CARTISH

BY AIRRITY

Product report | MA4 - ID11 | May 2017

Birgitte Fromsejer Nøkleby | Christoffer Høg Jørgensen

TITLE PAGE

Project title:
Cartish - The future in airport security

Type of report:
Product report

Time period:
01.02.2018 - 31.05.2018

Team:
Airrity - M.Sc. 04 - ID11

Main supervisor:
Louise Møller Haase

Technical supervisor:
Poul Kyvsgaard

Number of pages: 24

Birgitte Fromsejer Nøkleby

Christoffer Høg Jørgsensen

TABLE OF CONTENT

ABSTRACT

This is a Master Thesis regarding the development of a product for the future airport security checkpoints.

Most people know that the most stressing part about the airport is the security check. Passengers stress about separating their items, and to get through without trouble. The airport want the passengers through as fast as possible but also need to uphold the level of security. With more passengers traveling even more passengers are going through the airport, and with an increasing amount of security steps it is not getting easier to go through. There is a need for a radical change in the way we think about airport security checkpoints, so it can follow the increasing passenger numbers.

This Master Thesis project focuses on reducing the stress through security by focusing on families. The product Cartish is a cart which takes the families out of the regular security lane. Cartish provides the family with the time and space they needs to go through security. Cartish focuses on making the security check an experience the family can do together. The airport benefits of the tracking of the passengers, by receiving valuable information about how the airport is used.

INTRODUCTION

The following product report will be presenting the product, Cartish.
Cartish is a product designed for airport security checks. Cartish creates a less stressful security checks for families by providing them with the time and space they need. The stressful security check is a especially stressful for parents whom have more things to handle while in security. The increasing amount passengers means that security only will get more stressful. Cartish rethinks security to adapt to the future needs in airport security.

CARTISH

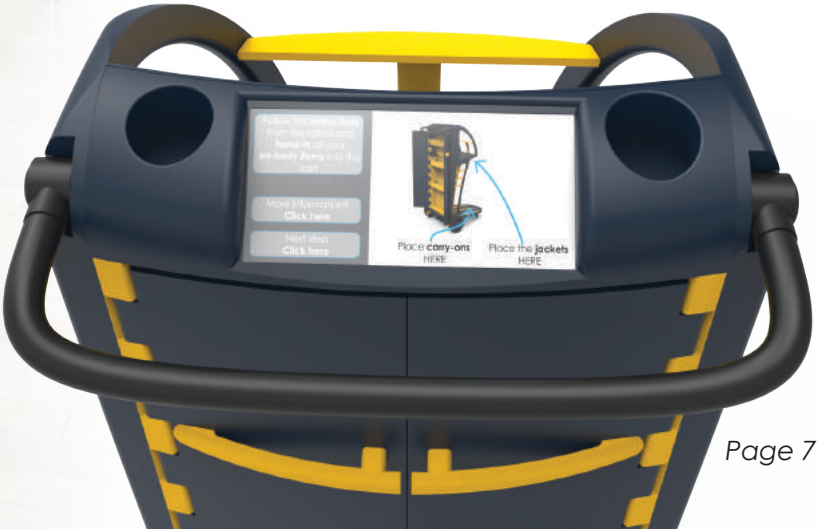
Meeting our costumers expectations today


P07

PREPARE TOGETHER

Cartish guides the family through the separation and hand-in process before entering the security.

Information is provided through the screen and silhouette. The silhouette allows the entire family to prepare together. The screen provide information for the parents about the next steps.




Passenger entrance
Place cart here

SEPARATED SECURITY LANE

Families using Cartish will be separated from the regular security lane. By allowing families their own lane the regular security check can move faster.

The family places Cartish in the scanner. The family do not need to separate any items inside the carry-ons, and can place the entire cart inside the scanner. The scanner searches for illegal items in the carry-ons and detects the amount of carry-ons placed on the bottom plate.

The screen informs the family about how to get through the security scanner.

** The security scanner are only on conceptual level*


Buy
1 for
10 DKK.-
GLOBSCHI'S

Discounts in tax-free

The screen on Cartish provides the family with a map of the airport to easier navigate in the airport.

Tracking of Cartish allows for targeted ads for each family. The screen suggests shops which might have the families interest.

The tracking allows for collection of data about movement patterns inside the airport.


Gates A2-A17
Gates B, C, D,

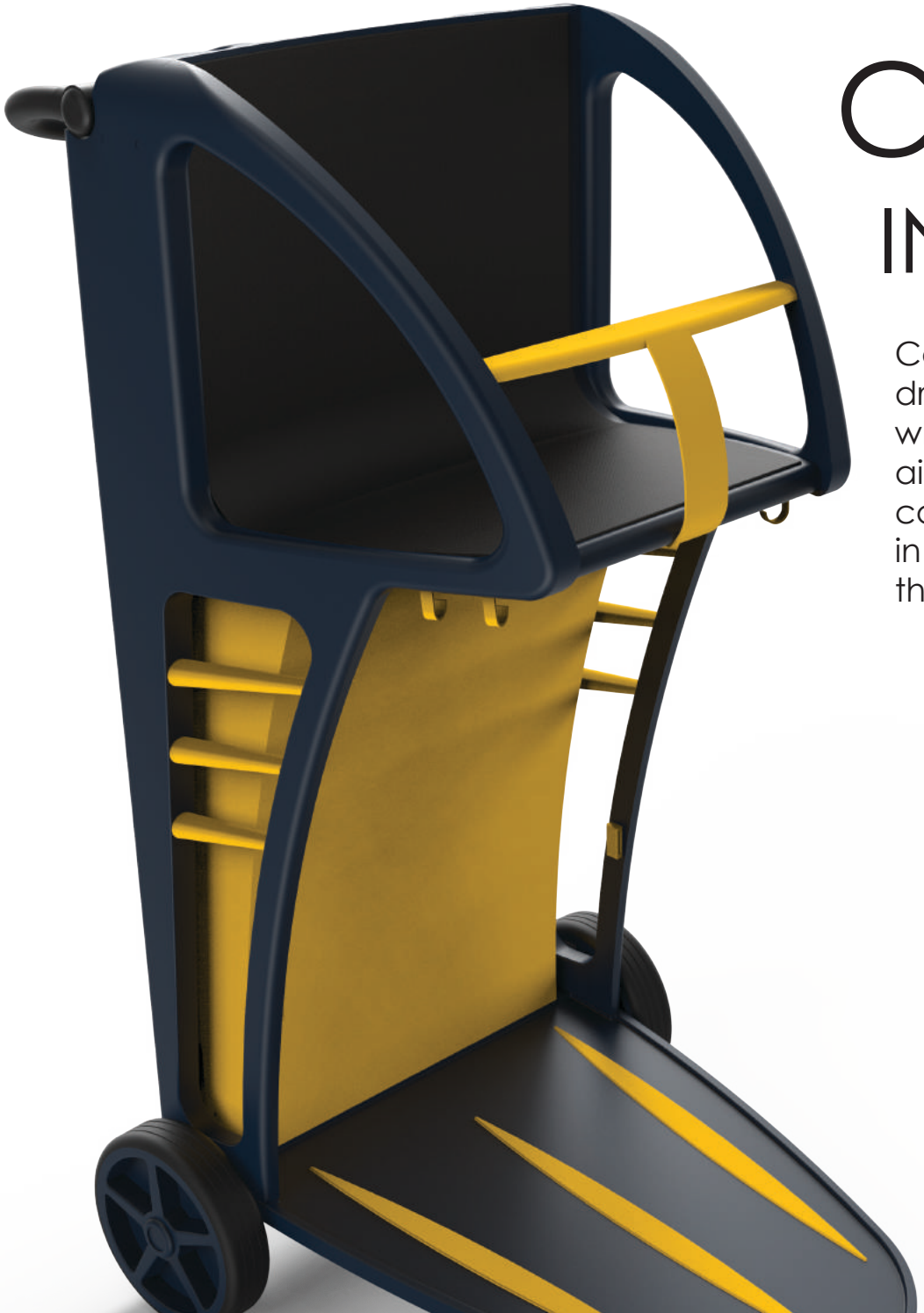
Guidance to the gate

The screen shows a map which guides the passenger to the gate.

The screen informs the family when they need to go to their gate. The information is based on the boarding pass information and the families location in the airport.

Creates a private room

The family can prepare together by helping each other while using the rabbit on the door. The door creates a small private room for the family to prepare in.



Children in focus

Cartish allows for the children to hold onto the cart while walking around the airport. Smaller children can be placed in the seat in height with the rest of the family.

Information on the screen

The screen provides the family with guidance. It informs the family about what to hand in and when to get to the gate when it opens. Additionally the family will receive information about places of interest and discounts in tax-free.

Room for all types of carry-ons

Cartish have room enough for placing multiple carry-ons in the bottom plate. A strap ensures the carry-ons stays in place while walking with the cart.

Cartish is easy to drive around with, due to the choice of turnable wheels in the front.

The passengers can hang their jacket on the coat hangers attached under the seat.

A Cartish for your airport

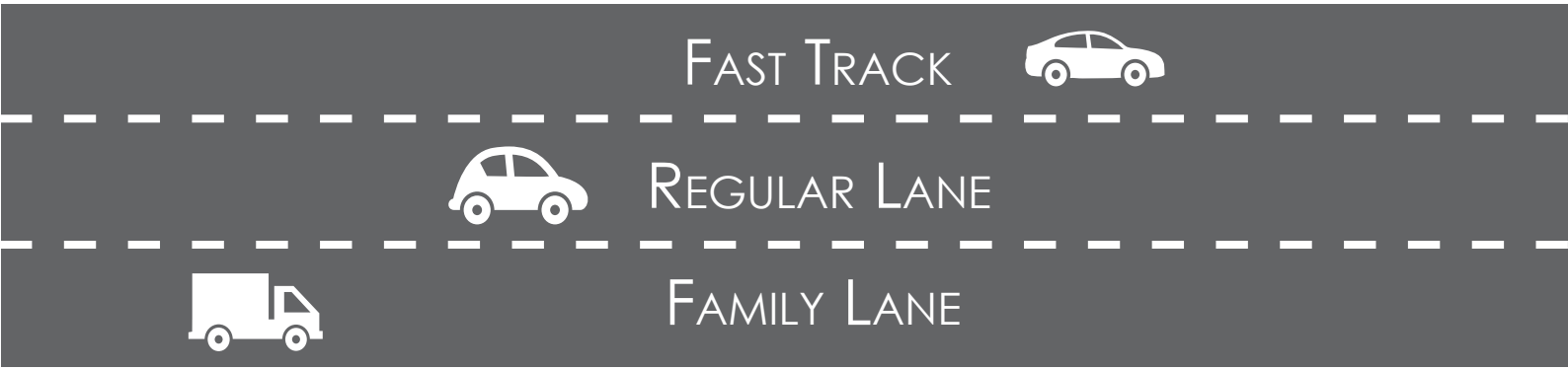
Københavns Lufthavne CPH

Bristol Airport
Amazing journeys start here

Schiphol
Amsterdam Airport

INCREASING PASSENGER FLOW

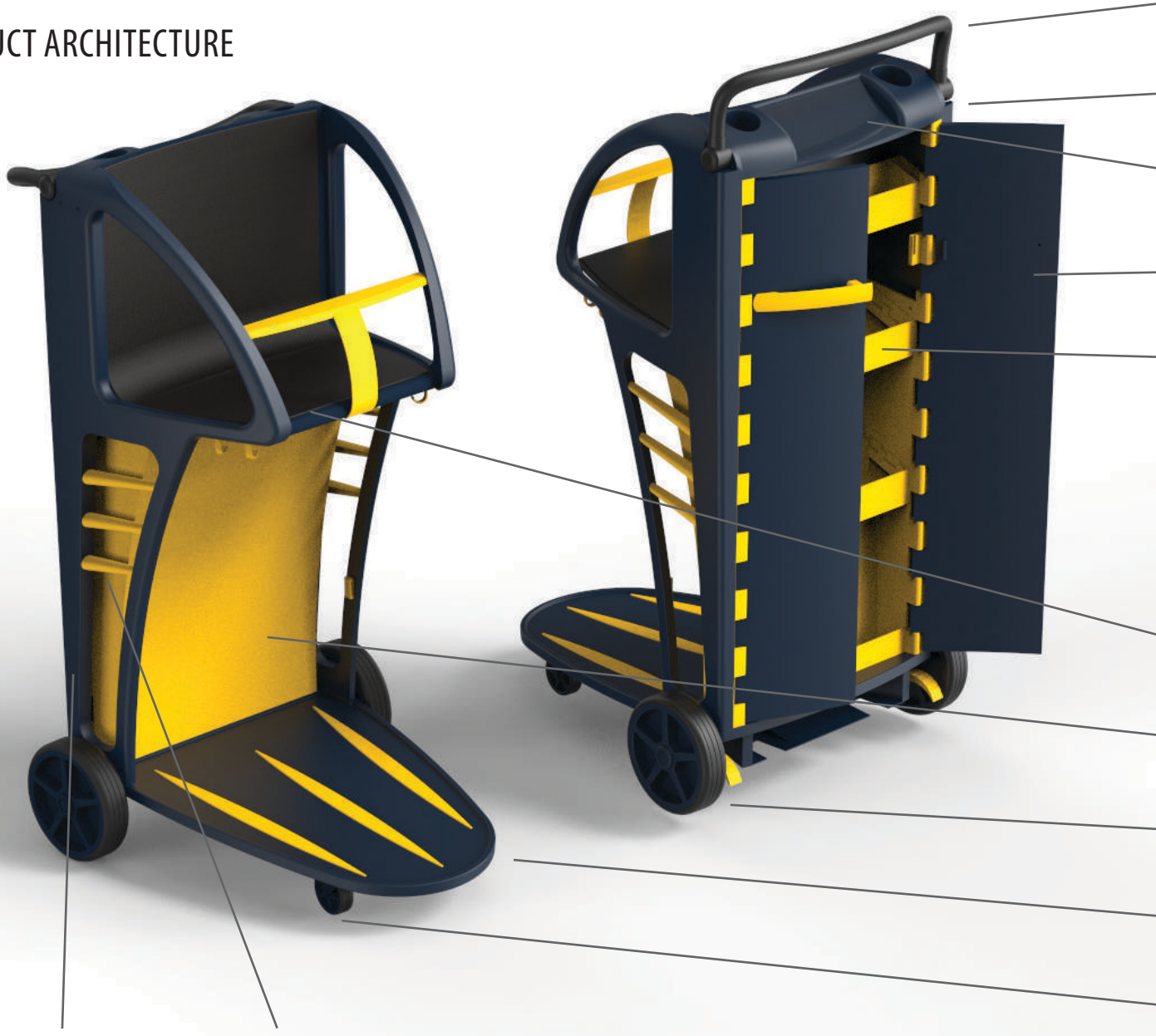
The families are provided with their own lane. This results in the regular lane being faster, and thereby increasing the passenger flow.

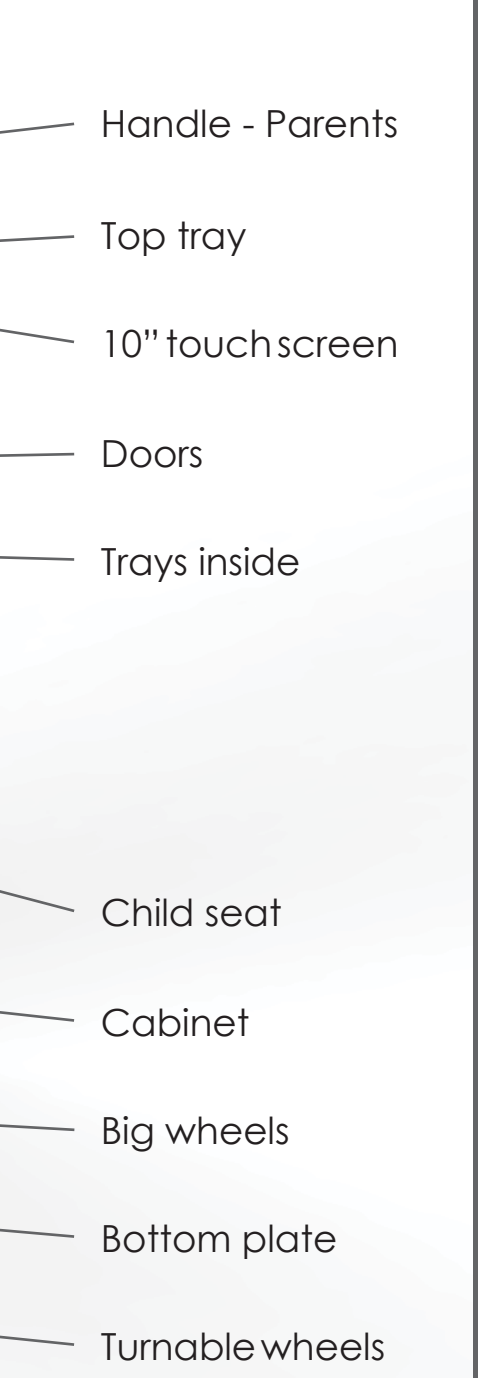


STACKING TO MINIMIZE SPACE

Cartish can be stacked together. This minimizes the required storage inside the airport. In addition, the stacking allows for transportation of multiple carts at a time.

PRODUCT ARCHITECTURE





PRODUCTION & MATERIALS

Special produced parts:

• Handle - Parents	PVC	Dip molding
• Top tray	ABS	Vacuum forming
• Doors	ABS	Vacuum forming
• Trays inside	ABS	Vacuum forming
• Child seat	ABS	Vacuum forming
• Cabinet	ABS	Vacuum forming
• Bottom plate	ABS	Vacuum forming
• Handles - Children	PVC	Injection Molding
• Sides	Dried Douglas Fir + PUR	Gas-Assisted Injection Molding

Standard components:

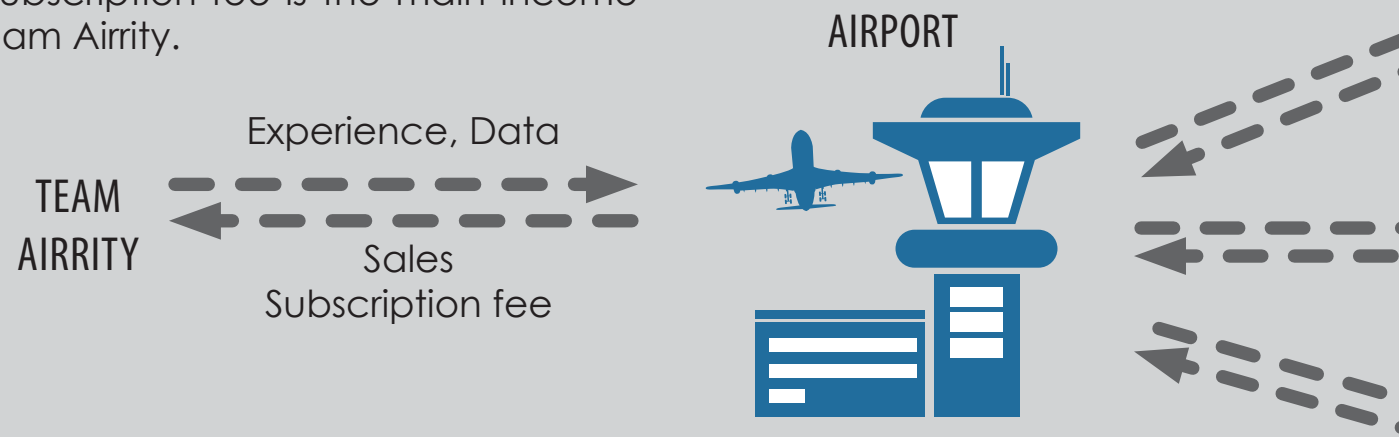
- 10" touch screen
- Big wheels
- Turnable wheels

PRODUCTION PRICE

The estimated total product cost for one Cartish is **240€**. Cartish will be sold to a price on **400€**, which give a profit on 60%.

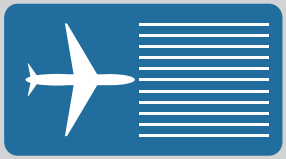
BUSINESS CASE - TEAM AIRRITY

Team Airrity sells Cartish as a one time investment from the airports. The airports pays a subscription fee for get access to the data for tracking the passengers. The subscription fee is the main income for team Airrity.



BUSINESS CASE - THE AIRPORT

AIRLINES

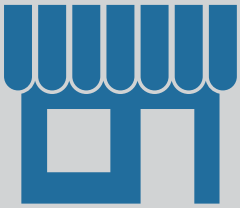


The airport sell information about number of carry-ons to the airlines.

Data - faster turn-around

Subscription-fee

STORE



The airport tracks the passengers through the tax-free. The data is sold to stores to targeted ads and get information about the effect of the marketing.

Data,
Increased income

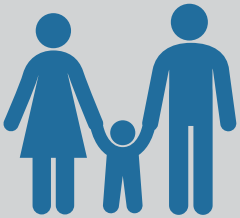
Subscription-fee

Experience

Returns for next vacation

Increased spending in tax-free

FAMILIES



The family receives a better experience through the entire airport. The family will return to the same airport for the next flight.

CARTISH

BY AIRRITY

Process report | MA4 - ID11 | May 2017

Birgitte Fromsejer Nøkleby | Christoffer Høg Jørgensen

0.1 TITLE PAGE

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Number of appendix: 32

0.2 ABSTRACT

This is a Master Thesis regarding the development of a product for the future airport security checkpoints.

Most people know that the most stressing part about the airport is the security check. Passengers stress about separating their items, and to get through without trouble. The airport want the passengers through as fast as possible but also need to uphold the level of security. With more passengers traveling even more passengers are going through the airport, and with an increasing amount of security steps it is not getting easier to go through. There is a need for a radical change in the way we think about airport security checkpoints, so it can follow the increasing passenger numbers.

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Birgitte Fromsejer Nøkleby

Christoffer Høg Jørgsensen

0.3 PREFACE

This project is a Master Thesis project compiled by M.Sc. 04 team 11. The Master Thesis is compiled as the final project on the education Industrial Design at Aalborg University.
The project started the 1st February 2018 and was handed in the 31th May 2018.

The project expectations is to create; *A vision for how the future can be*. This created requirements for thinking differently and take technologies and trends into another level of meaning and usefulness.

Throughout the project the team have been in contact with multiple persons to benefit from their expertise and get supervised in the process. The team wants to thank the following companies and persons. Further information about the persons can be found in Appendix I.

- Louise Møller Haase, Main supervisor
- Poul Kvygaard, Technical supervisor
- Mathias Lund, Research assistance at Aalborg University

Billund airport, with a special thanks to

- Michael Hedegaard Rasmussen, Ramp manger

Aalborg Airport, with a special thanks to;

- Tomas Nielsen, Assisting department manager
- Michaela Joseph, Security manager
- Pia, Klaus, and Morten, Security guards

BEUMER Group A/S, with a special thanks to;

- Ulrik Steen Hansen, Research and Developing Manager
- Per Engelbriksen, Business Development Director

Copenhagen Airport A/S, with a special thanks to;

- Thomas Bruun Pedersen, Department manager SPS
- Brian Cilinder-Hansen, Department manager, Security Check Special

VELUX A/S, with a special thanks to;

- Michael Larsen, Mechanical Engineer at VELUX Technology centre
- Søren Nørgaard, Project Manager within Production Engineering PU

00 FINDING

Information which leads to a Need or Demand

0.4 READING GUIDE

This project is documented in three reports: A product report, A process report, and A technical folder. It is recommended to read the reports in the following order:

- Product report: The report describes and presents the overall features and design of the product.
- Process report: The report describes the work and the decision made thought the project, which lead to the final product. The process report are presented in chronological order.
- Technical folder: The technical folder is the last report to read. The folder contains the components within the product. The folder presents the overall proportions. The production methods and budget is represented in the technical folder.

References in the reports will by presented using the Harvard-Anglia method. In the text the reference will be presented (Last-name, Year). All references are listed in the bibliography in the back of the report.
Illustrations are displayed as Illustration 3.1, where 3 refers to the page number and 1 indicate the first illustration on the page.

In the beginning of each section a short introduction will be presented. This introduction gives an overview of the section and the results. The used methods are presented in the introduction.

Dark blue colored boxes in the sections highlights sum-ups or conclusions.

The project works with emotional needs and demands, which have not been possible to translate into precise specifications. The Product Reasoning Model have been used to describe the emotional needs and demands (Haase and Laursen, 2017). Each time a frame is added or updated in the Product Reasoning Model it will be presented on its own page.

Through the process report important information and insights will be highlighted and categorized into Findings or Insight. A description of what categorizes a Finding and an Insight are presented in the boxes below. Each Finding or Insight will receive a number, which will be used as reference through the report.

00 INSIGHT

Relevant/Interesting information which is taken into account through the project but is not a need or demand

0.5 TABLE OF CONTENT

0.6 INTRODUCTION

As the general wealth is increase around the world an increasing amount of people have started to travel by plane. The industry is growing fast and passenger numbers are set to double within the next 20 years (Airbus, 2017). The increasing amount of passengers put pressure on the entire airport, but especially the dreaded security check. Security is under pressure from multiple sides, by the increasing passenger numbers but also from the increasing demands to the security level. As the industry is moving towards more low-cost flight, passengers have started to travel with more carry-ons, so an increasing amount of luggage is moving through security. The pressure to get more passengers through security faster and safer creates a stressed atmosphere for the passengers. In the stress one passenger segment have more to do than the other segments, the family. While everybody have to do the same thing, the parents needs to do it multiple times because of their children. To alleviate the pressure and adapt to the future a radical change is needed in the way we think about the security check in airports.

0.7 PROCESS TRACKING

This section will present the different steps in the process to create an understanding of the iterative process through the project. The report are divided into five phases, and will be present as close to the chronological order as possible. The phase Understand consist of to main parts, The research and The initial ideation.

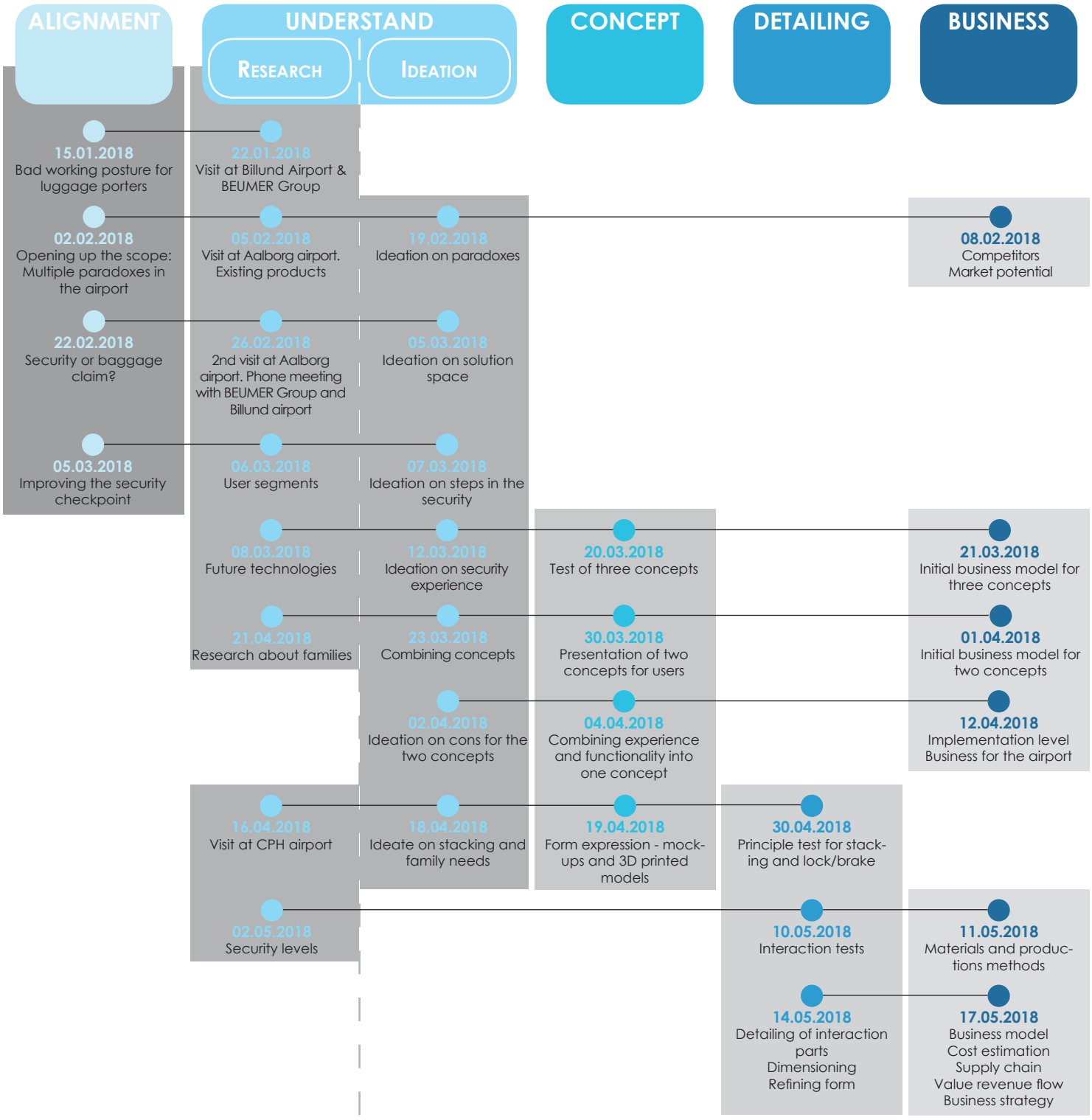


Illustration 6.1 - Process tracking

0.8 TERMS

In the report different terms have been used, which are described below.

Luggage
Luggage is categorized as the suitcases, stroller, etc., which the passengers deliver at the baggage drop.

Carry-on
A carry-on is a small suitcase or bag which are allowed on the airplane.

Hand-in items
Items which needs to be sorted into trays in the security, such as: electronics, metals, and liquids.

On-body items
Items on the body which needs to be handed in before going through the security check, such as: watch, wallet, belt, phone, etc.

Turn-Around
The time from when a plane parks at the airport to take-off.

0.9 PROJECT MANAGEMENT

The process through the project have been manage using the agile management tool SCRUM. The tool provides an overview of the process and the assignments needing to be done. The overview of the assignment provide the team with an overview of which assignment the other team-member were doing to, which help when working in parallel. The team used SCRUMban (to do, doing, done) to keep track of all the assignments. Each assignment had a worksheet stating what to do, how to do it, and what the purpose were. Assignments were time boxed to ensure team were moving forward.

Through the process two milestones were dictated by the study setting certain goal. The team had smaller milestones planned every second week with two other groups from the study. The milestones were used to get feedback from outsiders of the project.

Framing was used to communicate and control the direction of the project aligning the team in what the focus on the project were and what the team were trying to achieve.

1.0 **ALIGNMENT**

Illustration 8.1 - Visit at Aalborg Airport

1.1 INITIAL RESEARCH

The following section describes the initial research which lead the team to the airport industry. This section is based on: Desktop research.

The team started the project with desktop research, and looking at news from different profession specific. This lead to a report from "Videncenter for Arbejdsmiljø" (Winge, 2016). The report presented an issue with heavy lifts and non-ergonomic postures while transporting luggage at airports. The report is based on a survey with 3500 participants. The report investigated the problems and consequences while handling luggage. The handling often results in lower back pain and osteoarthritis in the back, shoulder, and knee.

There are currently different coping strategies on the market. Implementation and use is rare, and the study describes how they are not used in the work environment. (Winge, 2016) The aviation industry has grown with 25% in the last decade. If the growth in aviation continuous it can be expected that the amount of luggage going through the airport will increase. This can result in more focus will be put on the working environment for the luggage carriers. (The World Bank, 2018)

1.2 VISITS

To get more insight in the airport business, Billund and Aalborg Airport have been visited. The visits were arranged to gain knowledge about the luggage handling process, and see the similarities and differences in the airports. In addition, the team were interested in gaining more insight in companies providing products and systems for the airports. Meetings were arranges with managers at BEUMER Group, who provides logistic solutions for handling luggage at the airport. This section is based on: Desktop research, situated interviews, and observations through shadowing.

BILLUND AIRPORT

The first visit were conducted with the Ramp Manager Michael Hedegaard Rasmussen at Billund Airport, information about Michael can be found in Appendix I. At the visit the team got a guided tour following the luggages path through the airport.
Billund airport have introduced self-service stations for check-in and baggage drop, to reduce the wages but at the same time increase the service efficiency. (Mortimer & Dootson, 2017) The path for the luggage is automated by conveyors from the baggage drop and divided into suites. From the suit the luggage is loaded onto a transport wagon. The transport of the luggage to the wagon is done manually, and a vacuum mover have been implemented to ease the lifts. At Billund they use a PowerStow, which is a flexible and transportable conveyor which can extend to reach all spots inside the cargo hold in the airplane. The product are used for loading and unloading the airplane. A more detailed description and pictures of the luggage path through Billund can be found in Appendix II.

BEUMER GROUP

The second visit were arranged with BEUMER Group, who provides fully automated logistic solutions for luggage handling in airports. Two meetings were arranged, one with Ulrik Steen Hansen who is a developing manager and one with Per Engelbrechtsen who is the business director at BEUMER Group, more information can be found in Appendix I. The luggage handling system uses totes to transport the luggage. The totes are traceable and shows the precise position for the luggage at all time. BEUMERs automated system stops when the luggage needs to be moved from the conveyor to the transportable wagon. Ulrik Steen Hansen says "*the industry is going towards more automation which enables for tracking the luggage the entire way to the airplane*". This is a important factor for the airlines in order to avoid paying for missing luggage. Airports uses the regular tags with a bar code to identify the luggage. Some tags contains a RFID tag. More information about the meetings can be found in Appendix III.

AALBORG AIRPORT

A visit to Aalborg Airport were arranged to look at similarities and differences between Billund and Aalborg. The meeting were conducted with Tomas Nielsen who is Assisting Department Managers for the Cargo Center, Appendix I. Aalborg Airport have implemented self-service check-in and baggage drop. The tags for the luggage contain a bar-code and a RFID tag. Even though Aalborg is an international Airport, 58% of all flights are domestic. The main route Aalborg to Copenhagen makes up 50% of all domestic flights. Tomas Nielsen tells "*in Aalborg we deal with a lot of commuters, who often only travel with carry-ons. They often do not have luggage with them which need to be checked in to the cargo hold in the airplane.*" When there is luggage which needs to be placed in the cargo hold, the luggage are moved to the transportable wagon by the vacuum mover. Aalborg airport uses the same transportable conveyor PowerStow as Billund, to place luggage in the cargo hold. A more in-depth description of the visit can be found in Appendix II.

01 INSIGHT
Self-service reduces wages and increase service efficiency

02 INSIGHT
The industry goes towards automation

03 INSIGHT
Aalborg Airport is mostly domestic flights with commuters, which only travels with carry-ons so the porters do not needs to handle the luggage

The visits at the different airports and company resulted in research which were closely related to the luggage handling process and the structure in the airport. In order to open up the solutions and to be able to think outside the existing structure it was decided to open up the scope and try to find multiple paradoxes in airport. The following sections will describe the process of opening the scope up again and choosing a specific subject to be investigated further.

AALBORG AIRPORT

Second biggest airport in Jutland

Flies to 38 destinations

Handles 4.000 passengers during busy days

58% of all flight are domestic

320 employees

Uses self service check-in and baggage drop.
Uses RFID tags.

BILLUND AIRPORT

Biggest airport in Jutland

Flies to 90 destinations

Handles 6.000-7.000 passengers each day during summer

940 employees

Uses self service check-in.
Relatively new implementation of self baggage drop.
Uses bar code tags

BEUMER GROUP

Delivers automated conveyor systems

Develops solutions for industries such as:

- Airport baggage handling
- Post and parcel
- Warehouse and distribution

4.200 employees worldwide

Predict robots in the future.
Uses totes for transporting the luggage.

Illustration 11.1 - Information about the different places visited in the initial phase. (Aalborg Airport, -.) (Billund Airport, -.) (Beumer group, ,-)

1.3 VISIT AT AIRPORTS - *TASKS*

This section describes the different tasks the passenger and the luggage are going through under departure and arrival. Each step refer to the numbers on Illustration 13.1. The description of the tasks creates the foundation for the selection of one paradox for further work. This section is based on: Apprenticeship(Sperschneider & Bagger, 2003) and empirical gathered knowledge through visits and research.

DEPARTURE

Passenger

1. The passenger check-in with the luggage, this can either be done by service from an employee or on self-service stations. After check-in the boarding pass and a tag for the luggage is printed. The tag for the luggage contains a bar code and can contain a RFID tag.
2. After check-in, the luggage is delivered at the baggage-drop station. This is the last time the passenger sees the luggage before arriving at the destination.
3. The passenger enters the security checkpoint by scanning the boarding pass. The passenger separates all items from their carry-on and their on-body items before walking through a metal detector. When the passenger is approved they are allowed into the tax-free area.
4. The passenger waits at the gate before entering the airplane. If multiple passengers have carry-ons with them, some of the carry-ons can be ordered down in the cargo hold in the airplane before departure.

Luggage

5. When the luggage have been delivered at the baggage drop, it is transported to the handling area, where it gets security scanned to ensure it does not contain any illegal items. After the security scan, the luggage is sorted by destination into suits. The sorting is done by reading the printed tag which is placed on the luggage either by laser, RFID reader, or camera.
6. The luggage is moved from the window to the transport wagon. The move can happen by the help from a vacuum mover or by manually lifting.
7. The transport wagons drive to the airplane, where the luggage is moved onto the plane with a transportable conveyor(PowerStow). 1-3 workers arrange the luggage inside the plane. This can be done manually by lifting or with the transportable conveyor.

ARRIVAL

8. When the airplane arrival the luggage is unloaded by 1-3 workers. The luggage can be unloaded by the help of a transportable conveyor(Power -Stow) or manually to the transport wagon.
9. The wagon transports the luggage to a conveyor belt where it is unloaded by manually lifts from the workers.
10. The luggage is transported by the conveyor to the terminal. Passengers stand and wait at the luggage carousel to collect their luggage.

1.4 PARADOXES

The presented tasks in the airport opened up for multiple paradoxes and problems to work with. Four of these paradoxes have been chosen for further work. This section is based on: Situated interviews, observations, and desktop research.

Multiple paradoxes have been elaborated by the use of the Product Reasoning Model (Haase and Laursen, 2017) in Appendix IV, and created the foundation for selection of four paradoxes for further research. The four selected paradoxes is:

- Security checkpoint (step 3). The passenger experience the security as one of the most stressed steps while going through the airport. (SITA, 2016)
- Carry-ons (step 4). Multiple passengers travel only using carry-ons. The airplanes are not designed to handle a big number of carry-ons. This means some carry-ons needs to be transported from the gate area down to the cargo hold at the airplane.
- Heavy lifting of luggage (step 6). The workers do not use the existing equipment design to help the lifting, because the equipment is slower than during it manually.
- Luggage carousel (step 10). When the passenger arrives at the terminal, multiple passengers hurry to collect their luggage at the luggage carousel, which results in creating a chaos.

A more detailed description of the four selected paradoxes and their stakeholder can be found in Appendix V. In addition, research about existing products for the four paradoxes are shown in Appendix VI. This research created the baseline for selecting the paradox within the security checkpoint (step 3) for further work.

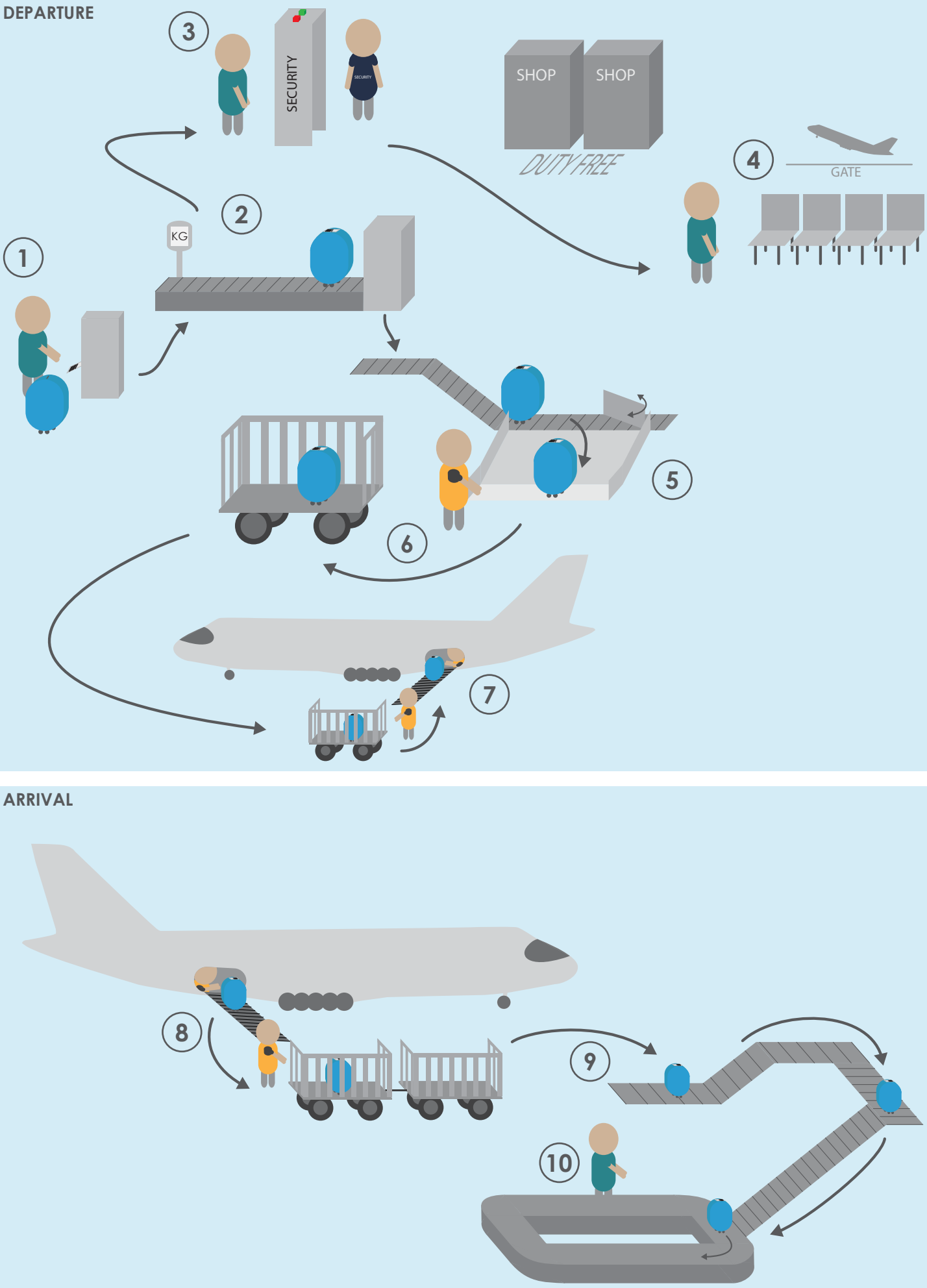
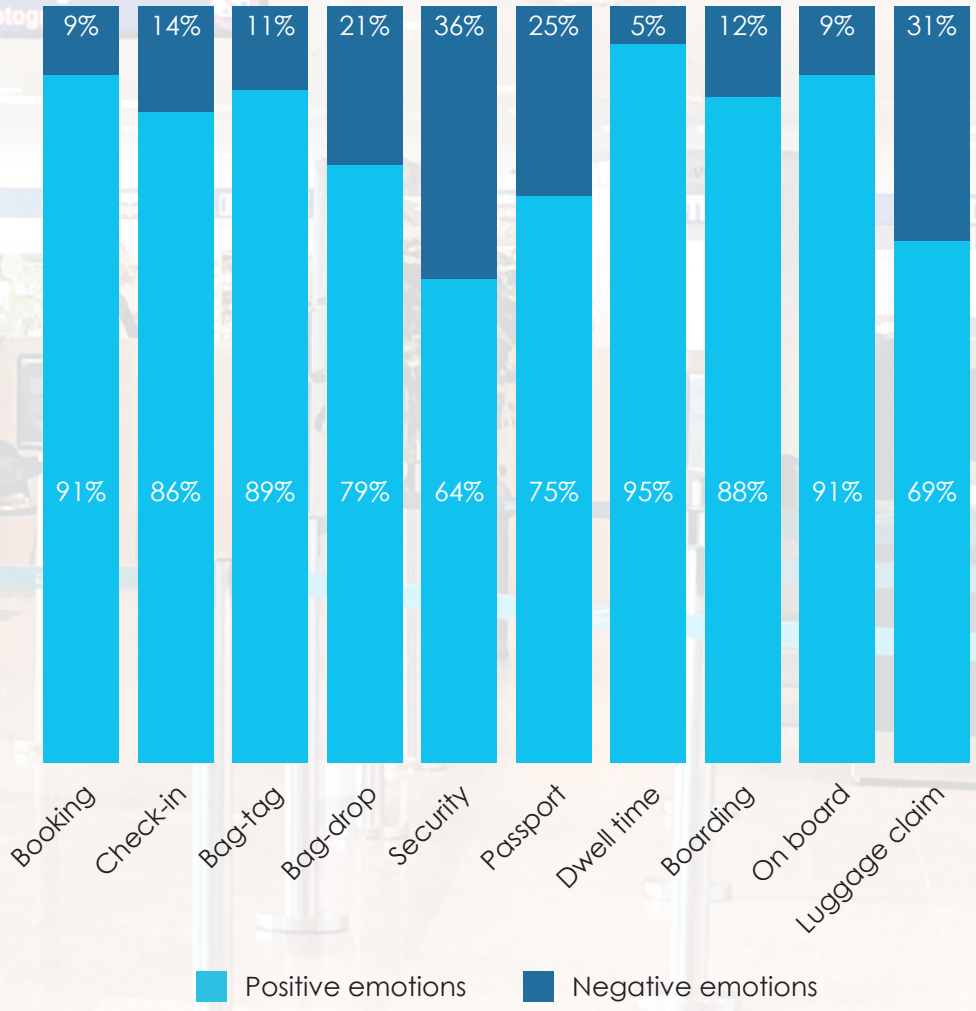


Illustration 13.1 - Tasks in the airport

2.0 **UNDERSTAND**
- THE PROBLEM -

2.1 PARADOX SELECTION

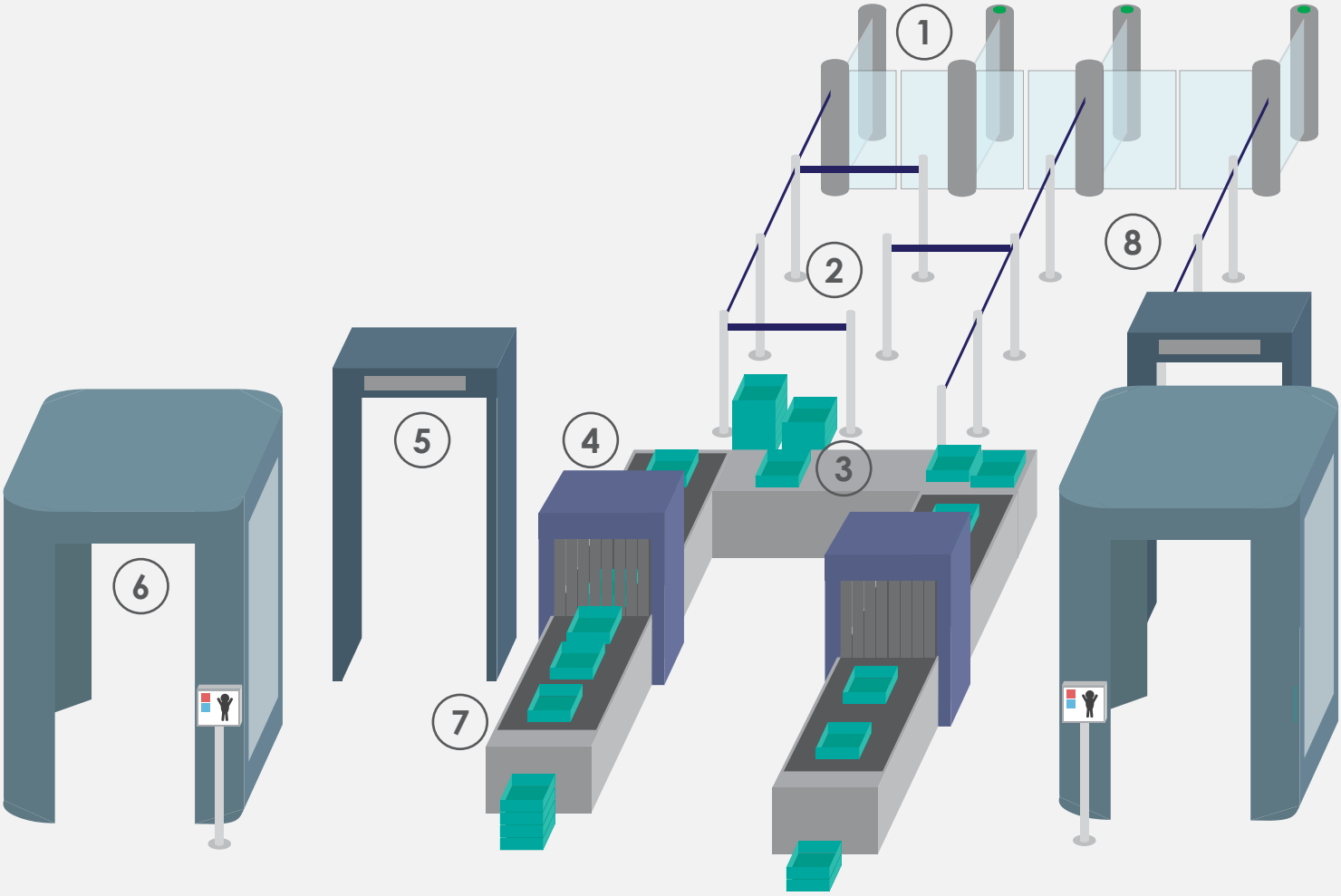
It has been chosen to work further on the development of a better security checkpoint based on interviews, observations, and desktop research. Multiple studies shows that the steps in the airport journey which creates the most negative emotions is the security check. The graph below, Graph 15.1, shows the percentage of positive and negative emotions and how they change according to the different steps while going through the airport (SITA, 2016). Different aspects in the security checkpoint makes the experience worse. The varying passengers segments all work in their own pace are slowing down each other, depending on the passengers experience. The passengers stress to get their on-body items and carry-ons into trays. The security guards uses profiling to spot potential troublemakers by looking at specific behaviors. When passengers are stressed it gets harder for the security guards to identify the potential troublemakers.



Graph 15.1 - Positive and negative emotions during the different steps while going through the airport

2.2 SECURITY FLOW

This section describes the entire security flow which the passenger needs to go through. During the description the pros and cons in the different steps are elaborated and highlighted. The different steps refers to the steps on Illustration 16.1. The pros are highlighted with **green** *and the cons are highlighted with* **blue**. *This section is based on: Situated interviews, apprenticeship(Sperschneider & Bagger, 2003) and shadowing(Sperschneider & Bagger, 2003).*



Duty free area

Illustration 16.1 - Mapping over security checkpoint

STEP 1. SCANNING OF BOARDING PASS
The first thing the passenger do is scanning their boarding pass at a **self-service scanner** before entering the security checkpoint.

STEP 2. STANDING I QUEUE
After entering the security checkpoint multiple lanes for the boarding pass scanners are narrowed down to one lane which result in **creating a queue. Younger and experienced passengers often prepare the hand-in items** while standing in the queue. If many passengers are standing in the lane **the security guards ask the passengers to prepare their stuff.** Not all passengers think that the rules apply for them, which result in them **being unprepared which slows down the rest of the queue.**

STEP 3. HAND-IN ITEMS IN TRAYS
The passengers have to hand-in their metal and liquid items into trays. The **trays are easy and simple** for the passengers to handle and **they can contain all types of items.** The passengers are often **unsure about what to hand-in and how to arrange the items,** which result in the passenger using longer time or forgetting items. The passengers often have to **use multiple trays** which becomes difficult to handle. There are a limited area for the passengers to sort their items in the trays. The trays are design so they do not interfere with the x-ray photo.

STEP 4. SCANNING OF ITEMS IN X-RAY
The trays are now transported by a conveyor though the x-ray, which makes it possible for the **security guards to control the speed of the conveyor.** The x-ray can **detect the different materials** and notify the security guards if it have **identified a potential danger.** The conveyor and x-ray is big enough to **handle different types and sizes of carry-ons.** If an overloaded tray runs through the x-ray the **items call fall out.**

STEP 5. SCANNING OF PASSENGER IN METAL DETECTOR
The metal detector **quickly detect metal items** on the person walking through. If something is detected it **indicated a smaller area** which needs to be search by a security guard. The metal detector **can only detect metal.** 10% of all passengers walking through are randomly selected by the metal detector to check if they carry liquid or other materials.
Some passengers often **doubt when to walk through the metal detector** and are waiting on getting a signal from the security guard. **The passengers have a hard time interpretation the signals from the detector** when walking through it. When a security guard is occupied, other passengers walk through without waiting for a signal. This **creates a lack in control** of when and who are getting through.

STEP 6. SCANNING OF PASSENGER IN PROVISION
If the metal detector have reached on a passenger, the passenger will be sent into the ProVision. When a passenger enters the ProVision the security guard asks **the rest of the queue to stop** until the passengers have been search by a security guard. Even through the ProVision have footprint on the floor, the passengers often **finds it difficult to know where and how to stand inside the machine.** The **ProVision can detect metal, liquid, and organic materials** and **show the precise position on the body** the material have been detected. This scanning requires the **passenger to stand still** inside the machine, which results in it taking longer time.

STEP 7. COLLECTING ITEMS AFTER SCANNING
When the passengers is accepted they need to pick up their items at the end of the conveyor. The passengers often **stands next to the conveyor which limits the pick-up area** for other passengers to get their items. Passengers needs to **stand in a queue to access their items.** When the passengers collect their items, some forget or overlook items in the trays resulting in them forgetting the item.
The **empty trays needs to be transported** by the security guards from the end of the conveyor to the start, multiple times per hour, to ensure the passengers have trays for emptying their items.

STEP 8. FAST TRACK
The **fast track is a service the passengers pays for**, so they can get through security faster. The passengers are going through the same steps as they do in the regular security lane. The passengers using fast track are **often experienced travelers.** There is a smaller amount of passengers going through fast track, which makes the **flow going faster.** The fast track are **not designed for handling many passengers at a time**, which can result in creating a queue if many passengers arrive at the security at the same time. It have been observed that **the fast track can be slower than the regular lane** if there are many passengers. The fast track **requires one dedicated security guard** no matter the numbers of passengers.

2.3 MARKET

To elaborate on the market and the different trends for traveling, there is looked into the different sizes of airports and the increasing amount of passengers. The development of security checkpoint from previous years will be presented and compared with the evolution of passenger flow. This section is based on: Interviews and desktop research.

MARKET TRENDS

Across Europe there are various sizes of airports who vary in the number of travelers they handle. To gain a better understanding of the market potential, the diagram 18.1 shows the percentage of how airport are distributed based on the passenger count. The diagram is based on data from 16 European countries and are from 2014-2015, further data about the airports and countries can be found in Appendix VII. Diagram 18.1 shows that most airports handles between 1-5 million (53%) passengers each year, this includes Aalborg and Billund airport in Denmark. Followed by the sections which handles between 5-10 million (19%) and 10-25 million (18%) passengers each year. (Wikipedia, 2018)

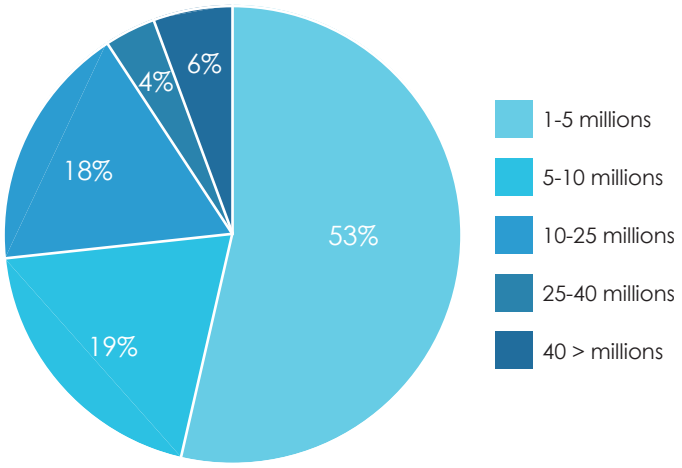
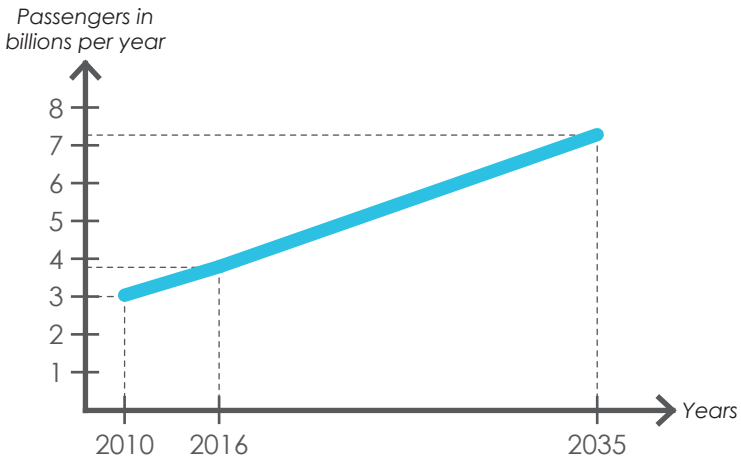


Diagram 18.1 - The different sizes of airports in Europe divided in the amount of passengers traveling each year (Wikipedia, 2018)

Oxera describes that the European aviation market have grown 25% between 2010 and 2016. The high growth is caused by a large increase of low-cost carrier(LCC) airlines, such as Ryanair and WizzAir. They sell discount flight routes. The LCC are responsible for 76% of the total growth in all sizes of airports in Europe. (Oxera, 2017)(ACI EUROPE, 2017)
One of the ways LCC earns money is by charging a fee to check-in luggage. This results in the passengers do not check in their luggage but instead use carry-ons. This increases the amount of carry-ons which needs to be scanned by the x-ray in the security checkpoint.



Graph 18.1 - Illustrates the increased amount of passengers now and in the future. 2010: 3,0 billion passengers. 2016 3,8 billion passengers. 2036: 7,2 billion passengers. (Oxera, 2017)(ACI EUROPE, 2017)(Airbus, 2017)(IATA, 2016)

It is predicted that growth of passengers will continue and by 2036 the amount of passengers will be doubled since 2016, shown on Graph 18.1.(Airbus, 2017)(IATA, 2016)

04 INSIGHT
The aviation market have increased by 25% the last 6 years

05 INSIGHT
75% of the increase are by low-cost carriers (discount airlines)

06 INSIGHT
Low-cost carriers charges a fee for in-checked luggage, resulting in many travels with carry-ons

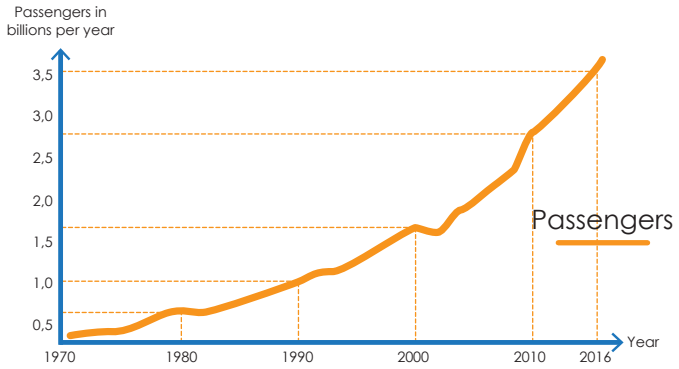
07 INSIGHT
The amount of passengers have been predicted to be doubled in 20 years

DEVELOPMENT OF SECURITY

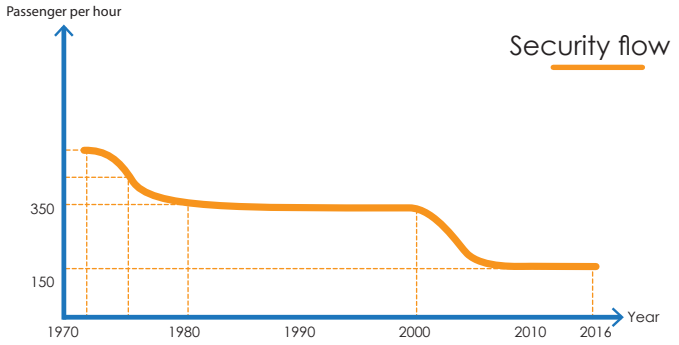
This section will elaborate how the development of the security have changed in the pass decades. The passenger numbers are increasing [Insight 4 & 7]. The increase from years 1970 to 2016 are shown on Graph 19.1, (The World Bank, 2018). The increase of passenger is influencing the level of security. In the late 1960's the first steps towards airport security were taken, with the introduction of security guards in the airport and the first metal detectors. Through the 1970-80's stricter security checks were implemented with the introduction of scanning of all carry-ons, people, and checked in luggage. After 9/11 attack in 2001 uniform security practices were started to be implemented. Security develops through addition, presented on Graph 19.2. If the airport needs to be more secure a new step is added. When a step is added to security it adds additional time for the passengers to go through. (BBC, 2016) (Engle, 2011)

SCALE OF INNOVATION

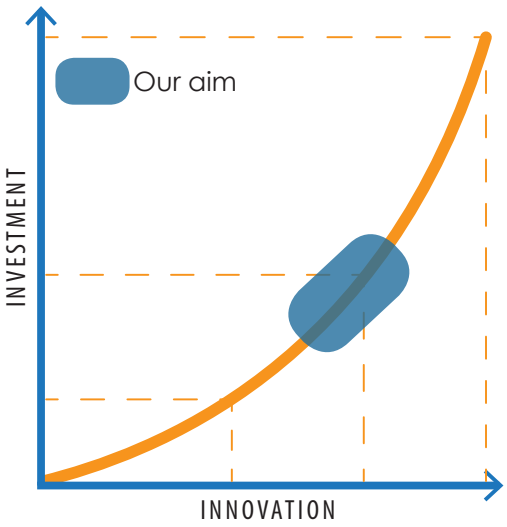
The development of security checks and the increase in passengers are contradicting each other by decreasing passenger flow when passenger count is increasing. This section will describe where to be positioned on the scale of innovation, to add up the future development in the airport security checkpoint. To understand the position for a new product, the level of investment must be taken into consideration. A solution which can be implemented in the current security system requires a small investment. A solution which is invasive or innovative, multiple elements of the current security system is rethought and needs to be changed, which results in the investment being high. Airports capital is dependent on its size. Larger airports have higher capital and have bigger investment pools. This means that the level of innovation effects the choice of which size of airport are in focus. The increase of passengers in the future combined with how the security flow is evolving, indicates a need for a radical change. Due to these factors the team aims high in the level of innovation, which is indicated on Graph 19.3.



Graph 19.1 - Passenger increase from 1970 to 2016 across the world (The World Bank, 2018)



Graph 19.2 - The decrease of passenger flow from 1970 to 2016. After 9/11 in 2001 the speed though security got a big decrease because of an increase of the security level. (Richardson, 2013) It have not been possible to find data on passenger flow before 1980, but it is estimated to be higher due to the lower security restriction



Graph 19.3 - Scale of innovation shows the relation between innovation and investment for our case. While also presenting our aim.

The increasing amount of passengers and discount airlines creates a problem for the security checkpoint. They needs to adapt for handling more carry-ons but still separate and scan them during the security check. The development of the security check in the pass decades shows a stepwise implementation of new security levels decreases the passenger flow. This indicates a need for making a radical change in new systems for the security checkpoint, to add up with the increasing amount of passengers. The team wants to focus on making a product with a medium to high innovation level. This results in a high investment from the airports. Even through the majority of airports handles between 1-5 millions passenger each year, it is not the airports which a new product aims for. The increase of passenger traveling results in many of the small airports are expanding, and reaches the other airport sizes. It is chosen to aim for the rest of the airports, which handles between 5 - 40 > million passenger each year.

