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OG AKERSHUS

Master thesis

Concept product design

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Mobile X-ray equipment design

Wang Ting

Oslo and Akershus University College of applied sciences

Abstract

This research project has a focus on the redesign of a user friendly mobile X- ray machine and a suspension for the connected detector. User friendliness is a trend of industrial design and is also a main goal of redesign. Based on user- centered design principles combined with other methods the author is trying to inquire that what the needs of end user might be, what the problems of existing product are, how to satisfy these needs and finally how to solve these problems. Through iterating design and test process the author sought the best result as well as a worthy process that can be applied in similar project.

The report is divided into six sections through raising question, analyzing and solving problems respectively. The main contents are following:

The first section: to introduce research question, goal, motivation and different methods applied in paper.

The second section: to give a brief relate of definition and principle of user centered design and present the definitions of end user, emotional design and user friendliness.

The third section: to apply different study methods for the project and problem summarization.

The fourth section: to search and analyze the need of end users and the problems of the existing product. The end user and designer together summarize the criterion of new product which makes the key words for design principle used in this process.

The fifth section: to introduce the process of product development including concept design, concept comparison, three-dimensional models, test model and final design.

The last section: to briefly relate reflection and conclusion which completes in are nine steps concerning the process of redesign.

Key words:

Redesign, user friendly, mobile X-ray machine, the suspension for detector

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1.0 Introduction

This chapter introduces the research question and the “What”, “Why” and “How” of this project including the goal, the motivation and the method.

1.1 Research question

In order to facilitate a better understanding, I list my research question at very beginning. My research question is [how to redesign user friendly mobile X-ray equipment?](#)

1.2 What, Why, How (3W about this project)

1.2.1 What

1.2.1.1 What is the problem?

This project comes from Akershus university hospital and it is also a cooperation product with Campus Kjeller AS and Oslo and Akershus University College of applied sciences. Currently mobile X-ray equipment belongs to Akershus university hospital and it normally is used approx 1200 nursing homes and 250 prison inmates. Every time radiographer should drive to nursing homes or prisons from hospital with mobile X-ray equipment and examine patients in their room. The image will bring back to the hospital for interpretation and feedback. In the process of using the equipment, the operator met some problems and inconveniences. They hope designer can help them solving these problems.

In hospital there have some very professional X-ray rooms and some mobile X-ray machines according to different patients the doctor can choose different place and different machine examining them. But outside hospital radiographer only takes mobile X-ray equipment visiting patients in their room. Therefore, they need some objects that are similar to machine in hospital. This project is a system product including different parts for example mobile X-ray machine, the suspension for detector, car, and holder etc. But my main work is to

develop a new mobile X-ray machine and a product to hang up the detector in patient's room.



Figure 01 the cooperator of mobile X-ray equipment project



Figure02 different X-ray equipments in Akershus university hospital

1.2.1.2 What is the goal?

The goal of research is to develop a user friendly mobile X- ray machine and a suspension for detector.

1.2.2 Why

There are two aspects of reason why I choose this topic as my master thesis.

1.2.2.1 Personal context

After graduation, I will go to work in school. As a teacher, the practical experience of product design is a kind of valuable because I think product design is different from other subject. The theoretic research also is quite necessary. But it is most important that theory should be combined with practice. The ultimate aim of any product is production and be used by people. How to design a user friendly product is a new trend of industrial design. Through this project, I wish I can obtain some knowledge and experience as common saying 'experience is the best teacher'.

1.2.2.2 Client context

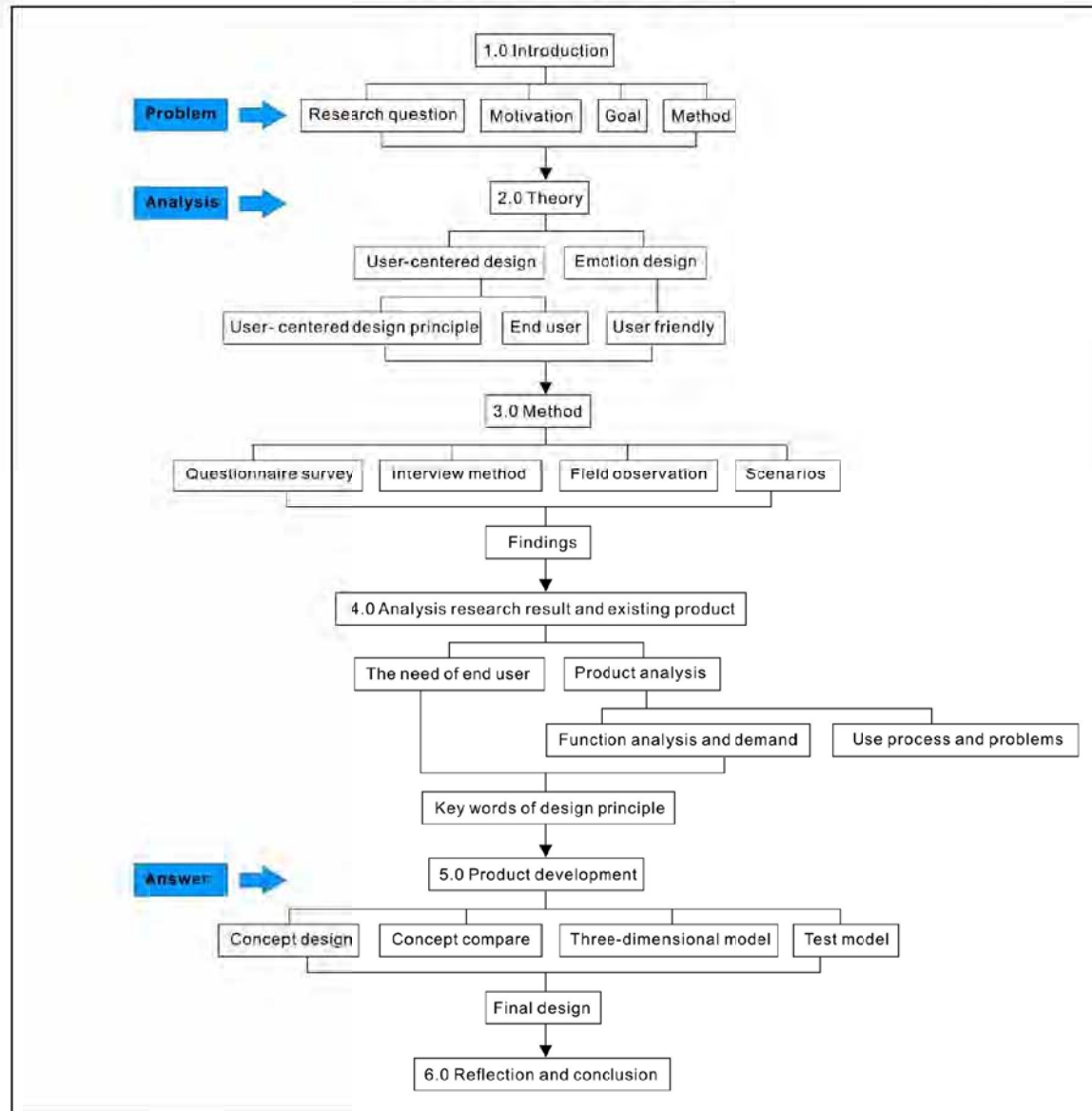
In my 12 weeks of practice period, I have already started to work with Campus Kjeller AS and Akershus university hospital. It was a very well cooperation and a smooth process of the whole project. The project coordinator of Campus Kjeller AS and the radiographer of Akershus university hospital gave me some useful information. I gave them some concepts and models in the meanwhile I got good feedback. Both of us hope to continue this cooperation and develop new mobile X-ray machine.

1.2.3 How

In order to achieve the goal of research and obtain good result, I will synthetically use four methods including questionnaire survey, interview method, field observation and scenarios. Because this project is the medical product and it is not familiar to me. Therefore, I think different methods will help me comprehensive understanding of design objects. Through these methods I should be familiar with user and production as soon as possible. Redesign is different from creating totally new product because we already have some important information that is radiographer's experience. I will research some aspects about product context, use process, needs of user and so on.

1.3 Framework

Table 01 framework of thesis



2.0 Theory

This chapter introduces the background theory of research including user-centered design and emotional design.

2.1 User-centered design

2.1.1 What is user- centered design?

The term 'user-centered design' originated in Donald Arthur Norman's research laboratory at the University of California San Diego in the 1980s and became widely used after the publication of a co-authored book entitled: *User-Center System Design: new perspective on Human-Computer Interaction*.

In broad terms, user-centered design(UCD) is a design philosophy and a process in which the needs, wants, and limitations of end users of a product are given extensive attention at each stage of the design process. The chief difference from other product design philosophies is that user-centered design tries to optimize the product around how users can, want, or need to use the product, rather than forcing the users to change their behavior to accommodate the product. (http://en.wikipedia.org/wiki/User-centered_design)

2.1.2 User- centered design principle

There are four important UCD principles: (http://www.usabilitynet.org/management/b_overview.htm)

1. A clear understanding of user and task requirements
2. Incorporating user feedback to refine requirements and design
3. Active involvement of user to evaluate designs
4. Integrating user-centered design with other development activities

According to UCD principles, the first step of following research is focus on the end user and understanding what is the end user need? The second step is analysis and summary user need. The third step is end user should take part in the process of design and give some ideas and suggestions for designer. Last step is best way is synthetically use user-centered design and other method.

2.1.3 Definition of End user

End user is the person who uses a product. The end user may differ from the person who purchases the product. For instance, an end user of a computer system is someone who operates the computer, as opposed to the developer of the system who creates new functions for end users. (http://en.wikipedia.org/wiki/End_user)

So, for this project, Akershus university hospital is the purchaser, they are not the really end user. Radiographer and patients is the really primary end user. Maintenance man of hospital is the secondary end user. This project will mainly study the primary end user.

2.2 Emotional design

2.2.1 What is emotional design?

Emotional Design is one of the masterpieces written by Donald Arthur Norman and is also one of the key directions in the research of modern product design. Modern science knows that the human being is the most emotional of all the animal kingdom. Moreover, emotions play a critical role in the human ability to understand the world, and how they learn new things.

Emotions aid in decision making. Positive emotions are as important as negative ones. Positive emotions are critical to learning, curiosity and creative thought. When people are relaxed and happy, their thought processes expand, becoming more creative, more imaginative. In contrast, when people are anxious they tend to narrow their thought processes. Attractive things always make people feel good, which in turn makes them think more creatively. For example aesthetically pleasing products appear to the user to be more effective, by virtue of their sensual appeal. This is due to the affinity the user feels for a product that appeals to it, due to the formation of an emotional connection with the product.

2.2.2 What is user friendly?

In short, user friendly is object enables positive emotions for all kinds of people. It means a machine or system easy to use or understand in the New Oxford Dictionary of English. It is a design philosophy widely applied in different area such as machine, tool, website, software application, process and so on.

For this project, the result of research should be giving the end user positive emotions. In other words, new mobile X-ray machine and the suspension for detector design should be easy to use or understand. That is user friendly product design.

3.0 Method

This chapter introduces four methods of this research that are questionnaire survey, interview method, field observation and scenarios.

3.1 Questionnaire survey

The questionnaire was invented by Sir Francis Galton. It is also a research instrument consisting of a series of questions and other prompts for the purpose of gathering information from respondents. Questionnaires have advantages over some other types of surveys in that they are cheap, do not require as much effort from the questioner as verbal or telephone surveys, and often have standardized answers that make it simple to compile data. (<http://en.wikipedia.org/wiki/Questionnaire>)

In order to comprehensive understand mobile X-ray machine, I designed two types of questionnaires for radiographer and patients, as shown below. Because it is the start of user communication some questions maybe are not sufficiently accurate in two questionnaires. But I will also use other methods to communicate with users and obtain more overall information. For the suspension for detector, I only use interview method and field observation to research.

Table 02 questionnaire of radiographer

Questionnaire of radiographer

Hello, this is questionnaire for operator of mobile X-ray machine.
Please fill in it and thank you very much!!!

Name: _____ Today's date: _____

Sex: Female Male

Telephone: _____ E-mail: _____

1、 How long have you been operating the machine?
 1 year 2 years 3 year 4years 4years more than 10 years

2、 In one week how often do you work with mobile X-ray machine?
 two times three times four times five times more than five times

3、 How much time do you spend on one visit?
 1 hour 2 hours 3 hours 4 hours 4 hours more than five hours

4、 How much time do you spend on take photo for one patient?

5、 Please could you tell me during operation what is your main problems ?

6、 Please could you tell me what is you want to change during working ?

Tusen takk!!!

Table 03 questionnaire of patients

Questionnaire of patients

Hello, this is questionnaire for patients of mobile X-ray machine.
Please fill in it and thank you very much!!!

Name: _____ Today's date: _____

Sex: Female Male

1、 Before have you been taking X-ray photo?
 Yes, I have. No, I haven't.

2、 Do you think the photo time is ok?
 I don't know. It is ok. I hope accurate photo. I hope just one minute.
 I think it is little longer because I should keep one posture.

3、 When you taking X-ray photo, how do you feel?
 I don't know. I'm ok. Just a little nervous. I'm so nervous. I'm afraid.

4、 What do think about the form of machine (mobile X-ray)?
 It is just a machine. It looks like an animal. It is strange. It is really ugly.
 It looks like robot. It is interesting.

5、 Do you like the color of machine (mobile X-ray)?
 I don't know. I like. I don't like. Just so-so.

6、 If we can change this machine, do you have some suggestion ?
Please write down!

Tusen takk!!!

3.2 Interview method

Interview method is a conversation between the interviewer and the interviewee where questions are asked by the interviewer to obtain information from the interviewee. (<http://en.wikipedia.org/wiki/Interview>) What follows is an interview with the radiographer about the mobile X-ray machine and the suspension for detector.

Table 04 interview of record

Q: According your answer of questionnaire, I know you have been operated mobile X-ray one year in Akshus.

A: Sure, before I am a radiographer in my hometown hospital.

Q: Only you go to outside check patient every time?

