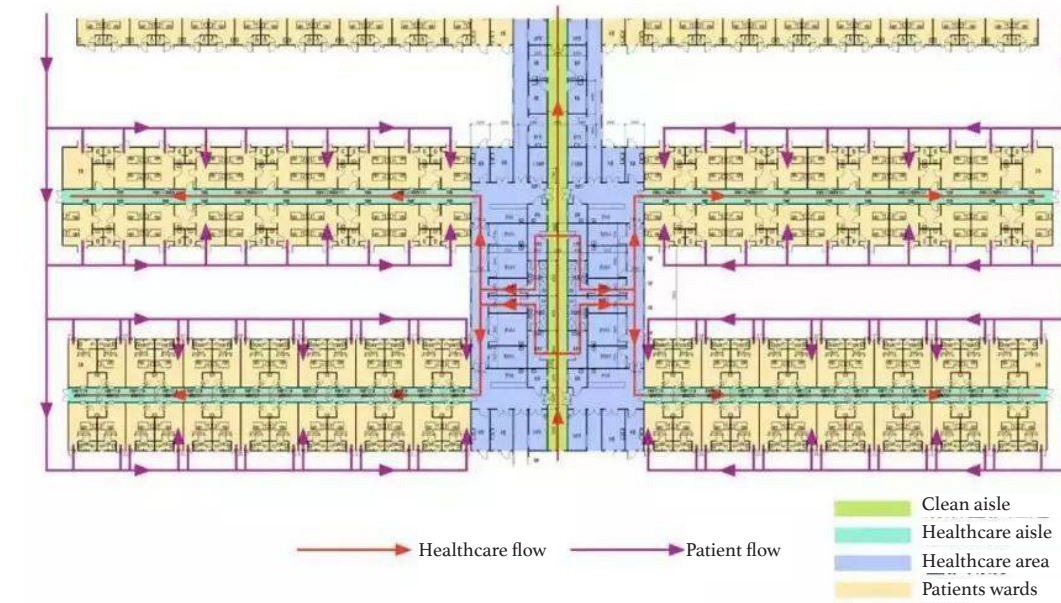
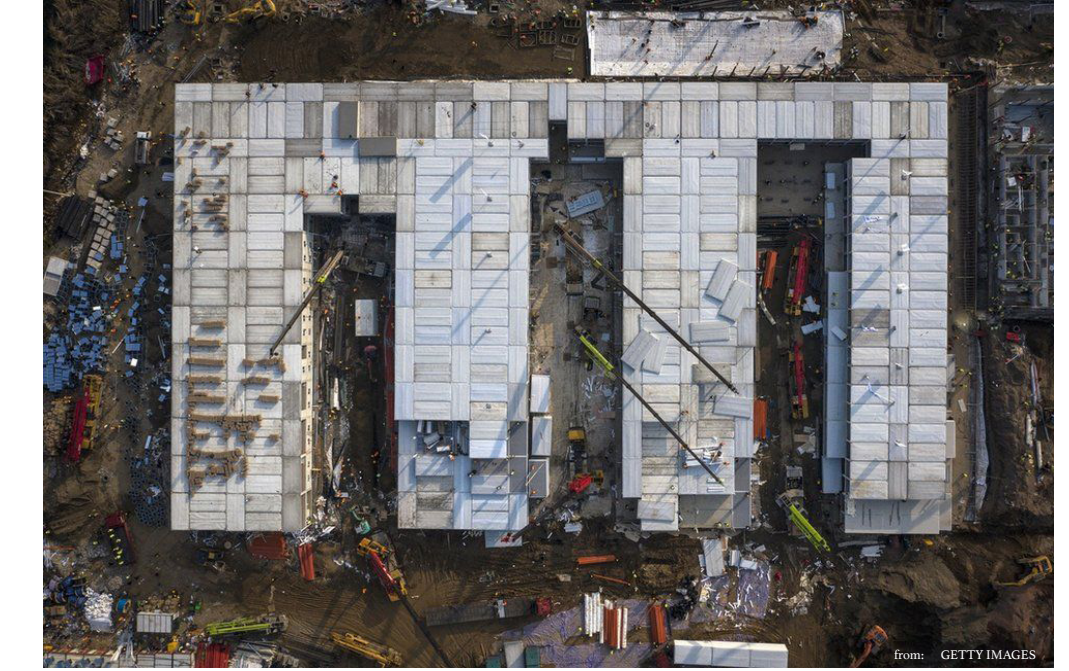


View of treatment area. (ICU)

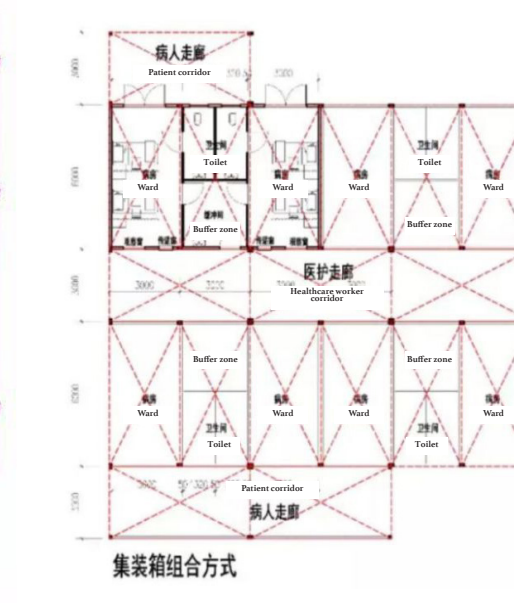
These are parts of the architectural plan of Huoshenshan hospital from Wuhan province in China.

Huoshenshan Hospital (Chinese: 火神山医院, lit: 'Mount Fire God Hospital') is an emergency specialty field hospital constructed from 23 January 2020 to 2 February 2020 in response to the COVID-19 pandemic. Because of the function of the hospital, Huoshenshan Hospital is an perfect example for me to get a deeper knowledge about the hospital context.

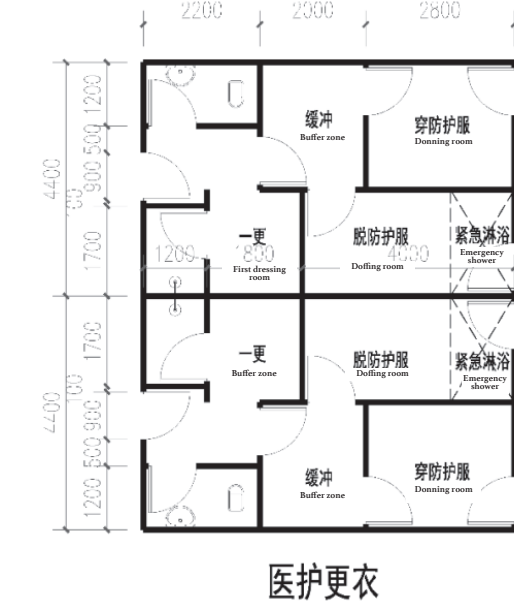
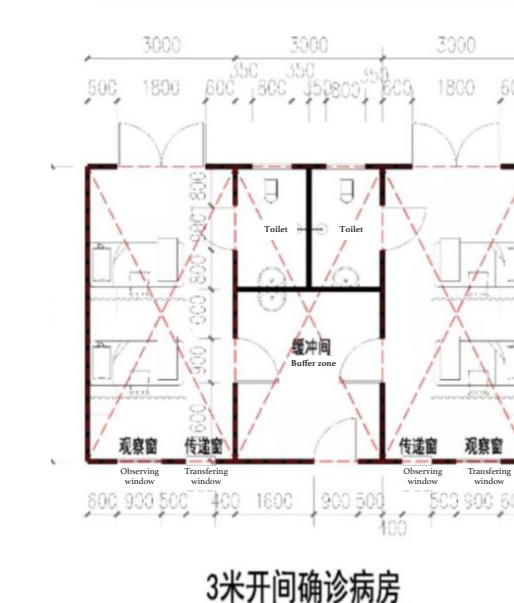
From the drawings in different scales, we can get an clearer image of the interior structure in terms of isolated healthcare and isolated treatment.



Overall layout



Container-combination treatment area



Challenge summarizing

- HIV AIDS
- Ebola virus
- Marburg virus
- 2019 nCoV
- 2012 MERS CoV
- 2003 SARS CoV
- Spanish flu
- 2009 flu pandemic

Direction I PPE design

Target challenges

- * Health care workers tend to have inadequate precaution in the very beginning of the pandemic.
- * It is time-consuming to take on PPE because of the complex procedure.
- * There are many risky factors when taking off their PPE, which lead to self-contamination.
- * It is suffering for health care workers to work with PPE.

After the research and mapping, I summarize the challenges into three big topics, which are HIV specific cases, General healthcare works and public measures. After that, I continued scope down into three different directions – **PPE design**, **Aerosol-generating procedures** and **Individual quarantine**.



The air we breathed out contains much moisture, and our breathing masks are always totally wet, water could drop

My gown always gets totally wet from the inside while the

After the breathing mask gets wet, it is stuffy, so I can hardly take a breath. I have to use my mouth to make the space a little wider so that I could be able to breathe in and breathe out a little bit. But that's a dangerous movement.

Someone asked me how I felt, I felt I was

-- A Chief doctor from **Liberia Medical Team**

PPE itself has many problem that cause low efficiency and discomfort during the healthcare works.



In the beginning of Ebola outbreak, healthcare workers in Syria didn't take proper level of personal protection before having close contact with patients. The consequences could be disastrous

SEQUENCE FOR PUTTING ON PERSONAL PROTECTIVE EQUIPMENT (PPE)

The type of PPE used will vary based on the level of precaution required, such as standard and contact, splash or airborne disease, or aerosol generation. The procedure for putting on and removing PPE should be tailored to the specific type of PPE.

- 1. GOWN**
 - Fully cover torso from neck to knees, arms to end of wrists, and areas around the back
 - Fasten in back of neck and waist
- 2. MASK OR RESPIRATOR**
 - Secure over nose, bridge or middle of face and under chin
 - Fit tightly to face and below chin
 - Place over nose and eyes and adjust to fit
- 3. GOGGLES OR FACE SHIELD**
 - Place over face and eyes and adjust to fit
- 4. GLOVES**
 - Fasten to cover wrist of isolation gown

USE SAFE WORK PRACTICES TO PROTECT YOURSELF AND LIMIT THE SPREAD OF CONTAMINATION

1. Limit surface contact
2. Change gloves when touch or heavily contaminated
3. Perform hand hygiene

Credit: CDC

SEQUENCE FOR REMOVING PERSONAL PROTECTIVE EQUIPMENT (PPE)

Stand to the right, remove PPE in sequence or in reverse. Remove respirator after leaving patient room and cleaning door.

- 1. GLOVES**
 - Grasp one of gloves at wrist
 - Roll glove away from face and under wrist
 - Peel glove off one hand
 - Repeat with other hand
- 2. GOGGLES OR FACE SHIELD**
 - Grasp top of frame or head strap
 - Remove frame by hand behind ear
 - Place in designated container for reprocessing or disposal
- 3. GOWN**
 - Break ties or straps at waistline, breaking at the back
 - Roll gown away from face and under wrist
 - Peel gown inside out
 - Repeat with other side and discard
- 4. MASK OR RESPIRATOR**
 - Place of "bottom" of mask behind ear
 - Grasp top of mask by head strap or ties
 - Roll mask away from face and under wrist
 - Repeat with other side and discard

PERFORM HAND HYGIENE BETWEEN STEPS AND IMMEDIATELY AFTER REMOVING ALL PPE

Credit: CDC

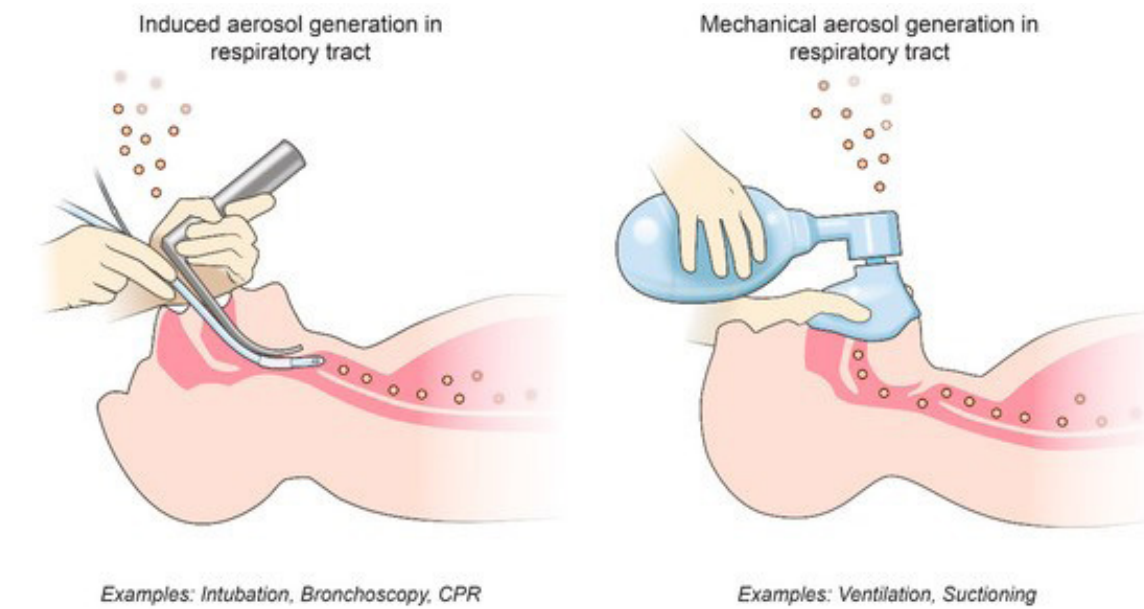
Strict and complicated PPE donning-doffing procedures. One single mistake would lead to self-contamination.

Direction 2 Aerosol-generating procedures

Aerosol-generating medical procedures (AGMPs) are increasingly being recognized as important sources for nosocomial transmission of emerging viruses.

Procedures that might generate aerosols (e.g. nebulized medications, BiPAP, or HFOV) should be avoided if possible.
-2009 H1N1 (CDC)

Use caution when performing Aerosol-Generating Procedures.
-2019-CoV, S.A.R.S (WHO)

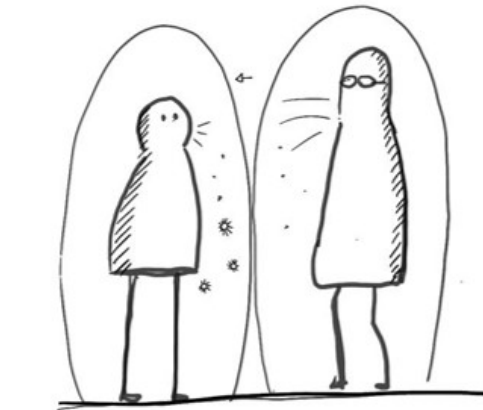


A Chinese doctor invented a special mask in SARS epidemic, the mask can filter the toxic aerosol by a V-tube, which can lower the risk of infection. However, this idea has not been widely used in today's treatment.

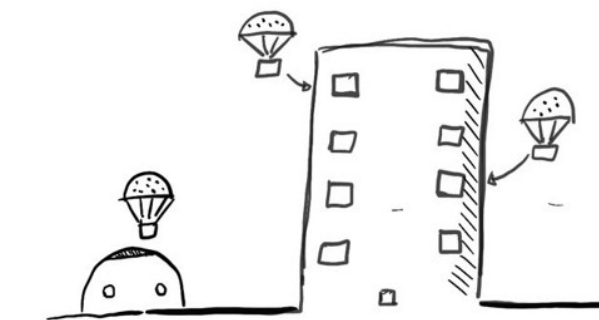
Direction 3 Individual quarantine

Target challenge

- *Self quarantine
- Overreaction in terms of unnecessary masks using.
- What is the most efficient and sustain way to quarantine?



- *Community quarantine
- How to minimize the risk of infectious exposure by community quarantine?



People are wearing masks to protect themselves. It is the best way to quarantine?



During the covid-19 pandemic, Wuhan once became an empty city because of strict community quarantine and isolation.

Determination

PPE design

I finally picked Direction1 (PPE design) as the direction for next step, the reason is as followed.

Direction2 (Aerosol-generating procedures)

This is a much specific direction, but it has too much requirment for professional knowledge, which is challenging for me to explore with very limited supports.

Direction3 (individual quarantine)

This direction still has a wide context that demands more broadening steps, which would unable me to scope down in a short time.

Compared with the other directions, Direction 1 (PPE design) is a more specific direction to work on and it is easier to learn and explore deeper.



/ PHASE 3

A much further, more focused researching phase was followed. Since medicine and epidemiology were totally unfamiliar field for me, I believed that valuable insights would emerge after I have gain adequate knowlege. While searching for more information from the internet, I also tried to find and talk with some professionals.

What is PPE

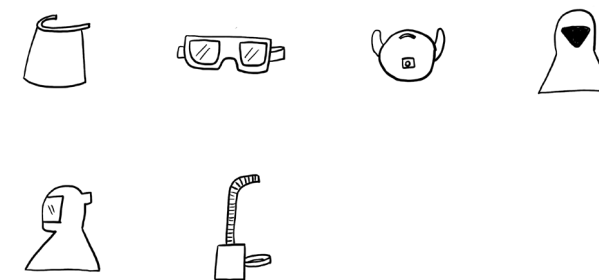
PPE (Personal Protection Equipment) is protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection. When very severe disease outbreaks, health care workers need to take on correct type of PPE before having a close contact with sick people (for example, nursing works, treatment operations) or the virus itself (for example, laboratory works)

PPE is mainly composed of three parts: **Face (Respiration) protection**, **Body protection**, **Hand protection**.



Face (Respiration) protection

Usually, people use normal hood, face shield, goggle and mask as face protections. When there is a need of higher-level protection, PAPR (Powered Air Purifying Respirator) is the best choice, it consists of PAPR hood and PAPR respirator.



Body protection

There are mainly two kind of suit for body protection, coverall and gown. Besides, health care workers also need to take on boot covers, sometimes, if there is a special need, they put on an extra apron.



Hand protection

In extreme pandemic disease situation, Health care workers need to put on two pair of gloves as a complete hand protection.



Journey

How the PPE is used ?

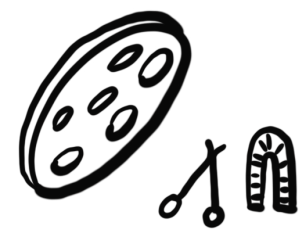
In order to I put the journey in four phases: Initial needs, Donning phase, Using phase and Doffing phase.

/I Initial needs

A) Regular missions



Daily healthcare



Daily operation

B) Emergency mission



C) Laboratory mission



Challenge 1
"Maybe I don't need to wear a PPE."
Inadequate precaution in the very beginning.

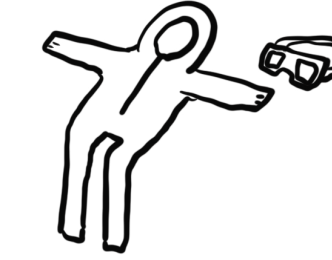
/2 Donning phase



1. Engage trained observer (if need)



2. Remove personal clothing



3. Inspect PPE for checking



4. Perform hand hygiene



5. Put on different equipment according to a specific sequence



6. Put on extra staff



7. verifying

Challenge2

It is time-consuming to take on PPE with a complex procedure

Challenge3

Potential mistakes that happens in donning phase will lead to self-contamination later

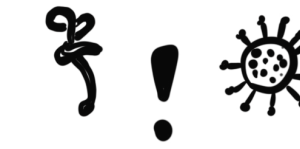
/3 Using phase



1. Enter the contaminated area (isolation room, specific epidemic area)



2. Perform missions with PPE



3. Deal with the PPE accident if happens



3. Finish and exit the contaminated area

Challenge4

It is suffering to wearing the PPE during missions.

Challenge5

Hard for identification

Challenge6

PPE accidentence – tearing, shedding, device malfunction etc. which lead to self-contamination.

1/4 Doffing phase



1. Inspect the PPE



2. Disinfect the PPE and gloves



3. Go into the doffing area



4. Engage the trained observer



5. Take off different equipment according to a specific sequence



6. Perform hand hygiene



7. Inspect body for checking any contamination



8. Exit the doffing area

Challenges 6

Mistakes that happens in doffing action will lead to self-contamination.



Focused Challenge

I summarized the challenges and picked two general directions.

-Using comfort

It is suffering for healthcare workers to work with uncomfortable PPEs

- >Lack of air circulation inside the PPE
- >Health care workers can't eat with PPE
- >Health care workers can't go to toilet with PPE

-Self contamination

- > Mistakes in donning phase which lead to self-contamination later
- > Mistakes in doffing phase which directly lead to self-contamination

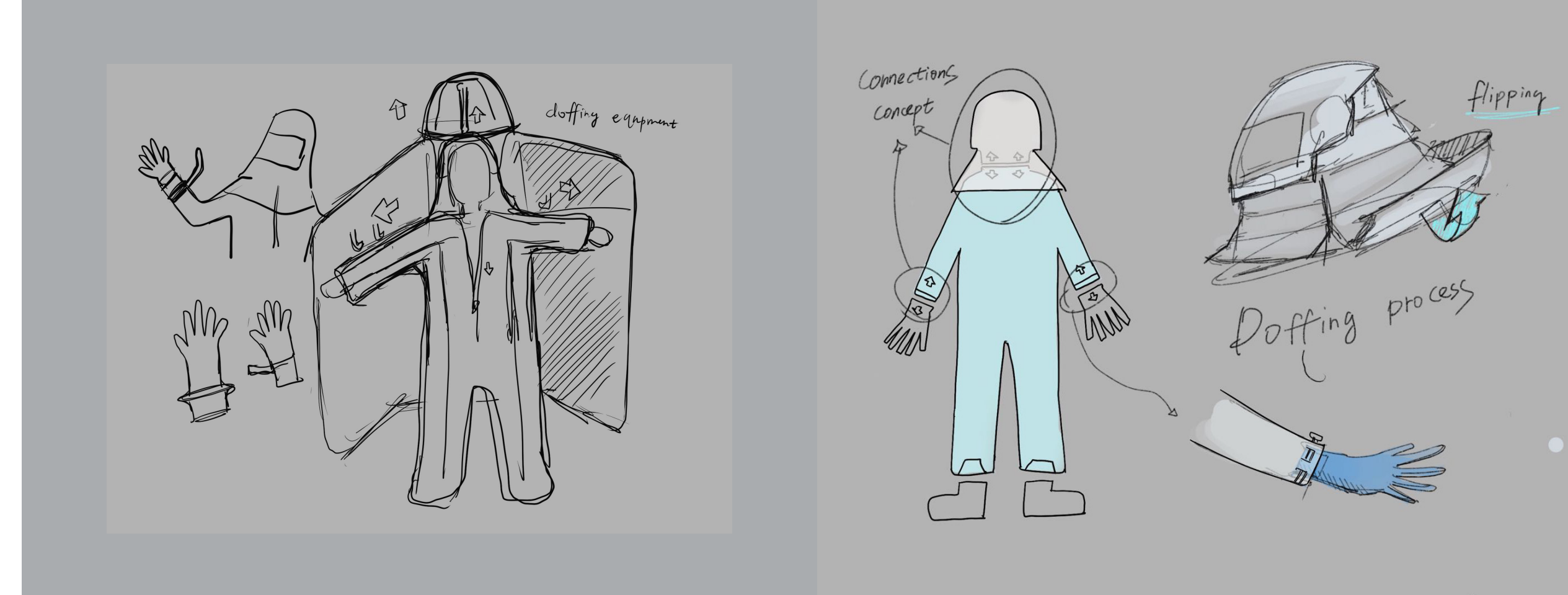
I didn't pick the challenge about PPE accident during the mission, because it is quite challenging to get the more detailed insights of the health care mission itself neither practically nor from resources.

Ideations

In this step, I basically use quick sketching to come up with several conceptual possible solutions for further explorations. The purpose of this step is not to end up with a specific solution idea, but to trigger an unknown discussion by showing them to professionals, which could let me harvest more potential insights that I didn't pay attention to.

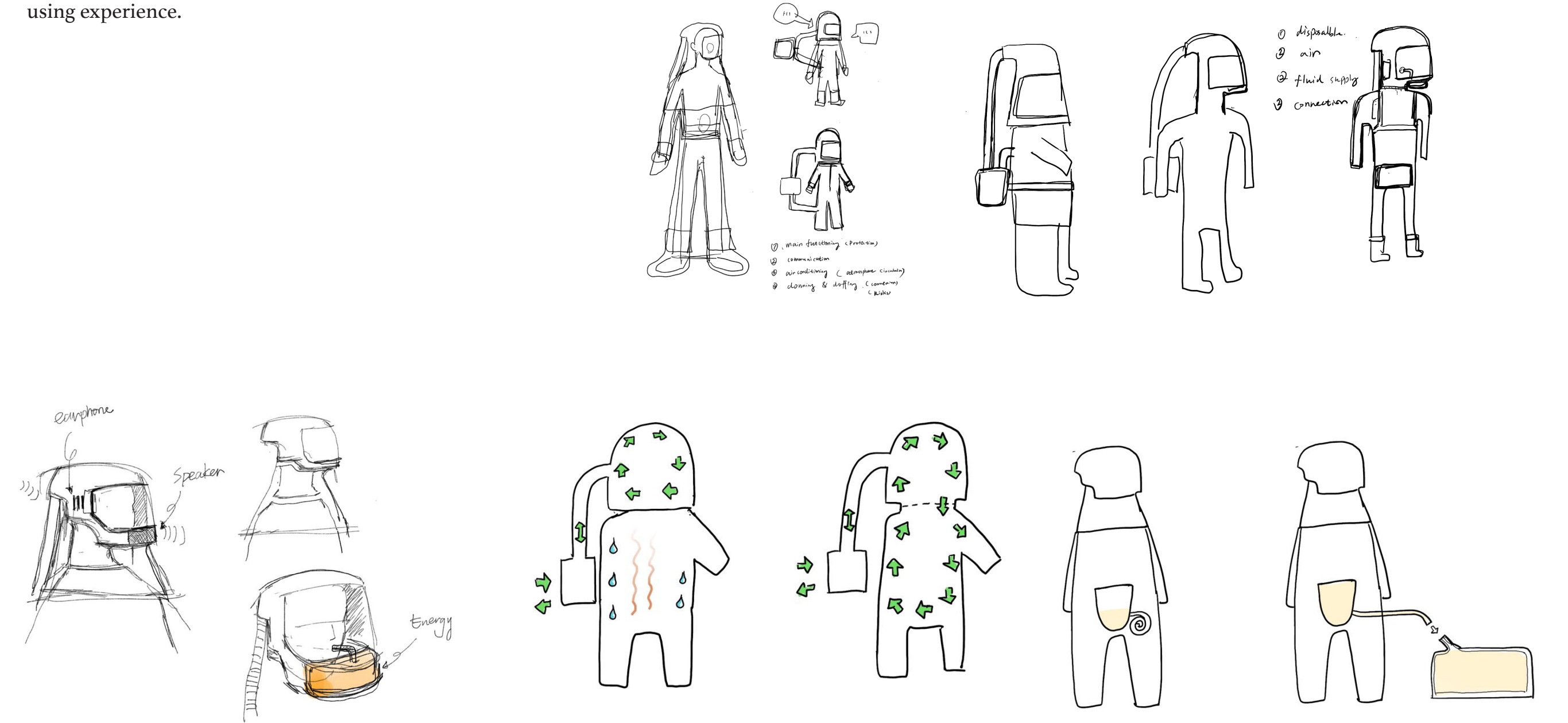
Self contamination

In this direction, I tried to come up with several ideas that focus on donning and doffing process, which are crucial procedures where extra attentions should be paid to avoid self-contamination.