2.4 FRAME

The following section describes the initial frame which the team were working with in the current stage of the project. This framing is based on the previous presented data and through the ideation presented in Section 2.5.

After the first visits at the airports the team constructed the initial frame for the project. The team constructed the frame to align; what the problem were, what the team were trying to accomplish, and how to accomplish it.
The frame is developed based on the interviews, observation and sketching. Sketching on working principles gave an indication about how to achieve the aspired value.
Table 20.1 present the initial frame at the current stage in the project.

		Like an traffic controller		
NEW	Main Paradox	**Insight** Passengers and the airports want a fast and effortless flow through security. Trouble arises as soon as one person is slower than the rest. It creates a trickle-down effect slowing down the whole queue.	**Aspired value** Getting passengers through security faster.	**Working principle** Flow control, ensure passengers are moving. Getting passengers who are done out of the way.

Table 20.1 - Framing

2.5 FIRST IDEATION - STEPS IN SECURITY FLOW

This section presents the first sketch round. The sketch round is based on the steps in the existing security flow which were presented on page 16. This section is based on: Empirical knowledge gathered through visits at airports and desktop research.

The first sketch round resulted in many different types of ideas, because they focused on many different problems in the security flow. All the ideas and the current steps they solve in the security flow are presented in Appendix IIX.

The research about the increasing amount of passenger and lack of development of the security equipment, indicated that a new product needs to be radical different. The sketching focused on the existing security flow which resulted in a limited solution space. Many ideas were add-ons to the existing flow. These ideas did not align with the previous presented research, which set a demand for thinking differently. The solution space needed to be opened up for making ideas which focused on the radical change in the flow. Some of the ideas for the first sketch round did contain some radical parameters and aspects. These ideas are presented on Illustrations 21.1-21.4.

The team found a need for focusing on a more specific area to clearly define different problems and needs for the passengers.

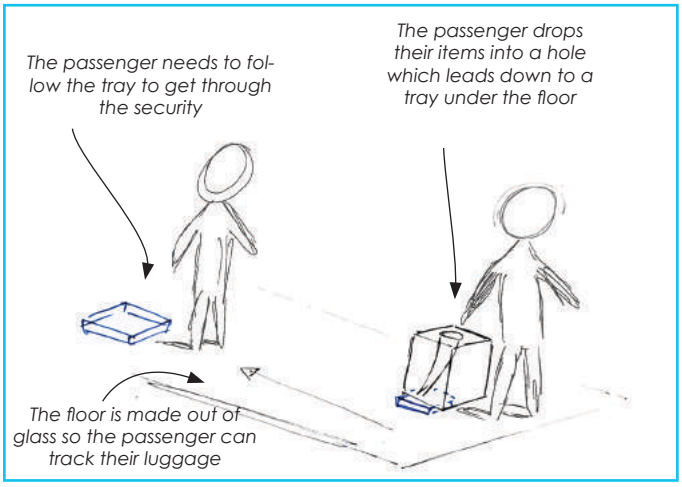


Illustration 21.2 - Trays under the floor
Principles: The passenger are guided through security by follow the luggage without the passenger needs to carry it

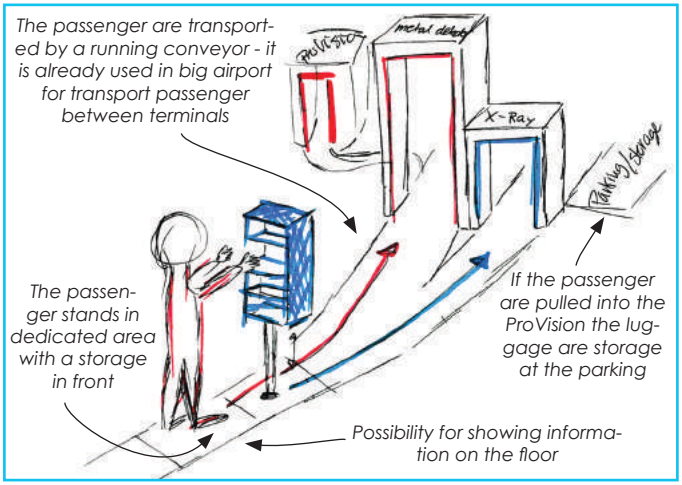


Illustration 21.3 - Running conveyor with individual storage
Principles: The running conveyor controls the speed and where the passenger and their luggage are going

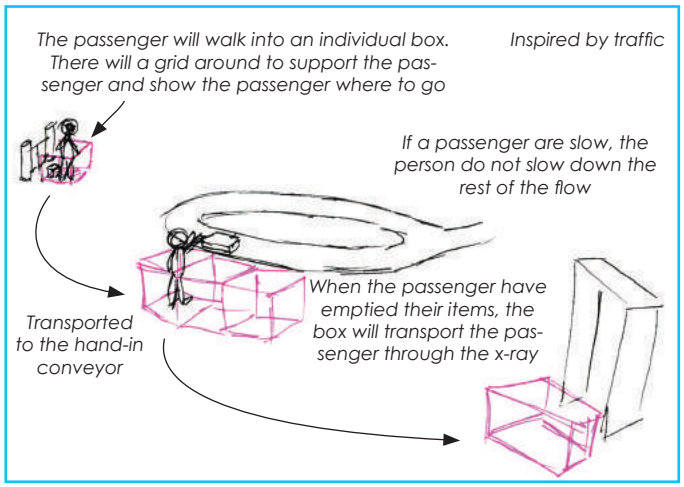


Illustration 21.1 - Individual transport of the passenger.
Principles: The cart drives the passenger and allows the passenger to use the time they need.

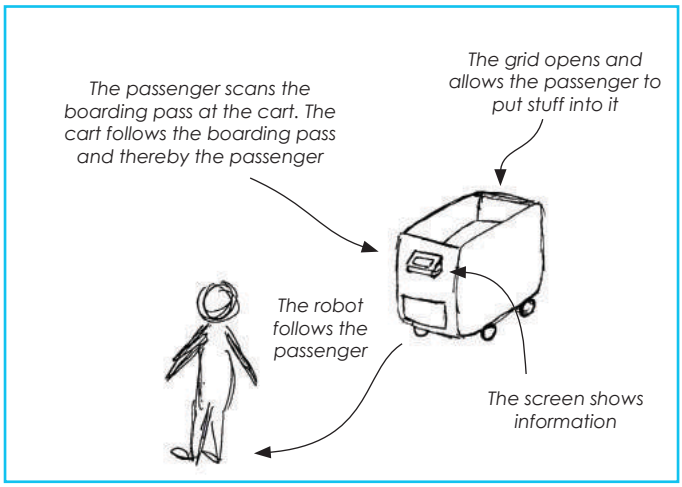


Illustration 21.4 - Self-driving cart
Principles: The passenger do not need to think about their luggage because it follows the passenger

2.6 SEGMENTATION OF PASSENGERS

After the first sketch round it was decided to research about the passengers to gain an better understanding of which passenger are traveling and their individual needs. The different passengers will be elaborated in this section and divided into four segments. Information about the segments and where they have problems in the security check are being presented. The segments are described based on; their personal relationship, their purpose of travel, and which part of security they have trouble with. This section are based on: Observations and situated interviews with passengers and security guards.

The higher number of passengers [Insight 4] leads to a mixture of different travelers. These travelers have been divided into four segment; Elderly, Families, Business, and Young. The different segments act differently while going through security check, which result in them having different needs.
For each of the segments there are made a description of where in the process they have problems. The description are based on Illustration 16.1. The description is a generalisation of the travelers, and are based on the observations and interviews made at the airport.

ELDERLY

The elderly takes longer time doing the steps because they are not in a hurry. They like to know the procedure and use time talking with the security guards.
Step 3: The elderly are unsure about what to place in the trays, which result in them getting stressed and thereby loss overview.
Step 5: They do not know when to walk through the metal detector and are having a hard time understanding the signals. The elderly are often afraid of during something wrong, because they might be afraid of the technology.
Step 6: They have a hard time knowing how to interact with the ProVision, and they do not know what to do when getting out of it.
Step 7: The elderly are slow to empty their trays at the end of the security check.

FAMILY

The parents are occupied by the children to ensure the children behave, feel safe, and that the children hand-in all the items. This results in the families taking longer time while during the steps.
Step 3: Needs to use multiple trays for carrying all their items. They can get distracted by the children which can result in forgetting to hand in items.
Step 5: The parents needs to keep the children in check and getting them through while still making them feel safe.
Step 6: If the parents are inside the ProVision, the children stand alone.
Step 7: The parents needs to keep the children in check but at the same time remember all trays and the items inside it.

BUSINESS

The business travelers are often experienced and know what to do. They are often in a hurry to get through security. They are willing to pay extra to use the fast track(step 8) to get more smoothly through the security.
Step 2: They can be slowed down by less experienced travelers.
Step 3: They need to separate a lot of their items which requires the use of multiple trays. It can also result in forgetting items for hand-in.

YOUNG

The young travelers are fast to understand what to do in the different steps and often preparing before entering the next step in the flow. They are not afraid of the technology or doing something wrong.
Step 3: The passenger often carry multiple electronic devices which needs to be separated and thereby requires the use of multiple trays.
Step 5-6: The passengers think they know what to do in these steps, but they often creates problems because they are doing it wrong or to fast.
Step 7: The young travelers often think they are fast enough to collect their items while standing at the conveyor. This can result in creating queue and not allowing other passenger to access their stuff.

08 INSIGHT

Parents are distracted by their children resulting in stress and forgetting to hand in items

09 INSIGHT

Families and elderly slows down the faster and more experienced travelers

2.6.1 SEGMENTATION OF PASSENGERS - *AIRPORT EXPERIENCE*

In the following section the different types of travelers are elaborated and divided into different segments based on their expectation to the airport.
This section is based on: Interviews, observations, and desktop research.

Traditionally passengers have been segmented based on; the purpose of their travel, and how frequent they travel. The traditional segmentation criterion's does not provide enough insight in the passengers needs. More recent models have been taken into use to elaborate these needs. A study from Copenhagen Airport based on interviews with over 100.000 passengers, resulted in a segmentation of passenger into four categories. The categorizing were based on the passengers engagement in the airport environment and expectations of service from the airport, see Illustration 23.1. The percentage shows the amount of all passengers in the certain category. (Harrison, et al., 2015) (Københavns Lufthavne A/S, 2012)
The airports have started to compete against each other, to attract most passengers due to the short distance between airports. One of the competing parameters is the experience in the airport. (Harrison, et al., 2015)

Each of the passenger segments, Elderly, Families, Business, and Young, all fits into the four categories. A rough generalization have been made, fitting the segments into the model, Illustration 23.1. The study presents that the efficiency customers often consist of business travelers. But when the business traveler travels together with family, the habit will be reflected in the entire family (Københavns Lufthavne A/S, 2012). The business travelers often represent a wealthier part of the population, and they are willing to pay for services to get faster through. They are on the other hand also a part who does not use the facilities such as restaurants or tax-free in the airport. They rarely browse the areas in the airport, making it hard for the airport to get a commercial gain on them. (Freathy & O'Connell, 2000)

The leisure travelers, Elderly, Families, and Young, are on the other hand are more into using facilities in the airport. The leisure travelers are in the airport for a longer time than the business travelers, because of the difference in check-in time. The wait means that this group is more prone to shopping in the tax-free zone. (Freathy & O'Connell, 2000)

10 INSIGHT

Airports are competing on the experience to attract passengers

11 INSIGHT

Leisure travelers, Elderly, families and young, see the airport as a travel experience

It have been chosen to work further with the family segment. The choice is based on that this segment is involved with the experience in the airport and they see the airport as a part of the traveling experience. Furthermore the families have more problems in the security than the other segments, because they need to have focus on their children.

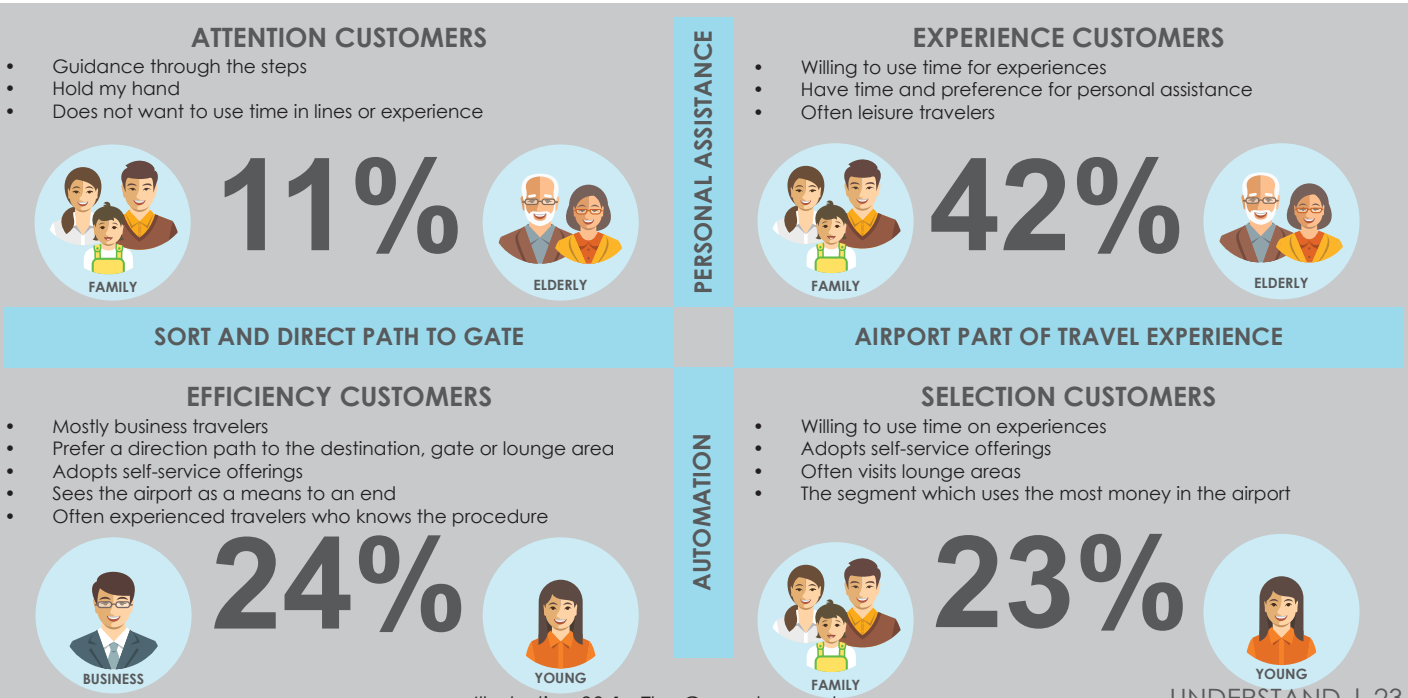


Illustration 23.1 - The Copenhagen taxonomy

2.7 FRAME

The following section describes the additional frames that the team were working with after further research into the customer segment. The framing is based on: Desktop research, observations, and interviews.

As the team gained a better understanding of the problem, the users, and their needs, additional frames emerged. After additional observation at the airport it became apparent that the families carry more items than the regular passengers. Families used more times to separate. The families look stressed and hurried a lot when separating the items. Table 24.1 is an updated version of the frame presented in table 20.1 on page 20. Additional frames have been added.

NEW UPDATED

Main Paradox	**Removing the slow**		
	Insight Families are the ones who have the hardest time in security. They are slower and more stressed than the other passengers [Insight 08]. Their slowness slows down the faster segments [Insight 09]	**Aspired value** Enable the fast to be fast	**Working principle** Remove the slowest segment from the regular security lane
Interaction	**Providing time and space**		
	Insight The parents are distracted by their children which creates stress and mistakes in the separation process [Insight 08]	**Aspired value** Provide families with the time and space necessary for them to be less stressed	**Working principle** Removing families from the regular security lane
Experience	**Stress reduction**		
	Insight Families are a segment who see the airport as a part of the traveling experience [Insight 11]. Their vacation start at the airport	**Aspired value** Create a less stressful experience for the families	**Working principle** Removing the families from the stressful environment

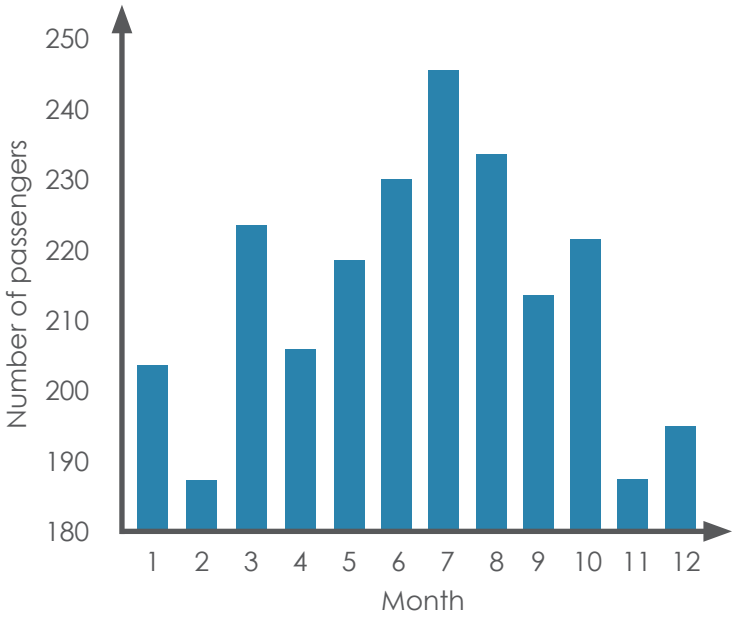
Table 24.1 - Framing

2.6.2 SEGMENTATION OF PASSENGERS - *FAMILIES*

This section elaborates on the families, to gain more insight in their traveling patterns. This section is based on: Observations and desktop research.

The families is an important factor for the tourism industry. The traditional family model consisting of two heterosexual parents and two children are starting to demise. The family sizes have changed, and a family can today be a minimum of two persons, containing a parent with one child. (Schänzel & Yeoman, 2015)
Families are starting to see the traveling as an educational experience, with possibilities for education on culture or activities (Poder, 2015).

The amount of passengers traveling depends on what time at the year it is. The distribution of passengers traveling each month are presented on Graph 25.1. The winter season, November to February, is the season with the lowest number of passenger traveling. The season were dominated by a low traveling distance for the different routes. Both spring and autumn are handling a bigger amount of passengers than the winter season. But the passenger flow peaks in the summer season, June to August. The peak is a result of many families with children having summer holiday during the summer season, and use time on traveling. (Mao, et al., 2015)



Graph 25.1 - Showing the number of passengers traveling each month in 2010

The top motivation for families for going on a vacation is to be together with the family. The following motivations which is close by, are the motivation to get away from the normal life and the motivation for relaxation. (Gelfeld & David, 2015)
These motivations are having an affect on how the passengers are moving around in the tax-free area in the airport. Young, families, and elderly are all using the restaurants as the top amenity at the airport. As the second amenity the young passenger and families are using time on retail stores. The second amenity for the elderly is to do nothing, as i.e. waiting at the gate. (Gelfeld & David, 2015)

The vacation begins and ends at the airport, which makes it possible for the family to be in the vacation mood when reaching the airport. The research indicates that the family sees the traveling as a part of the experience, because they want to use time with the family.

12 INSIGHT

The family sizes are changing to be a more varying number of parents and children

13 INSIGHT

The majority of families are traveling in the summer season, June to August

14 INSIGHT

Top motivations for families to go on vacations is to be together with the family, get away from the normal life, and relax

15 INSIGHT

Families and young passenger are using restaurants and retail store in tax-free area

2.6.3 SEGMENTATION OF PASSENGERS - *DECONSTRUCTION OF PASSENGER*

The following section describes the amount of items and carry-ons families carry while in the airport. A deconstruction of the on-body items will furthermore be elaborated to get information about the amount of items which needs to be handed in before walking through the security checkpoint. This section is based on: Observations, interviews, and desktop research.

A survey made by NEA shows that 76% of all passengers are carrying a carry-on when walking in the airport, Illustration 26.1 (Berdowski, et al., 2009).
Parents traveling with an infant under two years, will have the standard diapers bag with them, to ensure they have diapers, clothes, toys, food, etc. for the child. Parents traveling with toddlers and school-aged children, often pack a backpack for each child. It is possible to get backpacks suitable for children, which can contain toys, books, and clothes. (Poirot, 2010)

Passengers cannot bring liquid or gel which is more than 100 ml. Each passenger will receive zip-locked bags, to store all liquids. Parents traveling with infants are exempt from the rule, so they can carry breast milk or baby food. But the food needs to be removed from the carry-on bag before going through the security.

It is permitted to take infant carriers and strollers through security (Poirot, 2010). Observations at the airport showed that most families with one or multiple children brought their own or borrow one stroller at the airport, for transporting one child, even through they had multiple children.

A carry-on bag can have different sizes depending on the restrictions from the airline. The weight of the carry-on allowed varies depending on the individual airline, but range between 5-12kg. The area inside the airplane sets the limit for the size and weight for the carry-on. The carry-on must fit the compartment above the passenger or under the seat in front. The passenger must handle the carry-on without the help from a airline employee. The biggest and most common carry-on size is 56cm x 45cm x 25cm. (Kayuvalise, 2017) (Travel Made Simple, 2017)
The majority of airline allows the passengers to bring one carry-on together with a personal item. The personal item is categorized as a smaller bag, and could for example be a purse, laptop bag, briefcase, etc. (Travel Made Simple, 2017)

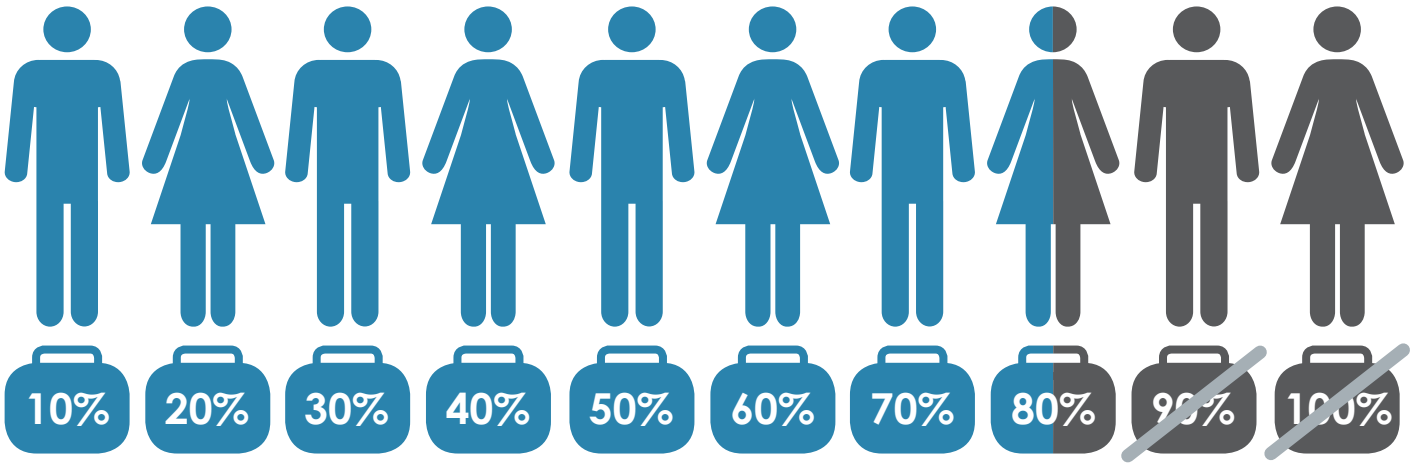


Illustration 26.1 - 76% of all passengers are traveling with a carry-on

ON-BODY ITEMS

Research and observations have been made to gain a better understanding of the on-body items which the families carries. The most average items are shown on Illustration 27.1. A more detailed description of the items can be found in Appendix IX. The information about the items indicated that the area which contains the most on-body items are the part around the wrist and hands. An estimation on the amount of on-body items for one family consisting of two parents and two children, resulted in a list of the amount of on-body items which a solution must be able to contain. The amount of items are presented on Illustration 27.1.

02 FINDING

The parents and children can carry one carry-on together with one personal item each

03 FINDING

A family uses one stroller independent of the number of children

04 FINDING

The biggest and most common dimension for a carry-on is 56cm x 45cm x 25cm

16 INSIGHT

Parents traveling with infant carries a standard diapers bag

01 FINDING

76% of all passengers are carrying a carry-on

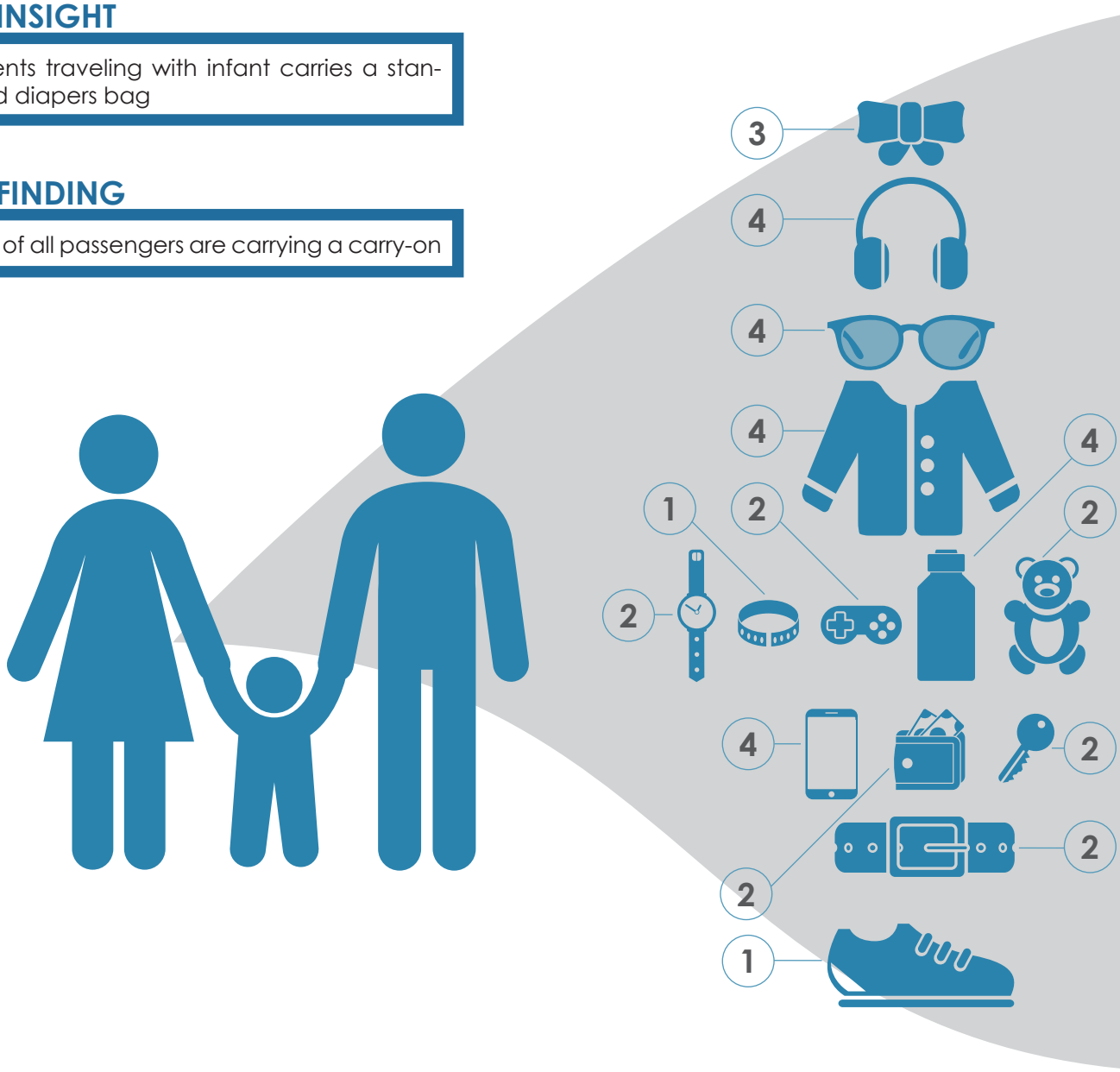


Illustration 27.1 - On-body items

2.8 EXISTING PRODUCTS AND CONCEPTS

This section elaborates on existing and new products used in todays security check. Some of these products have been implemented in new security setups around the world to make a more pleasurable security check. This section is based on: Interviews and desktop research.

As presented in section 2.2, a security check contain an x-ray machine to scan the carry-ons and the items. The machines used for scanning the passenger are first a Metal Detector and afterwards a Pro-Vision to ensure the passenger do not carry any illegal items. An example of a security checkpoint are shown on Illustration 28.1
Smith Detection is a company on the market providing x-ray machines and personal screening for security checkpoints. (Smiths Detection, -)

Airports and companies are trying to optimize and make the security checkpoint a better and faster experience for the passengers.
TSA (Transportation Security Administration) are testing a new CT scanner, which uses the same x-ray scanning technology as used in hospitals, Illustration 28.2. This makes it possible to create a 3D image of the items going through, which means the passenger do not need to use time on separate their items from the carry-on. (Stewart, 2017) (analogic, 2018)

Some airports are trying to ease the flow and make the experience in the security check better by changing the setup. The company Scarabee helps the airport to design and develop a security checkpoint which fits the airports needs (Scarabee, 2018).
The airport Schiphol in Amsterdam have tried to change the setup for the security check, by implementing round conveyors with trays appearing when you need it. They have tried to make the security more relaxed and cosy by using natural materials, Illustration 28.3. (Louwerse, 2014) (Scarabee, 2018)
The Bristol Airport in United Kingdom have designed and developed a security area which provided the passengers with a more user-friendly experience, by using round conveyors and adding natural materials, Illustration 28.4. (Scarabee, 2018)

05 FINDING

Using CT scanning of items to create a 3D image without the passenger emptying their carry-on

Illustration 28.1 - Security check in Aalborg airport

Illustration 28.2 - CT scanner developed by analogic. Creates a 3D image of the items inside it.

Illustration 28.3 - Schiphol airport in Amsterdam

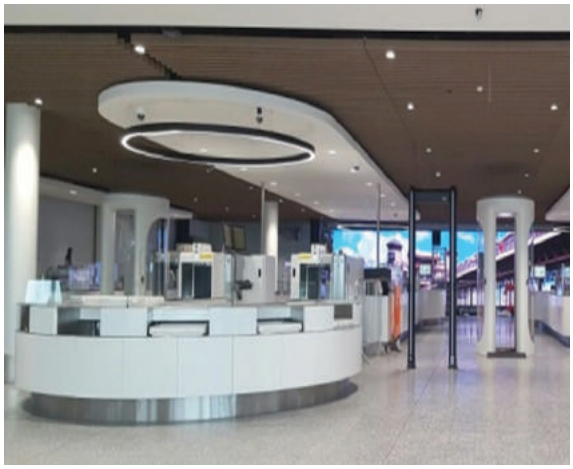


Illustration 28.4 - Bristol airport in United Kingdom

Illustration 29.1 - Qylatron

Illustration 29.2 - Exruptive

Illustration 29.3 - Walk through scanner by IATA

Illustration 29.4 - IATAs scanner search for different types of items depending of the passengers status

This section will present some existing concepts and how they will try to influence the future security checkpoint. This section is based on: Interviews and desktop research.

QYLATRON

The product Qylatron is a concept developed to create a new way for handing in items in a security scanner, Illustration 29.1. Qylatron have been tested within limited time period at a stadium in USA. The passenger scans their ticket at one of the green doors which afterwards opens. The passenger places the items in the box which is scanned. The Qylatron uses a combination of x-rays, a sensor to detect chemicals, and artificial intelligence to detect illegal items. If the items have been approved the door on the other side of Qylatron opens and allows the passenger to collect the items. (Matchar, 2015)

EXRUPTIVE

Exruptive is a concept which combine a new way for transporting the luggage and scanning it, Illustration 29.2. Exruptive have designed a Intelligent Trolley which allows the passenger to use from the check-in area to the gate. This makes it possible for the passenger to prepare their items before standing in the security check. The trolley have a screen which informs the passenger with important information. (Exruptive, 2018) Exruptive are at this point being tested at testing facility. (Exruptive 1, 2018)(DIS, -)

IATA

The concept from IATA (International Air Transport Association) have been developed to make the "Checkpoint of the future". The concept uses eye scanners, x-rays, metal- and liquid detectors for scanning the passenger and their items. The concept makes it possible for the passenger to walk though without handing in any items. The passenger needs to be signed up in a system before entering, which allows the passenger to enter one of the three gates; enhanced security, normal, and known traveler, Illustration 29.3. The three gates search for different items and materials on the passenger, Illustration 29.4. The "Checkpoint of the future" were presented in 2011 and it was predicted to be on the market within five to seven years. It have not been possible to find information about the progress and status on the concept now. (Nguyen, 2011) (Travelmail, 2011)

2.8.1 EXISTING PRODUCTS AND CONCEPTS - *MARKET POSITION*

The presented products and concepts from the previous section, will in this section be evaluated. The evaluation will be use to see which parameters the competing products compete on. Based on these parameters the team examine how the team's solution can differentiate. This section is based on: Desktop research, observations at airports, and interview with CPH Airport.

A visit at Copenhagen Airport were conducted. At the visit the team presented the previous presented products and concepts. The presentation included a mappings of the products and concepts according to the three parameters; Security, Flow, and Experience. The parameter Security imply the level of products used to ensure the a high level of security. The parameter Flow imply the speed of passengers going through. The last parameter Experience implies the experience the passenger feel while going through the security.

Together with the airport the team had a discussion about the mappings. This resulted in two mappings presented on Illustration 30.1 and 31.1. Illustration 30.1 presents the existing products in the security check, which have been divided into two; The Regular Security and The Modernized Security.
The Regular security focuses on security and flow optimization, and less on the security experience. This relates to the beginning of the implementing of security, where the main focus were the security check. This obstructed the flow and the experience for the passengers. When airports modernize the security checks, they starts to focus on the experience, by using natural material and changing the interior. The setup have incremental changes on how the check is done. Newer technologies are increasing the security level by being more precise and detailed.

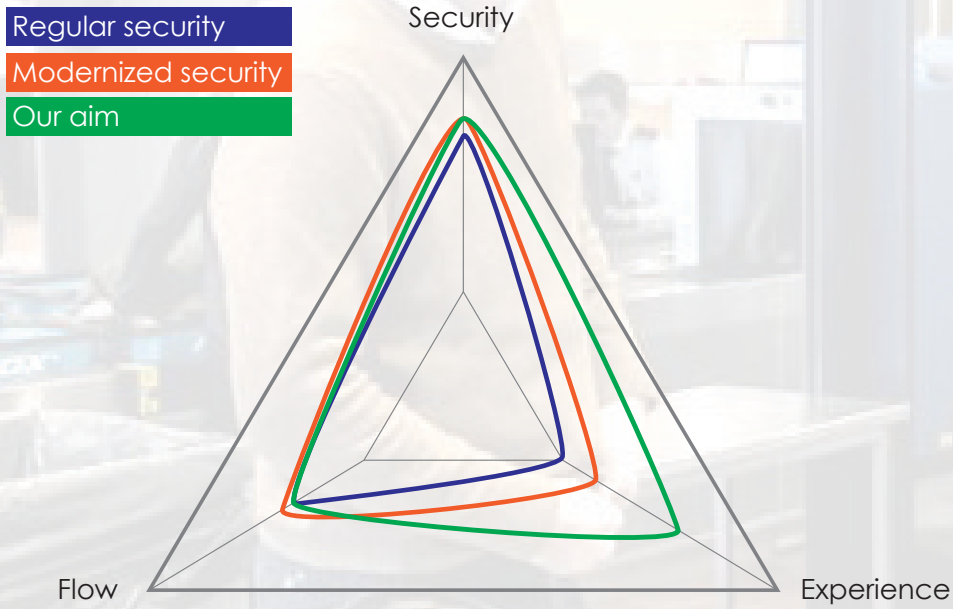


Illustration 30.1 - Mapping of the regular and modernized security, compared with our aim

17 INSIGHT

Airports are modernizing the security check to provide a better experience

Illustration 31.1 presents the mapping of existing concepts. These concepts focus on making the security checkpoint a better experience by changing the way passengers think about security.
Qylatron tries to improve the flow by allowing five passengers to scan their items at the same time. But the limited space makes it difficult for multiple passenger to stand next to each other. The product is currently presented as a stadium product meaning security features such as trays are not present, and no solution for on-body items is shown. The lack of solutions for on-body items could result in a worse experience.

Exruptive focuses on removing the sorting of the passengers carry-on, and provides the passengers with a place for on-body items. This creates a smoother experience for the passengers. The product uses a new x-ray technology to enable the passengers to scan the whole cart at once. Exruptive's main focus is to improve the passenger flow. (Exruptive 1, 2018)

IATA's security scanner which allows the passenger to walk through, together with their carry-ons and on-body items. This makes the speed of passenger flow fast, due to the passenger do not use time on handing in items. Furthermore are the security level high because all passenger receive a full body scanning. Because the passenger only walks through the scanner, the bad experience in the security check is minimizes because the passengers hardly notice they are security scanned.

18 INSIGHT

Existing concepts main focus is to improve the passenger flow

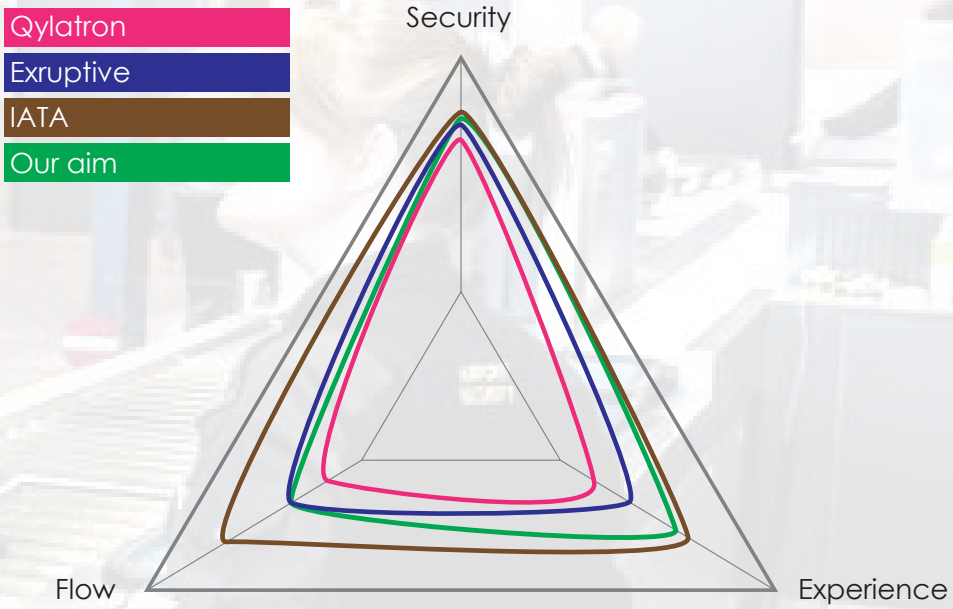


Illustration 31.1 - Mapping of existing concepts compared with our aim

New concepts indicates a trend which focuses more on the experience. This is also represented at the modernized security. The aim for a new product is to be a competitor to the experience which are created while going through the security checkpoint. The teams focus is on the experience in the security check, and it is the main parameter which the team is competing on. In addition, the team improve the flow by using a separation model on the passenger segments, to add up with the increasing amount of passengers in the future [Insight 7]. The product add up with the high level of security to keep up with increase of security demands in the future.

2.9 FRAME

The following section describes the additional frames that the team were working with after further research into the customer segment and competing products. This section is based on: Desktop research, Observation and interviews.

The team developed a deeper understanding of the problem but also the perception and expectations the families have to the airport. The insight [Insight 11, 14, 15, & 17] inspired the team to update the experience of security to accommodate the families expectations for the airport into the solution. The team started to see the security check as the first activity on the vacation, instead of the last activity before the vacation. The insight [Insight 18 & 19] in the competing product also underlined the need for more focus on the experience. As this were one of the competing parameters the competitors did not have in focus.
The current frames in this stage of the project is presented in table 32.1.

	Main Paradox	**Removing the slow**		
		The main paradox is the same as presented in Table 24.1 on page 24		
UPDATED	Interaction	**Providing time and space**		
		Insight The parents are distracted by their children which creates stress and mistakes in the separation process [Insight 08]. Families have more carry-on items than the other passengers [Insight 16][Finding 01, 02, & 03]. Meaning they have more to separate and therefor needs more time.	**Aspired value** Provide families with the time and space necessary for them to be less stressed	**Working principle** Removing families from the regular security lane
UPDATED	Experience	**Like an amusement park**		
		Insight Families are a segment who see the airport as a part of the traveling experience. Their vacation start at the airport [Insight 11]. Other companies main focus is on passenger flow [Insight 18]. Airports compete with each other. In this competition experience is an important parameter [Insight 10]	**Aspired value** Create an experience for the families	**Working principle** Implement a game in the security check. Sightseeing
NEW	Interaction	**Providing clarity**		
		Insight Families find it difficult to remember what to hand-in and what to separate because of the stress and the children being distracting [Insight 08]	**Aspired value** Give families the necessary information to help them separate and prepare for the security check	**Working principle** A screen providing families with information Silhouette showing where what to hand-in Step-wise progression for handing in items

Table 32.1 - Framing

2.0 **UNDERSTAND**
- THE SOLUTION SPACE -

2.10 IDEATION

This section presents the ideation on ideas where the purpose is to create a radical change in the security check. The ideation is based on the some of the principles presented in section 2.5. The ideation is created under the previously presented framing on table 32.1. The section is based on: Empirical knowledge gathered through visits at airports and research, together with the Concept screening matrix (Ulrich & Eppinger, 2012).

To create a more family-friendly security three parameters were in focus:

- Creates control by guidance and information
- Indicates the progress
- Creating fun by implementing a game

The team sketched on how to create a family-friendly security check which resulted in multiple solutions, all sketches can be found in Appendix X. A selection of six sketches have been chosen, based on their different approach to create a more family-friendly security. The description below describes the working principles for the selected sketches, presented on Illustration 34.1-35.3.

Illustration 34.1 - Idea 3: Creates an individual space for the passenger to prepare. When the passenger are ready to move forward the wagon moves and shows the way.

Illustration 34.2 - Idea 4: Creates a closed and individual room for the passenger. The passenger are scanned and at the same time informed about what to hand-in. When the passenger have handed all items in, the gates opens and allows the passenger through.

Illustration 34.3 - Idea 5: A self-driving cart which the family enter at the parking lot. The cart drives around at the airport and entertain the children while the parents separate the items before arriving at the security check.

Illustration 35.1 - Idea 6: Creating a game for handing in the items fast before being scanned. The passenger can compete against each other and thereby ease the hand-in process.

Illustration 35.2 - Idea 15: The passenger stand on a platform where a hologram appears and shows the passenger which items there have been dedicated on the body. The hologram ensure the passengers do not feel captured.

Illustration 35.3 - Idea 16: The podium indicates how far the passenger are in the security progress. When the passenger reach the top all items have been handed in and allows the passenger through.

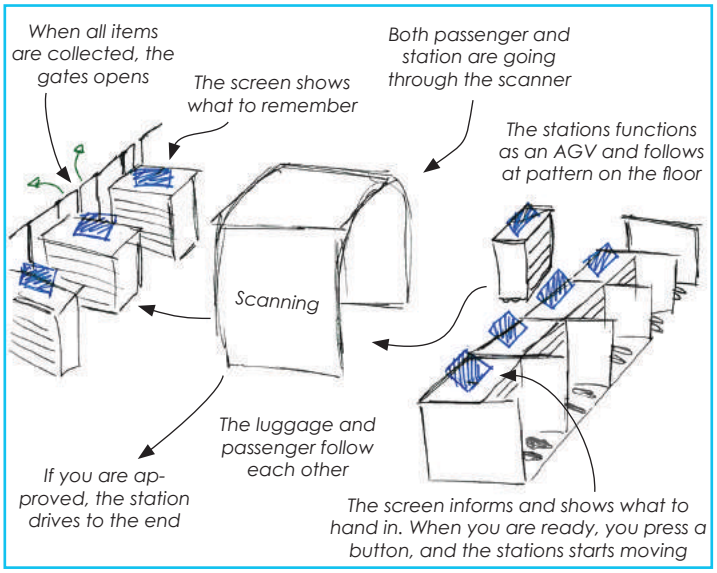


Illustration 34.1 - Idea 3: Individual and self-driving station

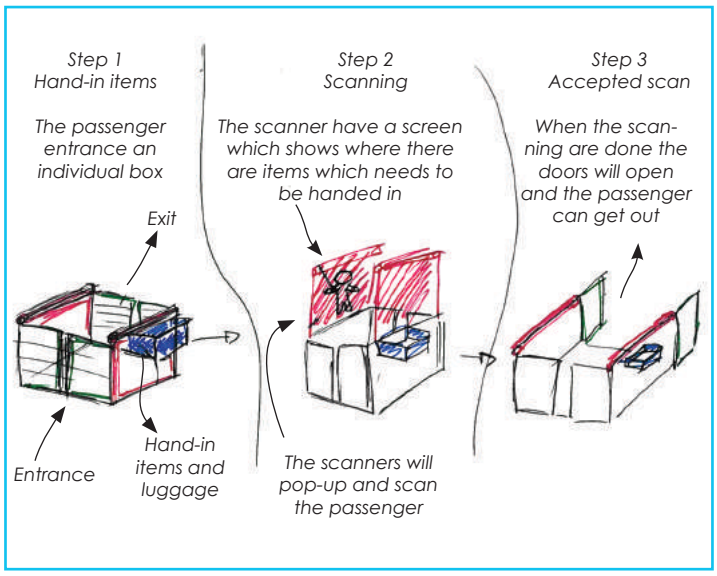


Illustration 34.2 - Idea 4: Individual scanning box

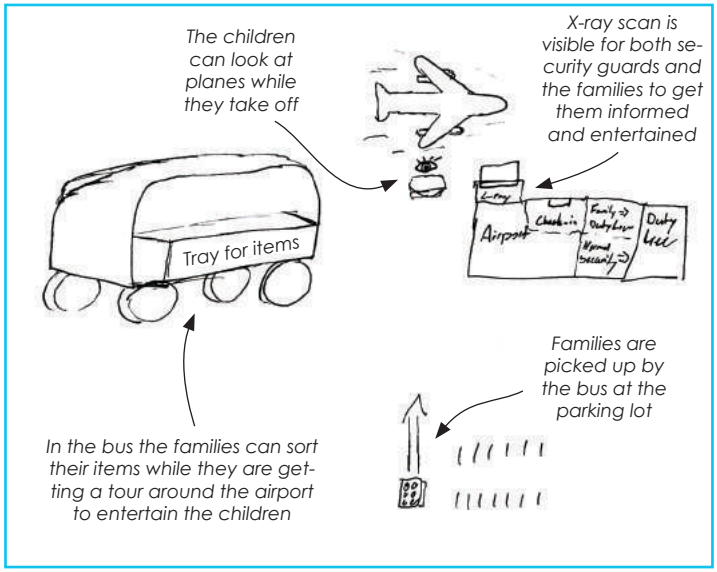


Illustration 34.3 - Idea 5: Family roller coaster

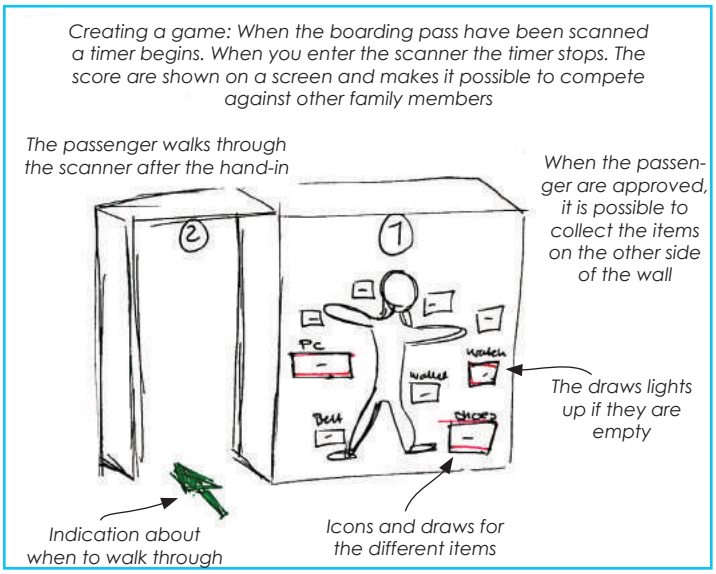


Illustration 35.1 - Idea 6: Game creation for handing in items

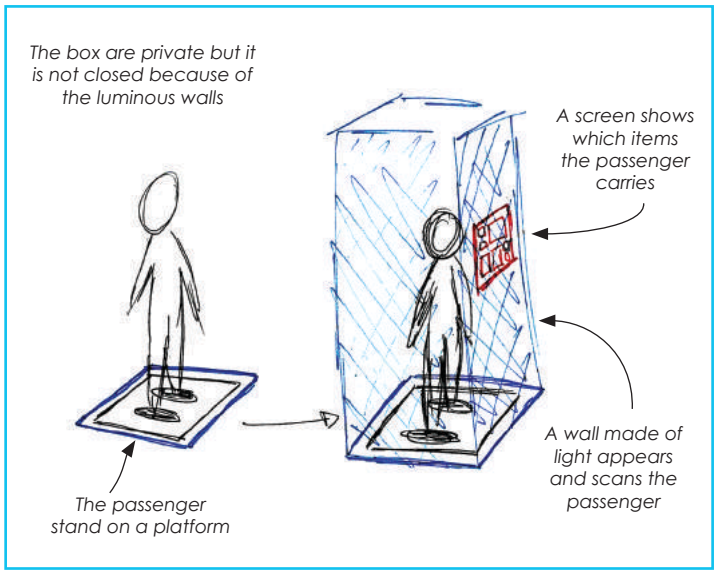


Illustration 35.2 - Idea 15: Hologram pop-up scanning box

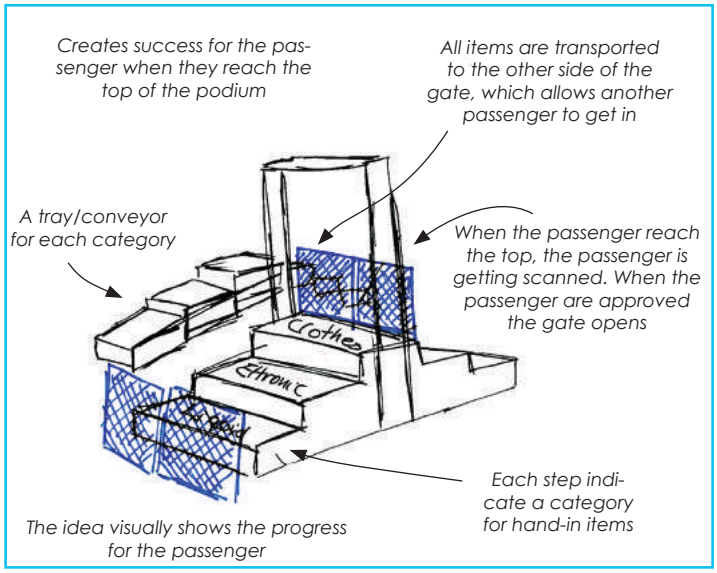


Illustration 35.3 - Idea 16: Winner podium for hand-in items

All sketches from the ideation have been rated based on the same criterion's. The list of criterion's can be found in Appendix XI. Each criteria have been rated from 1-5 according to its importance. The rating 1 is least important and the rating 5 is most important.
The team members evaluated the criterion's individually and discussed the results to get an agreement on the importance. The criterion's were presented for the security guards at Aalborg Airport which evaluated them through a conversation about the importance of each.

Each idea is being evaluated and compared with the existing solution in security checkpoint. The evaluations is rated from 0-2.

0: Worse than reference
1: Same as reference
2: Better than reference

The rating are multiplied by the importance factor. The calculation for all ideas can be found in Appendix XI.

REFLECTION

The evaluation from the security guards is based on how they do things today. In general criterion's focusing on passengers in regards to stress reduction and understanding the steps were rated high and technology and information gathering were rated low. It could have been useful to present the criterion's for people which have more influence on how the security check can look in the future - this could be IATA, how works with the work regulations and how to design the future in airport security.
The ideas have a big difference in the detail level, which influence the rating of the ideas. The team had a hard time separate the score between 0-2, because of the lack of detail. Ideas which where more detailed could easily receive 0's and 2's. Ideas which a lack of detail level were hard to compare and therefor often received 1's.

The evaluation of the ideas resulted in selection five ideas with the highest score. The ideas which were discussed based on their implementability and realization possibility. The five ideas were reduced to three ideas which will be presented in the following section.

2.11 SELECTION OF THREE IDEAS

In the following section three selected ideas will be presented. This section is based on: Ideation and interaction tests.

CONCEPT LUMINOUS

Concept Luminous focuses on creating a fluent experience were passengers can take the time they need in a enclosed hall. The floor is divided into multiple sections with light in different colors, Illustration 36.1. Passengers have to turn in certain items at each section i.e. electronics in one and liquids in the next. When passengers have handed in the items the light will light up indicating that the passenger have been approved to move on to the next section. The shifting light are there to provide a funnier experience for smaller children.

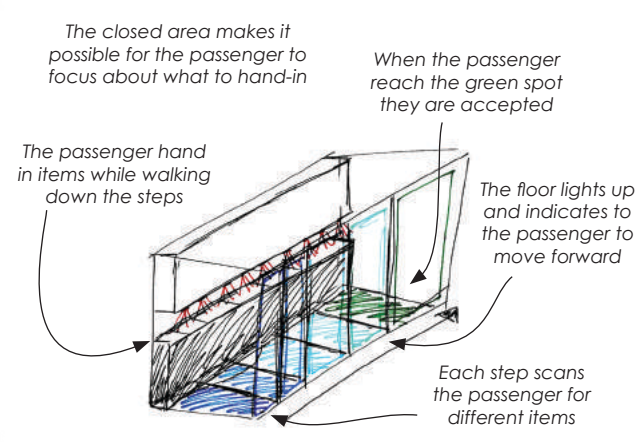


Illustration 36.1 - Concept Luminous

CONCEPT INDISCAN

Concept Indiscan focuses on creating a private experience where passengers can use the time they need. Passengers are scanned when entering the box and a silhouette shows passengers where they have items which needs to be place on a scanner in front of them, Illustration 36.2. Each marking have a timer which shows the time used for handing in the items. This enables parents to have a game/competition with their children to see who can do it fastest. When passengers have been scanned their are allowed through to tax-free.

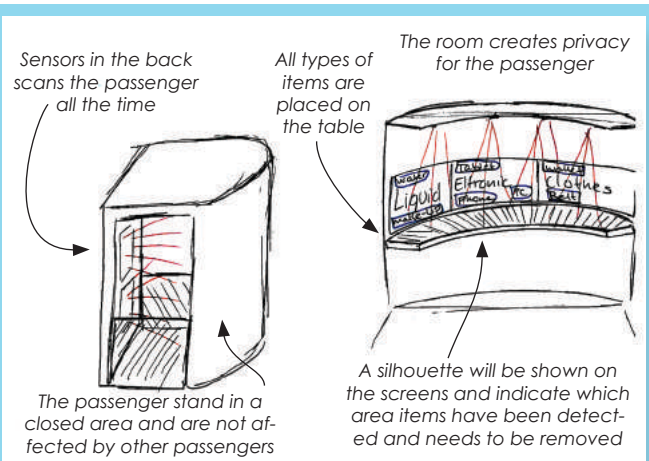


Illustration 36.2 - Concept Indiscan

CONCEPT CARTISH

Concept Cartish focuses on creating an opportunity for passengers to take the time they need by giving them a cart where they can prepare before entering the security check, Illustration 36.3. The cart will provide information on a screen about what to hand-in and where to go when the passenger is done sorting items. The screen will provide the passengers with a "treasure hunt" as a part of the experience to entertain the children. After the sorting of items passengers will move to a security checkpoint where they and the cart will be scanned.

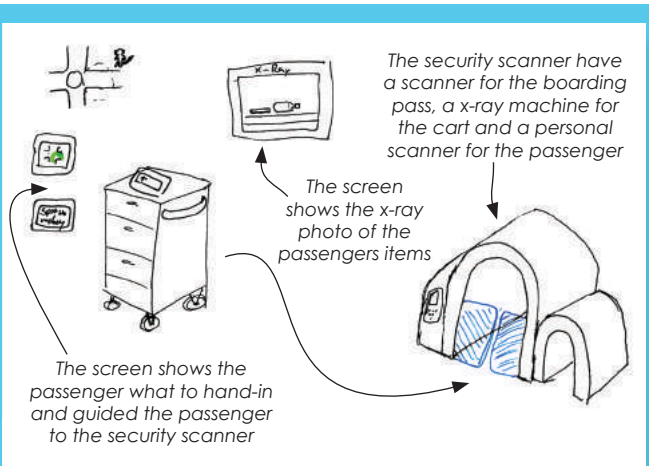


Illustration 36.3 - Concept Cartish

INTERACTION TEST

The following section is a short presentation of tests made on principle model, for further details about the tests and the results, evaluation, and reflection see Appendix XII.

A test concerning the interaction and feedback system with the lighting floor was conducted, Illustration 37.1. Participants would turn in their items based on illustrations or text at each section. When participants had handed their items in the floor color would change.
The results: Participants could understand the icons/text but preferred a mix of both.
Some though the floor was easy to understand and other did not notice or benefit from it.
Participants were often experienced, and knew what to turn in. Some participants emptied their pockets all at once, not following the steps.

Illustration 37.1 - Test with concept Luminous

A test concerning the interaction and feedback system with the silhouette was conducted, Illustration 37.2. Participants would stand in front of a silhouette were markings would be placed according to which items they had on them, a helping illustration with icons were provided.
The results: Participants found the silhouette easy to understand and did not look at the icons.
Participants though the help bottom would provide a help menu, with more information about what to do.

Illustration 37.2 - Test with concept Indiscan

A test concerning the interaction and feedback system with the cart and scanning system was conducted, Illustration 37.3. Participants were provided with a cart with a screen. Participants had to follow the instructions and go through security.
The results: Participants found the cart easy to understand.
Thought the map was a good feature.
Participants had a hard time understanding how to scan them self and the cart.
Two participants left the cart after handing in their items, thinking someone would take the cart and scan it.

Illustration 37.3 - Test with concept Cartish

06 FINDING

The silhouette was the easiest to understand

Based on the results and the feedback on the ideas it has been chosen to work further on with two concepts. The first concept is Luminous combined with the game feature from concept Indiscan. The second concept is Cartish.

2.12 CONCEPT IDEATION

After the test of the three concepts, the team needed to develop the two selected concepts in more detailed. The concept which combines Luminous and the game feature from Indiscan needs to be combined into one coherent concept. Concept Cartish needs to be developed to have the same detail level. The experience of the concepts needs to be developed, together with the expression and aesthetic of the concepts.

MOOD BOARD FOR AESTHETIC AND FUNCTIONS

A more detailed development of the two concepts needs to be made. To get a common agreement of the expression the concepts creates, different types of mood boards were created.
Five mood boards have been created. A selection of the mood boards are shown on illustration below, Illustration 38.1. The rest can be found in Appendix XIII.

The mood boards created guidelines for the form and aesthetic for further development of the concepts.

Illustration 38.1 - Mood boards for expression

CREATING AN EXPERIENCE

The experience which the concepts creates for the families needs to be elaborated. The team discussed and described different ways on how to express the experience, which resulted in quick white board drawings, shown on Illustration 38.2 and 38.3.

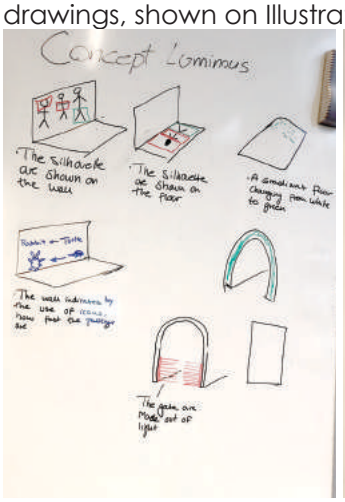


Illustration 38.2 - Creating experience for concept Luminous

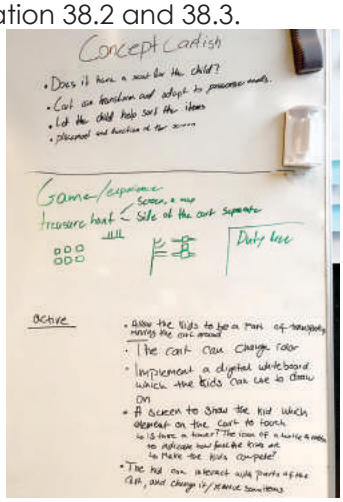


Illustration 38.3 - Creating experience for concept Cartish

The white board drawings created the foundation for an new ideation, Illustration 38.4 and 38.5.

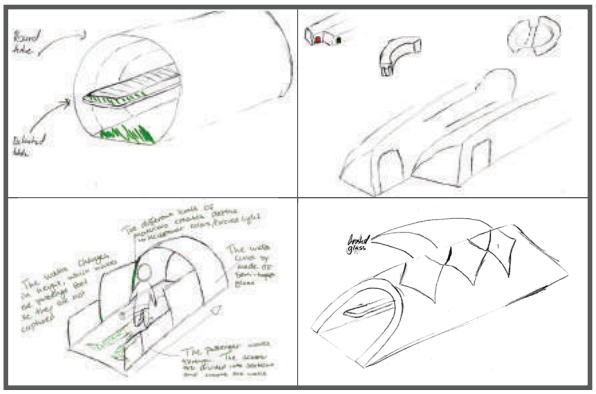


Illustration 38.4 - Ideation on creating an experience concept Luminous

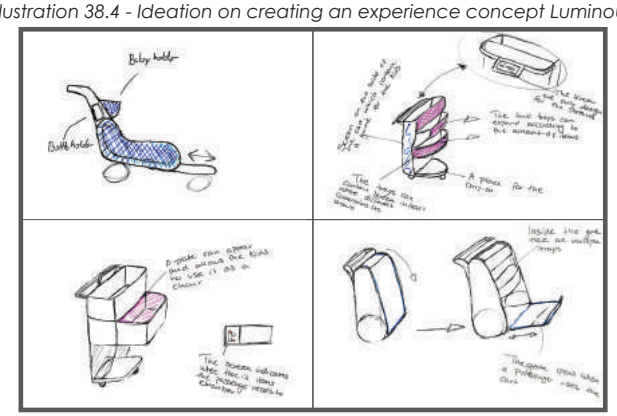


Illustration 38.5. - Ideation on creating an experience concept Cartish

The ideation on concept Luminous focused on creating a more open and welcoming room, together with the implementation of light for showing the progression. The ideation on concept Cartish focused on how to include the children, by implementing a game or a seat. The ideation resulted in a detailed development of the two concepts, presented in the next sections 3.1.1 - 3.1.2.

2.13 SECURITY LEVELS

Before conceptualizing the concepts in further detail information about how security is measure and which technologies can be used for scanning were needed. In the following section a description of the different security standards and technologies will be elaborated on. The purpose of the research is to determine which level of security the concepts needs to uphold. The section is based on: Desktop research and interviews with Copenhagen Airport.

To adapt to ever evolving security threats companies are creating new security scanners which can scan and detect different threats. Each newly developed scanner needs to pass certain test to be approved for the security check. Depending on what the scanner can detect and what level of separation is needed, it is allocated a standard certification, call a C-level. Each C-level explains what the scanner can detect and the separation level. (IATA, 2017) On illustration 39.1 - 39.3 the different levels are explained.

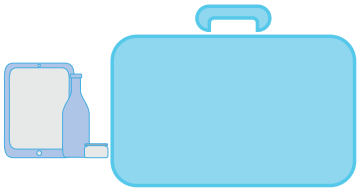


Illustration 39.1. - C1 - standard:
Electronics, Liquids Aerosols and Gels requires separation.