A: yes, because the space of car is limited.

Q: Like you said, in the car the machine need a safe and stable space, could you tell me now how to deal with this problem?

A: We solve this problem through two objects. One is fixation device in underbody another is belt on the side. It is not so good. You know, all parts should be stable on bumpy roads.

Q: Do you think it is easy to control that machine move in and out of the car?

A: It is not easy for me. When you follow me research I can show you.

Q: Could you tell me how many important parts in this mobile X-ray machine because I want to focus it.

A: It includes generator, computer, stand, arm, handles and wheels. Oh, I forgot the detector. Of course, detector is an independent product. But it is a very important part of mobile X-ray. Without detector we can not obtain photo.

Q: Do you think now what the problem of detector is?

A: I think if we can use wireless detector it better than existing product.

Q: Do you think what the problem of generator is?

A: In some case I can't see the control panel, because it is in front of generator.

Q: So the control panel should move to a good place.

A: I think so.

Q: Could you tell me the computer is a PC (personal computer)?

A: Yes, it is a PC. But we need a lightweight and smart computer. Sometime I can't click the button maybe my finger is so big.

Q: Ok, I know. Maybe we need a smart computer like iPad. It has Wi-Fi, long standby time, enough screen and clear button.

A: I like that.

Q: I know you hope the machine have a flexibility stand and arm. Is it very important?

A: For us, It is very important. If we have a flexibility stand and arm it is easy to operate and take photo for patients in different case. Now the stand can up and down but it can't rotate. The arm can adjust the length.

Q: How about handle?

A: I think it is good we can adjust the height if we need.

Q: Do you want to change the wheel?

A: Yes, I think if we have suitable wheels it is easy to move the whole machine especially in winter. There is a lot of snow in Norway.

Q: Please could you introduce the suspension for detector.

A: In some case, we have used the suspension for detector. It is only help us hold the detector, and then the patient can stand in front of detector to test. You know the space of patient room is not enough. So we just put it on the top of door and use doorstop holding the door. According to operation criteria, it is not easy that is the generator should be at a 90 degree angle with the detector.

Q: What are you expectations of new product?

A: I hope the new project should be security and stable suspension detector. It should be easily remove and adjust height. It should be fold up and pack into a pocket.

Q: Thank you so much and I expect I can follow you go to nursing home research as soon as possible.

A: My pleasure. I hope see you again.

3.3 Field observation

Field observation is a kind of method being used frequently on the domain of modern design. Designer goes to representative user's workplace and observes them work, to understand how the users are using the production to accomplish their tasks. This method can be used in the test and deployment stages of the development of the product. Through field observation, I have a deep understanding of mobile X-ray machine and the suspension of detector and have found some problems of existing product.



Figure 03 pictures about the suspension for detector

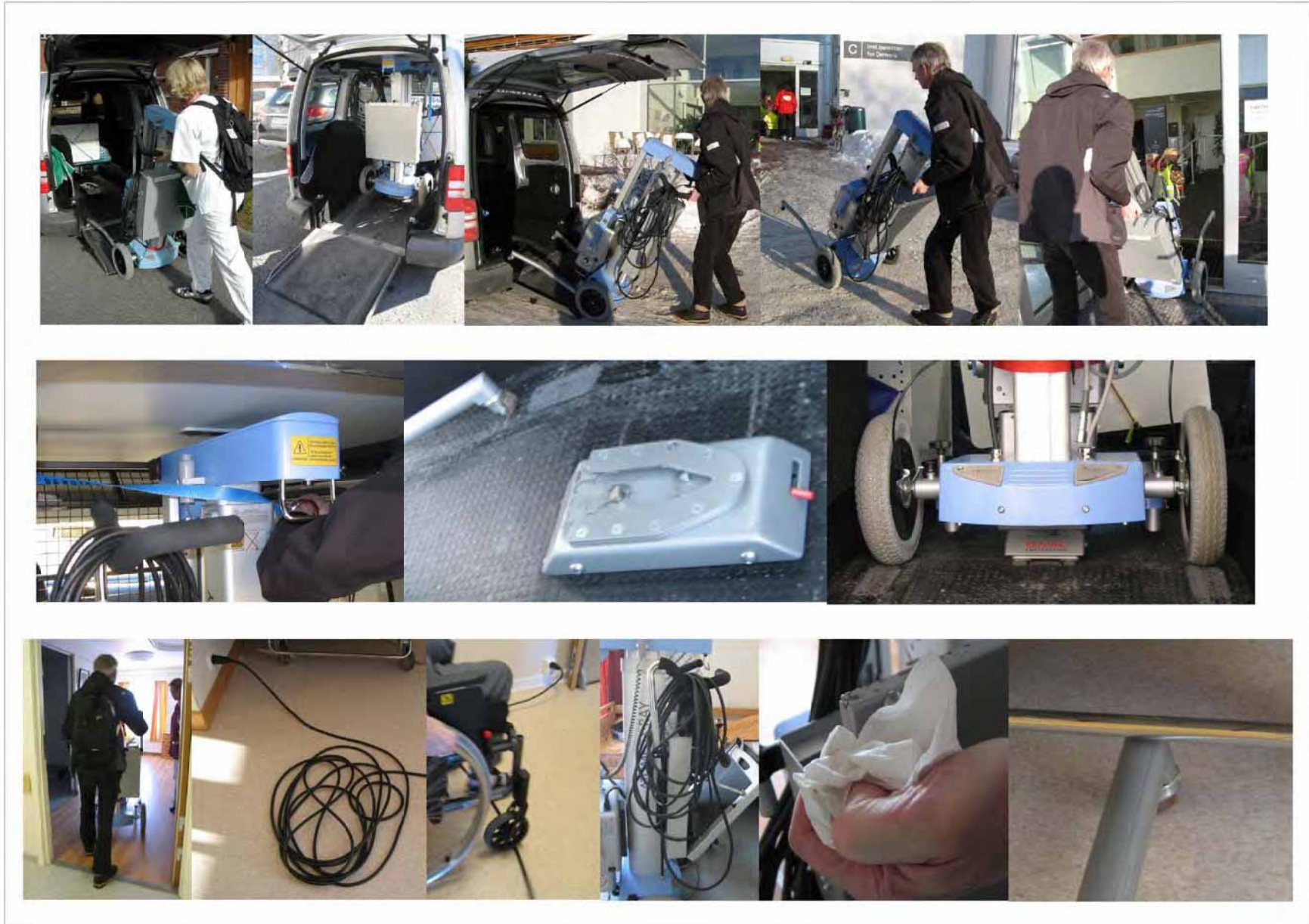


Figure 04 pictures about mobile X-ray machine

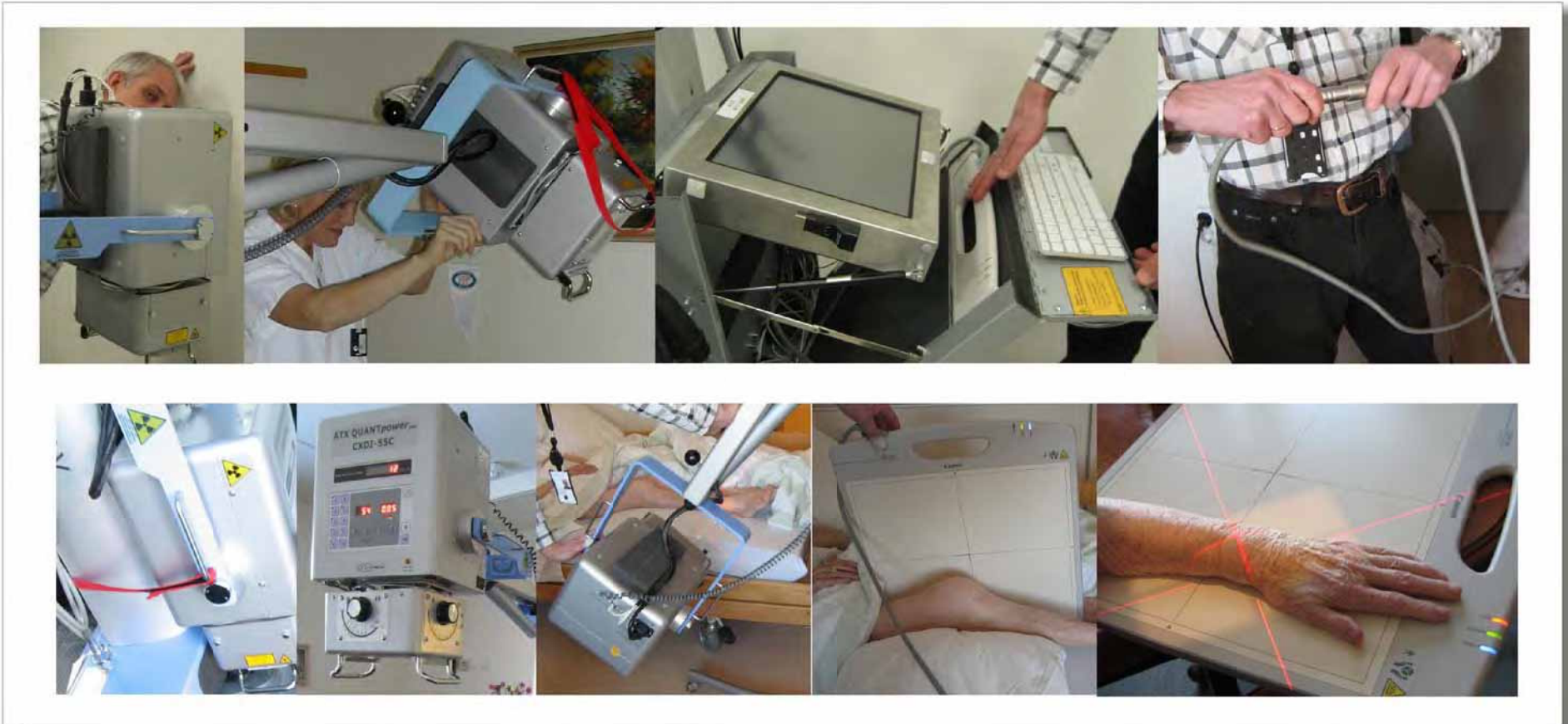


Figure 05 pictures about mobile X-ray machine

3.4 Scenarios



Figure 06 scenarios of patient

Scenarios help me awareness of different states of patient. I found when patient took photo with radiographer they always feel nervous and embarrassed. In following research, I should think about how to help them eliminating tense feeling.

3.5 Findings



Figure 07 problems about the suspension for detector

I have a relatively deeper understanding of my project and also discovered some problems at the same time through four methods of this research.

As figure 07 shows, there are some problems about the suspension for detector. First problem is if the door can't close, it is hard to find vertical for the radiographer. Second problem is the metal support is very difficult to get through handle. Third problem is if the suspension for detector need to keep balance, two metal hooks should be consistent with metal support and detector on the top of door. Fourthly if the operator wants to adjust height she or he had to push the two yellow plastic buttons at least twice. Last problem is the door has to be fixation using doorstop.



Figure 08 problems about mobile X-ray machine



Figure 09 problems about mobile X-ray machine

The mobile X-ray machine is used in three different contexts these are in the car, outside and in patient's room.

As figure 08 shows, in the car there are three problems about mobile X-ray machine. First problem is the radiographer use a belt to keep the machine in place for the security and stability. Second problem is for safety the operator also using a belt holding generator. The third problem is the radiographer can't see the fixation device in underbody when he moves the machine in and out of the car.

As figure 09 shows, outside there are two problems. First problem is it is difficult to move. Second problem is that wheels will take some dirt in the patient's room.



Figure 10 problems about mobile X-ray machine

In patient's room there are some problems as figure 10 shows. First problem is sometimes the lack of detail might hurt finger of radiographer. Second problem is unordered cables. Third problem is the operator need a place to put the form of patient information. Fourthly, the position and angle of computer isn't good enough to operate. Fifth, stand and arm are not very flexible, the stand can up and down but it can't rotate. Sixth, sometimes wire of the detector might affect the work. Last problem is sometimes front wheels and bottom holder might affect the work.

4.0 Analysis research result and existing product

This chapter summarizes the research result and analyzes the existing product.

4.1 Who is end user?

According to the definition of end user, the obvious answer is **radiographer and patients are the primary end user of mobile X-ray machine and suspension of detector**. Although Akershus university hospital is the purchaser, they are not the really end user. The radiographer is the really end user and they often operate machine taking photo for patients. The patients are also the really end user because they were photographed by machine. In addition, maintenance man of hospital is the secondary end user. This project mainly studies the primary end user.

4.2 What is the need of end user?

The result of research should be giving positive emotion for the radiographer and patients which is the aim of user friendly product design. In other words, new mobile X-ray machine and suspension of detector design should be easy to use or understand.

X-ray radiation is potentially harmful to our health. Without a doubt, **“security needs”** is the most fundamental needs of radiographer and patients. It is also the basic design principle of medical product. On the premise of security, the radiographer can operate machine taking photo for patients and patients can be photographed by machine.

Through investigation, I found that all the radiographers are rational because they have accumulated over one year of work experience.

They hope the new product will be **easy to use and convenient to operator in their whole working course** including different contexts. In the car, they hope the new machine will be ensured secure and stable. In this context, driver is their main task, rather than divert attention from shaking machine. Arrive at the destination, they hope the new machine will be easy to control and move from car to

patient's room whatever the weather. In the patient's room, they hope the new machine will be easy to operate X-ray photograph of a patient in different situation due to patient' room is a limited space.

For patients, they don't much care for the mobile X-ray machine and the suspension for detector as I would like to imagine. They focus mainly on the image quality. They hope they can [get an accurate X-ray picture that can help doctor analysis the situation of them](#). Some patients also hope [they have a relaxing state when they are taking photo](#).

4.3 Product analysis

4.3.1 Mobile X-ray machine

4.3.1.1 Function analysis and demand

Existing mobile X-ray machine includes four main parts including computer, detector, X-ray generator and mobile stand. When radiographer wants to take photo for patient, she or he has to use in conjunction with that four parts. Detector and X-ray generator are controlled by computer. X-ray generator emits X-ray and through X-ray we will get X-ray photographs (please refer to the figure 11). Mobile stand holds and adjusts height and angle of X-ray generator. Mobile stand also moves the whole machine and protects computer, detector and X-ray generator.