Using comfort

In this direction, I mainly focused on the present pain point about the using comfort out of the PPE, I tried to explore how to create a new PPE that can give a more comfortable using experience.



I have to say, most of the sketchings are stupid ideas, but the discussion out of them are so important for me to continue learning and exploring this totally new field for me

Although they are all very scrappy ideas and they are all very conceptual, all of them were targeting my initial goal for this project: To design a new PPE.

Coordinator

Luckily, I found a start-up company, EPI-GUARD, that is willing to help me to support the project. It is a small company that is devoted in developing health care products that aims at medical isolation and transportation systems. Their only product EPishuttle has gained a huge success in this field, which has won the DOGA design award in 2017. It is a big surprise for me to find this company in Norway, because the company's work is strongly relevant with my project.

I tried to contact the company, their owner and CMO, Fridtjof Heyerdahl replied me instantly and invited me for a lunch. I paid a visit to their office in Forskningsparken and got their warm welcome as a lunch. During the lunch, I introduced my project and showed them my ideas and discuss with them. From the meeting, I got their very helpful feedbacks.

After seeing the sketches, he said that they are all very interesting idea, but he still needs to give me some tips.



The owners of EPI-GUARD with their product -- EPiShuttle



Fridtjof Heyerdahl

For the direction of using comfort, he showed me some exist solutions that already or potentially have solved the problems.

He showed more interests in the ideas of avoiding self-contamination, he said this topic is a more significant direction than the other one, because this topic is highly relevant with the safety of PPEs and it secures workers' life.

"Maybe you should work on some smaller accessories rather designing a whole PPE."

"Always try to design something simple, the simpler it is, the safer it will be."



Surprisingly, they are also working on a new PPE by cooperating with a product design studio. Fridtjof said he would approve if I want to join his project, if not I could still continue my own project with his help. From that time, a new very important choice arose waiting for me to make the decision.

After that, I talked with Steinar about the tough choice, his advice is as followed.

" keep working on you own insights and then you will figure out the decision, always let the project dominated by yourself ."

His words encouraged me, after one week of more in-depth research, I decide to continue working on my own perspective and let the company as my professional support.

Make the decision

Based on the feedback from the company I picked the first direction, design for a new donning/doffing process to avoid self-contamination. Meanwhile, I change my initial goal from design a new PPE to design for PPEs.

~~Design a PPE~~



Design for PPEs

/ PHASE 4

As the project had been narrowed down in to a smaller view, I started to explore more detailed informations and tried to step into the scenarios which would lead me to find the biggest challenges. After the exploration, a concept was given.

Outbreak in Norway

After the first fruitful research phase, Covid-19 outbreak in Norway, the stressful situation totally stopped me from researching outdoor by some possible field trip in any hospital in or outside Norway. Because of that, the only thing I could do is to try to explore the resources that I could find from the internet and analyze them in detail.



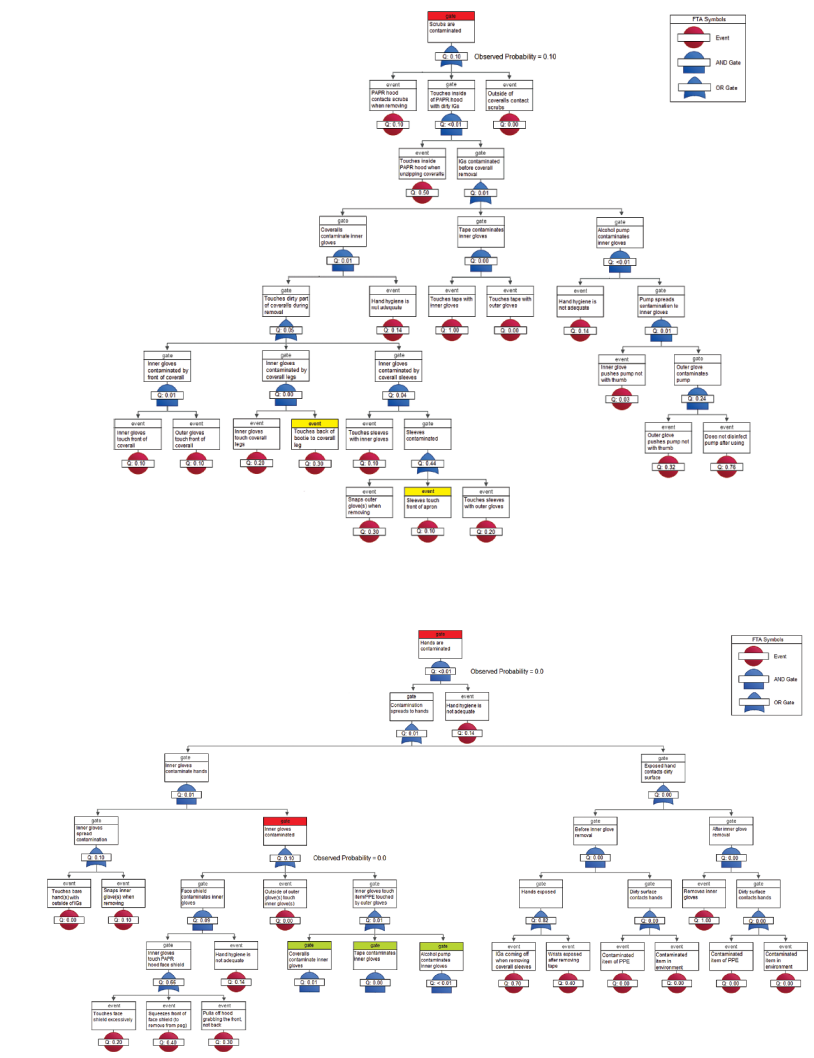
Source - Mistakes

After reading many relevant essays as well as watching different videos that introduce PPE donning/doffing process, I realized that the source of the risk is mistakes.

Because of the complex sequence and regulations of the process itself, people usually make different mistakes that lead to potential risks of self-contamination.



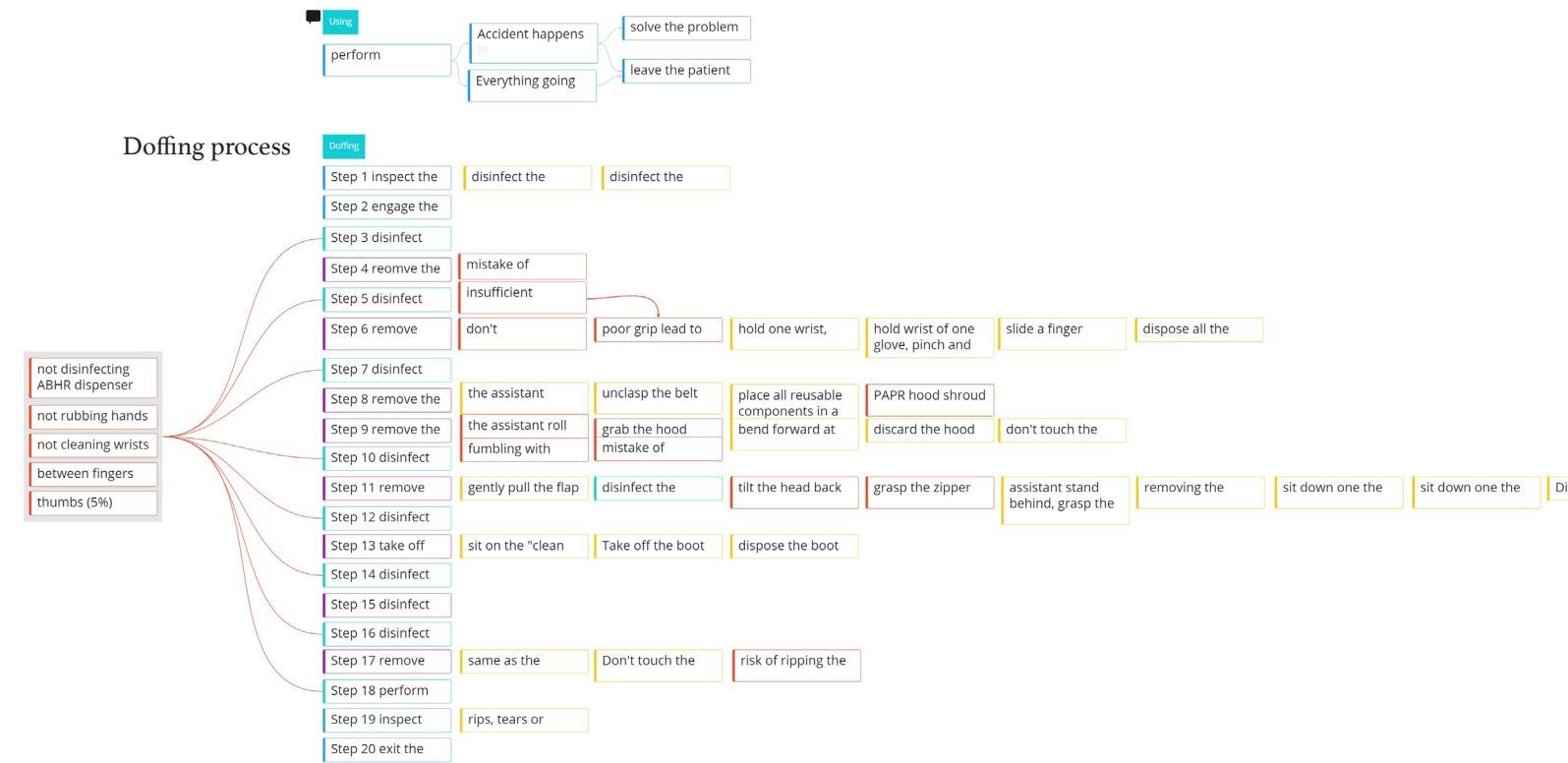
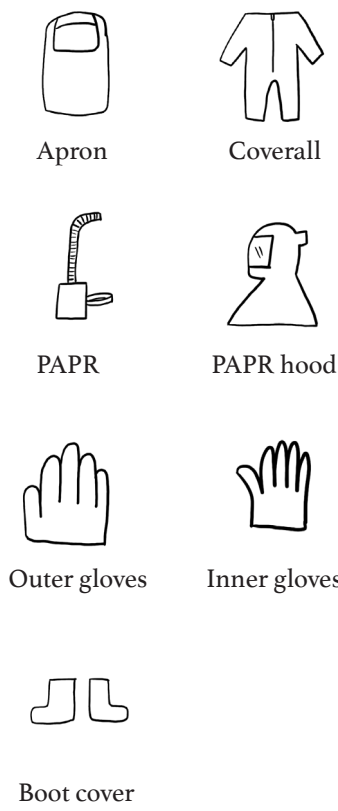
Photo by: Ted S. Warren



Luckily, I find several fault trees which are concluded by a series of experiments exploring the mistakes that happen in PPE doffing process. This material is extremely useful for me to look into the insights and challenges.

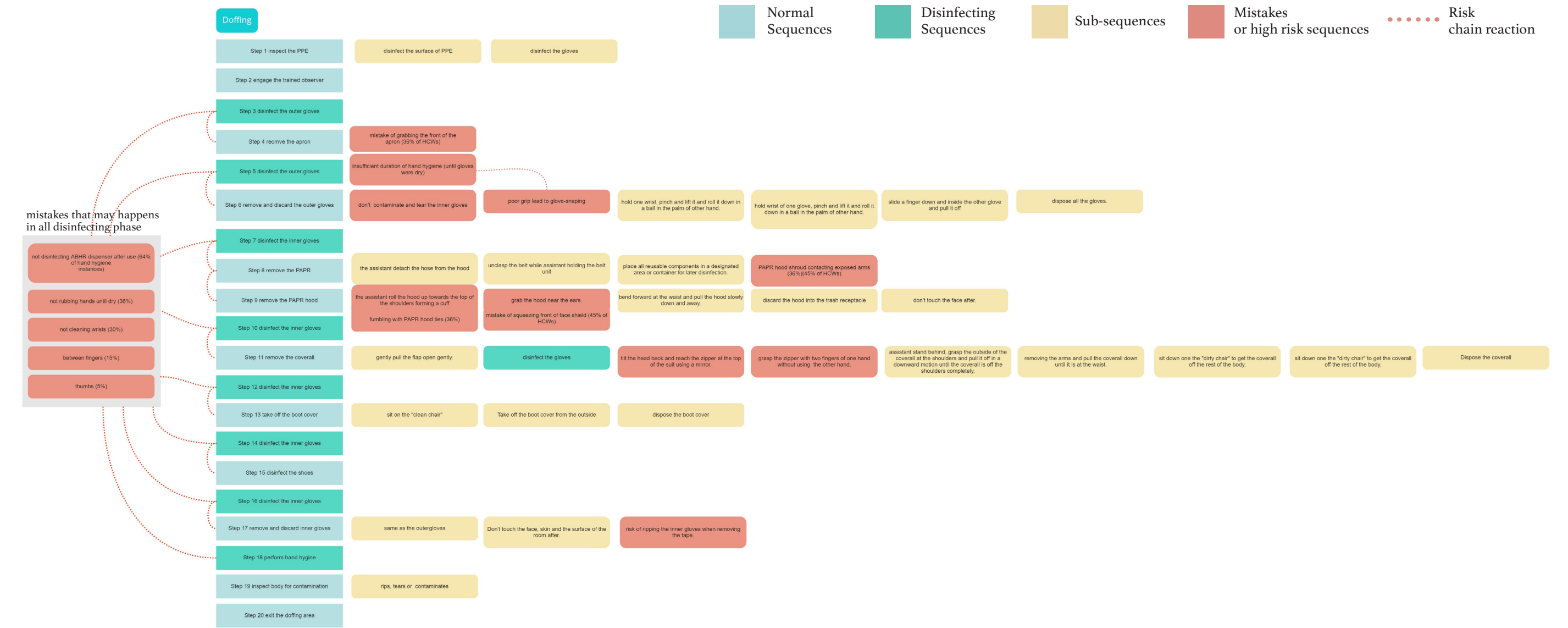
Mistake journey

Since there is a big variety of PPE combination, I put **PAPR + coverall + double gloves** as my sample PPE for analysis. Based on the exist application, I made a mistake journey (donning and doffing process) for the PPE sample.



From the journey, I found that most of the mistakes happens in **doffing process**. Then I scope down the risk analysis on to the doffing process

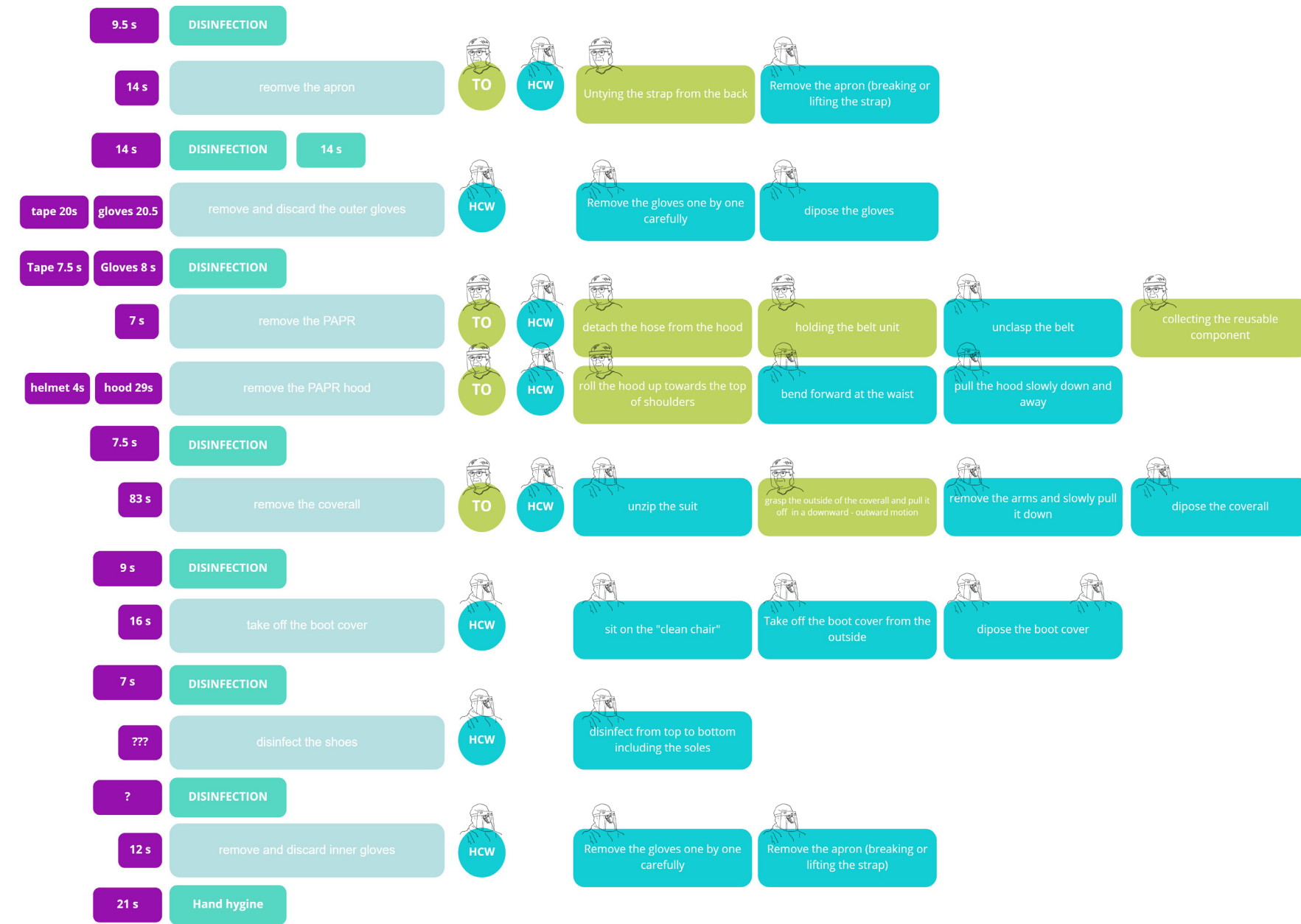
doffing process mistake journey



User analysis

During the analysis I found that the doffing process always completes in a collaboration between two or more people: the health care worker and trained observer (one or more). In order to get some more detailed insight, I made another user journey to show how the collaboration going on.

Besides, in this journey, I also put on the average time that spent in each disinfection phase and taking-off phase (data from <Human Factors Risk Analyses of a Doffing Protocol for Ebola Level Personal Protective Equipment Mapping Errors to Contamina>) to make the journey looks more complete



Finding 5

In many occasions, the health care worker also needs a trained observer to supervise and help him/her to finish the doffing process. To some extent, the trained observer would also face a risk of getting contaminated by the used PPE



video by: CDC

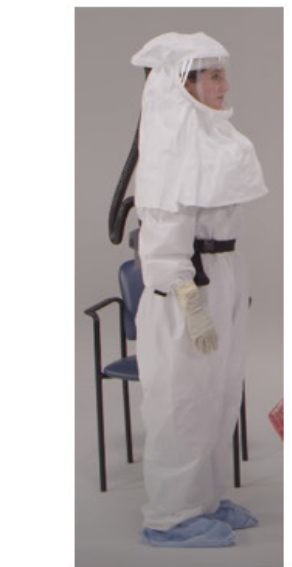
Finding 6

The average time that spent in traditional hand hygiene steps is fluctuating depending on different stage of the whole journey, but I couldn't figure out the reason of it.

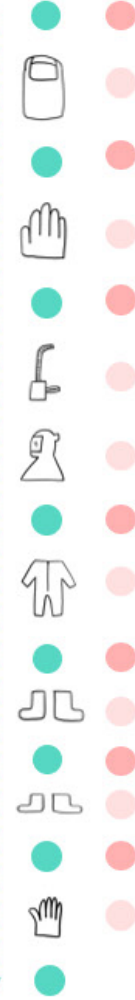


video by: CDC

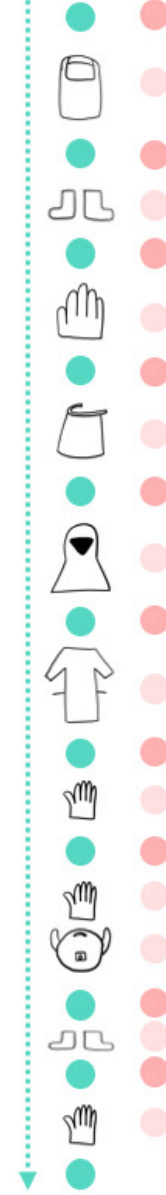
After this journey analysis, I went back to observe the three other usually-used PPE combinations and found that all of them have same problems, the only difference is the “taking-off-sequence”.



PAPR + coverall



Mask + gown

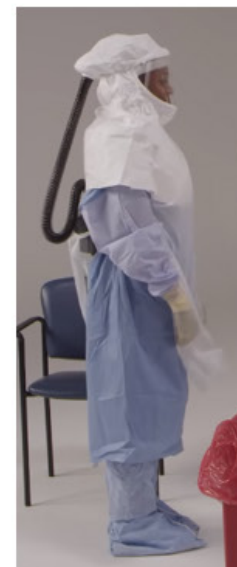


Disinfection stage

Risk waving



Mask + coverall



PAPR + gown



Conclusion

We can see that, the risk of getting self-contaminated is waving because of the constant hand disinfection stage. After performing hand hygiene, the risk gets lower but still exist; After taking off each part of PPE, the risk gets higher because the hands get contaminated again by the PPE. Once any disinfection phase isn't performed correctly, the risk would accumulate and effect the next step.

Base on all of the finding, I summarized the problems and conclude in a possible solution.

Problem summary

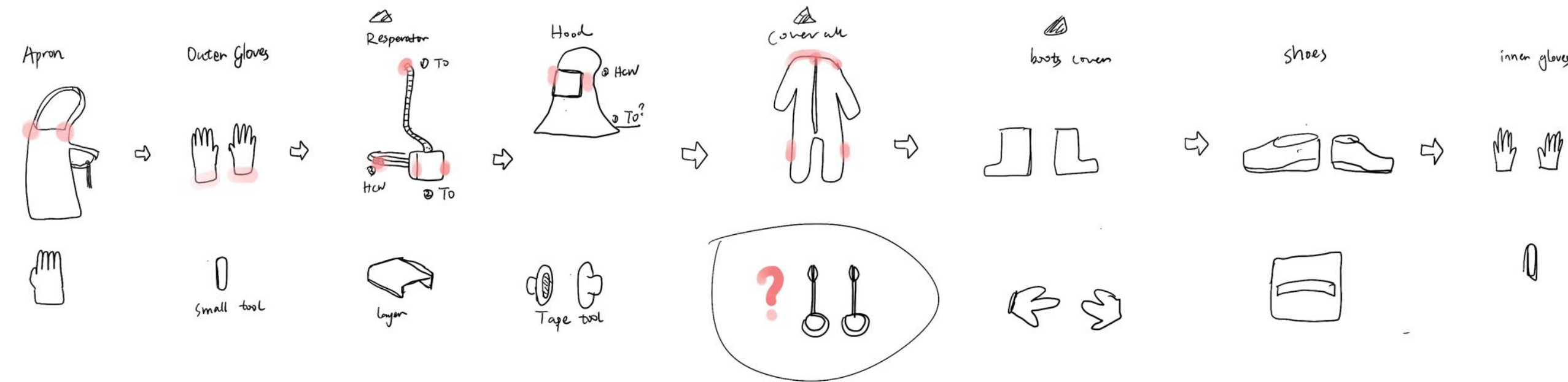
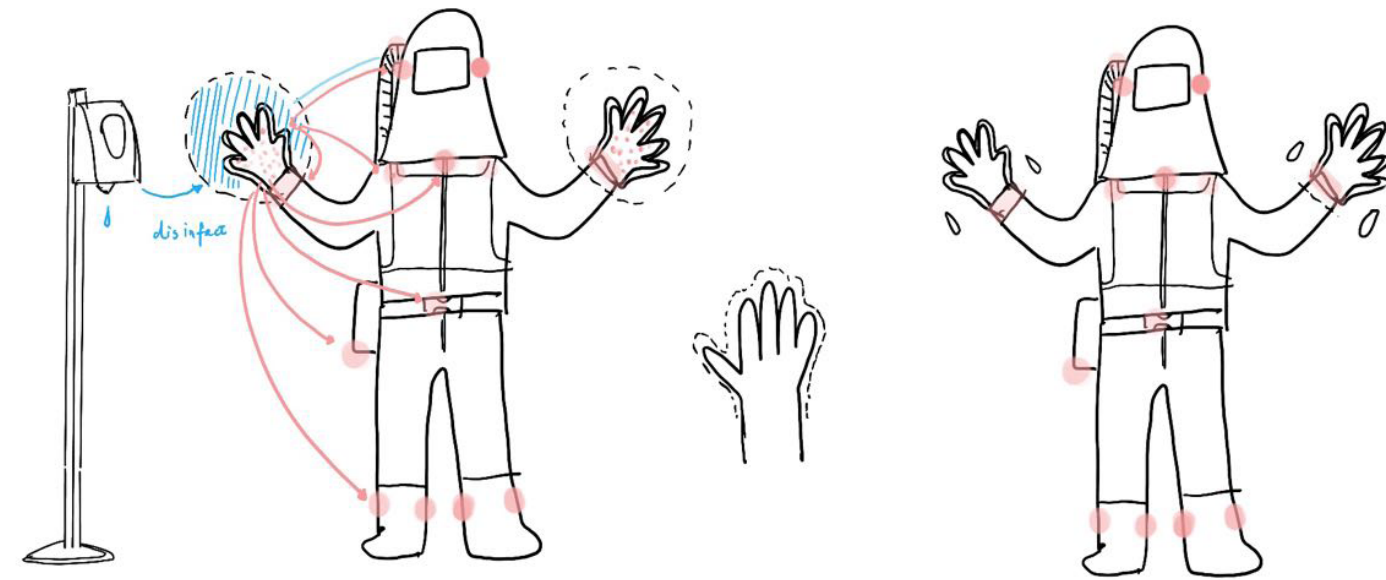
- / Repeating disinfection phase can reduce the risk of self-contamination to some extent.
- / Inappropriate disinfection way can lead to higher risks.
- / Frequent hand using is the main medium for self-contamination.