Illustration 39.2. - C2 - standard:
Electronics are allowed in the luggage. Liquids, Aerosols and Gels requires separation.

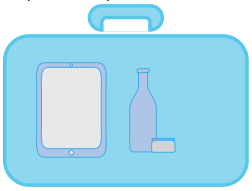


Illustration 39.3. - C3 - standard:
Everything is allowed within the luggage. No separation required.

07 FINDING

Security standard C3 is the highest level of security scanner

The research showed that it is possible to scan luggage without the need of separating the passengers luggage. Further research into the different scanning technologies is made in the following section to determine which technology is fitting for the concepts.

2.13.1 SCANNING TECHNOLOGIES

SINGLE VIEW AND MULTI-VIEW X-RAY

The standard x-ray machine used todays security check is with a security standard C1 or C2. (IATA, 2017) The passengers separated the carry-ons and on-body items according to the security standard. The x-ray radiates the items with electromagnetic radioactive. The different carry-ons and on-body items absorbs different amounts of the x-ray. A sensor takes the information relayed in the x-rays which have passed through the items. The information is displayed to the security guards through a screen or two, depending on the machine. (Harris, ,-) (Tyson & Grabianowski, -. a)

A single view x-ray provides the security guards only a top view of the scanned items. A multi-view x-ray provides two different view of the scanned items; a top view, and a side view. The two types of views are presented on Illustration 39.4

Illustration 39.4 - Example of "single view and multi-view" simplified.

The scanned items are divided into three color groups, organic, inorganic or metal. This eases the detection of dangerous items. In single and multi-view x-rays it is hard to detect thing through electronic devices, such as a PC, because of the many components inside. This makes it easy to hide items under the PC. This is the reason why the separation of items is needed.

CT-SCANNER

The CT-scanner is a well-known technology from the medical industry but have also been used in the aviation industry to scan check-in luggage. The CT-scanner is based on the same x-ray technology as the single-view and multi-view scanners. The difference is that CT-scanner revolves around the product and scans the items in small slices. These sliced images can be combined to create a 3D image. (Jansen, 2017) The 3D image of the carry-ons, makes it easier to detect hidden items in the carry-on. (Tyson & Grabianowski, -.b)

"The cluttered bag can be digitally unpacked" - Mark Laustra, vice president for Analogic Corp.

The scanning is more precise than using the regular x-ray, but it is slower because of the bigger amount of data which needs to be collected and processed. The CT-scanning makes it possible to detect explosives in laptops or liquids, which makes the CT-Scanner security Standard C3. Airports have started testing CT-scanner.
"We see that within the next couple of years CT scanning will the required by legislation" - Thomas Bruun Pedersen, section executive manager at Copenhagen Airport.
The implementation of CT-scanners in the security checkpoint are estimated to increase the productivity by 30% to 50%. (CBS, 2017) (Jansen, 2017) The illustrations 40.1 and 40.2 show a comparison of a scanned knife with x-ray and CT-scanning.

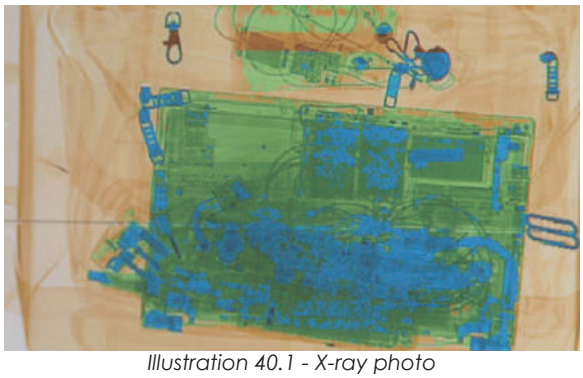


Illustration 40.1 - X-ray photo

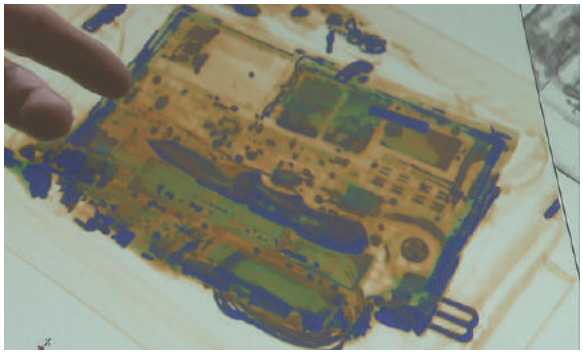


Illustration 40.2 - CT photo

COMPARING MULTI-VIEW AND CT-SCANNER

The two different scanning technologies have different properties. The CT-scanner is a better technology than x-ray because its scanning is more precise and the security clearance is higher. The x-ray is on the other hand faster and the product cost is less. The illustrations 40.3 and 40.4 compares some parameter for the different scanners.

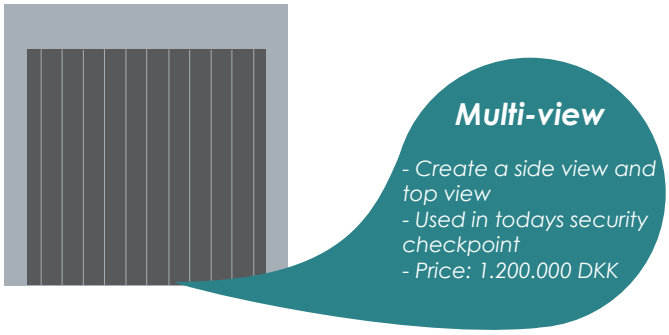


Illustration 40.3 - Multi-view

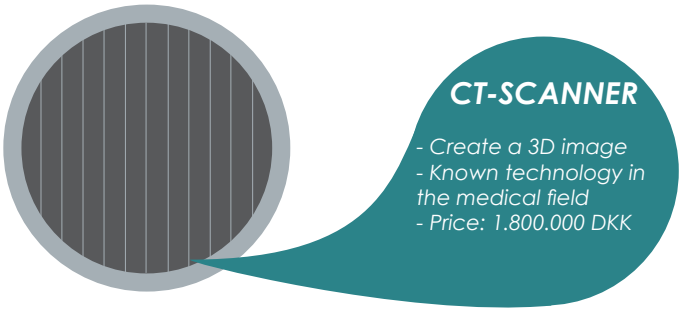


Illustration 40.4 - CT-scanner

08 FINDING

CT-scanner removes the need for separation of items from the carry-on

19 INSIGHT

Copenhagen Airport see that CT-scanner will be required by law

Based on statement from Copenhagen Airport and research indicates the implementation of CT-scanners are in the near future. This is to achieve the highest level of security. CT-scanners remove the problem with separation of carry-ons. Based on the research the team have decided to implement CT-scanning technology in the development of the new product.

3.0 **CONCEPT**

3.1.1 CONCEPT DESCRIPTIONS - *CONCEPT LUMINOUS*

Luminous is a stepwise scanner which creates privacy for the families. In addition, it allows the families to use the time they need in the security check, without being affected by the other passenger. Luminous informs the families about what to hand in, depending on how far they are in the progress. The information is shown on the lighting floor and the screens above the scanner. Luminous are shown on Illustration 42.1.

USER SCENARIO

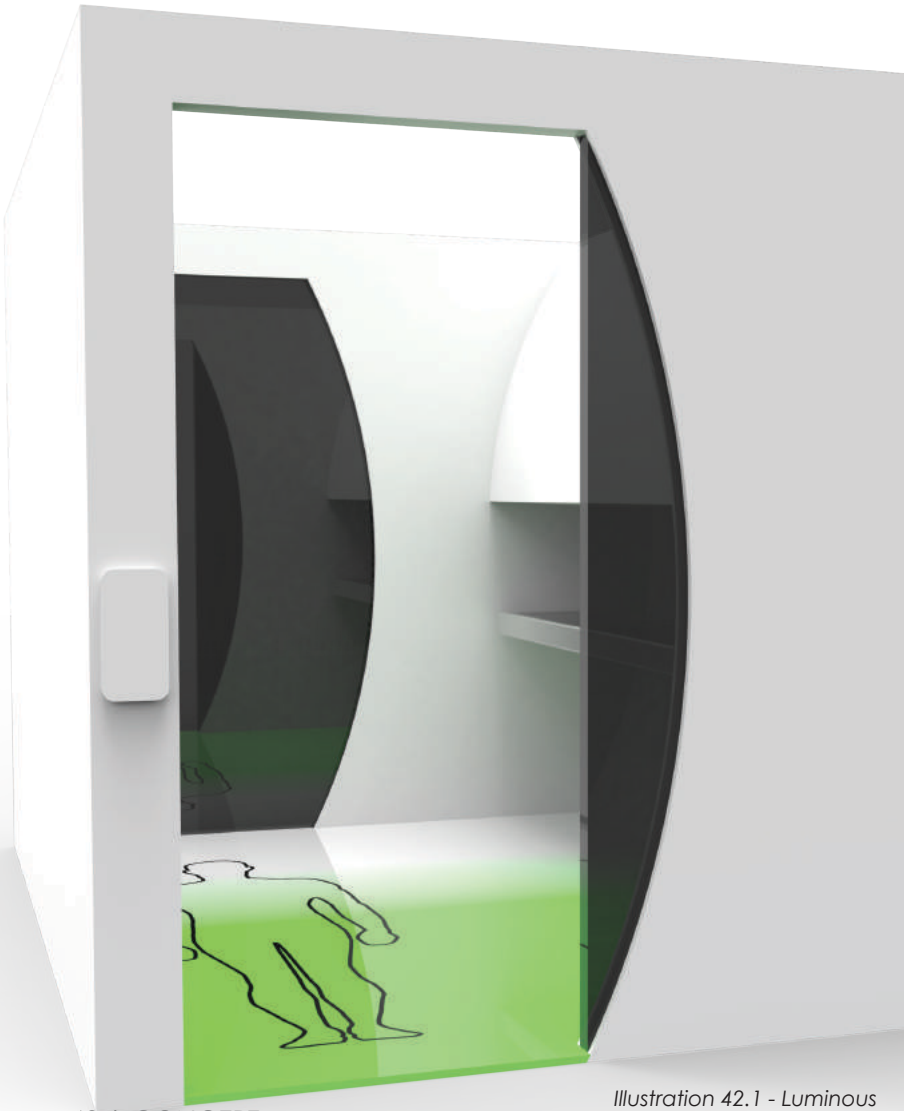
Step 1. The family arrives at the security station, with a semi-transparent door, to ensures the family do not disturb the passengers inside the station. The family scans their boarding pass next to the door.

Step 2. The door opens and the family walks into the security station together. The station is a closed room with lighting floor and wall. The open ceiling ensure the room do not feel closed.

Step 3. The silhouette on the screen and the colored floor indicates which body parts to focus on for removing the on-body items. The items and bags are placed on the conveyor.

Step 4. When the family is approved the silhouette turns green, and the family can take their belongings.

Step 5. The door will afterwards open and allow the family to enter the tax-free area.



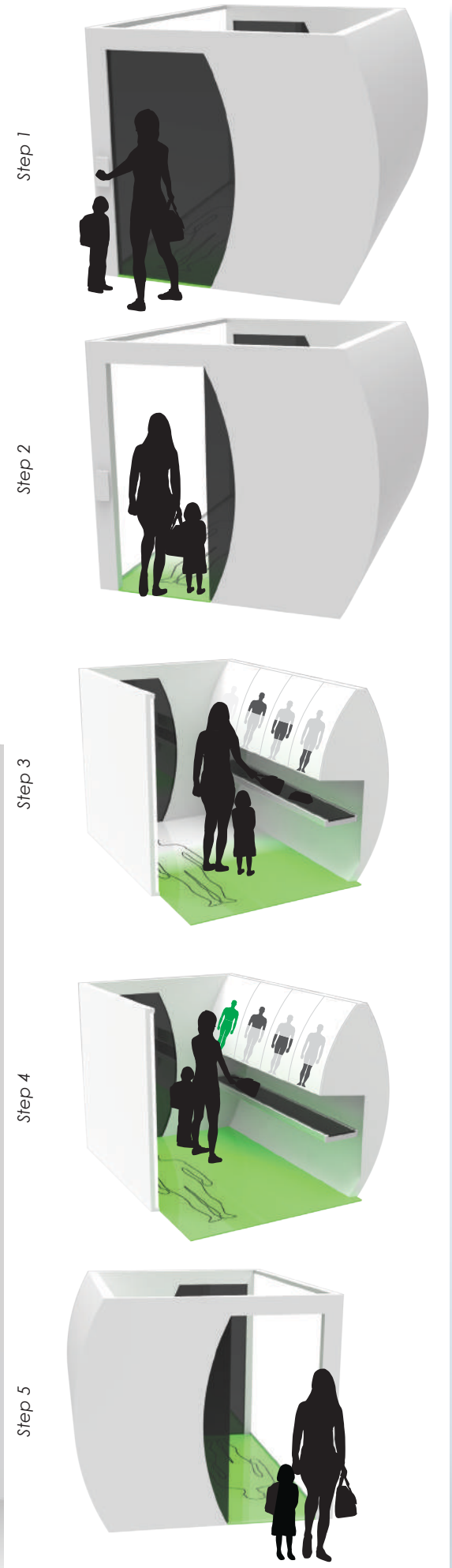


Illustration 42.1 - Luminous

FRAMING AND EXPERIENCE

Luminous is designed with the purpose to create privacy for the family when walking though the security checkpoint [Insight 08]. Luminous makes the security check an experience the family do together [Insight 10 & 11]. This makes it possible for the family to get the children to be a part of the security check. The lighting floor inside Luminous informs the family about the progress. In addition, the screen above the conveyor is showing the family the area on the body to focus on [Finding 06]. When the family have completed the three steps, they will be approved. The entire floor is lighting green, and creating a feeling of success for the family. Table 43.1 are describing the story by the use of the Product Reasoning Model. (Haase and Laursen, 2017) The associated frames are elaborated in Appendix XIV.

Story	Noise reduction		
	Insight	**Aspired value**	**Working principle**
	Families are stressed through the security check, because there are many things they have to handle; children, separating items, and remembering all on-body items	Give families the time and space they need to ensure that they feel less pressured through the security check.	Give them a private space to prepare in. Removing the need to separate carry-ons by implementing CT-scanning.

Table 43.1 - Presenting the story for concept Luminous by using the Product Reasoning Model (Haase and Laursen, 2017)

BUSINESS CASE

The initial business case for concept Luminous is described based on parameters from the Business Model Canvas (Osterwalder & Pigneur, 2010). The business case describes how team Airrity, as a company, earns revenue and communicate with both the airport and the passengers.

VALUE PROPOSITION

- Provide the passengers with an overview of how long they are in the process
- Informs the passengers about what to hand in
- Creates privacy
- The families have been removed from the regular lane - increase the speed
- Make the passengers feel calm because they cannot see the rest of the lane and queue

CUSTOMER RELATIONSHIPS

- Dedicated personal assistance (team Airrity to the Airport)
- Self-service (Airport to the passenger)

CHANNELS

- Present the product at conferences
- Sales force
- The airport will promote the product in commercials, to reach the passengers before they arrive at the airport
- Inform passenger at check-in

CUSTOMER SEGMENTS

- Families with young children
- The airport

REVENUE STREAMS

- Team Airrity gain revenue on sales and maintenance - The airport pays
- The airport creates a better costumer experience for families, and the families will select the same airport in the future
- The airport gets a faster flow through the regular security check - The passenger have more time in the tax-free area and can spend more time and money

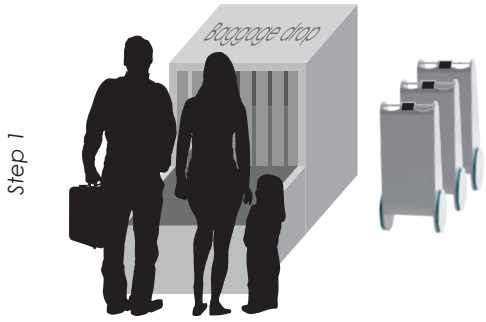
3.1.2 CONCEPT DESCRIPTIONS - *CONCEPT CARTISH*

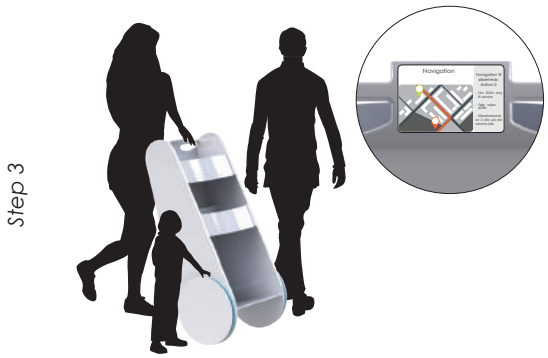
Cartish is a cart which allows the families to prepare before entering the security checkpoint. Cartish gives instructions about what to hand in. Carry-ons are placed in the bottom of the cart, without the passenger needing to sort the items inside it. When the family are ready, Cartish will guide the family to the security scanner. The scanner are separated into two, and contains one scanner for the cart and one for the passengers. Cartish are shown on Illustration 44.1.

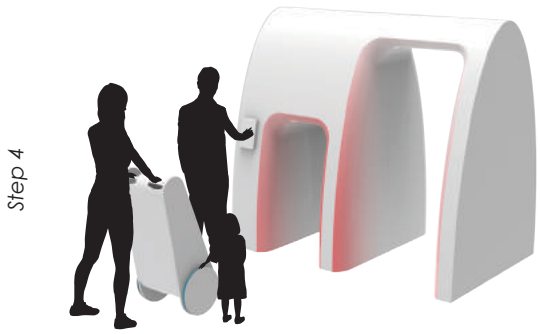
USER SCENARIO

Step 1. The family deliver their checked in luggage at the baggage drop, and picks up Cartish afterwards.
Step 2. The screen on Cartish informs the family about the items which needs to be handed in and where to place them.
Step 3. When the family have handed in all their items, the screen changes. A navigation are guiding the family to the security station. The child can use the wheel as a handle.
Step 4. The family arrives at the security scanner, and both entrances are lighting red. The boarding passes for all family members are scanned.
Step 5. The two entrance changes to green. The cart are placed in lowest entrance, and the family walks through the biggest. When the family are approved they can continue with the cart into the tax-free.

Illustration 44.1 - Cartish







FRAMING AND EXPERIENCE

Cartish is designed with the purpose to create less pressure for the family [Insight 08]. Cartish informs the passenger and creates clarity about what to do and hand-in by the use of a screen. Cartish merge the check-in, security, and tax-free together, because the family can use the cart in all three places. The cart allows the children to be a part of the hand-in process [Insight 11]. In addition, a handle is integrated on the edge of the wheel which allows the child to grab onto the cart. This creates clarity to the parents about where the child is [Insight 14].

Table 45.1 are describing the story by the use of the Product Reasoning Model. (Haase and Laursen, 2017) The associated frames are elaborated in Appendix XIV.

Story	Removing the slow		
	Insight	**Aspired value**	**Working principle**
	Families are stressed through the security check, because there are many things they have to handle; children, separating items, and remembering all on-body items	Give families the time and space they need to ensure that they feel less pressured through the security check.	Provide the passengers with a cart which allows them to prepare before entering the security. Remove the need to separate carry-ons by implementing CT-scanning.

Table 45.1 - Presenting the story for concept Cartish by using the Product Reasoning Model (Haase and Laursen, 2017)

BUSINESS CASE

The initial business case for concept Cartish is described based on parameters from the Business Model Canvas (Osterwalder & Pigneur, 2010). The business case describes how team Airrity, as a company, earns revenue and communicate with both the airport and the passengers.

VALUE PROPOSITION

- Remove the pressure from the passengers
- Information about what to hand-in (general icons on the screen)
- Information on the security flow (the map)
- The passengers are used to shopping carts, and the children know how to interact
- The airport can collect information about the passenger movement patterns (big data)
- Reduce number of guards
- A game to make the passenger move around in tax-free

CUSTOMER RELATIONSHIPS

- Dedicated personal assistance (team Airrity to the Airport)
- Self-service (Airport to the passenger)

CHANNELS

- Present the product at conferences
- Sales force
- The airport will promote the cart in commercials, to reach the passengers before they arrive at the airport
- Inform passenger at check-in

CUSTOMER SEGMENTS

- Families with young children
- The airport

REVENUE STREAMS

- Team Airrity gain revenue on sales and maintenance - The airport pays
- The airport needs to buy a new cart if one of them break
- The collection and use of big data
- Possibilities to increase sales in tax-free by getting the passenger through with the game

3.2 CONCEPT EVALUATION

This section will elaborate on the evaluation of the two concepts. The evaluation are based on presentations for the families at the airport which resulted in pros and cons for each concept. An ideation on solution for the pros and cons are conduct.

PRESENTATION FOR FAMILIES

The two concepts have been presented to families at the Aalborg airport, to get their point of view on the concepts. The concepts were presented on a A1 poster, which contained an big render with associated description and user scenarios, shown on Illustration 46.1. The concepts were presented for eight families. A detailed description of the families feedback on the concepts can be found in Appendix XV.

Illustration 46.1 - Presentation of concepts for the families at the airport

For concept Luminous the families highlighted the positivity for making it into a family experience. The families liked the closed room which allows to prepare without being disturbed by other passengers.

For concept Cartish the families highlighted the possibility to use the time needed and allowing for preparing before entering the security. They liked the possibility to have a cart for carrying all their items.

The presentation for the families did also result in cons for each concept. These cons have been translated into areas which needs to be improved, shown below:

Concept Luminous:

- Minimize expenses
- Creating a better flow of passengers
- Easy interaction

Concept Cartish:

- Adapt to the amount of carry-ons
- Securing valuables
- Combining stroller and cart

IDEATION ON CONS

The cons which the families pointed out resulted in a new ideation round to explore the solution space for the two concepts. All sketches can be found in Appendix XVI.

The team found it difficult to idea on the cons for concept Luminous, which resulted in significant lower amount of sketches. The team found the ideation on concept Cartish more straightforward, and resulted in more sketches.

The ideation on the two concepts indicated that some of the cons from Luminous were more complex to solve. The ideation on cons for Cartish were easier for the teams. This could be because the cons were more tangible and easier to find solutions on.

EVALUATION OF CONCEPTS

The previous sub-sections which elaborates the families point of view and the ideation round lead up to an evaluation of the two concepts, Luminous and Cartish. The concepts were evaluated based on the same parameters by the use of a concept screening matrix (Ulrich & Eppinger, 2012). The parameters are based on statements, research, needs, and demands, which have been found during the process. Each parameter are rated from 1-5 according to its importance. 1 is least important, while 5 most important. Each concept are furthermore rated from 0-10. 0: worse than reference. 5: same as reference. 10: better than reference.

The concept screening matrix and a detailed description of the evaluation can be found in Appendix XVII.

The concept evaluation showed that concept Cartish received the highest score.

The presentation for the families resulted in them having a hard time choosing one concept. The concept evaluation showed that concept Cartish received the highest score. Some of the parameters were hard to compare with the concepts.

It have been selected to work further on with concept Cartish. But the team want to develop the concept further, so it contains some of the main parameters from concept Luminous.

The parameters are:

- Creating a separate room for the family
- Easily shows the family what to hand in by using silhouettes

3.3 FRAME

The following section describes the development of the previous frames and additional frames. This section is based on: Desktop research, observation, interviews, and interaction tests.

After new interactions with the users and the presentation of the two concepts a new concept emerged. The team re-framed the experience to include the parents and the children actively doing something together. The interactions tests and interviews help update the working principle behind the information given. Under the presentation of the concepts a new frame was created. The new frame involve creating a private space in addition to the time and space provided. The current frames in this stage of the project is presented in table 47.1.

	Main Paradox	**Removing the slow**		
		Main paradox is the same as presented in Table 24.1 on page 24		
	Interaction	**Providing time and space**		
		Interaction frame is the same as presented in Table 32.1 on page 32		
UPDATED	Experience	**We do it together**		
		Insight Families are a segment who see the airport as a part of the traveling experience. Their vacation start at the airport [Insight 11]. Other companies focuses on flow and not experience[Insight 18]. Airports compete with each other. In this competition experience is an important parameter [Insight 10]	**Aspired value** Create an experience for the families	**Working principle** Letting parents and children help each other with the security check
NEW UPDATED	Interaction	**Providing clarity**		
		Insight Families have a hard time remembering what to hand in and what to separate because of the stress and the children being distracting [Insight 08]	**Aspired value** Give families the necessary information to help them separate and prepare for the security check	**Working principle** Silhouette showing what to hand-in in a step-wise progression with a supplemental screen providing families with information
	Experience	**Creating our own personal space**		
		Insight One of the stressing parts of being a parent in the airport is having other people around while; keeping children in check, sorting their own items, sorting the children's items.	**Aspired value** Create a space where the family feels a little more secluded, where they can do things in their own pace.	**Working principle** A cart which can open up and create a small wall between the family and the other passengers.

Table 47.1 - Framing

3.4 COMBINING CARTISH WITH PARAMETERS FROM LUMINOUS

This section describes the development of concept Cartish combined with the main parameters from concept Luminous. The section is based on: Desktop research, empirical knowledge gathered through interviews, and mock-ups.

FIRST IDEATION ROUND FOR COMBINING

An ideation round on how to combine the two concepts were made, and resulted in a CAD model of the form. The CAD model created an better understanding of the dimensions and functions of the cart, as presented on Illustration 48.1 and 48.2.

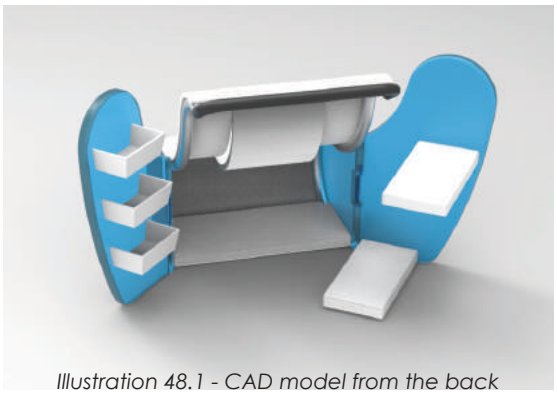


Illustration 48.1 - CAD model from the back

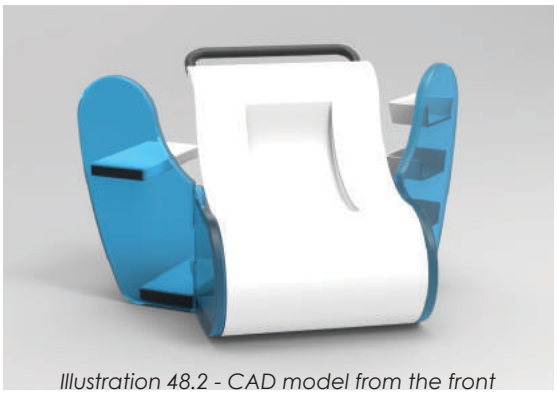


Illustration 48.2 - CAD model from the front

The concepts had implemented a seat for the child in front. On the back the wings opens up and creates a space where the family can stand an prepare for the security. When the wings are open there are access to the trays.

The size of the concept and the overall expression did not fit into the family segment. The team needed to get more insight in equipment and toys which are used by families and children.

MOOD BOARDS

To gain more insight in the children's world, the team created mood boards based on child toys and equipment. The mood board created information about what and how children are used to interact.

The mood boards created some guidelines for the further development. The mood board of strollers resulted in the overall geometric form, which combines a light and heavy structure. This can be transformed to contain a lifted part and a part which lifts. In addition, an interaction point for the children to grab will be implemented to create a reference to the known strollers.

IDEATION AND MOCK-UP ON FORM

Cardboard mock-ups were made to create a more three dimensional experience of the form and functions. The cardboard models were transformed into one 1:2 cardboard model containing the basic features, to get an understanding of the propositions. The 1:2 cardboard model are presented on Illustration 48.3.

Illustration 48.3 - Cardboard mock-up

09 FINDING

Letting the children interact with the cart

FORM AND FUNCTIONS
The scale model in cardboard resulted in a CAD model, to elaborate the proportions and functions, as presented on Illustration 49.1. The heavy top created the part which are being lifted. When the wings are open a light structure are lifting the heavy top.

Illustration 49.2 presents a new way for the wing to open and create the space for the family to prepare together. The wing contains a silhouette and information about what to hand-in. When one wing are open a tray will follow, and allow access for the passenger. A screen are implemented to provided information to the passenger through all processes in the airport.

Illustration 49.3 presents the child seat in front of the cart. Furthermore a tray and cup holder are implemented in the top part.

Illustration 49.1 - The cart with basic features seen from the back

Illustration 49.2 - User scenario of a family standing together an preparing for the security check

Illustration 49.3 - User scenario of a family walking with the cart

3.5 WE DO IT TOGETHER

The following section will go in depth with the frame: We do it together which were presented table 47.1 page 47. After the combination of Cartish and Luminous the focus of the interaction and the story changed for the team. The main story for the product is: We do it together. This section is based on: Interview, desktop research, and observations.

After multiple sketch- and ideation rounds, interviews, observations, and research, a story for the concept had emerged. The security check was something the family should experience together and do together. Children were put aside and taken through security without being included in what happened. Including the children became important for the team and the story of the product. Principle for including the children were already present:

- Silhouette [Finding 06]
- A handle for the children [Finding 09]

The principles became the main features and put the inclusion of the children in focus. Each of the features includes the children in different ways.

SILHOUETTE
The silhouette provides the children with a visual representation of what to do. The silhouette provides a possibility for the parents to go down in the children height and take them through the process together. Letting the children take part in the security check and providing them with positive feedback not only strengthens the family relationship but also learns the child what to do in a security check. Making them faster and better prepared when older. (Peterson, 2017)

HANDLE FOR THE CHILDREN
The handle provides the children with the possibility to help "push" the cart. The handle also keeps the children around the cart. The principle is well-known for the children as it is seen on strollers.

3.6 VISIT AT COPENHAGEN AIRPORT

The following section describes a meeting with Thomas Bruun Pedersen and Brian Cilinder-Hansen from Copenhagen Airport (CPH Airport), Appendix I. At the visit the team got a guided tour through CPH airport and thereby got insights in how the security runs behind the scene. The team presented concept Cartish followed by feedback from Thomas and Brian. This section is based on: Situated interviews, observations and presentations.

The security control in CPH airport have won the "world best security control" three times in the last four years. They have some of the best security in the world, but are still investing heavily in improvements. CPH airport just invested 250 millions to make a more efficient security checkpoint and is doubling the size for continuously keeping the security fast. CPH airport have made initiatives in the security check for families with children, so they can get a more calm and relaxed experience while walking through security.

Copenhagen Airport is working together with Vandelande whom are trying out a new security setup. Copenhagen airport is willing work together with companies to improve on the setups and technologies. But they willing to be first movers on totally new products. In the new setup they are testing out a CT-scanner.

> *We are renewing all security lanes for 170-180 million DKK. In the next 2-3 years we are testing a CT-scanner instead for the existing X-ray machines*

At the meeting the future in airport security checkpoint and how to handle the family segment were discussed. Families are a special focus group for CPH Airport

> *Families and handicapped(people with walking disabilities and in wheelchairs) are something which we focus on because we can see that they abrupt the flow through security*

The airport do not want to dictate where passengers go, but give them directions.

> *We do not want to control where the passengers go through security. But saying; If you choose to go to this lane instead you will get a better experience and go through faster, is something we would say.*

FEEDBACK ON THE CONCEPT

After the walk through of the security check, the team presented the concept Cartish for CPH Airport.

In general the Airport were positive about the focus of the concept.

> *It is good that we focus on the 10% instead of the 90% as everybody else does*

Providing families with the time a and space is a good idea letting them prepare outside security.

> *It is interesting looking at the experience, but it is also important that you do not forget about the flow*

The visit a CPH Airport confirmed the use of CT-scanners is the right way to go with the technology. The focus on families and experience is a good direction, but it is important to remember that we cannot slow down the flow.

20 INSIGHT
Testing CT-scanner instead of the existing x-ray machines

21 INSIGHT
Passenger is an important factor for the airports

10 FINDING
They want to guide the passenger without controlling them

11 FINDING
Focus on passenger flow

3.7 IMPLEMENTATION LEVELS

This section will elaborate the implementation level of the product, whether it is a add-on to the existing system, a whole new system or something in between. This section is based on: Research and interviews.

Concept Cartish can be implemented in different level depending on how invasive and altering the concept is. To gain a better understanding of the implication of the different level the team evaluated the concepts four different implementation level from different parameters. The full evaluation can be seen in Appendix XVIII. The result of the evaluation is presented on illustration 51.1.

LEVEL ONE - DIRECT IMPLEMENTATION
The concept is implemented into todays security checkpoint with the use of x-ray machines (Security Standard C1-C2). Trays must be remove from the cart and placed on the conveyor.

LEVEL TWO - CT-IMPLEMENTATION
CT-scanners (Security Standard C3) are implemented in the regular security. Trays still need to be removed from the cart for scanning.

LEVEL THREE - DEDICATED LINE
Dedicated CT-scanners to the cart is created and the families gets their own lane. Trays can stay in the cart.

LEVEL FOUR - TOTAL DEDICATION
Dedicated terminal with only security lanes for the cart. Other passenger segments are introduced to the cart.

EVALUATION
Each of the levels have pros and cons. Level one and two are cheaper than three and four, and can be implemented fairly quick. Level one allows for preparation but the family still have to separate everything ending up with multiple trays. Level one and two require the family to take out the trays to scan them. Even though trays are being scanned the cart cannot pass through the security lane without getting check or scanned. This would result in the cart having to be scanned or the family to deliver the cart before the check and then providing them with a new cart afterwards. Level three and four scans the cart which means the family can have the same cart through the entire airport. Level three and four are similar. The difference between three and four is that four is the only system and targets all segments, not only families. But the level four requires a high investment from the airport.

After evaluating the different levels it has been chosen to work further with level three. Because of the ability to use the cart through the entire airport. Level four have been deselected due to the high investment and the increase in project scope.

	LEVEL ONE	LEVEL TWO	LEVEL THREE	LEVEL FOUR
Implementation price	Low	Low	Medium	High
Estimated launch date	Today	5-10 years	7.5 - 12.5	15+
Flow improvement	Incremental	Incremental	Medium	Medium
Estimated guards reduction for a lane	0	1	2-3	2-3
Experience	Fair	Good	Good	Good

Illustration 51.1 - Simplified and reduced schematic of evaluation. Full evaluation is available Appendix XVIII.

3.8 FLOW

The following section will describe how the implications of the system at implementation level three will effect the flow in security. This section is based on: Desktop research, observations, and interviews.

The implementation of the system in level three, will remove the slowest passengers from the regular security flow. The creation of a specific lane to families creates three different lane types, see Illustration 52.1. The flow is inspired by the principle from a highway, which allows the fast travelers to be fast by limiting the slower travelers to one specific lane, as trucks on the highway. The segmentation are inspired by the way which concept IATA divided the passengers into segments, page 29.

Fast track will function as it does today. Passengers can pay to go through faster. This is where business passengers often will go through.

The regular security check will also continue as it does today, with the exception that a slower segment have been removed. The removal of the family segment means that passengers no longer slow down the others passengers. Thereby increasing the flow in the regular security lane.

The family lane is a new lane. The new system allows the families to prepare before the security check. By preparing before entering the lane families do not slow down each other in the lane. Families can move to the check as they are ready for it. As they can prepare before entering the lane, their preparation time do not slow down the flow. The family lane flow is defined by the speed of cart-scanner and passenger scanner.

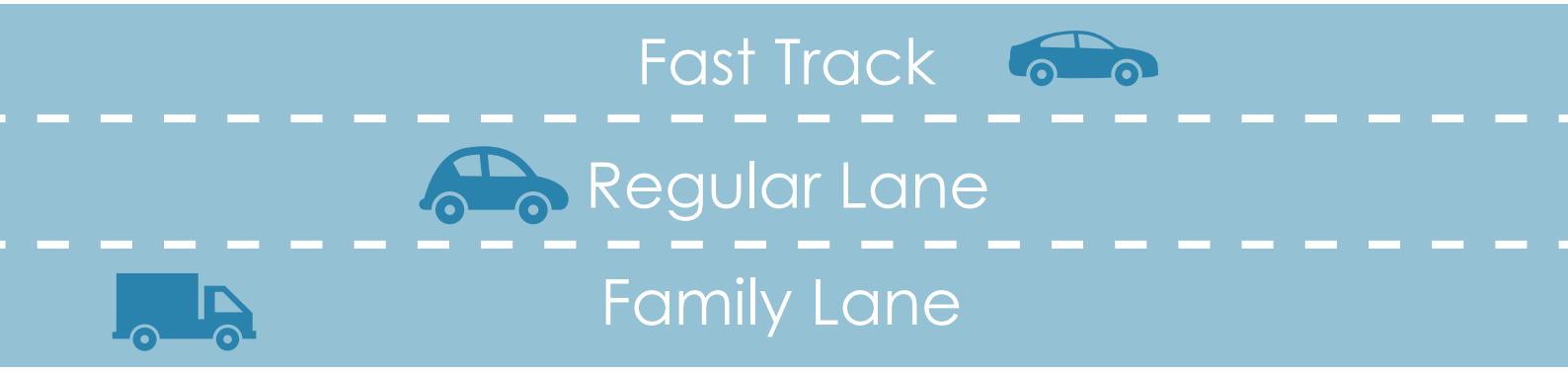


Illustration 52.1 - The three lanes visualised as a highway

3.9 DELIMITATION

This section will contain the delimitation from the project and the product.

The project focus have been on the experience which the cart creates, which have resulted in a need for delimit from certain aspect in the project. These aspect will not be specified, in order to go in depth with cart.

The security scanner which scans the cart and the passengers will not be specified. Multiple aspects concerning the scanner have been taken into considerations while developing the cart. A description and a proposal for the security scanner on a conceptual level will be presented in the following sub-section.

Part of the business case contain the collecting of data and transmission the data to the airport, tax-free shops, and airlines. The team delimits from how the data are communicated from the cart to the airport and to the airlines.

The cart needs to be stored in multiple places in the airport. The storage of carts requires a development of a station. Is it important that the station provides charging of the cart. It is necessary to ensure the cart can be charges to provide power for the screen. A potential solution for charging the screen, is by the use of induction from the station directly to the screen. The team delimits from the development of a station and charging method.

The logistic part in the airport needs to be developed and solved. This includes a solution on how to move the carts around in the airport - from the gates to the check-in areas. The team delimits from the development of a product for transporting the carts.

SECURITY SCANNER (DELIMITED)

The following section will present a proposal for the security scanner used for both the cart and the passengers. The proposal will be on a conceptual level.

Research shows that the highest c-level (C3 level) allows for scanning through multiple layers of materials at a time. The security scanner needs to live up to requirement for the C3 level. This is a need to be able to scan through the entire cart containing carry-ons and on-body items.

A few components in the cart will be produced by having wood covered with plastic - *detailed description can be found in section 4.11 page 72*. Research concerning the material usability to use in the different c-levels have not been public available. The scanning method and materials were discussed with CPH airport. They told the need for a specific and in-depth test for both the scanner and the cart to verify and accept their c-level. This would require a 1:1 model produced with the correct materials together with a model of the security scanner containing the scanning technology. The materials used for the construction of the cart is an estimation of acceptable materials.

CPH airport mentioned a possibility to make a specific algorithm which sort out the construction of the cart. This sets a requirement for scanning the cart in the roughly same position each time. A principle which can keep the cart in the same position, is the wheels and lock system used in IKEA's shopping carts, shown on Illustration 53.1 and 53.2. The system locks the cart to a moving conveyor and ensures it do not move. This makes it possible to transport the cart between two floors with a conveyor (Macht, 2012).

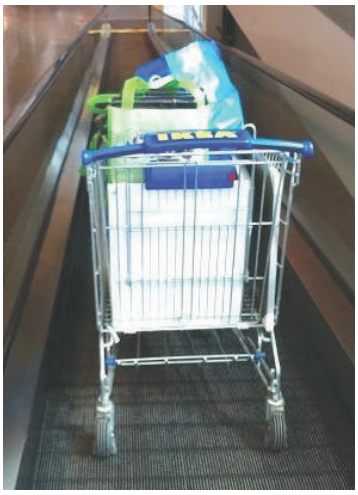


Illustration 53.1 - IKEA shopping cart locked on a moving conveyor which are moving downwards

Illustration 53.2 - IKEA shopping cart locked to the moving conveyor

The implementation of a similar lock on the cart, can make it possible to ensure the roughly same scanning position each time. The implementation of these wheels can effect the design of the cart and the stacking method.

Research shows that more airports are implementing self-service in sections of the airport. Self-service reduces wages and increase service efficiency [Insight 01](Mortimer & Dootson, 2017). The proposal for the security scanner will include self-service. This effect the number of necessary security guards in the security checkpoint. It is predicted that the implementation of self-service can reduce the number of security guards with two guards per scanner. This information will be used in the business case.
The implementation of self-service in the security requires a cultural change. Airports can find it frighting to leave the security check to the passengers them self, resulting in getting a first mover will be a tough challenge. A market which are seeing indication on moving on technology driven security is the Chinese market. Advancing technologies using artificial intelligence and big data to keep transport stations safe are being implemented, a description can be found in Appendix XIX.

The technology used for scanning the passengers will be similar to the ProVision 2. The ProVision 2 can detect both metallic and non-metallic materials. It uses millimeter radio wave (MMW), which do not use x-rays or other ionizing radiation. (L3 SDS, 2018) The scanning technology requires the passengers to stand still, which could result in problems and creation of queue.

The security scanner detect the amount of carry-ons on the cart. This information will be used in the business case, where a more detailed description can be found.

A proposal for the security scanner is shown on Illustration 54.1.

WHAT HAPPENS IF SOMETHING GOES WRONG?
The following section elaborates on the thoughts the team have about what happens if the family have forgotten to take something off before going through the security scanner.

In the event that the family have forgotten to take off some items there is a need for a method which enables the family for correcting the mistake and rescan it and them self. The rescanning of cart and family need to happen without obstructing the flow for the other passengers. The team thought about a solution with a double scanning system. The system allows families to proceed if they are approved. Passengers who have not been approved will to get a chance to hand in the forgotten belonging in the cart. The overall structure is presented on Illustration 54.2.

Illustration 54.1 - Proposal for the security scanner

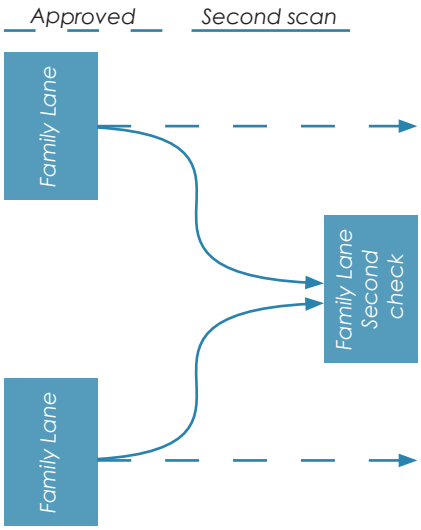


Illustration 54.2 - Concept of how a double scanning system could be implemented

3.10 FRAME

The following section introduces the expression frame for the product. This frame is based on the gathered data from the project in general, mood boards, and desktop research.

After the combination of the concepts, the team started on the aesthetics of the cart. The first iterations of the cart were function based. Through ideation, mood boards, and a look at other similar products the team developed a frame for how the cart should express it self. The process of the frame-creation can be seen in the section 3.11.

NEW FOCUS	Main Paradox	**Removing the slow**		
		Main paradox is the same as presented in Table 24.1 on page 24		
	Main Story	**We do it together**		
		Insight Families are a segment who see the airport as a part of the traveling experience. Their vacation start at the airport [Insight 11]. Other companies focuses on flow and not experience[Insight 18]. Airports compete with each other. In this competition experience is an important parameter [Insight 10]	**Aspired value** Create an experience for the families	**Working principle** Letting parents and children help each other with the security check
	Interaction	**Providing time and space**		
		Interaction frame is the same as presented in Table 32.1 on page 32		
	Interaction	**Providing clarity**		
		Interaction frame is the same as presented in Table 47.1 on page 47		
	Experience	**Creating our own personal space**		
		Experience frame is the same as presented in Table 47.1 on page 47		
NEW	Expression	**Having the smart new car**		
		Insight (frame created through iteration of form expression, section 3.11)	**Aspired value** Make the parents feel like they are one of the cool ones. They have the smart new cart and make the other passengers jealous.	**Working principle** A cart with a forwards moving look as a car, while still keeping the family friendly appearance.

Table 55.1 - Framing

3.11 FORM EXPLORATION

The following section will elaborate on the form and expression of concept Cartish. The first versions of the concept were highly dependent on the function of the concept which was reflected in the form. To gain a better understanding of how the product should look, different mood boards were constructed. The full form exploration and evaluation can be found in Appendix XX. This section will present highlights and the result of the exploration. The section is based on: Desktop research, mood boards, CAD modeling, and 3D printed models.

To make the cart look more family friendly a sketching round were conducted. The sketching round focused on creating a lifting part and a lifted part, which is present in strollers, section 3.4.

THE STROLLER LOOK AND HIGH CHAIR

The first round of ideation resulted in different expressions, each of the expression were discussed based on the aesthetics and functionalities. The evaluation resulted in four expressions being chosen, Illustration 56.1-56.4.

FORM 1

Illustration 56.1 - Form 1

FORM 4

Illustration 56.1 - Form 4

FORM 5

Illustration 56.1 - Form 5

FORM 6

Illustration 56.1 - Form 6

After the evaluation the team needed to see the concept in 3D to gain a better understanding of the shape and functionalities. The team mocked the models up in SolidWorks and 3D printed each model, see Illustration 56.5 - 56.8.

FORM 1

Illustration 56.5 - Form 1 with convex shape and curved child seat

FORM 4

Illustration 56.6 - Form 4 with flat side and a continues curvature on the side profile

FORM 5

Illustration 56.7 - Form 5 with straight side with a indentation in the middle for a child handle

FORM 6

Illustration 56.8 - Form 6 straight side with a hole in the middle for a child handle

The 3D printed models made it easier to talk about the expression of the cart. Form 1 had the most speedy look of all the carts. The rest of the cart looked very stationary and look like high chair for children. Form 5 and 6 had incorporated the child handle which is a important part of the concept [Finding 09]. Form 6 had a lightness to it structure which the others were missing. Form 6 incorporated the lifting part and a lifted part as presented in the expression of strollers.

After creating the CAD-files for 3D printing the team tested out different styling possibilities for each of the expressions to see the effect, see Illustrations 57.1-57.8.

FORM 1

Illustration 57.1 - Form 1 dark and light colors

Illustration 57.2 - Form 1 bright and light colors

FORM 4

Illustration 57.3 - Form 4 dark and light colors

Illustration 57.4 - Form 4 bright and light colors

FORM 5

Illustration 57.5 - Form 5 red of glass

Illustration 57.6 - Form 5 defuse light on light colors

FORM 6

Illustration 57.7 - Form 6 dark and light colors

Illustration 57.8 - Form 6 dark cart with bright seat

INCREASING NICENESS

After evaluating the different expressions the team decided to combine the speedy expression from form 1 with the use of a child handle in form 5 and 6. A mixture of 5 and 6's way of creating the lifting part and a part being lifted is also added to the form.

The team thought the product lacked in the expression. The cart needed something extra, so that families would want to use it, not only out of convenience but because it was cool. The team looked into sport cars for inspiration. The cars uses lines to create speed and dynamic in the product, and the front resembles a face given each car personality. The team aims to use some of the same aspects in the cart as cars uses, see Illustration 57.9 - 57.10.

Illustration 57.9 - Sport car using ventilation to create speed

Illustration 57.10 - Car using headlights and grill to create personality

The aspect from car design were implemented in a new sketch round. The team tried to implement the ventilation and speed from illustration 57.9 to create speed in the product. The holes at the child seat should be implemented to create the same type of personality as the headlights and grill on illustration 57.10. The sketching round resulted in four new sketches, see Illustration 57.11-57.14.

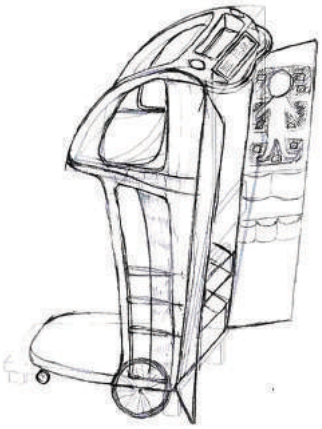


Illustration 57.11 - Sketch of the combination 1 and 5

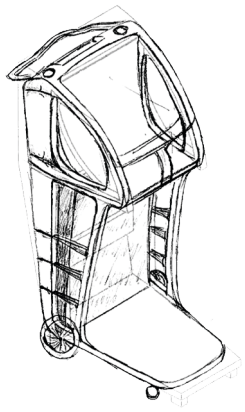


Illustration 57.12 - Sketch of the combination 1 and 5

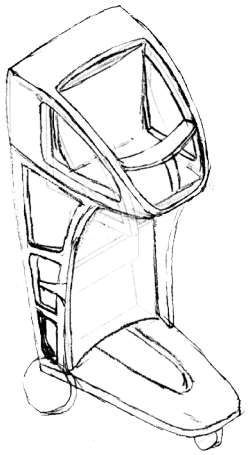


Illustration 57.13 - Sketch of the combination 1 and 5

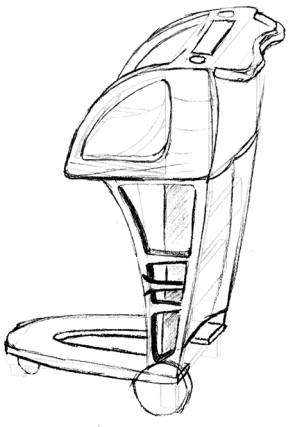


Illustration 57.14- Sketch of the combination 1 and 5

The last sketch round provided different takes on the combined expression but were all quiet similar. The sketches makes the basis for the further development of the expression which will be developed through SolidWorks and changes appearance depending on the functional needs.

4.0 DETAILING

4.1 TARGET SPECIFICATION

This section will present the needs and demands created through the use of the Target Specification(Ulrich & Eppinger, 2012). Interpreted needs based on statements from stakeholders and users are presented in Appendix XXI. These needs are translated together with further research into the final needs and demands presented in Table 59.1 and 59.2.

The importance of each need have been evaluated by the team members on a score from 1-5. 1 is least important while 5 is the most important.
This section is based on: Empirical knowledge gathered through visits at Aalborg airport, Billund airport, and Copenhagen airport, and target specification(Ulrich & Eppinger, 2012).

Needs					
No.	To who		Criteria	Imp.	Finding
1	Passengers	The concept	informs what to hand in through icons and silhouettes	5	6
2	Passengers		guides the passenger through security	4	10
3	Passengers		can contain all on-body items presented on page 27	3	-
4	Passengers		allows the passenger to prepare for the security	5	1, 2
5	Passengers		have a seat for one child	5	3
6	Airport		increase passenger flow	2	11
7	Airport		fulfill the highest security levels	5	7, 8
8	Passengers		can contain the average family number of carry-ons	4	1, 2
9	Passengers		can handle the biggest and most common carry-on size	5	4

Table 59.1 - Needs based on costumer statements and interpreted needs

Demands - Target specification					
No.	Need no.	Metric	Units	Marginal value	Ideal value
1	-	Stackable - Convex	Overlap %	10	90
2	1	Informs what to hand-in through icons	Binary	-	Yes
3	1	Informs where to search through a silhouette	Binary	-	Yes
4	1, 2	Screen	Inch	8-10	10
5	2	Effective range for tracking	Meter	10	<2
6	9	Carry-on size	Cm	56x45x25	56x45x25
7	8	Number of carry-ons	Pieces	3	2
8	5	Child-seat W*H*D	Cm	W:30-38 H:40 D:30-35	W: 35 H: 40 D: 33
9	5	Child-table height	Cm	15-20	15-20
10	-	Height position of the parents handle	Cm	>102-109<	105
11	-	Height position of the child handles	Cm	< 53 - 77 <	56-66-77
12	6	Increase passenger flow through security	Passengers/ Hours	151	200 <
13	7	C3 security Standard	Binary	Test needed	Test needed

Table 59.2 - Target specification

4.2 DESIGN OF DOORS

This section will describe the development of the doors on the solution. The doors on the back Cartish is an essential part of the concepts. To ensure the right look and space-creation the team looked at different ways of using the doors.

In order to create the private space for the families the door/doors of the cart needed to be specified. To test how the door/doors could create the space different principle were tested. Three different principle were sketched to see how it could be done, Illustrations 60.1 - 60.3

Illustration 60.1 - one big door

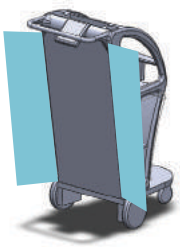


Illustration 60.2 - two smaller door

Illustration 60.3 - a sliding door

After sketching the team made a quick test to see how the different solutions were perceived. The test consisted of opening different cabinets as seen on Illustration 60.4 - 60.7

Illustration 60.4 - Test of one big door

Illustration 60.5 - Test of one big door

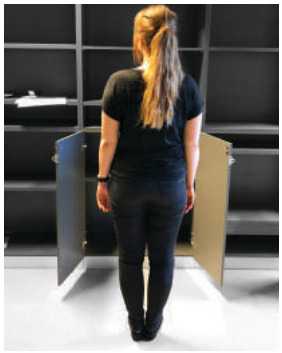


Illustration 60.6 - Test of two small doors

Illustration 60.7 - Test of two small doors

The evaluation showed that the one big door did not provide the space which was wanted. The big door also broke the symmetry of the product, making the product seem crooked. The sliding door had the same problems with the symmetry. But the sliding door did not create a space but a wall between the passengers and the other side. This resulted in the team choosing to go with two doors.

4.2.1 DESIGN OF HANDLES FOR THE DOORS

The following section describes development of the handles on the doors.

In order to open the doors on the back it is necessary to have something to hold on to. A short sketch round on how the handle could look and be implemented are shown on Illustration 60.8-60.13.

Illustration 60.8 - Vertical handle with a groove behind

Illustration 60.9 - Vertical handles without a groove

Illustration 60.10 - Vertical wide handles without a groove

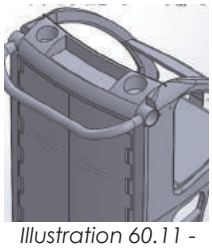


Illustration 60.11 - Horizontal handles

Illustration 60.12 - Horizontal wide handles

Illustration 60.13 - Grooves functioning as handles.

After the sketching, each sketch was evaluated. The sketches with grooves would result in the need for two different doors in production. The vertical handles does not follow any of the shapes on the concepts making them look misplaced. It is chosen to use horizontal handles which mimic the curvature on the cart.

4.3 STACKING

The following section elaborates on the development on the stacking of the carts. CPH Airport mentioned at the visit that it what important to be able to stack the carts, to save space. This section is based on: Desktop research, interviews, and mock-ups.

At the visit at CPH Airport it was mentioned that it was important to be able to stack the cart to save space. The stacking demand puts some restriction on the shape of the product. To stack the carts it needs to overlap with each other. This resulted in the cart needing to be convex.

The stacking of the cart can be divided into two different possible methods of stacking;

- Bottom plate and seat are stacked, meaning both things overlap
- Only the bottom plate stacks, this results in the cart taking up more space

The team sketched on different ways of stacking the carts and found three main ways of doing it;

1. Holes in the doors - Each door have a hole in it. The holes in the door fits with the side of the seat.
2. Fabric back - The back of the cart is a fabric sheet. When the carts are stacked the fabric is stretches and allows the cart to enter each other.
3. Only stacking the bottom plate - The only part of the cart allowing stacking is the bottom plate where carry-ons are placed.

Pros and cons where set up for each of the different solutions. A small principle test was performed with the fabric to see how it appeared and looked when moved, see Illustration 61.1.

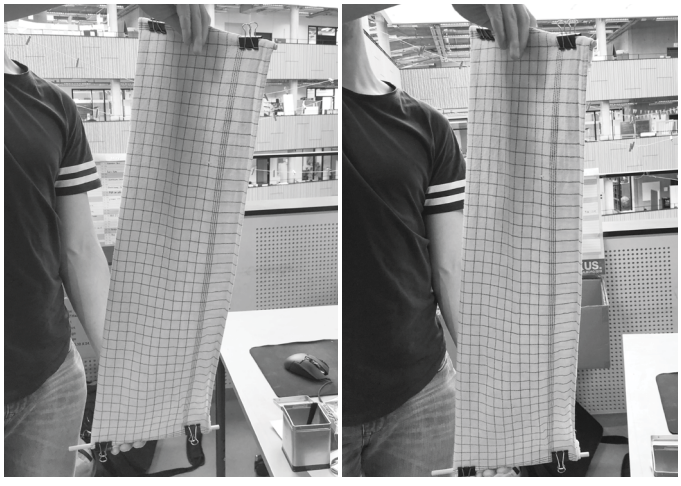


Illustration 61.1 - Mock-up test of turning a door made with a dishtowel

EVALUATION

1. Holes in the doors

Cons:

- Child seat needs to collapse which means extra components and complexity
- Moving part involves the risk of children getting their fingers squeezed
- The back ends up looking like a compromised solution ruining the expression

Pros:

- Stackable to 28 cm
- Solid back - Fits with the rest of the product

2. Fabric back

Cons:

- Create a different expression of the whole cart
- The back is not solid, making the items inside easily accessible
- Mechanism for controlling the fabric

Pros:

- Stackable to 28 cm
- Child seat can remain stationary
- Cheap and light materials in the back

3. Only Stacking the bottom

Cons

- Takes up more room when stacking - stackable with 20 cm

Pros

- There is no need for a extra mechanism
- Solid back

The evaluation resulted in the carts only stacking by use of the bottom plate. The decision is made based on the increased complexity the other solution added and how they change the expression. The frame "Having the new smart car" is one of the part driving the decision, as the team is trying to get a good looking product.

4.4 SILHOUETTE AND ICON LAYOUT

TYPE OF SILHOUETTE

This section will elaborate the different silhouette designs and the choice of one silhouette. The selected silhouette with associated icons be presented. The section is based on: Desktop research and interviews with families.

A significant amount of silhouettes, Appendix XXII, have created the basis for dividing the silhouettes into three categories; A traditional silhouette, A cartoon human silhouette, and A cartoon silhouette.
One silhouette from each category have been chosen and shown on Illustration 62.1-62.3.

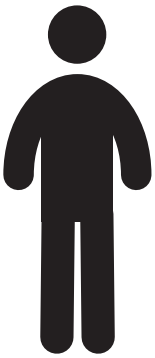


Illustration 62.1 - A traditional silhouette

Illustration 62.2 - A cartoon design of the human silhouette

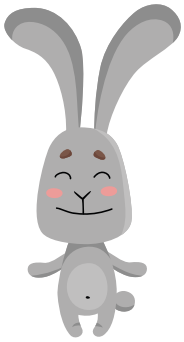


Illustration 62.3 - A cartoon figure as the silhouette

Based on section 2.6.3 knowledge were gathered about the basic on-body items which needs to be handed in. The icons presented in the section 2.6.3 are used on the three different silhouettes. A variating examples for showing the icons are presented in Appendix XXII.

Interviews with families were conducted and the different silhouettes and indication of the items were presented. The families choose the cartoon silhouette with a rabbit. One of the families mentioned "*animals always attracts the child's focus, and thereby makes it easier to get the child's attention to help handing in the on-body items*".

After the selection of the cartoon silhouette, the families were presented for the three different ways to indicate which items to hand-in. They liked the indication with a background which connected the places on the body together with the icons, Illustration 62.4. One of the families mentioned "*it could be useful to differentiate the grey colors, so the three areas were highlighted even more. Another color could also be used instead for grey*".

Based on the presentation for the families it is chosen to use the cartoon silhouette with a rabbit. The icons with a background which indicates the area on the body is selected. The colors and sizes of icons will be adjusted when it is placed on the final model.

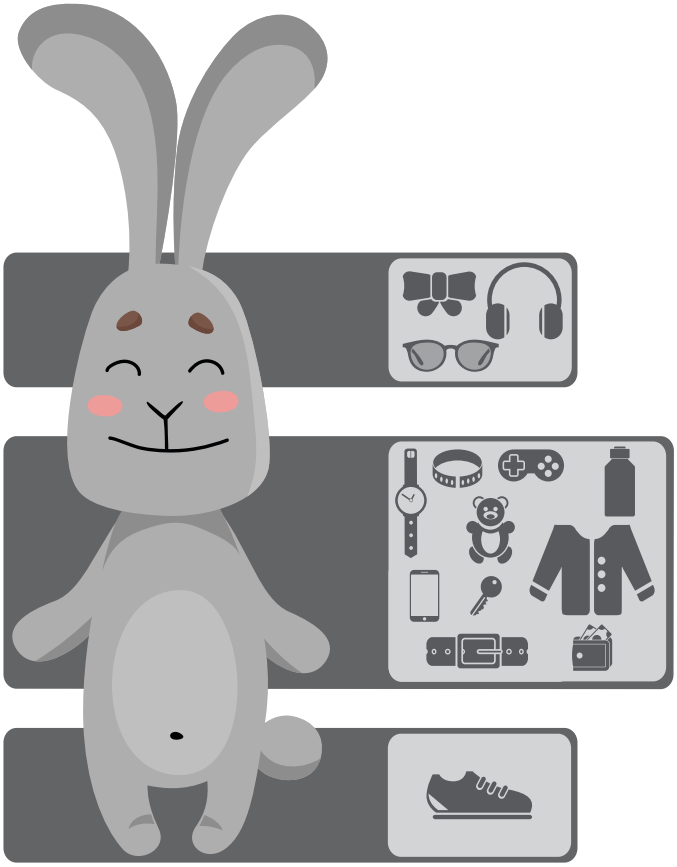


Illustration 62.4 - The chosen silhouette and way for showing the icons

DESIGN OF TRAYS

The section will describe the foundation for the set-up and the design of trays inside the cart based on interaction tests. The section is based on: Desktop research and interaction test.

To find the best setup for hand-in items inside the cart, a 1:1 model with the overall geometrics were made. The chosen silhouette and icons will be mounted on the model, to get feedback from the participants while they are during the test. The model were divided into three levels which made it possible to attach different types of trays. This resulted in three different setups:

- Setup 1: Three pockets are placed in the two top levels with a regular tray on the lowest level, Illustration 63.1.
- Setup 2: All three levels contains a regular tray, Illustration 63.2.
- Setup 3: All three levels contains trays which are tilted 20 degrees, Illustration 63.3.

The setups were tested on six participants. Each participant were told to hand-in their on-body items by using the silhouette, icons, and trays. The participants were commenting on the setup and what they though they should do. A full description of all the participants feedback can be found in Appendix XXIII.

None of the participants choose Setup 2. Some of the participants liked the use of small pockets for their basic items, such as phone, wallet, and keys. The use of tilted trays (setup 3) were the one which created the best overview of all the items, and the setup which most of the participants chose. It is chosen to work further on with setup 3, by implementing smaller rooms in the top tray.
The test showed a lack of room for jackets. Participants either folded their jacket, Illustration 63.7 or hung it on the side of the cart, Illustration 63.8. There is a need for finding another place for the jacket - this will be elaborated in Section 4.9.
There were not enough room for the shoes. Some of the participants placed the shoes on the ground, Illustration 63.4. This resulted in the need for finding another solution for placing the shoes, which will be elaborated in Section 4.8.
None of the participants used the silhouette, and found it difficult to connect the silhouette together with the icons. Further testing is needed to see how an entire family interact with the silhouette and icons, to find the best solutions for communication the hand-in process.

Illustration 63.1 - Setup 1

Illustration 63.2 - Setup 2

Illustration 63.3 - Setup 3

Illustration 63.4 - Setup 1. A participant are placing his on-body items inside the cart. His shoes are placed in the bottom of the cart.

Illustration 63.5 - Setup 2. The participant hung his jacket on the side of the cart

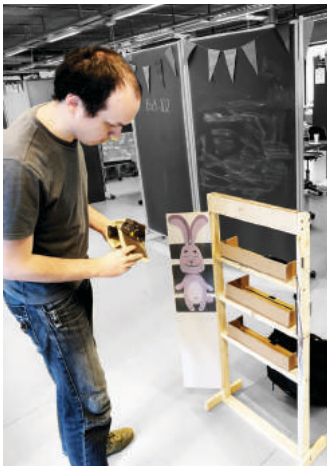


Illustration 63.6 - Setup 2. The participant have doubts about where to place his cap because it is not shown on the icons.