Through research, we know the main function of this mobile X-ray machine is “take X-ray photograph for patient outside hospital”. Because patient lives outside hospital, the radiographer should drive to nursing homes or prisons from hospital with mobile X-ray machine. So we think the new product should suit different contexts including in the car, out and in patient's room. The new product should have the following characteristics: it should be security and stability in the car; it should be fold easily moving outside and inside; it should be adjust height and angle easily to take photo for patient in patient's room. In other words that is the main function of new object.

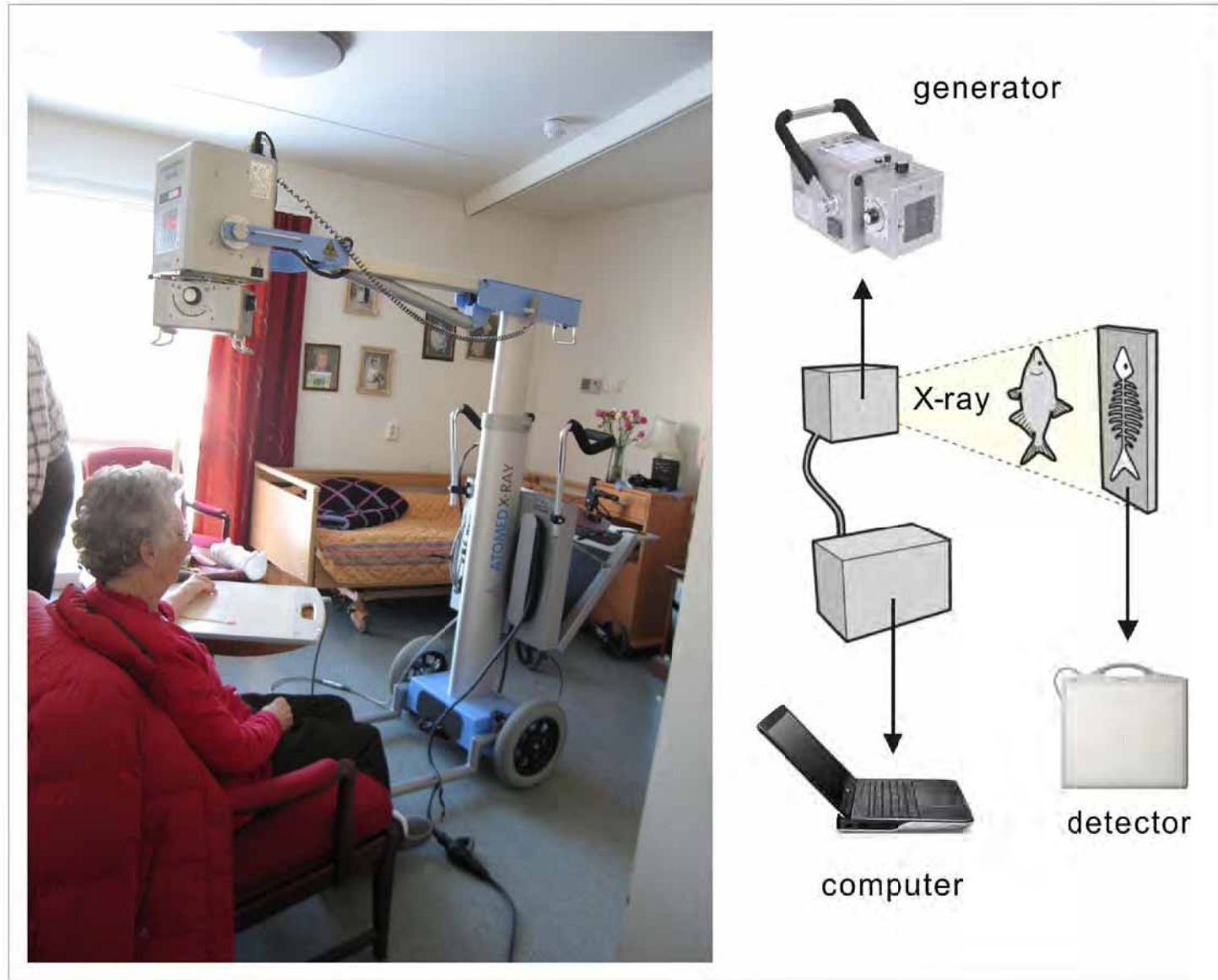


Figure 11 function analysis of mobile X-ray machine



Figure 12 use process of mobile X-ray machine

4.3.1.2 Use process and problems

The use process of mobile X-ray machine includes the following steps: (1) push machine into car and fix it using belt ; (2) drive car to nursing home or prison; (3) take out machine from car and push it into patient room; (4) switch on the power; (5) turn on computer and input patient's information; (6) take out detector and connect; (7) place detector to check position; (8) adjust position of generator; (9) take photo; (10) edit photo; (11) save photo using U disk. (Please refer to the figure12).

We think the whole existing product have some problems in the process of operation. To make it clear, I have designed a table of functions and problems analysis of mobile X-ray machine (please refer to the table 05). As shown in the table, if the detector is wireless, it is easy to use for end user (radiographer and patients). When not in use, the detector needs a safety space. The user needs a computer of friendly interface such as big screen, clear button. If the computer has Wi-Fi and battery, it is a convenient way for user. In some case, the radiographer can't see the control panel in front of generator. So the user needs remote control panel. Mobile stand is a very important part of whole machine. If the mobile stand has a flexible holder and arm, it is easy to operate taking photo. The radiographer also hopes the mobile stand is easy to move and clean.

Table 05 functions and problems analysis of mobile X-ray machine

Name		Function	Problems
1	detector	take photo for patient	1) wireless 2) need safety space
2	computer	control detector and X-ray generator	1) need battery 2) need friendly interface (big screen, clear button) 3) need Wi-Fi
3	X-ray generator	emit X-ray take photo for patient	1) need remote control panel
4	mobile stand	1) hold X-ray generator 2) adjust height and angle of X-ray generator 3) move the whole machine 4) protect computer, detector and X-ray generator	1) need flexible holder and arm 2) easy to move (suitable front wheels and big back wheels) 3) easy to clean

4.3.2 The suspension for detector

4.3.2.1 Function analysis and demand

Existing product consists of two parts. One is the object of suspension detector another is doorstop. When radiographer wants to hang up the detector she or he has to use in conjunction with that two objects. The object of suspension detector has three parts. Two metal hooks are often put on the top of door for suspension detector. Metal support holds detector and two plastic objects so as to adjust height.

Through research, we know the main function of this product is “hanging detector in patient’s room”. Because the space of patient room is not big the user wants to put it on the door or wall. We think the new product should have the following characteristics: it should be security and stability suspension; it should be easily remove and adjust height; it should be fold up and pack into a pocket. In other words that is the main function of new object.

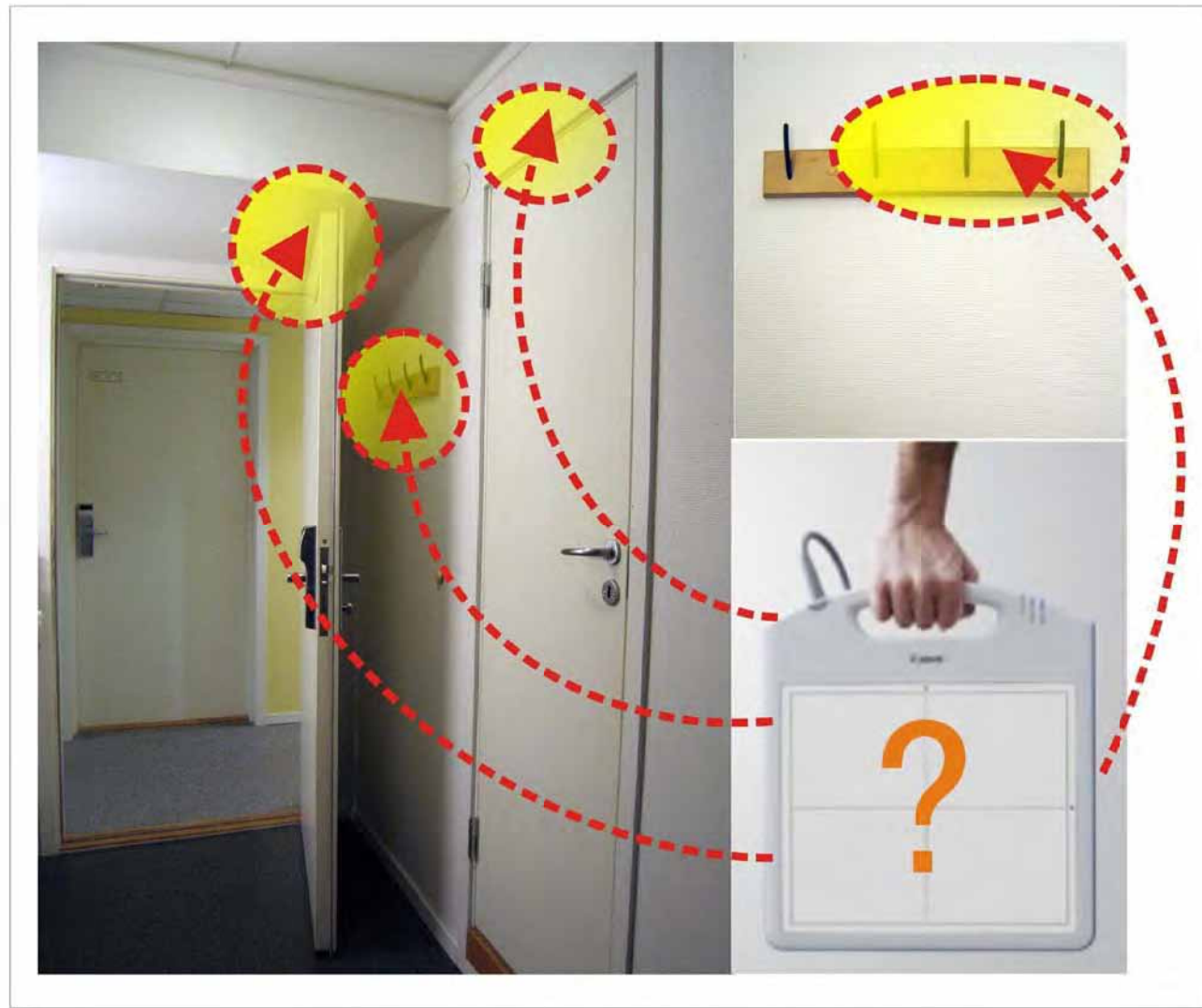


Figure 13 function analysis of the suspension for detector



Figure14 the existing product and use process

4.3.2.2 Use process and problems

The use process of the suspension for detector includes the following steps: (1) put two metal hooks on the top of door; (2) metal support pass through the hole of detector and hold the detector; (3) adjust height using two plastic objects; (4) keep balance of detector; (5) hold the door using doorstop. (Please refer to the figure14).

I think the whole existing product design lacks unity. There are some problems in the process of operation. First is radiographer has difficulty finding the best way to take photo for patient because the door can't close and they need vertical to x-ray machine. Second is metal support is very difficult through handle to hold detector just using two hands. We clear see the radiographer had to use her leg helping herself according to figure 14. Third is if the operator wants to adjust height she had to push that two yellow plastic buttons at least twice. In this process the detector can't keep balance. But I have to admit that the existing product has an advantage that is it can fold up and pack into a pocket.

4.4 Key words of design principle

According to the above analysis, end user and I summarize [three key words of design principle of new product that is "Security", "Stability" and "Flexibility"](#).

The new mobile X-ray should be secure and stable in the car; it should be secure and flexible moving outside; it should be secure, stable and flexible taking X-ray photograph for patient in patient's room.

The new suspension for detector should be secure and stable hanging the detector on the door or wall; it should be secure and flexible adjusting the position of detector.

5.0 Product development

This chapter introduces the process of product development including concept design, concept comparison, test model and final design.

5.1 X-ray machine design

5.1.1 Concept design

5.1.1.1 Concept one

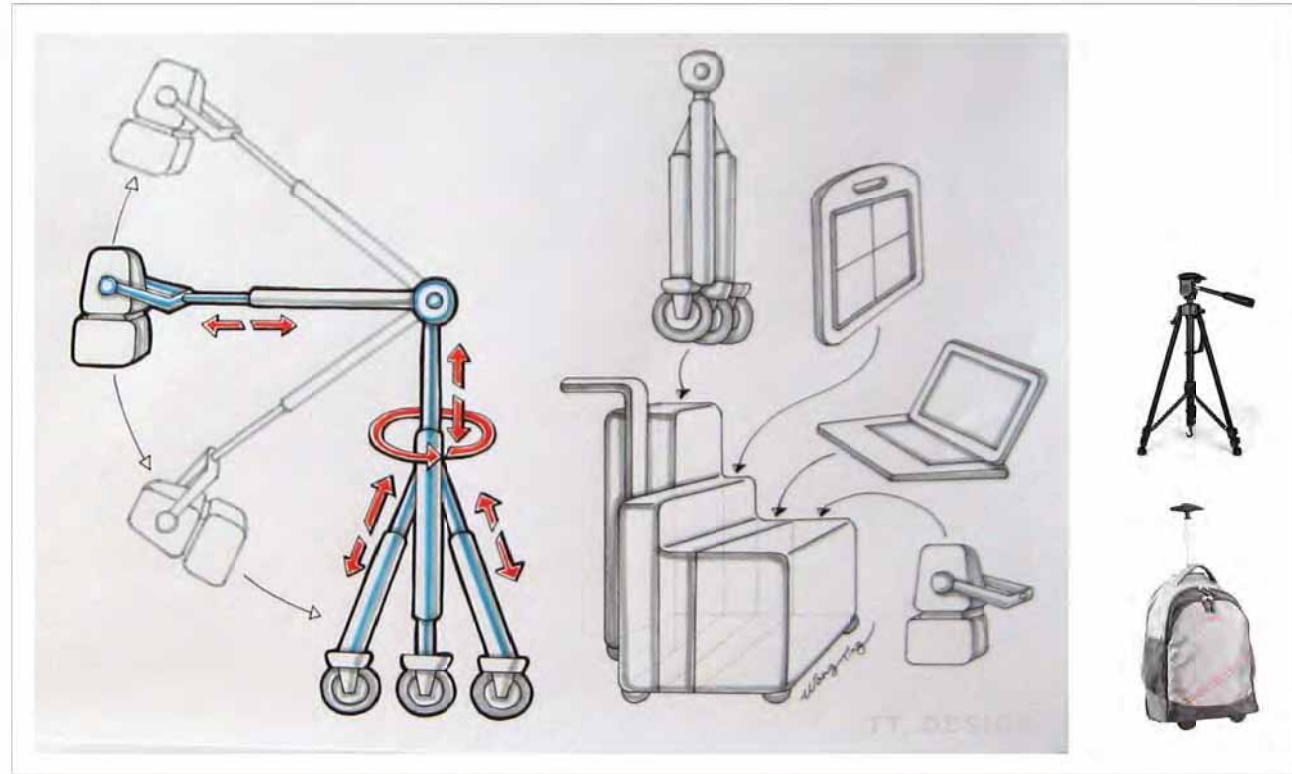


Figure 15 sketching of concept one

According to existing product analysis and key words of design principle, I want to design new product from main function and user needs. The new mobile X-ray should be security and stability in the car; it should be security and flexibility moving outside; it should be security, stability and flexibility taking X-ray photograph for patient in patient's room.