Possible solution

Abandon traditional disinfection way
+
Apply hands isolation throughout the period.

Motion tracking

Where is the specific area we need to isolate hand using?
 In order to figure out this question, I did a hand motion tracking analysis.
 By observing different doffing processes, I lay out the specific places where the hands engaged in the different part of PPE and marked them with red color below.



Then I categorized the hand motions into four paralleled scenarios based on the characteristic of them. They are Glove doffing, Unzipping, Flipping, Easy hand motions. Also, I attached the people who possibly take part in each scenario and also the corresponding PPEs which are relevant to the scenarios.

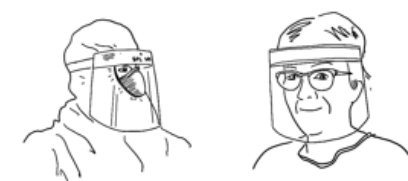
Glove doffing

-specific doffing way



Unzipping

-Searching & Unzipping



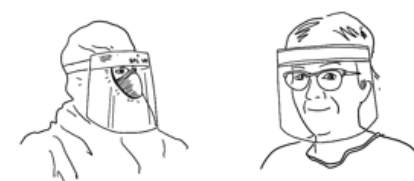
Flipping

-Flipping the textile



Easy hand work

-Detaching
-Unclasping
-Holding
-Untying
-Dragging



/I Glove doffing

Performer: Health care worker
Corresponding PPE: Outer gloves, Inner gloves

Potential risks

-Glove-snapping that caused by poor gripping

Wet slippery bare hands or inner gloves caused by insufficient duration of hand hygiene would lead to poor gripping, that results in glove-snapping, which would spread the virus into air as a form of aerosol.

-Contamination by accidental touching

Touching the beneath surface (inner gloves or skins) during doffing the gloves

-Contamination accidental tearing

Tearing the inner gloves by accident when trying to remove the extra tape (sometimes tape is used as an extra protection)



/2 Flipping

Performer: Trained observer
Corresponding PPE: Coveralls, PAPR hoods, Normal hoods

Potential risks

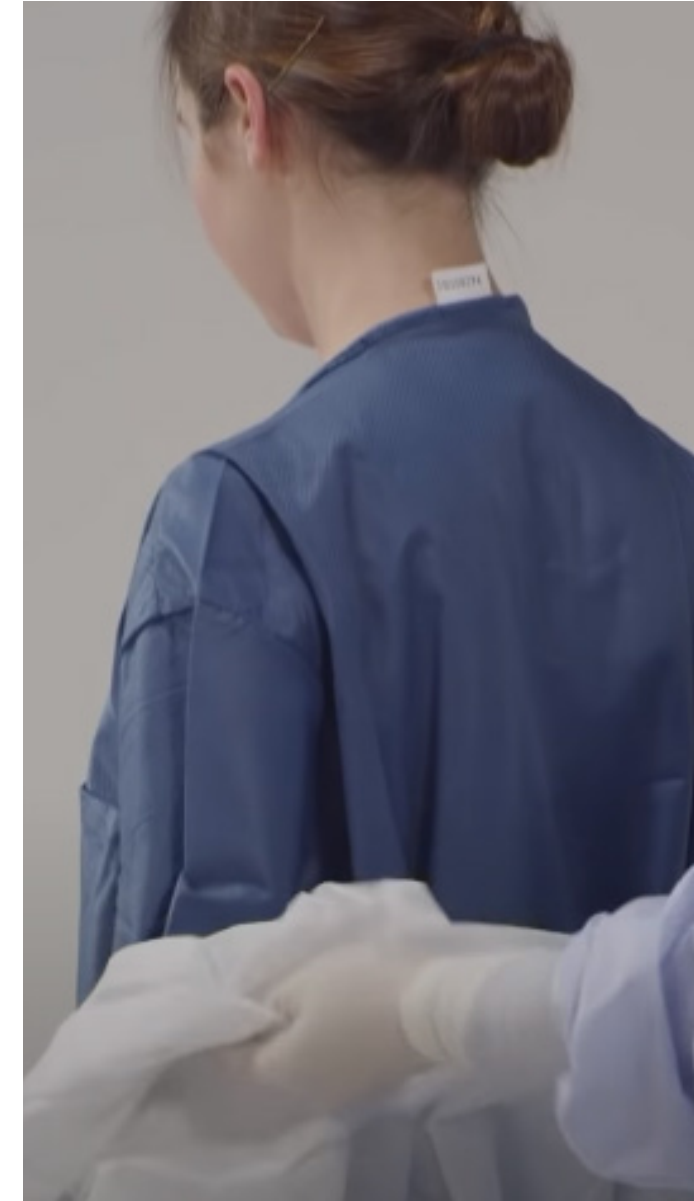
-Contaminating scrubs of health care workers by accidental touching

When the trained observer rolls the textile of coverall or hoods, the rotational flipping motion would cause contamination on the scrub of health care workers.
(outside of coverall --- gloves of trained observer --- scrubs of health care worker)

-Directly contaminating the trained observer (seldomly happens)



video by: CDC



video by: CDC

/3 Unzipping

Performer: Health care worker/ Trained observer
Corresponding PPE: Coveralls

Potential risks

Since the zipp of PPE are always very small and not easy to find, healthcare worker may got contaminated when searching for the zipper.

-Contamination by touching inside of hood

When searching for and unzipping the zipper of coverall, the dirty hand could accidentally touch the inside of hood, which is followed by contamination on the health care worker's face and scrub.

-Contamination by touching skin and scrub

Direct touching the skin or scrub with dirty hand accidentally when searching for the zipper.



video by: CDC



Video by: The Lancet

/4 Easy hand motions

Performer: Health care worker/ Trained observer
Corresponding PPE: Masks, face shields, normal hoods, PAPR hoods, PAPR respirator, boot covers, aprons, coveralls, gowns.

Potential risk

Butterfly effect
By touching the dirty PPE, the inner gloves or bare hands will easily get contaminated, which cause a butterfly effect that lead to contamination in different areas. The only way to get rid of the following risks is to perform hand hygiene, which has been proven not a good solution.



Manifesto

A new solution might also bring in new problems. Before I come up with the final concept, a set of criterions is needed as a restriction to avoid bringing new problems. Thus, I clamed a list of Manifesto for the new solution.

/1 The new product should avoid direct hand using of both HCW and TO throughout the doffing process.

The main idea is to abandon the traditional hand disinfection procedure and replace it with hand isolation, thus, the hand isolation should be strictly performed.

/3 The new product shouldn't bring in new contamination.

As getting contaminated is the main challenge to solved in this project, this criterion should be placed as the highest priority.

/5 The new product should be as sustainable as possible

When a pandemic outbreak, the shortage of materials is always considered a huge challenge. Therefore, the product needs to have the possibility of getting reused safely, in order to avoid the shortage issue. So, I should take this criterion into account throughout the design phase.

/2 The new product should be simple and easy to use.

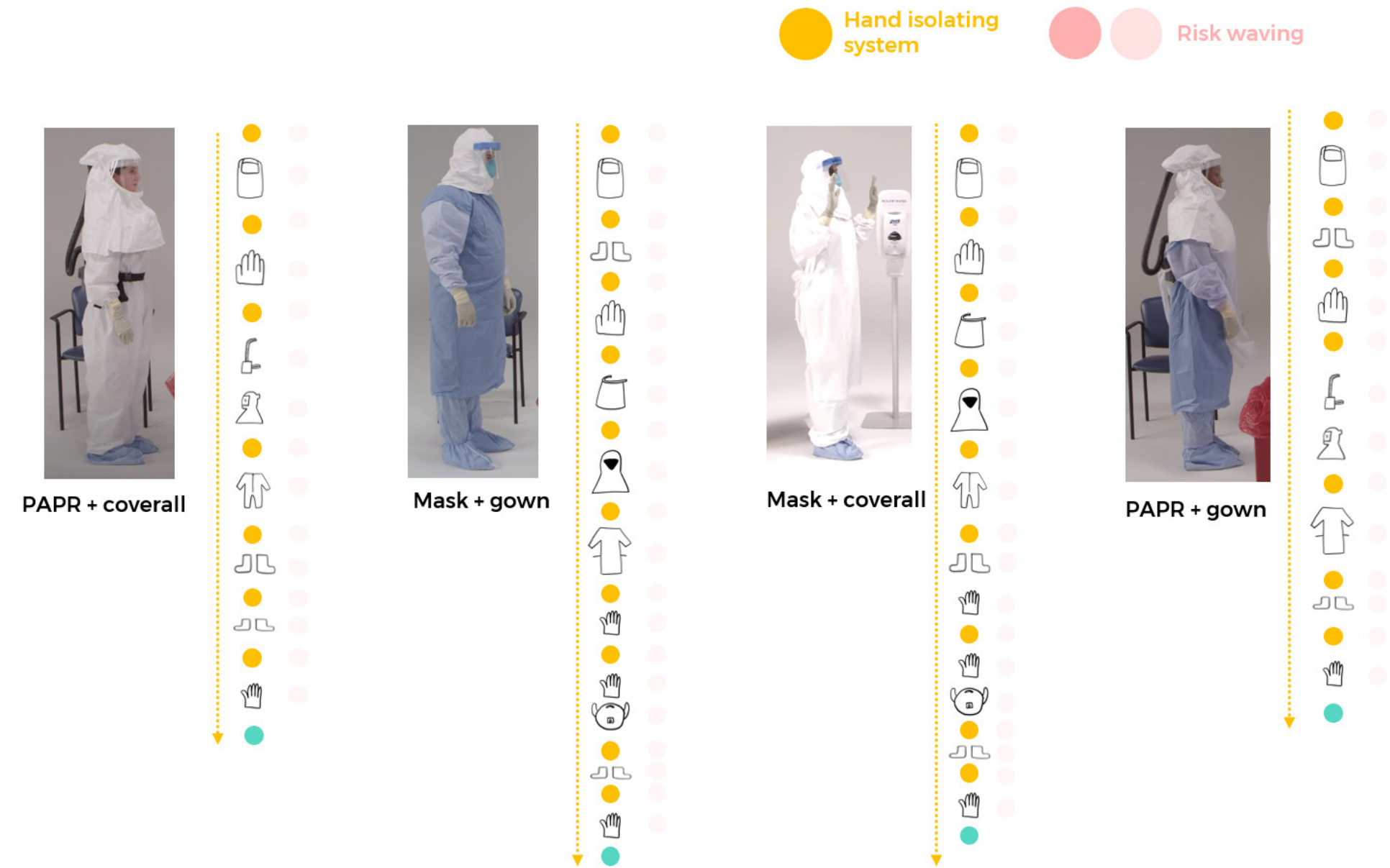
If the product is too complicated, it will lead to more other mistakes that may cause new risks of self-contamination. Also, the product is supposed to be time-saving, the easier the product is, the more time will be saved.

/4 The new product should be universally used in different kind of PPE

I should always take in to consideration of the universality of the new product, if not, the value of the product will be sharply reduced.

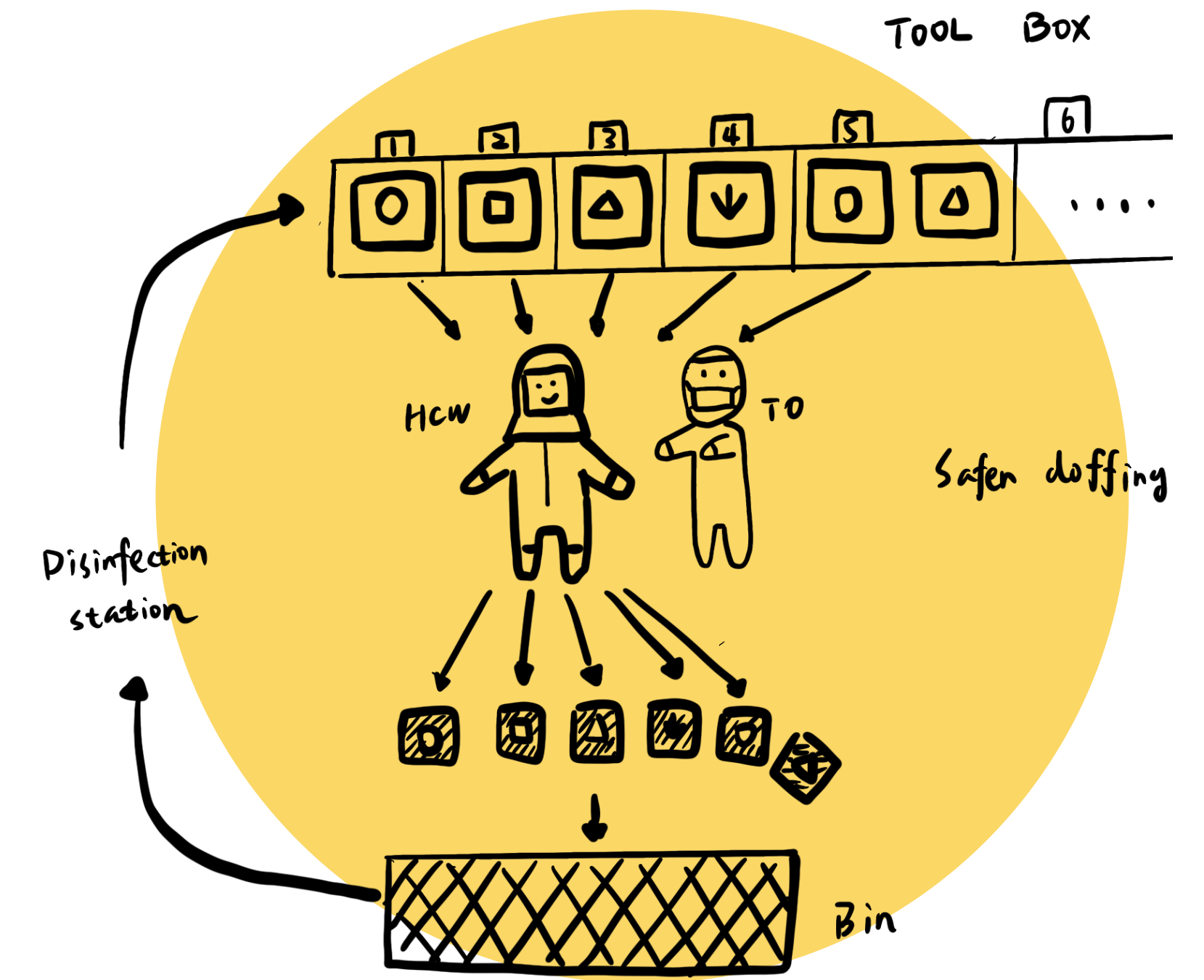
A Secure Touch

The concept is a **Hand-Isolation system**, the traditional hand disinfection phases are totally replaced by the system. By isolating hands from the virus, the mistakes from the traditional way will not ever exist, meanwhile the risk of getting self-contaminated would decrease into **zero**.



Hand-Isolation System

Corresponding to each doffing steps, healthcare workers and trained observers can pick a specific Secure Tool from a tool box in an already set sequence, and use them to take off each part of PPE. After that, users throw the used tools into a disinfection bin which is prepared for later cleaning. The disinfected tools can be placed back and reused in another doffing process.



Secure Tools

Secure Tools always have two function: hand-isolating and hand-collaborating. They are designed for finishing the corresponding doffing step by coordinating with hand using, while creating an isolation between hands and the contaminated PPE parts.

Based on the hand motion analysis from last phase, there are four Secure Tools to cover those four corresponding scenarios.

They are Glove doffer, Rapid glove, Flipper and Unzipper.



/I Glove doffer

Glove doffer is the secure tool which targets the glove doffing motion.

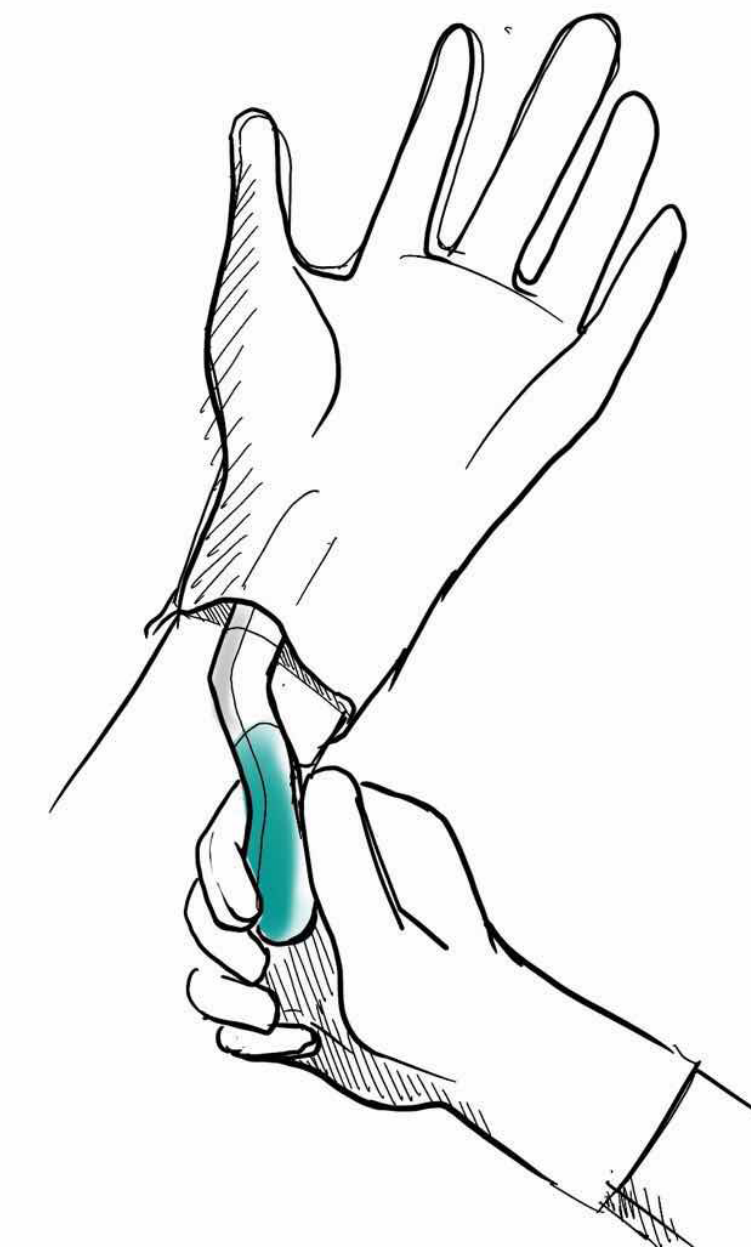
User: Health care worker

Corresponding PPE: Outer gloves, Inner gloves

Function:

-Taking off the outer gloves or inner gloves.

-Setting a distance between the dirty hands and the clean surface beneath the gloves.



/2 Flipper

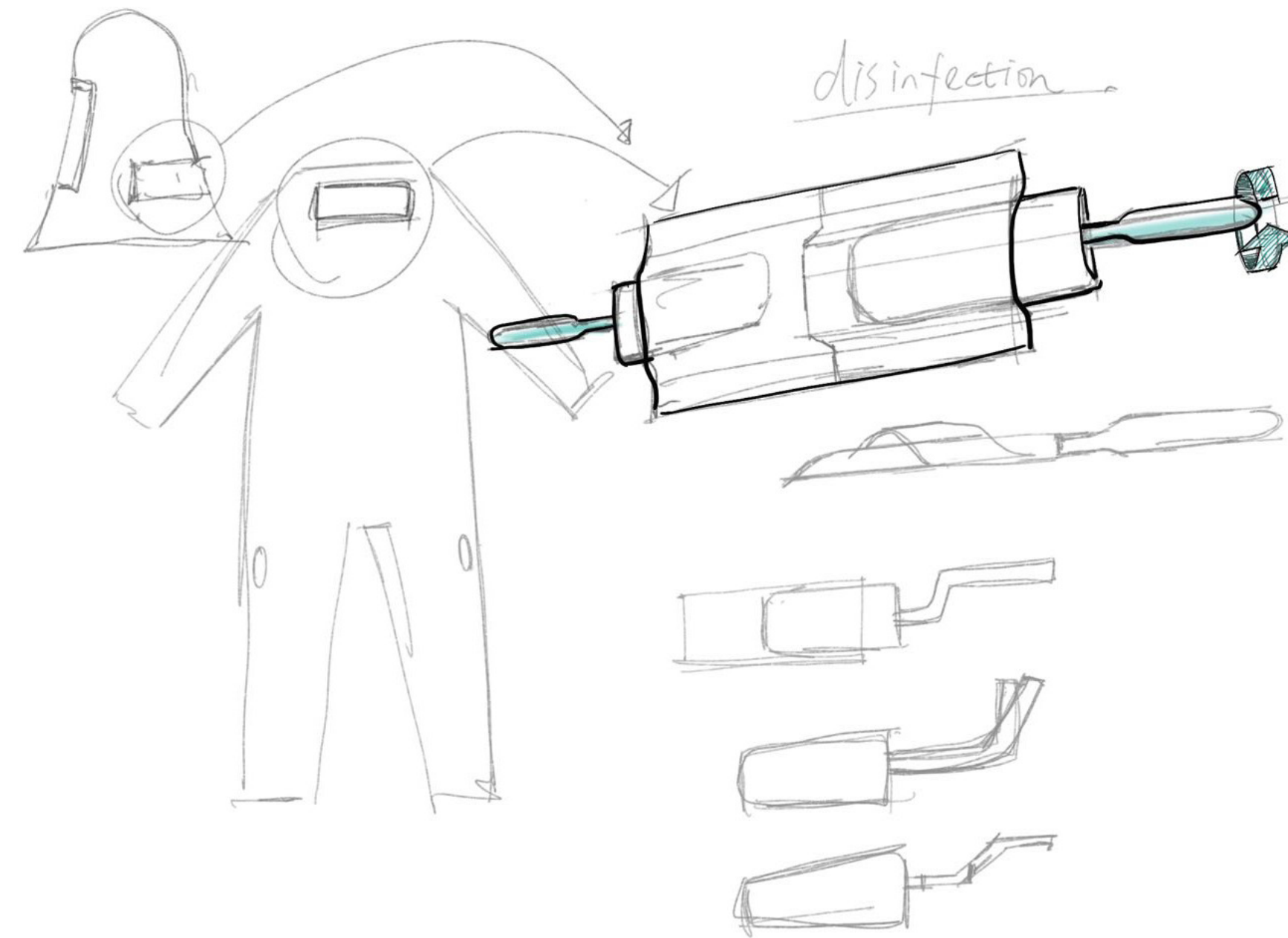
Flipper is the secure tool which targets the flipping motion.

User: Trained observer

Corresponding PPE: Coverall, normal hoods, PAPR hoods

Function:

- Rolling and flipping the textile of PPE
- Setting a distance between the clean/ dirty hands and the surface of textile.