Illustration 63.7 - Setup 3. The participant tries to fit the jacket inside the tray.

LAYOUT OF SILHOUETTE AND ICONS

This section will present different variations of the layout with the silhouette and icons. A selection of five layouts have been presented for families to get their feedback and gain knowledge about how they read the information. The section is based on: Interviews and observations with families.

The result from the interaction test, created the foundation for sketching on ten new layouts. Pros and cons were added for each layout, Appendix XXIV. This resulted in a selection of five layouts which were printed in full scale and placed on the 1:1 model, Illustration 64.1 - 64.5.

All layouts were presented for eight families to get their feedback. All the feedback can be found in Appendix XXV. At the test some of the participants involved their children, by going down in their height and talk to them to get their point of view about what they should do, shown on Illustration 64.6.
Many of the children were interested in the silhouette of the rabbit and found it fun and cute, Illustration 64.7.

Illustration 64.1 - Layout 1

Illustration 64.2 - Layout 2

Illustration 64.3 - Layout 3

Illustration 64.4 - Layout 4

EVALUATION

Layout 2 and 5 were the most popular. Layout 2 created the best overview and informed the participants the best about what to hand-in. Layout 5 were more fun and engaging than layout 2. Some of the participants expressed that some of the information about what to hand-in might be lost in the clutter of the drawing. One of the participants found it difficult to separate what needed to be handed in and what were a part of the drawing. A full description of the presentations for the families and a reflection upon it can be found in Appendix XXV.

The evaluation of the feedback resulted in layout 2 being chosen as the final silhouette design. Smaller changes to some of the icons will be made to make it clearer what they symbolizes.

Illustration 64.5 - Layout 5

Illustration 64.6 - A family with a mother and a 4 years old daughter. The mother are going down in the child's height.

Illustration 64.7 - A family with a mother and a 2,5 years old son. The son looks interested at the rabbit.

4.5 DETAILING OF INTERACTION PARTS

This section will describe the decisions for the interaction parts for both the parents and the children. The section focuses on the expression and shape of the parts. The section focuses on research on how standard strollers are dimensioned and shaped. Production and material selection will be presented in section 4.11. This section is based on: Desktop research, and interaction tests.

HANDLE - FOR PARENTS

The research about different types of handles for the parents are elaborated in Appendix XXVI. Based on the research, it is decided to work with is adjustable handle which can vary in height. These types of handles are often seen on stroller or baby carriages which are designed for parents to walk around with. The handle in designed to follow the curvature of the carts sides. The handle are presented on Illustration 65.1.

Illustration 65.1 - Handle for the parents

Research into handles used on strollers and interaction tests were used to specify the positioning of the handle, see appendix XXVI. The handles on strollers are often placed in a height between 102-109 cm. The interaction test showed that the height were fitting and with the possibility to adjust the handle should be positioned in an height of 102 cm, at the lowest points, with possibility to adjust upwards. See illustration 65.2 for the final result.

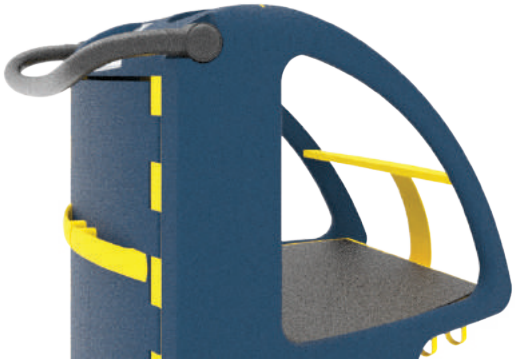


Illustration 65.2 - Final handle

HANDLE - FOR THE CHILD

A part of the concept is to have the children being a part of the security check [Finding 09]. To let the children be a part of the whole security check and to keep them by the cart small handles on the side of the cart have been implemented. This resembles the interaction children know from the stroller where there is places they can hold on to.

Research about different types of handles for the children have been made and elaborated in Appendix XXVI. The research showed that handles for children often have another surface and/or color than the rest of the product. This indicates an interaction point for the children, see illustration 65.3 -65.4. It have been decided to use color for separating the interaction points from the rest of the product for the children.

Illustration 65.3 - Picture of handle

Illustration 65.4 - Picture of handle

The cart interact with children in different ages, meaning there is a span in the height of the children. Research about the different heights can be found in Appendix XXVI. The different heights resulted in a decision to have three handles in different heights on the side of the cart. Based on the height of the lowest child, the lowest handle will be placed in a height of 40 cm, with an increase in height on 7.5 cm between each handle. See illustration 65.5 for final result.

Illustration 65.5- Final child handles

SEAT DIMENSIONS

To gain an understanding of the standard sizes for child seats research on existing strollers and car seats have been made. The existing products had a width between 30,5cm to 45cm. The car seats were the largest, because they provided extra protection for the child.

At CPH airport two different types of product are available for carrying children. A pictures and a detailed description of existing products can be found in Appendix XXVI.

The strollers and car seats from the research and the seat from CPH airport, created the basis for the dimensions of the seat. The final dimensions are shown on Illustration 66.1, and the final seat can be seen on illustration 66.2.

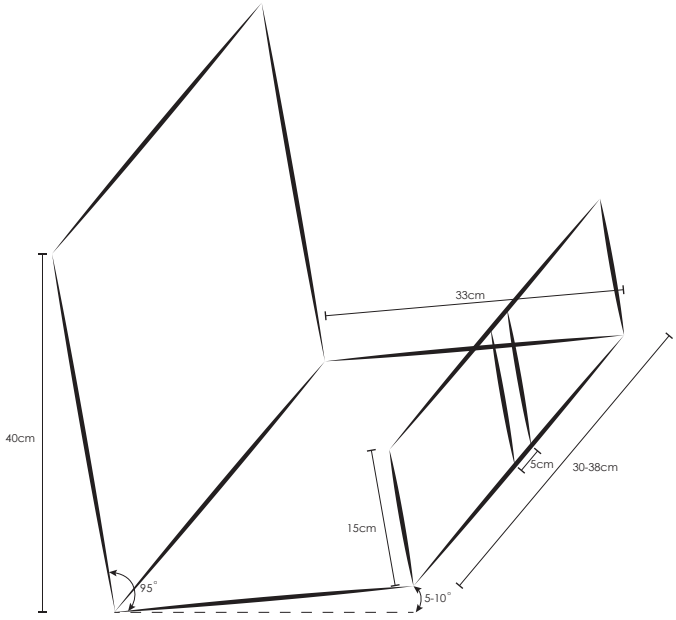


Illustration 66.1 - Dimensions for the seat

Illustration 66.2 - Final child seat

WIDTH ON CART

Research have been made to find the best width for the cart. Shopping carts and strollers are found as inspiration, which can be seen in appendix XXVI. The research showed a regular shopping cart have a width on 55cm, while strollers have a width between 45-52cm.

The research indicated that the existing strollers were smaller than shopping cart, which makes it easier to dive around with them. To ensure that the cart is easy to move around with it is decided to aim for a width on 50 cm. Which is smaller than a normal shopping cart. The cart with the final width can be seen on illustrations 66.3.

Illustration 66.3 - Back side of the cart

The final dimension on the cart ended up bigger than aimed for. The increase in width is a result of the measurements of the child seat. It was decided that the increase in width was acceptable.

4.6 LOCKING MECHANISM

In the following section a description of the locking mechanism for the door and the brake mechanism for the wheels are described. This section is based on: Mock-ups and desktop research.

The team looked at a solution which controlled the locking and unlocking of the doors and wheels in one solution which can be seen in Appendix XXVII. But it became apparent under the construction and implementation of the solution that multiple problems were within this solution. The space required by the lock for the doors, where greater than thought when the solution were constructed, in an already tight space. The lock for the wheel required multiple additional subsequent processes to make the locking of the wheels possible. This resulted in that the solution was put aside.

To keep the door closed and to keep the cart standing still when separating items, a locking and breaking mechanism is needed. For locking the wheels a attendant wheel lock was constructed, see illustration 67.1-67.2. The lock functions by the passengers stepping on a peddle which move a rod into the wheel locking it in place.

Illustration 67.1 - Example on attendant lock.

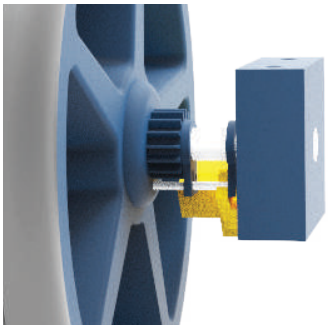


Illustration 67.2 - The attendant lock on the cart

To lock the door a lock with a he and a she part in place on the door and inside the cart, see illustration 67.3. The principle takes advantage of the plastic elastic properties. The she-part is made with a tight entrance so the he-part have to deform the she-part to enter. When the he-part have enter the she-part it is locked in place. The same principle about deformation happens when the doors needs to be unlocked.

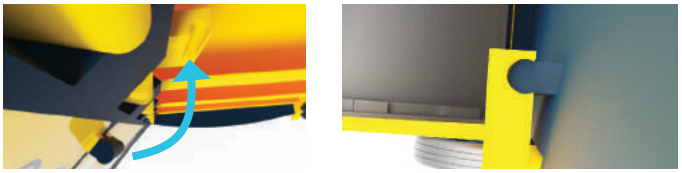


Illustration 67.3- The he-part on the door enter the she part locking it in place

4.7 TILTED OR STRAIGHT BACK

The following section describes the detailing of the products angle.

In the first many iteration of the concept the back was tilted in an angle of 10 degrees, see illustration 67.4 - 67.5. The team tilted the cart, as carts and other things which needs to be pushed around are easier to move around if the center of mass is in front of the applied force.

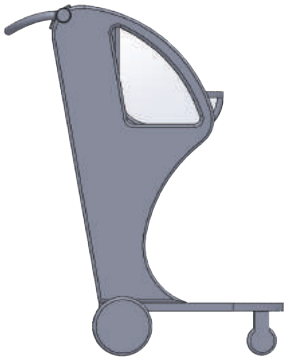


Illustration 67.4 - Early iteration of the concept with tilted back

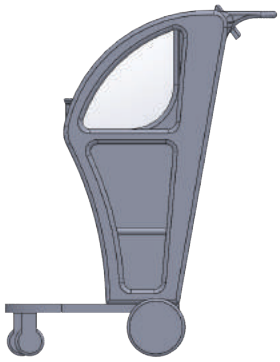


Illustration 67.5 - Early iteration of the concept with tilted back

After some iterations of the form expression and interaction scenarios it became apparent for the team that the tilted back would result in the doors wanting to open by them self. The tilted back would also result in the doors opening towards the floor, angling the silhouettes down towards the floor making them hard to see. The negative effects of the tilting of the back were to great compared to the gained effect of being easier to push and move around. The decision were to straighten up the back so the doors and silhouettes were clearly visible, as both are key parts of the interaction within the product. See illustration 67.6 - 67.7 for final results.

Illustration 67.6 - Straightened back seen from the side

Illustration 67.7- Backside of the product with open door and straightened back

4.8 SHOE PLACEMENT

This section describes the development of the placement of shoes in the cart. The section is based on: Desktop research and SolidWorks mock-ups.

In rare instances passengers have to remove shoes to go through the security check. To accommodate these instances the team looked into the possibility of fitting a shoe holder in the cart. The team researched different ways of storing shoes to seek inspiration.

The team looked to fit a size 50 into the back of the cart under the trays. After looking for inspiration the team mocked a size 50 up in SolidWorks to see how much space it required. The mock-up test showed only one possible way for the shoes to turn in order to fit. The one way it could fit would be a tight fit for a pair if slipper. In order to properly fit a shoe in the back the larges size would be a size 42. The downgrade in size mixed with the rarity of shoes which needs to be scanned it is decided not to incorporate a shoe holder within the cart. At the interview with CPH Airport, a scanner with shoe scanning capabilities were prensented. This underline the decision not to incorporate shoe handling in the cart.

4.9 PLACE FOR JACKETS

This section will describe the development of the coat hangers. This section is based on: Desktop research and act it out(Sperschneider & Bagger, 2003).

When going through security passengers need to take of their jackets. To accommodate the need a coat hanger were developed. The development of the coat hangers can be seen in appendix XXVIII. Multiple solution were tested out with act it out *(Sperschneider & Bagger, 2003)* to see how the interaction could be. When acting out the team noticed that the jacket were longer than the product. Meaning that if the jacket is placed on the side of the product it would in some cases be dragged along the ground. This meant that the jacket needed to be placed either in the cabinet or under the seat. The room in the cabinet is limited and would require the jacket to be folded together in the bottom to keep it inside the cabinet. Placing the hanger under the seat allows the jacket to be hung over the carry-ons. It was decided to implement the coat hanger under the child seat. See illustration 68.1 for the final solution.

Illustration 68.1 - Coat hangers placed under the child seat

4.10 ASSEMBLY

This section will elaborate the components within the cart. The elaboration are made by a showing the different steps which needs to be completed for assembling the product. The proportions for the different components are detailed in the Technical folder.

The different steps are based on Illustration 69.1.
Step 1: The hinges are slided into the sides
Step 2: The sides are mounted onto the bottom plate
Step 3: The inner cabinet is mounted followed by the three inner trays
Step 4: The doors with handles are mounted to the hinges. The child seat are slided into a groove in the side followed by the table
Step 5: The handles for the parents are mounted, followed by the top tray which are mounted to the two sides
Step 6: Front and back wheels are mounted, followed by the stacking plate
Step 7: The coat hangers and the covers for the child handles are mounted
Step 8: The entire cart have been assembled

It is estimated that the total assembly time will be three hours for an entire cart. This information is used in the calculation for the production price.

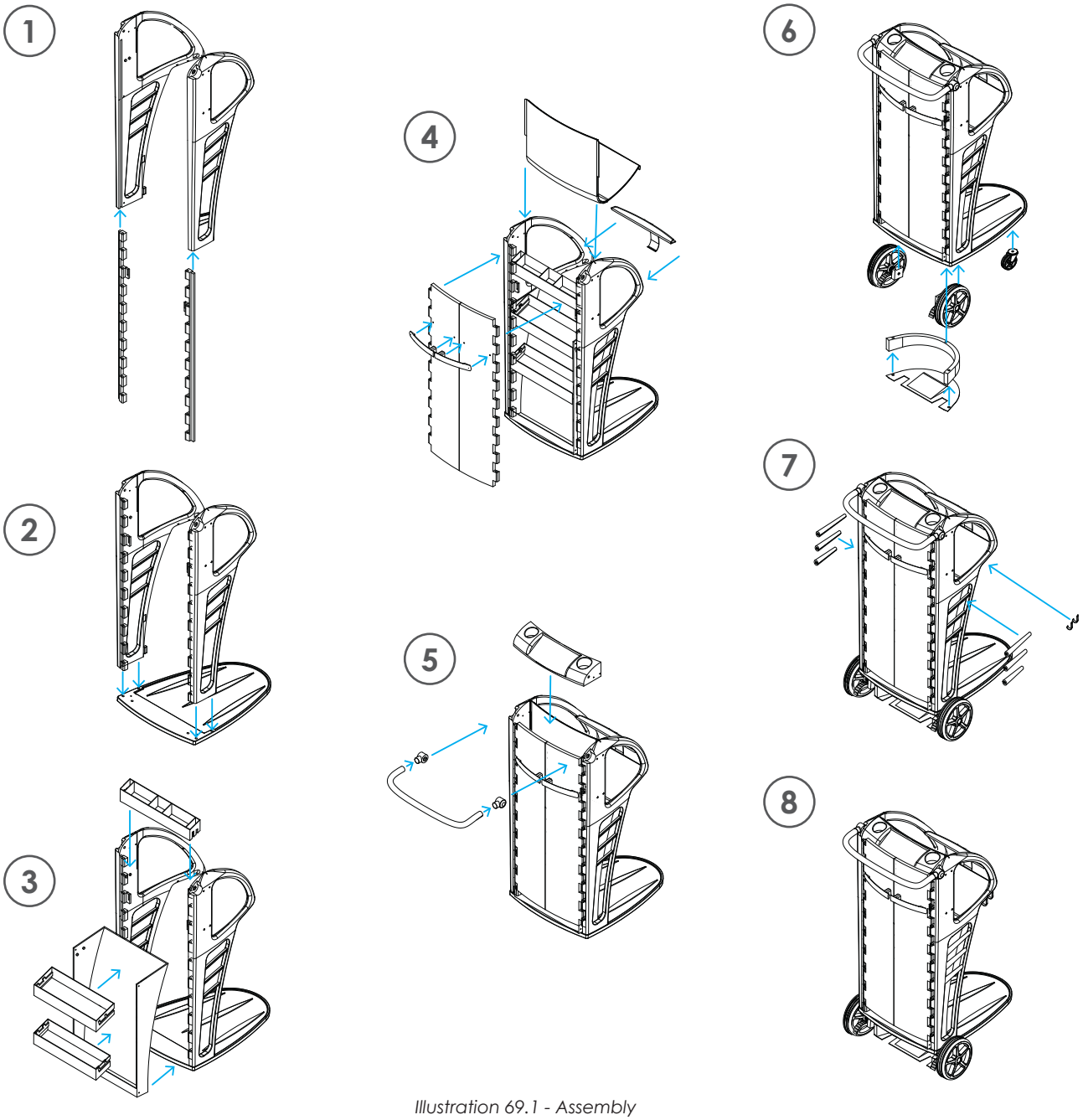


Illustration 69.1 - Assembly

4.11 MATERIAL AND PRODUCTION

This section contains the material choice and production method for non-standardized components. See the Technical folder to gain an understanding of components within the product. This section is based on: Desktop research and expertise from companies.

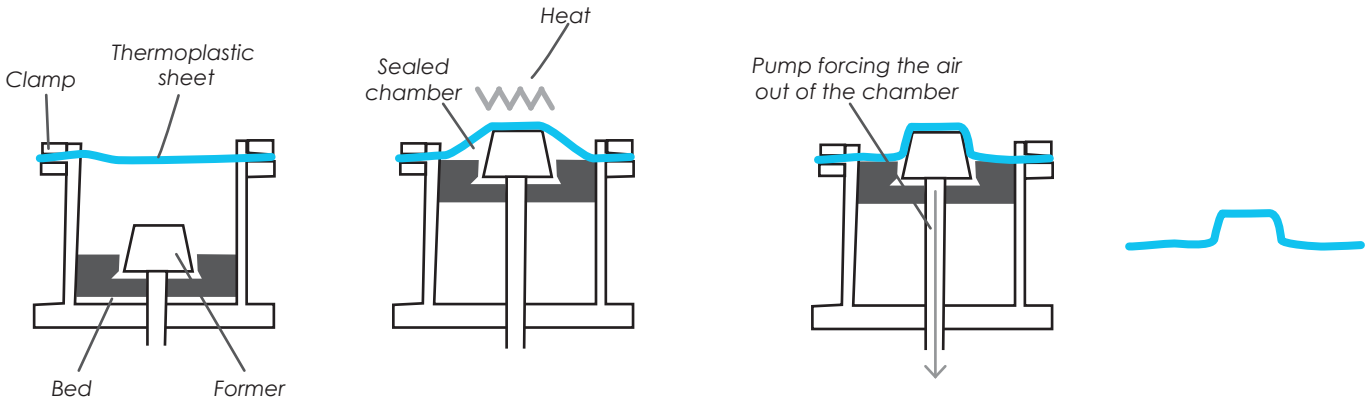
ABS AND VACUUM FORMING

The cart consist of multiple parts which needs a high strength and stiffness but still have a low cost. The components are:

- Top tray
- Doors
- Child seat
- Trays inside
- Cabinet
- Bottom plate

The material ABS have been chosen to accommodate these requirements. ABS is easy to color in a variety of colors, which is fitting when coloring the cart in the airports colors. There are suppliers available around the world. All the parts using ABS will be produces by vacuum forming (thermoforming). The use of vacuum forming can be used for both small and large scale production. The tools used can be fairly cheap, depending of materials used for the form. The forms can be produced in both MDF, epoxy, or other materials, which are used for small production runs. While forms designed for mass production will be made in aluminum. (Lefteri, 2012) All vacuum formed parts needs to be adjusted so they have a taper/draft angle on 5° to release the plastic from the mold easier. (Formech International Ltd, -) Illustration 70.1 shows the vacuum forming process.

VACUUM FORMING



1. THE FORMER (MADE IN WOOD, ALUMINUM, ETC.) IS ATTACHED TO A BED

2. THE FORM IS RAISED AND A HEATER MAKES THE THERMOPLASTIC SHEET FLEXIBLE. A SEALED CHAMBER IS CREATED.

3. A PUMP FORCES THE AIR OUT OF THE CHAMBER, WHICH RESULTED IN THE SHEET BEING SUCKED TO THE FORM

4. THE FINAL SHAPE CAN BE REMOVED FROM THE FORM AFTER IT HAVE BEEN COOLED DOWN

Illustration 70.1 - Shows the vacuum forming process

PVC AND MOLDING

Two different handles needs to be produces and mounted on the cart. The components are:

- Handle - Parents
- Handles - Childs

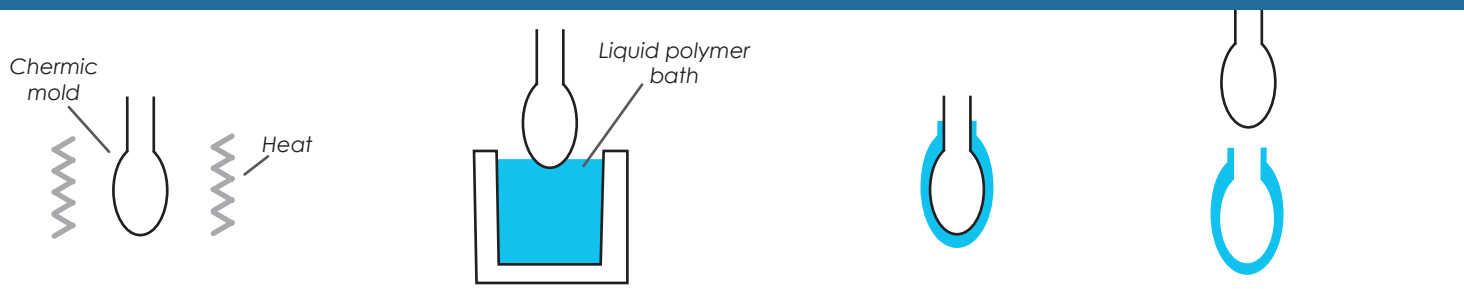
The handle for the parents needs to follow the curvature on the cart, and are therefor a specially produced component. The handle requires stiffness and strength for controlling the entire cart. The surface must be comfortable and have relatively high friction to provide a good grip.

It is decided to produce the handle for the parents in two parts. The inner part will contain of a bended plastic pipe, which will create the stiffness and strength. The outer part will be a cover which will be produced in PVC by Dip Molding. PVC is a materials which are often used on handler grips on children's bikes, and provide a good grip and surface. (Lefteri, 2014)

Dip Molding is a production method used for both prototype and for mass production. The method uses reasonable cheap tools, and it is possible to produce the parts in a fairly short time. It is the method also used for producing the handlebar for bikes. (Lefteri, 2012)

The handles on the side of the cart for the children requires a comfortable surface and grip. The handles for the children will only consist of PVC, because they will be mounted on a solid structure on the cart. The handles must be produced in six variations, and afterwards clicked onto the model. It is decided to produce the handles by using Injection Molding. The tool cost used for Injection Molding is high, but the unit price can be low if many pieces are produced. (Lefteri, 2012)

DIP MOLDING



1. A CERAMIC MOLD ARE BEING HEADED UP

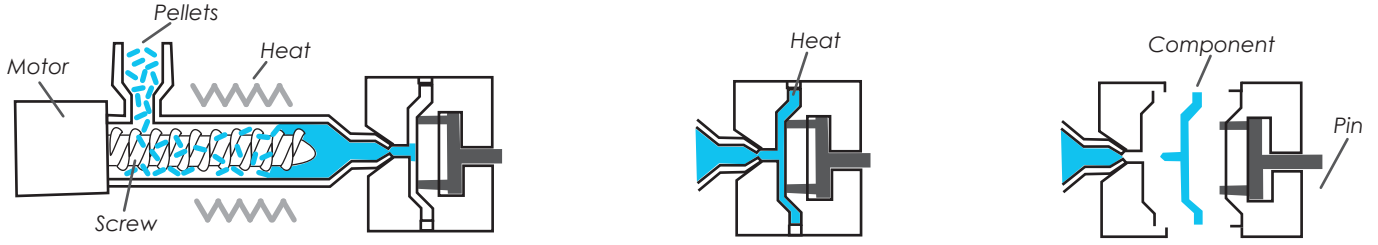
2. THE MOLD ARE DIPPED INTO A LIQUID POLYMER BATH AND THE POLYMER STICKS TO THE MOLD

3. THE MOLD ARE COOLED DOWN TO EASE THE REMOVAL OF THE COMPONENT

4. THE MOLD ARE REMOVED AND

Illustration 71.2 - Shows the dip molding process

INJECTION MOLDING



1. PLASTIC PELLETS ARE ADDED AND MOVED TO THE HEATED CYLINDER

2. THE PELLETS ARE BEING MELTED AND FED INTO A MOLD WHERE THE COMPONENT IS FORMED

3. AFTER MOLDING THE MACHINE OPENS AND THE COMPONENT ARE RELEASED BY A PIN

Illustration 71.2 - Shows the injection molding process

WOOD + PUR AND GAS-ASSISTED INJECTION MOLDING
The sides on the cart have a complex shape which limits the possible materials and production methods. It is important that the sides have a high strength because many of the other parts are mounted on the sides. The sides on the cart have be analyzed by a Finit Element Method(FEM) to get an understanding of the deflection, strain and stress, the analysis can be found in Appendix XXIX.

Based on research it were selected to look into the production method Gas-Assisted Injection Molding. A correspond with employees at VELUX A/S, resulted in feedback on the CAD model of the sides. The feedback from the employees agreed on using the Gas-Assisted Injection Molding as the production method for a mass production. The machinery and molds used for the production method are expensive. Information about the price can be found in the Technical Folder. It was suggested to look into glass fiber or vacuum formed plastic as a cheaper solution in the beginning with a smaller quantity. (Larsen, 2018)

It is selected to detail the Gas-Assisted Injection Molding method, because of the estimation of using this method in mass production when the product is produced in a high quantity.

The Gas-Assisted Injection Molding is similar to the standard injection molding, the difference being a gas is added. The gas (usually nitrogen) is injected in the mold cavity when the plastic is in the molten state. The Gas-Assisted Injection Molding can be used as internal or external molding. Internal molding uses the gas to force the plastic to remain in contact with the mold surface - this creates a solid surface which is hollow. External molding is often used for larger surfaces. The external gas forces the plastic to dissipate onto big surfaces and into smaller details in the mold. (Lefteri, 2012)
The sides for the cart will be produced by external molding.

The use of Gas-Assisted Injection Molding allows for placing a secondary material inside and mold around that material to reduce cost and cycle times. Feedback from VELUX A/S resulted in suggestion for looking into the following materials: Balsa, Bamboo, and Douglas Fir (Larsen, 2018). A description of all three materials can be found in Appendix XXX. (Lefteri, 2014)
It is selected to use dried Douglas Fir for the inner construction in the sides. The material provides a high stiffness and bending strength. The high density will make the product more sturdy. (Lefteri, 2012)

It is selected to use PUR as the material which will be molded around the inner construction. PUR have a high resistance to abrasion and have a overall high toughness. This ensure the product stays good-looking, even though it is being stacked and moved around in the airport both by the staff and the families. (Lefteri, 2014)

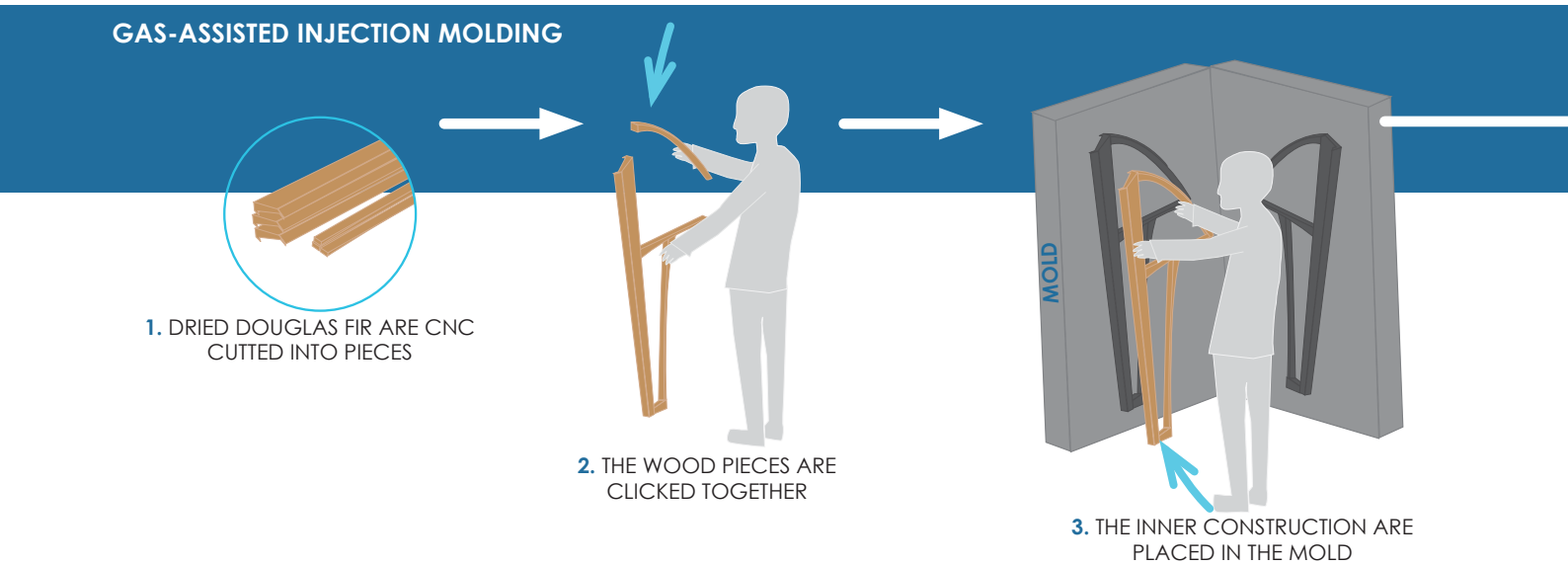


Illustration 72.1 - Shows the production process from wood to a molded side

To get an better understanding of the production process, it is presented on Illustration 72.1. The illustration shows that the inner construction will be assembled by multiple pieces of Douglas Fir, step 1. A more detailed picture of the connections made for assembly is shown in Illustration 73.1.
The Douglas Fir pieces will be cut with the precise details by the use of Computer Numerical Control (CNC) cutting. To enable the high detail level of the pieces, there is a need for using a six axes CNC cutter. (Lefteri, 2012)

The material thickness for PUR is allowed to vary between 3-5mm (Larsen, 2018). This is presented on Illustration 73.1 and 73.2.

After the product have been molded excess material can be on the product. There is a need to deburr the product - this can be done manually or automated by a robot. The cheapest solution is to do it manually, as shown on Illustration 72.1 - step 6.

After the deburring the sides needs to be painted into the request color.

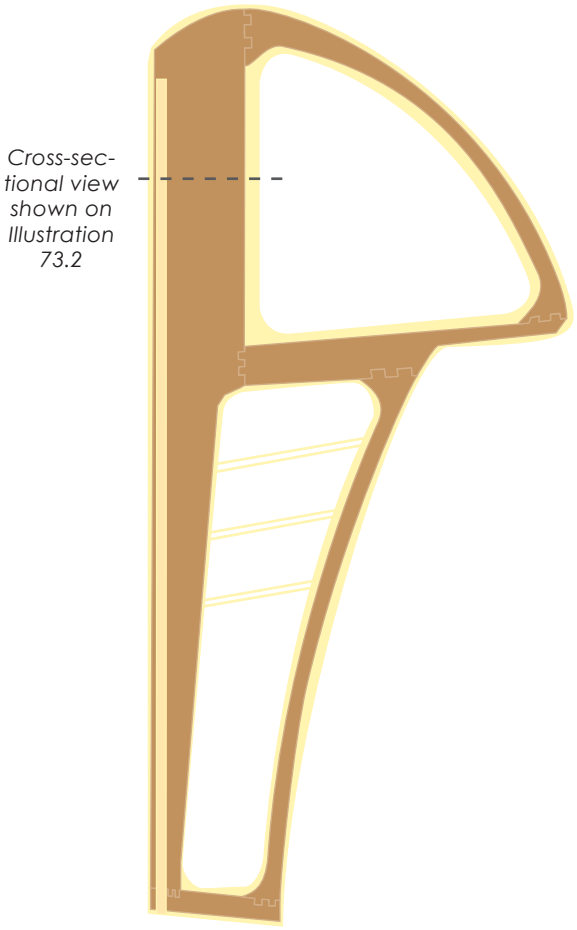
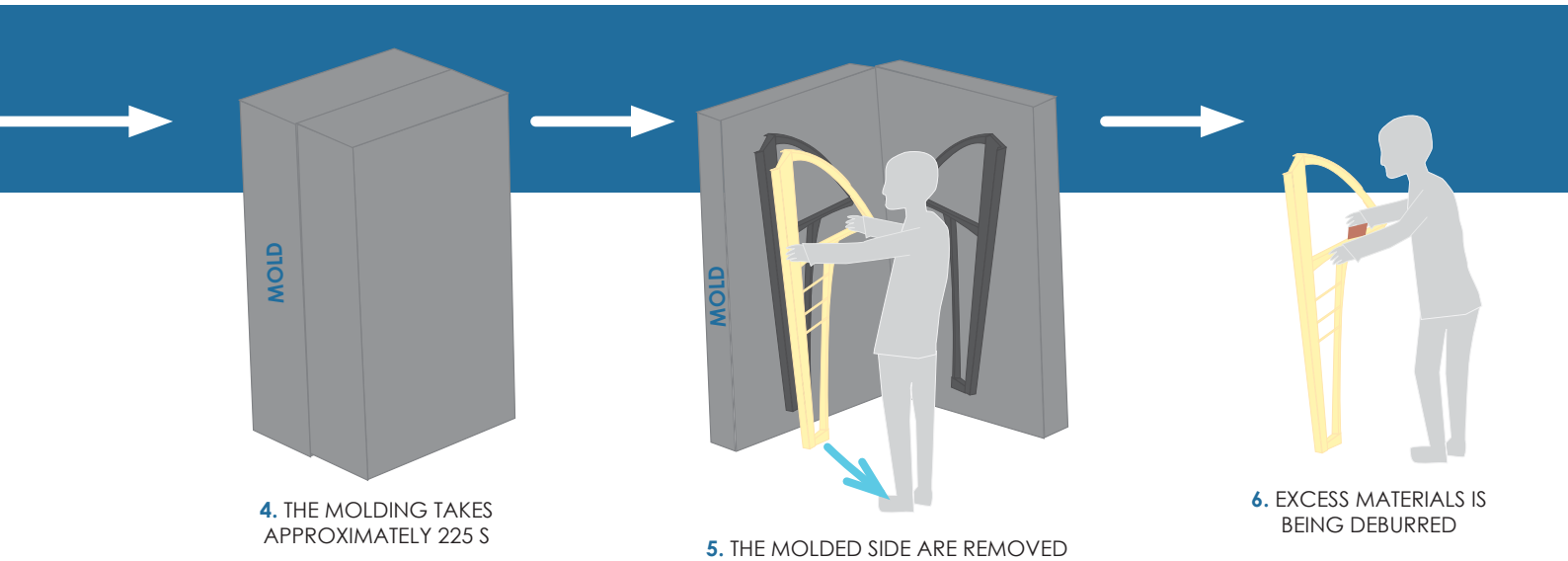


Illustration 73.1 - Shows a sectional view of the side of the cart. The light yellow shows the PUR while the brown color shows the Douglas Fir.

Illustration 73.2 - Shows a cross-sectional view of the side of the cart. The roughness in the wood ensure the PUR sticks better



4. THE MOLDING TAKES APPROXIMATELY 225 S

5. THE MOLDED SIDE ARE REMOVED FROM THE MOLD

6. EXCESS MATERIALS IS BEING DEBURRED

4.12 INDOOR POSITIONING SYSTEM

In the following section a selection of different indoor positioning system (IPS) methods and companies will be presented. The purpose of the research is to identify the IPS method needed to track the cart. This section is based on: Desktop research.

MAGNETIC POSITIONING

Magnetic positioning (MP) takes use of the magnetic fields created by buildings. MP can make use of magnetic positioning chips, which is often found in smartphone. By mapping out the airport and the paths in the airport it is possible to create a magnetic map and thereby identify where the passengers is within a area of 1-2 meters. This method is limited in that it needs to be in a magnetic stable area to function properly. (Geospatial World, 2014)

WI-FI-BASED POSITIONING SYSTEM

Wi-Fi positioning system (WPS) uses Wi-Fi transmitters and receivers to makes two devices talk together. If the receiver is connected to more than two transmitters it is possible to estimate its position based on it relative position to the transmitters. The estimation is created by triangulation based on the strength of the signal. WPS have a relatively low precision on 4-5 meters. Wi-Fi have a long signal range but the range is obstructed by walls, and signals can interfere with each other and make the measurements imprecise. (Infsoft.com, ,-)

BLUETOOTH

Bluetooth can be used as a positioning system the same ways as Wi-Fi by triangulation. Bluetooth and Wi-Fi differs in the power consumption and the signal range. Bluetooths power consumption is lower than Wi-Fi and can easily be power by a battery whereas Wi-Fi have need for an external power source(or a very strong battery). But the low power consumption comes at a price which is a sorter range. Bluetooth have an effective range of 100-200 meters, but it is dependent on power source which means that normally the range is around 10 meters. Bluetooth can provide a precision on 2-3 meter. (Blaz, 2015)(Dunning, ,-)

EXISTING SYSTEMS

Currently there are many companies in the IPS industry, but some of the biggest are the tech giants Apple with iBeacons and Nokia with HERE(Geospatial World, 2014). The systems are not directly design for airport usage but for retailing which is closely related to the tax-free zone. iBeacons is a system which functions with bluetooth, were small units are placed around the venue or stores. The systems talks to users phones via bluetooth and locates the user with it(-Clausen, 2016). HERE is a similar system but works with a combination of either Wi-Fi or Bluetooth. HERE also utilize the users smartphone (Stevenson, 2016). Since both system utilize the users smartphones to locate their position, it means that both systems are opt-in systems. Users actively need to use the system for it to be effective. If users are not actively seeking out the use of the system no data is collected.

A company with another approach is Danish company Blip systems. Blip system uses an array of different tracking methods ranging from Wi-Fi and Bluetooth to Cameras and people counters. The systems tracks peoples movement with use of the different technologies to track flow, queue management, and more. The system is made for different industries where airports are one of them. The system is not a opt in system, but uses the movement of mobile devices to access movement and flow patterns. (Carstens, 2017)(BLIP Systems A/S, ,-) As the system is not an opt in system, it is assumed that information about the passenger gained from this solution is about how they move around in the airport and about the overall flow. Information relating to passengers social status, reason for traveling, and other informations is unknown.

Based on the research about IPS, it is concluded that a IPS system for the cart needs to be developed specifically for the cart as no existing solution provides the necessary service. The system will be based on iBeacons and HERE with the use of Bluetooth, because of the lower power consumption and the higher precision. The low power consumption is important as the cart runs on batteries. The high precision is important in relation to the targeted ads, as the precise location can be related back to a specific product or brand. The passengers needs to check into the cart to fully use its functions, which enables the airport to gain informations about the passengers travel plans and create the possibility of creating an understanding of the segments habits.

5.0 BUSINESS

5.1 BUSINESS MODEL

The following section will explain the business model for Team Airrity. An overview over the business model is presented, to show the relation between the customer segment and the value proposition. The following section is based on: Desktop Research and business Model Canvas. (Osterwalder & Pigneur, 2010)

Airrity's business model is driven by two main factors: Value & Finance. Airrity create new value for the passengers, while creating a new revenue stream for the Airport. This make Airrity's business model a multiple-epicenter driven plan. Airrity is planing on working together with the scanning company Analogics. Airrity will be working under Analogic.

In the next part the different steps of the business model canvas will be explained from the point of view of Airrity. (Osterwalder & Pigneur, 2010)

CUSTOMER SEGMENT
Niche market(Airports): Team Airrity aim for a niche market in the Airports. The market is niche since the product cannot be segmented into other industries.

VALUE PROPOSITIONS
Performance: Increased flow of passengers.

Convenience: Provides passengers with informations about what to hand in, and where to go.

Information: Data relating to; Flow, number of carry-ons, store visits and walk by.

Brand/Status: Providing the Airport with the possibility to brand them-self as a family friendly airport.

CHANNELS
Direct: Web sales and sales force. Team Airrity's sales force will actively seek out Airports to sell the solution. Airrity will be active in the different conferences which happens around the world. To further increase awareness and sales.

CUSTOMER RELATIONSHIPS
Co-Creation: While in development the team will work closely with some of the smaller airports, who are more open to being first movers, before rolling the solution out into the market.

Personal assistance: Each Airport have the possibility to contact team Airrity if there is any problems with the system.

Dedicated personal Assistance: Some Airports are high profile airport, which are the airport whom other airports look to. CPH Airport is an example of such an airport. To ensure the satisfaction of the high profile Airports dedicated personal will be assigned to these airports

REVENUE STREAMS
Asset sales: Airports buy the system and carts for a one time fee of Team Airrity

Subscription Fee: Team Airrity handles the data for the Airports. The Airport buys the data of the team. The Airport can then use and sell the data to Airlines and the companies in the airport.

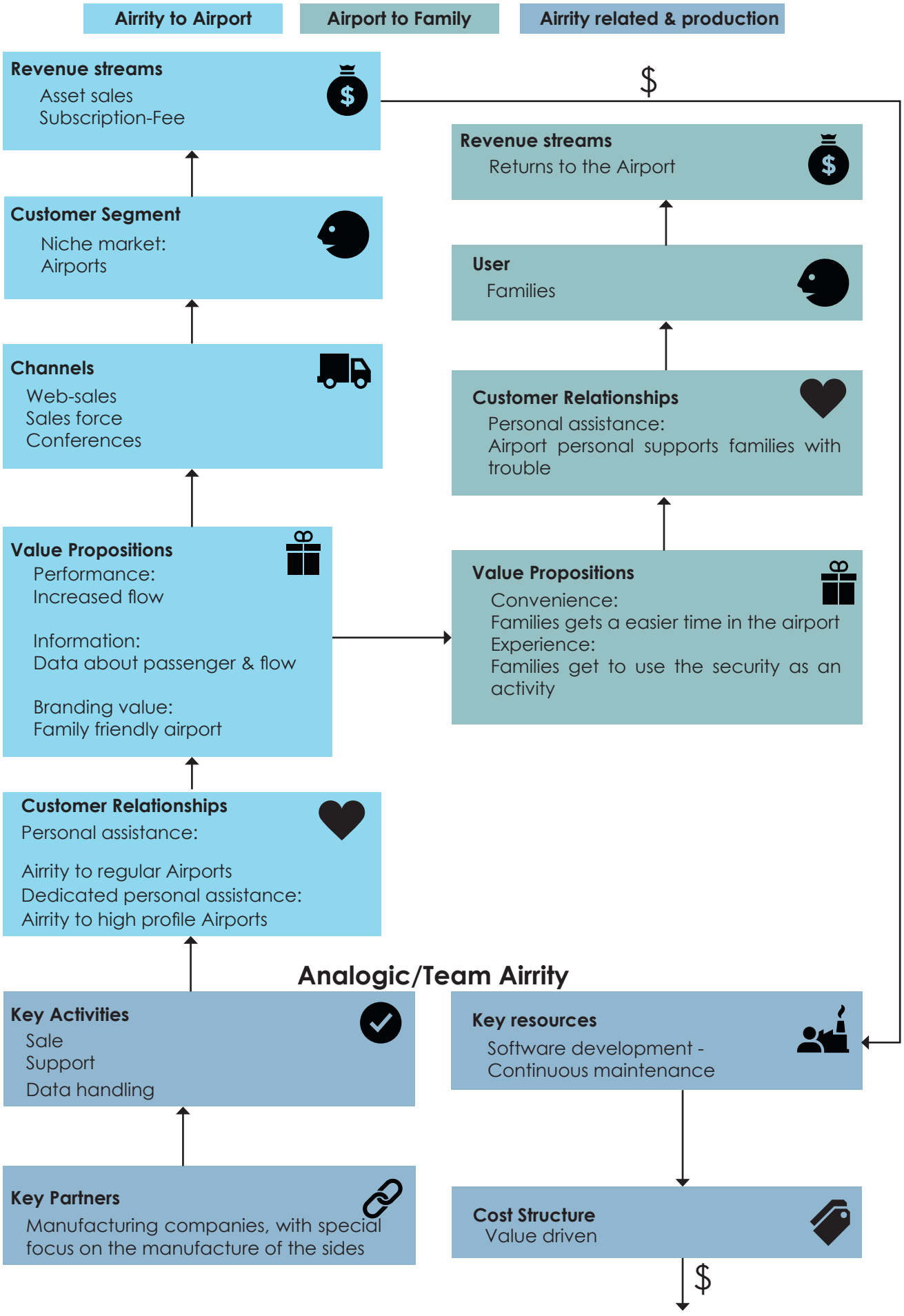
KEY RESOURCES:
Physical: Team Airrity relies on it suppliers and their manufacturing facilities.

Human: There is a need for software developers and employees handle the data from the Airports.

KEY PARTNERSHIPS:
All parts will be outsourced to other manufacturing companies. The team will try an establish a close connection to the manufacture of the gas assisted injection moulded sides. The team will enable the company to use the sides as a case for the company, show casing their abilities to manufacturing complex shapes.

KEY ACTIVITIES
Airrity's main activity is sale, support, and data handling.

COST STRUCTURE
The cost structure is value driving in Cartish. The structure is value driving because the product is about creating value for the families and to make the Airport more competitive. The product also focuses on increasing the flow in the security, and providing the Airport with other revenue streams. The value driving structure have resulted in some more expensive production methods, to ensure the value for the family.


Airrity to Airport
Airport to Family
Airrity related & production
Revenue streams
Asset sales
Subscription-Fee
$
Revenue streams
Returns to the Airport
Customer Segment
Niche market:
Airports
User
Families
Channels
Web-sales
Sales force
Conferences
Customer Relationships
Personal assistance:
Airport personal supports families with trouble
Value Propositions
Performance:
Increased flow
Information:
Data about passenger & flow
Branding value:
Family friendly airport
Value Propositions
Convenience:
Families gets a easier time in the airport
Experience:
Families get to use the security as an activity
Customer Relationships
Personal assistance:
Airrity to regular Airports
Dedicated personal assistance:
Airrity to high profile Airports
Analogic/Team Airrity
Key Activities
Sale
Support
Data handling
Key resources
Software development -
Continuous maintenance
Key Partners
Manufacturing companies, with special focus on the manufacture of the sides
Cost Structure
Value driven
$

5.2 VALUE REVENUE FLOW

The following section will elaborate on how the value and revenue flows between the different stakeholders in the Airport. This section is based on: Desktop research and interviews.

Team Airrity's Cartish provides the different stakeholders in the Airport with a gain. Team Airrity main customer is the Airport. Normally when the Airport adds new steps or technology to the security check it is just an expense. The security provides no monetary gain for the Airport and is just a regulatory demanded investment. This means that security needs to be pay by having other sources of income. These sources are the Airlines who pay the expenses indirectly. (Pedersen & Cilinder-Hansen, 2018) It is important that there is balance in the business model and each of the stakeholders have a gain from the implementation. The lack of balance in the business plan would result in a hole in the market which would create a clear place for competition to compete.

AIRRITY TO AIRPORT
Airrity provides the Airport with a better customer experience for the family segment. In addition, it provides data about how passengers move around in the airport and how much carry-on luggage they have with them. Airrity provides and handles the data for the Airport for a yearly subscription fee. The subscription fee is the main source of income for team Airrity. The subscription fee is estimated to cost the Airport 20.000€ each year.

The gains the airport gets from Airrity is mediated to the different stakeholders by the Airport. The biggest stakeholders are:

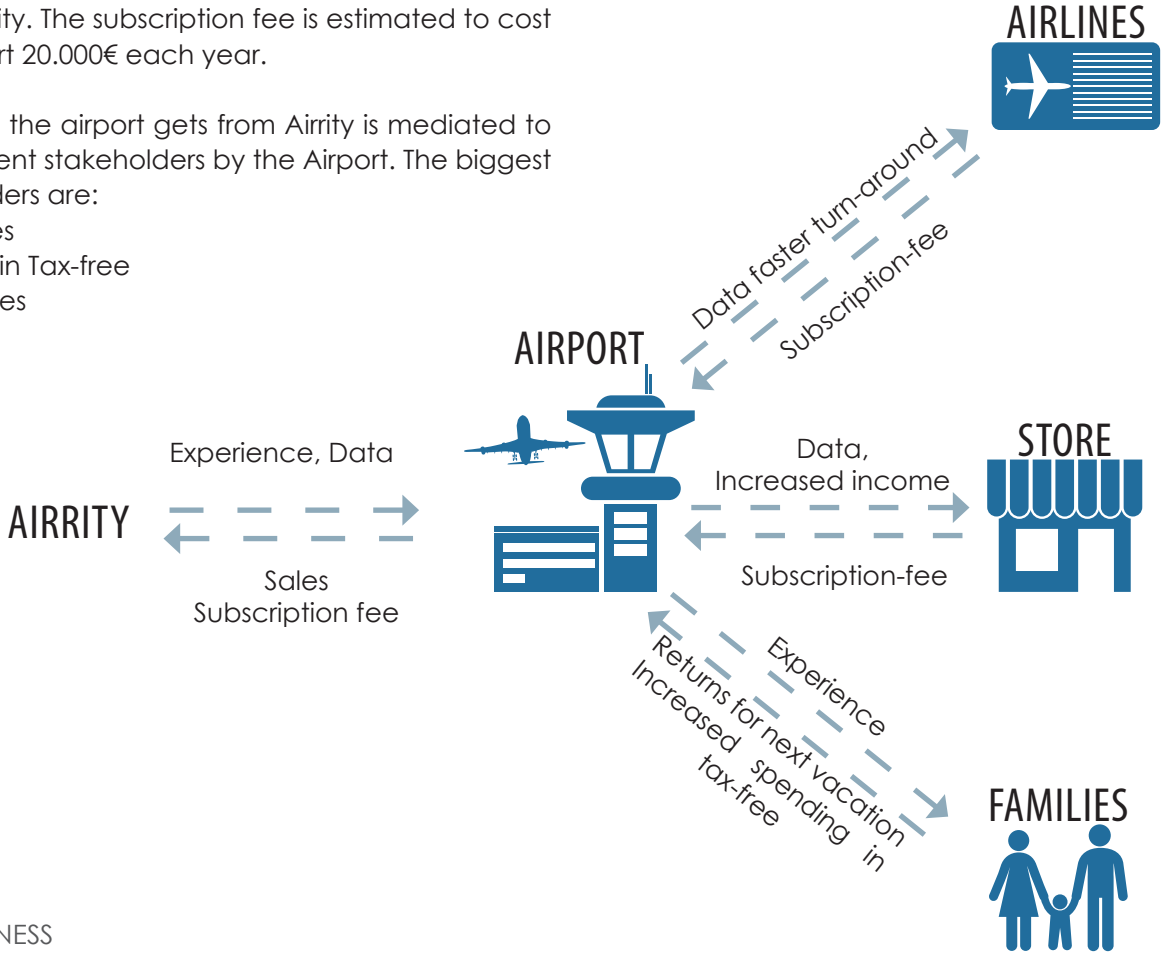
- Airlines
- Store in Tax-free
- Families

The flow of value and revenue can be seen on illustration 78.1.

AIRPORT TO AIRLINE
The Airport gains data from Cartish about the amount of carry-ons families carry. The information is sold to the Airlines so that they can prepare if there is to much luggage. This information can be used to prepare the movement of carry-ons to the cargo-hold. By being prepared Airlines can reduce the turn-around time for the flights.

AIRPORT TO STORES
The positioning data the Cartish provides to the Airport can be used by stores. The data can provide insight into which store passengers are in, providing the possibility for targeted ads. The information about the flow can be used by the marketing department in the store to see if advertisement is effective or if there is a segment which are not using there store.

AIRPORT TO PASSENGERS
The use of Cartish provides the Airport with a better security and airport experience for families. Families will remember how it was easier and a better experience to be in the airport, and they will return to the airport for their next travel. By providing the families with a cart there is an increased change for them using money in the tax-free area.



5.3 BUSINESS STRATEGY

This section will describe how Team Airrity will implement Cartish in the aviation industry. The calculations for production cost can be found in the Technical Folder. This section is based on research (Hansen, 2016).

The business strategy is divided into nine steps explaining how the implementation and optimization on the product will happen, to adapt to the costumers needs.

Step 1 - Functional test - Prototyping
A production of 10 carts will be made. The 10 carts will be used to test the stacking principle and to get an understanding of required space. The 10 carts will be produced by vacuum forming all parts. The forms will be made by CNC milling layers of MDF to get the right shape. By vacuum forming all parts it limits the strengths of the carts, but give insight about the outer propositions. The calculation for the production cost can be found in the Technical Folder.
The cart models will be used for the development for the scanner and the charging stations.
The development of the screen on the cart will be detailed. This includes the interface and information communicate to the passengers. The development of the data setup be made. The setup contains how to receives, process and distribute the data to other parties - Airport, Airlines, Shops. This includes the transmitter and the interfaces.

Step 2 - Optimization
The test can result in different parts or functionalities within the cart being adjusted. These will be optimized according to reach the best functionality and aesthetic but still have the production in mind. This can result in parts within the product are being standardized rather than specialized production.
The components which requires expensive molds - the two side produced by Gas-Assisted Injection Molding and the children handles produced by Injection Molding - all need to be specified in this step and optimized with the intension of creating a product platform.

Step 3 - Certification of security level
A test needs to be conducted to certify the security level to ensure it meets the requirements. The test requires that the scanner and the cart can be tested as one coherent unit. The cart needs to be produced with the correct material in the detailed production method.
To achieve the security level, it can be necessary to change part of the product. This could influence the aesthetic and the functionality within the product.

Step 4 - 0 series production
A test setup with 200 carts will be implemented in Billund Airport. The cart estimation of the needed numbers of carts can be found in appendix XXXI. Billund Airport are interested in being first movers on project and be are part of the development, to achieve the best solution. (Rasmussen, 2018) Billund Airport have many charter travelers including families.
Billund Airport will get the 200 carts for free, as they provide the team with important insight.
The 200 carts will be produced as describe in the Technical Folder; production cost for 1.000 carts, based on the description of a production of 1.000 carts. The test setup at Billund Airport will contain one security scanner which will be placed in the security checkpoint. In addition, multiple tracking devices will be mounted to collect the passengers movement.

Step 5 - Optimization
The test will result in insight in how the cart is used in the airport. This can result in a redesign of parts of the cart or adding new features.
The collected data for tracking the passengers will be processed. The data influence how to optimize the data setup to find the best solution for gathering as much information as possible.

Step 6 - Test in higher scale
An implementation of 1.000 cart will installed in Copenhagen Airport. Together with the carts the security scanner will be installed in a dedicated security lane for the families. The 1.000 carts will be produced as describe in the Technical Folder.
Copenhagen Airport is a high profile airport which inspires other airports on the experience and the used technology (Pedersen & Cilinder-Hansen, 2018). This creates press coverage and thereby attract other potential airports to implement Cartish.

Step 7 - Diversifying the user segment
A test will be conducted to test the use of Cartish for other user segments. It could be possible to implement variation of Cartish for different user segments, hence creating a diversifying market potential.

Step 8 - Optimization
The earlier presented optimization of the product platform enables the testing of different variations of Cartish, making it possible to adapt the product architecture to contain multiple variations. This might

result in changes for essential parts of the product. Or the addition of extra production setup and production costs.
The test makes it possible to modify the production setup before mass production.

Step 9 - Mass production
High quality molds (aluminum) for the vacuum formed parts are needed. These will ensure the best quality and allows to deliver a high amount of parts in a short time. (Lefteri, 2012)

An estimation shows that 23% of all passengers is families, Appendix XXXI.
100.000 carts will be produced as describe in the Technical Folder, and creates the foundation for the mass production.

5.4 SUPPLY CHAIN

This section will present the supply chain, which includes the connections and communications between the supply side and the demand side (Slack, et al., 2010). The section are based on Research.

A calculation for the estimated production cost for in-house production, resulted in a high unit price. Another calculation were made in relation to the renting of the machinery, which resulted in a reduction of the unit price. It is decided to outsource the production, to keep the production price low in the beginning. By outsourcing the product different pros and cons appears, which the team needs to take into consideration.

Pros: The supplier have specific knowledge and experience about the production. The suppliers are interested in reducing their cost and thereby motivated to get materials for a lower price.
Cons: It can be difficult to communicate with the suppliers. Risk for a big delay on the deliveries. There is added an overhead price for each unit produced.

Illustration 80.1 shows an overview of the different suppliers. It presents how the information and physical flow relates between the supply side and the demand side (Slack, et al., 2010).

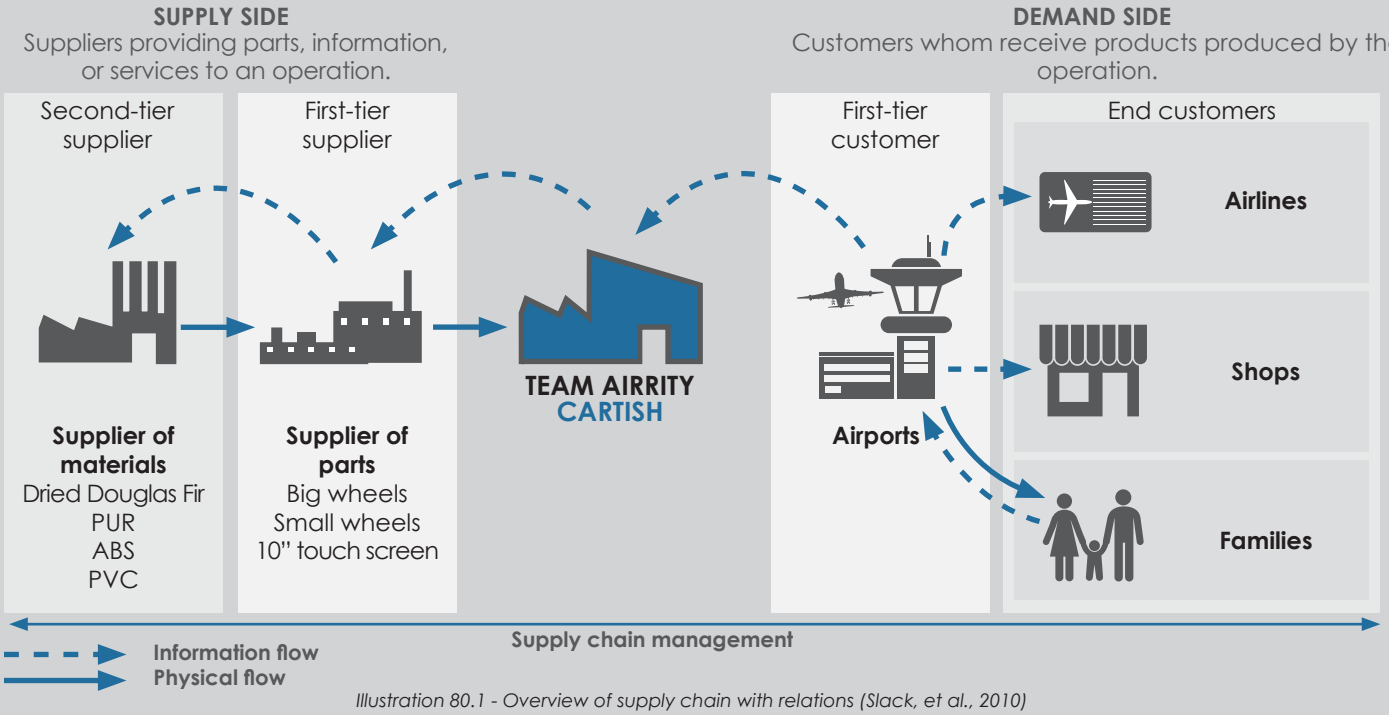


Illustration 80.1 - Overview of supply chain with relations (Slack, et al., 2010)

5.5 PRODUCT COST

This section will present the estimated product cost. In addition, it will give an estimation about the needed investment. The data are used to estimate the Return of Investment, and thereby give an indication about when the product break-even. The section are based on: Desktop research and Interviews.

A estimated product cost have been calculated. The product cost included the special produced components and the standard components. The prices for standard components can be found in the Technical Folder. The calculation for all special produced components can be found in the Technical Folder - includes calculations for 10 units, 1.000 units, and 100.000 units.
The calculation in this section are based on the production cost for 1.000 units.

The prices for the standard components are based on available prices. It is possible to reduce the prices if they are bought in higher quantities.

The estimation of special produced parts are based on renting the machineries. This results in a lower investment, but influences the overall prices due to the renting company applies a overhead on 30% of their production cost.

The estimated total product cost for one unit/cart will be **240€**.
The cart will be sold to a price on **400€**, which give a profit on 60%.

INVESTMENT

The investment includes the entire development of the cart and the implementation time. This included prototyping and testing of the product. Furthermore will two years be allocated for the test of the security level.
Investments are made to go to conferences and present the solution for potential buyers.
The table 81.1 shows the investment. An estimation of the years for the different investments are presented in the table. This gives an indicated about the continuous investment needed.

Project cost	
Salary *(programming)(2 men for 1 year = 1700h, 1h = 40€/h) (year 1)*	-136000 €
Salary *(2 men for 5 year = 1700h, 1h = 40€/h) (year 1-5)*	-340000 €
Prototyping *(10 units - vacuum forming) (year 1)*	-1940 €
Prototyping *(200 units - vacuum forming) (year 3)*	-38000 €
Traveling *(conferences) (year 1-10)*	-1000000 €
Tools *(Molds, etc.) (for 1000 units) (year 4)*	-325000 €
Tools *(Molds, etc.) (for 100.000 units) (year 5-10)*	-377000 €
Test of security level *(year 2-3) *wild guess*	-500000 €

Table 81.1 - Investment

RETURN OF INVESTMENT (ROI)

The product are produced in a continuously flow, for faster delivery to the buyers. This requires a room for storage. The test of the security level sets a limit for the possible market entrance. It is estimated that the first units sold will be 1.000 units to Copenhagen Airport in year 4. The subscription fee included the yearly payment (20.000€) for the airport to get the data for tracking the passengers processed. It is estimated that the average airport buys 500 units. Table 81.2 presents the business forecast. It is estimated that 100.000 units will be sold over a period of 10 years.

Business forecast

Prices in €	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Units sold	0	0	0	1000	1000	5000	8000	15000	25000	45000
Sales price	400	400	400	400	400	400	400	400	400	400
Subscription fee	-	-	-	40,000	40,000	200,000	320,000	600,000	1,000,000	1,800,000
Product cost	240	240	240	240	240	240	240	240	240	240
Turnover	-	-	-	440,000	440,000	2,200,000	3,520,000	6,600,000	11,000,000	19,800,000
Variable Cost	-	-	-	240,130	240,130	1,200,650	1,921,040	3,601,950	6,003,250	10,805,850
Contribution Margin	-	-	-	199,870	199,870	999,350	1,598,960	2,998,050	4,996,750	8,994,150

Table 81.2 - Business forecast

BREAK-EVEN ANALYSIS

The analysis is based on the previous presented data over a 10 years period, Table 82.1. The estimated investments are presented in Year 1. This would be different in reality due to the investment being continuous, as indicated on Table 81.1 previous section.