Concept one inspired by tripod and luggage. As figure15 shows, concept one has two different statuses. When using, the radiographer takes out all components from the luggage including tripod, detector, computer and X-ray generator. Then he or she puts X-ray generator and tripod together and takes photo for patients. When not in use, the operator can put tripod, detector, computer and X-ray generator in the luggage. It is very easy to operate.

Tripod is a kind of very familiar product. It has many advantages such as easy to fold and open, easy to adjust height, light weight, relatively stable and easy to clean. Luggage is also a familiar object. It has some good points such as easy to move, easy to place in the car, protection components and easy to clean. Base on these advantages, concept one will be able to realize the main function and design requirement.

Disadvantage of concept one is radiographer has to cost some time assembly or disassembly X-ray generator when using or after use. Although the operation is not too difficult, that is both an advantage and a disadvantage of concept one.

5.1.1.2 Concept two



Figure 16 sketching of concept two

As figure 16 shows, this idea comes from the drawer type luggage. Concept two is the greatest feature that all components integrate together like a unit. Another striking feature of the machine is its tilting user interface of computer. Because according to human engineering principle, if the user interface has reasonable angle, it is more convenient for the standing operator.

Concept two is also a very flexible object like drawer. In different conditions, it can be quite easy to open or close transforming different shapes. In the car, it can be folded and placed in the back. Outside, the radiographer can push or pull this machine easily moving. In patient's room, it can be open its stand and arm and adjust height and angle taking X-ray photograph for patient.

5.1.1.3 Concept three

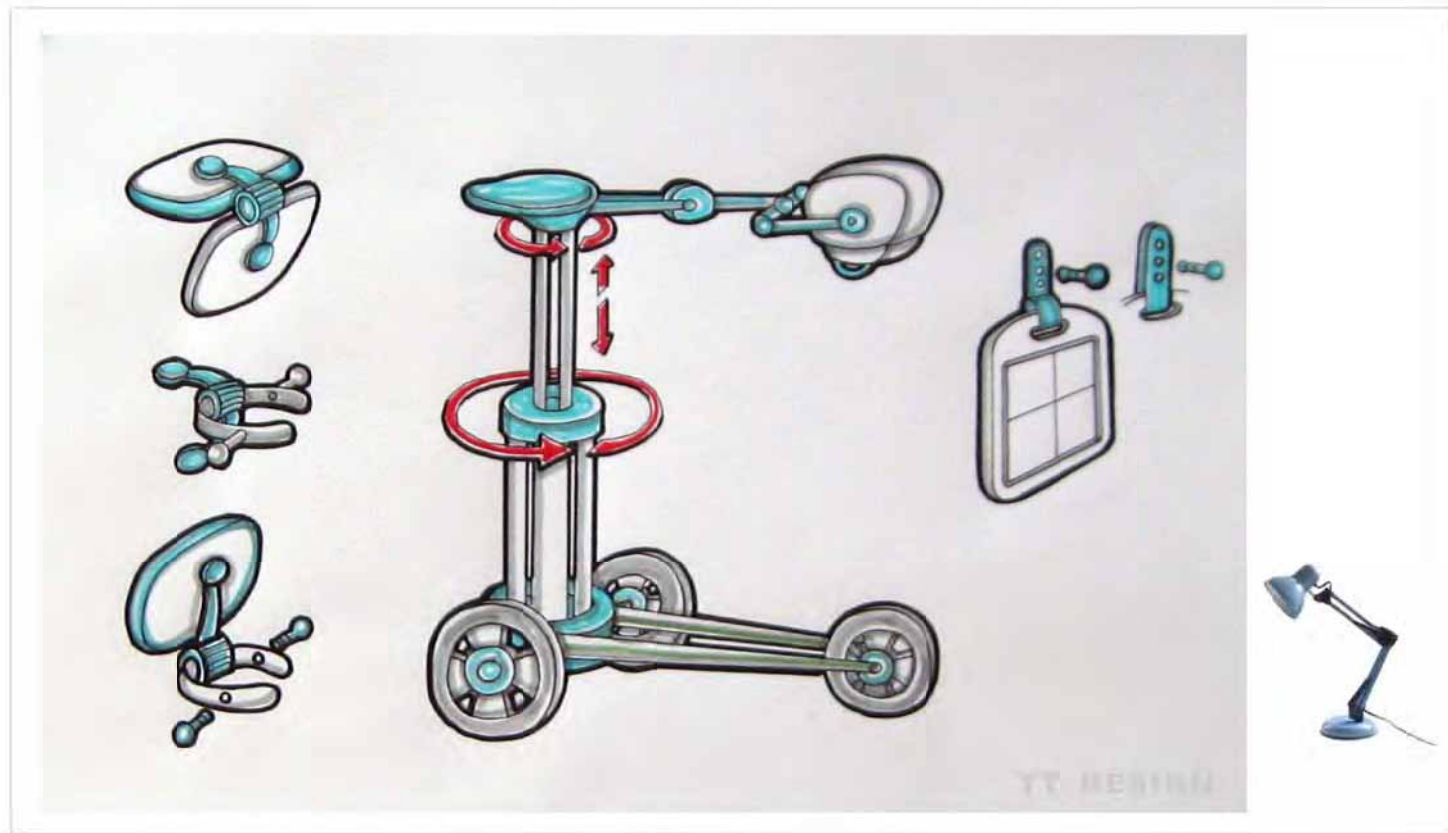


Figure 17 sketching of concept three

Concept three inspired by folding lamp which is a common household object. Like folding lamp, the biggest advantage of concept three is light and flexible. The design of three big wheels can realize flexible moving function. The stand design of frame style lost a lot of weight. The stand of machine not only can adjust height, but also can rotate freely. In a certain range, it can ensure the X-ray generator can take photo at any height and direction. It can bring a lot of convenience for the radiographer. Through auxiliary equipment the detector and computer were hung on the stand but the security and stability of this way should be improved.

5.1.1.4 Concept four

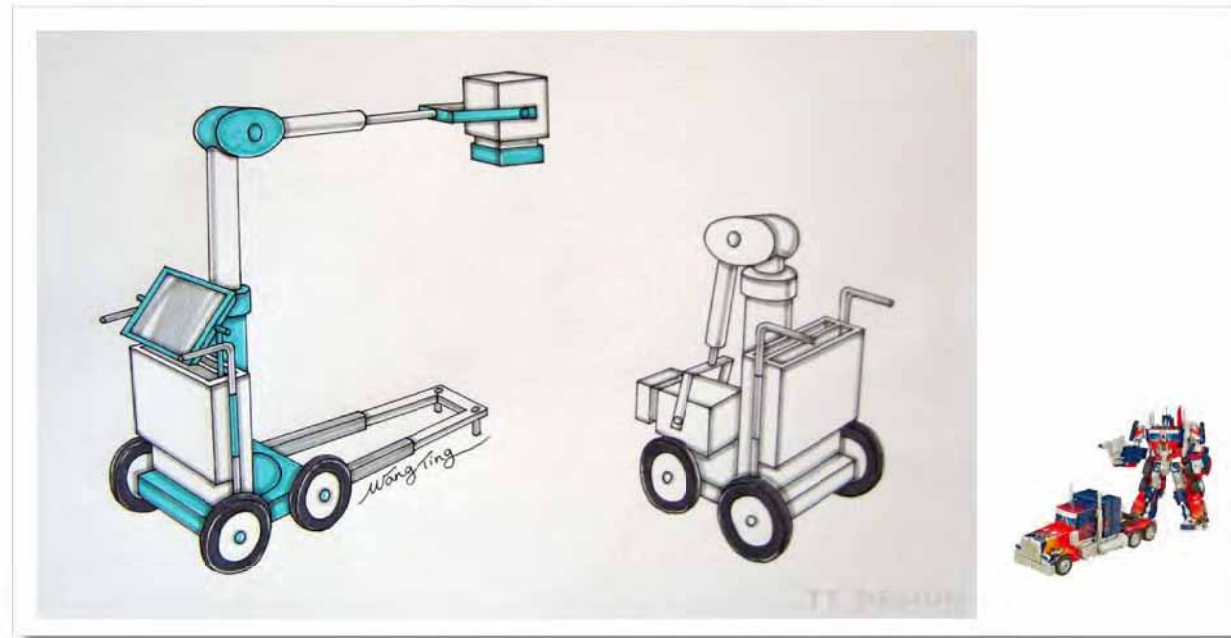
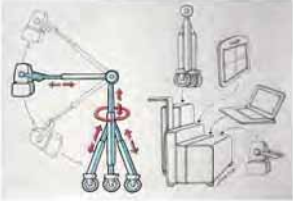

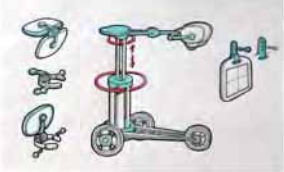
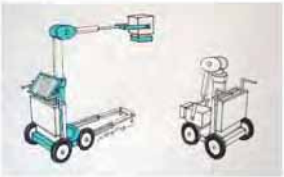


Figure 18 sketching of concept four

This idea comes from Transformers. Concept four also is a combination of merits of concept two and three. It is characteristic of simple, practical and flexible. This design has a strong sense of integrity and wholeness. Like transformers, it can adapt to different contexts through transform. When in use, it can be opened up quickly. When not in use, it can be folded away. Whether indoor or outdoor, freely moving is no longer a very difficult thing as four wheels of machine. According to user needs, the radiographer can easy to adjust the height and angle of stand or the length and angle of arm in different cases. The design of retractable bottom holder increases the stability and security of whole machine when taking photo. Computer has a unique style whose positions and angles can be adjusted, which is convenient for operator to use. Handles also can be adjusted to the height of any radiographer. Box design provides a very safe space for the detector and computer.

5.1.2 Concept comparison

Table 06 concept comparison using key words of design principle

Name	Sketching	Security	Stability	flexibility
<p>Concept one</p>				<p style="text-align: center;">✓</p> <p>easy to move, place, clean, repair</p>
<p>Concept two</p>		<p style="text-align: center;">✓</p> <p>foldable stand protects generator, bottom holder guarantee safe operation</p>	<p style="text-align: center;">✓</p> <p>bottom holder help working machine keep balance</p>	
<p>Concept three</p>				<p style="text-align: center;">✓</p> <p>easy to move, adjust height, rotate stand</p>
<p>Concept four</p>		<p style="text-align: center;">✓</p> <p>box protects computer and detector, foldable stand protects generator, bottom holder guarantee safe operation</p>	<p style="text-align: center;">✓</p> <p>bottom holder help working machine keep balance, four wheels keep stable move</p>	<p style="text-align: center;">✓</p> <p>easy to move, place, fold and open, adjust height and angle, rotate stand</p>

In general, each of concepts has its own distinct characteristics. As table 06 shows, concept one has a good flexibility. It is made up of five self-contained parts and all parts coordinate with each other. It is easy to move, place, clean, repair, and replace. But it has a low security and stability.

The overall design of concept two has very good security and stability but it has very limited flexibility. The stand and arm can adjust height, length and a certain angle. However, the stand cannot rotate. It will give the radiographer some trouble or inconvenience in small patient's room.

It is obvious that flexibility and lightweight are visible characteristics of concept three. But security and stability are not satisfactory.

Concept four is a better design because it is in complete accord with key words of design principle that is "Security", "Stability" and "Flexibility". When not in use, it can be folded in order to move or place. At same time, the detector and computer were securely and steadily placed in the box. When in use, the stand and arm can be flexibly opened and rotated for taking photo. The detector and computer also can be easily taken out and used according to the user needs.

Base on the above analysis, I want to design three-dimensional model for concept two and four using design software. Then I will compare them once again.