/3 Unzipper

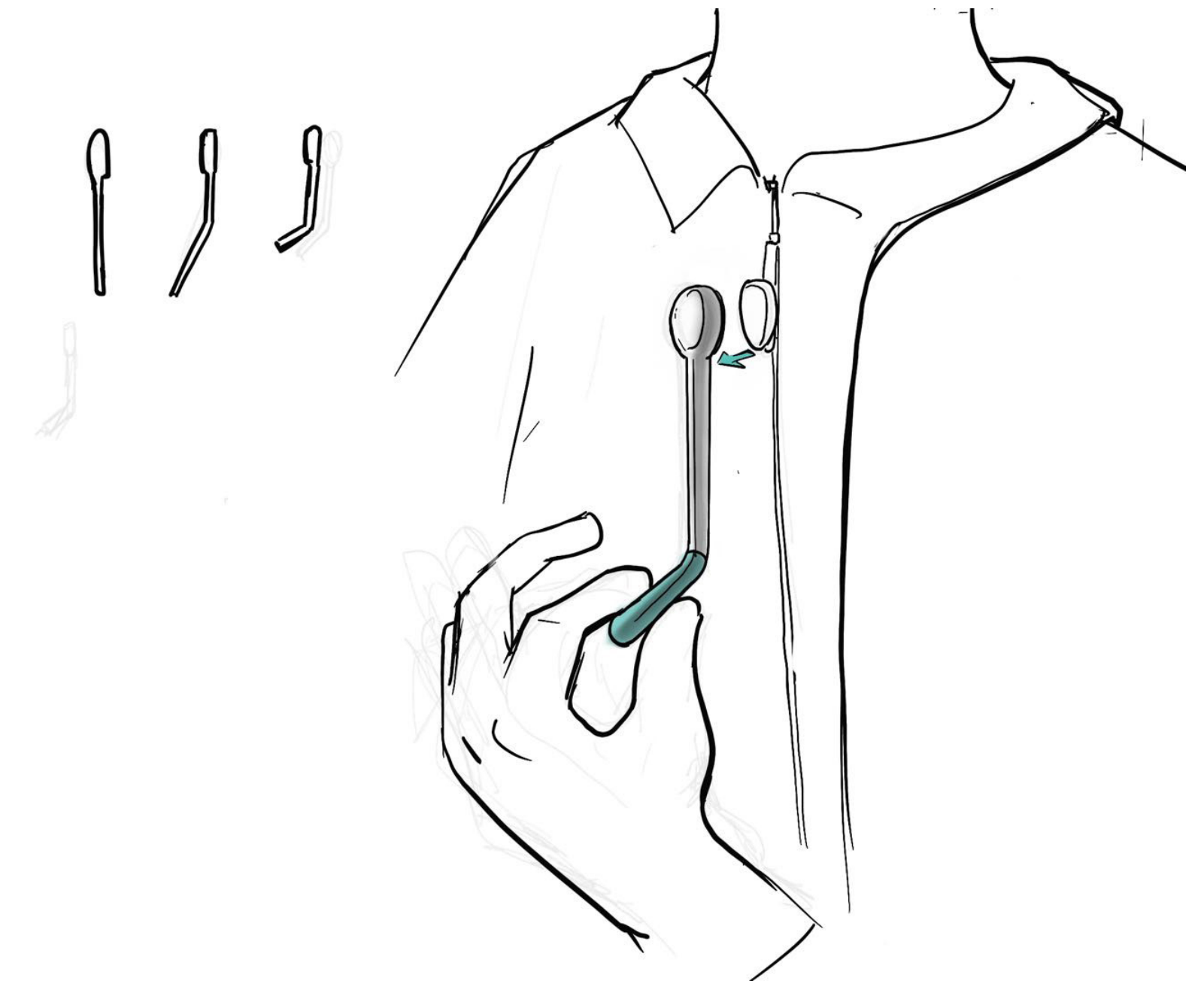
Unzipper is the secure tool which targets the unzipping motion

User: Health care worker

Corresponding PPE: Coverall

Function:

- Searching for the zipper
- Unzipping
- Setting a distance between the hands and hood; setting a distance between the hands and the surface next to the zipper.
- Replacing the engagements of trained observers

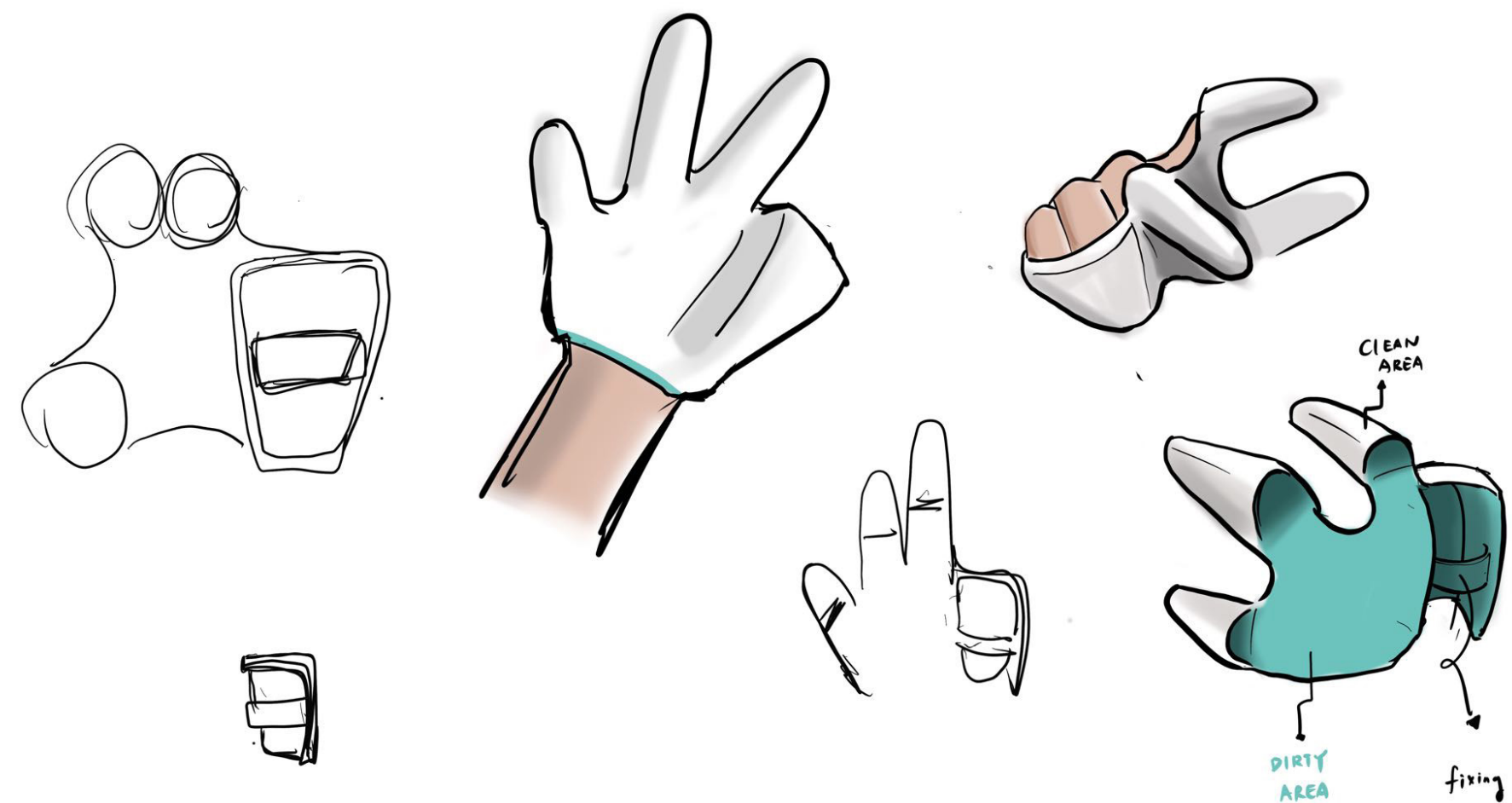
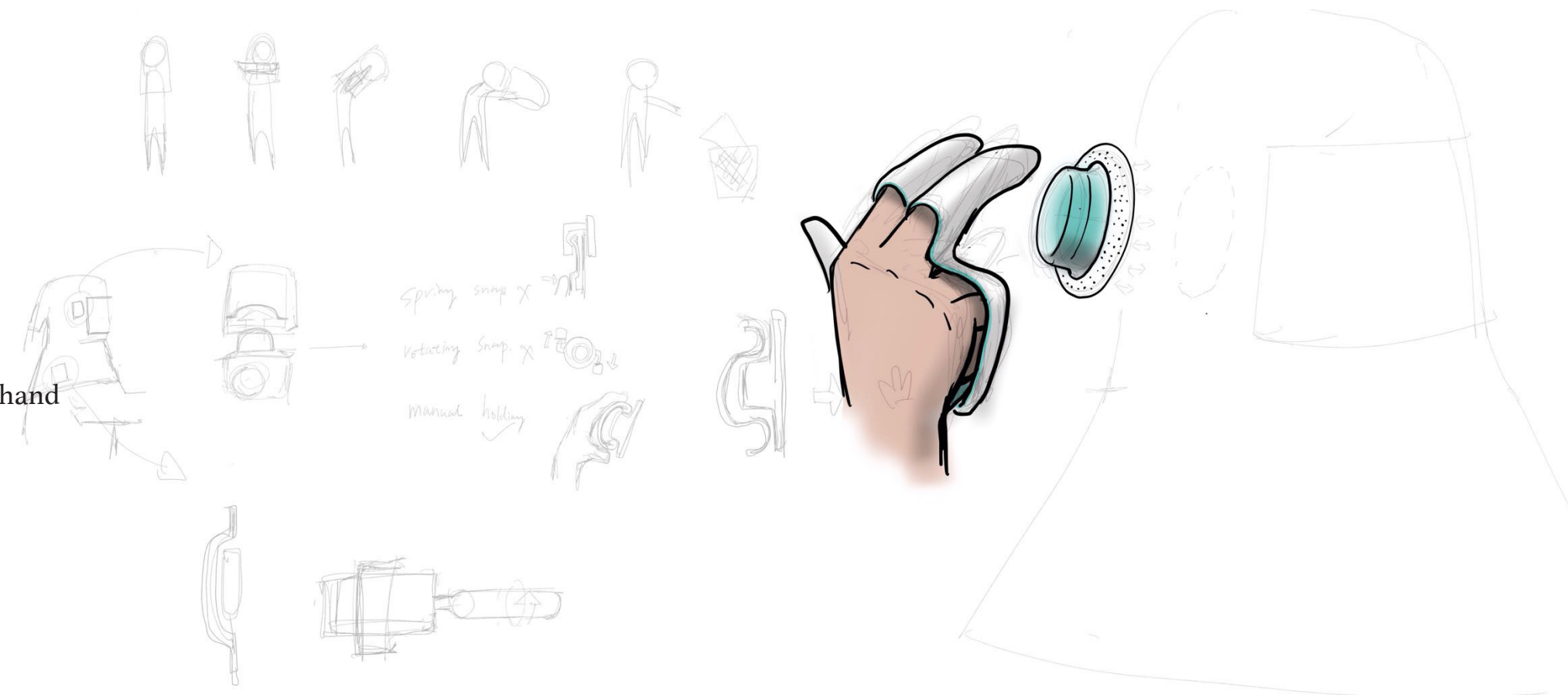


/4 Rapid glove

Rapid glove is the secure tool which targets the easy hand motions

User: Health care worker, Trained observer.
Corresponding PPE: All

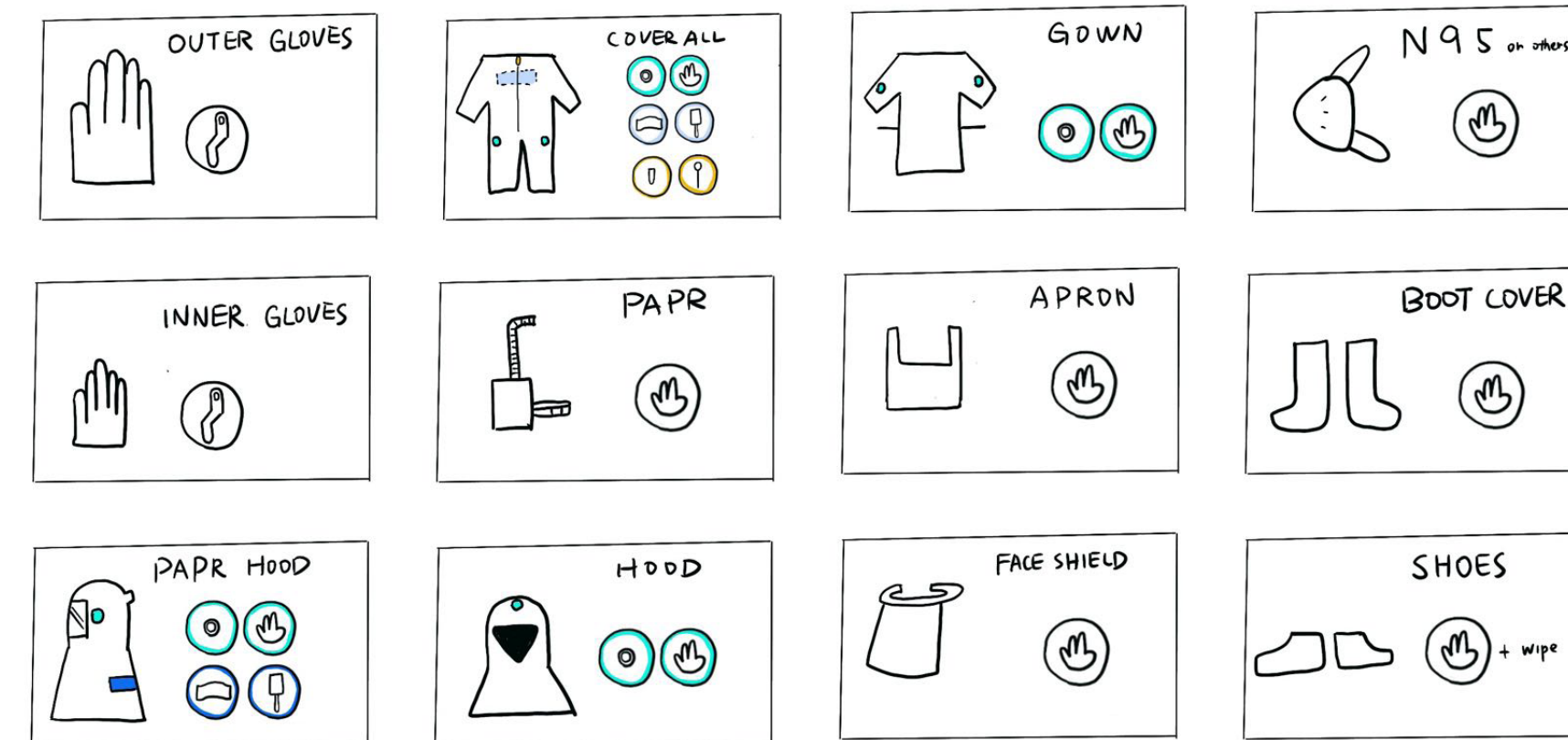
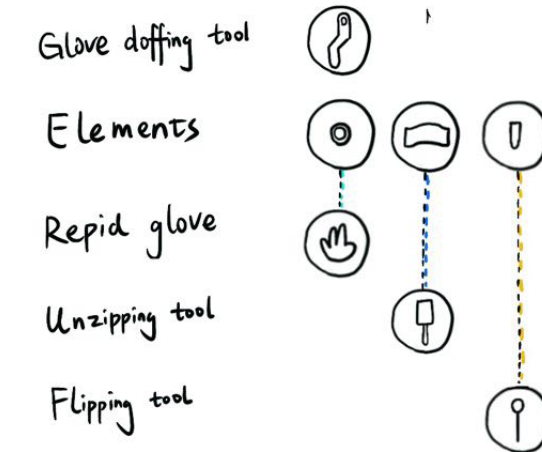
Function:
-Finish different kind of easy hand motions.
-Isolating and quarantining the hand or inner glove.



Instruction card

The four different secure tools can respectively accomplish their unique functions, sometimes they can still collaborate with each other in some demanding doffing phases.

I therefore made a series of instruction cards for different PPE elements to introduce the specific application Secure Tools.



Feedback

Before going into design process, I was desired to hear some voice of professional.

Without hesitating, I contact Fridtjof Heyerdahl again and showed him my progress. Since we could only have an online video meeting and he seemed too busy to have enough time, he didn't follow the whole concept, but he understood most of them and gave me very useful feedbacks.

He showed more interests in the [Rapid gloves](#) and [Unzipper](#).

He strongly agreed with the idea of Rapid gloves, he said,

"Sometimes we have to take on a new glove during the doffing process to avoid self-contamination. The rapid glove can make things much easier and safer"

For the Unzipper, he said,

"Unzipping tool is a very relevant idea, but I think it can be simpler."

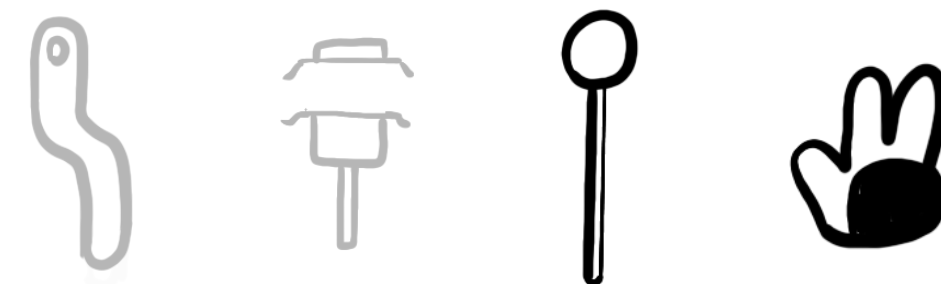
"Maybe you can only make a new tab which is long enough to be found by hands instead of using magnets."

"We also find it is quite struggling to figure out how to take off goggles in a safer way, the tab can also stick to goggles for people to hold on and take off."

He didn't say too much about the flipper. He hasn't experienced that special doffing process, neither the hospitals in Norway don't take such a demanding doffing process because covid-19 doesn't have as such a high infectiousness as extreme dangerous diseases like Ebola.

He didn't agree with the idea of glove doffing tool because he thought the traditional way is already safe enough.

As a designer, I need to keep humble and respect all kind of feedbacks from the professionals. Thus, I decided to continue working on the idea of [Unzipper](#) and [Rapid glove](#) while [saving the whole systematic concept](#).



/ PHASE 5

In this phase, I did a series of further researching work as well as the exploration in terms of designing the new product for the PPE isolation system.

/Unzipper

Since there are several challenges in making an actual rapid glove with the special situation and limited technique supports, I put the Unzipper as the first prioritized project for the design stage.

Concept

Unzipper is the Secure Tool for achieving a more secured unzipping motion while abandoning traditional hand hygiene process, it mainly targets the user group of health care worker.

Function

- Searching for the zipper
- Unzipping
- Setting a distance between hands and hood
- setting a distance between hands and the surface next to the zipper.



Review

While taking into consideration of the feedback from last interview, I come up with several conclusion as a review of the concept.

Simplifying

I need to consider the simple design guideline and try to simplify the design of Unzipper.

Attachable tab

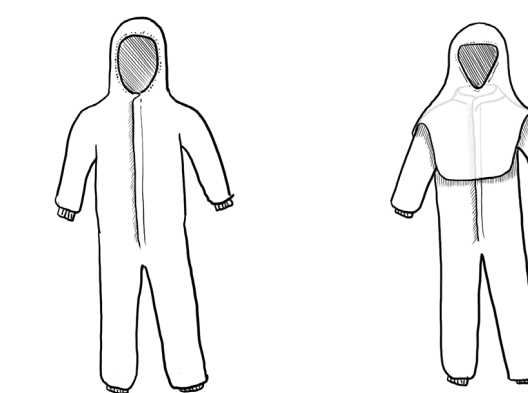
Attachable tab could be a good idea to make the product easier and lower the expense of manufacture. However, Mr. Fridtjof only took the integrated coverall into account but ignored some more complicated scenario. Since the product is supposed to be universal to different kind of PPE, I need to think about the special scenarios.

If the PPE have a deep hood that already hides most area of the zipper, the tab needs to be very long and huge that may cause a lot of potential risks during the healthcare mission. Also, different PPE have different dimension of the hoods. In addition, gender and height of healthcare workers may also effect the distance of the sheltered area, which means one simple tab can't meet the need of universal design.

Other application?

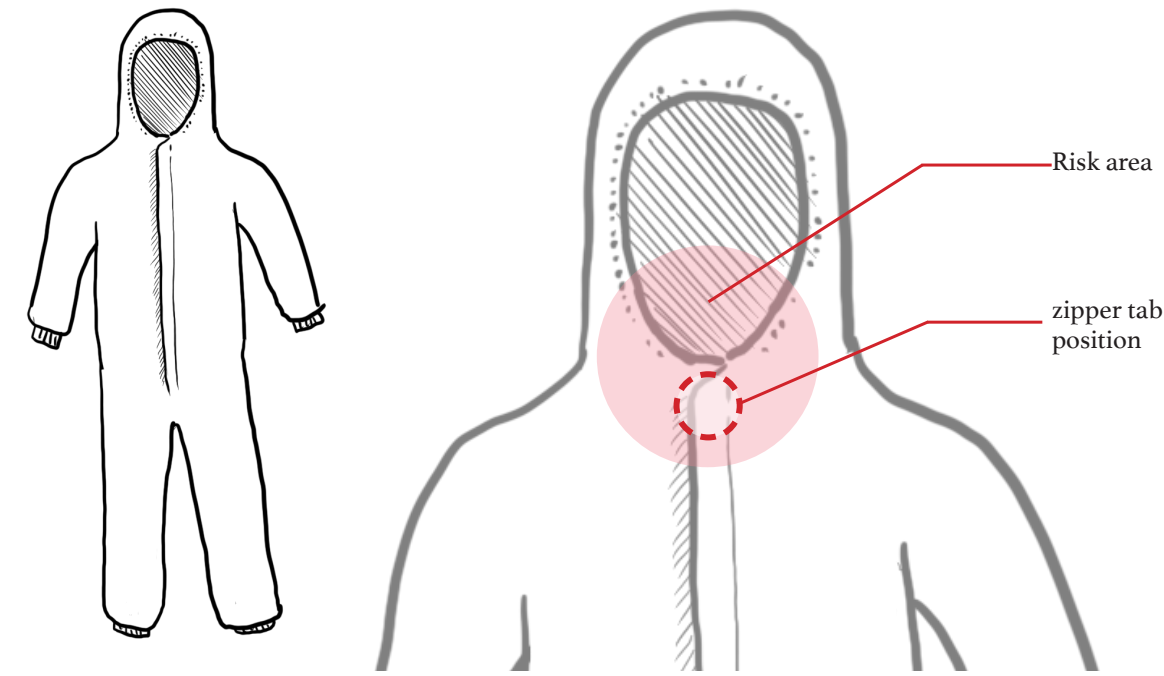
As for the idea of the using unzipper to remove the goggles, I also took it into consideration and figured out the dilemma.

The needs can be achieved by the other Secure Tool, Rapid Glove, rather than spoiling the original function of the product.



As a starting point of the exploration phase, I should firstly figure out two different scenarios which have a huge impact on the next several steps.

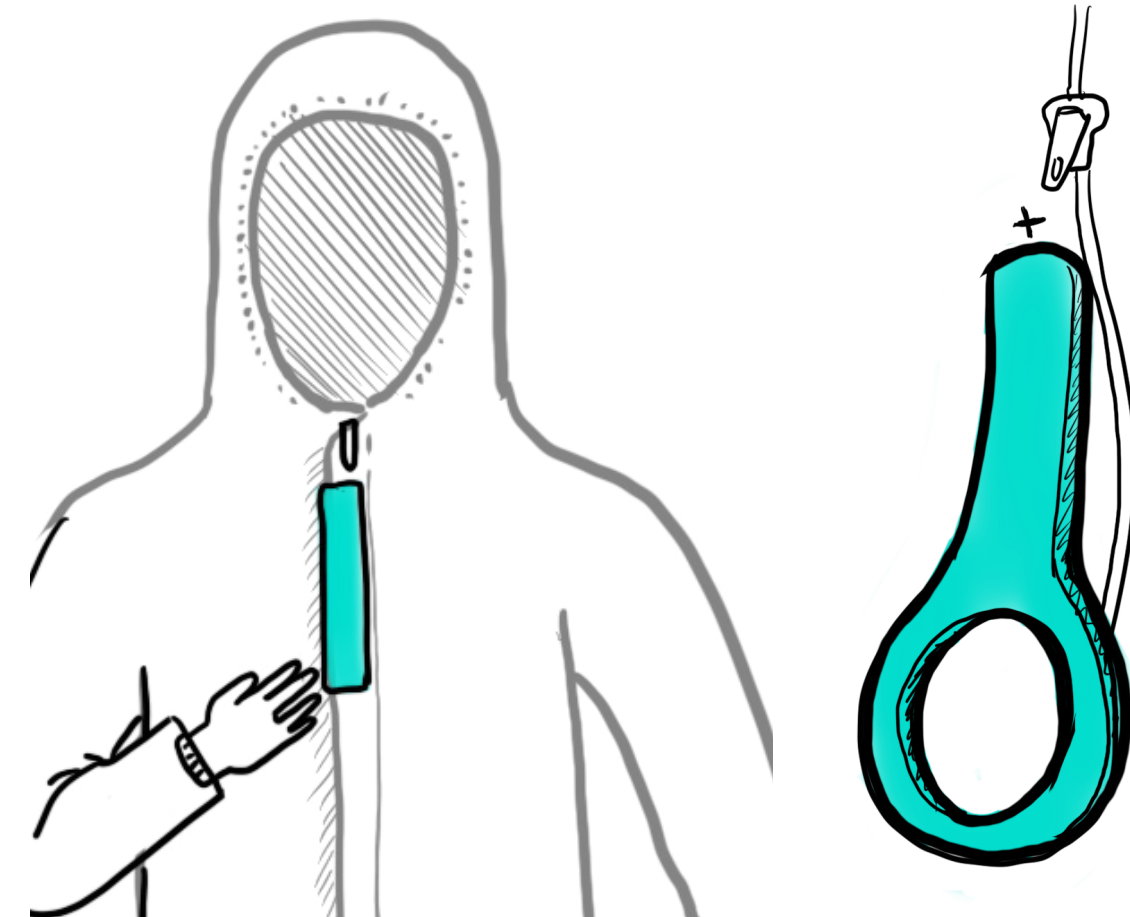
Two scenarios



Scenario 1 Integrated coverall

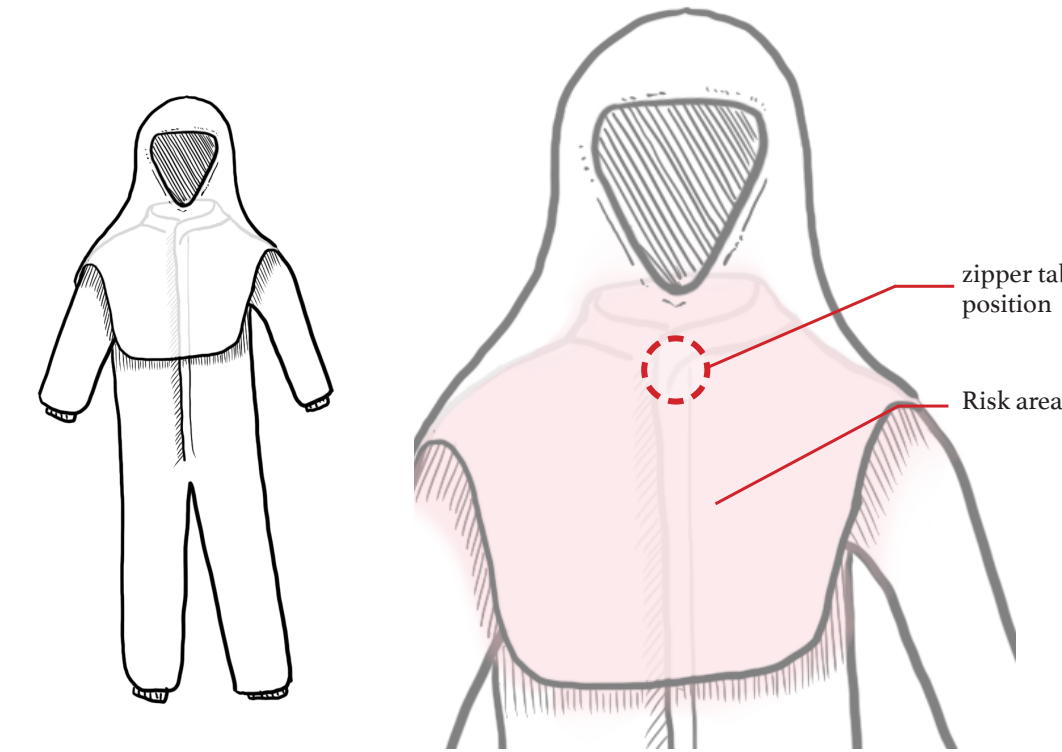
This type of coverall is connected with a integrated hood. Therefore, the zipper on intergrated coverall are always been exposed outside. The healthcare workers who are doffing this kind of coverall would only have the risk of contaminating their exposed skin or inner scrub when searching for the zipper.

The challenge of this type of coverall can be solved by a much bigger tab which is easier to find.



Hand-Isolation System for PPE Doffing Process

Scenario 2 Separate coveral



This type of coverall doesn't have an integrated hood, it is always used in combination with an extra hood (PAPR hood or normal hood). The zipper is always hidden by the extra hood. Thus, the health care workers who are wearing this kind of coverall will face two type of risks of getting self-contamination:

Risk one
Contamination by touching inside of the hood
When searching for zippers and unzipping the coveralls, dirty hands could accidentally touch the inside surface of hoods, which is followed by contamination on healthcare workers' faces and scrubs.