The analysis shows that the break-even happens between year 6 and year 7.

Break-Even analysis										
Prices in €	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Investment	-2,717,940	-2,717,940	-2,717,940	-2,717,940	-2,518,070	-2,318,200	-1,318,850	280,110	3,278,160	8,274,910
Contribution	-	-	-	199,870	199,870	999,350	1,598,960	2,998,050	4,996,750	8,994,150
Remaining	-2,717,940	-2,717,940	-2,717,940	-2,518,070	-2,318,200	-1,318,850	280,110	3,278,160	8,274,910	17,269,060

Table 82.1 - Break-Even analysis

KEY NUMBERS

The return of investment over a 10 years period is 17.269.060€. This gives a **ROI on 635%**, Table 82.2. The cash flow are presented on Illustration 82.1, which gives a indication of the flow.

Return	17.269.060€
ROI	635%

Table 82.1 - Key numbers

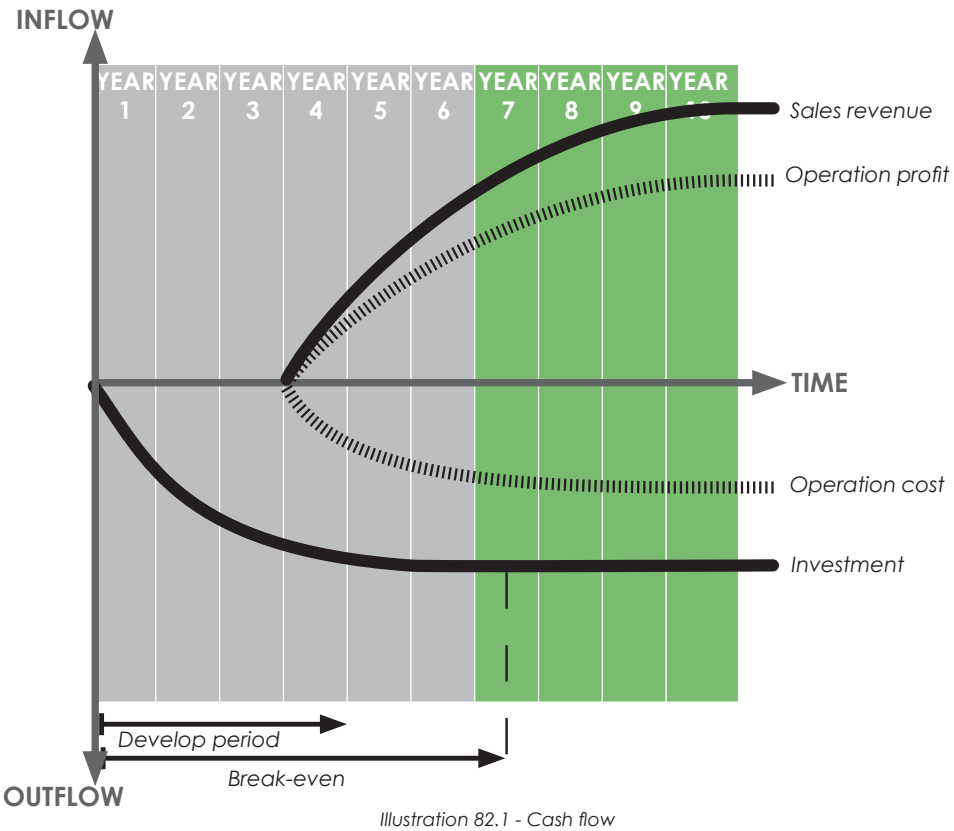


Illustration 82.1 - Cash flow

ENDING

The calculation used for this section are based on the production cost for 1.000 units. A calculation for 100.000 units resulted in a unit price on 95€ + 50€(standard components) = 145€/unit. This is a reduction on 65%. This will result in a reduction of the break-even time.

It have not been possible to find any estimation about the cost for the development of the security scanner. The estimation of time used for the development of the scanner are based on interviews with CPH airport (Pedersen & Cilinder-Hansen, 2018).

6.0 CLOSING

6.1 CONCLUSION

The project dealt with creation a design proposal for the stressed environment in airport security checkpoints, where the team worked with; Creating a vision for how the future can be.

The initial focus of the project were creating a faster security experience, which quickly developed into the focus of removing the slow passengers from the regular security to provide the faster segment to be fast. The removal of the slow turned into a framing about creating a better experience for the segment based on: Interviews and observations made in the three largest airports in Denmark, Aalborg Airport, Billund Airport, and Copenhagen Airport.
The investigations changed the overall focuses to creating a better experience for families going through the airport security checkpoints.

Multiple framings and re-framing of the problem resulted in the final concept - Cartish. Through interaction tests, user interviews, analysis of product aesthetics, 3D printed modeling, the final design was refined and detailed to accommodate the gained knowledge and user needs such as creating clarity and privacy into a one coherent design solution.

Cartish provides families with the time and space they need to prepare unstressed for security while informing them about what they need to do to ensure they get through in the first try. Cartish provides the families with an experience involving the entire family.

Through investigations inside the entire airport it was possible to gain an overview over the problems in the different parts of the airport and the overall structure for the airport business. The overview of the problems and the business developed into a business model. The model incorporated the important stakeholders into the business case providing each stakeholder with a value in the proposed solution.

Cartish provides the airport with both a better experience for its customer, making them more competitive in an increasing market. Cartish also providing the airport with new revenue streams, through the gathered data, marking security a revenue creating part of the airport.

6.2 REFLECTION

This section will reflect upon the activities and process done during the project.

The team were created on the earlier work experiences, to ensure that the team could work together and had the same work-approach to make the project run smoothly. The team new each others weaknesses and strengths. The team is strong in the pre-phase, research and construction. The teams weaknesses is in the concept and form giving phases. This were apparent in the concept phase as the team had problems visualizing and creating a coherent concept. The team spent a long time in the concept phase to create a concept which fulfilled the vision and framing the team had. The use of mock-ups and 3D printed models helped to visualize the form, and should have been introduce before to ease the process of creating a form.

The project used a agile project management style resembling scrum. The team used the equivalent of daily and weekly scrum meetings aligning assignment and tasks. The use of milestones which dictated the progress of the project. Mini-milestones were conducted with two other teams through the initial phases of the project. The mini-milestone were used to see if the direction the teams went in made sense. The other teams provided feedback on what could be important to look at. In the initial part of the project the team used time boxing to ensure that the team did not use to much time on each assignment. This worked in until the team came into the concepts phase, were the team found it difficult to time box the activities.

The team have actively been using framing as a part of the project to set up demands for the concept. Multiple re-framings have happened through the process due to gain knowledge. Using framing to control the project have been effective and a good way of setting up demands. In relation to setting up demands, the team used needs and demands in the target specification(Ulrich & Eppinger, 2012).
The use of this method have not been an active tool in project as intended. The method is specific and good to handle tame problems. As this project have been wicked the model created more stress and confusion than it helped. This resulted in framing being used as the demand tool and when specific demands, such as the hight on the handle for parents and children, were research and the result were written directly in as a fully defined demand, without being written in as a need.

The project focused on the creation of a better experience for families and made multiple interaction tests with the principle of the cart. User involvement have been an important part of the project and each time the team have been in contact with the user segment it has provided valuable insights to the solution. But the testing have been segmented and the concept have not been tested as one coherent concept. Testing is required to know if the solution is creating the intended experience.

The teams business case shows a long and expensive development. The investment is to big and the lack of technological knowledge creates a high risk if the team should be a startup. The business strategy is to work together with an already established company.

The development of the production methods have been made with correspondence with VELUX A/S and have giving insight into a specific production method. The product is on the other hand still in the concept phase and needs changing to be get ready for production. Some of the connections between the different part of the products such as the connection of the child seat are not as integrated as intended, and would need to be revisited.

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Birgitte Fromsejer Nøkleby | Christoffer Høg Jørgensen

CARTISH

BY AIRRITY

Technical folder | MA4 - ID11 | May 2017

Birgitte Fromsejer Nøkleby | Christoffer Høg Jørgensen

TITLE PAGE

Project title:
Cartish - The future in airport security

Type of report:
Technical folder

Time period:
01.02.2018 - 31.05.2018

Team:
Airrity
M.Sc. 04 - ID11

Main supervisor:
Louise Møller Haase

Technical supervisor:
Poul Kyvsgaard

Number of pages: 42

ABSTRACT

This is a Master Thesis regarding the development of a product for the future airport security checkpoints.

Most people know that the most stressing part about the airport is the security check. Passengers stress about separating their items, and to get through without trouble. The airport want the passengers through as fast as possible but also need to uphold the level of security. With more passengers traveling even more passengers are going through the airport, and with an increasing amount of security steps it is not getting easier to go through. There is a need for a radical change in the way we think about airport security checkpoints, so it can follow the increasing passenger numbers.

This Master Thesis project focuses on reducing the stress through security by focusing on families. The product Cartish is a cart which takes the families out of the regular security lane. Cartish provides the family with the time and space they needs to go through security. Cartish focuses on making the security check an experience the family can do together. The airport benefits of the tracking of the passengers, by receiving valuable information about how the airport is used.

Birgitte Fromsejer Nøkleby

Christoffer Høg Jørgsensen

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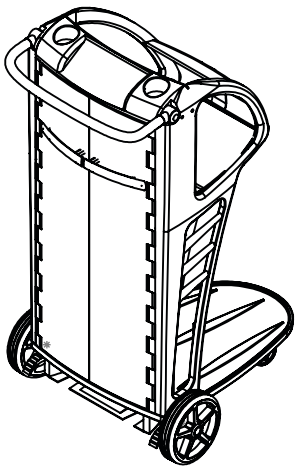
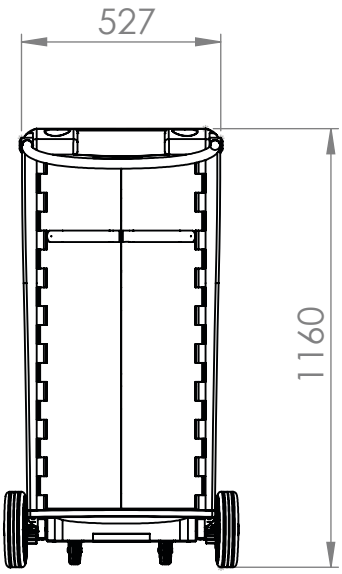
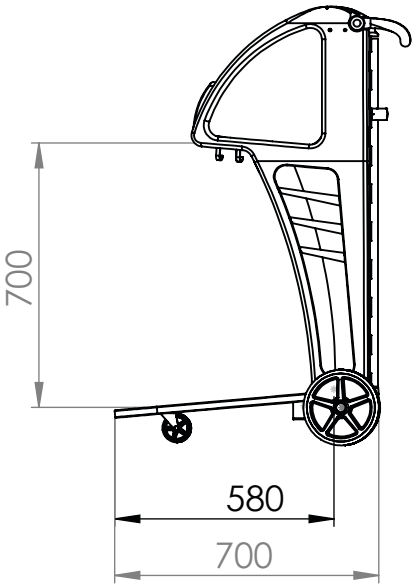
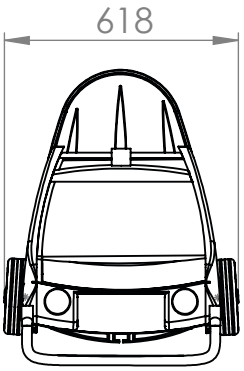
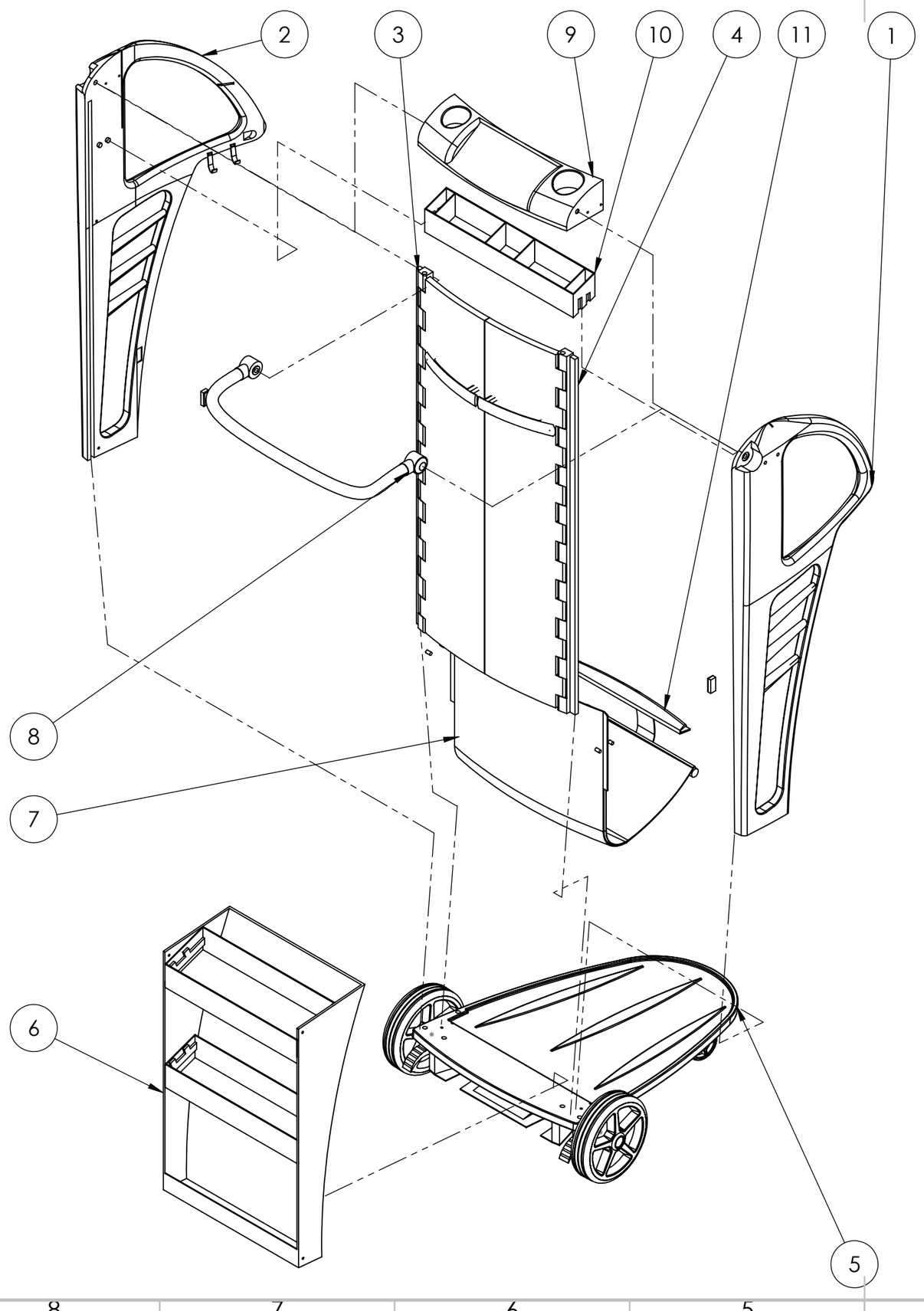








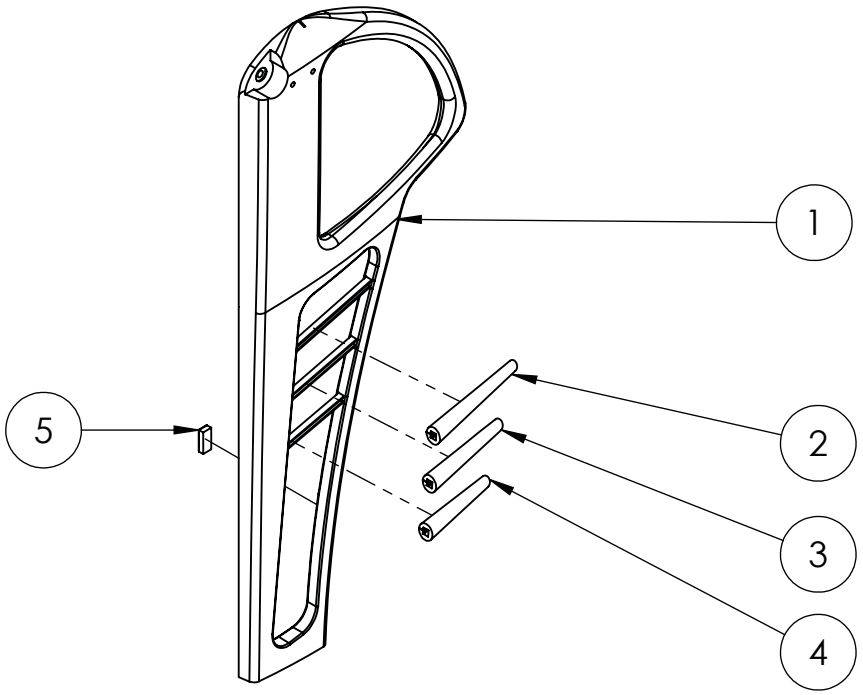
Part: CARTISH **Cartish - Isometric**		Responsible: Team Airrity All dimensions in mm unless otherwise specified
First angle projection	Drawing number: # -	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: -	Scale: 1 : 20
Manufacturing: -	Supplier: -	



ITEM NO.	Sub assembly #	DESCRIPTION	QTY.
1	1	Right side, childhandles, coat hangers and strapholder	1
2	-	Left side- No sub assembly, the side is a mirror of the right side	1
3	2	Left door, hinges and handles	1
4	-	Right door - No sub assembly. Mirror of left door	1
5	3	Bottom plate, Stacking items, wheels, antislip	1
6	4	Cabinet, 2nd tray. 3rd tray	1
ITEM NO.	Drawing #	Describtion	QTY
7	17	Child seat	1
8	-	Handle for Adults	1
9	18	Top tray	1
10	19	1st tray	1
11	20	Child table	1

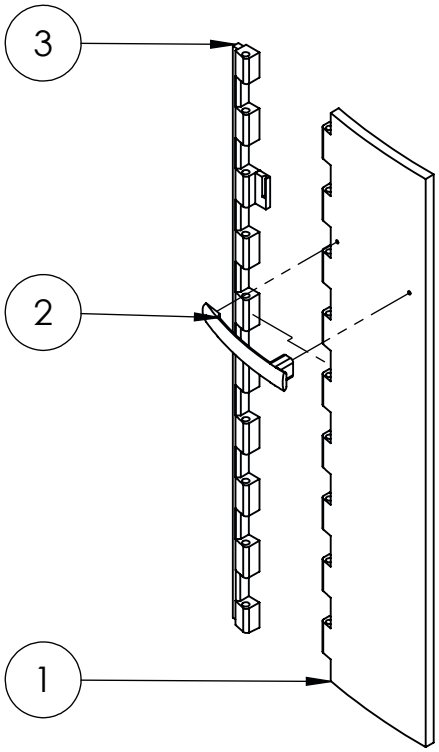
Part: CARTISH **Exloded view w. BOM**		Responsible: Team Airrity All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #00	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: -	Scale: 1 : 10
Manufacturing: -	Supplier: -	

ITEM NO.	DRAWING NUMBER #	DESCRIPTION	QTY.
1	05	Wing - Right side	1
2	06	Child handle high right	1
3	07	Child handle medium right	1
4	08	Child handle low right	1
5	-	Strap holder	1

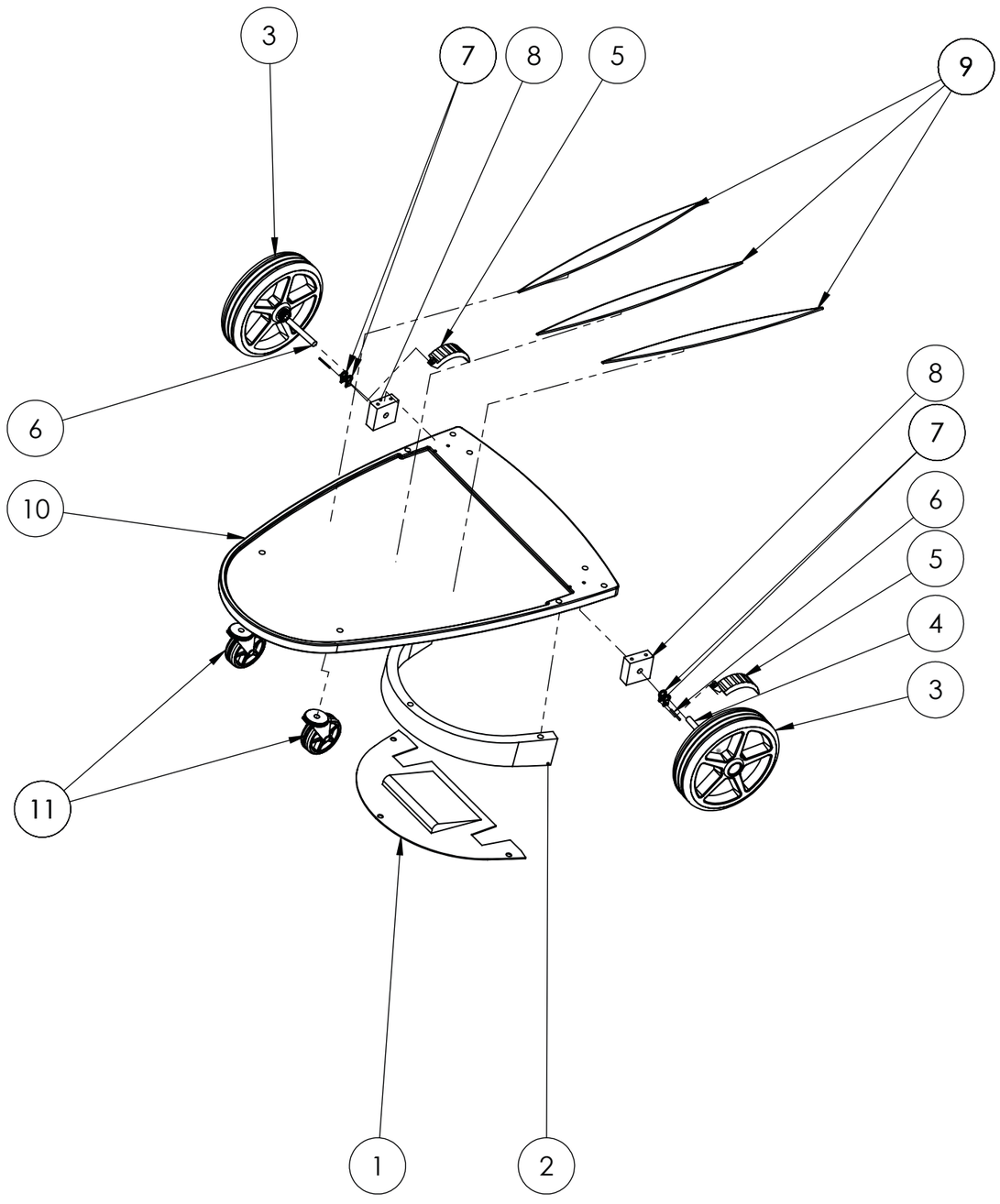


Part: Sub-assembly 1 - Right side	CARTISH	Responsible: Team Airrity
		All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #01	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: -	Scale: 1 : 10
Manufacturing: -	Supplier: -	

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	09	Door	1
2	-	Door handle	1
3	10	Hinge Left	1



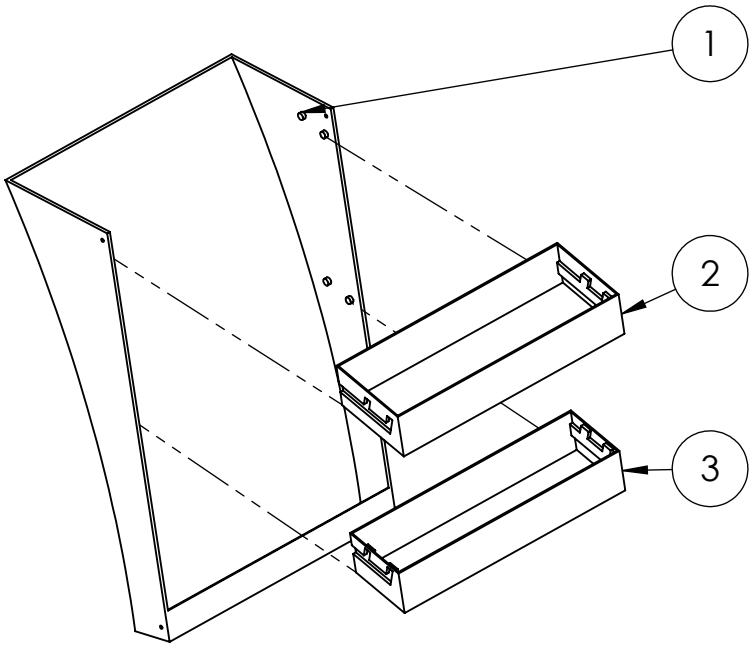
Part: Sub-assembly 2 - Left door	CARTISH	Responsible: Team Airrity
		All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #02	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: -	Scale: 1 : 10
Manufacturing: -	Supplier: -	



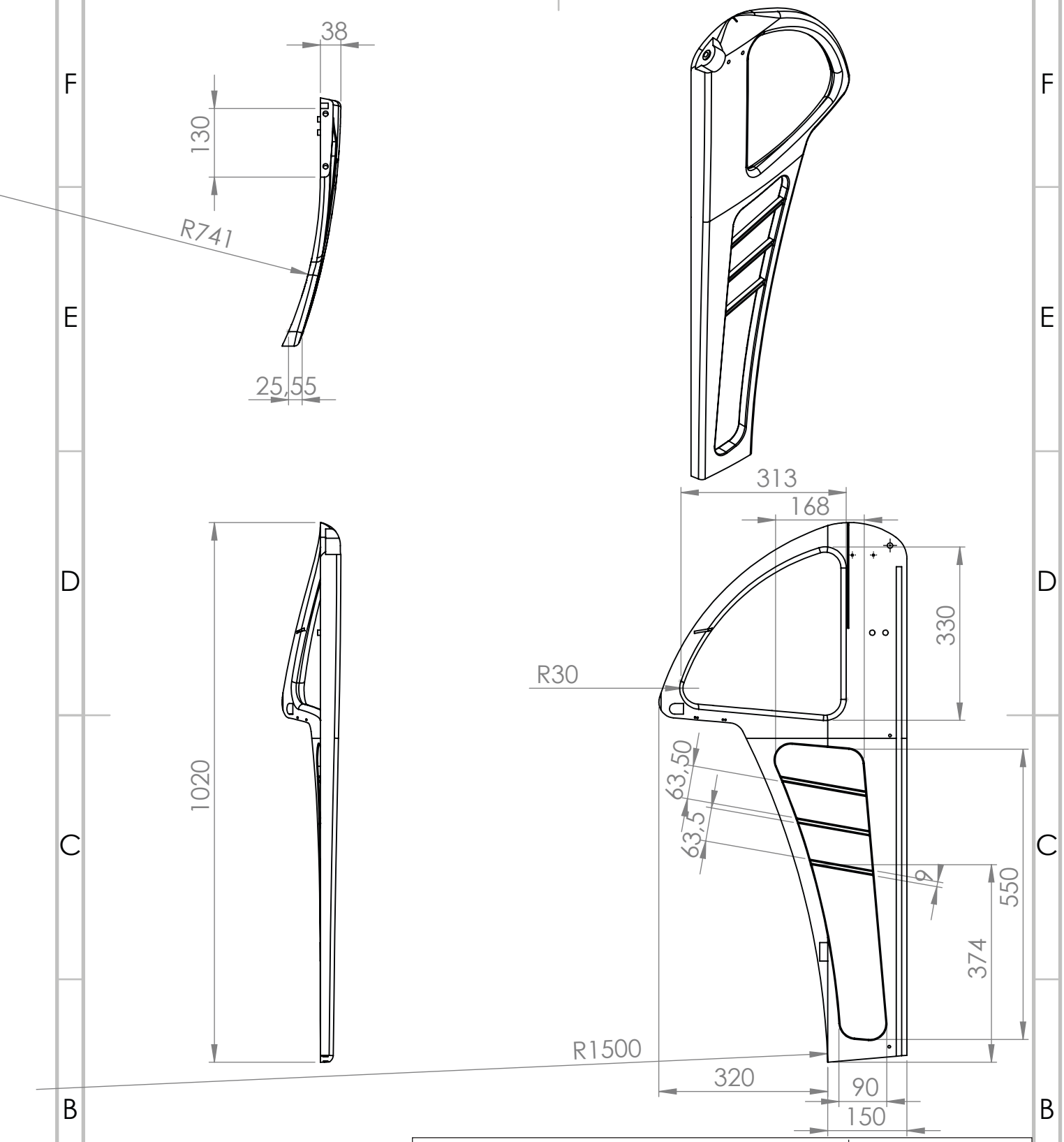
ITEM NO.	Drawing #	DESCRIPTION	QTY.
1	11	Staking part 1	1
2	12	Staking part 2	1
3	-	Back wheel	2
4	-	Axle	2
5	-	Pedal	2
6	-	Lock straps	2
7	-	Rotating element	4
8	-	Box for the brake	2
9	-	Anti slip surfac strips	3
10	13	Bottom plate	1
11	-	Front wheel	2

Part: CARTISH Sub-assembly 3 - Bottom plate		Responsible: Team Airrity All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #03	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: -	Scale: 1 : 10
Manufacturing: -	Supplier: -	

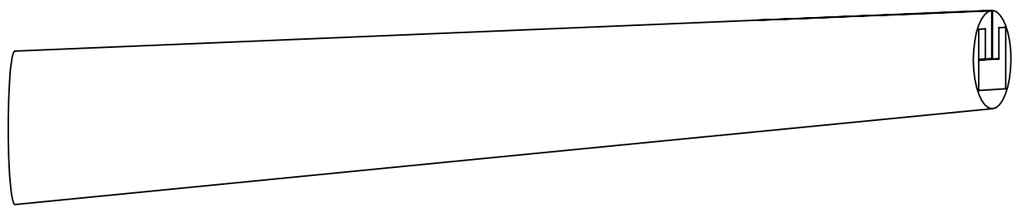
ITEM NO.	Drawing #	DESCRIPTION	QTY.
1	14	Cabinet	1
2	15	2nd tray	1
3	16	3rd tray	1

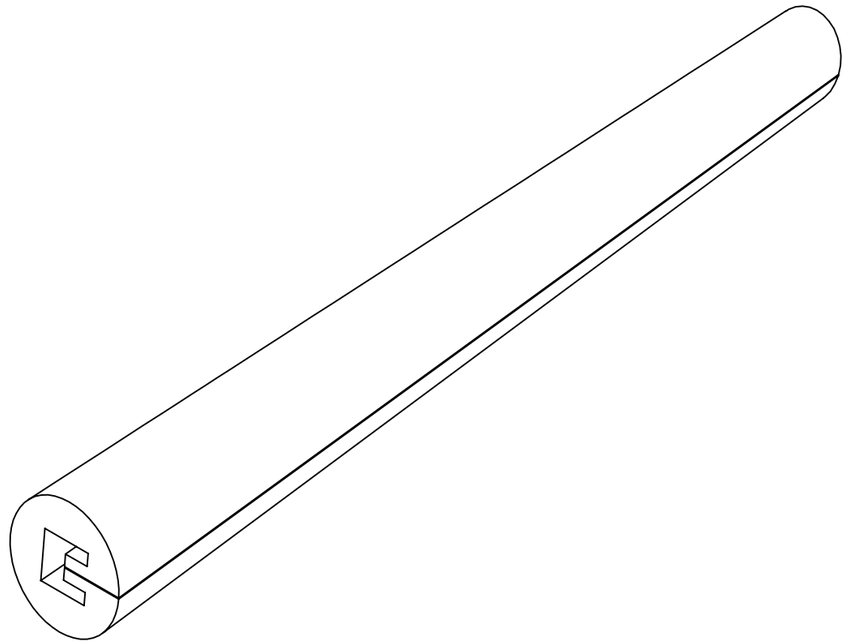


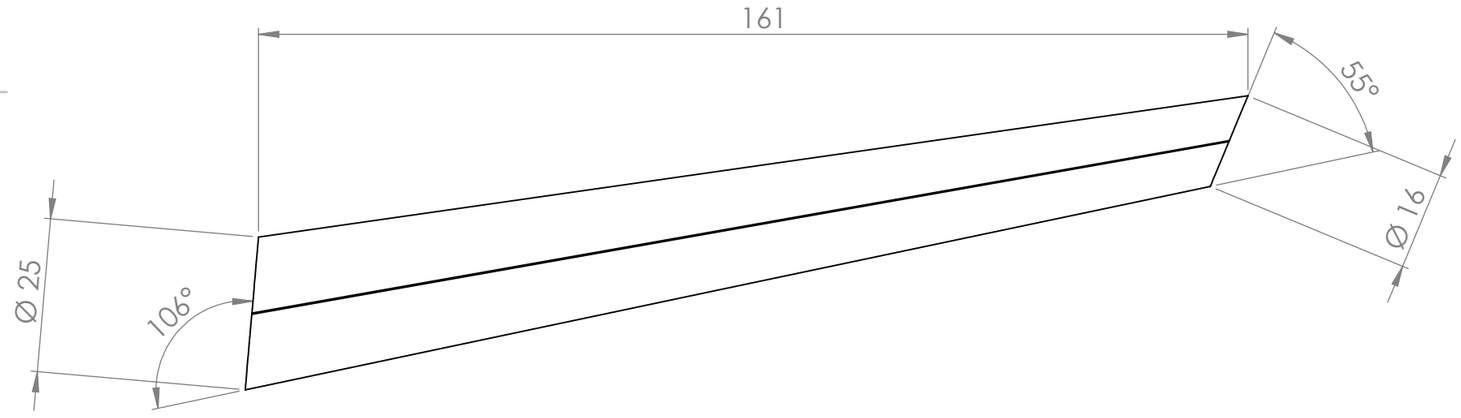
Part: Sub-assembly 4 - Cabinet and trays	CARTISH	Responsible: Team Airrity
		All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #04	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: -	Scale: 1 : 10
Manufacturing: -	Supplier: -	

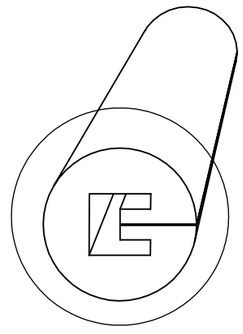


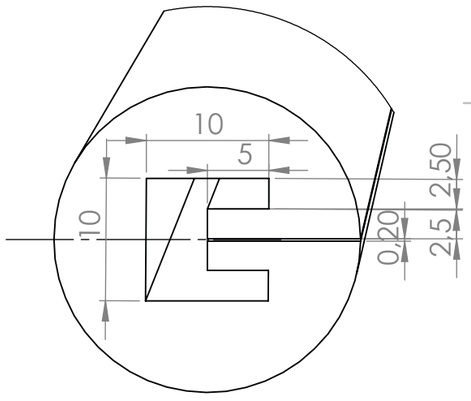
Part: CARTISH		Responsible: Team Airrity
Wing - right side		All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #05	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: Dried Douglas Fir+PUR	Scale: 1 : 10
Manufacturing: Gas-Assisted Injection Molding	Supplier: Own part	







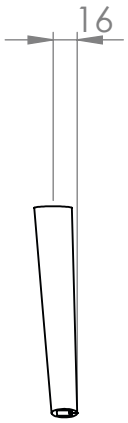


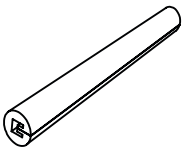


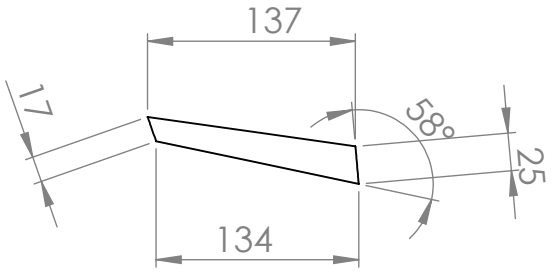
DETAIL B

SCALE 2 : 1

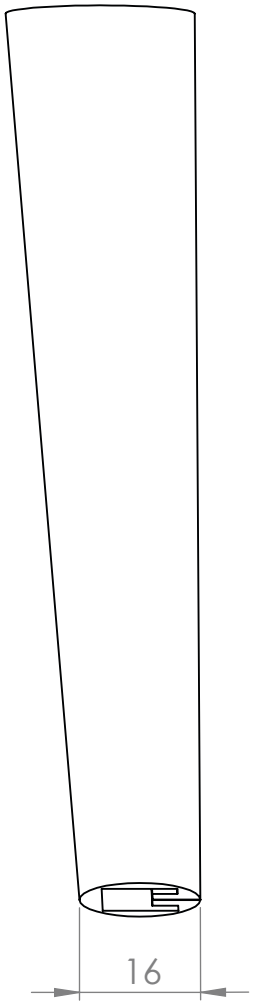
Part: CARTISH Child handle - high		Responsible: Team Airrity All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #06	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: PVC	Scale: 1 : 1
Manufacturing: Injection molding	Supplier: Own part	

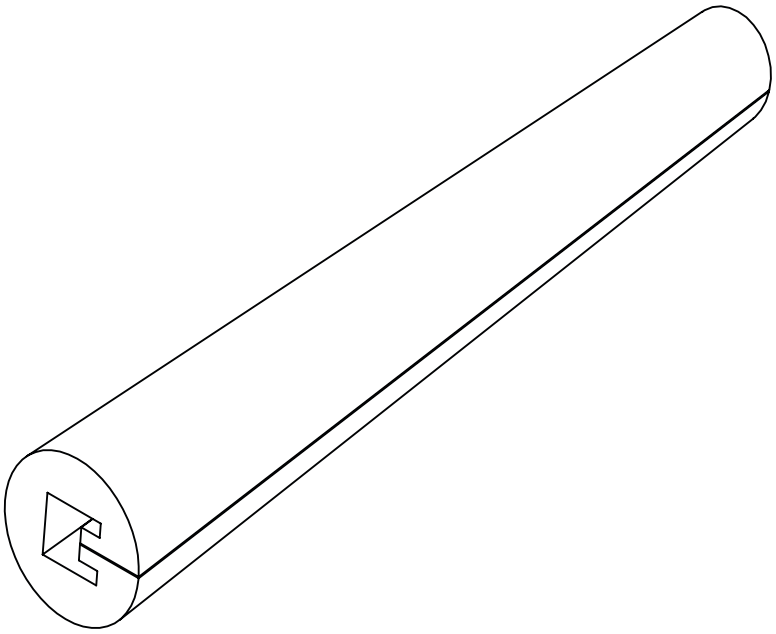


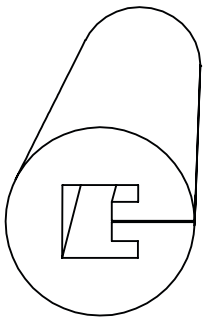


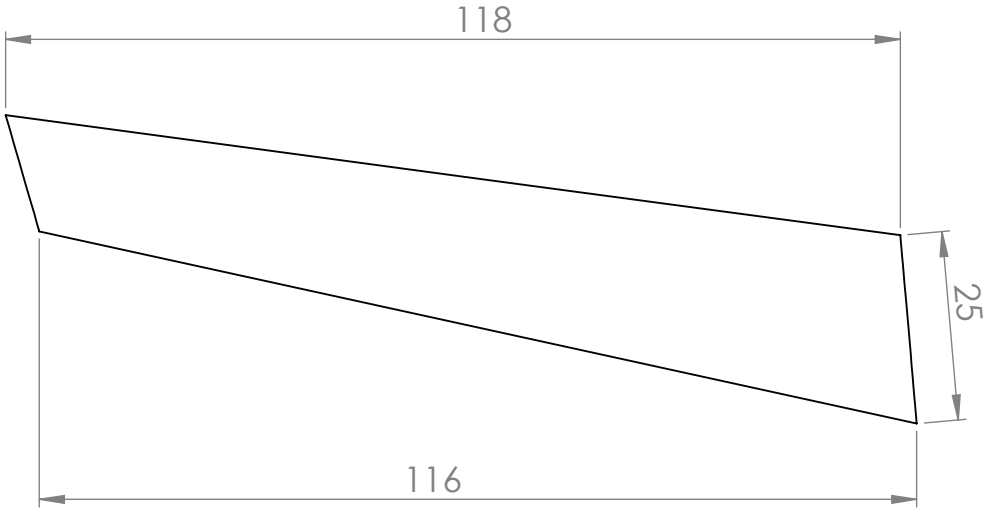


Part: Child handle - medium	CARTISH	Responsible: Team Airrity
		All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #07	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: PVC	Scale: 1 : 5
Manufacturing: Injection molding	Supplier: Own part	

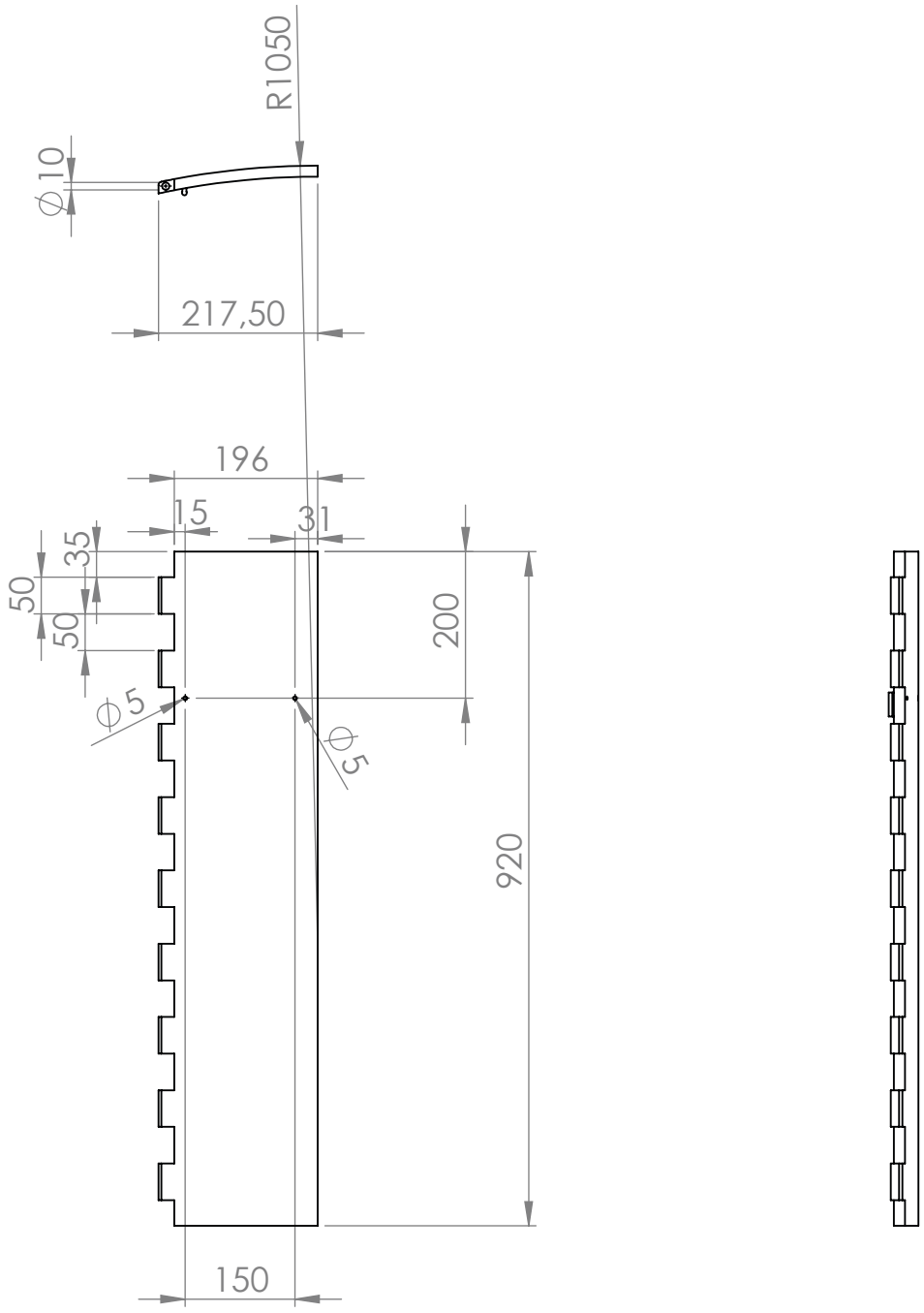




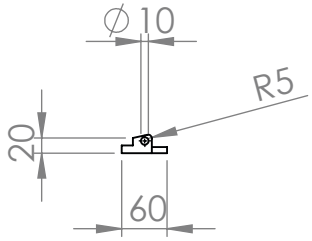


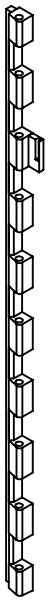


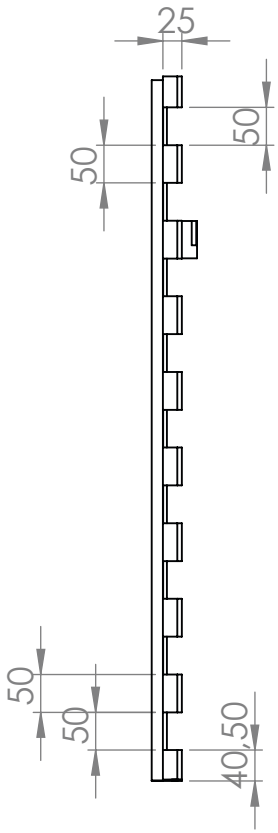
Part: Child handle - low	CARTISH	Responsible: Team Airrity
		All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #08	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: PVC	Scale: 1 : 1
Manufacturing: Injection molding	Supplier: Own part	

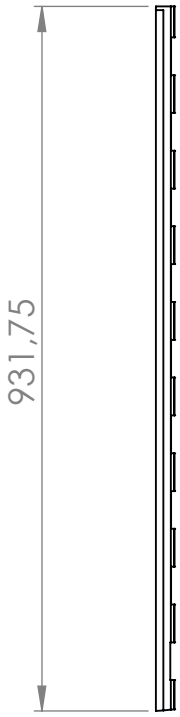


Part: Door	CARTISH	Responsible: Team Airrity
		All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #09	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: ABS	Scale: 1 : 10
Manufacturing: Vacuum forming	Supplier: Own part	

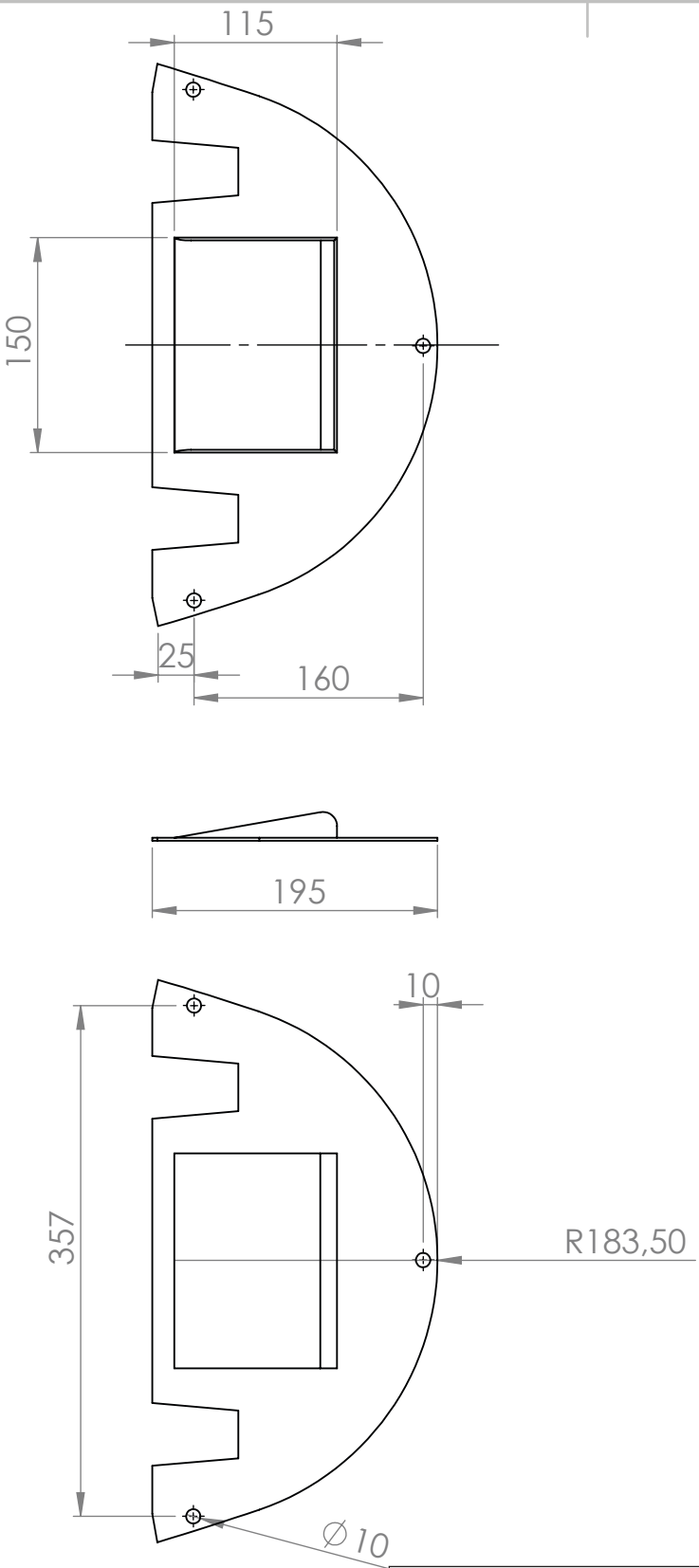




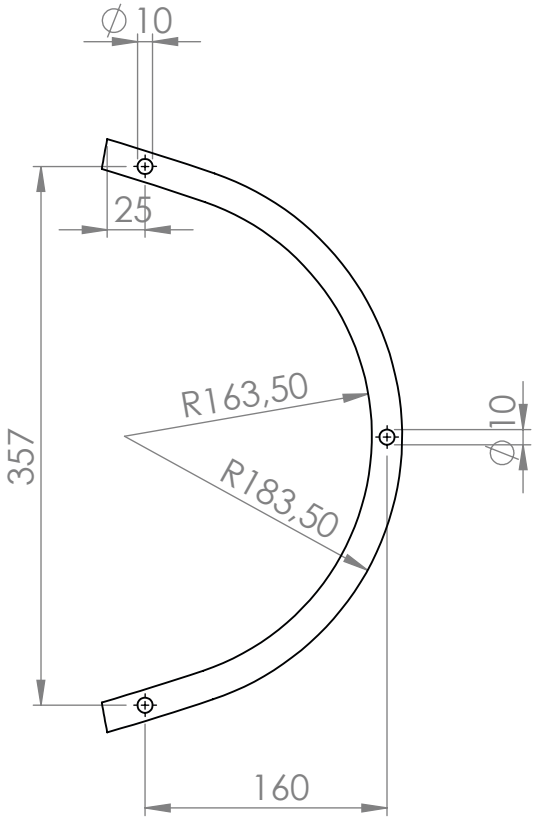


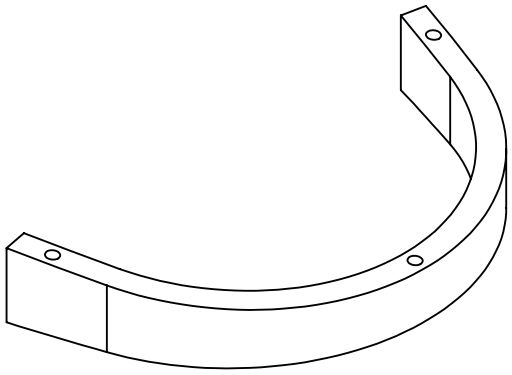


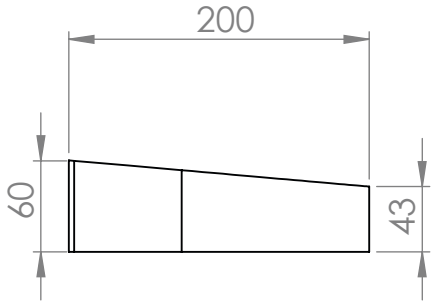
Part: Hinge	CARTISH	Responsible: Team Airrity
		All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #10	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: -	Scale: 1 : 5
Manufacturing: -	Supplier: Own part	

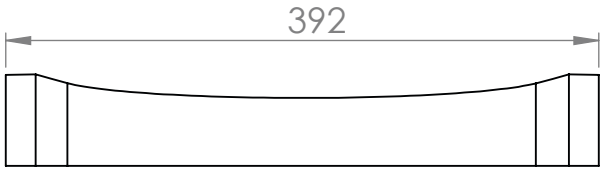


Part: Stacking - part 1	CARTISH	Responsible: Team Airrity
		All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #11	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: ABS	Scale: 1 : 5
Manufacturing: -	Supplier: Own part	

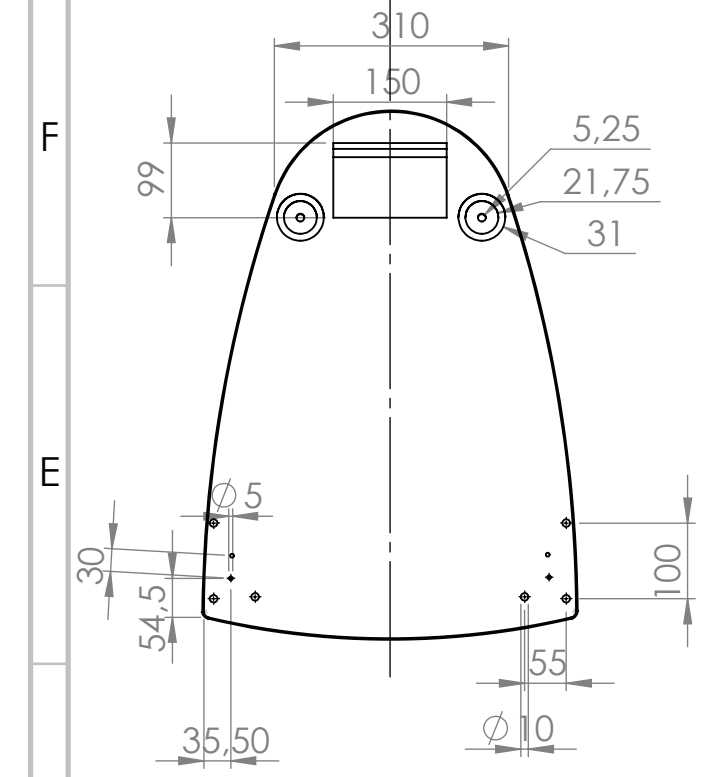


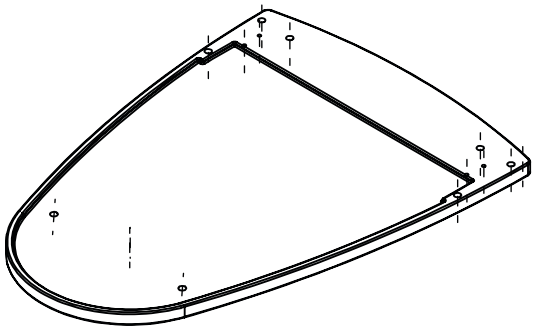


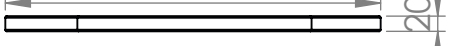


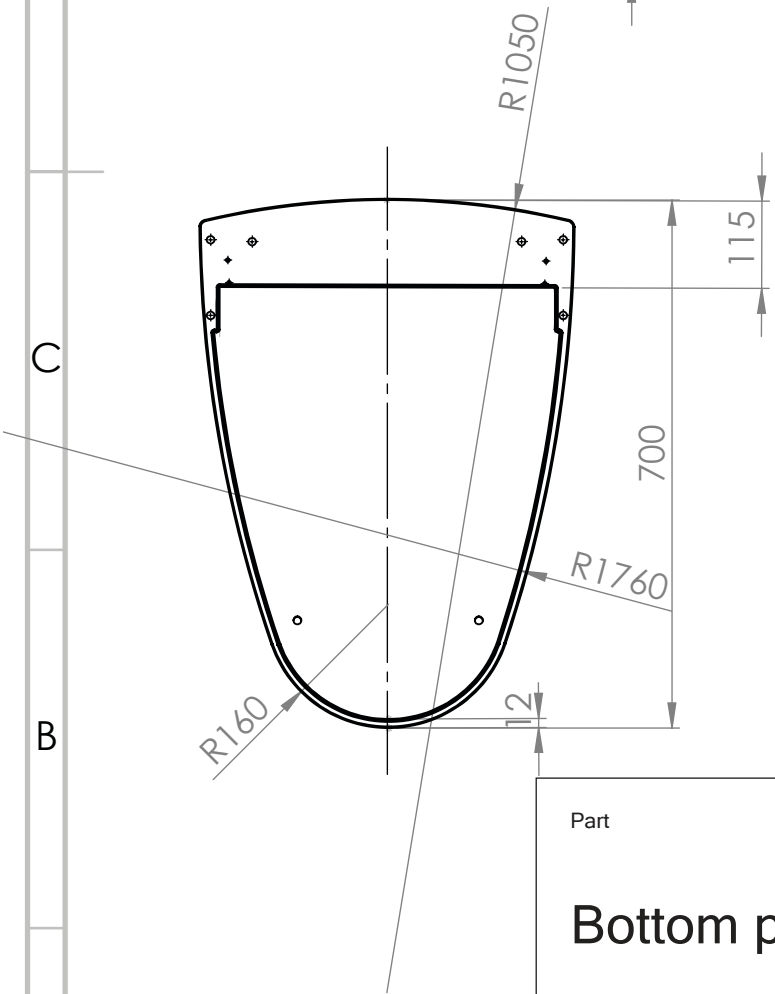


Part: Stacking - part 2	CARTISH	Responsible: Team Airrity
		All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #12	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: ABS	Scale: 1 : 5
Manufacturing: -	Supplier: Own part	

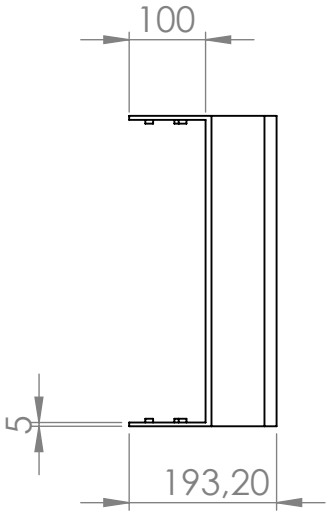


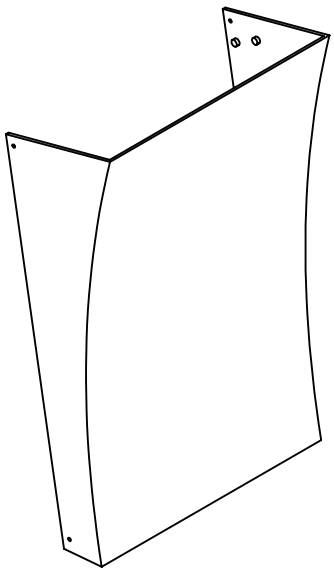


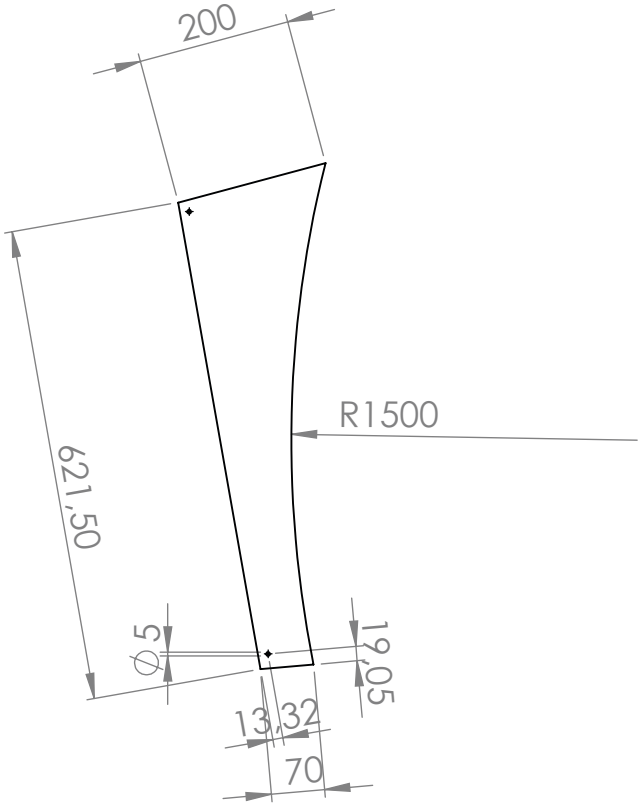


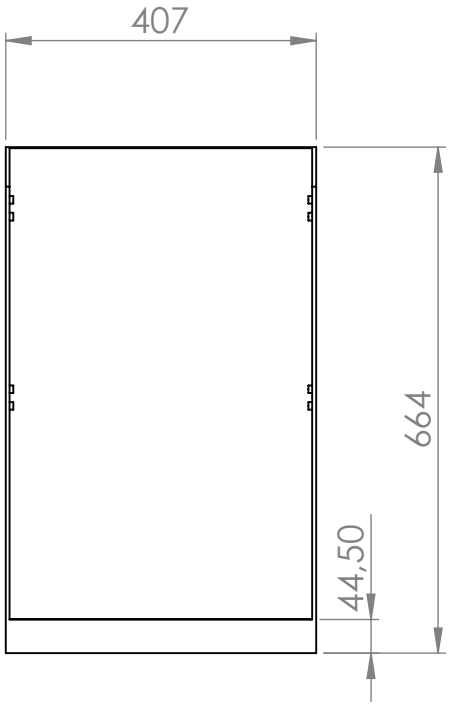


Part: **Bottom plate**		CARTISH	Responsible: Team Airrity
			All dimensions in mm unless otherwise specified
First angle projection		Drawing number: #13	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m		Material: ABS	Scale: 1 : 10
Manufacturing: Vacuum forming		Supplier: Own part	

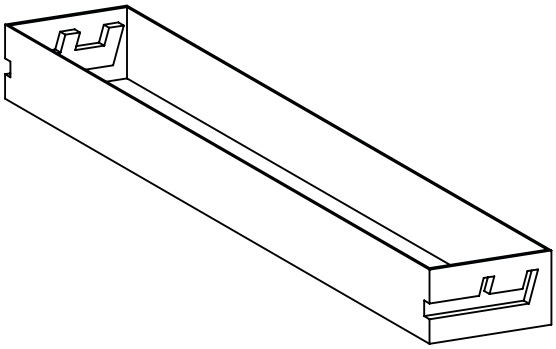


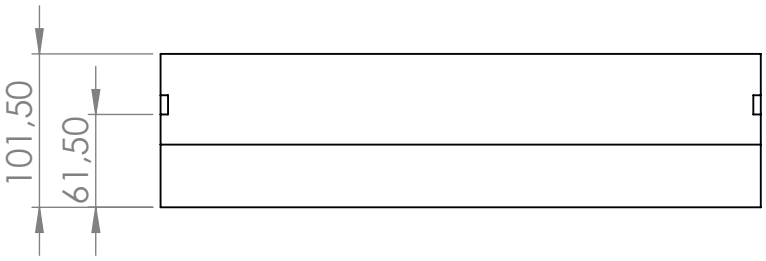


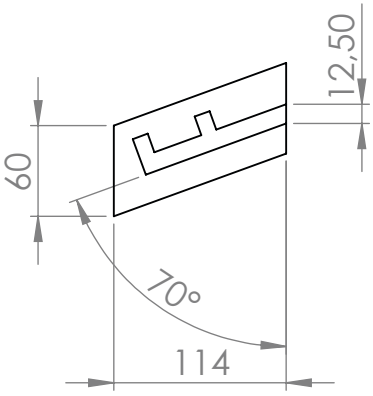


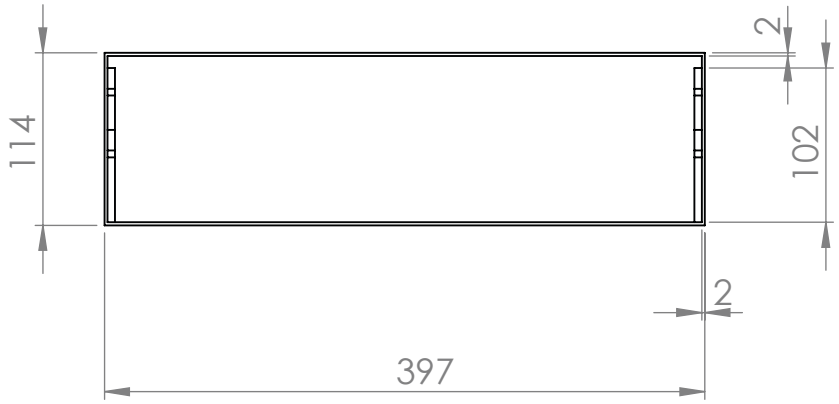


Part: **Cabinet**	CARTISH	Responsible: Team Airrity All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #14	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: ABS	Scale: 1 : 10
Manufacturing: Vacuum forming	Supplier: Own part	