5.1.3 Three-dimensional model using design software

5.1.3.1 Concept two



Figure 19 three-dimensional model of concept two

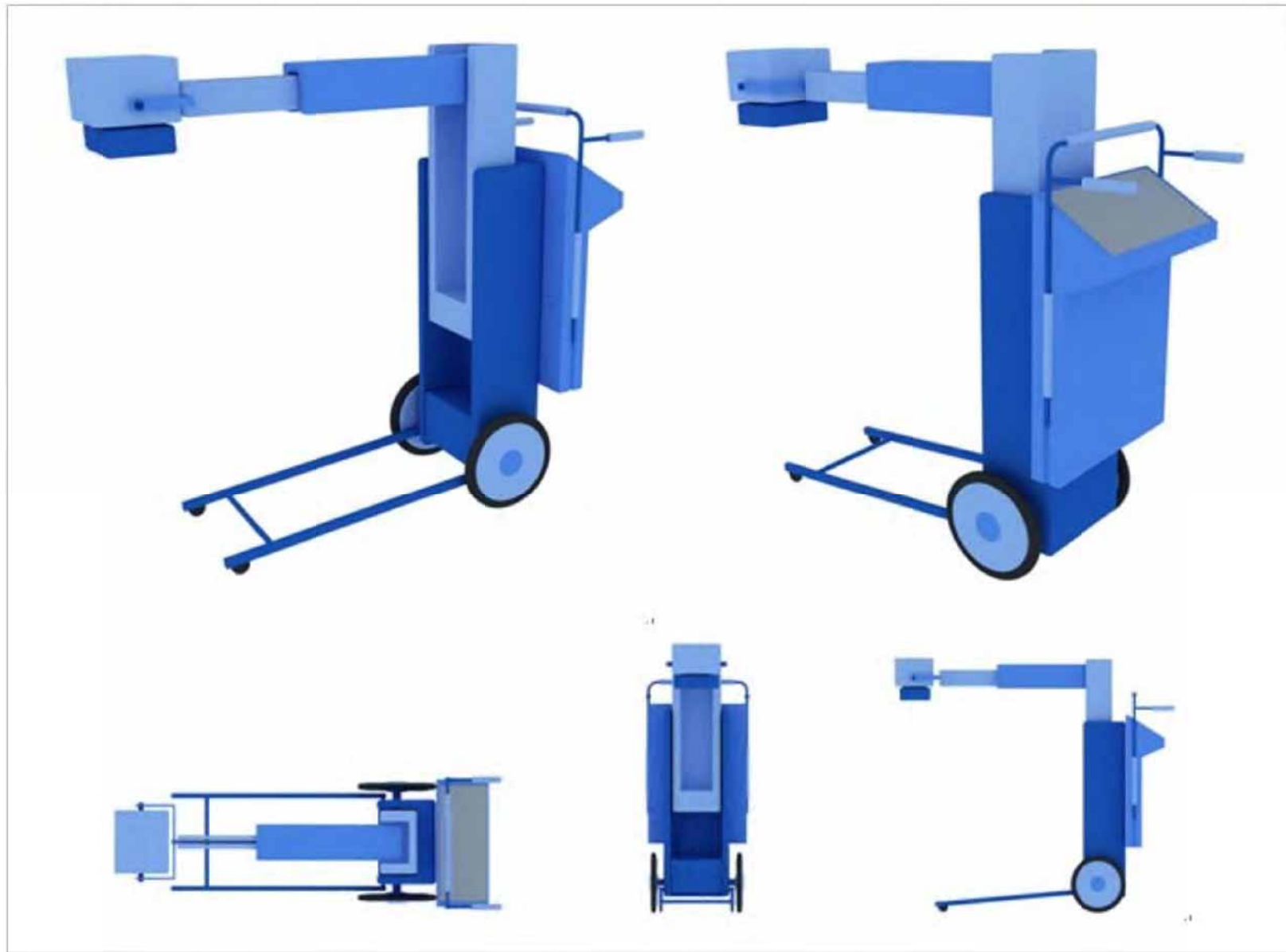


Figure 20 three-dimensional model of concept two

5.1.3.2 Concept four

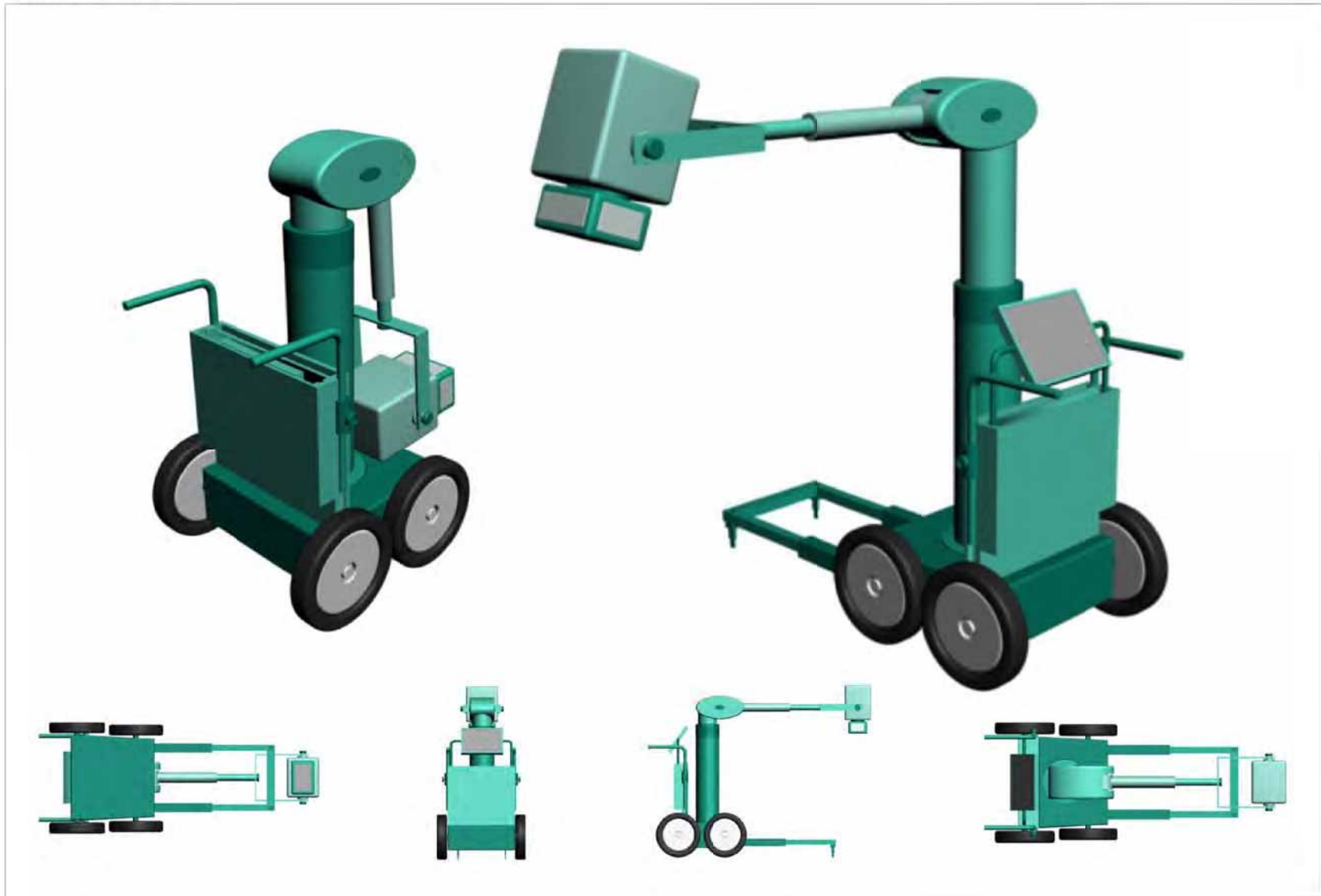


Figure 21 three-dimensional model of concept four



Figure 22 three-dimensional model of concept four

By comparing advantages and disadvantages of the two concepts, it is easy to find that concept four better than concept two. It includes the following reasons. When not in use, both concepts can be folded. But concept four can move more easily than concept two because it has four wheels. When in use, both the stands and arms can be open and adjust the height, length and certain angle. But the stand of concept two cannot rotate. In other words, concept four has a greater operational range and it is more flexible than concept two. Advantages of concept four will be able to help the radiographer freely taking photo for different patients. So, I want to make test model of concept four and improve this design.

5.1.4 Test model

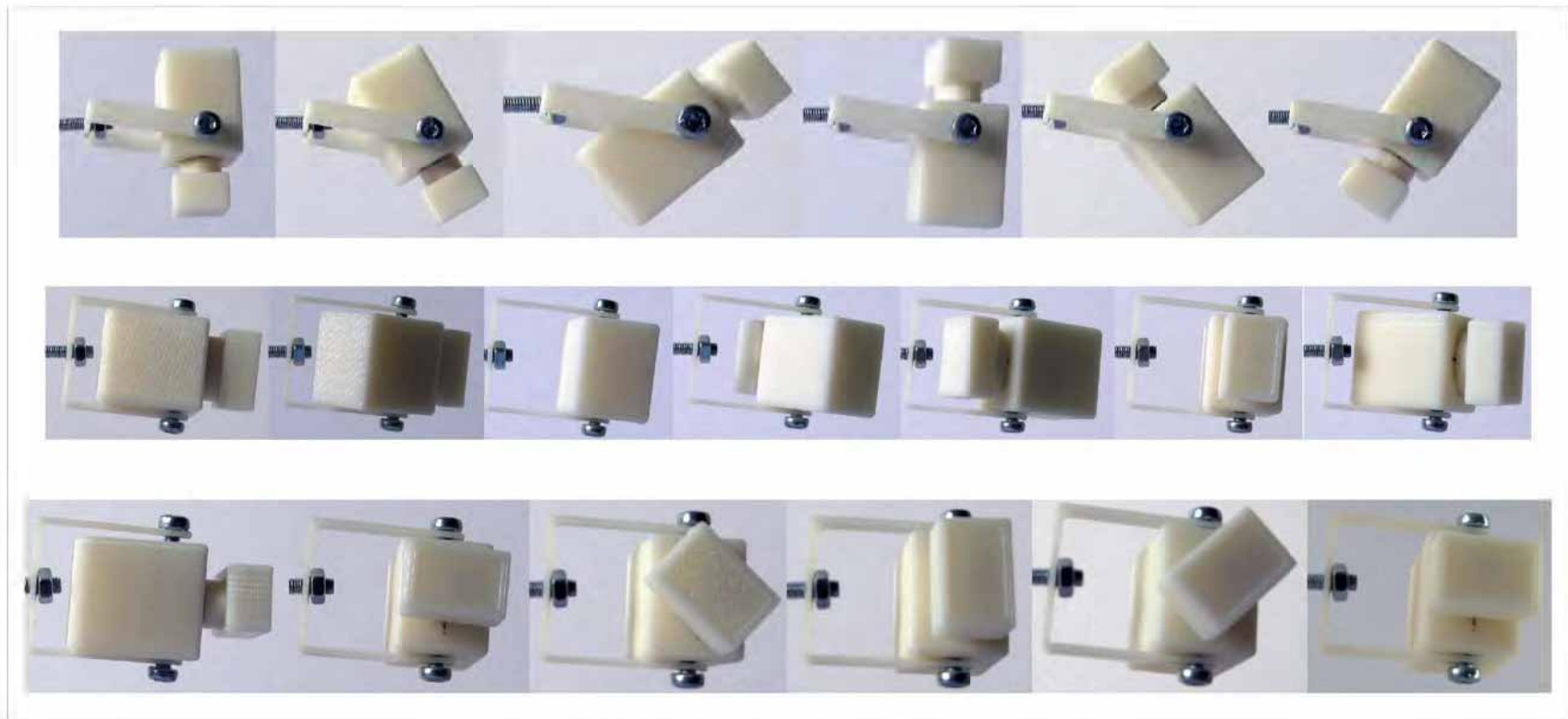


Figure 23 detail model of concept four

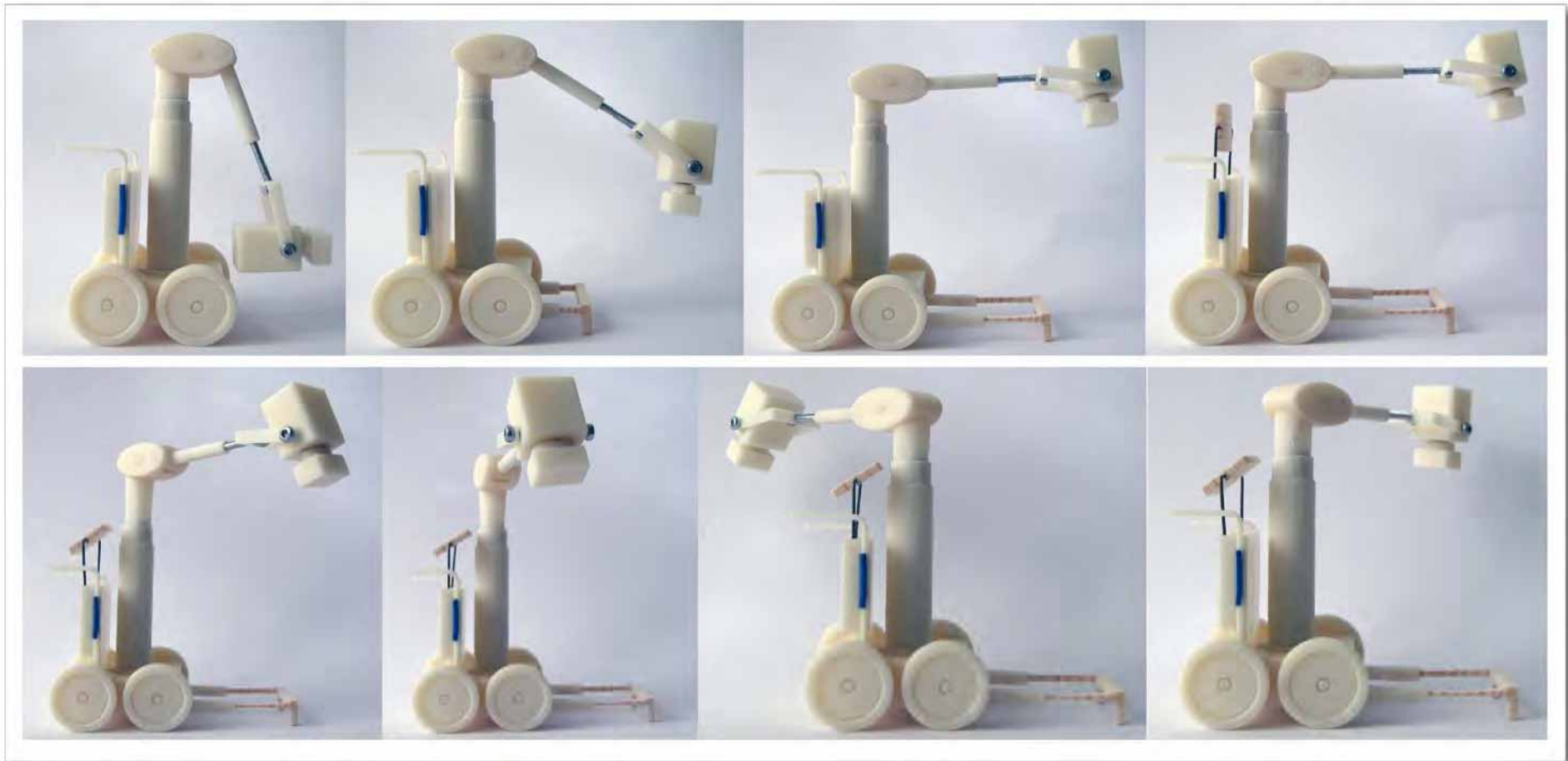


Figure 24 test model of concept four

As expected, test model can accomplish the main functions and it can basically conform to the key words of design principle. However, some limitations are found in the model-making process. For instance, I should improve the pedestal in order to protect the X-ray generator when fold and easy to position in the car. I should design a cap for computer and detector in order to better protect them. If computer have a handle, it will be more convenient operation. If the arm can rotate freely, I should adjust the space around the axle. If there have brush on wheels, it will be easy to clean dirt. So I continued to improve this object. (Please refer to the figure 25).