Risk two
Contamination by touching skin and scrub
Direct touching skin or scrubs with dirty hands when searching for the zippers and unzipping the coveralls would also bring contaminations.



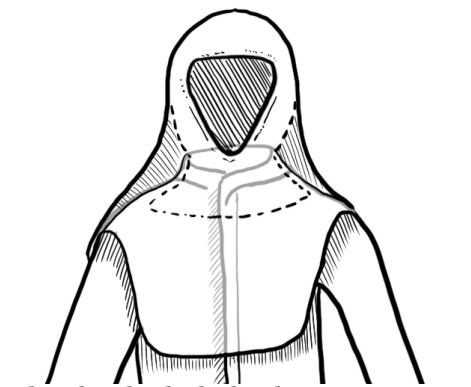
Whereas, this kind of coverall has two different circumstances depending on the connecting structure of the hood. Which lead to a huge difference in terms of risks.

Circumstances 1
hood without a locked-in layer
This kind of hood doesn't have an extra layer to be locked inside the coverall, which means the doffing sequence should be: **remove the hood – unzipping the coverall**
This kind of combination only have the first risk that I referred to.
The challenge of this type of combination can be solved by a much bigger tab which is easier to find.



hood without a locked-in layer which can be removed before unzipping

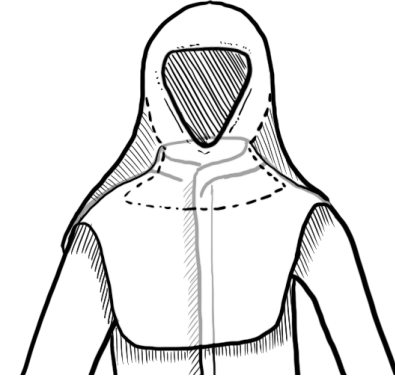
Circumstances 2
hood with a locked-in layer
This kind of hood has an extra layer that are supposed to be locked inside the coverall, which means the doffing sequence should be: **unzipping the coverall – remove the hood**
This kind of combination have both two risks that I referred to.
The challenge of this type of combination need to be solved by **another solution** which is more protective.



hood with a locked-in layer coverall should be unzipped first

In conclusion, I need to mainly figure out the most complicated circumstances of Scenario 2— **separate coverall with a locked-in hood**, which is the most challenging scenario. And also, I need to figure out how to adapt the function available for all scenarios.

For convenience, in the rest of the report, I would use 'Scenario 1' to refer to the Scenario 1 and circumstances 1 of Scenario 2 while using 'Scenario 2' to refer to the circumstances 2 of the previous Scenario 2.



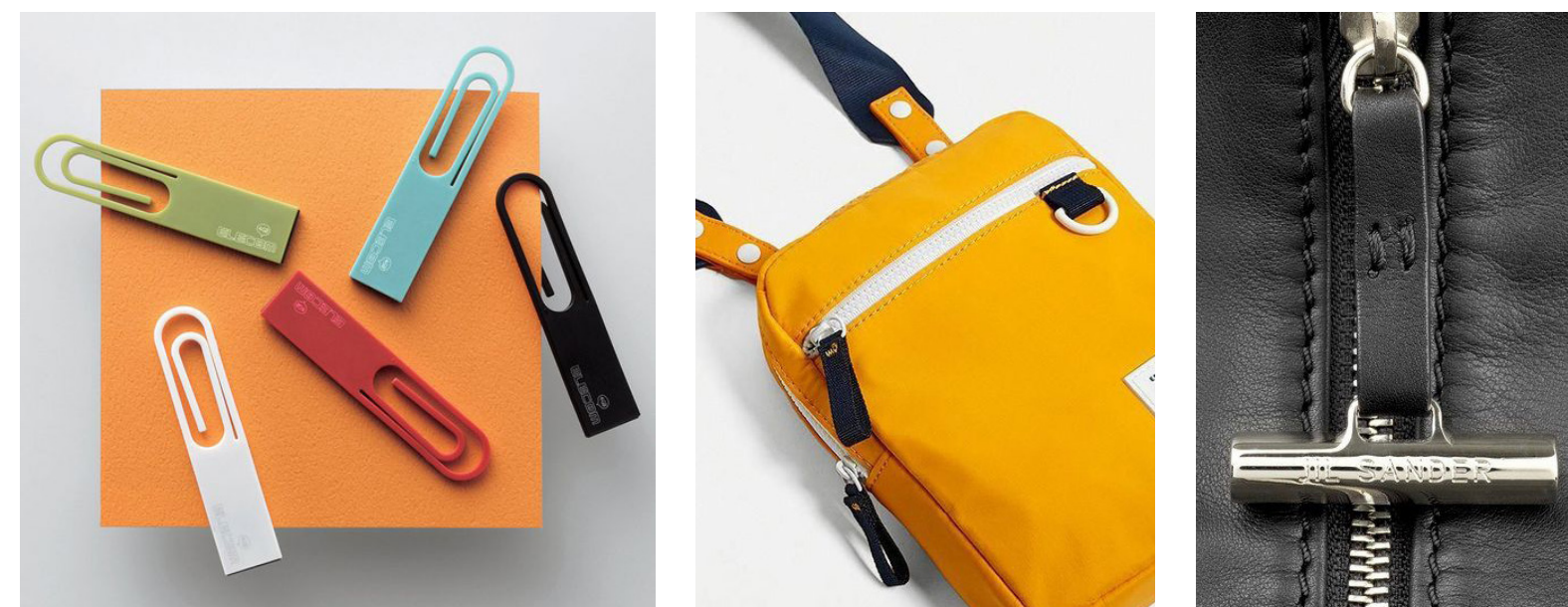
Thanks to Mr. Fridtjof's help, I got a physical coverall, which was going to be a very valuable physical material for my further study. I instantly started to have an close touch with the suit, and from that time, all of my mock-ups are tested based on this suit.



Inspirations



A Secure Touch



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Hand-Isolation System for PPE Doffing Process

Mock-ups ideation

*Simple long tab

The tab is long enough to go through all kind of hoods and be exposed to users.



Problem:
They are too long and too dangerous.
They may bring in danger when doing healthcare missions.

A Secure Touch

*Adjustable long tab

The tab can be adjusted into different length and fit well with both two scenarios.

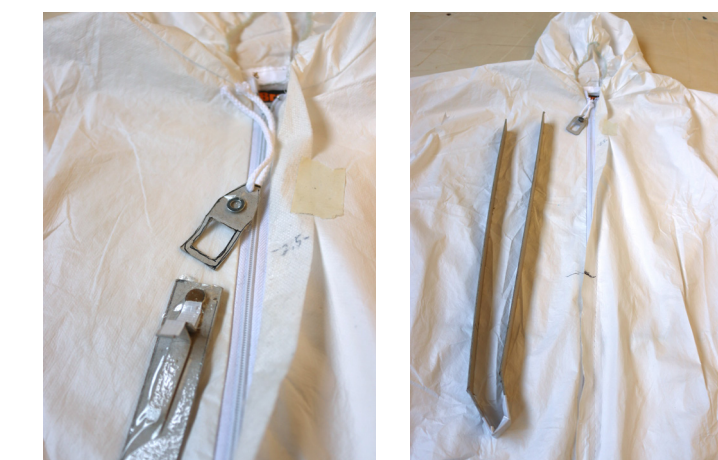
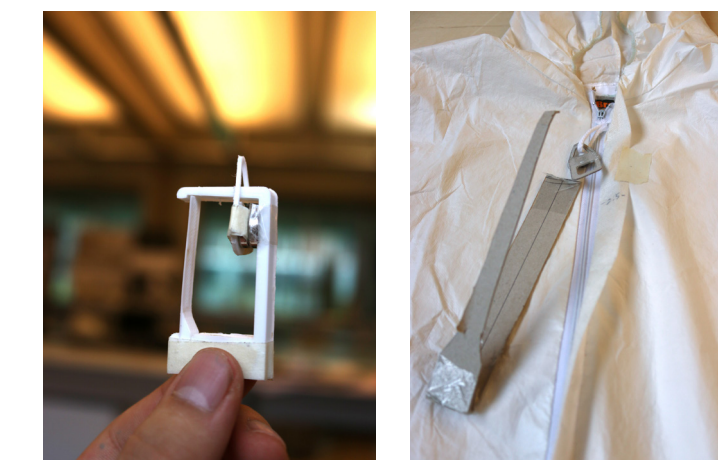


Problem:
-Idea1, Idea2: When adjusted in a short size, the ring become too big which may lead to accident during the mission.
-Idea3, Idea4: They have too complicated structure that make the product too difficult to use, hard to disinfect and time-consuming.

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*Small tab + searching tool

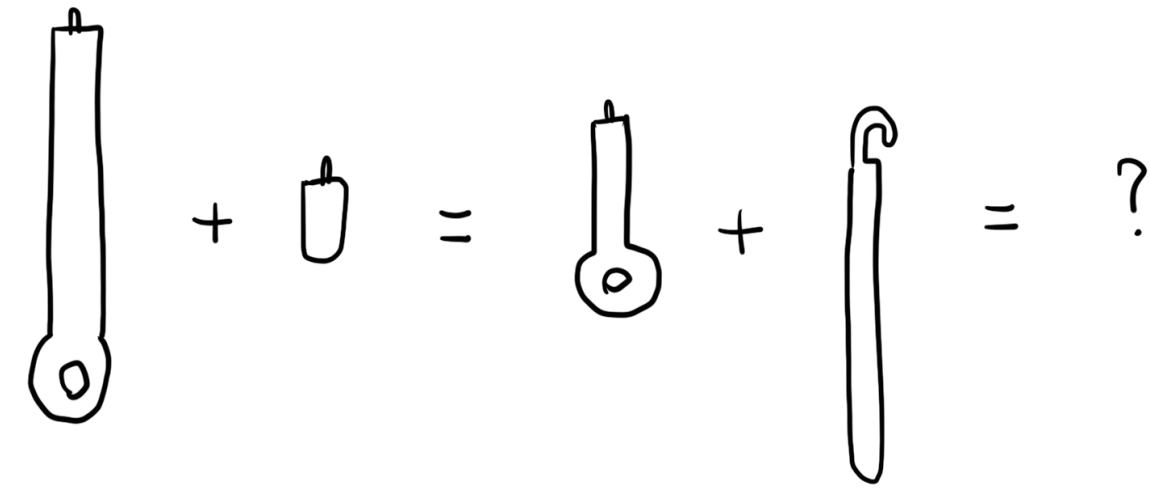
Using a searching tool to search for the zipper, then use the tool to unzip the coverall.



Problem:
For integrated coverall, the using journey could be too complicated.

Hand-Isolation System for PPE Doffing Process

Why not merge the ideas together?



Soft tab + Searching handle

I end up with an idea that split the product into 2 different using ways.

For Scenario 1
Only use the soft tab for searching and unzipping.

For Scenario 2
Try to use the soft tab for searching and unzipping.
If the tab is hidden by the hood, use the handle to search for the tab and unzip.

How to search?
I use magnets to achieve the searching function



Sequences

In order to find more requirements and challenges for the detailing design, I made two different kind of using sequences based on two different Scenario.

Scenario 1

Only use the soft tab to find the zipper and unzip.



1 Attach the tab on the zipper



2 Zip on the suit



3 Flap on the hiding layer



4 Tapping on



5 Working



6 Mission end



7 Open the hiding layer -Tab is visible



8 Grasp the tab and unzip



9 Remove the tab



10 throw the tab into a collecting box



11 disinfection

Scenario 2

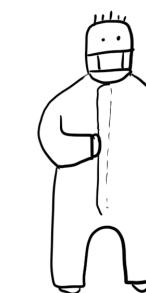
Use the handle to find the tab and unzip.



1 Attach the tab on the zipper



2 Zip on the suit



3 Flap on the hiding layer



4 Tapping on



5 Working



6 Mission end



7 Open all/part of the hiding layer



8 Get the searching handle



9 Reach the handle into the dress of the hood following the flap



10 feel the tab matching with handle



11 pull down the tab until the suit totally unzipped



12 Remove the handle out of the tab



13 throw the handle into a collecting box



14 Remove the tab



15 throw the tab into a collecting box



16 disinfection

Requirements

It must

- *Universal for different kind of zippers
- Available to connect
- Available to remove
- *Not affect the doffing process
- Smooth to zip on
- Smooth to unzip
- Fit with the flap of the zipper trail
- Not bring in new contaminations
- *Safe use
- Not sharp, with a smooth surface
- Not affect the health care missions
- *Available for disinfection
- smooth surface, don't have tiny gaps
- correct material
- *Unzip function
- Have a smooth grab motion
- Have a smooth unzipping motion
- Long enough to isolate the hands from risky areas
- Bear the pull force

It should

- Easy to connect
- Easy to remove
- able to refer the user to correct use
- Comfortable when using it
- Portable and easy to store

It could

- Have a clear signal when found the zipper
- Aesthetic acceptable

The hidden distance

The distance of the hidden area by different hoods is a very important data that determines the dimension of the product. So, I started by figure out the range of the hidden distance.

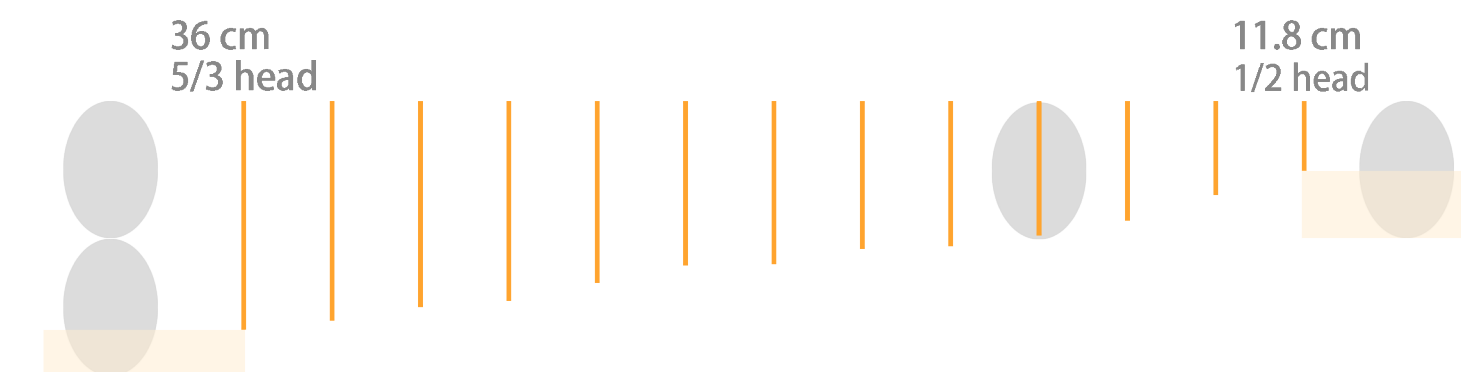
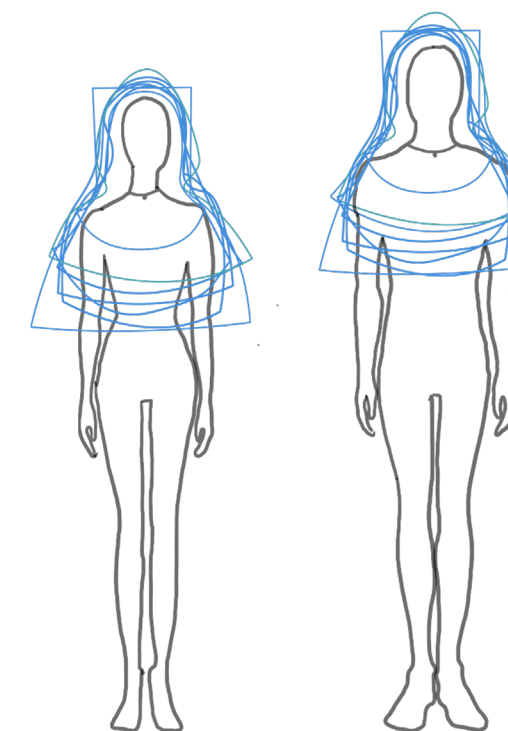
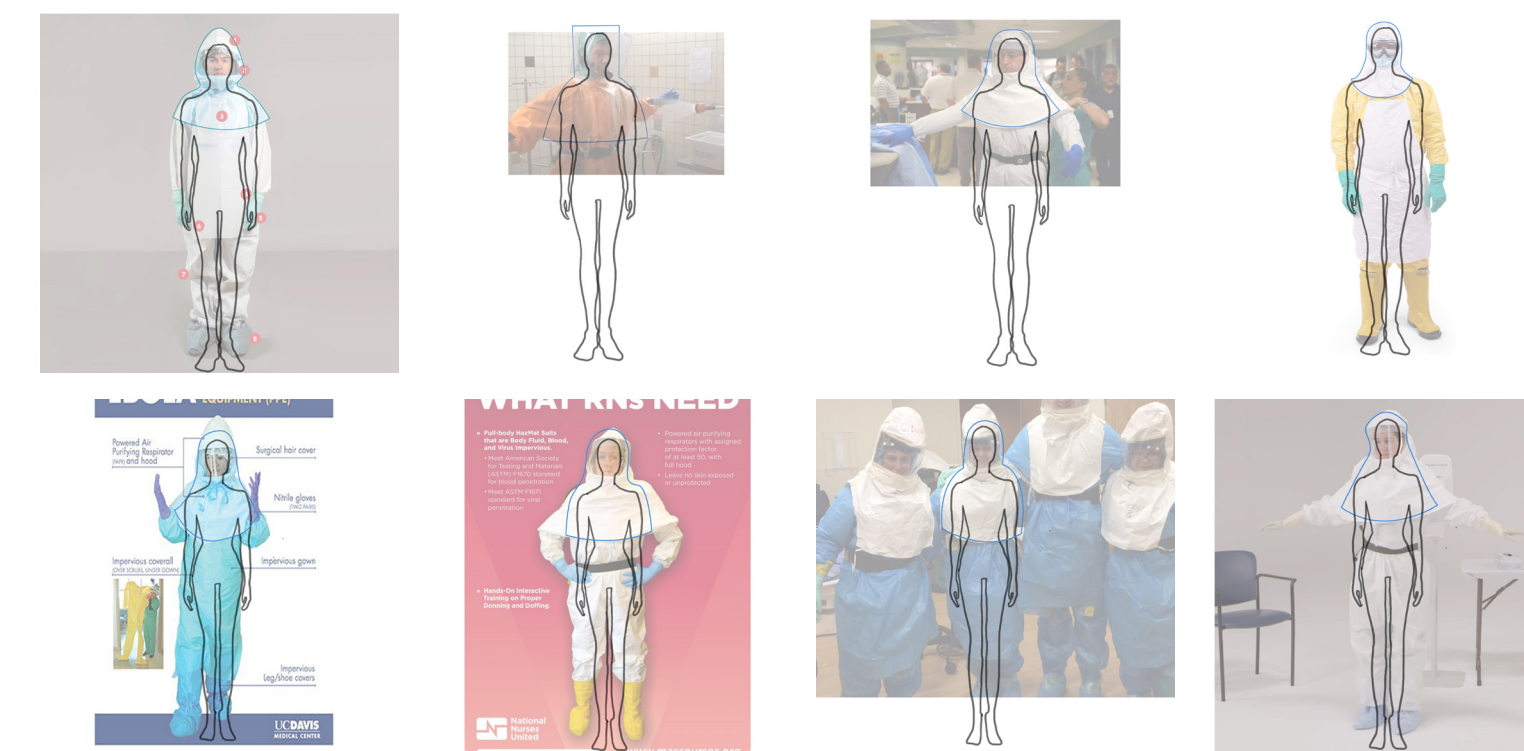
Unlucky I couldn't get any physical hood available for me to measure, but I still got the rough number of the distance in a smart way.

Firstly, I try to get as much pictures of people who wearing different PPEs with hoods as possible, and keep them as samples for later use.

Then, I found two standard human illustrations (male and female) as a rough reference. After that, I overlapped the illustrations with the picture samples to get a series of rough outline of the hoods, from the outline I could clearly figure out how much of the body is hidden by different hoods.

By adapting data of anthropometry, I got a rough range data of the hidden distance:

118mm~360mm



Searching

Unluckily I only come up with the idea of using magnet to search for the position of the zipper.

In the very beginning I put two magnet buttons on both the tab and searching handle.

Later I realized that the magnet on tabs would adsorb metals when users are working, which can be annoying or even dangerous.

To get rid of this problem, I replaced the magnet button on the tab with an iron ring, while keeping the magnet button on the handle.

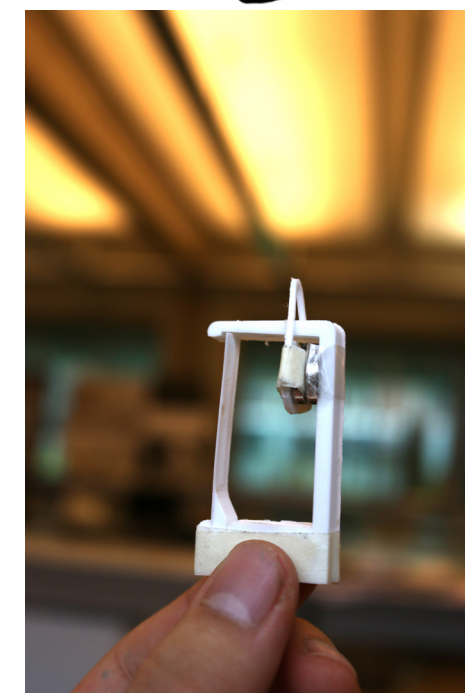
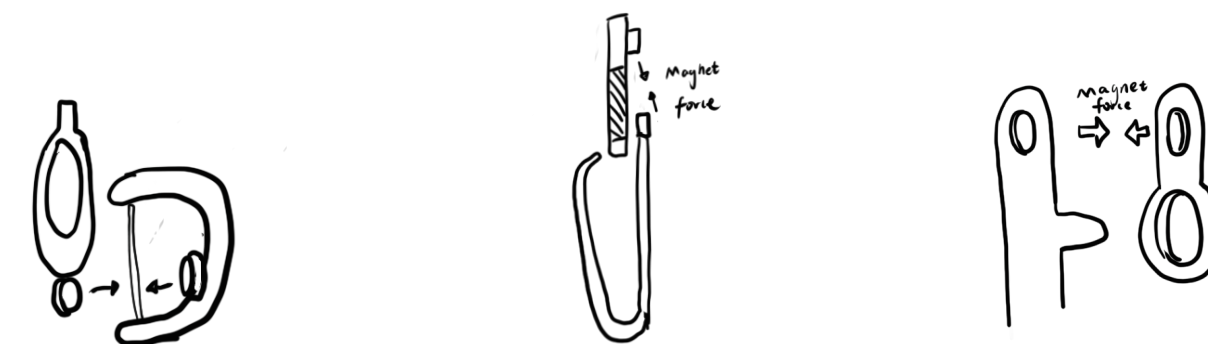


Lock in

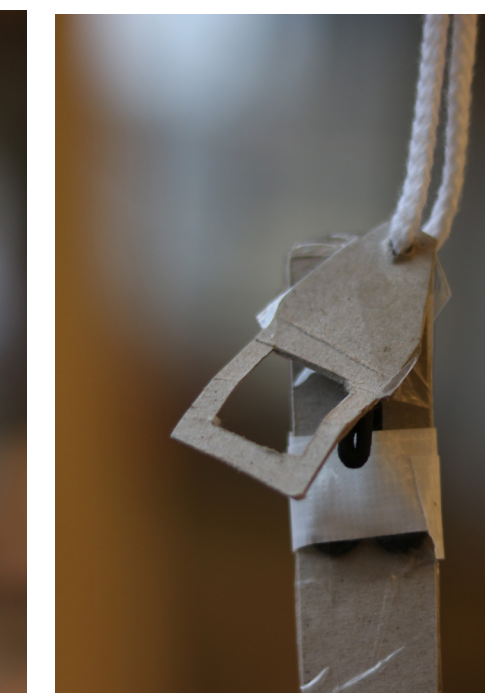
When the handle gets matched with the tab, it should instantly get locked with the tab so that the user can finish the unzipping step smoothly.

How to lock in?

After many mock-ups making, I figured out the best solution, when the magnet match with the tab, the hook of the handle will smoothly go throw a bigger hole on the tab, after the user feels the matching force and try to pull down the tab, the tab would be tightly hooked with the handle.



I found that sometimes it could fail to lock in because of wrong angleS and the limited size of the hole. After serveral more mock-ups and the progress in unzipping motion research, I figured out the issue.