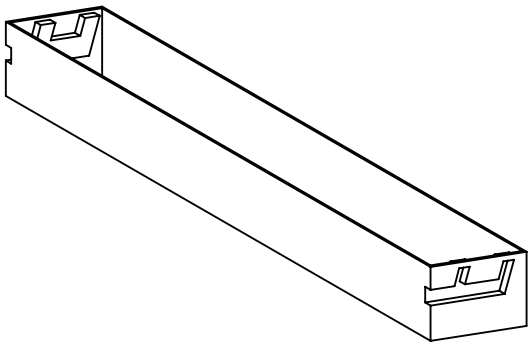


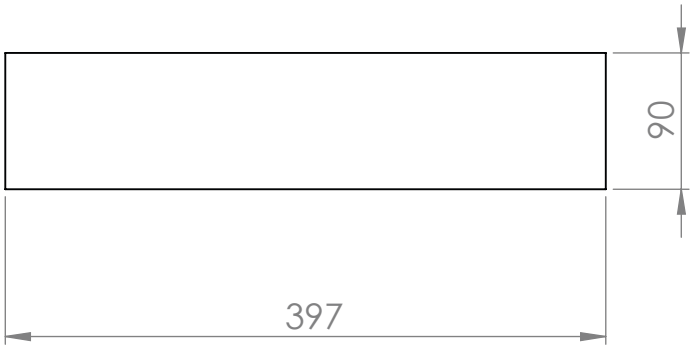


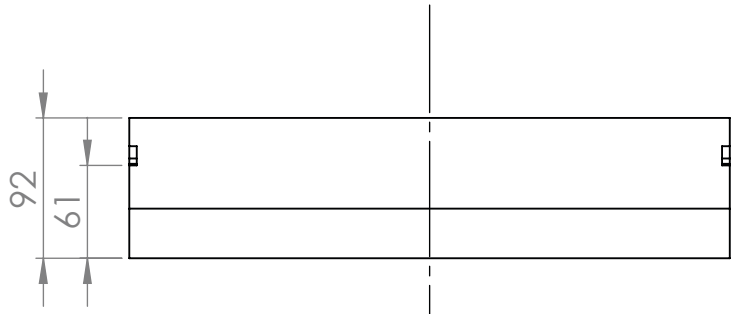


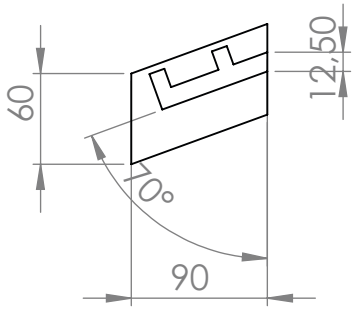


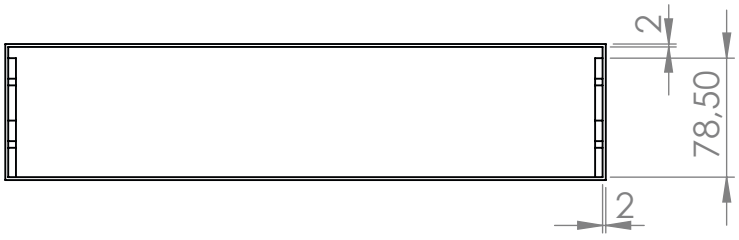
Part: 2nd tray	CARTISH	Responsible: Team Airrity
		All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #15	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: ABS	Scale: 1 : 5
Manufacturing: Vacuum forming	Supplier: Own part	



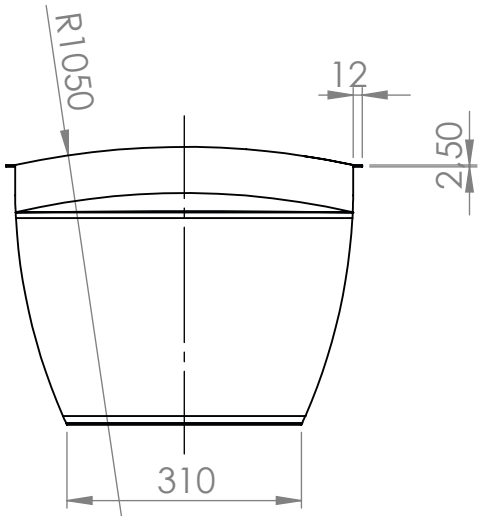


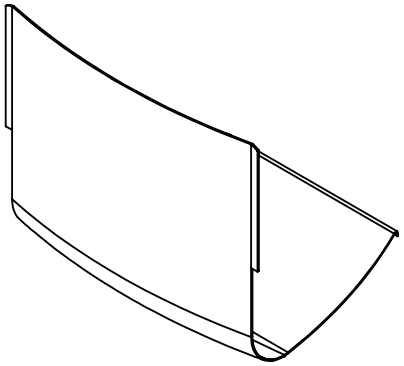


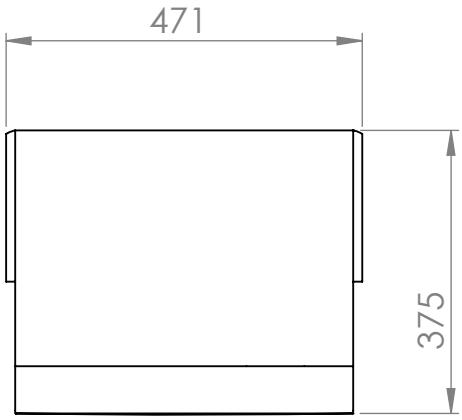


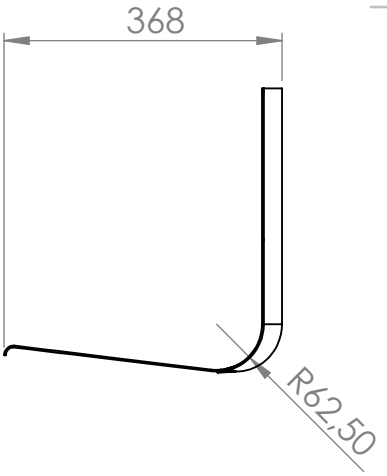


Part: 3rd tray — CARTISH		Responsible: Team Airrity All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #16	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: ABS	Scale: 1 : 5
Manufacturing: Vacuum forming	Supplier: Own part	

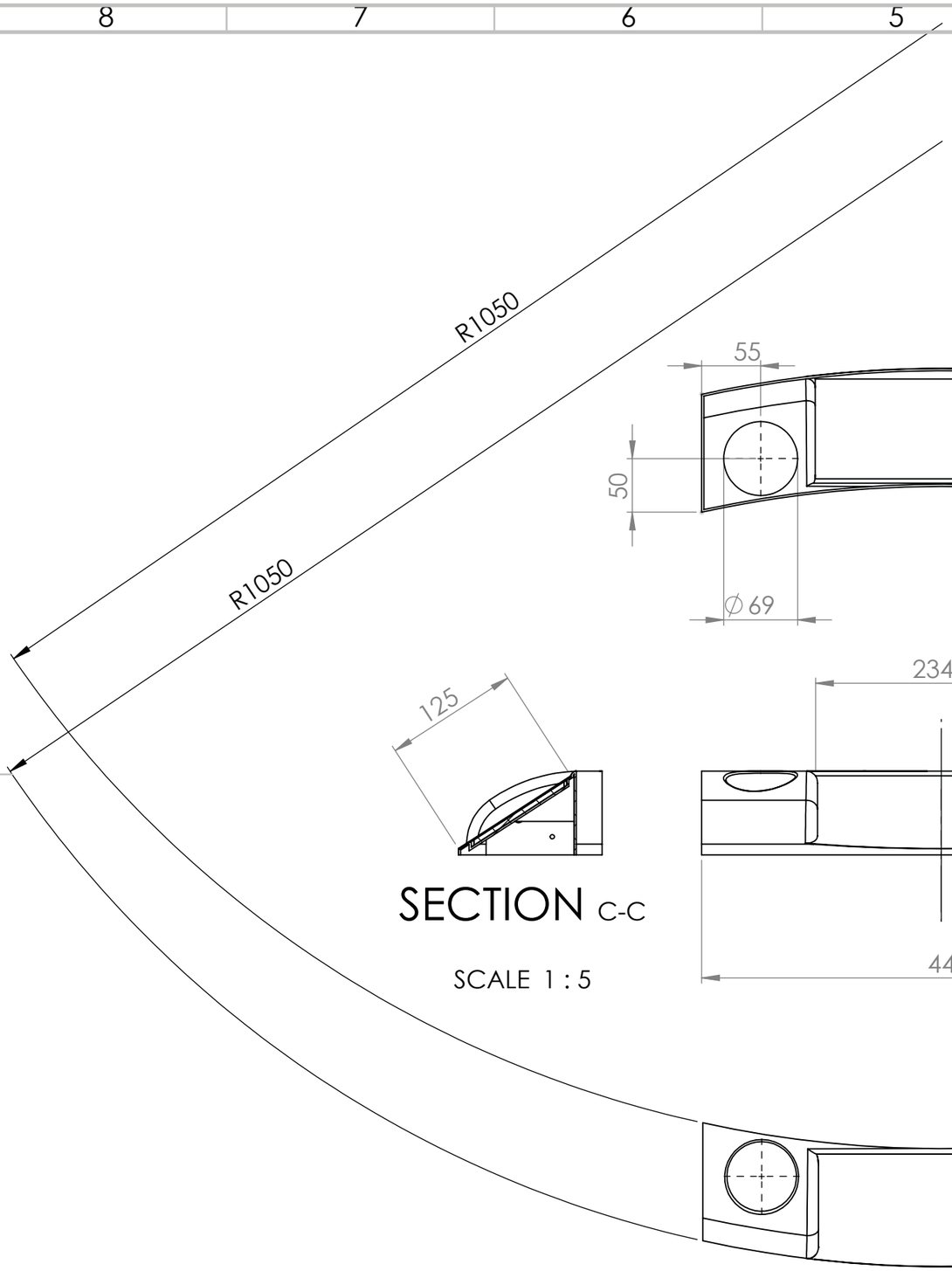


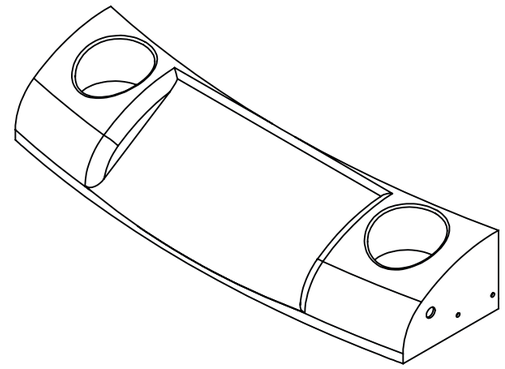






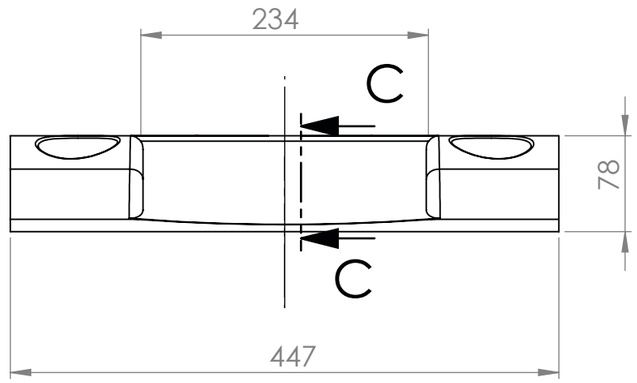
Part: Child seat	CARTISH	Responsible: Team Airrity
		All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #17	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: ABS	Scale: 1 : 10
Manufacturing: Vacuum forming	Supplier: Own part	

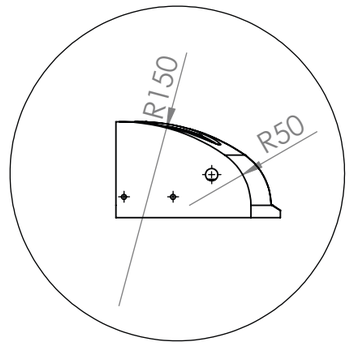


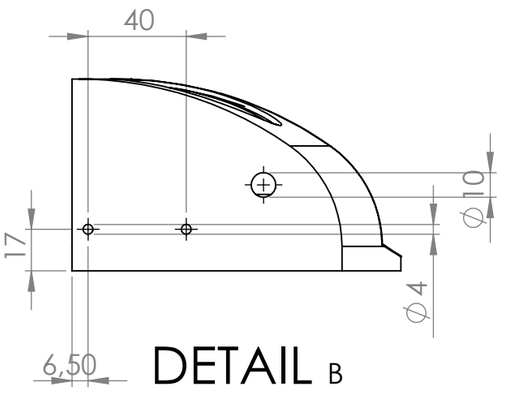


SECTION C-C

SCALE 1 : 5

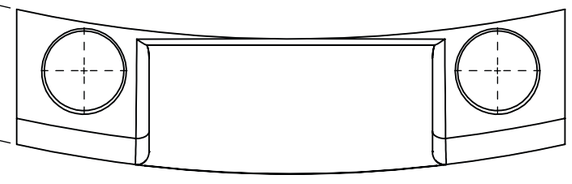




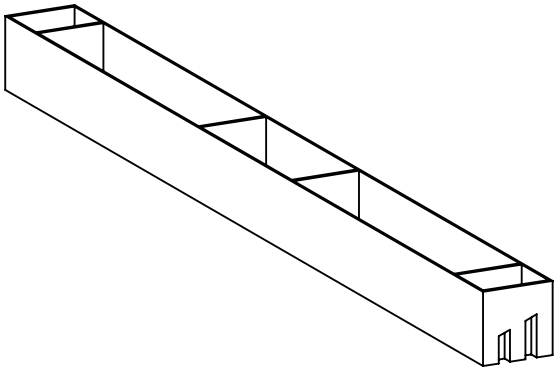


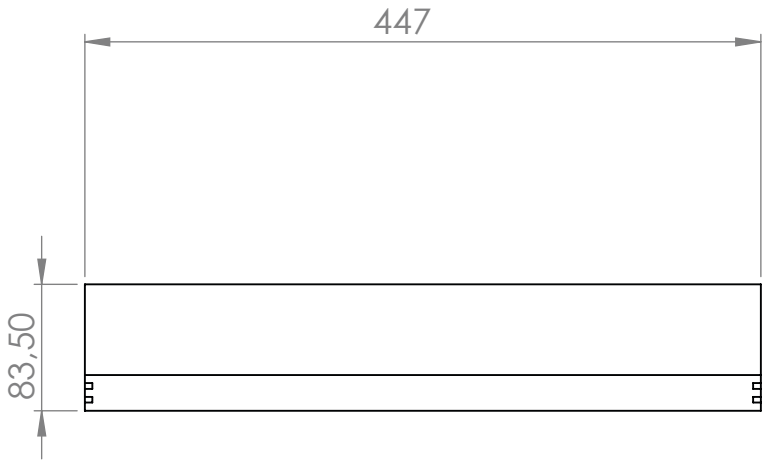
DETAIL B

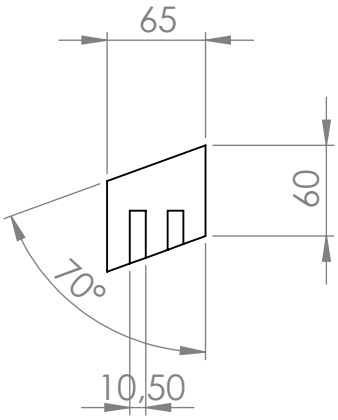
SCALE 2 : 5

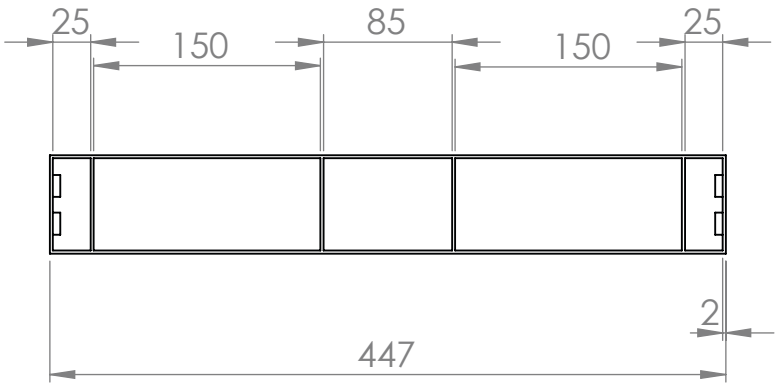


Part: Top tray	CARTISH	Responsible: Team Airrity
		All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #18	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: ABS	Scale: 1 : 5
Manufacturing: Vacuum forming	Supplier: Own part	

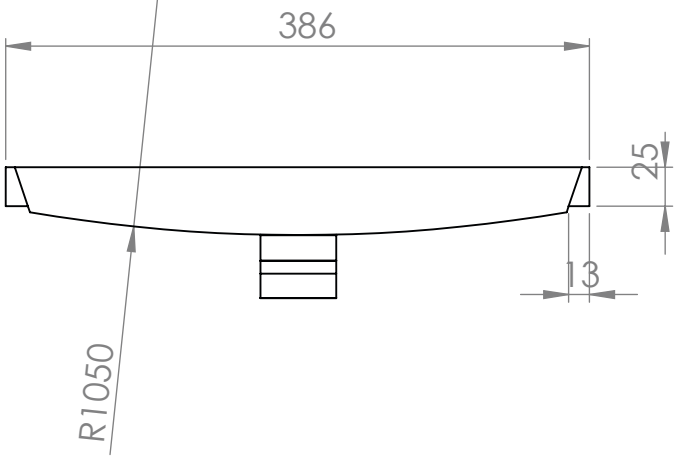


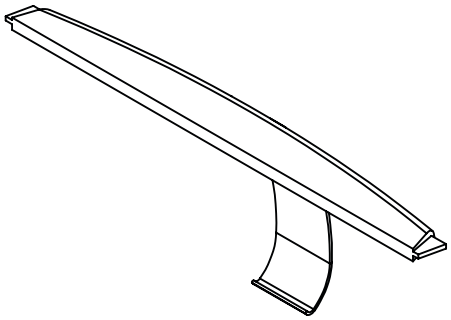


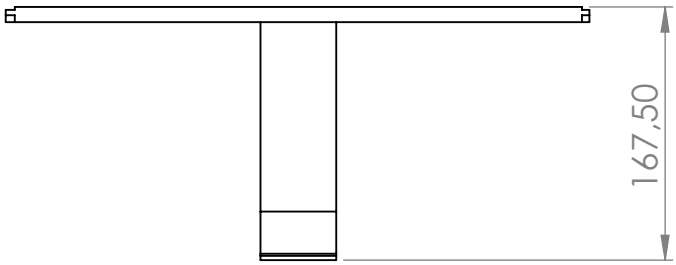


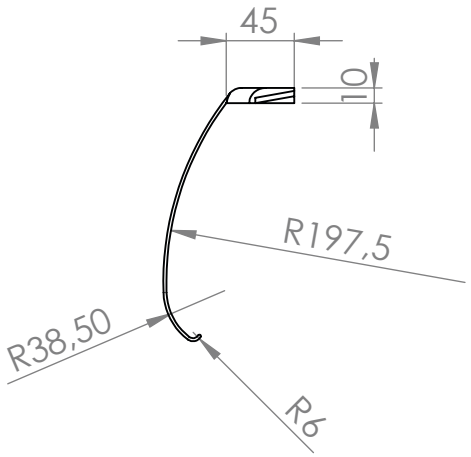


Part: 1st tray — CARTISH		Responsible: Team Airrity
		All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #19	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: ABS	Scale: 1 : 5
Manufacturing: Vacuum forming	Supplier: Own part	









Part: Child table	CARTISH	Responsible: Team Airrity
		All dimensions in mm unless otherwise specified
First angle projection	Drawing number: #20	Date: 30-05-2018
Tolerances unless otherwise specified: DS/ISO 2768-1-m	Material: ABS	Scale: 1 : 5
Manufacturing: -	Supplier: Own part	

CENTER OF MASS

This section describe where the center of mass is positioned for the entire model. The center of mass will give an indication of the stability of the cart.

The correct material have been applied for all parts within the cart. PUR have been applied for the sides of the cart.

The center of mass is presented on Illustration 26.1 and 26.2. Illustration 26.2 shows that the center of mass is located closest to the bottom. In addition, is the center of mass located in front of the back wheels. This makes the product more stable and it is more difficult for the product to tilt.
Illustration 26.1 shows the center of mass is the center of the entire cart. This makes sense because of the symmetric through the entire product.

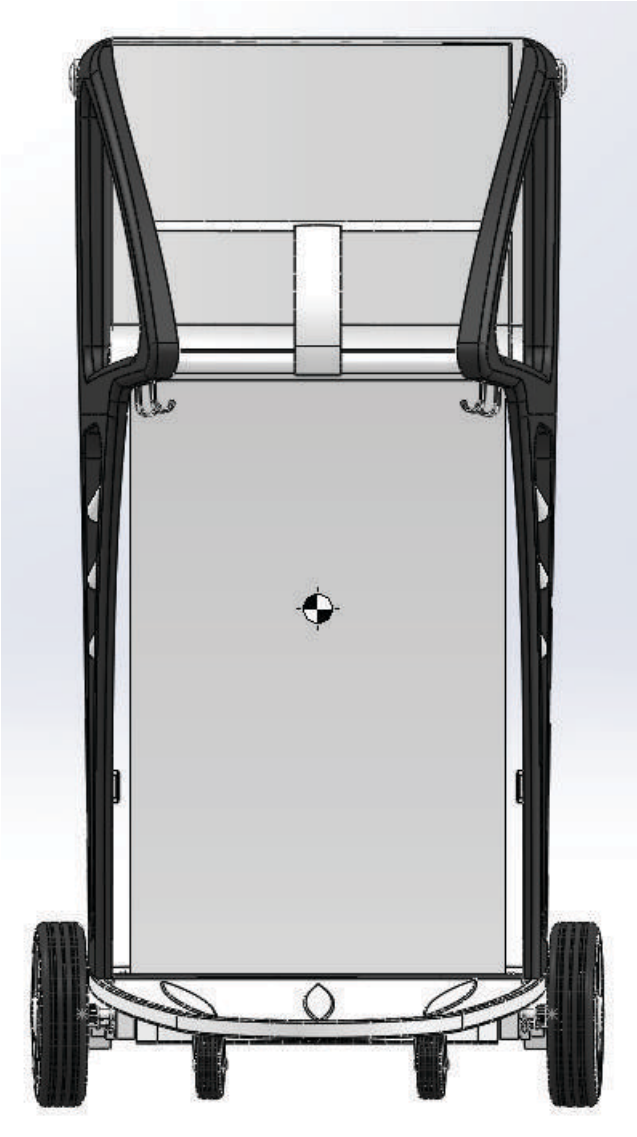


Illustration 26.1 - Shows the center of mass seen from the front of the cart

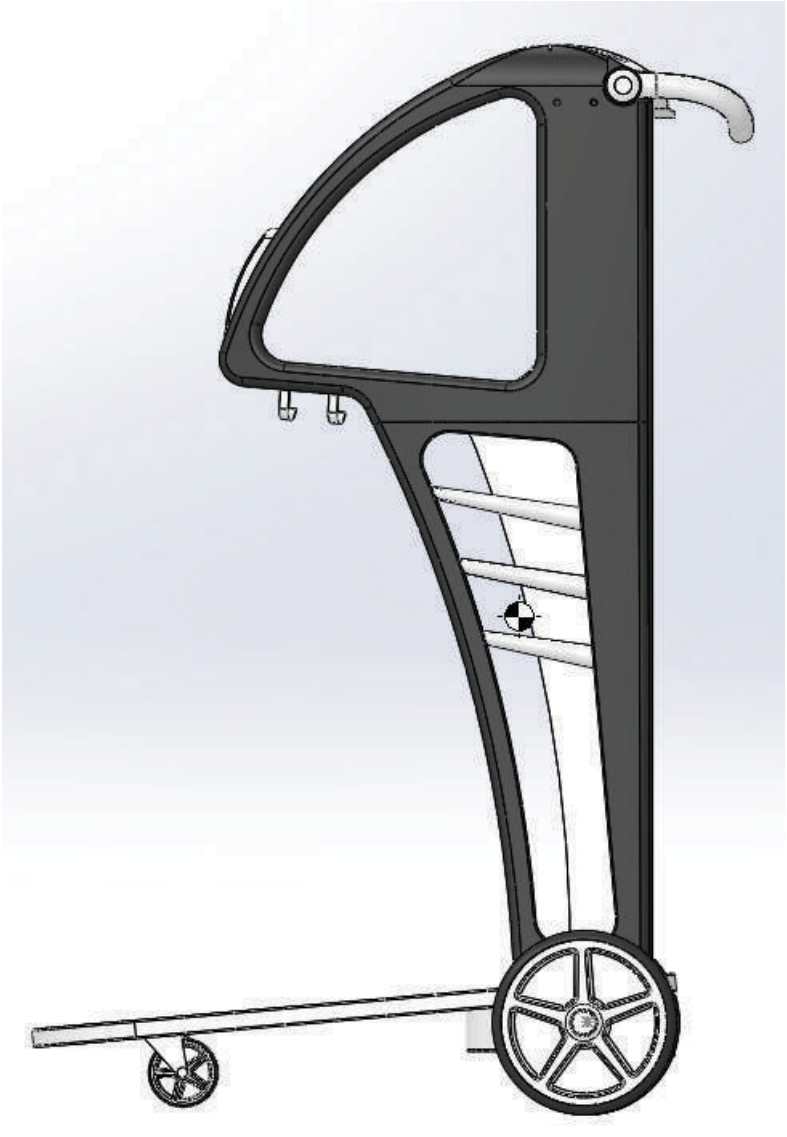


Illustration 26.1 - Shows the center of mass seen from the side of the cart

STANDARD COMPONENTS

This section presents some of the standard components used on each cart.

Standard components				
Item no.	Description	Quantity	Supplier	Price
1	Big wheels	1	Ideal Chemical & Hardware Co., Ltd. *(Ideal Chemical & Hardware Co., Ltd., -)*	1.53 €
2	Small wheels	1	Finehope (Xiamen) Polyurethane Products Co., Ltd. *(Finehope (Xiamen) Polyurethane Products Co., Ltd., -)*	0.85 €
3	10" touch screen	1	*Shenzhen Longview Technology Co., Ltd. (Shenzhen Longview Technology Co., Ltd., -)*	47.75 €
Estimated total standard cost (€)				50.13 €

Table 27.1 - Standard components

The standard components resulted in a **total price on 50€**, which will be added to the production cost for each cart.

The standard components are based on the available data. By buying a higher quantity, it can be possible to lower the price for each standard components.

PRODUCTION COST- FOR 10 CARTS

This section presents an estimation for a production of 10 carts. All parts will be produced by vacuum forming and in ABS.

Item no	Description	Quantity	Manufacturing	Material	Mold cost
1	Top tray	1	Vacuum forming	ABS	1,500€
2	Left side	2	Vacuum forming	ABS	1,500€
3	Right side	2	Vacuum forming	ABS	1,500€
4	Doors	2	Vacuum forming	ABS	1,500€
5	Child seat	1	Vacuum forming	ABS	1,500€
6	Trays inside	3	Vacuum forming	ABS	1,500€
7	Cabinet	1	Vacuum forming	ABS	1,500€
8	Bottom plate	2	Vacuum forming	ABS	1,500€
9	Handles - Kids	6	Vacuum forming	ABS	1,500€
10	Handles - Parents	1	Vacuum forming	ABS	1,500€

Table 28.1 - An estimation of the production for 10 carts (Formech International Ltd, -)

	€/pcs
Materials	26
Cost of operation	56
Mold cost	0.2
Overhead	112
Total production cost	194

Table 28.2 - Production expenses

The production cost for producing all parts in vacuum, results in a total production price for one cart **on 194€**. All molds used for prototypes are in MDF. It is estimated that all mold used have the same price. The price will change according the size of the components.

The vacuum forming of all parts can result in problems according to the assembly and the stiffness and strengths in essential parts.

PRODUCTION COST- FOR 1.000 CARTS

This section will describe the machine cost for the production of 1.000 carts. The calculation contains all special produced parts. Information and data included in the calculations are gather by research and interviews. Through the entire document the "," will represent thousands while a "." will identify the decimal number.

INFORMATIONS

Table 29.1 shows the information used to the next calculations. The table shows that there will be produced a 1.000 carts. The product requires four different production methods; Gas-Assisted Injection molding, Injection molding, Vacuum forming, and CNC.

Name / category	Number / Price		Source
Pieces	1,000	#	
Operators	4	#	
Production facility	130	m2	
Cost per mold - Gas-Assisted Injection molding	135,000	€	(Larsen, 2018)
X Gas-Assisted Molds	2	#	
Molds price total - For Gas-Assisted Injection molding	270,000	€	
Cost per mold - Injection molding	40,000	€	(Hansen, 2016)
X Molds - with 6-cavities	1	#	
Molds price total - For injection molding	40,000	€	
Cost per vacuum form	1,500	€	(Formech International Ltd, -)
X Vacuum forms	10	#	
Molds price total - Vacuum	15000	€	
X products needs to be CNC cutted	2	#	(Formech International Ltd, -)
CNC price total	57000	€	
Wage	30	€/h	
Machine(s)	4	#	

Table 29.1 - Informations

The production cost will be calculated from the perspective of the team renting the machines. Therefor is the information in Table 29.1 only showing the mold cost for the different parts.

1. PRODUCTION TIME

Table 30.1 shows production time for the different components, which are being specified with the production method and material.

Part name	Pieces(psc)	Production method	Material	Cavity per mold	Cycle time	Total time	
	#			#	sec	hours	days
Top trays	1,000	Vacuum forming	ABS	1	120	33	5.1
Left side	1,000	CNC	Dried Douglas Fir	1	900	250	38.5
Right side	1,000	CNC	Dried Douglas Fir	1	900	250	38.5
Left side	1,000	Gas-Assisted Injection Molding	PUR	1	225	63	9.6
Right side	1,000	Gas-Assisted Injection Molding	PUR	1	225	63	9.6
Doors	2,000	Vacuum forming	ABS	1	80	44	6.8
Child seat	1,000	Vacuum forming	ABS	1	60	17	2.6
Trays inside	3,000	Vacuum forming	ABS	1	120	100	15.4
Cabinet	1,000	Vacuum forming	ABS	1	200	56	8.5
Bottom plate	2,000	Vacuum forming	ABS	1	60	17	5.1
Handles - Kids	6,000	Injection Molding	PVC	6	30	8	1.3
Handles - Parents	1,000	Dip Molding	PVC	1	30	8	1.3
Efficient Production Time						**925**	**142**
Change moulds - Gas-Assisted Injection Molding				2	hours	12	hours
Change colours/materials - Gas-Assisted Injection Molding				1	hours	6	hours
Change vacuum form				10	hours	10	hours
Shut down each night				0			
Start up time each morning				0			
Total production time						**953**	**147**

Table 30.1 - Shows the production time for all special produced parts

Information about the cycle time are found using the following sources: Vacuum forming (Formech International Ltd, -). CNC (Lefteri, 2012). Gas-Assisted Injection Molding (Larsen, 2018). Injection Molding (Formech International Ltd, -). Dip Molding (Lefteri, 2012).

All parts which are being vacuum formed are produced by ABS plastic. The difference in the cycle time depends on the thickness of the material. Some of the vacuum formed parts are split into two pieces - the doors and the bottom plate.
The Gas-Assisted Injection Molding method requires the wood pieces to be process, before going into the mold. This requires an entire process with a CNC to produce these parts.
The cycle time for the Gas-Assisted Injection Molding is insight from VELUX A/S (Larsen, 2018).
Six component is being injection molded. It is decided to use a 6-cavity mold for this process. This makes it possible to produce all kids handle in one cycle.

There are used 6,5 hours for one day of work. This results in a ***total of 144 days*** for producing all special components for 1.000 carts.

2. ESTIMATION OF HOURLY MACHINE COSTS

As described earlier the team will rent the different machines used for the production. The following four tables shows the estimated hourly machine cost for the company which owns the machines. On the following four tables the hourly wages will be on 30€, because it is estimated that the production will happen in Denmark.

2.1 ESTIMATION OF HOURLY MACHINE COSTS - GAS-ASSISTED INJECTION MOLDING

Table 31.1 shows the hourly machine cost for the gas-assisted injection molding.

Machinery:			Gas-Assisted Injection Molding Machine	Number:	1	Pcs
Manufacturer (if relevant):				Type (if relevant):		
Space requirements m² :			40	Power consumption :	17	kWh
				Initial cost:	135,000	€
				Depreciation period:	7	Years
Operator demand:			2	Hourly wage:	30	€
Additional equipment						
	Number		Type	Initial Cost €		
	1.00				-	€
	1.00				-	€
	1.00				-	€
Total initial cost of additional equipment					0	€
Salvage value						
	Machinery		0.10		13,500	€
	Equipment		0.10		0	€
Depriciation per year					17,357	€
Internal interest rate			0.10	Internal rate of return	8,293	€
Sundries						
	Insurance		0.00		0	€
	Maintenance		0.05		0	€
	Oil ect.		75.00	€	75	€
	Power		0.30	€ per kWh	319	€
	Rent		55.00	€ per m²	2,200	€
	Heating		10.00	€ per m²	400	€
Total expenditure per year					28,644	€
Utilized capacity hours			125	Available capacity hours	1,700	Hours
Average utilization ratio per machine					**7**	%
Machine cost per hour					16.85	€
Machine cost per hour, wage included					**77**	€

Table 31.1 - An estimation of Hourly Machine Costs for Gas-Assisted Injection Molding (Larsen, 2018)

Table 31.1 shows that the production of the two sides will take ***125 hours to produce***. This will only take up ***7%*** of the yearly production for the entire Gas-Assisted Injection Molding machine. Thereby it is possible for the company, who owns the machines, to rent it out to other party.

The calculation resulted in a machine cost per hour including wages on ***77€***. This it the production price for the company. There will be added an overhead on 30% in section 5.

2.2 ESTIMATION OF HOURLY MACHINE COSTS - VACUUM FORMING

Table 32.1 shows the hourly machine cost for the vacuum forming.

Machinery:			Vacuum forming machine	Number:	1	Pcs
Manufacturer (if relevant):			Formech	Type (if relevant):		
Space requirements m² :			20	Power consumption :	17	kWh
				Initial cost:	40,000	€
				Depreciation period:	7	Years
Operator demand:			2	Hourly wage:	30	€
Additional equipment						
	Number		Type	Initial Cost €		
	1.00				-	€
	1.00				-	€
	1.00				-	€
Total initial cost of additional equipment					0	€
Salvage value						
	Machinery		0.10		4,000	€
	Equipment		0.10		0	€
Depriciation per year					5,143	€
Internal interest rate			0.10	Internal rate of return	2,457	€
Sundries						
	Insurance		0.00		0	€
	Maintenance		0.05		0	€
	Oil ect.		75.00	€	75	€
	Power		0.30	€ per kWh	723	€
	Rent		55.00	€ per m²	1,100	€
	Heating		10.00	€ per m²	200	€
Total expenditure per year					9,698	€
Utilized capacity hours			283	Available capacity hours	1,700	Hours
Average utilization ratio per machine					**17**	%
Machine cost per hour					5.70	€
Machine cost per hour, wage included					**66**	€

Table 32.1 - An estimation of Hourly Machine Costs for Vacuum Forming (Formech International Ltd, -)

Table 32.1 shows that the production of all six vacuum formed parts will take ***283 hours to produce***. This will only take up ***17%*** of the yearly production for the entire vacuum forming machine. Thereby it is possible for the company, who owns the machines, to rent it out to other party.

The calculation resulted in a machine cost per hour including wages on **66€**. This it the production price for the company. There will be added an overhead on 30% in section 5.

2.3 ESTIMATION OF HOURLY MACHINE COSTS - INJECTION MOLDING

Table 33.1 shows the hourly machine cost for the injection molding.

Machinery:			Injecting molding	Number:	1	Pcs
Manufacturer (if relevant):				Type (if relevant):		
Space requirements m² :			40	Power consumption :	17	kWh
				Initial cost:	60,000	€
				Depreciation period:	7	Years
Operator demand:			2	Hourly wage:	30	€
Additional equipment						
	Number		Type	Initial Cost €		
	1.00				-	€
	1.00				-	€
	1.00				-	€
Total initial cost of additional equipment					0	€
Salvage value						
	Machinery		0.10		6,000	€
	Equipment		0.10		0	€
Depreciation per year					7,714	€
Internal interest rate			0.10	Internal rate of return	3,686	€
Sundries						
	Insurance		0.00		0	€
	Maintenance		0.05		0	€
	Oil ect.		75.00	€	75	€
	Power		0.30	€ per kWh	21	€
	Rent		55.00	€ per m²	2,200	€
	Heating		10.00	€ per m²	400	€
Total expenditure per year					14,096	€
Utilized capacity hours			8	Available capacity hours	1,700	Hours
Average utilization ratio per machine					**0.5**	%
Machine cost per hour					8.29	€
Machine cost per hour, wage included					**68**	€

Table 33.1 - An estimation of Hourly Machine Costs for Injection Molding (Formech International Ltd, -)

Table 33.1 shows that the production of all six handles for the kids will take ***8 hours to produce***. This is because there is used a 6-cavity mold. This will only take up ***0.5%*** of the yearly production for the entire injection molding machine. Thereby it is possible for the company, who owns the machines, to rent it out to other party.

The calculation resulted in a machine cost per hour including wages on ***68€***. This it the production price for the company. There will be added an overhead on 30% in section 5.

2.4 ESTIMATION OF HOURLY MACHINE COSTS - SIX AXES CNC

Table 34.1 shows the hourly machine cost for a six axes CNC.

Machinery:			Six axes CNC	Number:	1	Pcs
Manufacturer (if relevant):				Type (if relevant):		
Space requirements m² :			30	Power consumption :	17	kWh
				Initial cost:	57,000	€
				Depreciation period:	7	Years
Operator demand:			1	Hourly wage:	30	€
Additional equipment						
	Number		Type	Initial Cost €		
	1.00				-	€
	1.00				-	€
	1.00				-	€
Total initial cost of additional equipment					0	€
Salvage value						
	Machinery		0.10		5,700	€
	Equipment		0.10		0	€
Depriciation per year					7,329	€
Internal interest rate			0.10	Internal rate of return	3,501	€
Sundries						
	Insurance		0.00		0	€
	Maintenance		0.05		0	€
	Oil ect.		75.00	€	75	€
	Power		0.30	€ per kWh	1,275	€
	Rent		55.00	€ per m²	1,650	€
	Heating		10.00	€ per m²	300	€
Total expenditure per year					14,130	€
Utilized capacity hours			500	Available capacity hours	1,700	Hours
Average utilization ratio per machine					**29**	%
Machine cost per hour					8.31	€
Machine cost per hour, wage included					**38**	€

Table 34.1 - An estimation of Hourly Machine Costs for Vacuum Forming (Formech International Ltd, -)

Table 34.1 shows that the production of all wood parts will take ***500 hours to produce***. This will only take up ***29%*** of the yearly production for the entire CNC machine. Thereby it is possible for the company, who owns the machines, to rent it out to other party.

The calculation resulted in a machine cost per hour including wages on ***38€***. This it the production price for the company. There will be added an overhead on 30% in section 5.

3. MATERIAL COST

This section will present the volume of the different component. The volume will be used to calculate the estimated material cost for each component.

Part Name	Pieces(psc)	Volume	Material	Weight	Yearly consumption	Materials cost per	Materials cost per
	#	cm^3		grams	kg	€/kg	€/pcs
Top tray	1,000	384	ABS	392	392	3	1
Left side	1,000	2,449	Dried Douglas Fir	1,298	1,298	1	1
Right side	1,000	2,449	Dried Douglas Fir	1,298	1,298	1	1
Left side	1,000	1,205	PUR	1,518	1,518	3	5
Right side	1,000	1,205	PUR	1,518	1,518	3	5
Doors	1,000	857	ABS	874	874	3	2
Child seat	1,000	771	ABS	786	786	3	2
Trays inside	1,000	621	ABS	633	633	3	2
Cabinet	1,000	2,166	ABS	2,209	2,209	3	6
Bottom plate	1,000	1,186	ABS	1,210	1,210	3	3
Handles - Kids	1,000	121	PVC	157	157	1	0.1
Handles - parents	1,000	28	PVC	36	36	1	0.03
				11,929	11,929		
Total materials cost per unit							**28**

Table 35.1 - Material cost for all components

Material densities			
Dried Douglas Fir	0.53	g/cm3	(Alibaba, 2018)
PUR	1.26	g/cm3	(Larsen, 2018)
ABS	1.02	g/cm3	(SolidWorks, 2018)
PVC	1.30	g/cm3	(SolidWorks, 2018)

Table 35.2 - Material densities

Table 35.2 shows th material densities for the different materials which have been used. The densities are being used in Table 35.1. The table shows that where is used almost ***12 kg per cart excluding waste***. Furthermore will each cart cost ***28€*** in materials.

4. DEPRECIATION THE MOLDS

This section will depreciation of the different molds used for producing the cart.

Cost per mold - Gas-Assisted Injection molding	135,000	2	Molds	270,000	€
Cost per mold - Injection	40,000	1	Mold	40,000	€
Cost per vacuum form	1,500	10	Vacuum forms	15,000	€
On this order 10,000		All cost		Pieces(psc)	
		€		#	€/pcs
	Gas-Assisted injection molding	270,000		20,000	13.50
	Injection Molding	40,000		10,000	4.00
	Vacuum	15,000		100,000	0.15
Total price per unit					**17.7**

Table 36.1 - Depreciation the molds (Formech International Ltd, -)(Larsen, 2018)(Hansen, 2016)

Table 36.1 shows the depreciation for the three different type of molds. It is estimated that the molds presented on Table 36.1 can be used for more that the required 1,000 units. It is estimated that all molds/forms can be used for an order on 10,000 units.

The vacuum forming mold will be produced in MDF which resulted in a low start price. The MDF form can not resist many cycles. It is estimated that one MDF mold for each for the ten different vacuum form is enough for producing 10,000 units.

The depreciation on the molds resulted in a price on ***17.7€ per cart***.

5. COST OF OPERATION (HOURLY MACHINE COST)

This section will present the cost of operation, where an extra overhead for the renting company are being added. The overhead will be on 30% of the Machine Cost per hour including Wage.

Outsourced		Total production time	Production cost per hour	Pieces (psc)		Production cost + 30% overhead
		hours	€	#	#	€/pcs
	Gas-Assisted	125	77	2,000		6.2
	Vacuum forming	283	66	10,000		2.4
	Injecting molding	8	68	1,000		0.7
	CNC	500	38	2,000		12.5
			Wage	Pieces(psc)	Operators	Without overhead
			€/hour	#	#	€/pcs
	Wage	953	30	1,000	2	57
			Wage	Pieces(psc)	Operators	Without overhead
			€/hour	#	#	€/pcs
	Assembly	3,000	2	1,000	1	6
Total Operation Cost						**85**

Table 36.2 - Cost of operation (hourly machine cost)

Table 36.2 are divided into two sections. The first section (in the top) are presenting the outsourced machine cost, which were calculated in Section 3. In the table a overhead on 30% are added.

The table presents furthermore the wages and the assembly time which needs to be used for assemble an entire cart.

The total operation cost is ***85€ per cart***.

6. OVERHEAD (RENT, SALARIES, PROFIT)
This section will present the overhead.

	m^2	€/m2	€	€
Rent	130	55		7,150
	Amount	Salary €		
Salaries	2	50,000		100,000
	Total production time hours	Hours per year	Pieces	Rent + Salary
Total	953	1,700	1,000	107,150
				€/pcs
Total Overhead				**60**

Table 37.1 - Overhead

Table 37.1 present the overhead for the rent and the salaries for the team members. The total overhead are calculated with knowledge about the total production time (in hours), the hours per year, pieces, and the rent+salary. This makes it possible to estimate the total overhead will be around ***60€ per cart***.

7. PRODUCTION EXPENSES
This section will present the summary of the production expenses.

	€/pcs
Materials	28
Cost of operation	85
Mould cost	17.7
Overhead	60
Total production cost	190

Table 37.2 - Production expenses

Table 37.2 presents the total production cost. The table is a summery of the data and calculations made in the previous sections. The calculations resulted in a total production cost per cart on 190€ which is 1,418DKK.

PRODUCTION COST- FOR 100.000 CARTS

This section will describe the machine cost for the production of 100.000 carts. The calculation contains all special produced parts. Information and data included in the calculations are gather by research and interviews. Through the entire document the "," will represent thousands while a "." will identify the decimal number.

INFORMATIONS

Table 38.1 shows the information used to the next calculations. The table shows that there will be produced a amount of 100.000 carts. The product requires four different production methods; Gas-Assisted Injection molding, Injection molding, Vacuum forming, and CNC.

Name / category	Number / Price		Source
Pieces	100,000	#	
Operators	4	#	
Production facility	130	m2	
Cost per mold - Gas-Assisted Injection molding	135,000	€	(Larsen, 2018)
X Gas-Assisted Molds	2	#	
Moulds price total - For Gas-Assisted Injection molding	270,000	€	
Cost per mold - Injection molding	40,000	€	(Hansen, 2016)
X Molds - with 6-cavities	1	#	
Molds price total - For injection molding	40,000	€	
Cost per vacuum form	6,700	€	(Formech International Ltd, -)
X Vacuum forms	10	#	
Molds price total - Vacuum	67000	€	
X products needs to be CNC cutted	2	#	(Formech International Ltd, -)
CNC price total	57000	€	
Wage	20	€/h	
Machine(s)	4	#	

Table 38.1 - Informations

The production cost will be calculated from the perspective of the team renting the machines. Therefor is the information in Table 38.1 only showing the mold cost for the parts.

1. PRODUCTION TIME

Table 39.1 shows production time for the different components, which are specified with the production method and material.

Part name	Pieces(psc)	Production method	Material	Cavity per mold	Cycle time	Total time	
	#			#	sec	hours	days
Top trays	100,000	Vacuum forming	ABS	1	120	3,333	512.82
Left side	100,000	CNC	Dried Douglas Fir	1	900	25,000	3,846.15
Right side	100,000	CNC	Dried Douglas Fir	1	900	25,000	3,846.15
Left side	100,000	Gas-Assisted Injection Molding	PUR	1	225	6,250	961.54
Right side	100,000	Gas-Assisted Injection Molding	PUR	1	225	6,250	961.54
Doors	200,000	Vacuum forming	ABS	1	80	4,444	683.76
Child seat	100,000	Vacuum forming	ABS	1	60	1,667	256.41
Trays inside	300,000	Vacuum forming	ABS	1	120	10,000	1,538.46
Cabinet	100,000	Vacuum forming	ABS	1	200	5,556	854.70
Bottom plate	200,000	Vacuum forming	ABS	1	60	3,333	512.82
Handles - Kids	600,000	Injection Molding	PVC	6	30	833	128.21
Handles - Parents	100,000	Dip Molding	PVC	1	30	833	128.21
Efficient Production Time						**92,500**	**14,231**
Change moulds - Gas-Assisted Injection Molding				2	hours	12	hours
Change colours/materials - Gas-Assisted Injection Molding				1	hours	6	hours
Change vacuum form				10	hours	10	hours
Shut down each night				0			
Start up time each morning				0			
Total production time						**92,528**	**14,235**

Table 39.1 - Shows the production time for all special produced parts

The information about the cycle time are found using the following sources: Vacuum forming (Formech International Ltd, -). CNC (Lefteri, 2012). Gas-Assisted Injection Molding (Larsen, 2018). Injection Molding (Formech International Ltd, -). Dip Molding (Lefteri, 2012).

All parts which are being vacuum formed are produced by ABS plastic (Lefteri, 2014). The difference in the cycle time depends on the thickness of the material. Some of the vacuum formed parts are split into two pieces - the doors and the bottom plate.
The Gas-Assisted Injection Molding method requires the wood pieces to be process, before going into the mold. This requires an entire process with a CNC to produce these parts.
The cycle time for the Gas-Assisted Injection Molding is insight from VELUX A/S (Larsen, 2018).
Six component are being injection molded. It is decided to use a 6-cavity mold for this process. This makes it possible to produce all kids handle in one cycle.

There are used 6,5 hours for one day of work. This results *in a total of 14,235 days for* producing all special components for 100.000 carts.

2. ESTIMATION OF HOURLY MACHINE COSTS

As described earlier the team will rent the different machines used for the production. The following four tables shows the estimated hourly machine cost for the company which owns the machines. On the following four tables the hourly wages will be on 20€, because it is estimated that the production will happen in Poland.

2.1 ESTIMATION OF HOURLY MACHINE COSTS - GAS-ASSISTED INJECTION MOLDING

Table 40.1 shows the hourly machine cost for the gas-assisted injection molding.

Machinery:			Gas-Assisted Injection Molding Machine	Number:	2	Pcs
Manufacturer (if relevant):				Type (if relevant):		
Space requirements m² :			40	Power consumption :	17	kWh
				Initial cost:	270,000	€
				Depreciation period:	7	Years
Operator demand:			2	Hourly wage:	20	€
Additional equipment						
	Number		Type	Initial Cost €		
	1.00				-	€
	1.00				-	€
	1.00				-	€
Total initial cost of additional equipment					0	€
Salvage value						
	Machinery		0.10		27,000	€
	Equipment		0.10		0	€
Depreciation per year					34,714	€
Internal interest rate			0.10	Internal rate of return	16,586	€
Sundries						
	Insurance		0.00		0	€
	Maintenance		0.05		0	€
	Oil ect.		75.00	€	75	€
	Power		0.30	€ per kWh	31,875	€
	Rent		55.00	€ per m²	2,200	€
	Heating		10.00	€ per m²	400	€
Total expenditure per year					85,850	€
Utilized capacity hours			12.500	Available capacity hours	13,600	Hours
Average utilization ratio per machine					**92**	%
Machine cost per hour					6.31	€
Machine cost per hour, wage included					**46**	€

Table 40.1 - An estimation of Hourly Machine Costs for Gas-Assisted Injection Molding (Larsen, 2018)

Table 40.1 shows that the production of the two sides will take ***12.500 hours to produce***. This will take up ***92%*** of the yearly production for the two entire Gas-Assisted Injection Molding machine. The production is over a two years period where the production runs day and night, with two works. The information to fulfill 40.1 is based on information from VELUX A/S (Larsen, 2018).

The calculation resulted in a machine cost per hour including wages on ***46€***. This it the production price for the company. There will be added an overhead on 30% in section 5.

2.2 ESTIMATION OF HOURLY MACHINE COSTS - VACUUM FORMING

Table 41.1 shows the hourly machine cost for the vacuum forming.

Machinery:			Vacuum forming machine	Number:	4	Pcs
Manufacturer (if relevant):			Formech	Type (if relevant):		
Space requirements m² :			80	Power consumption :	17	kWh
				Initial cost:	160,000	€
				Depreciation period:	7	Years
Operator demand:			4	Hourly wage:	20	€
Additional equipment						
	Number		Type	Initial Cost €		
	1.00				-	€
	1.00				-	€
	1.00				-	€
Total initial cost of additional equipment					0	€
Salvage value						
	Machinery		0.10		16,000	€
	Equipment		0.10		0	€
Depriciation per year					20,571	€
Internal interest rate			0.10	Internal rate of return	9,829	€
Sundries						
	Insurance		0.00		0	€
	Maintenance		0.05		0	€
	Oil ect.		75.00	€	75	€
	Power		0.30	€ per kWh	72,250	€
	Rent		55.00	€ per m²	4,400	€
	Heating		10.00	€ per m²	800	€
Total expenditure per year					107,925	€
Utilized capacity hours			28,333	Available capacity hours	27,200	Hours
Average utilization ratio per machine					**104**	%
Machine cost per hour					3.97	€
Machine cost per hour, wage included					**84**	€

Table 41.1 - An estimation of Hourly Machine Costs for Vacuum Forming (Formech International Ltd, -)

Table 41.1 shows that the production of all six vacuum formed parts will take ***28.333 hours to produce***. This will take up ***104%*** of the production over a two years period where the production runs day and night, with two works. This means the production will take roughly two years to produce.

The calculation resulted in a machine cost per hour including wages on ***84€***. This it the production price for the company. There will be added an overhead on 30% in section 5.

2.3 ESTIMATION OF HOURLY MACHINE COSTS - INJECTION MOLDING

Table 42.1 shows the hourly machine cost for the injection molding.

Machinery:			Injecting molding	Number:	1	Pcs
Manufacturer (if relevant):				Type (if relevant):		
Space requirements m² :			40	Power consumption :	17	kWh
				Initial cost:	60,000	€
				Depreciation period:	7	Years
Operator demand:			2	Hourly wage:	20	€
Additional equipment						
	Number		Type	Initial Cost €		
	1.00				-	€
	1.00				-	€
	1.00				-	€
Total initial cost of additional equipment					0	€
Salvage value						
	Machinery		0.10		6,000	€
	Equipment		0.10		0	€
Depriciation per year					7,714	€
Internal interest rate			0.10	Internal rate of return	3,686	€
Sundries						
	Insurance		0.00		0	€
	Maintenance		0.05		0	€
	Oil ect.		75.00	€	75	€
	Power		0.30	€ per kWh	2,125	€
	Rent		55.00	€ per m²	2,200	€
	Heating		10.00	€ per m²	400	€
Total expenditure per year					16,200	€
Utilized capacity hours			833	Available capacity hours	1,700	Hours
Average utilization ratio per machine					**49**	%
Machine cost per hour					9.53	€
Machine cost per hour, wage included					**50**	€

Table 42.1 - An estimation of Hourly Machine Costs for Injection Molding (Formech International Ltd, -)

Table 42.1 shows that the production of all six handles for the kids will take ***833 hours to produce***. This is because there is used a 6-cavity mold. This will only take up ***49%*** of the yearly production for the entire injection molding machine. Thereby it is possible for the company, who owns the machines, to rent it out to other party.

The calculation resulted in a machine cost per hour including wages is ***50€***. This it the production price for the company. There will be added an overhead on 30% in section 5.

2.4 ESTIMATION OF HOURLY MACHINE COSTS - SIX AXES CNC

Table 43.1 shows the hourly machine cost for a six axes CNC.

Machinery:			Six axes CNC	Number:	5	Pcs
Manufacturer (if relevant):				Type (if relevant):		
Space requirements m² :			30	Power consumption :	17	kWh
				Initial cost:	57,000	€
				Depreciation period:	7	Years
Operator demand:			1	Hourly wage:	20	€
Additional equipment						
	Number		Type	Initial Cost €		
	1.00				-	€
	1.00				-	€
	1.00				-	€
Total initial cost of additional equipment					0	€
Salvage value						
	Machinery		0.10		5,700	€
	Equipment		0.10		0	€
Depriciation per year					7,329	€
Internal interest rate			0.10	Internal rate of return	3,501	€
Sundries						
	Insurance		0.00		0	€
	Maintenance		0.05		0	€
	Oil ect.		75.00	€	75	€
	Power		0.30	€ per kWh	127,500	€
	Rent		55.00	€ per m²	1,650	€
	Heating		10.00	€ per m²	300	€
Total expenditure per year					140,355	€
Utilized capacity hours			50,000	Available capacity hours	34,000	Hours
Average utilization ratio per machine					**147**	%
Machine cost per hour					4.13	€
Machine cost per hour, wage included					**24**	€

Table 43.1 - An estimation of Hourly Machine Costs for Vacuum Forming (Formech International Ltd, -)

Table 43.1 shows that the production of all wood parts will take ***50.000 hours to produce***. This will take up ***147%*** of the production over a two years period where the production runs day and night for five CNC machine. This means the production will take take over two years to produce.

The calculation resulted in a machine cost per hour including wages on ***24€***. This it the production price for the company. There will be added an overhead on 30% in section 5.

3. MATERIAL COST

This section will present the volume of the different component. The volume will be used to calculate the exact material cost for each component.

Part Name	Pieces(psc)	Volume	Material	Weight	Yearly consumption	Materials cost per	Materials cost per
	#	cm^3		grams	kg	€/kg	€/pcs
Top tray	100,000	384	ABS	392	39,201	3	1
Left side	100,000	2,449	Dried Douglas Fir	1,298	129,801	1	1
Right side	100,000	2,449	Dried Douglas Fir	1,298	129,801	1	1
Left side	100,000	1,205	PUR	1,518	151,788	3	5
Right side	100,000	1,205	PUR	1,518	151,788	3	5
Doors	100,000	857	ABS	874	87,363	3	2
Child seat	100,000	771	ABS	786	78,607	3	2
Trays inside	100,000	621	ABS	633	63,303	3	2
Cabinet	100,000	2,166	ABS	2,209	220,935	3	6
Bottom plate	100,000	1,186	ABS	1,210	120,973	3	3
Handles - Kids	100,000	121	PVC	157	15,712	1	0.1
Handles - parents	100,000	28	PVC	36	3,636	1	0.03
				11,929	1,192,910		
Total materials cost per unit							**28**

Table 44.1 - Material cost for all components

Material densities			
Dried Douglas Fir	0.53	g/cm3	(Alibaba, 2018)
PUR	1.26	g/cm3	(Larsen, 2018)
ABS	1.02	g/cm3	(SolidWorks, 2018)
PVC	1.30	g/cm3	(SolidWorks, 2018)

Table 44.2 - Material densities

Table 44.2 shows the material densities for the different materials which have been used. The densities are being used in Table 44.1. The table shows that where is used almost ***12 kg per cart excluding waste***. Furthermore will each cart cost ***28€*** in materials.

4. DEPRECIATION THE MOLDS

This section will depreciation of the different molds used for producing the cart.

Cost per mold - Gas-Assisted Injection molding	135,000	2	Molds	270,000	€
Cost per mold - Injection	40,000	1	Mold	40,000	€
Cost per vacuum form	6,700	10	Vacuum forms	67,000	€
On this order 100,000		All cost		Pieces(psc)	
		€		#	€/pcs
	Gas-Assisted injection molding	270,000		200,000	1.35
	Injection Molding	40,000		100,000	0.40
	Vacuum	67,000		1,000,000	0.07
Total price per unit					**1.8**

Table 45.1 - Depreciation the molds (Formech International Ltd, -)(Larsen, 2018)(Hansen, 2016)

Table 45.1 shows the depreciation for the three different type of molds. It is estimated that the molds presented on Table 45.1 can used for the production of all 100,000 units.
The vacuum forming mold will be produced in aluminum which resulted in a higher start price, than the MDF models used for the first production. It is estimated that one aluminum mold for each for the ten different vacuum form is enough for producing 100,000 units.
The depreciation on the molds resulted in a price on ***1.8€ per cart***.

5. COST OF OPERATION (HOURLY MACHINE COST)

This section will present the cost of operation, where an extra overhead for the renting company are being added. The overhead will be on 30% of the Machine Cost per hour including Wage.

Outsourced		Total production time	Production cost per hour	Pieces (psc)		Production cost + 30% overhead
		hours	€	#	#	€/pcs
	Gas-Assisted	12,500	46	200,000		4
	Vacuum forming	28,333	84	1,000,000		3
	Injecting molding	833	50	100,000		0.5
	CNC	50,000	24	200,000		8
			Wage	Pieces(psc)	Operators	Without overhead
			€/hour	#	#	€/pcs
	Wage	92,528	20	100,000	2	37
			Wage	Pieces(psc)	Operators	Without overhead
			€/hour	#	#	€/pcs
	Assembly	300,000	2	100,000	1	6
Total Operation Cost						**58**

Table 45.2 - Cost of operation (hourly machine cost)

Table 45.2 are divided into two sections. The first section (in the top) are presenting the outsourced machine cost, which were calculated in Section 3. In the table a overhead on 30% are added.
The table presents furthermore the wages and the assembly time which needs to be used for assemble an entire cart.
The total operation cost is ***58€ per cart***.

6. OVERHEAD (RENT, SALARIES, PROFIT)
This section will present the overhead.

	m^2	€/m2	€	€
Rent	130	55		7,150
	Amount	Salary €		
Salaries	2	50,000		100,000
	Total production time hours	Hours per year	Pieces	Rent + Salary
Total	92,528	13,600	100,000	107,150
				€/pcs
Total Overhead				**7**

Table 46.1 - Overhead

Table 46.1 present the overhead for the rent and the salaries for the team members. The total overhead are calculated with knowledge about the total production time (in hours), the hours per year, pieces, and the rent+salary. This makes it possible to calculate the total overhead which will be ***60€ per cart***.

7. PRODUCTION EXPENSES
This section will present the summary of the production expenses.

	€/pcs
Materials	28
Cost of operation	58
Mold cost	1.8
Overhead	7
Total production cost	95

Table 46.2 - Production expenses

Table 46.2 presents the total production cost. The table is a summery of the data and calculations made in the previous sections. The calculations resulted in a total production cost per cart on 95€ which is 708DKK.

REFECTION

This section will reflect upon the construction and production of the cart.

The center of mass calculation showed that the center of mass were in the lower part of the product, but still fairly high. Calculation and test about the product would need to be conducted to ensure the stability of the cart.

In the list of standard components only a selected few were found, which resulted in the end price. The price estimation only take the found components into account. When the rest of the component is added the price for the cart will increase. The price increase will make the cart more expensive, but the team do not plan to increase the sales price as the cart is not the main source of income. The main source of income is the sold data.

There have been made some initial FEM analysis on the side of the cart to see if they would break, see Appendix XXIX. There have not been made on a FEM on the final product. Therefore some strength requirements might chance some of the cart connections and the expression, to ensure the child's safety.

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CARTISH

BY AIRRITY

Appendix | MA4 - ID11 | May 2017

Birgitte Fromsejer Nøkleby | Christoffer Høg Jørgensen

0.1 TITLE PAGE

Project title:
Cartish - The future in airport security

Type of report:
Appendix

Time period:
01.02.2018 - 31.05.2018

Team:
Airrity
M.Sc. 04 - ID11

Main supervisor:
Louise Møller Haase

Technical supervisor:
Poul Kyvsgaard

Number of pages: 103

Number of appendix: 32

0.2 ABSTRACT

This is a Master Thesis regarding the development of a product for the future airport security checkpoints.

Most people know that the most stressing part about the airport is the security check. Passengers stress about separating their items, and to get through without trouble. The airport want the passengers through as fast as possible but also need to uphold the level of security. With more passengers traveling even more passengers are going through the airport, and with an increasing amount of security steps it is not getting easier to go through. There is a need for a radical change in the way we think about airport security checkpoints, so it can follow the increasing passenger numbers.

This Master Thesis project focuses on reducing the stress through security by focusing on families. The product Cartish is a cart which takes the families out of the regular security lane. Cartish provides the family with the time and space they needs to go through security. Cartish focuses on making the security check an experience the family can do together. The airport benefits of the tracking of the passengers, by receiving valuable information about how the airport is used.

0.3 TABLE OF CONTENT

I - PERSONAL PROFILE

Name: Michael Hedegaard Rasmussen
Contact information:
Phone: +45 27 15 76 03
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Education: Sergeant
Work: Ramp manager at Billund Airport
Background: Michael have been manager for the Tax-free area in 16 years. Afterward he become the security manager in 6 years. Michael have now been the ramp manager in 5 years.