Figure 25 improvement design of concept four

5.1.5 Final design



Figure 26 final design



Figure 27 final design



Figure 28 final design

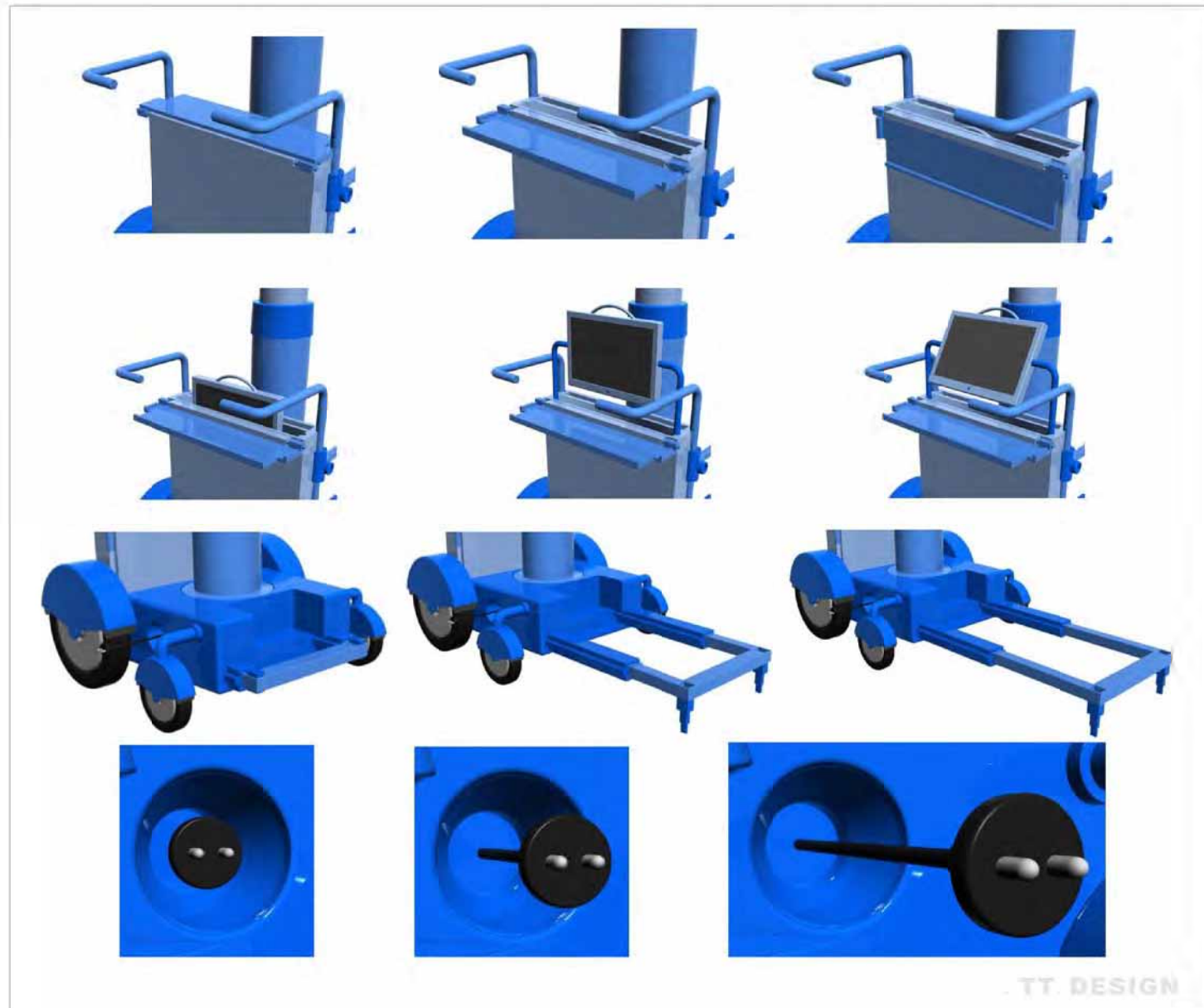


Figure 29 final design

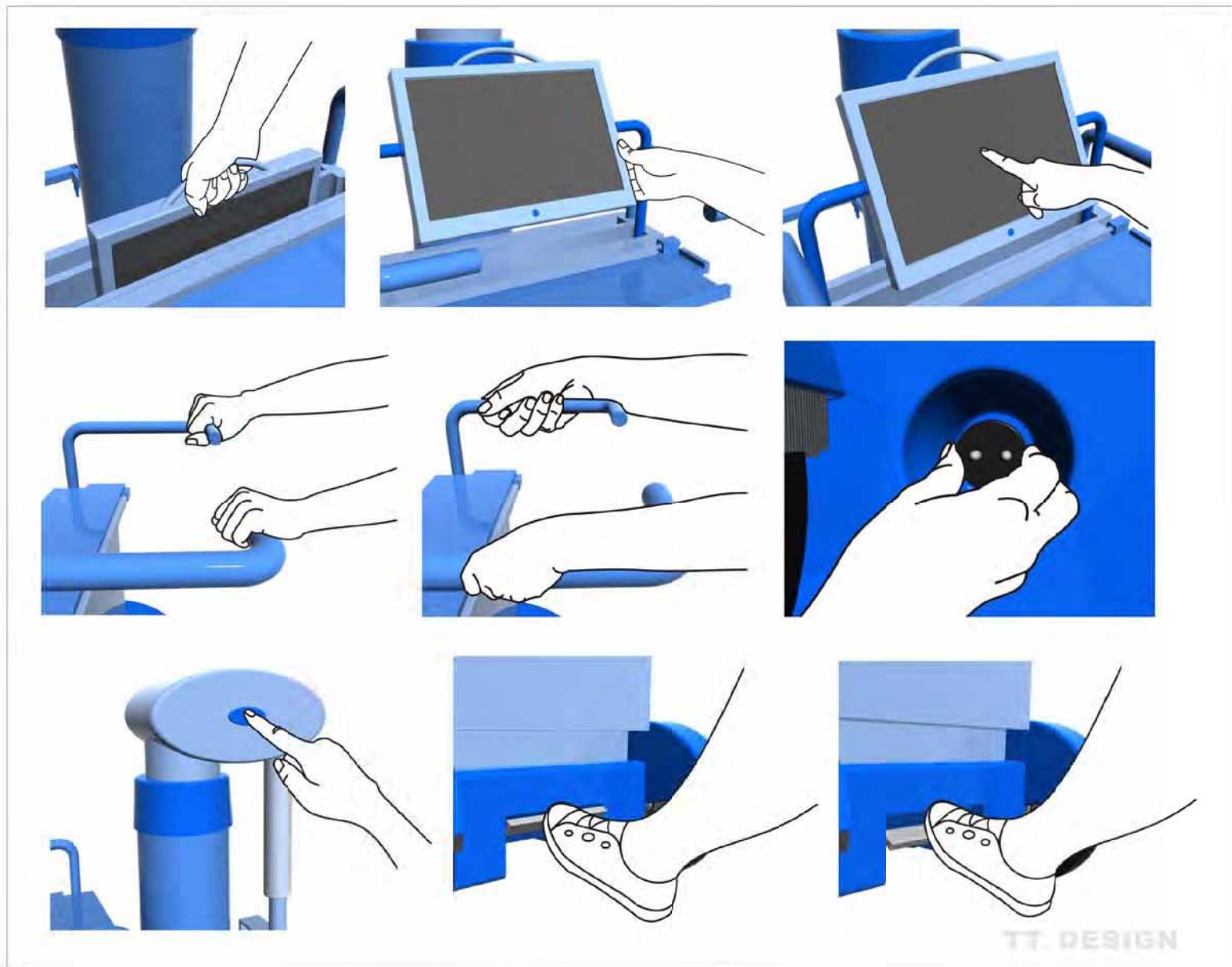


Figure 30 final design

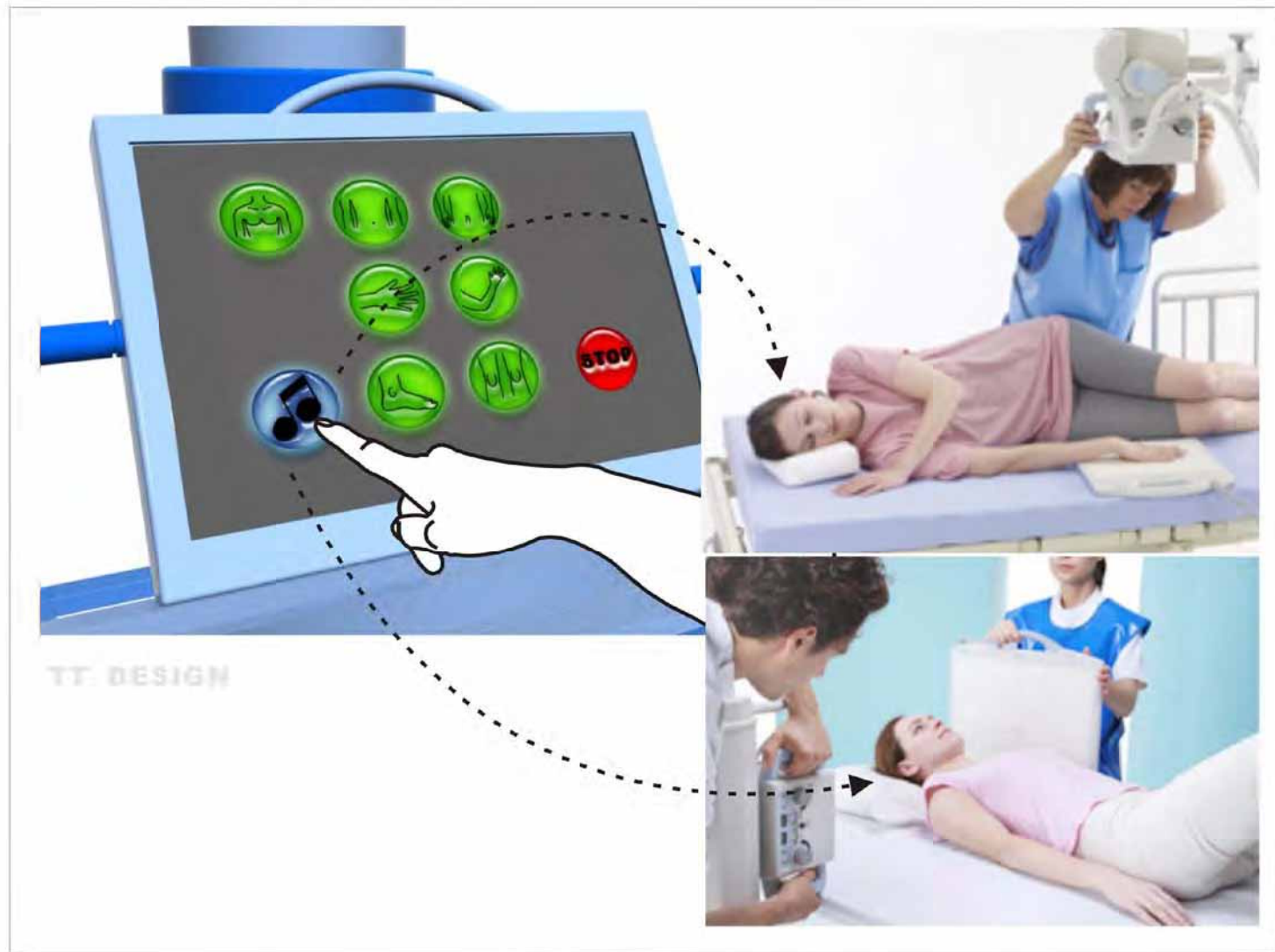


Figure 31 final design

Through research, we knew some patients hope they have a relaxing state when they are taking photo. Music is the best way of relaxation. If patient can enjoying music when they are taking photo. That might be helping them relieving some stress.