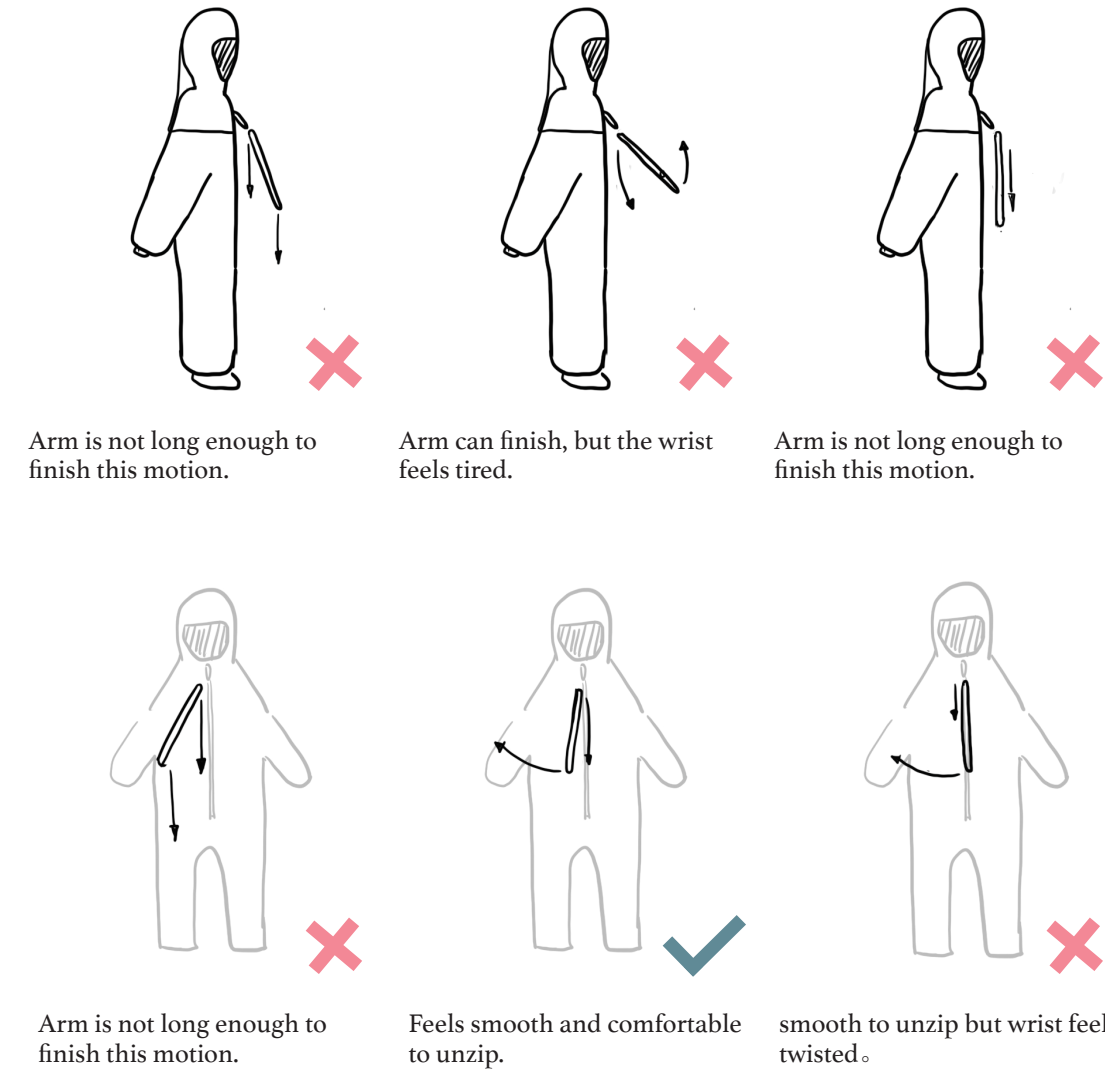


Unzipping motion

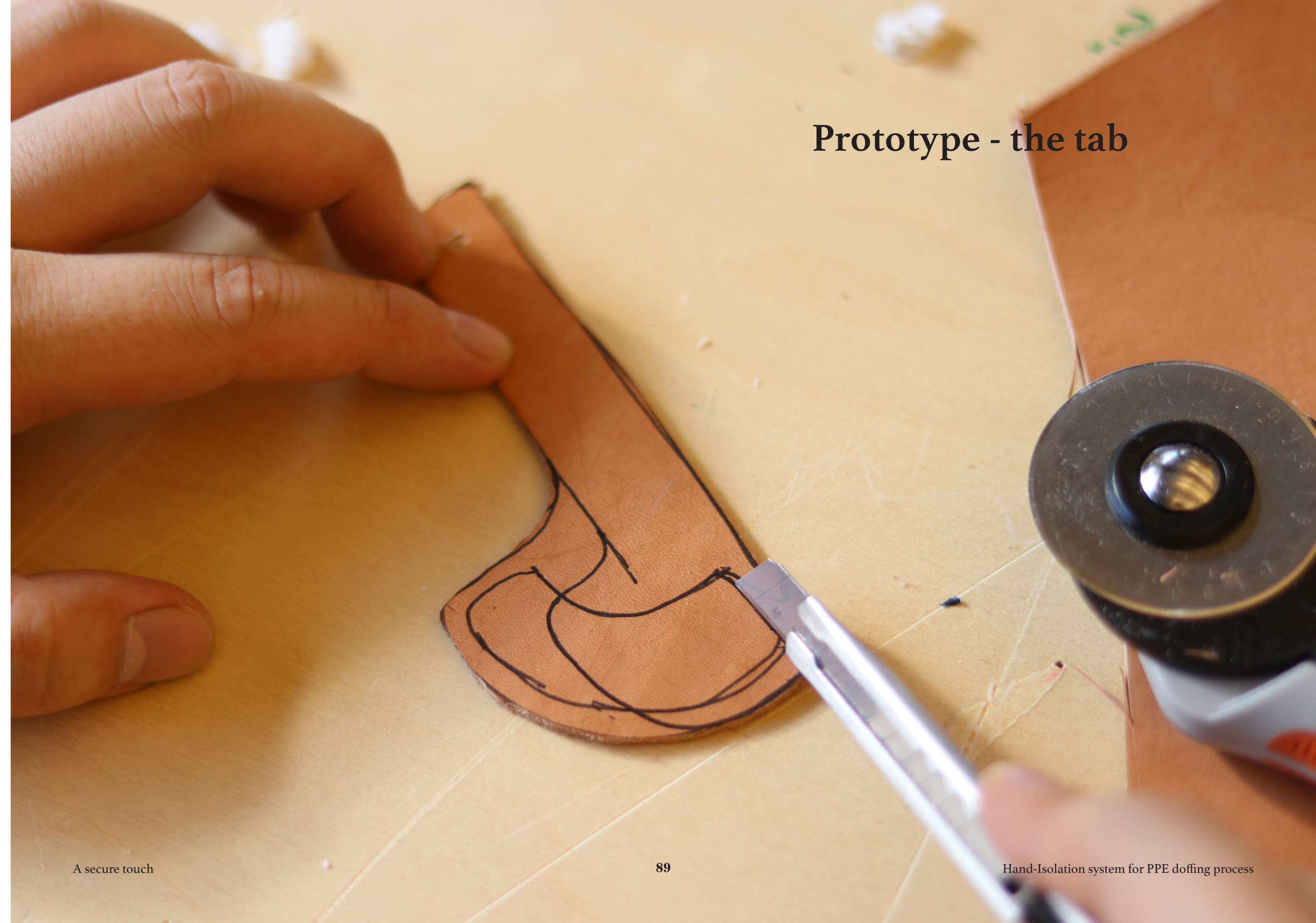
What is the most smooth and comfortable motion to unzip?
 In this phase i tried to answer this question by testing different motion on my coverall, and eventually I got some fruitfull conclusion.



I tried different motion with a variety of perspectives, trails and axis (positions and directions) to find the most smooth and comfortable motion.(in condition of not getting contaminated.)



Prototype - the tab





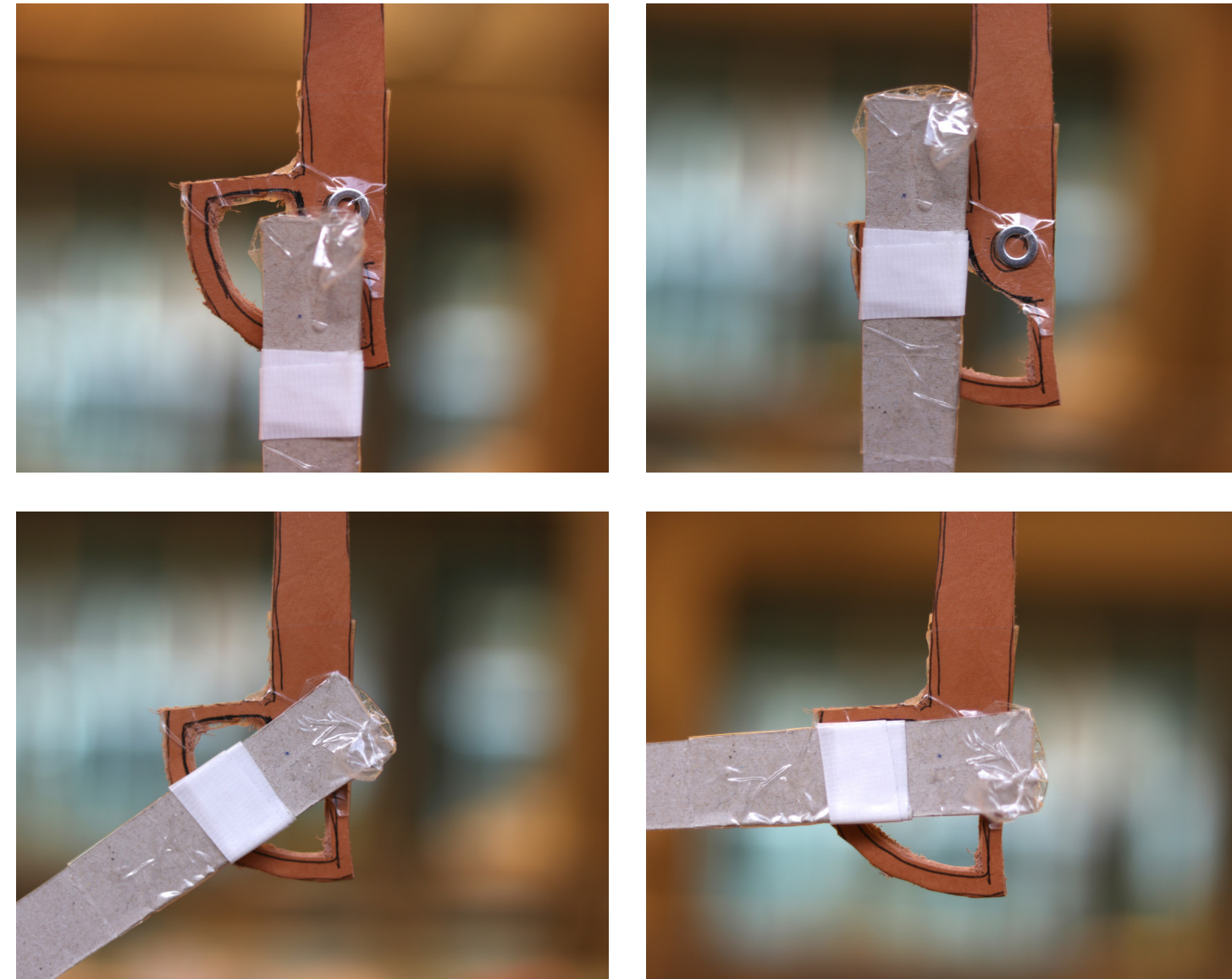
A Secure Touch

Finally, I came up with the idea of the tab.

The asymmetric shape was given for pursuing exact functions. One edge is in straight line for following the flap of the coverall, which make it perfectly fit with the structure of the suit.

The other edge is curving out for several functions:

- Enabling the tab to be visibly and physically exposed, easier to be found.
- Shaping a 1/4 circle for fitting with the best unzipping motion
- Maximizing the hole for being locked with the handle
- Creating a variety of possibility for getting hooked.



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Hand-Isolation System for PPE Doffing Process



Prototype - the handle

A secure touch

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Hand-Isolation system for PPE doffing process

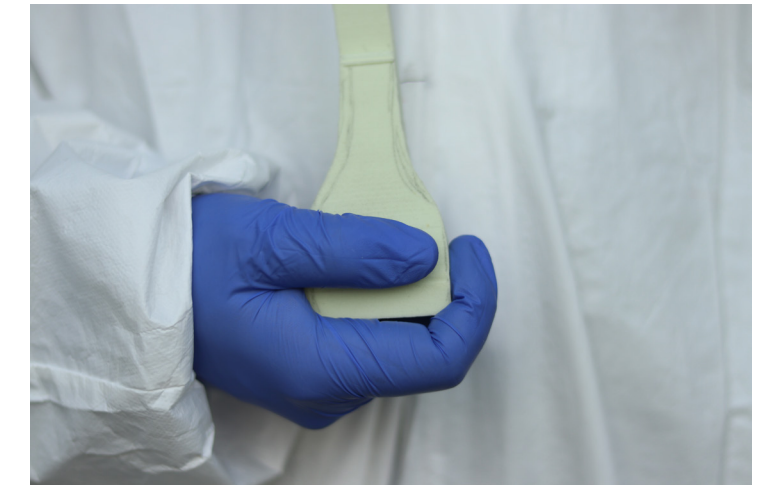
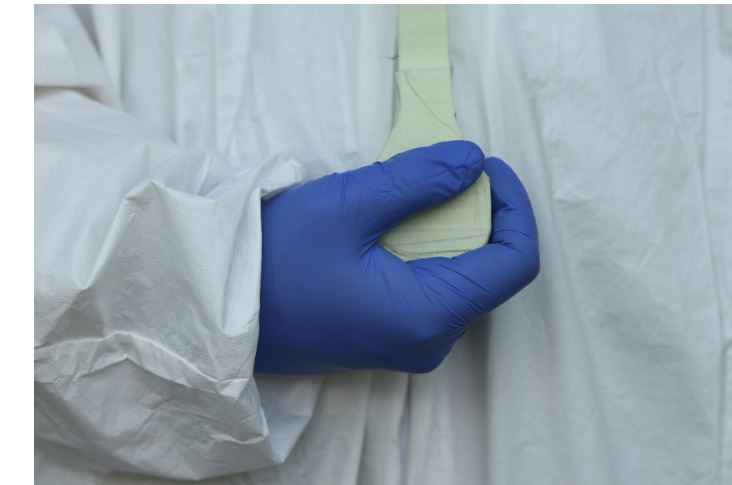
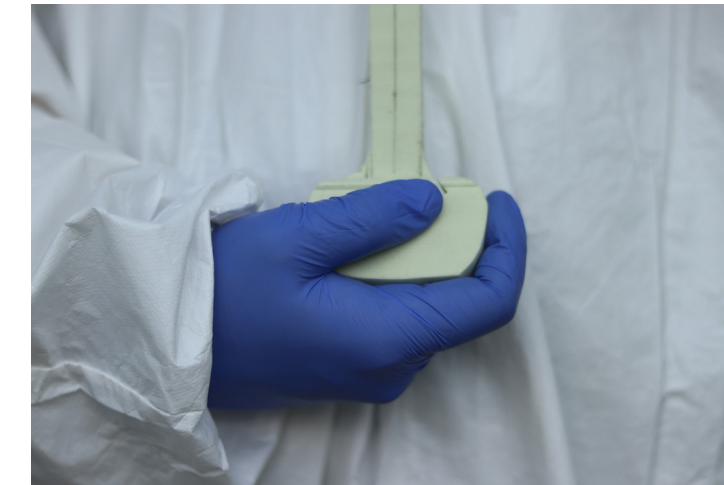
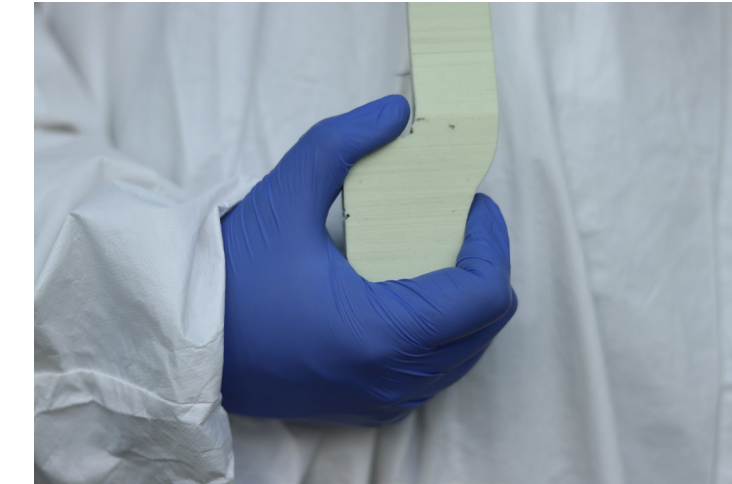
Handle test

I made eight different handle with different bending, grab and size for further a further handle test.

During the testing work, I took **searching accuracy, unipping smoothness, time taken, safety, comfort and other problems** as main testing index. I marked each of them with exact numbers and performed searching-unzipping motion in 10 times with each of them. I wrote down different index in a table and summerized the data later.



Grab test

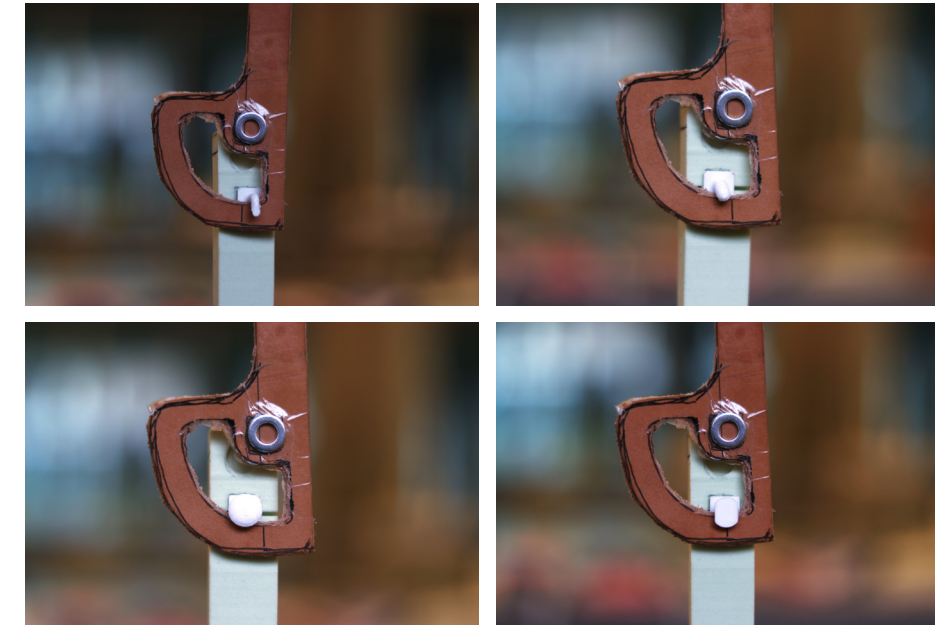


During the handle test, I also picked the best grab shape out of six, which can better fit with the given unzipping motion.

Hook test

What kind of shape of hook can fix the tab better?
In order to try different type of hook and sort out the best solution, I reused the handles from handle text for a hook test.

I made an easy joint on each of the handle so that i can put different hook unit on it.
After that, I built several hooks that i could imagine and printed all of them, set them on the handles and test them.



Connection

How to connect the tab with the zippers?
The challenge is:
1. zippers from coveralls are always small
2. different coverall use different kind of zippers

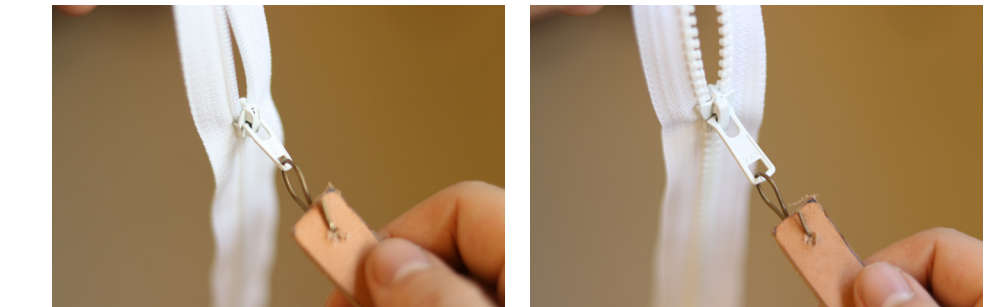
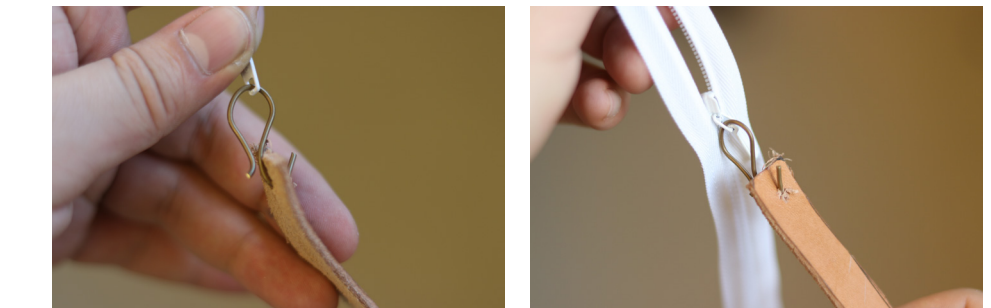


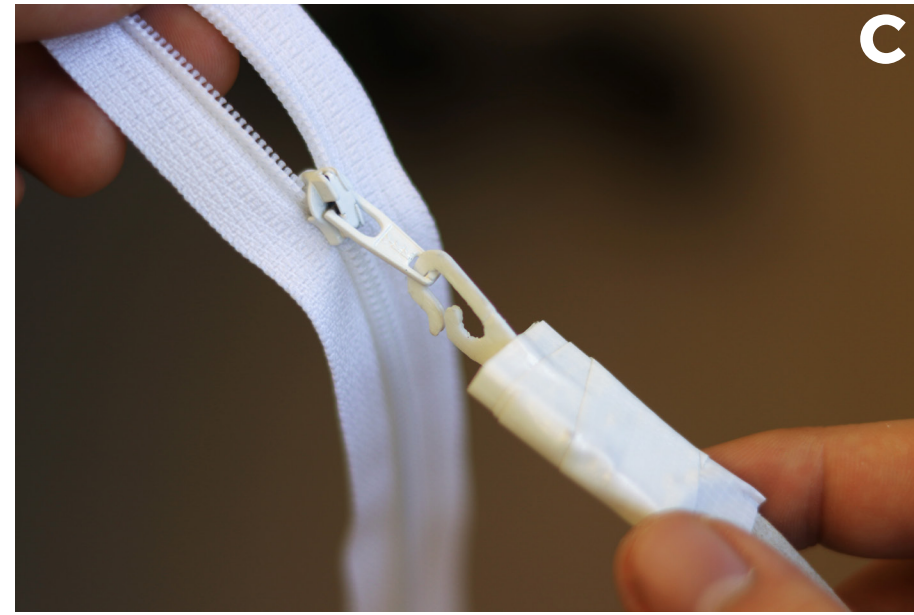
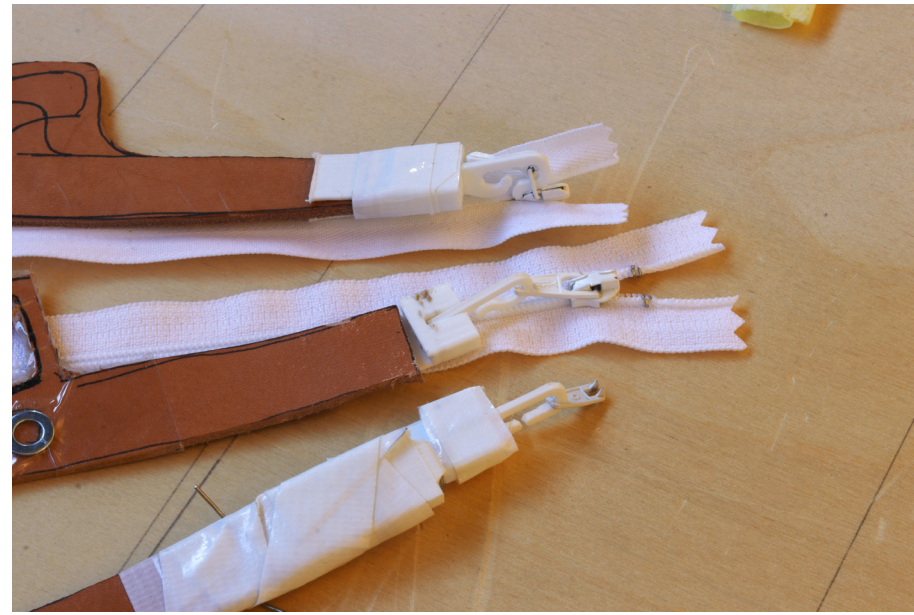
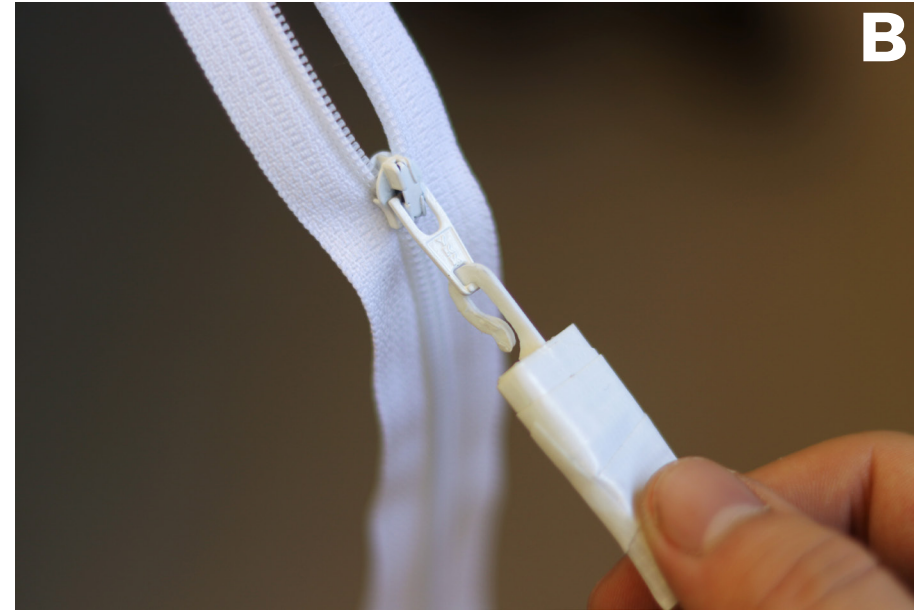
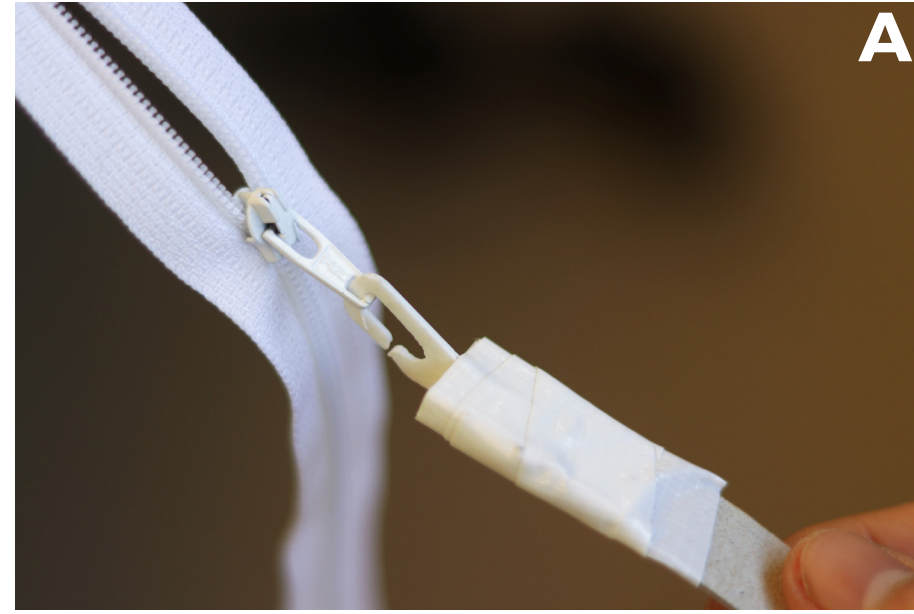
My initial idea is to design a standard zipper base for all the coveralls, then I could cooperate with different coverall suppliers to put on the zipper base right before going into the market. In condition of all this achievement, I only need to design a hook that can match with the standard zipper base. Yes, this is so complicated!