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Background:

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Background:

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Background:

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Education:
Work: Project Manager within Production Engineering PU at VELUX A/S
Background:

II - VISIT AT AIRPORTS

To gain a better insight in the airport business the two biggest airports in Jutland have been described. This section is based on: Desktop research, interview, and observation.

VISIT AT BILLUND AIRPORT

After the initial research a tour and interview with Billund Airport was arranged to gain an insight in the luggage handling process. The meeting was arranged with Michael Hedegaard Rasmussen the ramp manager, Appendix I.

Billund Airport is an international airport placed in the south-west Jutland and is the second largest airport in Denmark. Billund Airport is in the stock market and are owned by the government. The airport is run as a private company. The airport have flight routes to more than 90 destination and travels 6.000-7.000 people each day during the summer period. (Billund Airport, -) The airport have 940 employees to manage the shops, airplanes, luggage, etc. In the summer period 150 people are hired as an extra help due to the bustle.

To optimize the work efficiency the check-in stations is changed to self-service. Passengers check-in and drop off their luggage at baggage drop, with out contact with an employee. The self-service stations are an increased business and are used in business such as gas stations, supermarkets, and cafeterias. The self-service stations are created to reduce wages but at the same time increase the service efficiency. (Mortimer & Dootson, 2017)

To ease the luggage porters job of moving luggage from the conveyor belt to a transport wagon, Billund have introduced a vacuum mover have been implemented in the luggage hall. The mover can handle different materials and shapes. Michael Rasmussen estimates it is possible to use it on 75-80 % of the suitcases coming through the airport. From the wagons the luggage is moved into the plane by a transportable conveyor belt, which is flexible and can extend into the airplanes cargo hold. The conveyor belt can be moved around to arrange the luggage within the cargo hold.

The same conveyor belt is used when removing luggage from the cargo hold again. In Billund they are a part of the development of a new luggage wagon, which focuses on removing lifts. Michael Rasmussen tell "*It has been an interesting process to be a part of the development of this product because there is a lot of different factors in play. We would like to remove all luggage at ones, but at the same time we cannot have the product be to big as other people and vehicles needs to be around the plane while we remove the luggage*". From this wagon the luggage is move to a conveyor which transport the luggage to the luggage carousel, where the passengers regain the luggage. A more in-depth explanation of the tasks will be presented on page 13 in the process report.

Illustration 6.1

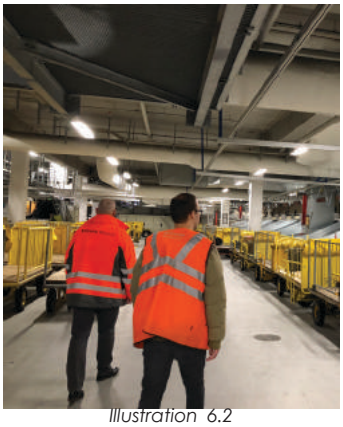


Illustration 6.2

Illustration 6.3

Illustration 6.4

Illustration 6.5

Illustration 6.6

VISIT AT AALBORG AIRPORT

After the visit to Billund a tour and interview in Aalborg airport was arranged. The meeting were conducted to look at similarities and differences between Aalborg and Billund's luggage handling process. The meeting were conducted with Tomas Nielsen who is assisting department manager at the Aalborg airport Cargo Center, Appendix I.

Aalborg Airport is an international airport in the northern-Jutland and is the third largest airport in Denmark. Aalborg Airport is a state owned by six municipalities which means that it is a non-profit organization. The airport have over 320 employees. Even though the Aalborg Airport is an international airport 58% of all flight are domestic. With the main route Aalborg - Copenhagen makes up 50 % of all domestic flights. The airport handles about 4000 passengers on the busiest days. (Aalborg Airport, -)
Aalborg Airport also use self-service check-in and baggage-drop to optimize their work. The difference being, at check-in the passenger prints out a tag for their luggage with an RFID tag. Which enables an automated tracking process through the airport.
Aalborg Airport uses the same vacuum mover as Billund Airport to transport luggage to the wagon. To move luggage from the wagon to the cargo hold of the airplane and out, a similar transportable conveyor belt and the same transportable conveyor belt as the one in Billund Airport is used. Tomas Nielsen tells "*In Aalborg we deal with a lot of commuters, which often only travel with carry-ons. They often do not have luggage with them which need to be checked in to the cargo hold in the airplane.*"
The porters do traditionally not have anything to do with carry-ons. Some Airlines have responded to this by sending carry-ons into the cargo hold if passengers have two carry-ons with them.

When the luggage is removed from the cargo hold again on arrival, the transportable conveyor is used again. In Aalborg they use the same wagons to transport the luggage to the luggage carousel as they use to move it from the luggage hall to the airplane. This result in the porters either having to lift the luggage to the conveyor by hand or with the vacuum mover. A more in-depth explanation of the tasks will be presented on page 13 in the process report.


Illustration 7.1


Illustration 7.2

Illustration 7.3


Illustration 7.4


Illustration 7.5

III - BEUMER GROUP

After the visit at Billund airport the group were interested in get more insight into companies which provides products and systems for the airport. Two meeting were arranged, one with Ulrik Steen Hansen who is a developing manager and one with Per Engelbrechtsen who is the business director at BEUMER Group, Appendix I. This section is based in interview, observations, and desktop research.

BEUMER Group provides logistic solutions for different industries such as airport baggage handling. In the airport business BEUMER offers transport systems for all sizes of airports. Their systems are fully automated and transport the luggage from the check in, through a security screening and further to the suits. The system uses totes instead of a traditional conveyor to transport the luggage. Totes travels along a rail, which is shown on Illustration 8.1. Every tote have integrated a RFID tag which enables to track the individual luggage at any point through the process.
BEUMERs automated transport system ends at the point were the luggage is delivered to the suit. Further handling of the luggage depends on the individual airport, and can be done manually or automatically.
Ulrik Steen Hansen says "*the industry is going towards more automation which enables for tracking the luggage the entire way to the airplane*". BEUMER Groups are interested in looking at the potential for transporting the luggage the final steps and place the luggage at the airplane.
A competitor to BEUMER Groups is the Dutch company Vanderlande, which provides transport and logistic for luggage in airports. Vanderlande differentiate from BEUMER because they are already now working on how to automate the last step, by implementing a robot to move the luggage from the suit to the transport wagon, Illustration 8.2. (Vanderlande, 2018)
Per Engelbrechtsen describes the use of a robot as a temporary solution, due to the price for implementation additionally manual work is still faster. He sees the best solution as semi-automation which combines the human and technology to assist the employees.
The tracking of each individual luggage is an important factor for airlines in order to avoid paying for missing luggage. Currently airports uses regular paper tags on the suitcases, but some airports have implemented RFID tags inside the paper tags. The use of camera technology to detect the paper tags is the most used. Detecting RFID tags is an upcoming technology but not as implemented because of the price. Per explains the challenges in the airport "*when is the price low and the development of a technology high enough, so it will pay off to change the system to implement the new technology?*" Per estimates the camera technology as the leading technology now and in the nearest future.
In the summer 2018 new regulations sets a demand for tracking incoming luggage from airplanes.

Illustration 8.1 - BEUMER Groups totes to handle individual luggage

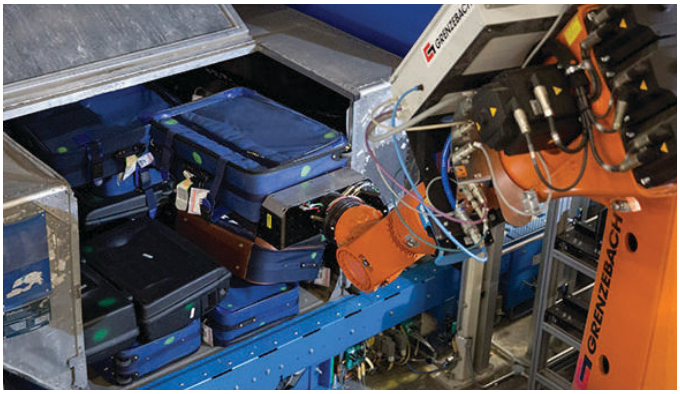


Illustration 8.2 - Vanderlande using a robot to move the luggage from the suit to the wagon

IV - DESCRIPTION OF PARADOXES AND PROBLEMS

This appendix are containing all the initial main paradoxes explored at the airport. All paradoxes are describe with the Product Reasoning Model (Haase & Laursen, 2017) to create the same baseline for all paradoxes. The Product Reasoning model combines the framing parameters and the parameters from the value-vision.

	Heavy lifting against time		
Main Paradox	**Insight** Luggage porters have to move luggage from the suit to the transport wagons. Each suitcase weighs 15 kg in average, and each porter lifts approximately 5 tonne each day. Which can result in work injuries. There are exiting tool to help alleviate the lifts, but workers are not using it because it is slower than doing it manually.	**Aspired value** Alleviate or eliminate lifts from the luggage porters without increasing the time used to lift each suitcase/Fill a wagon	**Working principle**

Illustration 9.1

Illustration 9.2

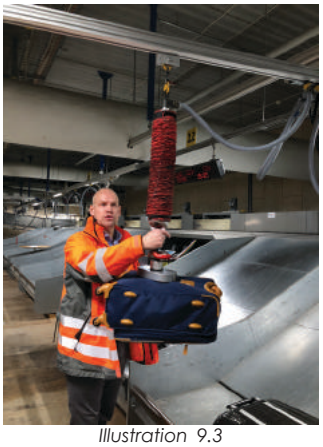


Illustration 9.3

	Carry-ons only		
Main Paradox	**Insight** A new trend of people commuting and only carrying handbags to avoid the increased luggage fee and waiting time at arrival. One person is allowed two handbags, but planes are not design for each person bringing two handbag, so some of the handbags must be moved to the cargo hold. This is done late in the process as it is done in the boarding area. This causes problem for the porters because of the late arrival of the luggage and short time period to get it on the plane. **Currently there is no solution or system in place for this.**	**Aspired value** Create a system/solution which alleviate the stress from the porters when they suddenly have to handle the unexpected luggage.	**Working principle**

Illustration 9.4

Illustration 9.5

Main Paradox	**An antidote for chaos**		
	Insight There is a high degree of control of the luggage from when the passenger hand-in the luggage. The control is decreased at arrival and things goes into chaos at the luggage carousel.	**Aspired value** Creating an antidote for the chaos	**Working principle**
Experience	**Wake up call**		
	Insight The vacation starts at the airport after security. There is a big contrast in the difference between going on the plane and going of the plane. When arriving and you need get your luggage your vacation is thrown into chaos or your vacation suddenly stop.	**Aspired value**	**Working principle**

Illustration 10.1

Illustration 10.2

Main Paradox	**Handling the pressure**		
	Insight The Airport wants the passengers through security as fast as possible, so they have more time in tax-free. But the busier it gets, the slower people come through. This means that the passengers have less time to use in tax-free. Some people feel unsafe being in the large crowed before the security.	**Aspired value** Creating an adaptable security which changes according to the amount of passengers.	**Working principle**

Illustration 10.3

Illustration 10.4

Main Paradox	One size fits all		
	Insight Bigger airplanes uses Ulds to lessen the step of luggage loading because it can handle up to 40 pieces of luggage. If the Uld is provided with a ceiling the helping tool (Vacuum mover/ Lifting hook) cannot be used to load the luggage. Thereby forcing the porters to manually move the luggage.	**Aspired value**	**Working principle** Minimize the manual work by creating a tool which works for both uld with and without a ceiling, and the normal wagon.

Illustration 11.1

Illustration 11.2

Main Paradox	Do it yourself boarding		
	Insight We are moving towards self-service, but the boarding is still handled by handing your boarding pass to a employee who scans it for you before you enter the airplane	**Aspired value** Create more free time for more important tasks than scanning a bar-code before boarding	**Working principle** The subway-system, the one-person carousel.

Illustration 11.3

Illustration 11.4

Main Paradox	Keep an eye out		
	Insight People have one or two handbags, which they need to carry around at all time before they can board the airplane, because you are not allowed to leave luggage unattended	**Aspired value**	**Working principle**

Illustration 12.1

Illustration 12.2

Main Paradox	The self-driving luggage		
	Insight To ease the passengers journey from parking lot to terminal, several luggage carts are placed in the parking lot. These carts are often hard to control do not drive well. This makes the transport of the luggage frustrating.	**Aspired value** Ease the traveling process for the passengers.	**Working principle**

Illustration 12.3

Illustration 12.4

Main Paradox	Metaphor/One liner		
	Insight When people are in the airplane and the food wagon is going around it blocks the hallway. This results in that people cannot go to the bathroom	**Aspired value** Ensure that people can go to the bathroom whenever they want	**Working principle**

Main Paradox	Metaphor/One liner		
	Insight	**Aspired value**	**Working principle**
	A lot of time is used to move the trays back to the check-in area. The trays are used for soft luggage, like sleeping bags. It is used to ensure that soft item do not get stuck in the conveyor system. This is a time consuming assignment which does not provide value for the customer.	Creating more time for other tasks and save money.	Creating a system which can automatically move trays up or a system which do not need trays.

Main Paradox	Metaphor/One liner		
	Insight	**Aspired value**	**Working principle**
	Big sized luggage is separated from regular luggage, this requires space. The amount of luggage is only a fraction of the regular sized luggage. Even though a lot of time and space is used. This space could be used to expand the regular luggage area.	Make the luggage handling area more efficient	

Illustration 13.1

Illustration 13.2

Illustration 13.3

Main Paradox	Metaphor/One liner		
	Insight	**Aspired value**	**Working principle**
	In Billund the luggage is manually check and scanned before leaving the suit, to after-check that it is going to the right destination. This is done manually because of the bar-code and the lack of RFID		

V - THE FOUR PARADOXES

AIRPORT SECURITY CHECKS: HANDLING THE PRESSURE

In airport the security is one of the top priorities. To ensure the security, the passengers have to go through security checks. The security checks can be a stressful experience for the passengers as there is many different steps to go through. Passengers understand why the security checks are necessary, but want to go through the security check as quickly as possible. While the airport want to keep the safety on a high level, the airports still want the passengers to go through the security check, just as fast as the passengers want to. The airport earns some of their money in the duty free zone, and while the passengers are in the security line they are not earning profit on the passengers. The problem is that when there is a lot of passengers the security checks slows down. The slow down is in part because of the higher number of passengers, but the higher number of passengers stress the system and the passengers. Passengers feel pressured to quickly get their stuff in trays to make room for the next. When stressed the passengers often start to forget what the need to do in the security check; Which items needs to be put in the tray?, How the items need to distributed in different tray?.

STAKEHOLDERS

The security guards is an authoritarian figures who keep the airport secure and helps passengers get through security with as few problems as possible

Illustration 14.1

The passengers want to go through the security check with as little trouble as possible. Gets stressed if to many things happens at ones

Illustration 14.2

VISION

Create a solution which provide the passengers with clarity, so that they feel prepared.

Illustration 14.3

CARRY-ONS ONLY

In 2014 Ryanair introduced a fee for checking in luggage. (Duggan, 2014) The change move the industry and other airlines followed suit. The move resulted in passengers starting a new trend where commuters and weekend travelers will travel with only carry-ons. Each passenger is allowed two carry-on, on the airplane. But the airplanes are not designed for that many carry-ons. An example is; One of the most used airplane is designed for 90 pieces of carry-ons, but 140 passengers. If each passenger have one or two carry-ons with them much of it needs to be put in the cargo hold. When the carry-ons needs to be moved to the cargo hold it is checked-in, in the gate. This new trend is a challenge for the airport and the porters, as there is no solution for handling luggage from the checked-in at the gate.

STAKEHOLDERS

I need 14 sets of clothes for my weekend at home because I need to meet my old friends in the city

Illustration 15.1

I get the passengers to load their bags on a wagon, so when they have boarded we can load the plane. After boarding we have about 7-8 min. to load the plane.

Illustration 15.2

I cannot really force passengers to turn in their carry-ons so we have to go around and ask people if they would be willing to do it

Illustration 15.3

VISION

To create a solution which can anticipate and create control over the process.

Illustration 15.4

LUGGAGE HANDLING: HEAVY LIFTS AGAINST TIME

When the passengers check in their luggage it is move by conveyor to the luggage hall. When arriving in the hall the luggage is sorted in suit according to their destination. When it is time for the luggage to be move towards the plane, it needs to be move from the suit to transport wagons. Each suitcase have an average weight on 15 kg. The Danish airports have provided the porters in the luggage hall with different tools to alleviate some of the lifts and to comply with the Danish work regulations about heavy lifting. (Arbejdstilsynet, 2005)

When using the tools to move the luggage the porters are using more time one each piece of luggage. This results in the porters not using the tools provided to them. When not using the tools the porters are lifting the luggage manually. The manual lifting often result in the work related injuries, such as; shoulder and knee arthritis. (Mikkelsen, et al., 2016)

STAKEHOLDERS

Illustration 16.1

VISION

Create a solution which provide the porters with a product which ensures that the average time used on each suitcase does not increase

Illustration 16.2

Illustration 16.3

AN ANTIDOTE FOR CHAOS

From when you arrive at the airport and till you arrive at your destination there is a high degree of control. The passengers luggage is handle without them having to think about it, and the passengers goes through the security check. When it is time to board the plane, screens shows the gate, and announcement are over the speaker. The whole situation is surrounded by a calmness and control from the airports side. But as soon as the passengers arrive at their destination the control is let loose. There is no control over how the passengers get their luggage, at the luggage carousel. Passengers do not know when their luggage arrive or if it even will arrive. Passengers are often anxious to get home or continue on their trip.

STAKEHOLDERS

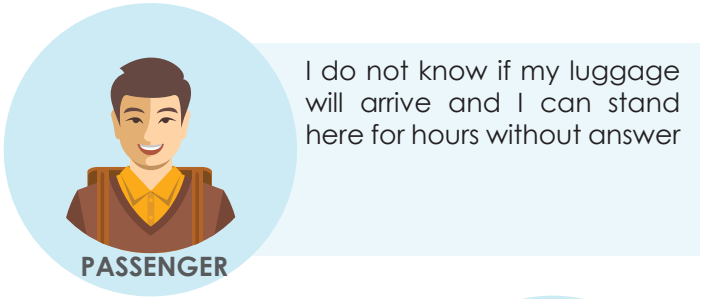


Illustration 17.1

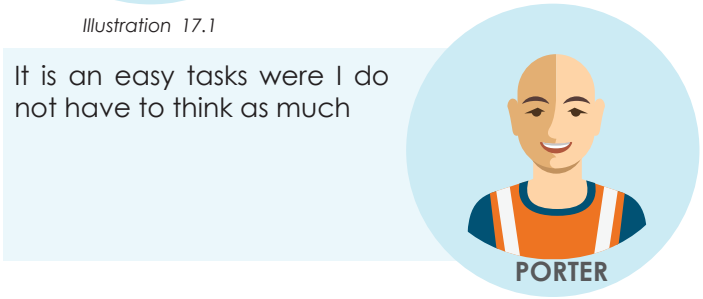


Illustration 17.2

VISION

Create an antidote for the chaos.

Illustration 17.3

VI - EXISTING PRODUCTS FOR THE FOUR PARADOXES

The section will research the solutions for the four different products. The section is a collection of selected pictures of the solutions. This section is based on: Desktop research

HEAVY LIFTING AGAINST TIME

In Airport there are different ways of handling luggage depending on which step it is in the process. For containers there exists container unloading systems

Illustration 18.1- container unloading systems (CUS).
Unload speed: 20 bags/minute
Stroke: 100-1840 mm

Illustration -18.2 - Vacuum mover
Lifting height: 1,5 m
Lift capacity: up 50 kg
Rotation of load: Endless
Noise level soft bags: 66 dB
Noise level hard bags: 0 dB

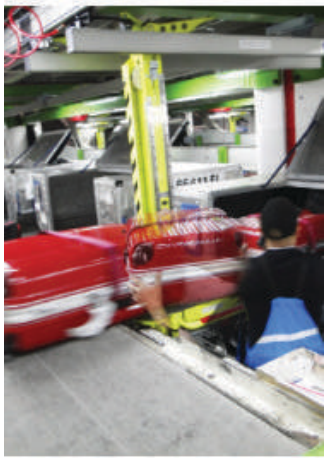


Illustration 18.3 - Container Loading System (CLS)
Load speed: 10 bags/minute
Lifting height: 100-1840 mm
Lift capacity: standard up to 40 kg

Illustration 18.4 - ULD baggage loading with SPEED-Loader
Load speed: 10 bags/minute
Max load: 40 kg
Lifting from: Carousels
Lifting to: Containers and trolleys

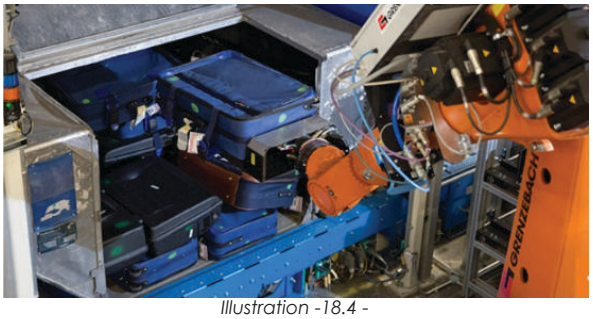


Illustration -18.4 -
Vanderlande. Using a KUKA robot

AN ANTIDOTE FOR CHAOS

There are no solutions for the problem on the market

CARRY-ONS ONLY

Mostly elevators or lift for transporting the luggage down

Illustration -18.6 -
Bag Lift provides the solution for moving bags to and from the terminal gate to the aircraft's cargo hold. At terminal level passengers load their own bags into the cart which is then lowered to the ramp and pushed to the aircraft for unloading

Illustration -18.7 -
NOVA Baggage Lift airport innovation

Illustration -18.8 -
Baggage Chute P6000

HANDLING THE PRESSURE

Few new methods. It is mostly concept thinking about walking straight through

Illustration -19.1 - Qylatron

Illustration -19.2 - IATA

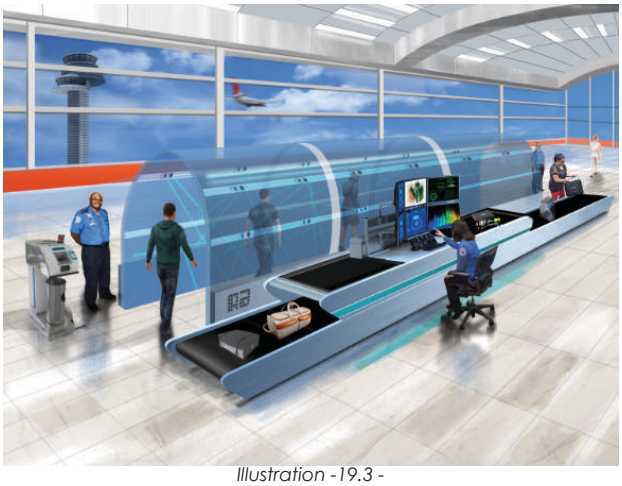


Illustration -19.3 - Qylatron

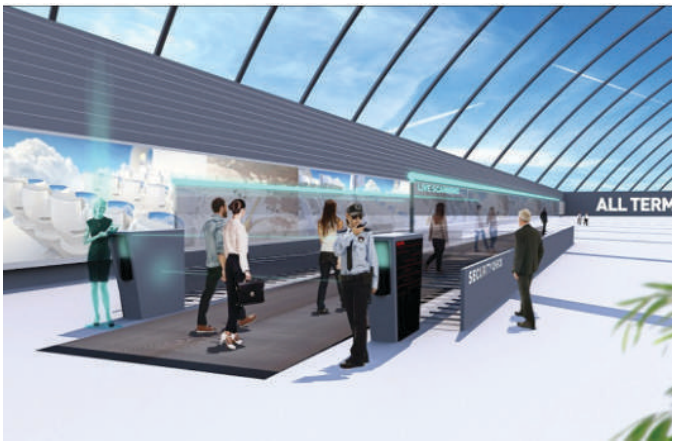


Illustration -19.4 -

VII - MARKET

This section elaborates the aviation industry and the amount of passengers traveling in different sizes of airports across Europe. This are showing the different markets and a potential aim for where to implement a product.

Research about the numbers of travelers in airports across Europe are collected and shown on table 20.1. The table are including 16 countries across Europe. The data numbers of passengers in the single airports are from year 2014, 2015, or 2016. (Wikipedia, 2018)

	France	Ireland	Netherlands	Spain	Austria	Germany	Greece	Italy	Switzerland	Hungary	Denmark	Finland	Iceland	Norway	Sweden	United Kingdom	Total
1-5 millions	7	2	2	8	1	7	6	13			2		1	8	5	10	72
5-10 millions	5			5		3	2	6	1					1	1	2	26
10-25 millions	1			4	1	5	1	2	1	1		1		1	1	5	24
25-40 millions	1	1		1					1		1						5
40 > millions	1		1	1		2		1								2	8

Table 20.1 - Showing the different sizes of airport divided in the different countries.

The data from the table can be converted to show the distribution of the different sizes of airport. The percentage are shown on Diagram 20.1.

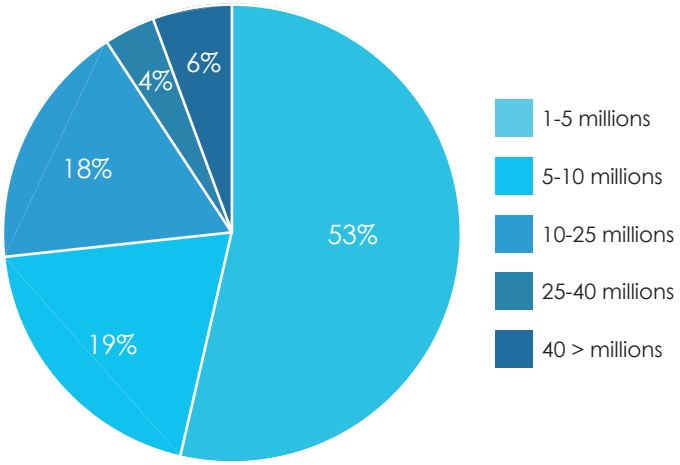
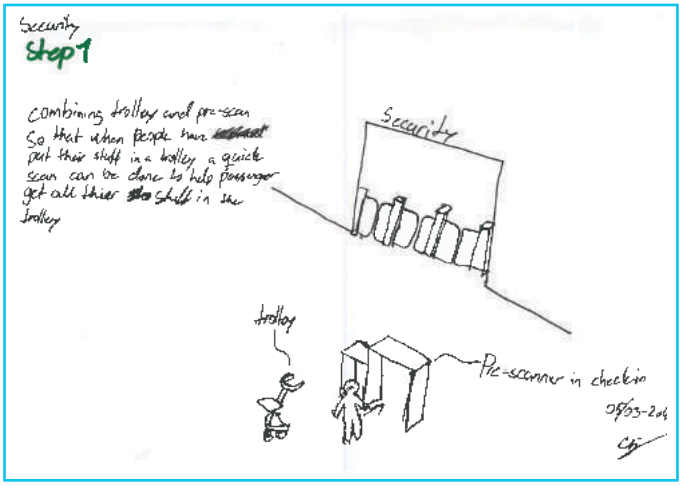


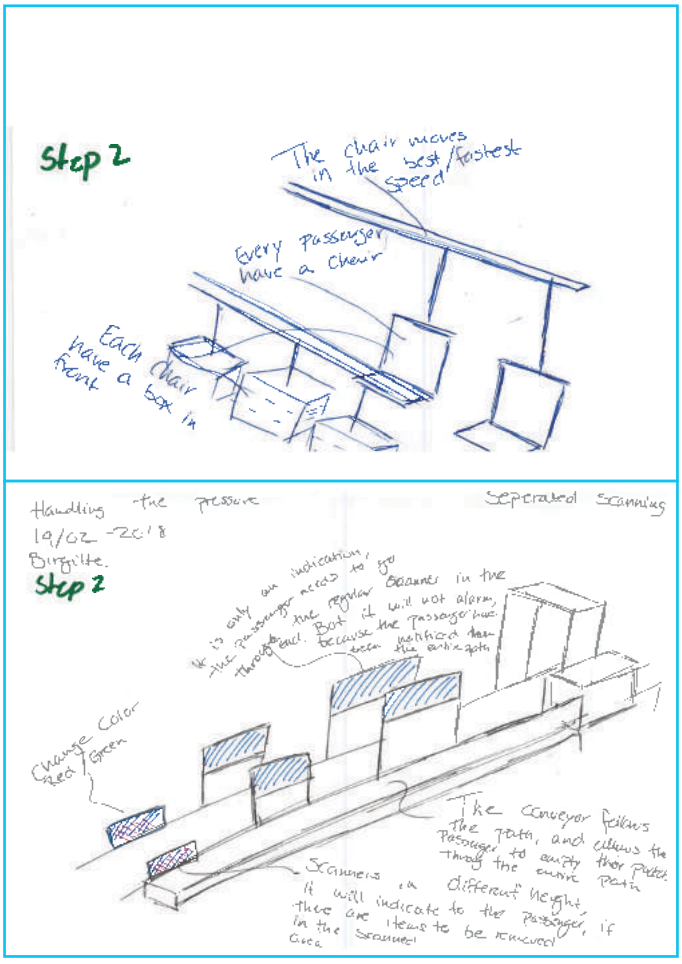
Diagram 20.1 - The different sizes of airports in Europe divided in the amount of passengers traveling each year (Wikipedia, 2018)

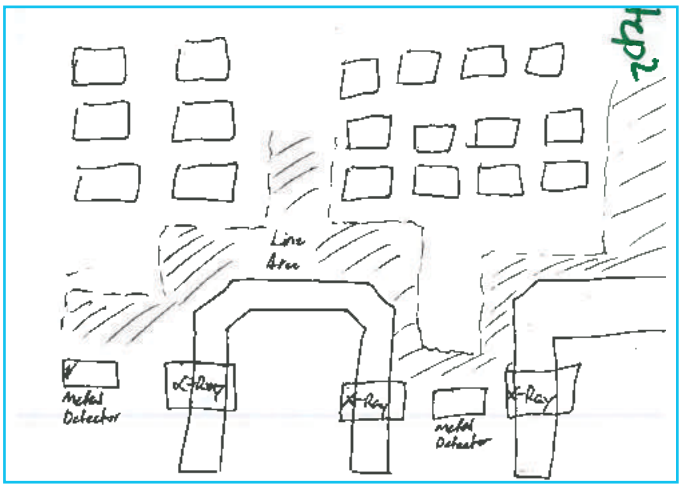
VIII - IDEATION ON STEPS IN SECURITY FLOW

STEP 1

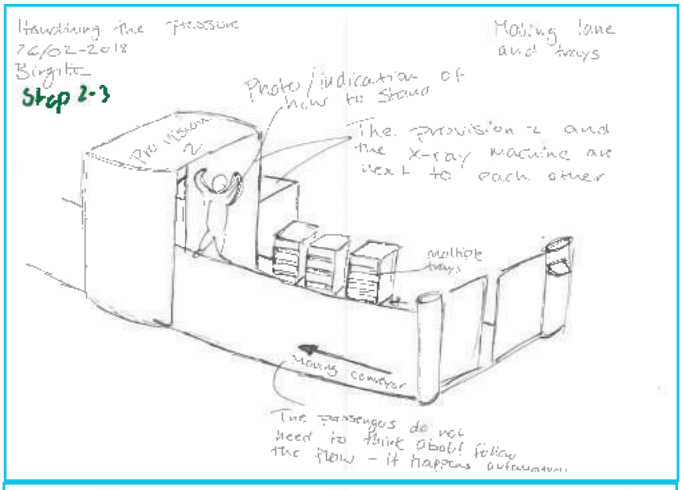


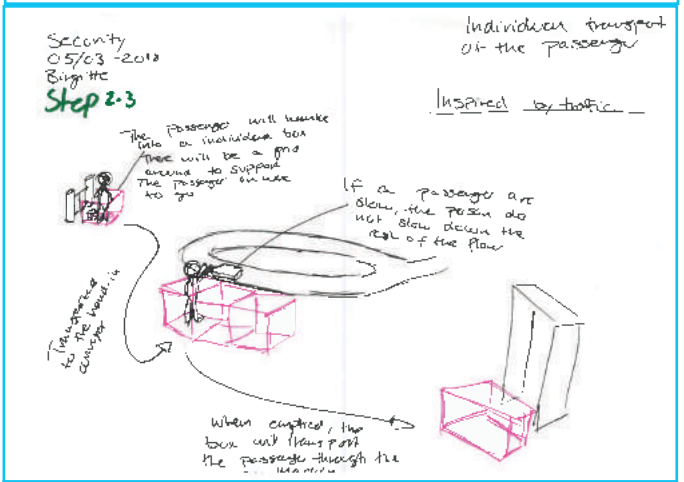
STEP 2

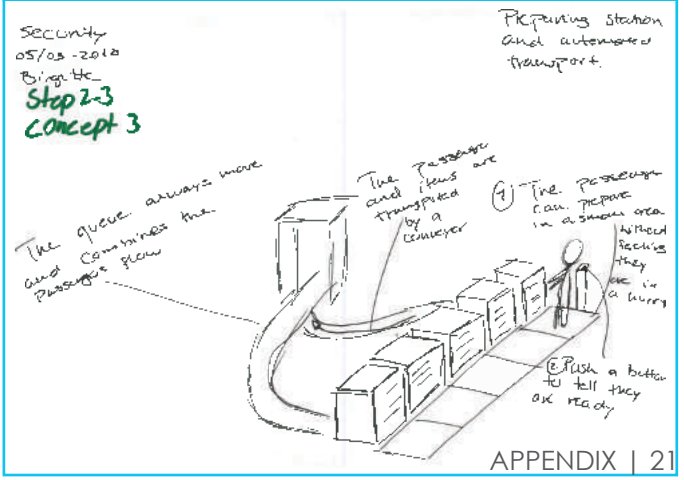




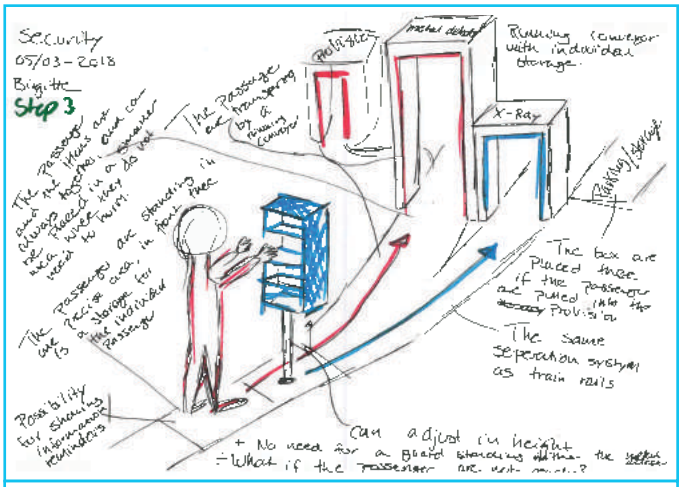
STEP 2-3

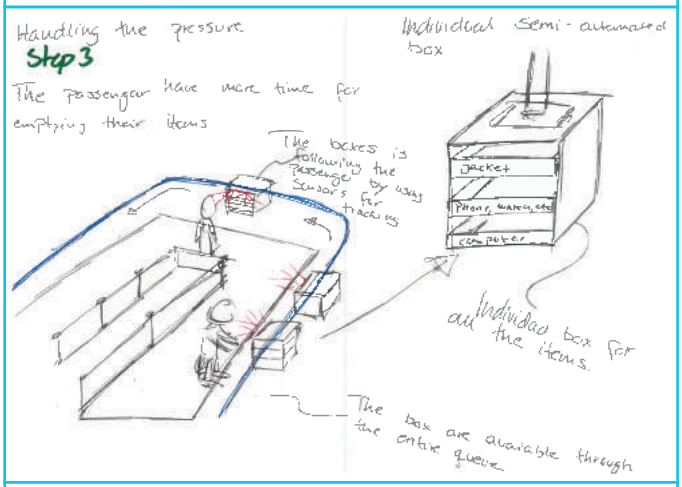


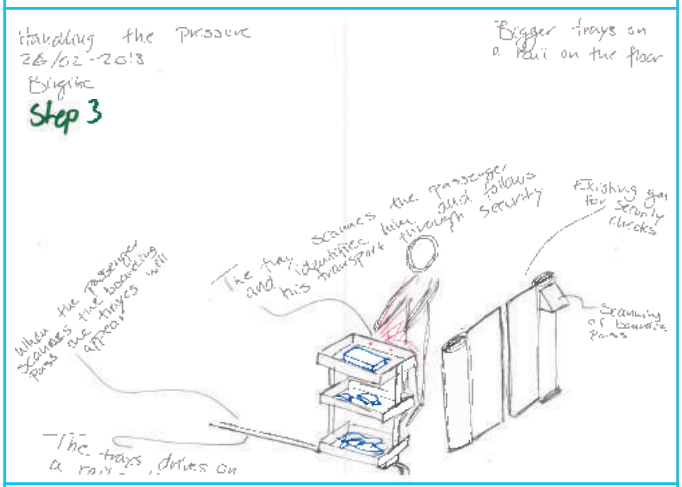


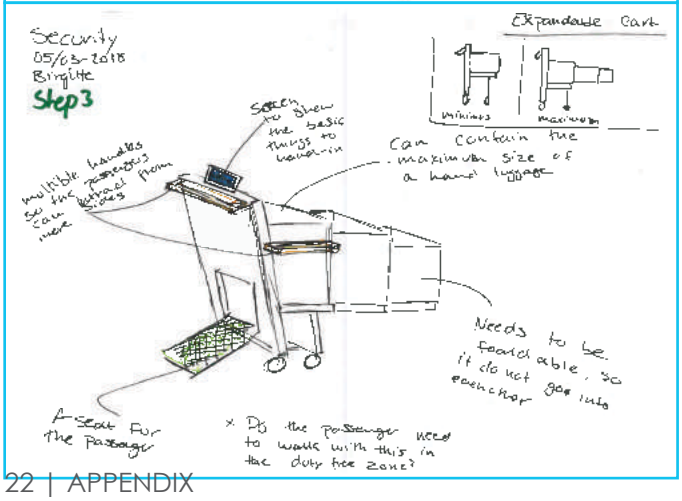


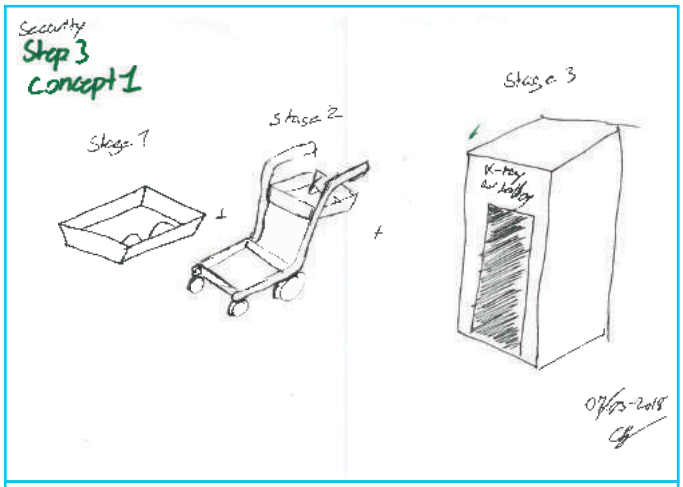
STEP 3

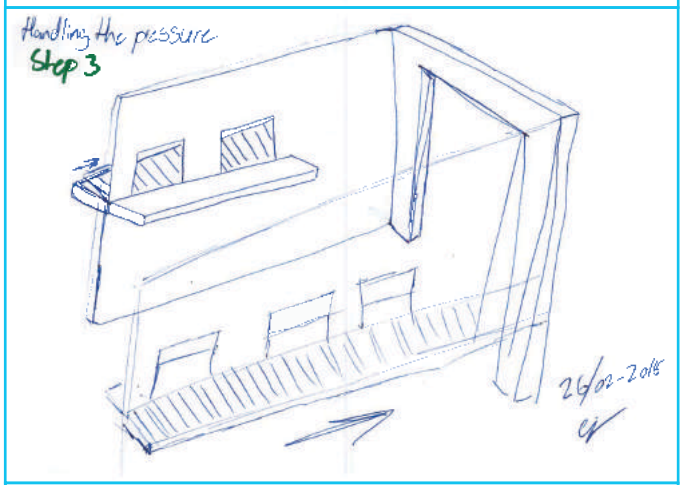

Security
05/03-2018
Brigitte
Step 3
Running conveyor with individual storage.
X-Ray
The box are placed there if the passenger are placed into the security Provision
The same separation system as train rails
Possibility for showing informations reminders
+ No need for a Board standing at the entrance
÷ What if the passenger are not...?

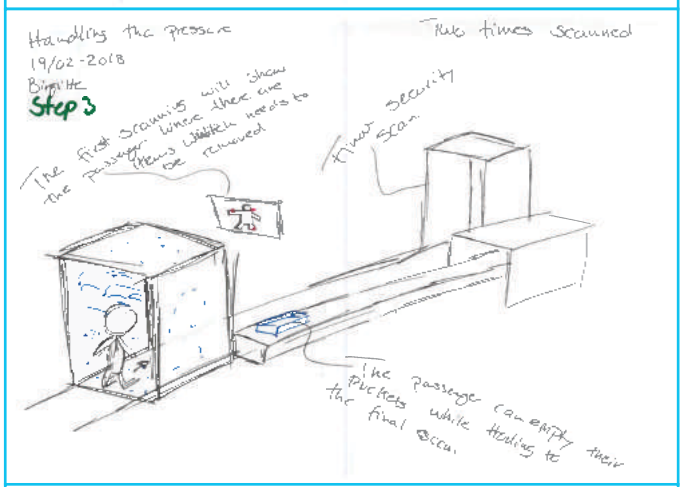

Handling the pressure
Step 3
Individual Semi-automated box
The passenger have more time for emptying their items
The boxes is following the passenger by using sensors for tracking
Jacket
Phone, watch, etc
Computer
an individual box for the items.
The box are available through the entire queue

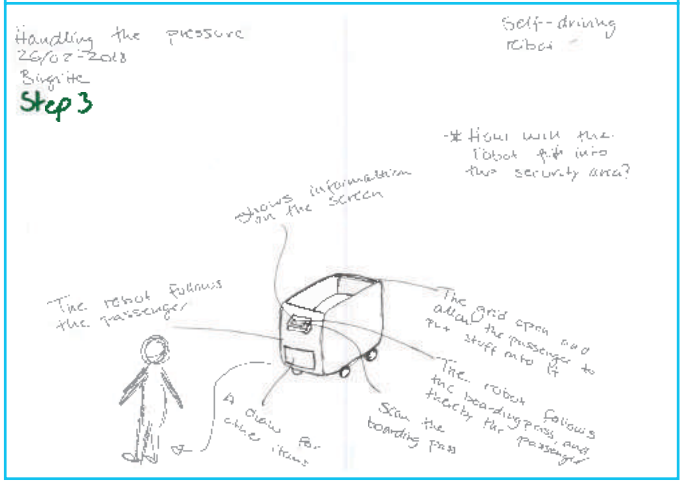

Handling the pressure
26/02-2018
Brigitte
Step 3
Bigger trays on a rail on the floor
The tray scannes the passenger, identifies, his transport and follows through security
Existing gray for security checks
Scanning of boarding pass
When the passenger scannes his boarding pass the trays will appear
The trays drives on a rail

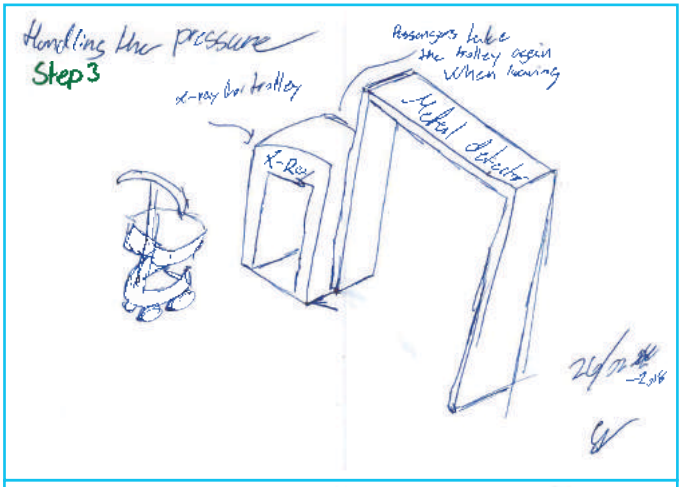

Security
05/03-2018
Brigitte
Step 3
Expandable Cart
Can contain the maximum size of a hand luggage
Screen to show the basic things to hand-in
Invisible handles to see the things from more
Needs to be foldable, so it do not get in each other
Seat for the Passenger
Do the passenger need to walk with this in the duty free zone?

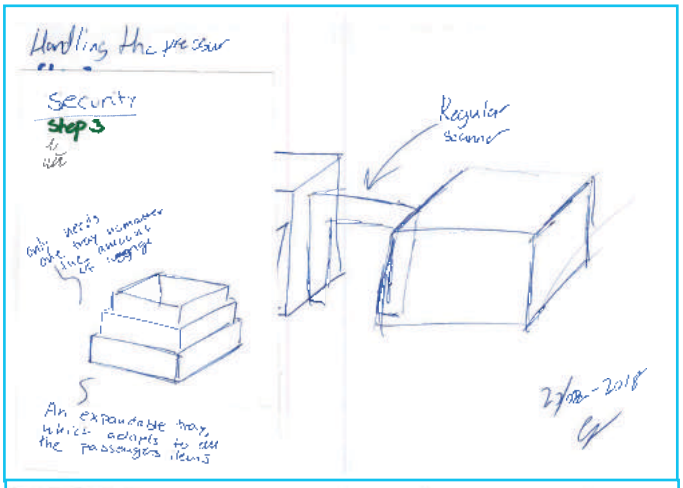

Security
Step 3
Concept 1
Stage 1
Stage 2
Stage 3
X-ray security
07/03-2018

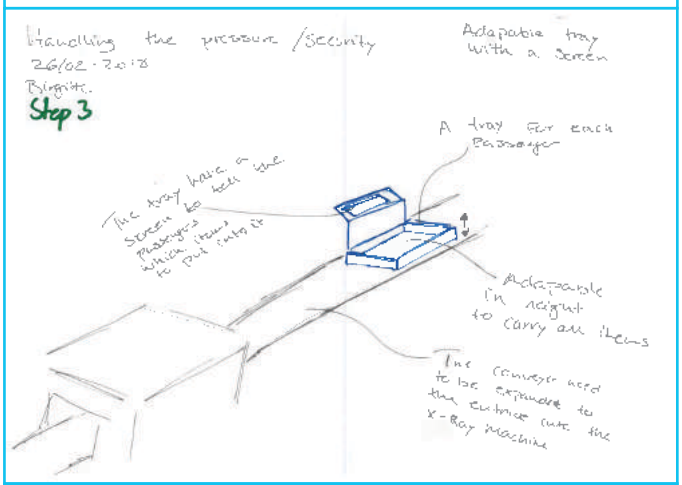

Handling the pressure
Step 3
26/02-2018

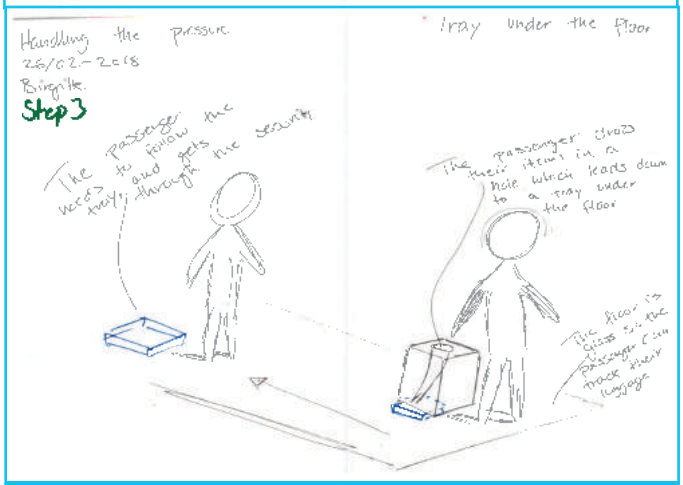

Handling the pressure
19/02-2018
Brigitte
Step 3
Two times scanned
The first scannis will show the passenger where there are items which needs to be removed
Final security scan
The passenger can empty his pockets while heading to the final scan.

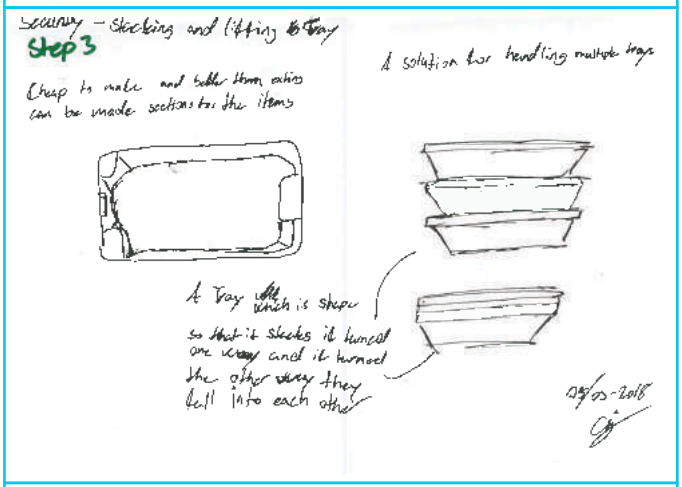

Handling the pressure
26/02-2018
Brigitte
Step 3
Self-driving robot
How will the robot get into the security area?
Shows information on the screen
The robot follows the passenger
The robot grab the passenger to put stuff into it
The robot follows the boarding pass and security for passenger
Scan the boarding pass
A drawer for other items

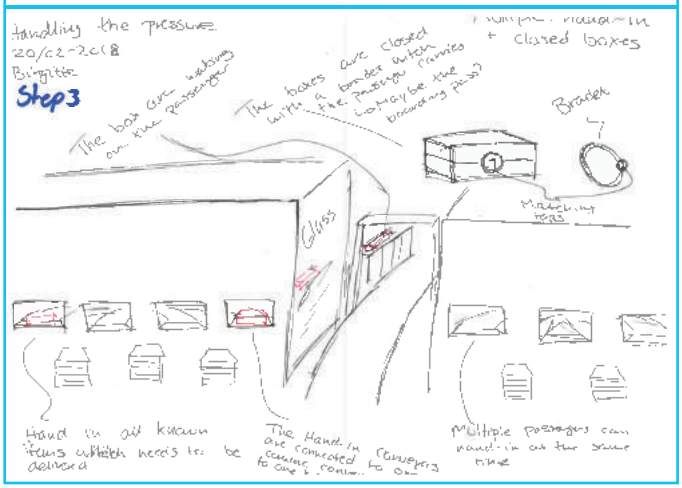

Handling the pressure
Step 3
Passengers take the trolley again when leaving
x-ray bin trolley
X-Ray
Metal detector

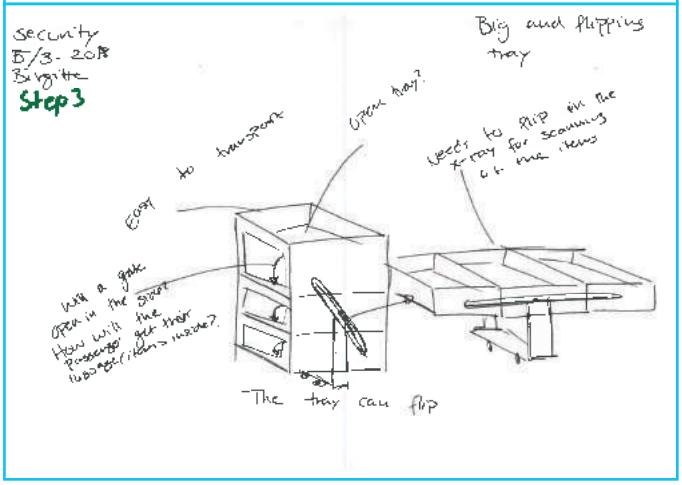

Handling the pressure
Security
Step 3
Regular scanner
An expandable tray, which adapts to all the passengers items


Handling the pressure / security
26/02-2018
Brigitte
Step 3
Adaptable tray with a screen
A tray for each passenger
Adaptable in height to carry all items
The conveyor need to be extended to the entrance into the x-Ray machine

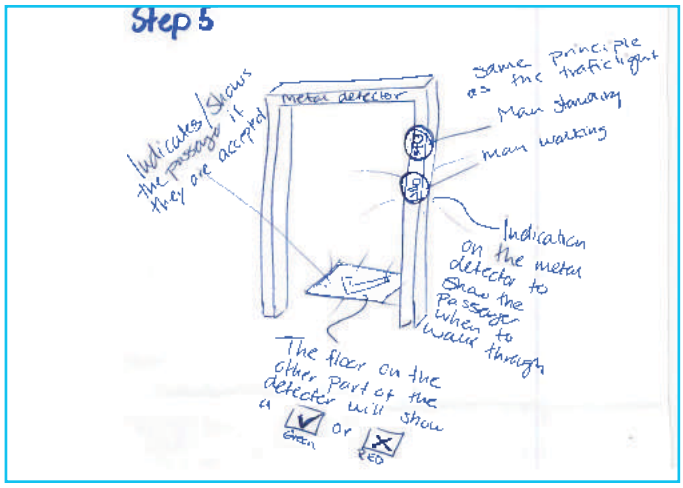

Handling the pressure
26/02-2018
Brigitte
Step 3
tray under the floor
The passenger loads their items in a hole which leads down to a tray under the floor


Security - stacking and lifting trays
Step 3
A solution for handling multiple trays
Cheap to make and better than extra can be made sections for the items
A tray which is shape so that it stacks if turned one way and if turned the other way they fall into each other

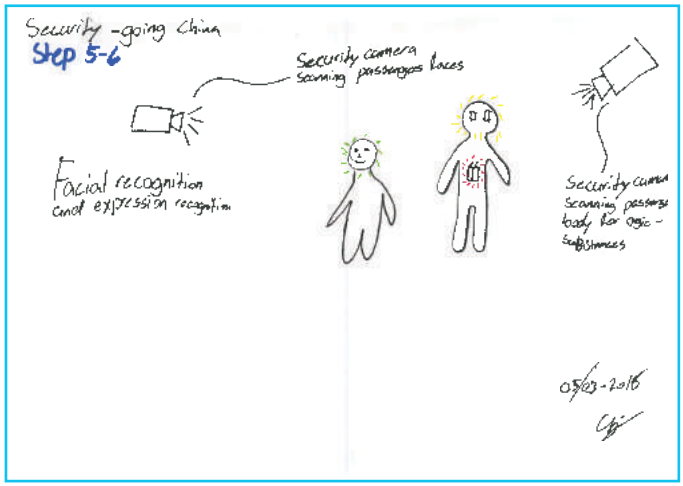

Handling the pressure
20/02-2018
Brigitte
Step 3
+ Cleared boxes
Bracket
Glass
Multiple passages can hand-in at the same time


Security
5/3-2018
Brigitte
Step 3
Big and flipping tray
Open tray?
Easy to transport
Needs to flip for the x-ray for scanning of the items
With a grab open in the side? How will the passenger get their luggage/items inside?
The tray can flip

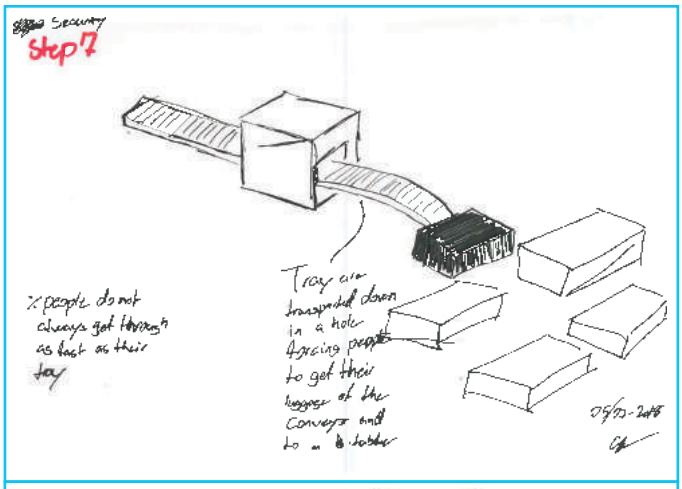
STEP 5

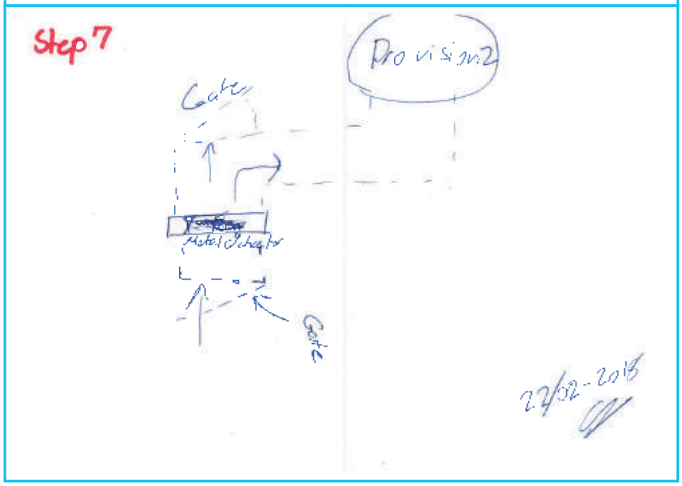


STEP 5-6



STEP 7





IX- DECONSTRUCTION OF ON-BODY ITEMS

The families needs to prepare for the security check, and thereby needs to remove all their on-body items and place them inside the trays on the cart.
To get a better overview over which items needs to handed in, a list will be complete for the different body parts.
The body will be divided into three body parts:

- The upper body, containing the head, shoulder, and top arm.
- The middle body, containing waist, top legs, and hands
- The lower body, containing lower legs, feet

ON-BODY ITEMS WHICH NEEDS TO BE HANDED IN
The two lists below are showing the on-body items which the parents and children mainly carries.

The parents:
The upper body:

- The jacket / coat
- Headphones around the neck
- Sunglasses

The middle body:

- Belt
- Phone
- Wallet
- Keys
- Watch
- Metal bracelet

The lower body:

- Shoes containing metal arches or buckles

The children:
The upper body:

- Jacket / Coat
- Headphones
- Sunglasses

The middle body:

- Belt
- Metal bracelet
- MP3 player
- Phone
- Game boy or similar
- Water bottle / juice / similar
- Toy

The lower body:

- Shoes containing metal arches or buckles, or any type of electronic (shoes with light or wheels)

The different on-body items can be translated into specific icons, which are presented on Illustration 25.1

Illustration 25.1 - Icons for on-body items

The average family consist of two parents and two children. A rough estimations shows with the numbers next to Illustration 25.1. The total amount of on-body items which needs to be handed in is: 36 items.

SCENARIO OF DECONSTRUCTION OF ON-BODY ITEMS

SCENARIO FOR ONE FAMILY

A scenario for one family deconstruction them self before entering the security check are made. The scenario will give an indication of how much space are needed for the on-body items.

The family consist of:

- A mother
- A father
- Son, age 8
- Daughter, age 5
- Son, age 2

Illustration 26.1 shows the amount of the different items which the family carries.

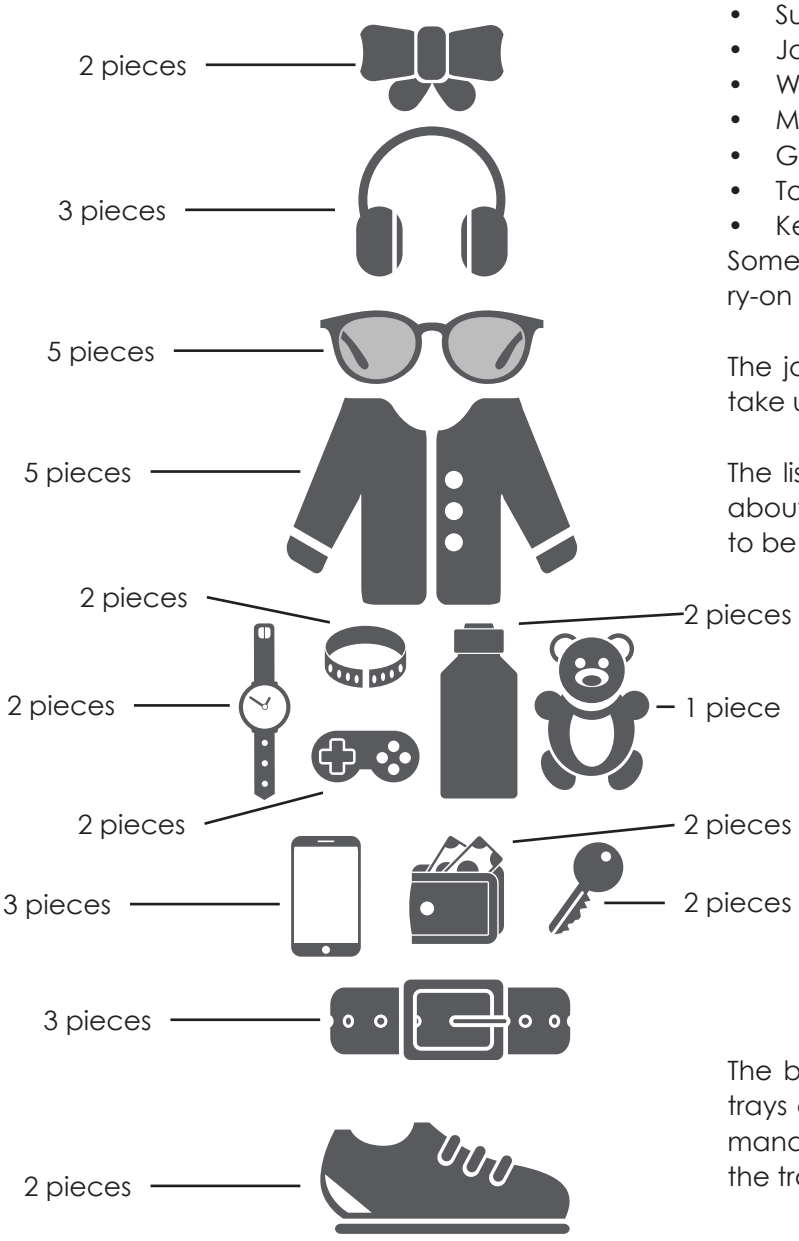


Illustration 26.1 - Amount of items which a family on five carries

Items which the family want to keep up unto the last minute before entering the security check are:

- Water bottle / juice / similar
- Phone
- Wallet
- Belt
- Shoes containing metal arches or buckles

It is important that the family easily can get rid of these items. A top tray in the cart are design, to contain the items and water bottles. The shoes will be placed in the bottom plate of the cart together with the carry-ons.

Items which the family do not need to use before the security check are:

- Hair jewelry
- Headphones
- Sunglasses
- Jacket
- Watch
- Metal bracelet
- Game boy or similar
- Toy
- Keys

Some of the mentioned items are placed in the carry-on bag when it is not used.

The jackets will be placed on a hook, and will not take up space in the trays.

The list of the different items resulted in knowledge about the necessary amount of items which needs to be stored in trays.