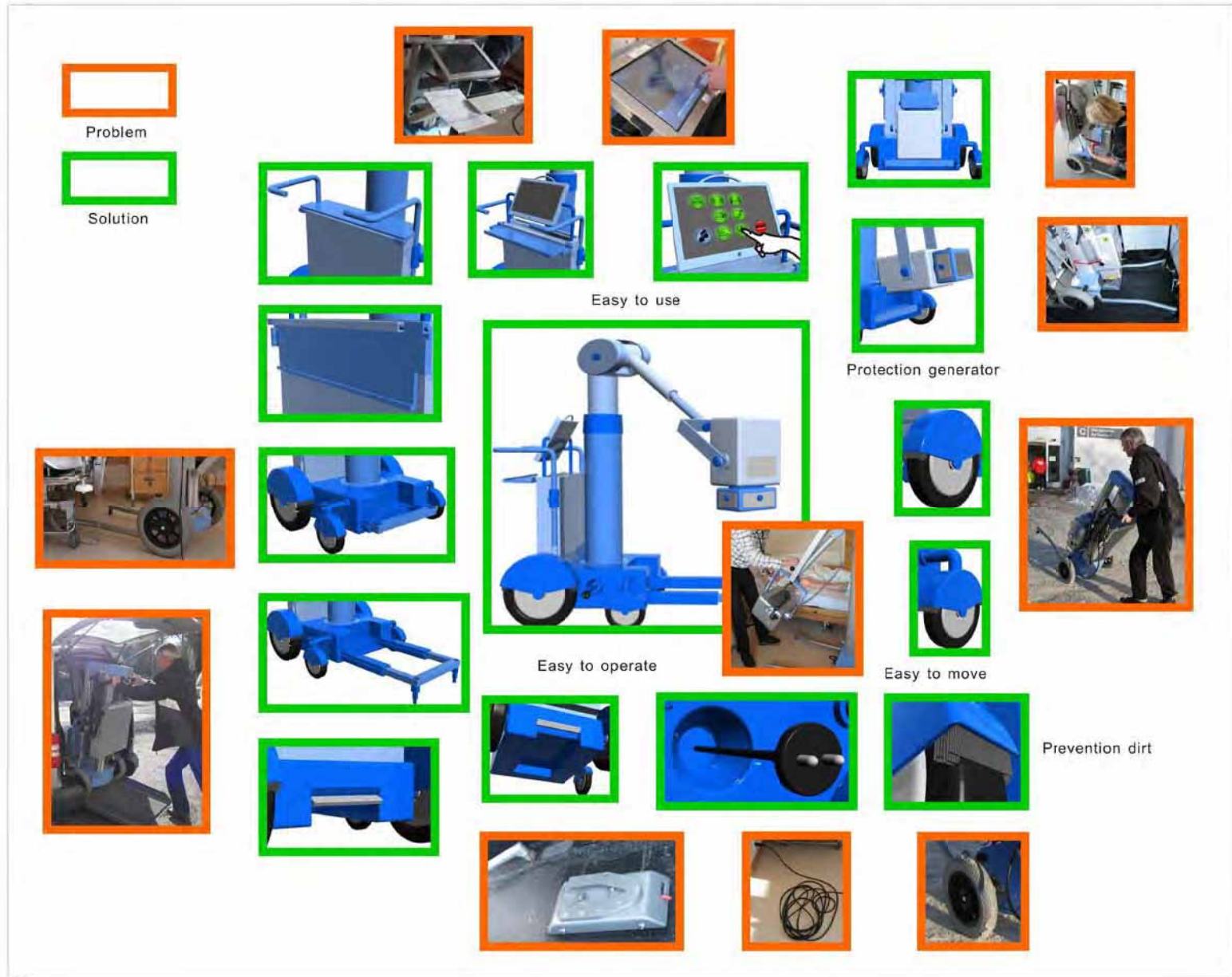


Figure 32 final design

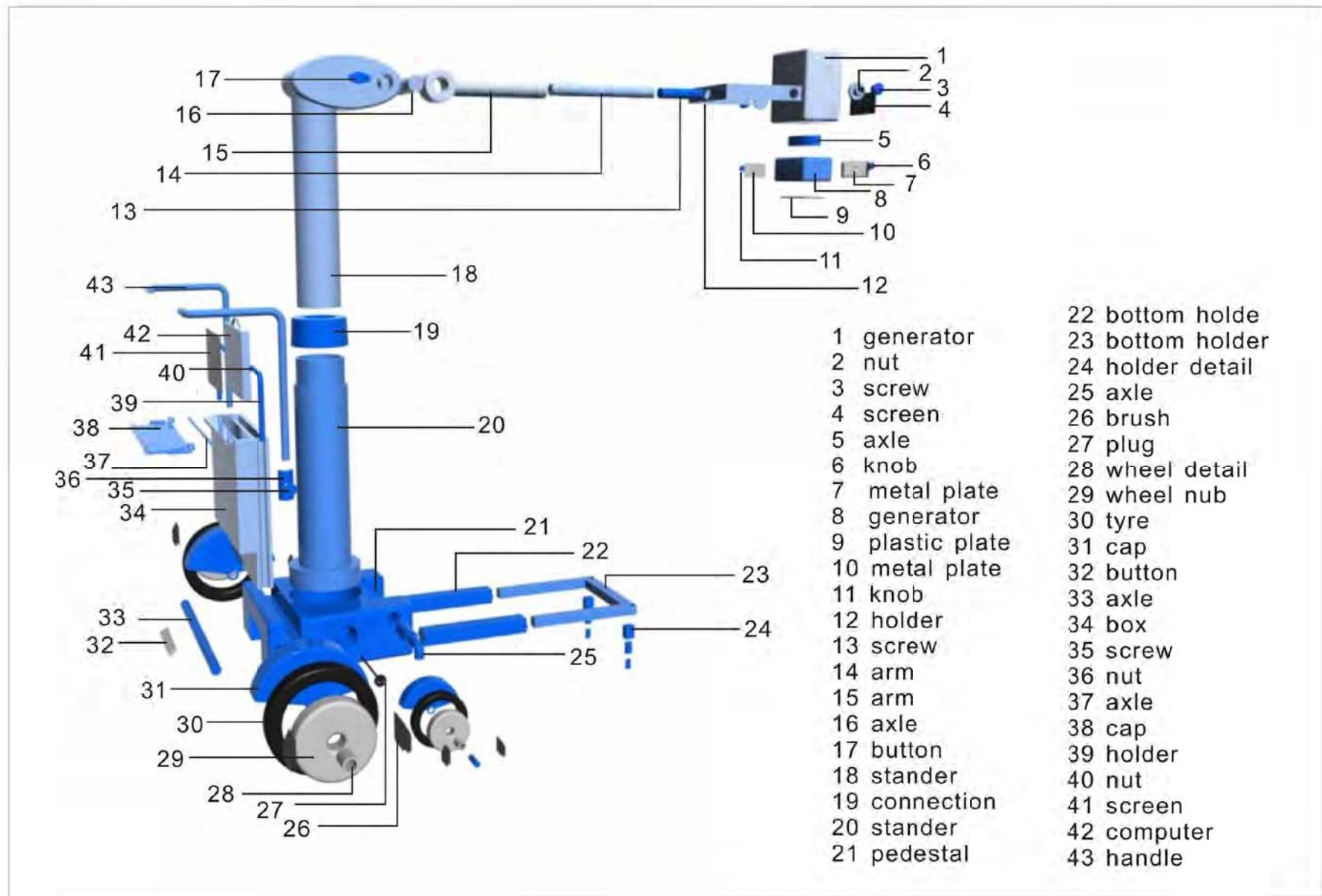


Figure 33 structure of final design



Figure 34 color scheme of final design

This machine is little different than other medical machine in hospital because it is just used for outside for example nursing home and prison. Color scheme of final design will give user some different choice. Different color can indicate different hospital and that might be conducive to help patient remembering hospital service. For patient, different color might be bringing different psychological feeling.

5.2 The suspension for detector design

5.2.1 Concept design

5.2.1.1 Concept one

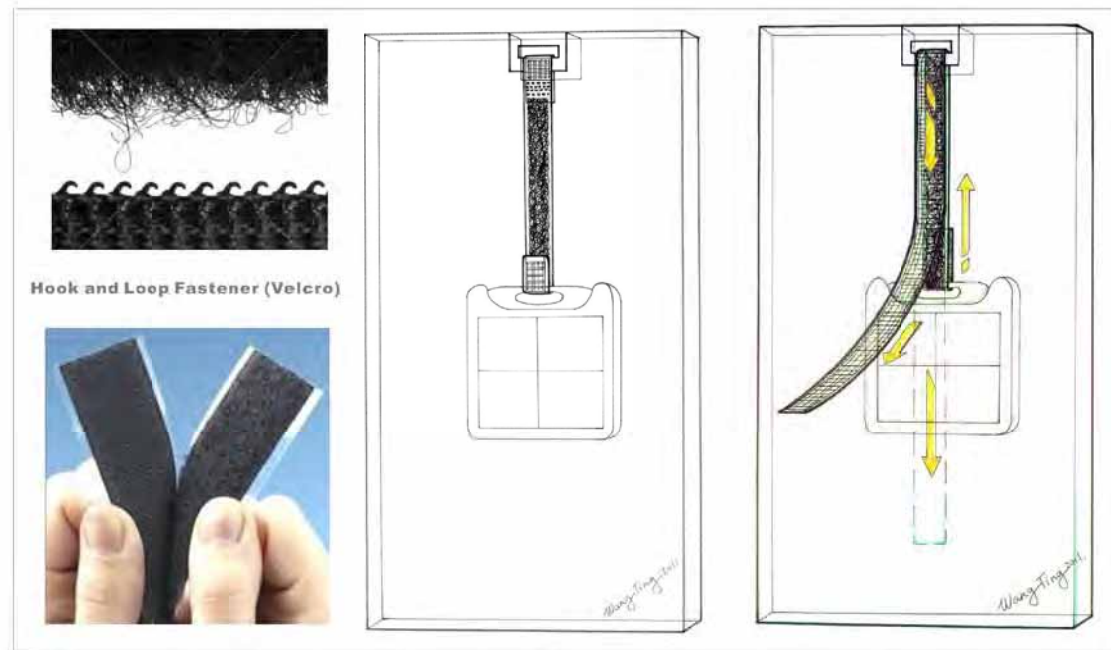


Figure 35 sketching of concept one

This part of work I completed in practical placement but that is a part of mobile X-ray equipment so in this report I should use it. According to existing product analysis and the key words of design principle, I want to design new product from main function and user needs. The new project should be depending on a door or wall to hang up the detector. It should be secure and stable suspension. The new object should be easily remove and adjust height. The new design should be fold up and pack into a pocket. Concept one inspired by Velcro (Hook and Loop Fastener). This kind of material is widely used in many fields. It has many advantages such as easy to adhere and open, very strong, comparatively light, easy to clean, very cheap and so on. Base on these advantages,

concept one will be able to realize the main function and design requirement. As figure 35 shows, concept one includes two parts: metal object and belt of Velcro. The function of metal object is suspension detector on the top of door through belt. The belt of Velcro has two functions one is secure and stable hang up the detector the other is remove and adjust height.

Before use the radiographer just put metal object and belt of Velcro on the top of door. When using the operator open at one end of belt through the handle suspension detector. It is very important that is this part never opens until they finished the work. If the radiographer wants to remove and adjust height of detector she or he only opens and pulls at other end of belt. After the proper height is achieved, the operator just adhere this part. It is very easy to operate and control. After use it is easy to fold up and pack into a pocket.

5.2.1.2 Concept two

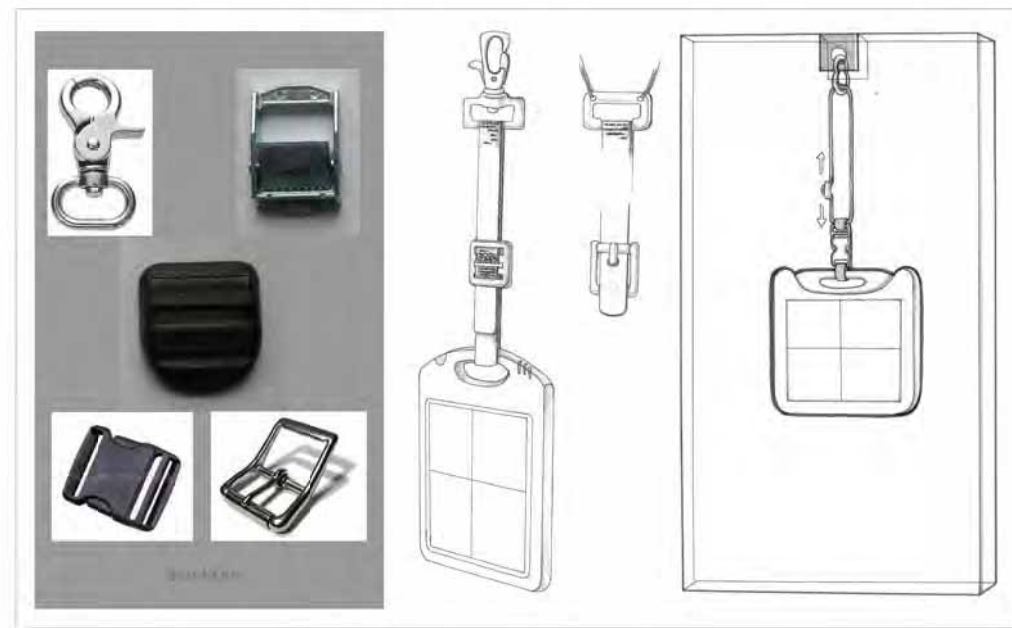


Figure 36 sketching of concept two

This idea comes from leather belt and schoolbag. Concept two has one important characteristic that is it can be used by door or wall in patient room. It is more convenient for the radiographer. This design consists of three main parts. The first part is metal object and hook.

The second part is narrow belt and plastic buckle. The third is wide belt and plastic lock buckle.

As concept one, before use the operator only put this object on the top of door or on the hook of wall. When using the radiographer open the plastic lock buckle through the handle suspension detector. It also is important that is this part never open until they finished the work. If the user wants to remove and adjust height of detector she or he only pulls narrow belt or plastic buckle. It is very easy to operate and control because all the parts of this object come from the people's daily necessities. After use it is easy to fold up and pack into a pocket.

5.2.1.3 Concept three






Figure 37 sketching of concept three

Concept three inspired by Foot block single with jammer and Key Bak. It has two parts in this project. One part is metal object and block. Other is wide belt and plastic lock buckle. The function of metal object and block is move detector and adjust height. Wide belt and plastic lock buckle just hang up the detector.