I always doubt whether this is a valid idea that can achieve the goal of universal product. Finally I couldn't persuade myself and dropped this idea.

Later I figured out that there is a common similarity of most of the zippers - You can always find a hole to go through from the tab of the zippers.

Based on the finding, I came up with a several mock-ups that may break the challenge.





After controlling the dimension of the cross section(2mm*2mm), the connection hook was proven to perfectly work with different kind of zippers

I picked the concept C, because it is stronger fixed and easier to connect on.

/ Rapid glove (unfinished)

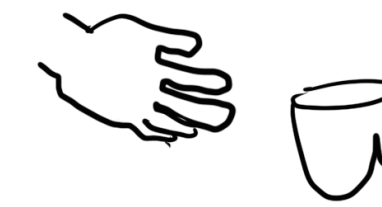
Concept

Rapid glove is the Secure Tool for achieving a more secured **easy hand motions** while abandoning **traditional hand hygiene** process, it mainly targets the user group of health care worker and trained observer.

- Function
- Finish different kind of easy hand motions.
 - Isolating and quarantining the hand or inner glove.

Sequence

In order to figure out the more detailed functional requirement of Rapid glove, I made an using sequence to analyze the scenario.



1 Reach the rapid glove



2 Take on the rapid gloves without contaminating them.



3 Tighten the gloves



4 Perform corresponding doffing phase.



5 Finish the doffing phase.



6 Take off the rapid gloves without contaminating user's body



7 Through the rapid gloves into a collecting box



8 Disinfecting

Requirements

It must

- *Have a wide entrance for hand to reach in
- *Stiff enough
- *Have some elements to tighten the glove
- *Flexible for finishing easy hand motions
- *Have some elements available to take off safely
- *Big enough to isolate the most used surface of hands

*Safe use

- Not sharp, with a smooth surface
- Not affect the health care missions

*Available for disinfection

- smooth surface, don't have tiny gaps
- correct material

It should

- Single hand putting on
- Single hand taking off
- able to refer the user to correct use
- Comfortable when using it
- Portable and easy to store

It could

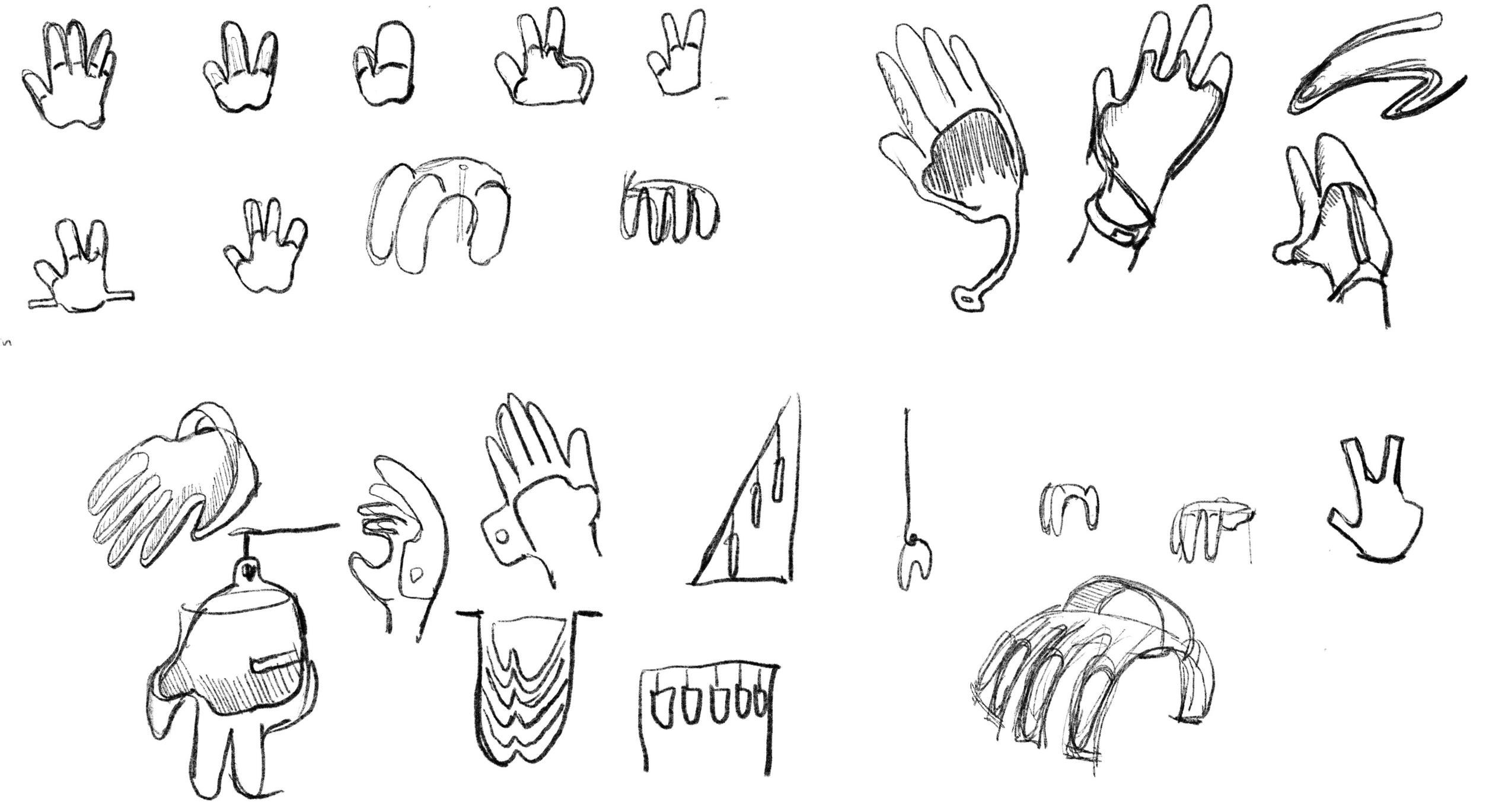
- Detecting and showing the contaminated condition when using it.
- Aesthetically acceptable.
- Playfull, emotional satisfaction.

Inspirations

Lots of surprising pictures had been found and they became very dynamic inspiration in material as well as the structure design for the gloves.



Concept exploration

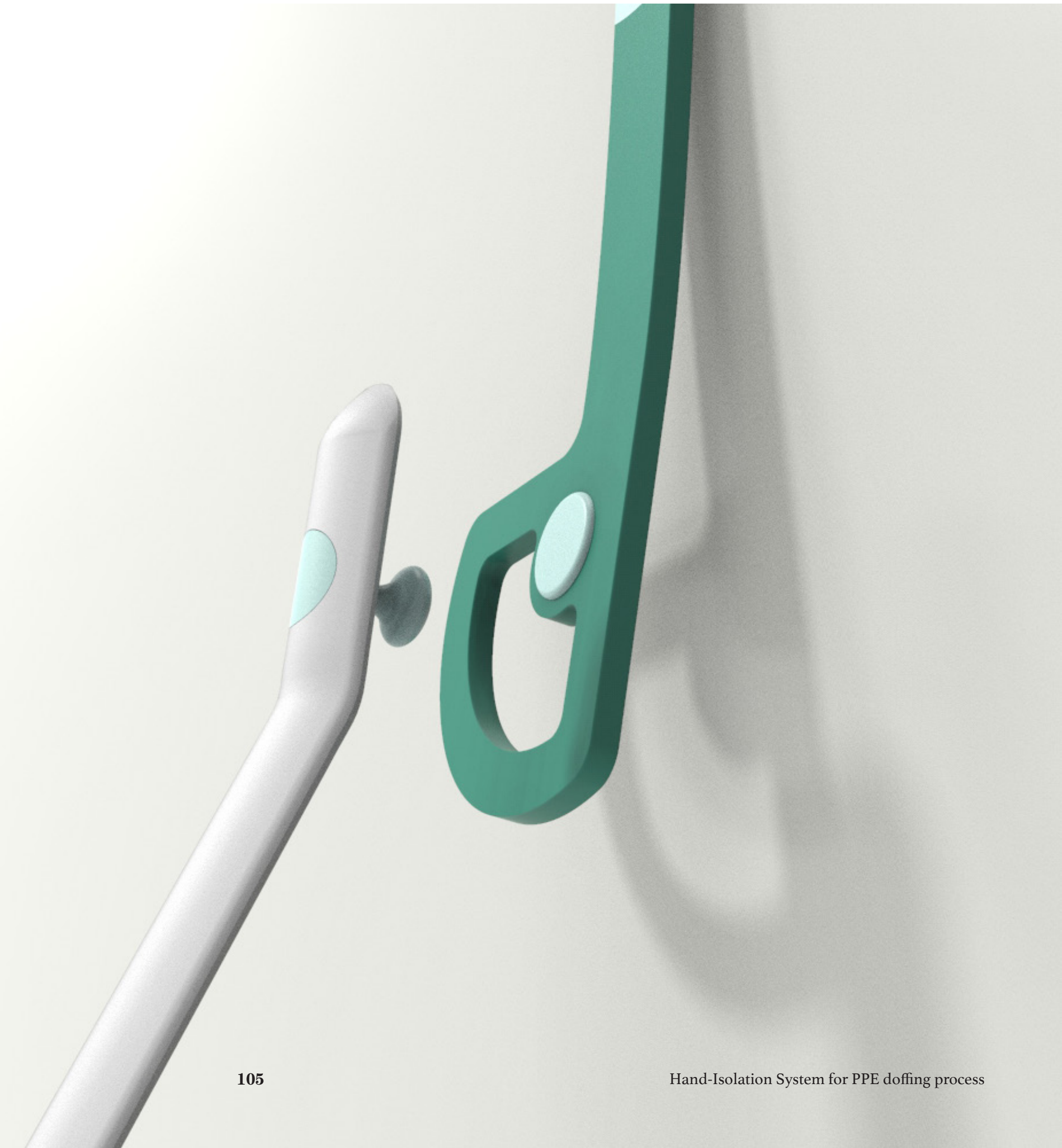


Mock-ups ideations



/ DELIVERY

Unzipper



Unzipper Tab

Unzipper Tab is the part that connecting with normal zipper tabs from coveralls. Tab is the most important part for Unzipper, it is the main part for the function of searching and unzipping, while creating a short distance between hands and high risk areas.

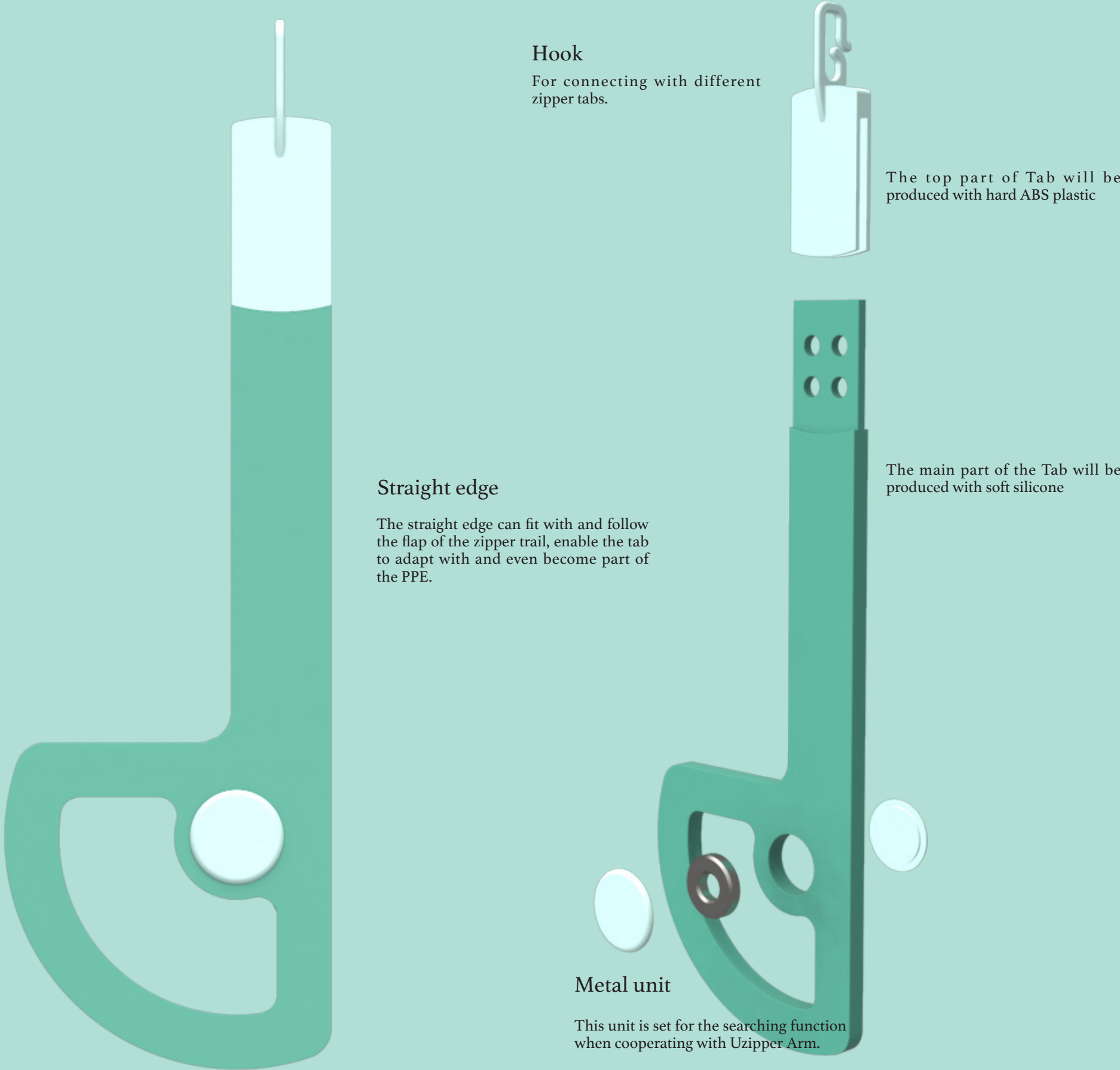
The tab can be used in double faces, which means it can adapt well with the open direction of different zipper flaps.

1/4 circle Ring

This design makes part of the Tab visibly and physically exposed to user, enable them to find the zipper in a easy way.

When the Tab cooperates with Unzipper Arm, this structure can adapt well with the unique unzipping motion.

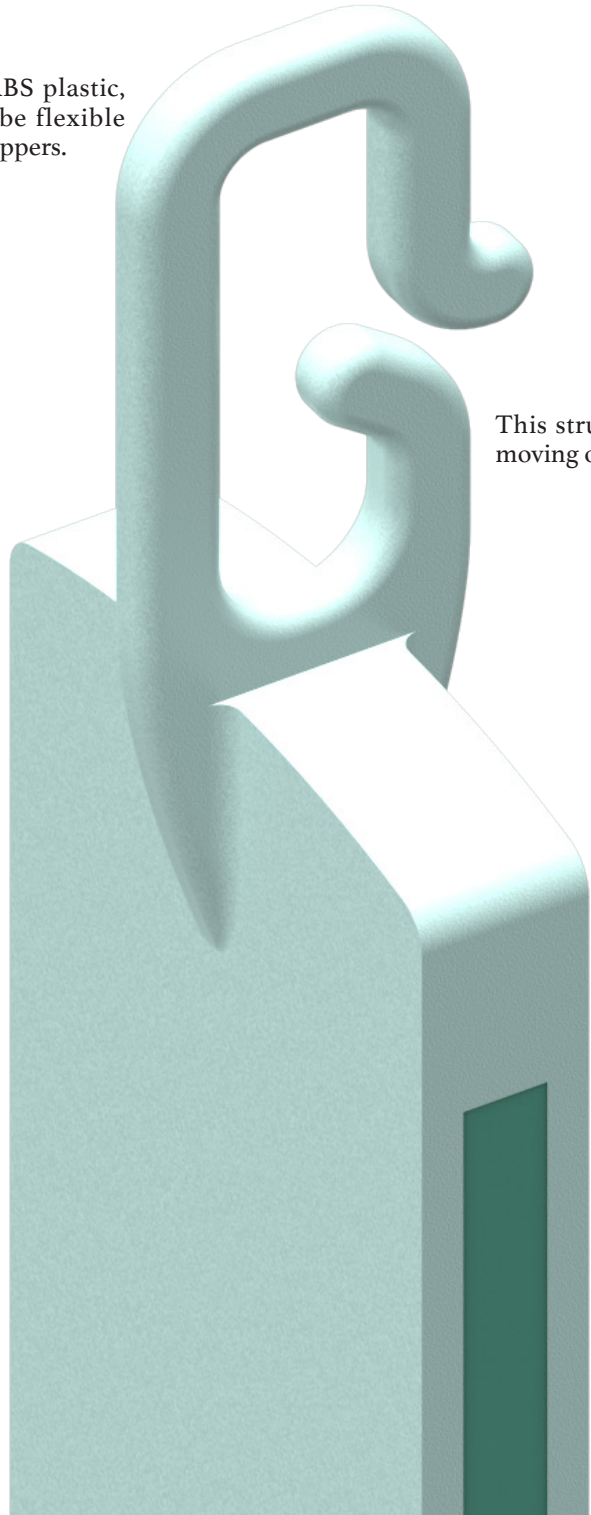
Also this structure can be easily locked with the hook of Unzipper Arm.



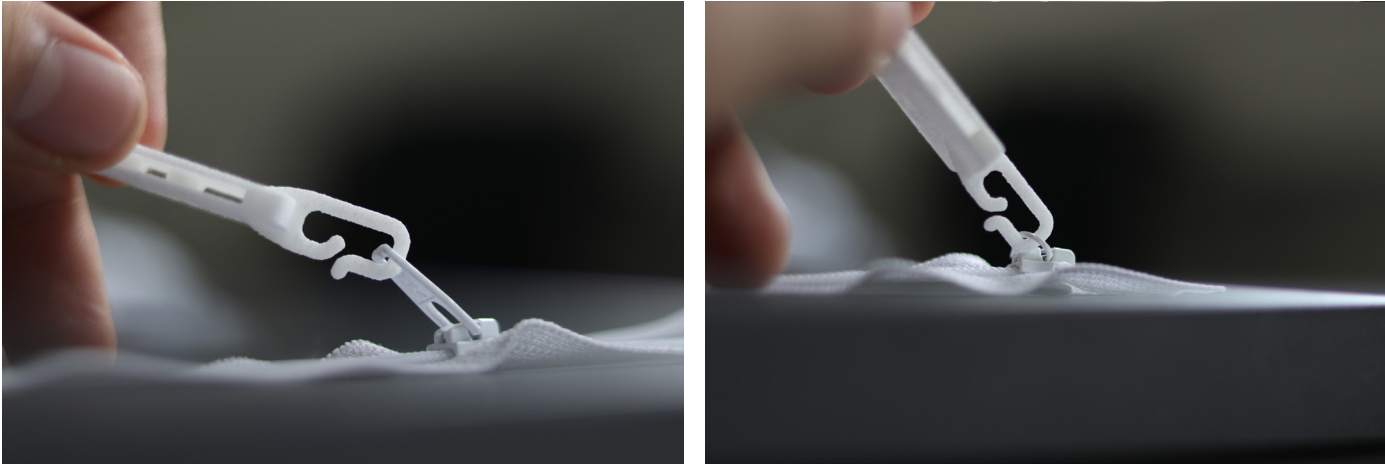
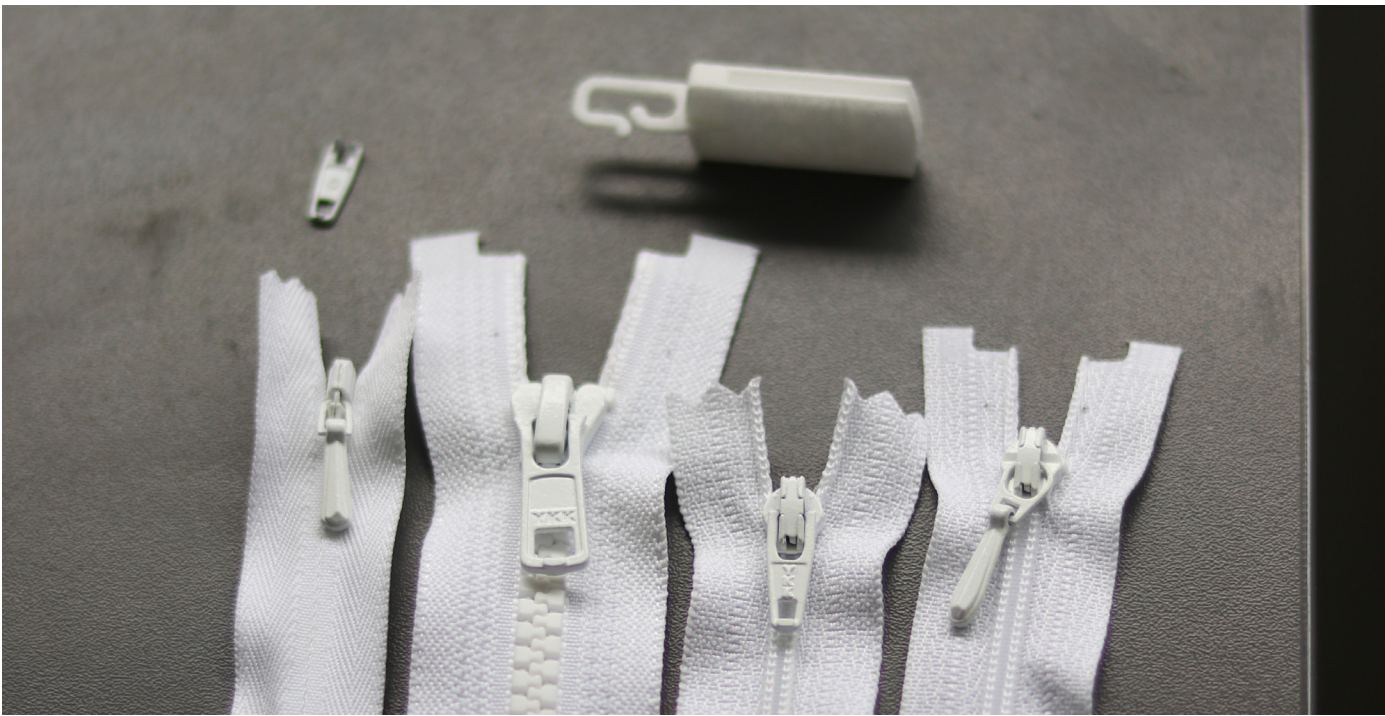
Connection

The hook from the top can perfectly be connected with different kind of zipper tab, enable the product to be universally used with different PPE.

The hook will be made in ABS plastic, which enables the hook to be flexible enough for different kind of zippers.

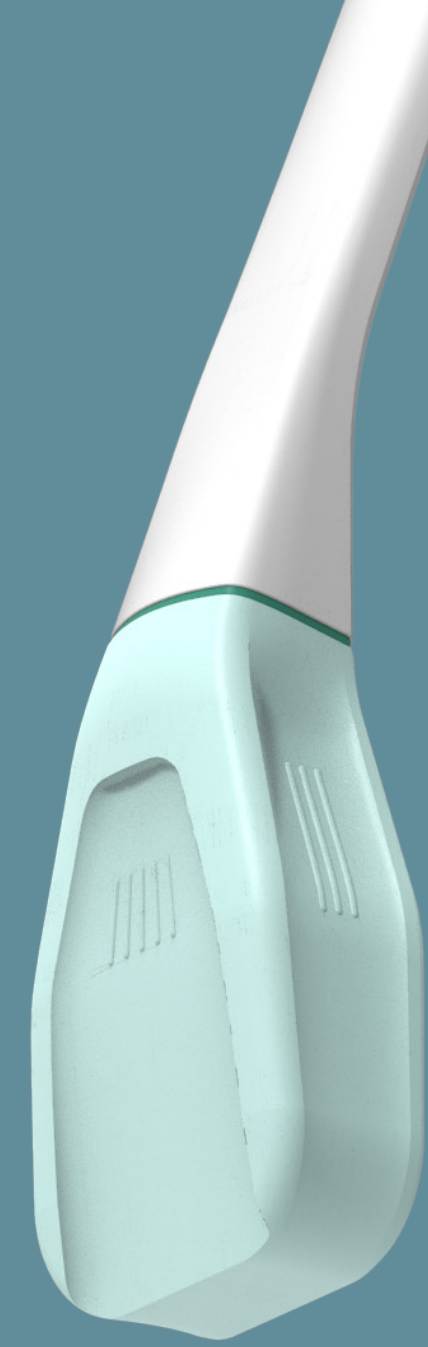


This structure can stop the zipper tab moving out while working



Unzipper Arm

Unzipper Arm is the auxiliary tool for Unzipper Tab. It is only used when the Tab is totally hidden by hoods. Unzipper Arm can achieve the function of searching and unzipping.



Warning line

The warning line is a visible line that stops users reaching their hand further, which enables the hand to keep a safe distance from high risk areas, to create a secure touch.

Small texture

Small texture is set for guiding users to follow the correct grabbing way. The texture has been simplified and minimized for creating a smoother surface for the disinfection needs.

Symmetry

The whole grab part is designed in a totally symmetric form, to create an user-friendly product which is available for both left-hand users and right-hand users.



Magnet unit

This unit is set for the searching function when cooperating with Uzipper Tab.

Ellipsoid hook

The hook is designed in ellipsoid form for smoother locking in with the ring of Tab. Also the round shape allows users to unzip in different angle, which creates a flexible unzipping motion.

The hook is separately produced and assembled with the main part in order to sustain more force when using. The modular design makes the product more durable and easier to repair.

Sharp edge with chamfer

The sharp edge is designed for easier reaching in and following the zipper flap, if there is an extra tape, the edge can also peel off the tape along the flap.

Triangle cross section

The triangle cross section secures a better rigidity of the Arm.





A Secure Touch

Using scenario 1

For the scenario that the Unzipping Tab is not hidden by any hoods.
Only **Unzipping Tab** is used in this scenario.