5.2.2 Concept comparison

Table 07 concept comparison using key words of design principle

Name	Sketching	Security	Stability	flexibility
Concept one		✓	✓	✓
Concept two		✓		
Concept three		✓		

With the analysis and comparison, the radiographer and company both agree concept one better than concept two and three. As the saying goes, "less is more." Concept one is a whole, simple, clear design and it meets the design requirement just through two parts. Base on these reasons, I want to focus on concept one in the following design.

5.2.3 Test model



Figure 38 test model of concept one

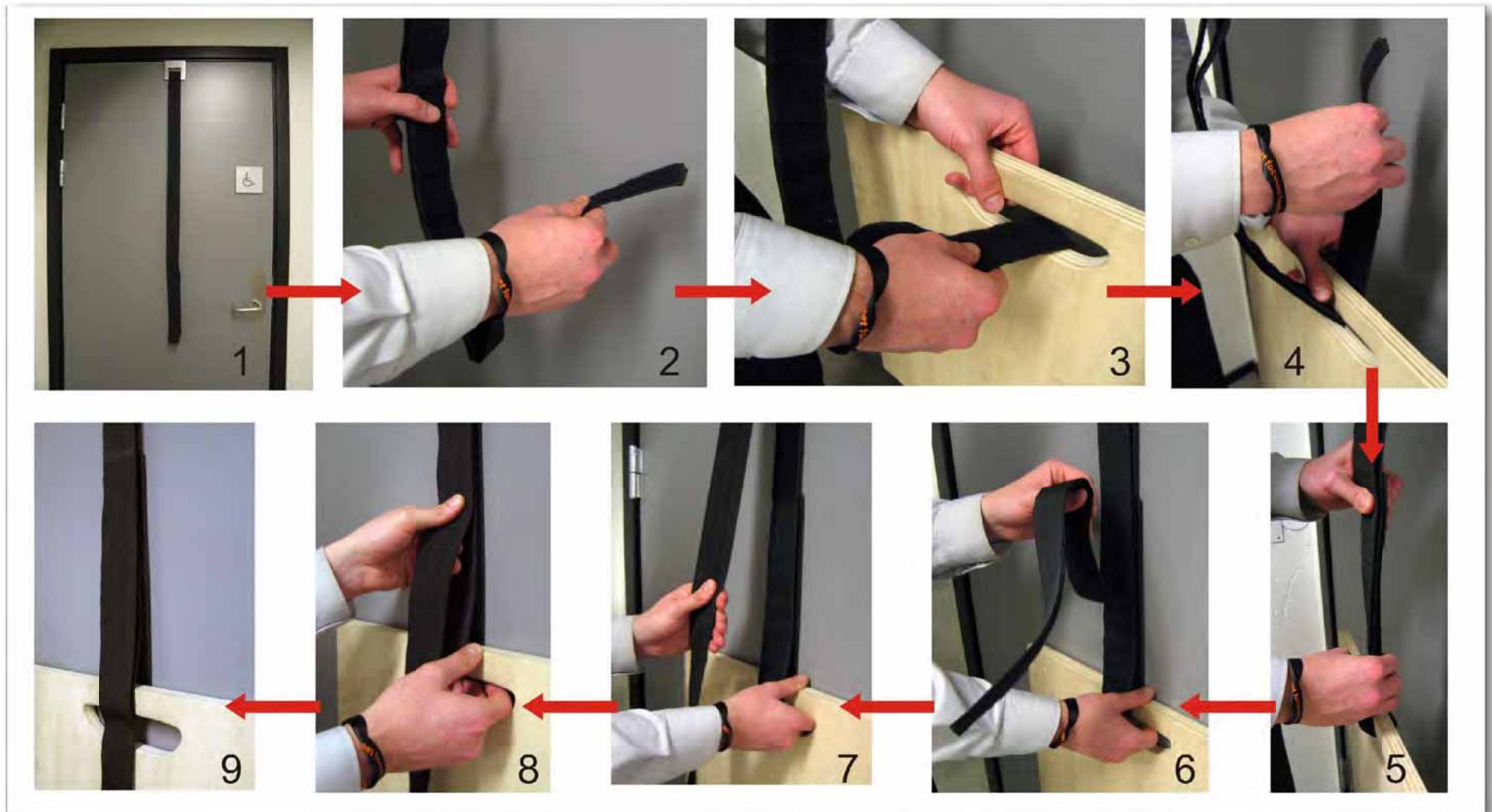


Figure 39 how to use concept one

After I made the models, I have tested the model of concept one in campus and hospital. As expected, concept one was able to realize the main function and design requirement. It can secure and stable suspension the detector on the door. It can easily remove and adjust height. It can fold up and pack into a pocket. (Please refer to the figure 38-39).

But meantime, the radiographer and professor of Akershus university hospital have offered the other new requirement. They hope this project can be applied to door of different sizes such as wardrobe door, bookcase door, bathroom door etc. and the door must close because they need vertical to x-ray machine.

I was beginning to consider the new requirement. Through repeatedly thought and tested, I found out two solutions to solve the new problems as shown in figure 40—41. This is illustrated in figure 40, which clearly show how to use metal object 01 and its evolution. It can be used directly and there is no upfront operation. Figure 41 spells out how to use metal object 02. According to different size door, the operator only links two metal pieces through different hole before use. It is very easy to operate and control. Use new models I have tested concept one again in campus and hospital. At same time I have obtained the satisfactory result (Please refer to the figure 42-43).

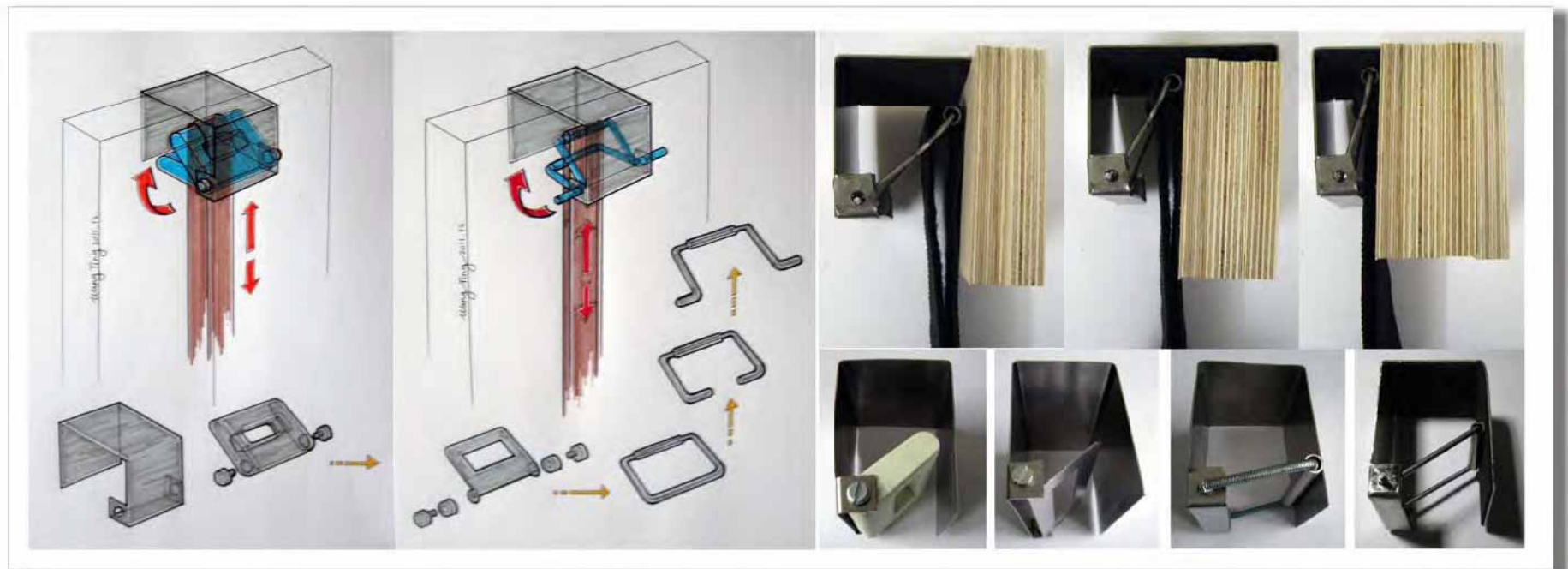


Figure 40 test model of concept one



Figure 41 test model of concept one



Figure 42 test model of concept one

5.2.4 Final design



Figure 43 final design





6.0 Reflection and conclusion

Redesign is a common tactics in product design. It is different from creating totally new product because designers can obtain important information and user experience or existing production. This information will help designer to have an improved and comprehensive understanding of design task. User friendliness is a new trend in industrial design and is also a main goal of redesign. How to redesign a kind of easy-to-use product is a question that every designer should think over. The dissertation is just an attempt.

This project is based on User- centered design principles and combines with different methods the author is trying to inquire into that what is the need of end user, what is the problems of existing product, how to satisfy these needs and solve these problems. Through repeating design and test the author found the best result and the worthy process that can be learned. However, due to special causes the study of patients is not deep enough that is short of regret greatly.

This investigation set out with the aim to achieve development a user friendly mobile X- ray machine and a suspension of detector. In order to achieve this User- centered design and Emotion design were used, meanwhile the research about design methods were also study. After the generally research on both sides: the need of end user and the problem of existing product, the criterion of new product which is the key words for the design were generated. The key word of design principle is “Security”, “Stability” and “Flexibility”. Based on the key words, the author obtained and decided on a final design. During the whole product development process, there were some findings about the process of redesign which can be recommended for the future. (Please refer to the table 08)

Table 08 redesign steps and applied case

Redesign steps		Reference case
1.	Setting goal	The goal of research is to develop a user friendly mobile X- ray machine and a suspension of detector.
2.	Study background theory	User-centered design, Emotion design
3.	Study project using different methods and find user needs and problems	Questionnaire survey, Interview method, Field observation
4.	Analysis existing product and find user needs and problems	Function analysis and demand Use process and problems “security needs” , easy to use and convenient to operator in their whole working course
5.	Design key words of design principle	“Security”, “Stability” and “Flexibility”
6.	Design concepts	
7.	Compare concepts using key words of design principle and choice better concept	
8.	Improvement concept and make test model	
9.	Design final design	

Appendix 1: The questionnaire

Questionnaire of radiographer

Hello, this is questionnaire for operator of mobile X-ray machine.
Please fill in it and thank you very much!!!

Name: Rune Johnsen Today's date: 26 Jan

Sex: Female Male

Telephone: +4797690669 E-mail: rujo@ahus.no

1、 How long have you been operating the machine?
 1 year 2 years 3 year 4years 4years more than 10 years

2、 In one week how often do you work with mobile X-ray machine?
 two times three times four times five times more than five times

3、 How much time do you spend on one visit?
 1 hour 2 hours 3 hours 4 hours 4 hours more than five hours

4、 How much time do you spend on take photo for one patient?
30 minute

5、 Please could you tell me during operation what is your main problems ?

In the Car: The machine should be easy to roll in and out of the car. Weight is essential. It should be easy to secure the machine in the car and all parts should be steady on bumpy roads. It should be easy to release the machine from the cars attachment devices.

In the nursing home / prison: As a rule there are very little space in the examination room (e.g. patient room). A small, steady and easy moveable machine is essential. The free space under the beds are often less than 17 cm.

The machine: There should be possible to direct the x-ray in full orbit. Foot height should be less than 16 cm. Maximum height from floor to x-ray tube should be min. 180-200 cm. Horizontal arm-length should be at least 80-100 cm. Cables should be rolled into the machine to avoid them to be run over in positioning and transport. For detector unit a wireless device should be used.

The system should operate safely with a currency of 230 V and 16A. The maximum power

consumption at exposure should be more than 5 kW.

The software system should be backed up by battery power so that it is not necessary to turn the system off and on while moving between rooms in the same nursing home. Software system should also have WiFi connection for importing patient data and exporting images.

All displays should be easily readable and operative from different angles around the equipment.

The machine should be easy to clean and desinfective agents should be used without damaging risk.

Wheels should be as big as possible so that moving the machine outdoor or in e.g. snow is easy. Wheels should also be easy to clean.

6、 Please could you tell me what is you want to change during working ?

The specifications above will make it very easy to handle the machine.

Tusen takk!!!

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Appendix 4: The reference

Book

1. Patrick W. Jordan (2000) Designing Pleasurable Products, London: Taylor & Francis
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3. Oxford English Dictionary

Website

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2. www.usabilitynet.org
3. http://en.wikipedia.org/wiki/End_user
4. <http://en.wikipedia.org/wiki/Questionnaire>
5. <http://en.wikipedia.org/wiki/Interview>

Appendix 5: The Project progress plan (Time schedules)

2012								
Week	Month	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	January				5 Course start	6 Make a plan	7	8
2		9 Research	10	11	12	13 Analysis research	14	15
3		16	17	18	19	20 Analysis research	21	22
4		23	24	25	26	27 Analysis research	28	29
5	February	30	31	1	2	3 Analysis research	4	5
6		6 Concept design	7	8	9 Milestone meeting	10	11	12
7		13	14	15	16	17	18	19
8		20	21	22	23	24	25	26
9	March	27	28	29	1	2	3	4
10		5 Write report	6	7	8	9	10	11
11		12	13	14	15	16	17	18
12		19	20	21	22 Milestone meeting	23	24	25
13		26	27	28	29	30	31	1
14	April	2	3	4	5	6	7	8
15		9	10	11	12	13	14	15
16		16	17	18	19	20	21	22
17		23	24	25	26	27	28	29
18	May	30 Print first report	1 Repair report	2	3	4	5	6
19		7	8	9	10 Print final report	11	12	13
20		14	15	16 Submission project	17 Prepare presentation	18	19	20
21		21	22	23	24	25	26	27
22		28	29	30 Oral presentation	31 Oral presentation	1	2	3

■ Important day
 ■ Research
 ■ Analysis research
 ■ Concept design
 ■ Write report
 ■ Print and repair report
 ■ Prepare presentation
 ■ Weekend