Using scenario 2

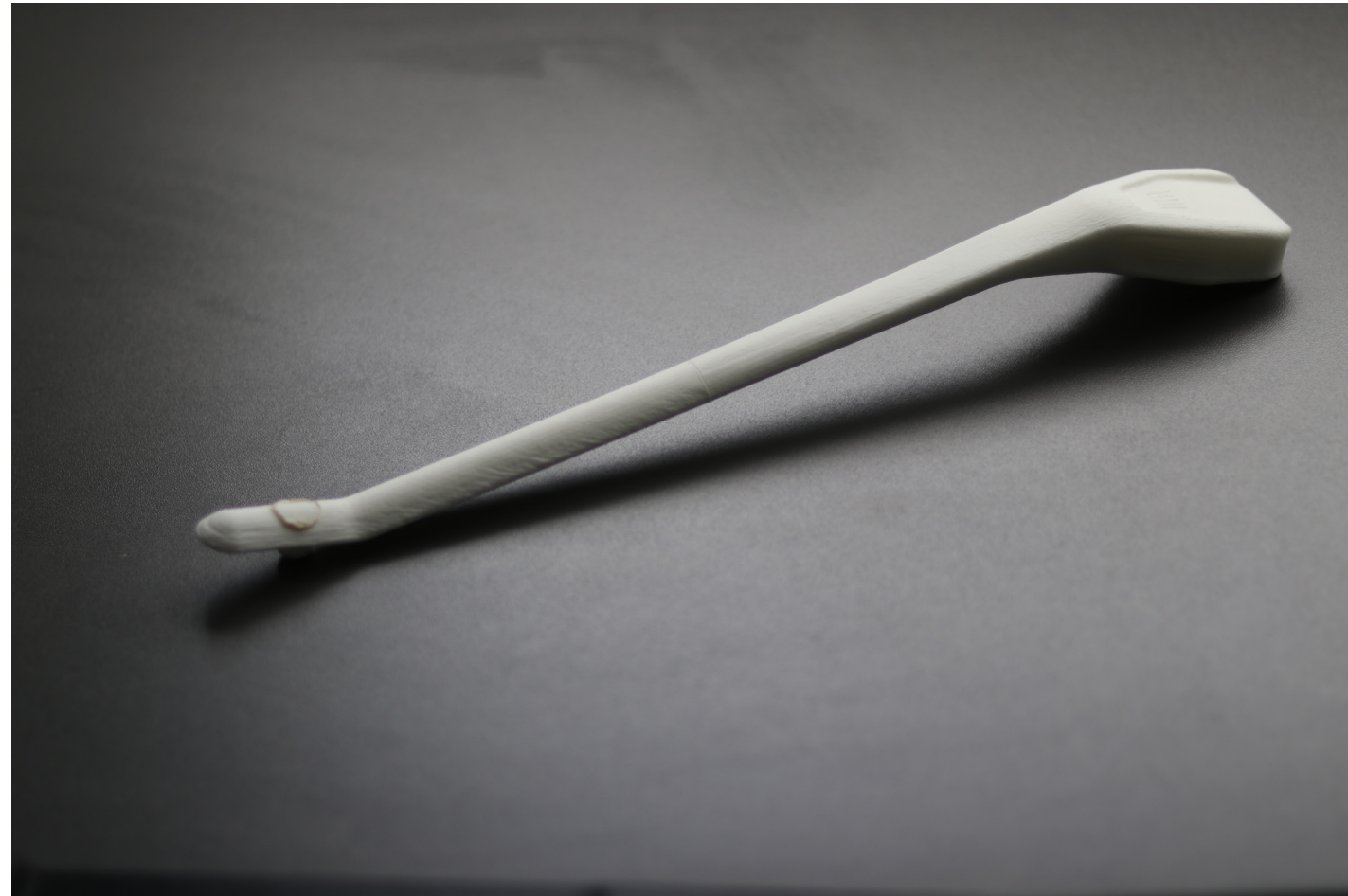
For the scenario that the Unzipping Tab is hidden by any hoods,
which need a cooperation with **Unzipping Tab** and **Unzipping Arm**.



Hand-Isolation System for PPE Doffing Process

Prototype

Unlucky, I haven't finish the final physical model of the product. I would only place some pictures of the components here, I will finish the rest of the prototype and display them in the coming presentation as well as the exhibition.



A Secure Touch

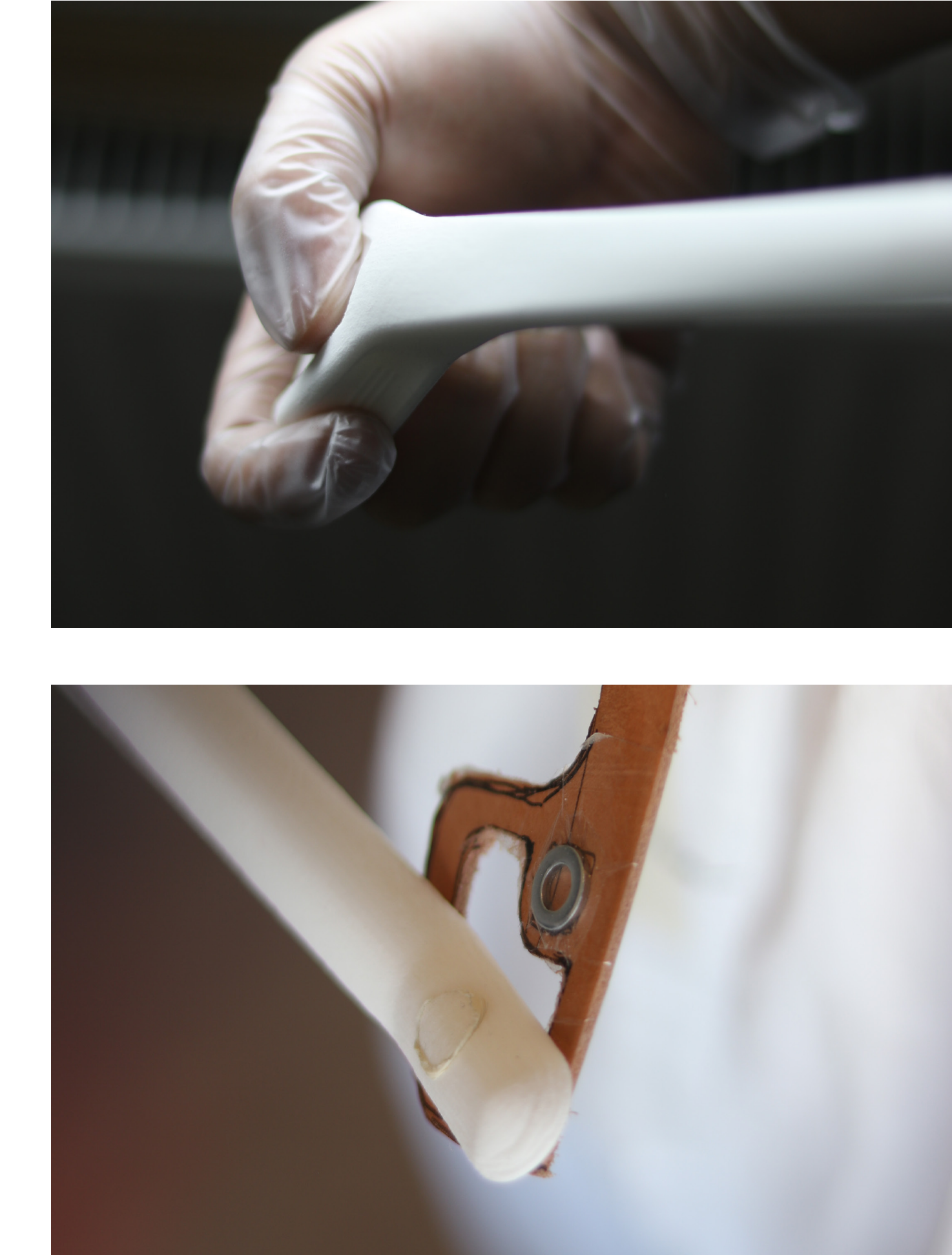


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Hand-Isolation System for PPE Doffing Process



A Secure Touch



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Hand-Isolation System for PPE Doffing Process

Material

I chose the material based on several principle which is targeting to medical equipment.

- Non-toxic, easy to sterilize, easy to store
- Lightweight and not easily to be broken
- Have good mechanical strength
- Durable

ABS (Acrylonitrile Butadiene Styrene copolymers)

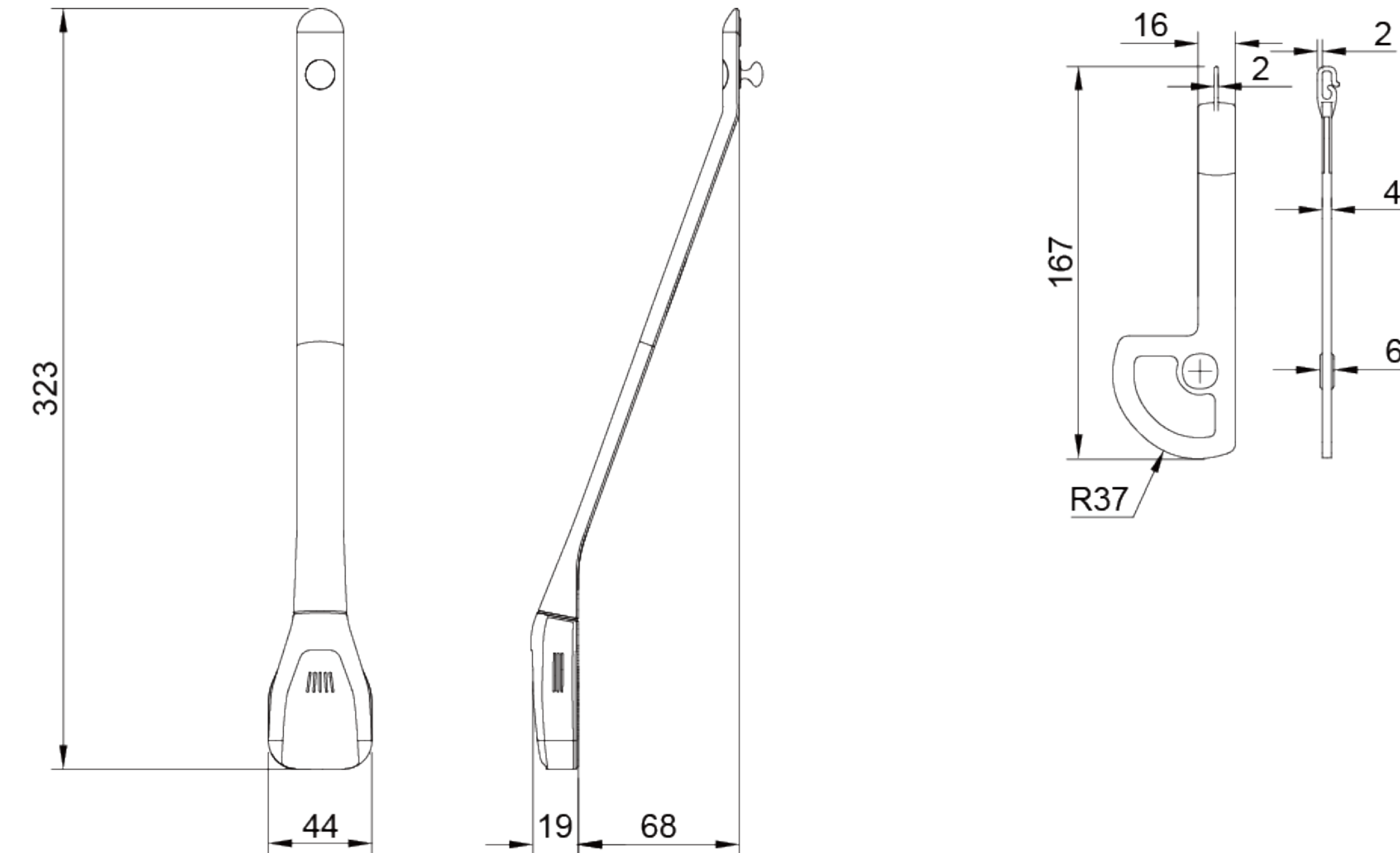
ABS has certain rigidity, hardness, impact resistance, chemical resistance, radiation resistance and resistance against ethylene oxide disinfection.

In medical field, ABS has been widely used in surgical tools, roller clips, plastic needles, tool boxes, diagnostic devices, shells of stethoscope or even some larger medical equipments

Silicone

I chose silicone as the material for the soft part of the tab. Silicone has good chemical stability, which means it hardly react with other substances. Also, silicone has good resistance to high temperature, so it is easy to sterilize. As a soft material, silicone has good tenacity and it is not easy to deformed.

Dimension





Rapid glove

Because of the limitation of deadline, I can not finish the concept of Rapid glove. But since this product is also part of the **Hand-Isolation system** as well as the **Secure Tool** finally, I would like to give some of my conclusion based on the exploration phase as part of the delivery.

Smoothness and cut line

In order to put on and take off the glove more smoothly, the cut line on the back of gloves should be as deep as possible. The more hand-back exposed, the smoother the putting-on-taking-off motion will be.

Flexibility

For better flexibility, the design should try to separate as more single finger as possible. Compromise can be taken for some possible function need such as glove tightening, positioning and fixing.

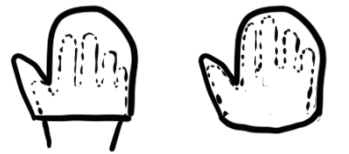
Material

Soft material like silicone should definitely be chosen, in addition, the material should be much stiffer than the ones of normal medical use gloves.

Challenges

After some testing work, I found several challenges of this concept that need to be solved later.

1/ How to tighten with simple motion?
After trying the mock-ups, I realized that it is quite challenging to tighten the glove without using another hand. Maybe some simple objects such as **shaped boxes** or **frames with hooks** could solve the challenge.



2/ How to make it closely attached with the hand?
During the testing work, I found that because of the open structure of the glove, the surface of glove can't closely attach with the hand and always flutters around. Maybe an extra fixing element such as a **fixing belt** should be added.



3/ How to take off without using another hand?
Another hand shouldn't be used for taking off the glove in order to avoid contamination. Thus, I need to figure out a smart inner structure to achieve a **single-hand-motion** to take off the glove.



Validation

In the end of the project, I had one online meeting with Kari Anne, a nurse who is recently working in a hospital in Oslo. I introduced my project and asked several questions that I always worried about.

Unfortunately, she said the hospital doesn't use coverall as PPE, instead they use gown, so I couldn't get a very relevant feedback of the Unzipper project. But she still showed appreciation of my work and said it can be a very good solution to minimize the risks of contamination. While she had more comments on Rapid glove.

Q1. Do you think the magnet from Uzipping Arm could bring in some electronic problems to the hospital?

"I don't think so, since we would only use the Arm in the changing room, and there will not be any electronic stuffs in that room, so it would not be a problem."

Q2. Would there be any problem in terms of disinfecting my products?

"We just throw them in a big container and wash them, then dry them and reuse them again like the goggles that we are using everyday, so it would not be a problem for the Unzipper product ."

"As for the Rapid gloves, since we always wash our own stuffs by ourselves, it could be too much stuffs to wash, haha."

Q3. Do you have some more comments?

"Maybe you don't have to split all the finger with the gloves for better putting on." (Rapid gloves)

"I can see the potential in your idea, they are valuable"

"Maybe you can put different thickness depending on different fingers."(Rapid gloves)

Disinfecting story

Kari also showed me the specific disinfecting procedure in her hospital. It is a story about yellow boxes.

Firstly, We have a clean yellow box with clean goggles on the outside where we get dressed.

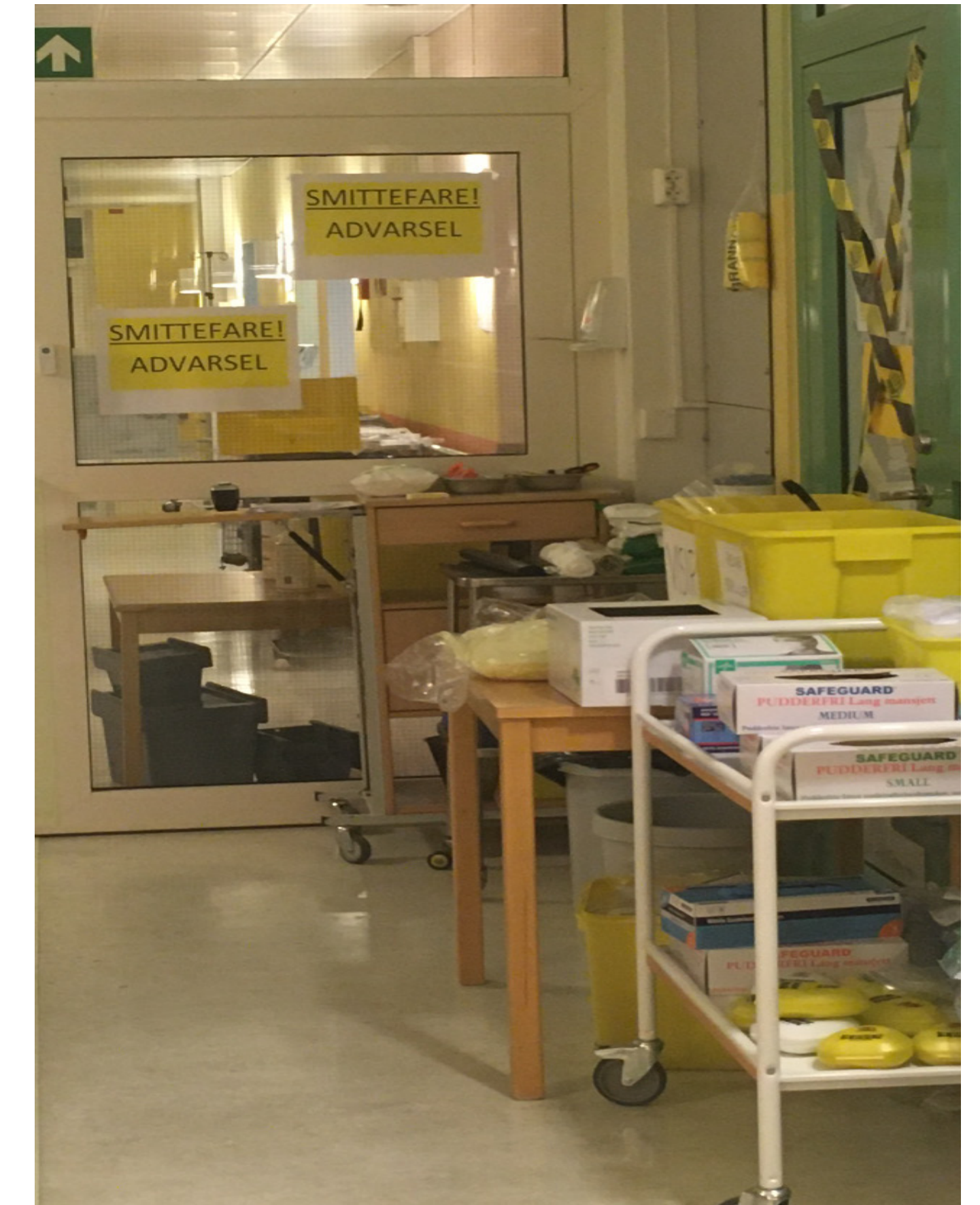
Then we have another set of boxes inside the patient area, we use the boxes there to store dirty/used goggles before leaving the patient area.

Before we moving the dirty goggles, we need to place them in a bag first, then we carry the bag to another room, where we have some other yellow boxes with special soap for washing the goggles.

After that, we dry them and put them back in the yellow box in dressing room.

That is the circle.

From the picture, I can see the yellow box is large enough to disinfect my products.



Impact

Value for healthcare workers

The Hand-Isolation system provides a much safer environment of PPE using. The system creates a distance between the healthcare worker and the used PPEs, enable healthcare workers to take off their PPE in a safer and more chilling way. By adapting the product system into the doffing process, the mistakes that always happens in traditional ways would disappear, and the risk of getting self-contamination would decrease to "o".

Value for trained observers

By offering a safer PPE-doffing environment, the engagement of trained observer in the process will get reduce. Thus, in a way, the product system also protect the group of trained observers.

Value for patients

Less infection happening in healthcare worker group brings a safer healthcare environment as well as a higher level of healthcare quality. In this circumstances, more patients will be taken cared properly and get a better treatment. Eventually, less people will die of pandemic.

Value for PPE suppliers

The product will also bring more cooperation as well as competition towards other PPE suppliers, which will push the PPE industry forward in a higher level, along with a better quality of new PPE products.

What did I prioritize?

From the beginning to the end, I keep telling myself, I am working on a project that could solve real problems. More than that, this is a project that is supposed to save people's life. With this attitude, I always put realism and rigorousness as my highest priority. In every phase of my project, I always tried to make the decision based on truths rather than my personal preference. Because of that, I can state with confidence: I am doing an honest project.

Since this project is place in a complex context, also, before starting this project, I knew so few about the field of pandemic, I always emphasized the importance of rich research, and tried to learn by researching. If a product emerges without a huge amount of research, it cannot become a reliable product. Designing a product that can solve real problems is always my goal, in order to let the new product have more real-life impact, I continued doing as much research as possible to enrich my knowledge, along with lots of analysis, to make sure I was in a correct trail.

Because of the outbreak of covid-19, I lost lots of opportunity of doing physical testing, most of design decision were based on academic knowledge and my own assumptions. I realized that, a project that has escaped from tests of the real world deserves more self-criticism. Therefore, I had been trying to criticize my project, to find the best solutions, I had been seeking for more details with ignored problems, trying to answer them, so that I can end up with a more solid and reliable concept.

What could be better?

Up to now I have only finished 1/4 of the whole project, which is far from my initial expects. Although this was a project with a background of huge medical system, I still think I could have achieved more.

I need to find the problem. I believe that I did spent too much time in the broadening research stage and I didn't scope down the project sooner, which caused I had too limited time left to have a deeper exploration in this interesting project. If I could do this project again, I would scope down the range of research earlier, so that I could concentrate more in the most important parts.

Outcomes

This is the first time for me to work on such a huge topic. Although there was a time I kind of got lost and struggled a lot during the project, I feel proud that I could finally overcome the difficulties and handle the project.

If someone ask me to describe an overall image of the project in one word, I would say, surprising. I am quite surprised about what was finally ended up with in the end of this huge project. The story is, I started the project because of an accident, and ended up with a totally unexpected product, indeed, i should feel suprised - Design is amazing !

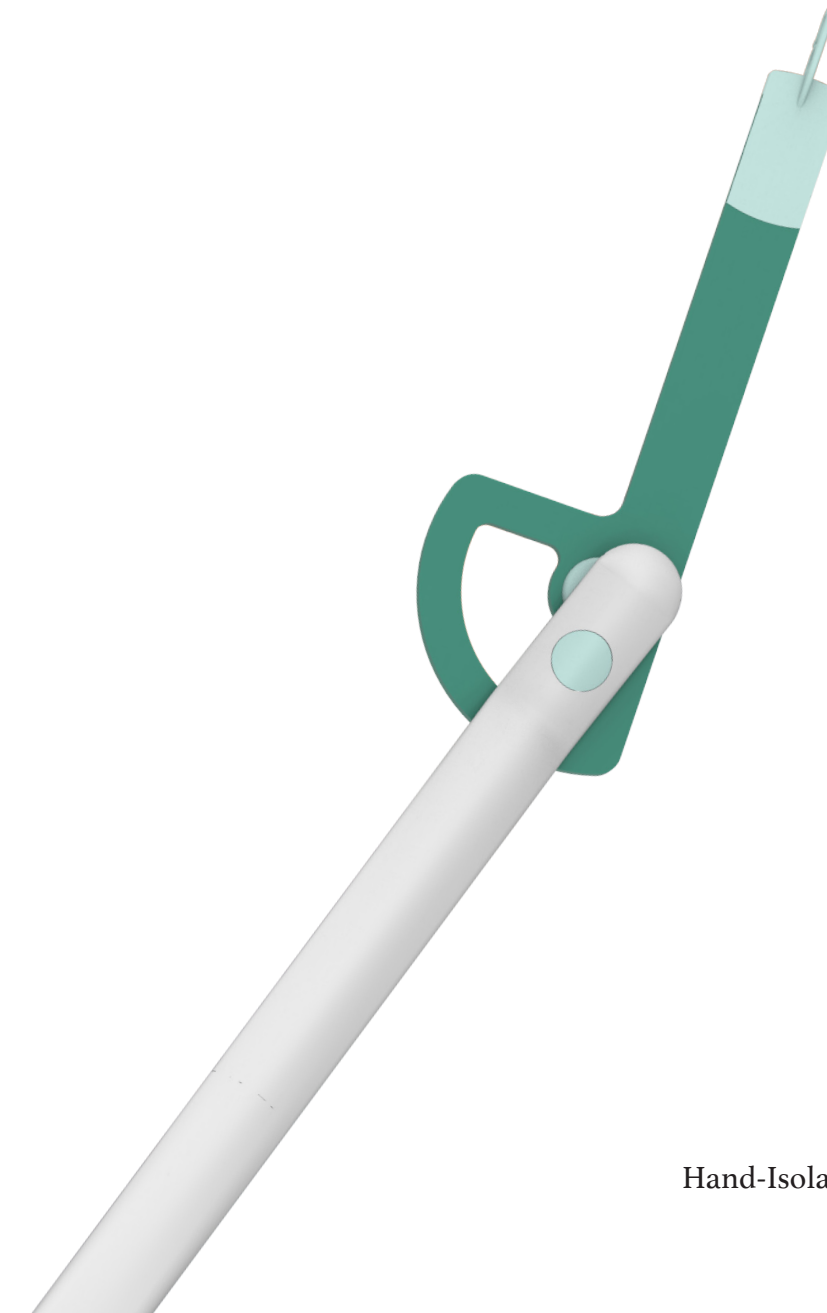
I have harvested a lot from this project. I have learnt the professional knowledge about pandemic, I have met many people to share the knowlege and create friendships, also, I gained more experience in design - How to make the hard desicion? How to analyze different materials? How to design by studying? In the meantime, too shy for asking, bad time management, too late to start making ... a lot of my own problems exposed and slapped me in face, tought me a leason and pushed me forward.

As for the project itself, I am quite happy to get this opportunity to look deep into this field, pandemic and healthcare works. I didn't invented a huge madical equipment, but I discovered a risk, or a series of problems, and tried to solve it by myself. However the project is too huge for me to complete in a limited time, I am still happy to see the achievement that I have done, while feeling sad to say goodbye for now.

What's next?

Pandemic will still be an enemy for humanbeing for a long time, there is still a long way to go to defeat this monster.

I have seen so many potential from my project, it still takes time for me to finish the whole Hand-Isolation system as well as Secure Tool product family. I would keep working on this project, have more talk with different professions and try to push it into a real life impact.



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