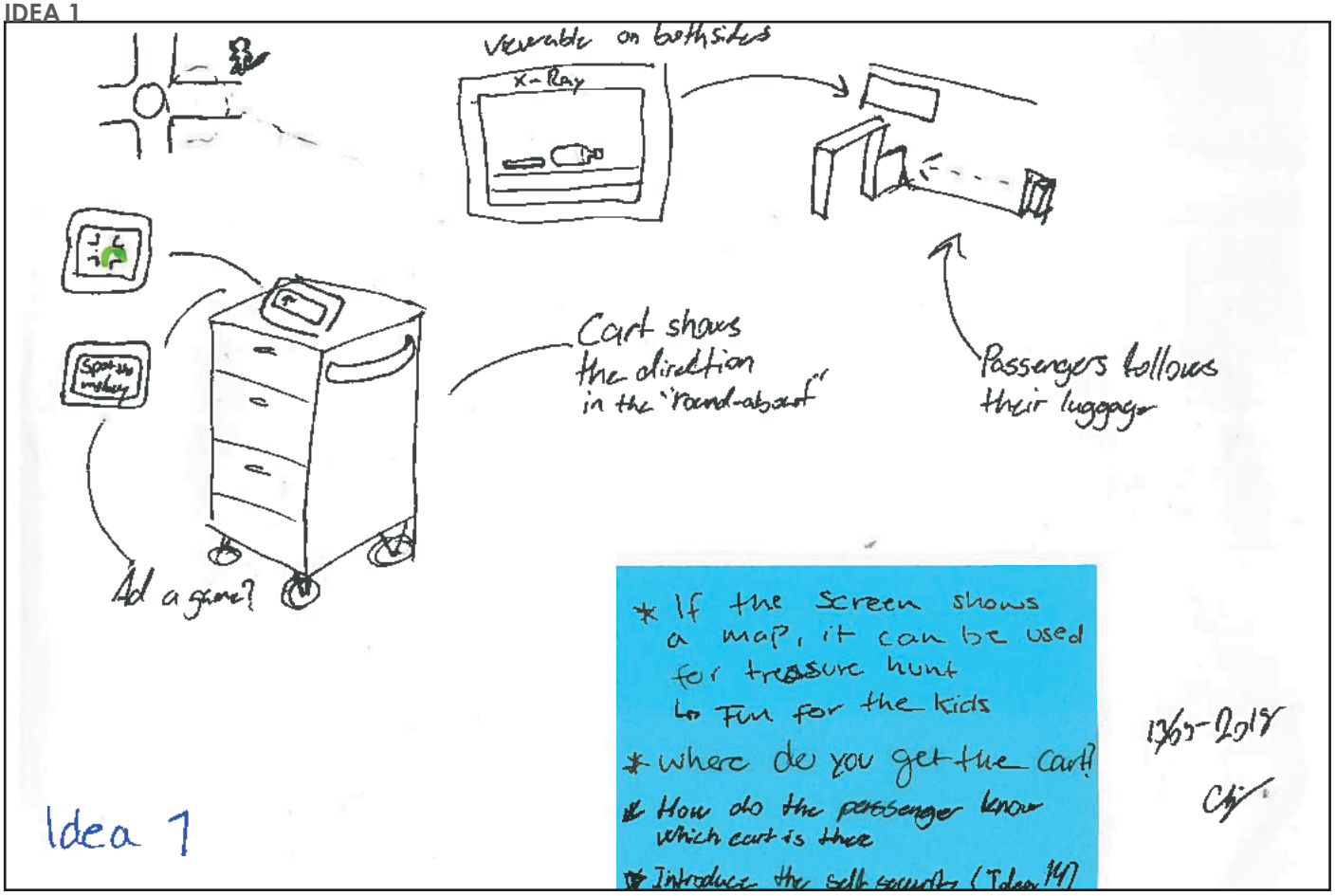
• Hair jewelry	2 pcs
• Headphones	3 pcs
• Sunglasses	5 pcs
• Watch	2 pcs
• Metal bracelet	2 pcs
• Gameboy or similar	2 pcs
• Toy	1 pcs
• Keys	2 pcs

It is important that some of the mentioned items do not get broken because of the lack of space in the trays. This results in a need for two trays to contain all the items.

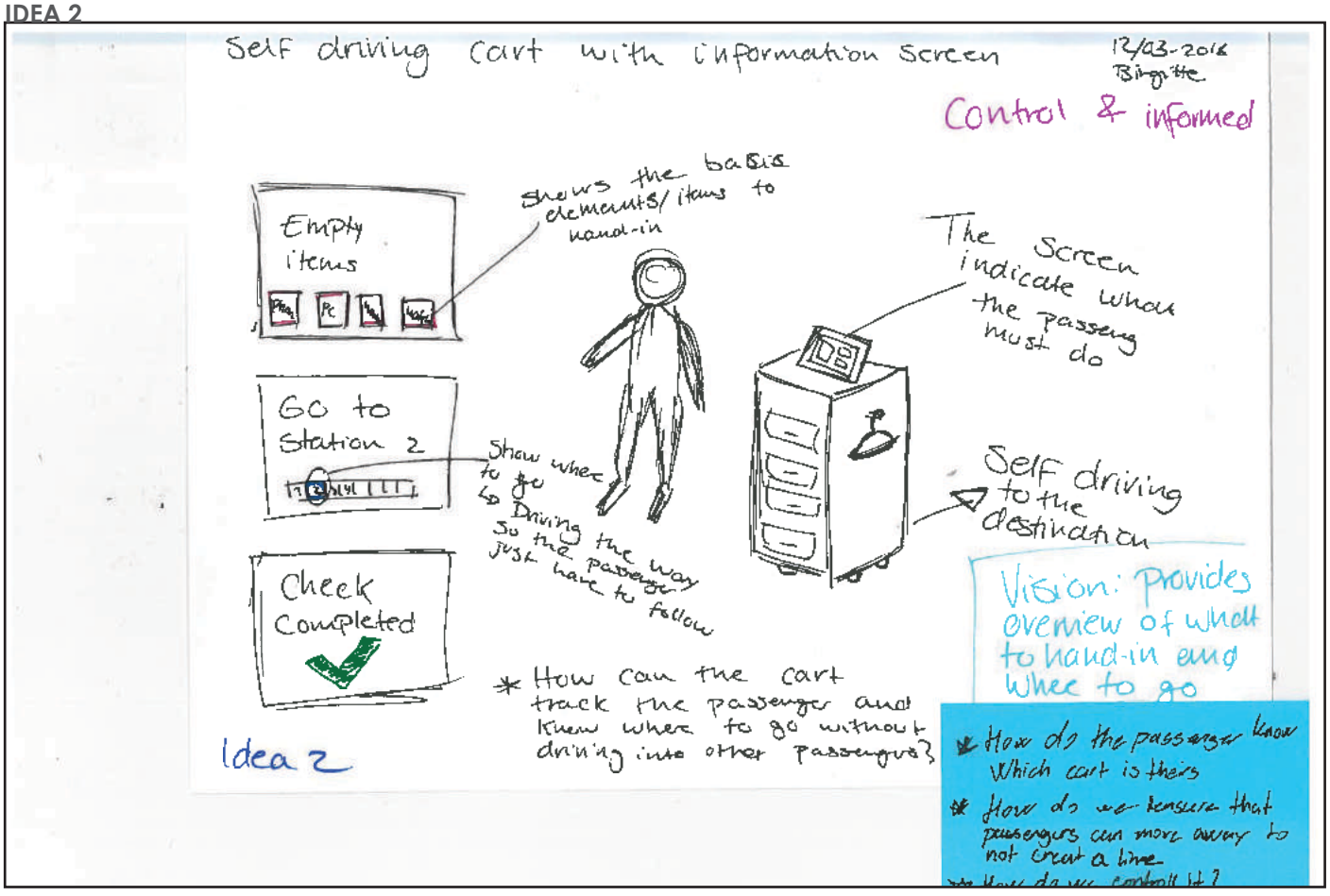
The biggest items which need to be placed in the trays can be; Headphones and Toys. This sets a demand for the side of the trays. The minimum depth of the trays are: 20cm.

8. X - IDEATION

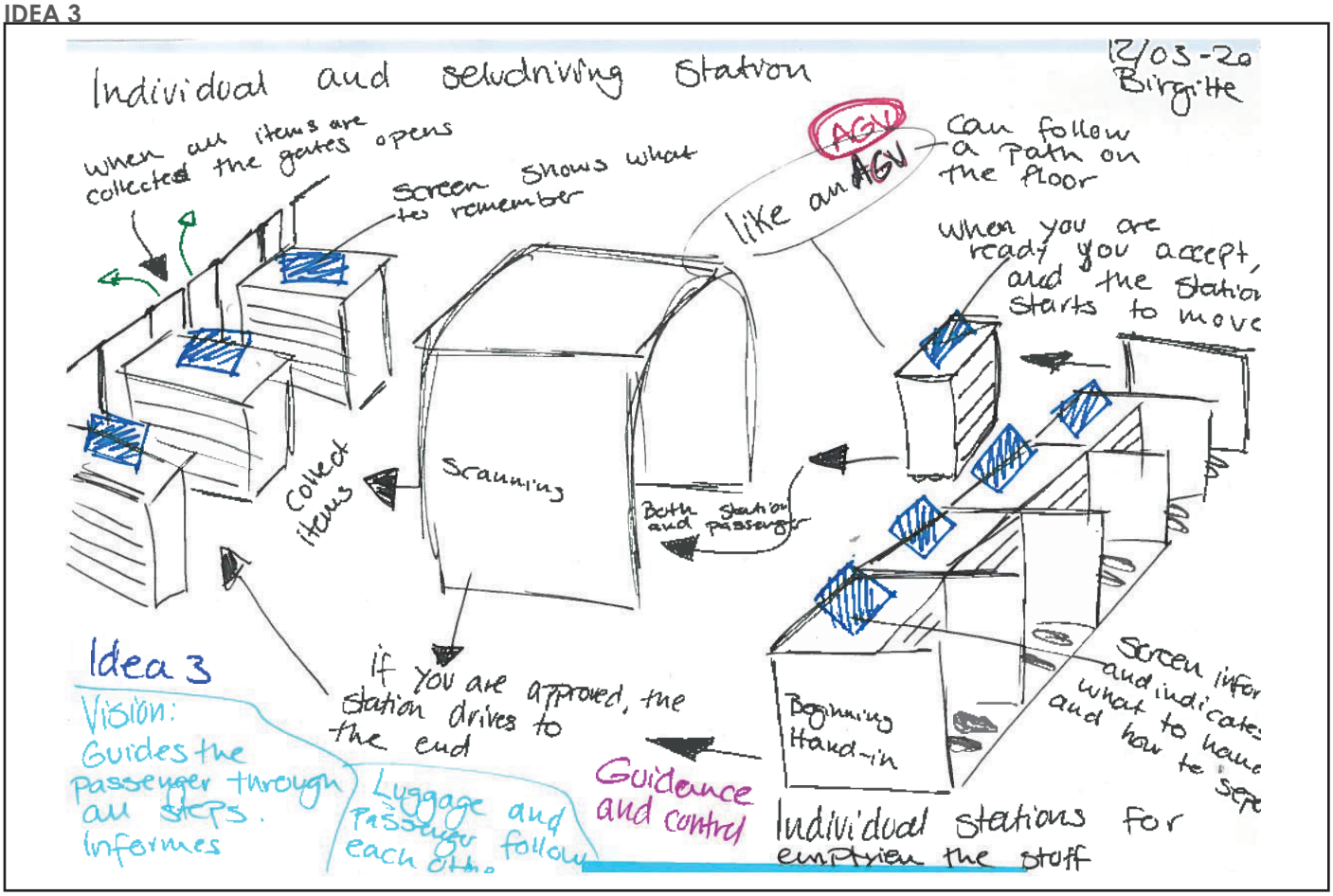
IDEA 1



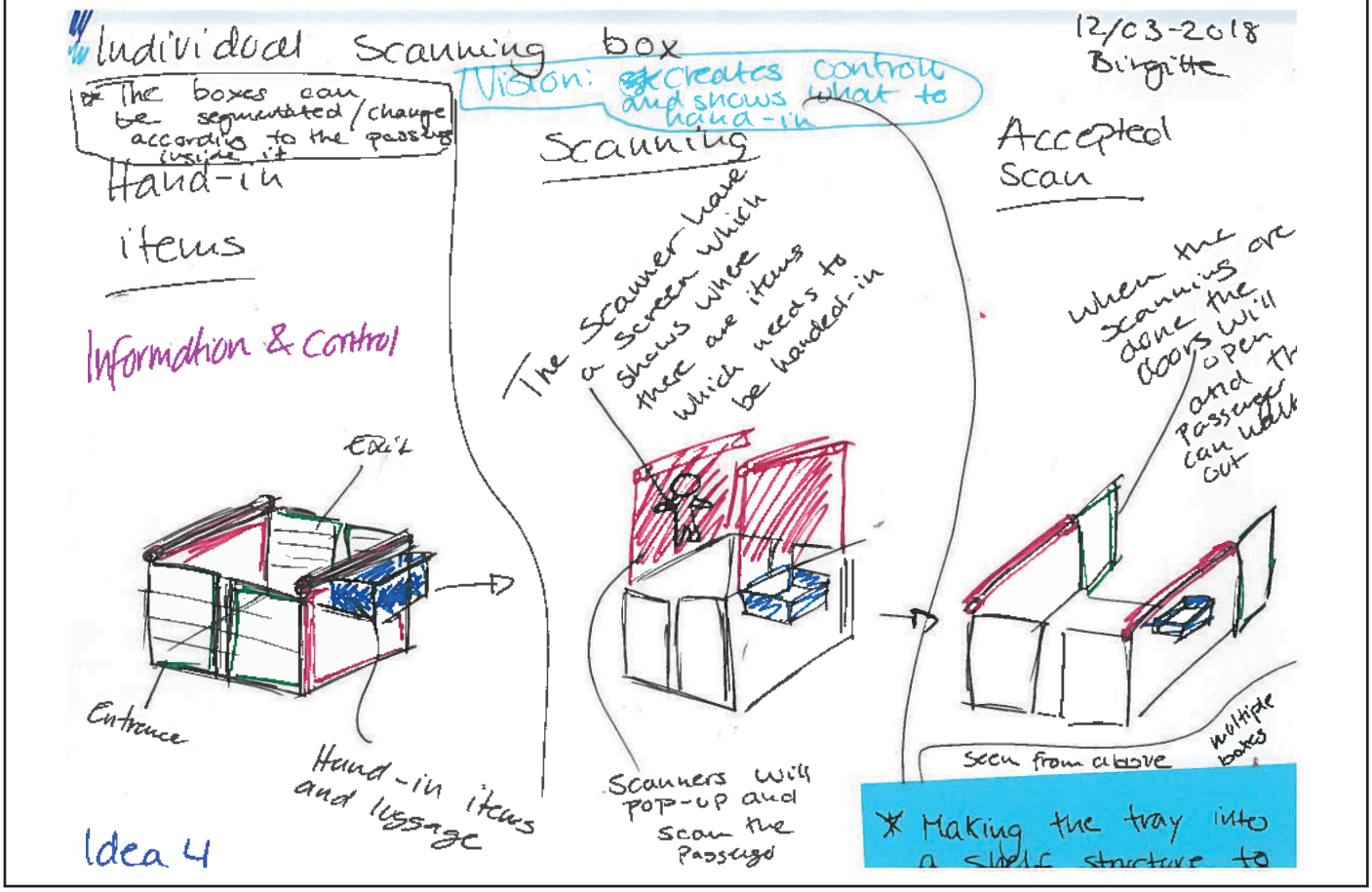
IDEA 2



IDEA 3


Individual and selfdriving Station
12/03-20
Birgitte
when all items are collected the gates opens
screen shows what to remember
AGV
like an AGV
can follow a path on the floor
when you are ready you accept, and the station starts to move
Collect items
Scanning
Both station and passenger
Idea 3
Vision:
Guides the passenger through all steps. Informes
if you are approved, the station drives to the end
Luggage and passenger follow each other
Guidance and control
Beginning Hand-in
Individual stations for emptying the stuff

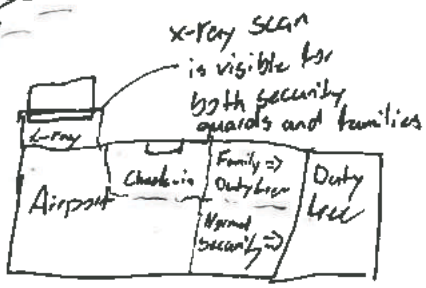
IDEA 4


Individual Scanning box
12/03-2018
Birgitte
The boxes can be segmentated/change according to the passenger using it
Vision: creates control and shows what to hand-in
Hand-in items
Information & control
Scanning
The scanner have a screen which shows where there are items which needs to be handed-in
Accepted Scan
when the scanning done the doors will open and the passenger can walk out
Exit
Entrance
Hand-in items and luggage
Scanners will pop-up and scan the Passeger
seen from above
multiple boxes
* Making the tray into a shelf structure to
Idea 4

The family rollercoaster

Inspiration: Amusement park

Children can look at the planes while they take off



Families are picked up by a "bus" in this bus, families can sort their items while getting a tour around the airport using both the airplane and X-Ray as attractions

Picked up at the parking lot

12/03-2018

Idea 5

* What do the passenger do with their ~~bound~~ Check-in luggage (big suitcase)

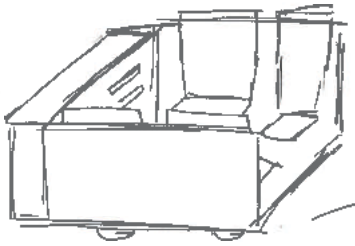
Self-driving cart for multiple passengers

* Why does it have to move and drive around?

Inspired by a rollercoaster

* What does it solve?
  - Flow?
  - Why will passengers use it?

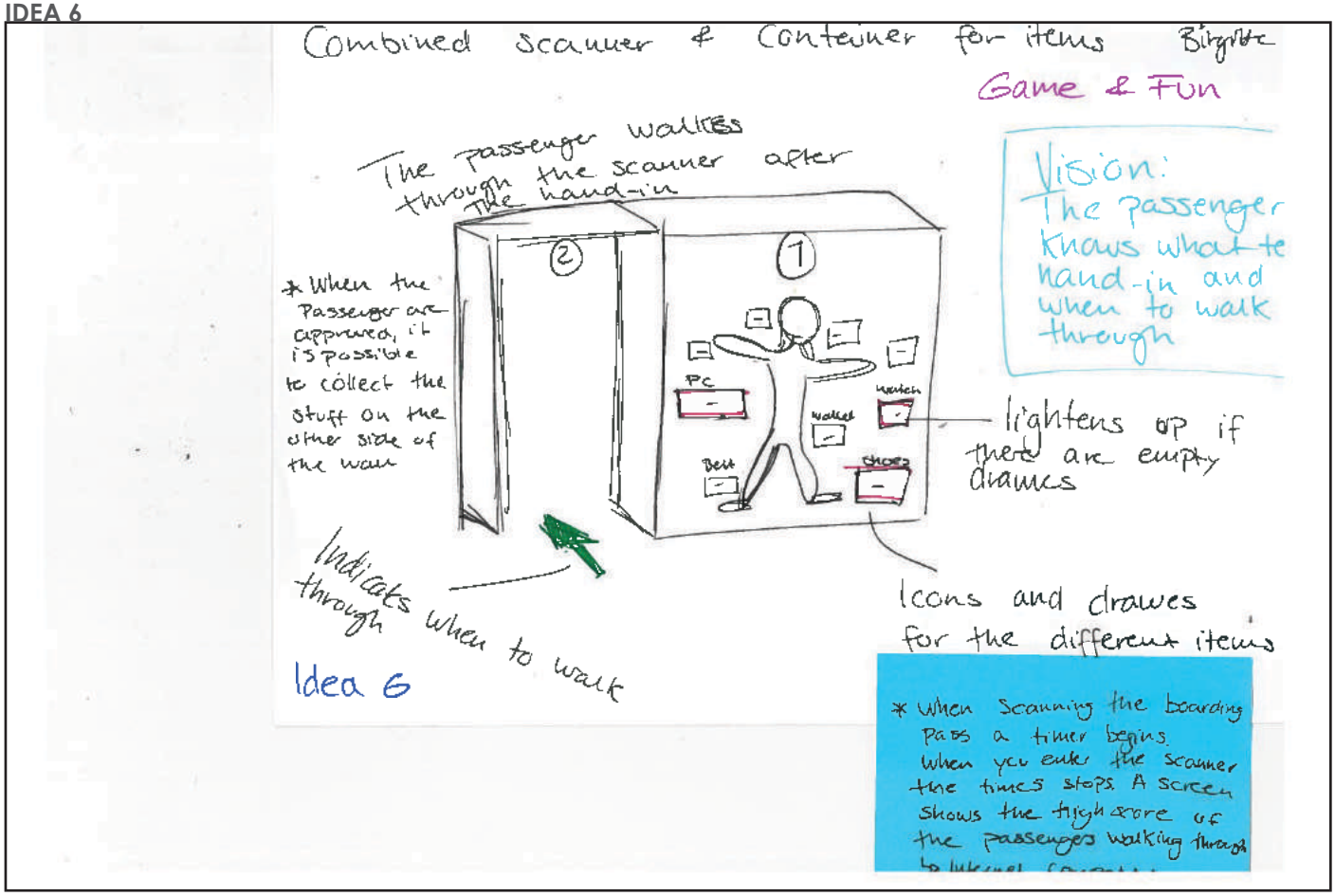
Creates a fun experince for the Passengers



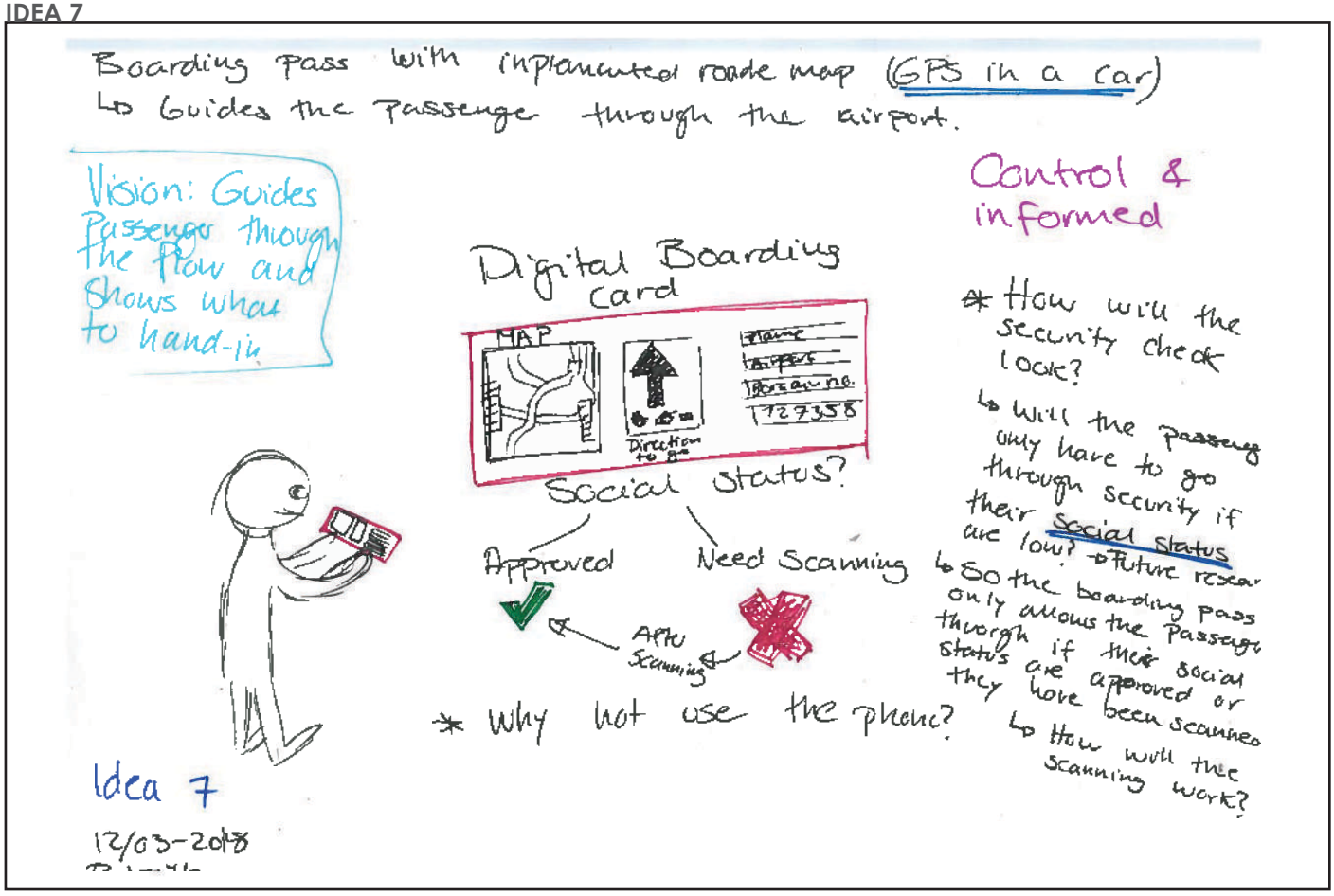
A self-driving cart which can handle a entire family, and allow them to hand-in meanwhile they are driving

Idea 5

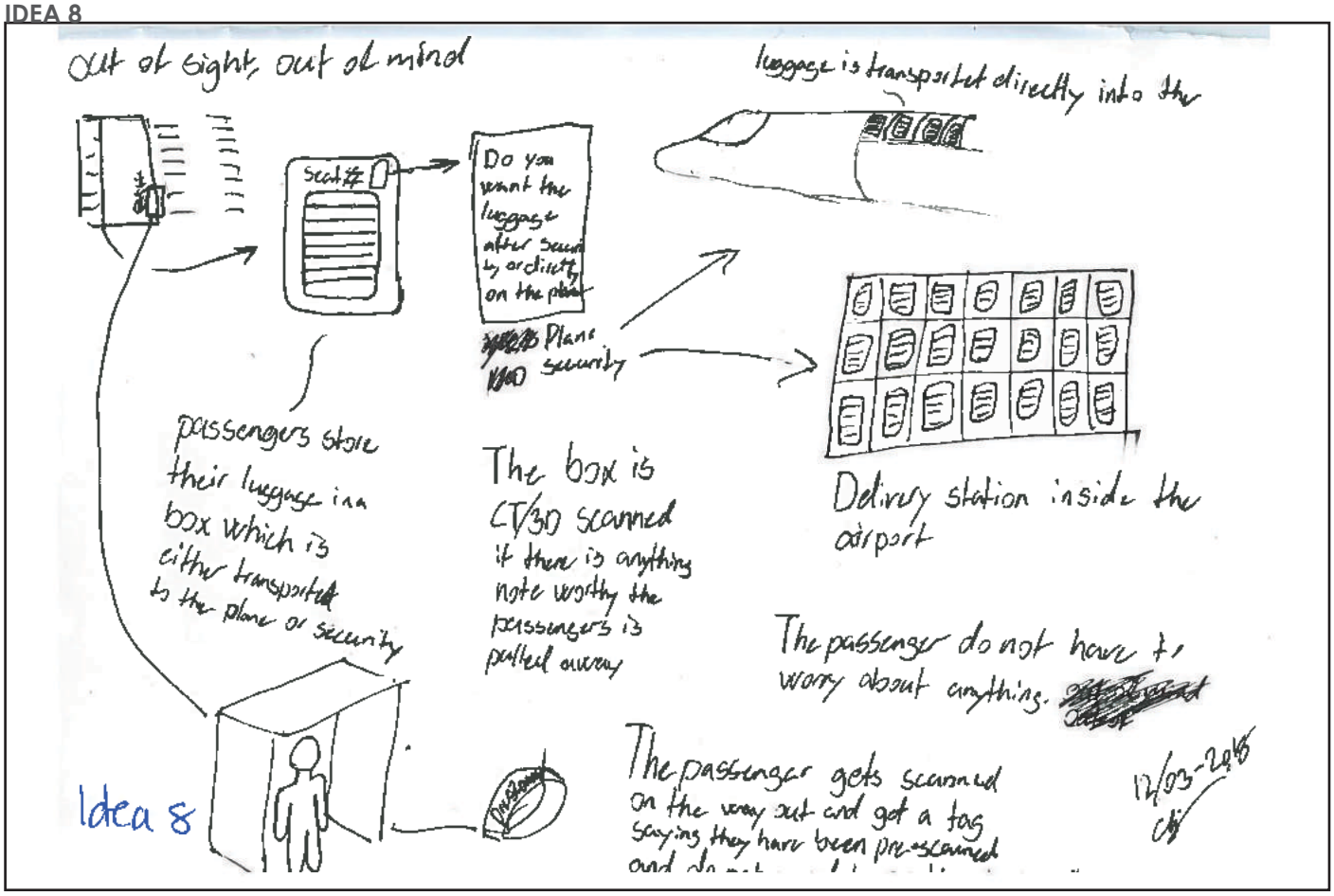
IDEA 6


Combined scanner & Container for items
Game & Fun
The passenger walkes through the scanner after the hand-in
Vision:
The passenger knows what to hand-in and when to walk through
* When the Passenger are approved, it is possible to collect the stuff on the other side of the wall
2
1
PC
watch
wallet
Belt
shoes
lightens up if there are empty drawes
Indicats when to walk through
Icons and drawes for the different items
Idea 6
* When Scanning the boarding pass a timer begins. When you enter the scanner the timer stops. A screen shows the high score of the passengers walking through

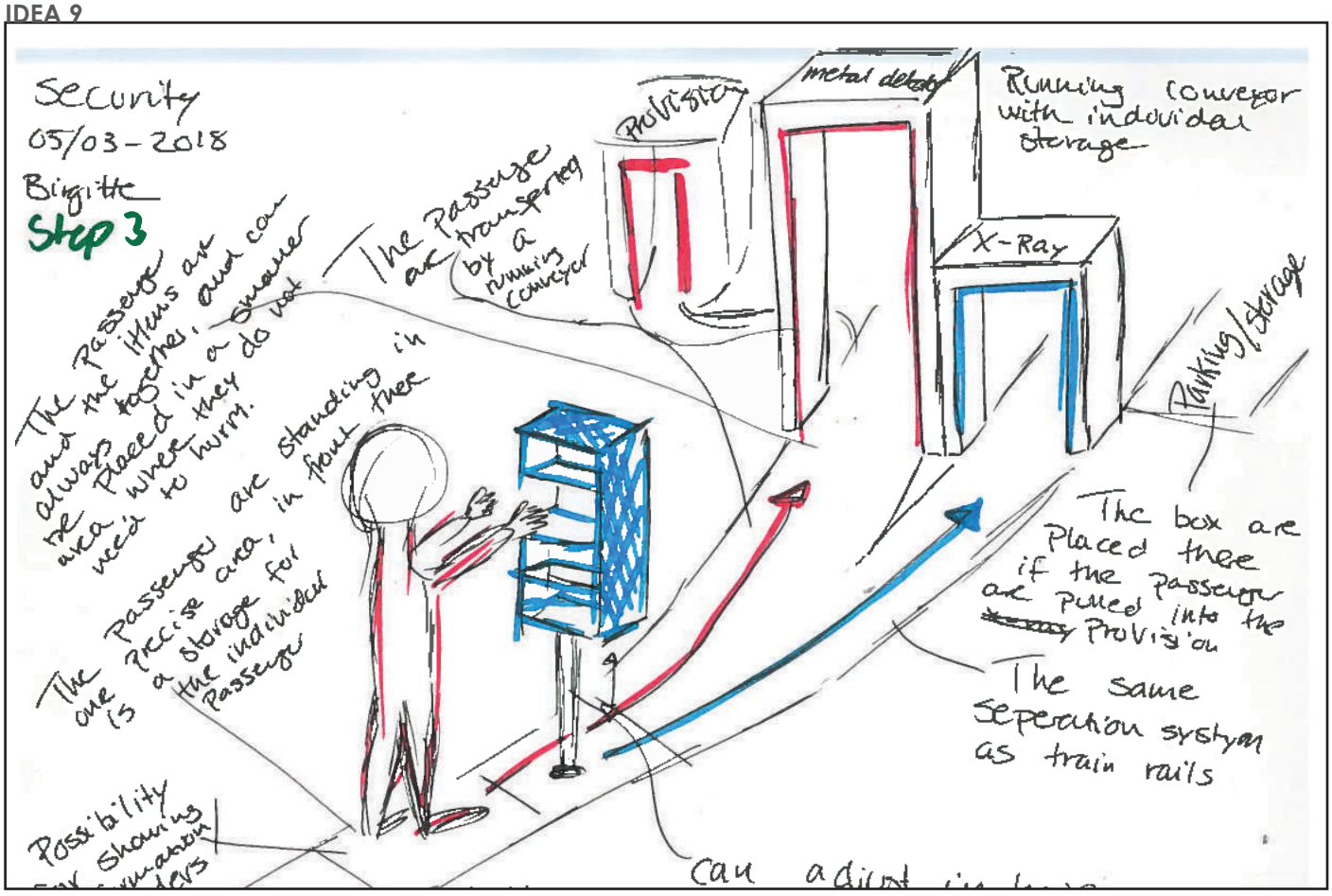
IDEA 7


Boarding pass with implemented roade map (GPS in a car)
to Guides the passenger through the airport.
Vision: Guides Passenger through the flow and shows what to hand-in
Control & informed
Digital Boarding card
MAP
Direction to go
Name
Terminal
Boarding no.
127358
Social status?
Approved
Need Scanning
Apply Scanning
* Why not use the phone?
* How will the security check look?
to Will the passenger only have to go through security if their Social Status are low? → future resear
to So the boarding pass only allows the passenger through if their social status are approved or they have been scanned
to How will the scanning work?
Idea 7
12/03-2018

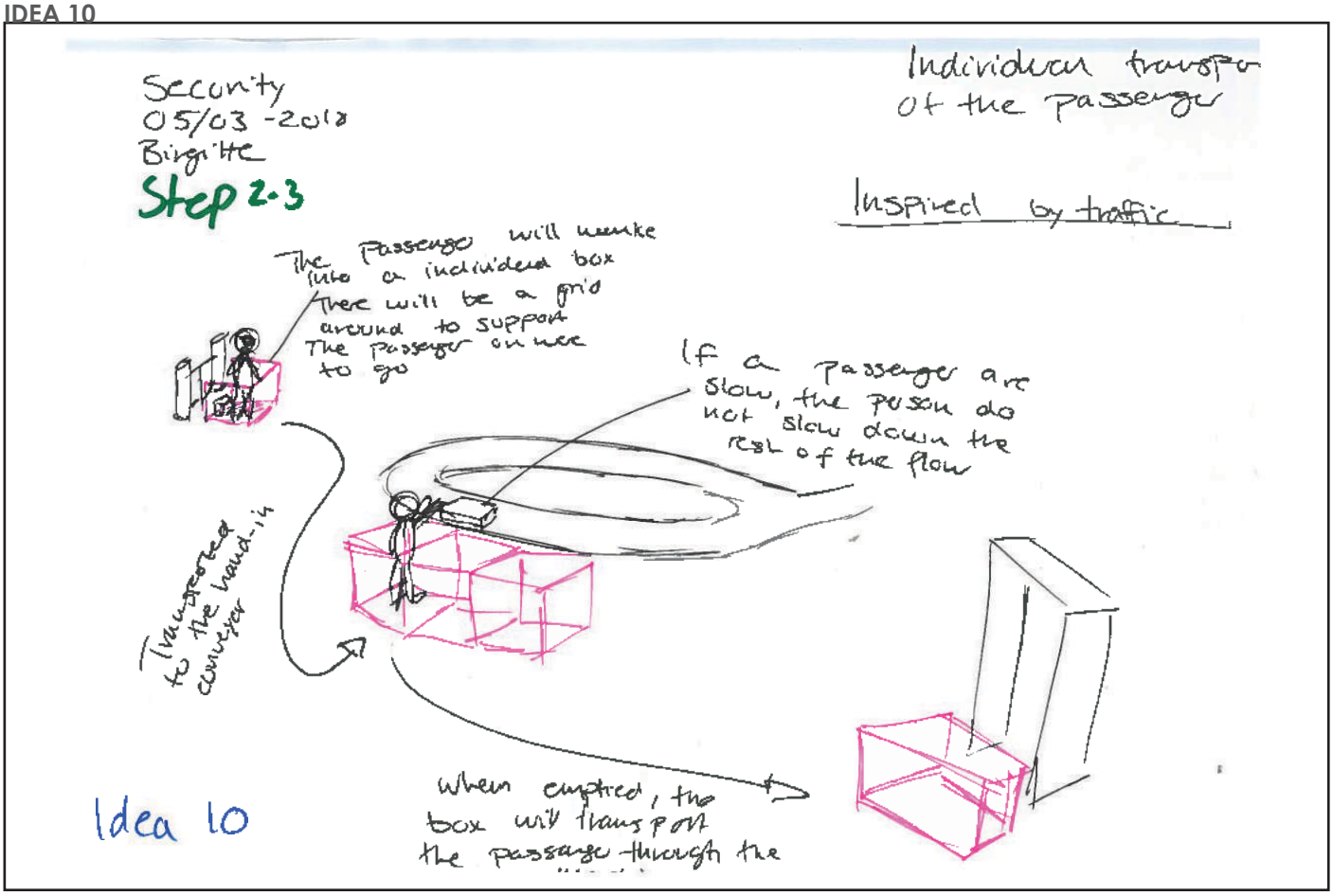
IDEA 8


out of sight, out of mind
luggage is transported directly into the
Do you want the luggage after security or directly on the plane
Plane
security
passengers store their luggage in a box which is either transported to the plane or security
The box is CT/3D scanned if there is anything note worthy the passengers is pulled away
Delivery station inside the airport
The passenger do not have to worry about anything.
Idea 8
The passenger gets scanned on the way out and get a tag saying they have been pre-scanned
12/03-2018

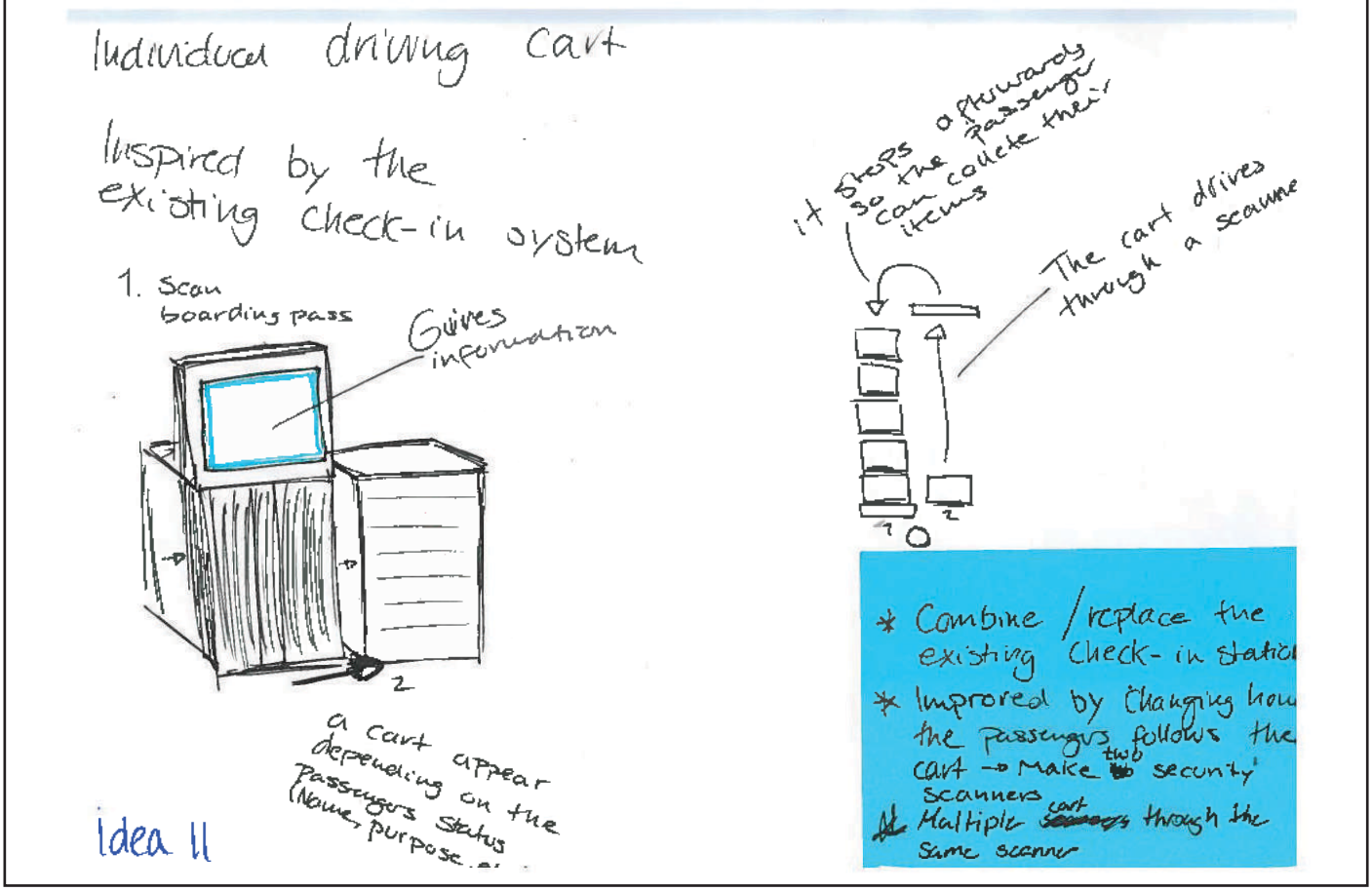
IDEA 9


Security
05/03-2018
Birgitte
Step 3
The passenger and the items are always together, and can be placed in or manner where they do not need to hurry.
The passenger are transported by a running conveyer
Provision
metal detector
Running conveyor with individual storage
X-Ray
Parking/storage
The passenger are standing in one is a storage for the individual passenger
The box are Placed there if the passenger are pulled into the Provision
The same seperation system as train rails
Possibility for showing
can

IDEA 10



IDEA 11

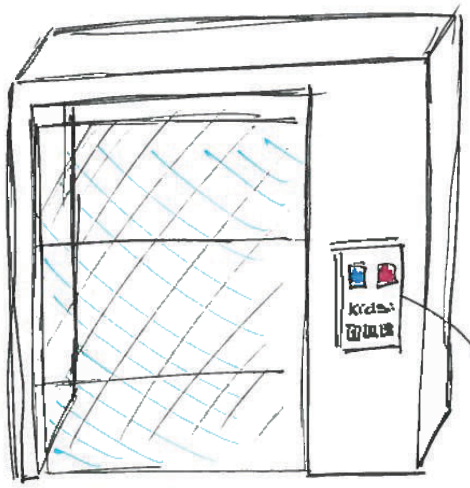


IDEA 12

Individual box

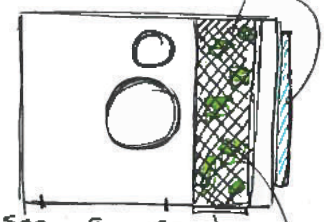
Inspired by an elevator

Creates Privacy and informs what to hand-in



A screen showing what to hand-in and if the items are approved.

All items are placed on one table



Seen from above

It will be Scanned by a camera in the ceiling

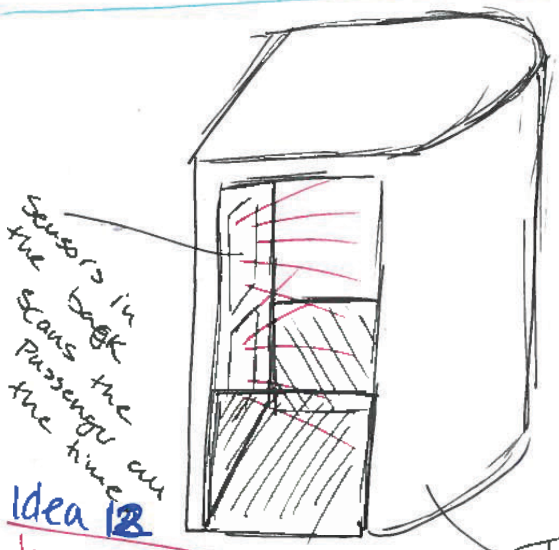
Selecting gender and kids before entering the box or it does it automatically based on your boarding Pass

Idea 12

* How will the passenger feel when placed in a closed box? to like an elevator

Individual box which create a privat room with information screens

Vision: Privatey, informative & relaxed - Multiple People

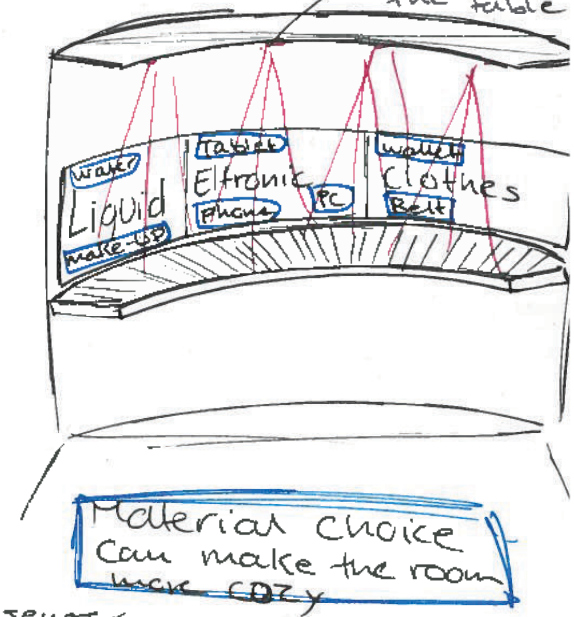


Sensors in the back Scans the Passenger on the time

Idea 12

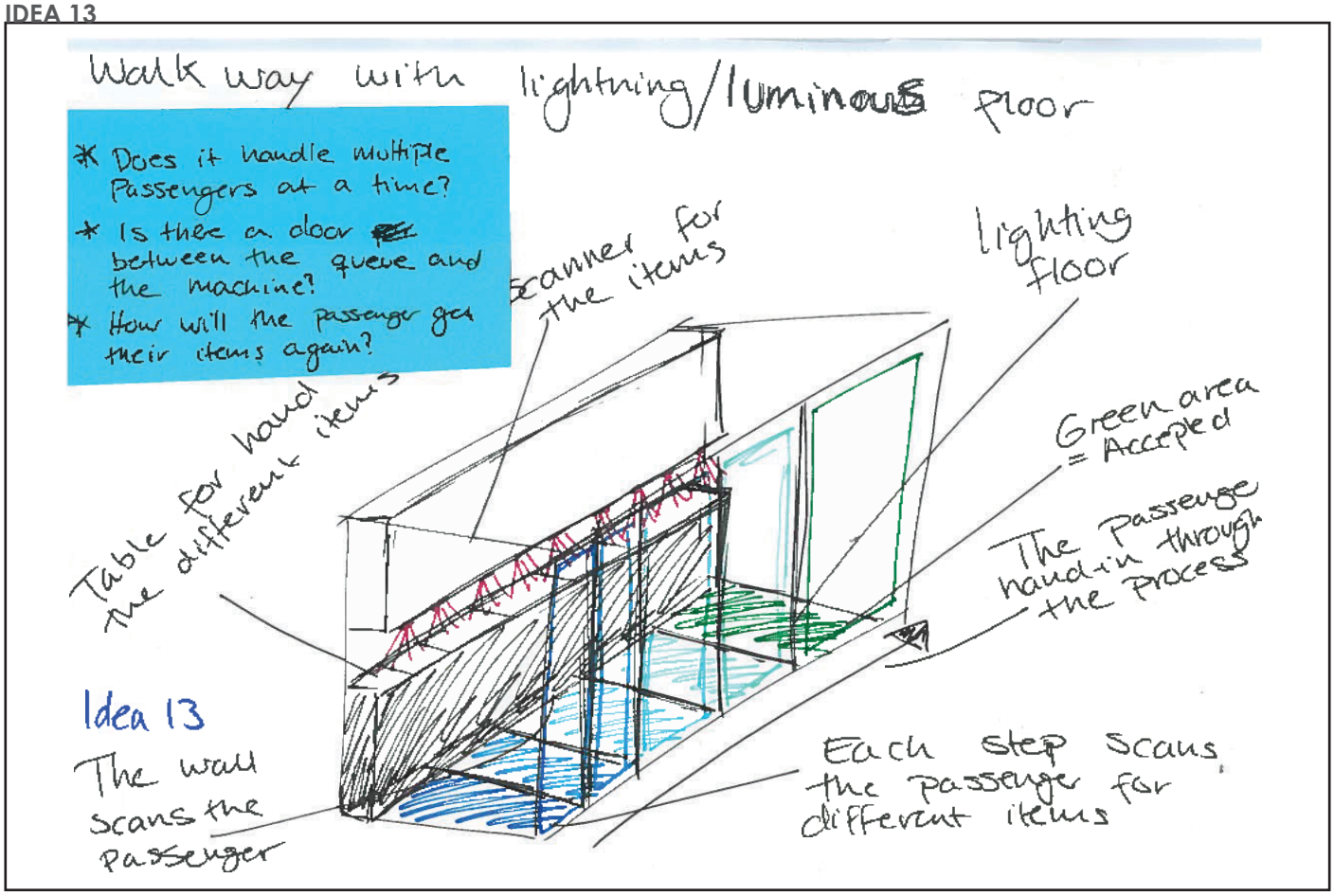
Inspired by a dressing room

Sensors scans items on the table

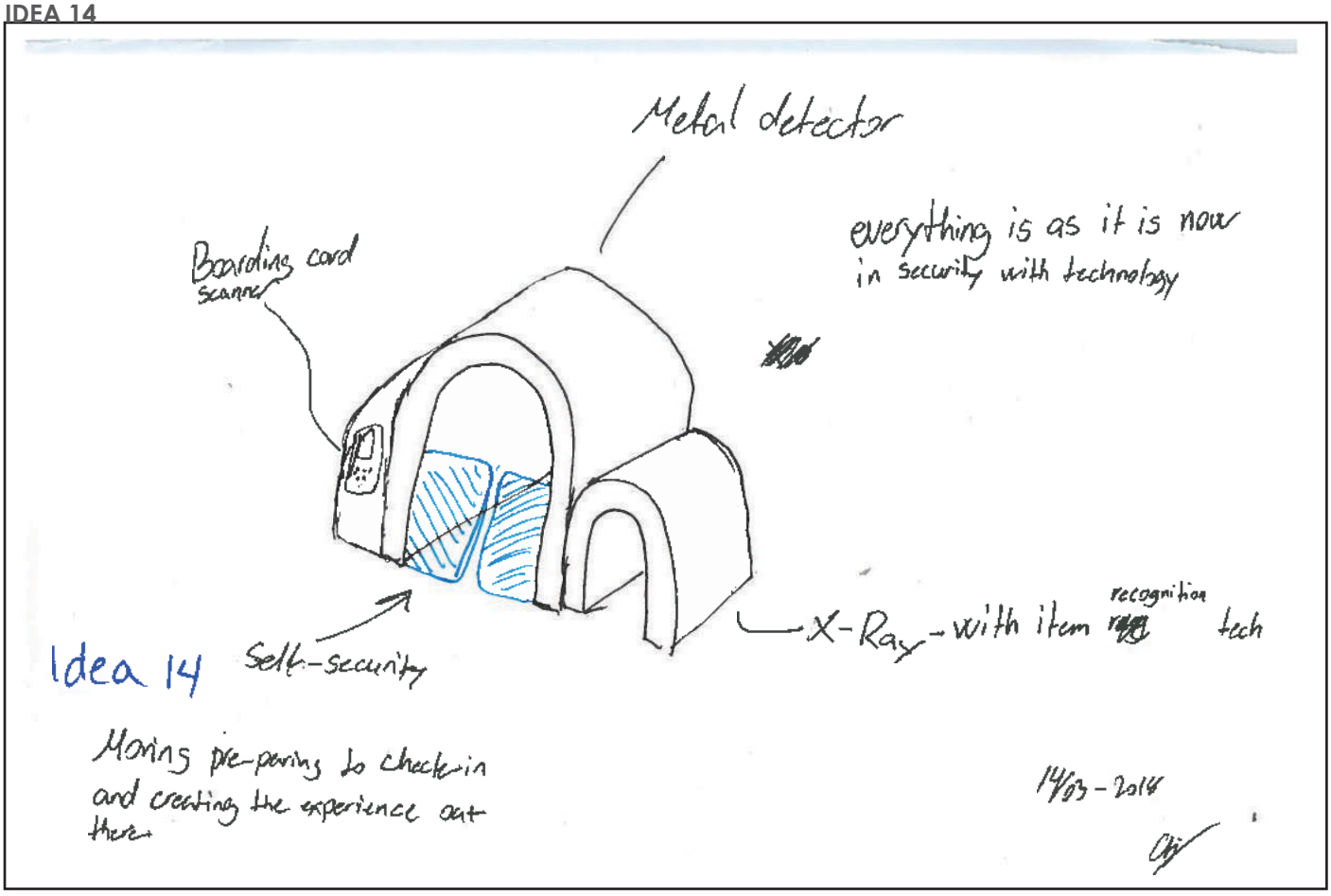


The passenger can stand in the closed area and not getting effected by other passengers

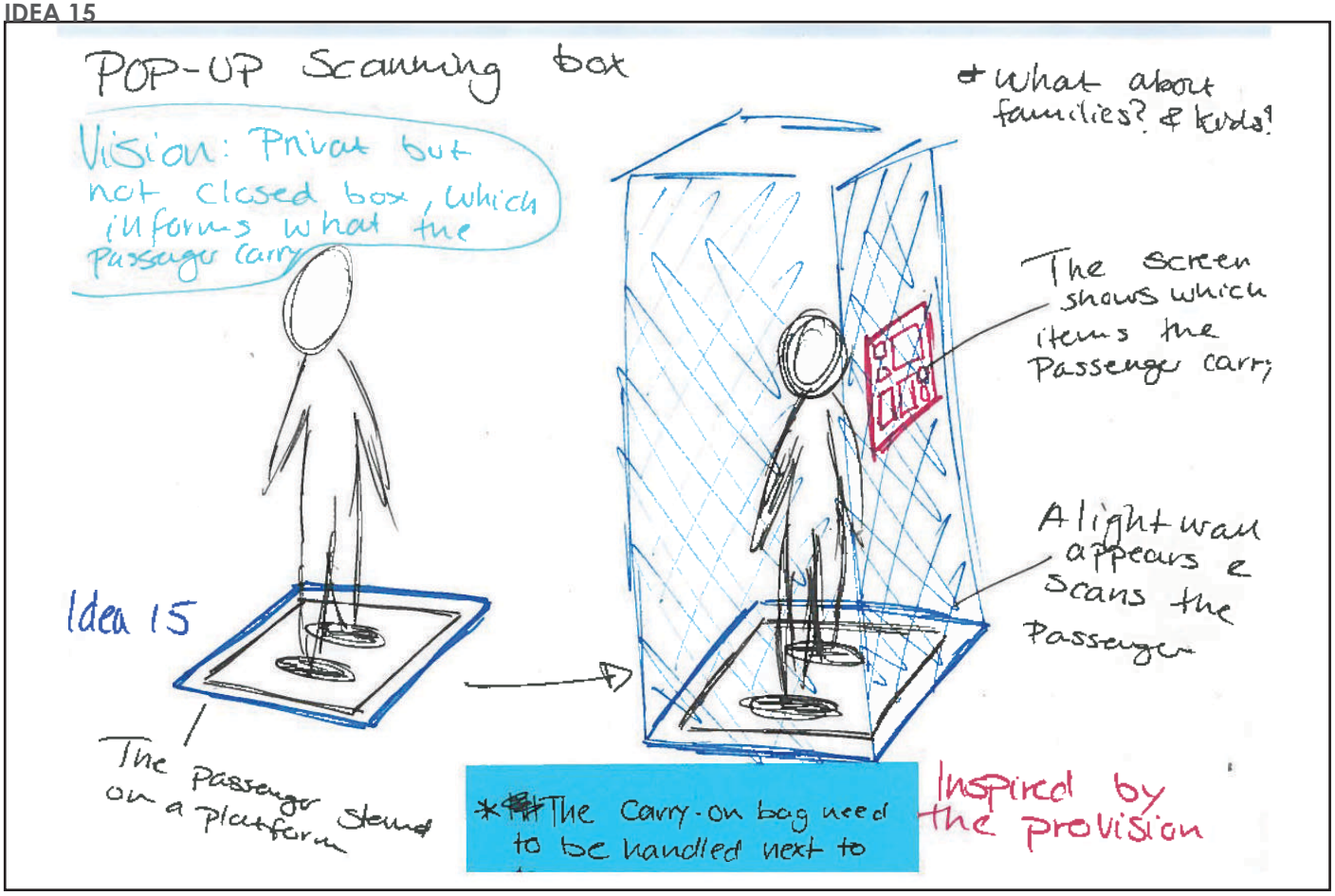
IDEA 13



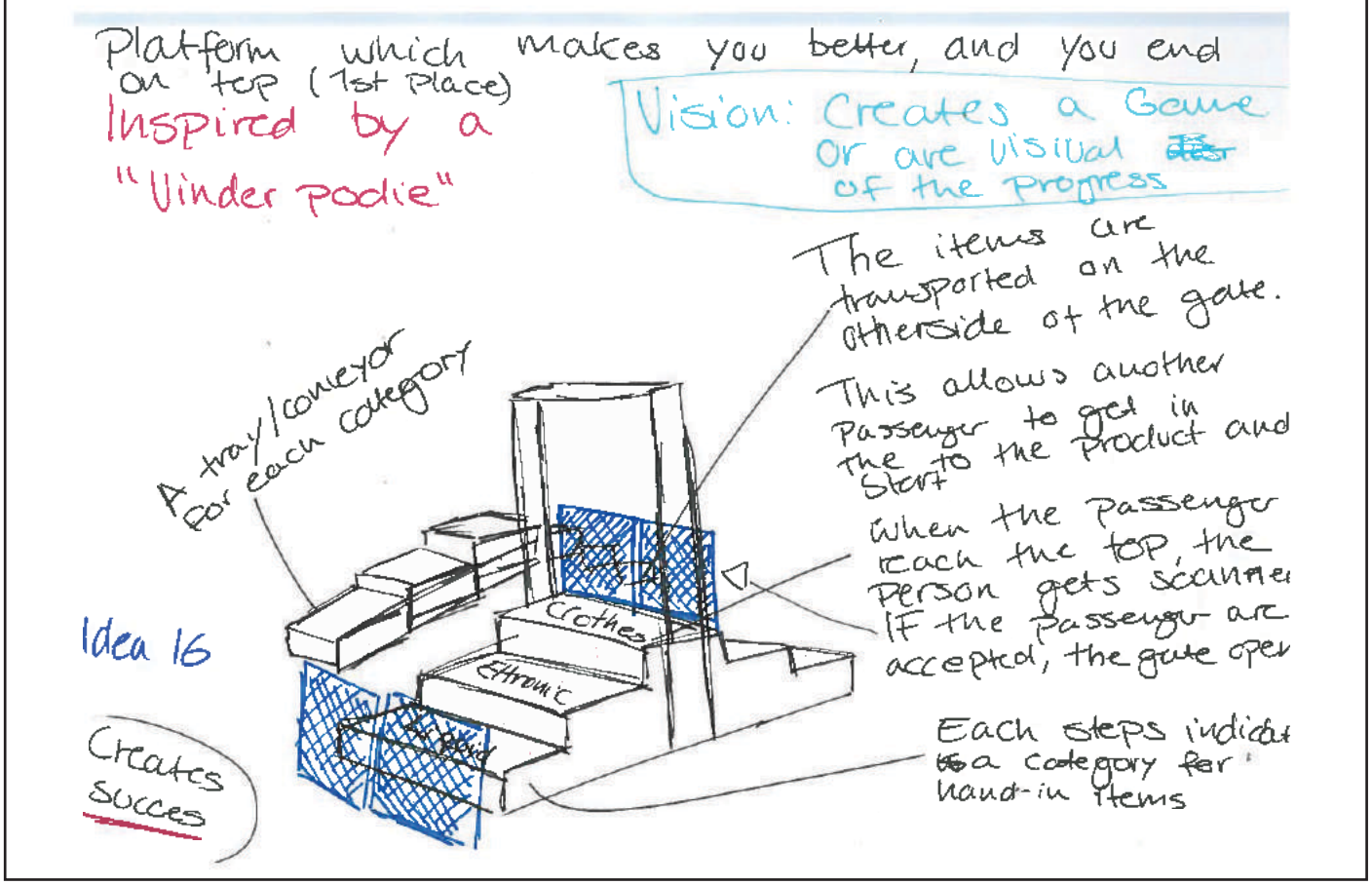
IDEA 14



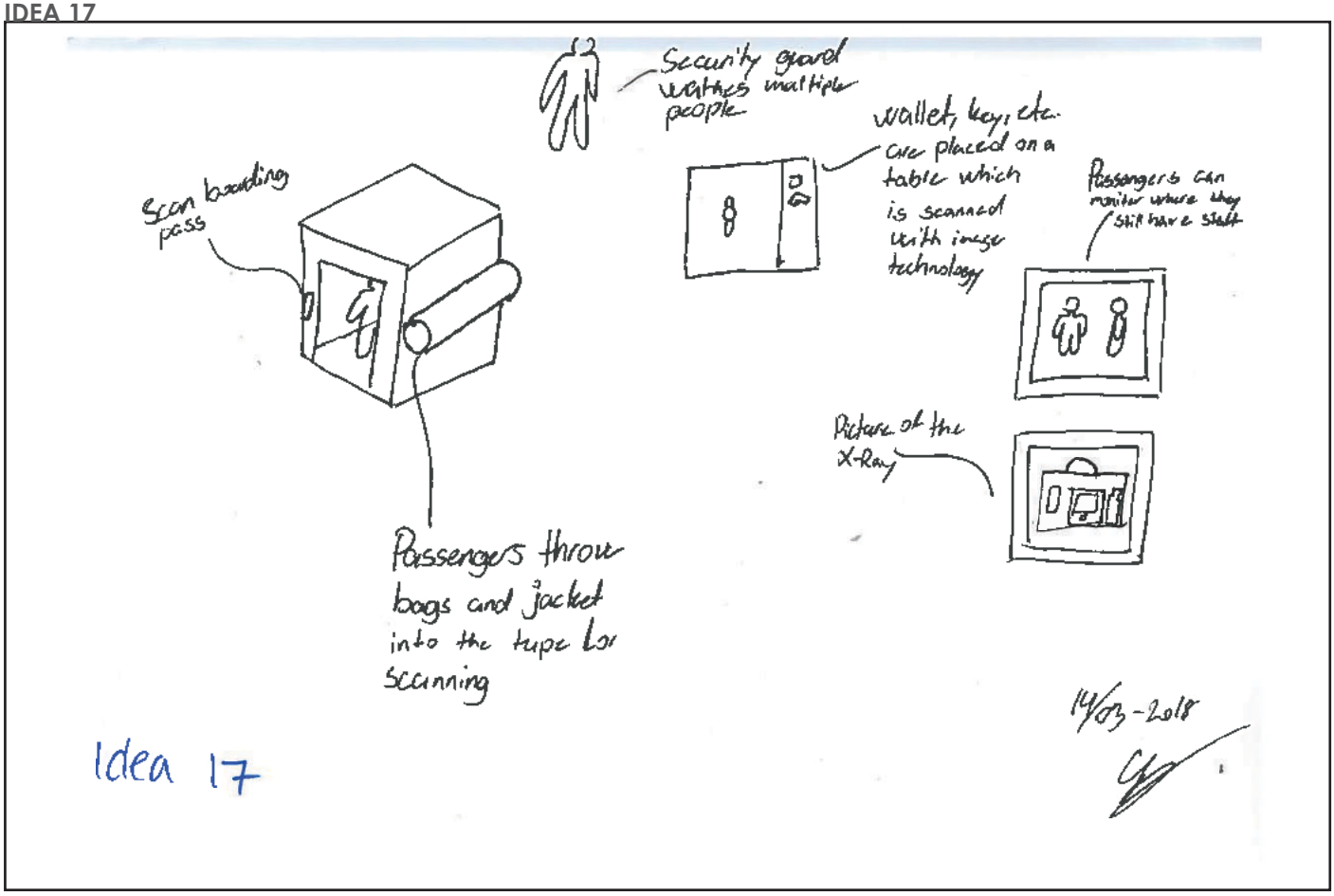
IDEA 15



IDEA 16



IDEA 17


Security guard watches multiple people
wallet, key, etc. are placed on a table which is scanned with image technology
Passengers can monitor where they still have stuff
Scan boarding pass
Picture of the X-Ray
Passengers throw bags and jacket into the tube for scanning
Idea 17
14/03-2018

XI - EVALUATION OF IDEAS

The table below shows the evaluations of the 17 ideas. The evaluation are based on the costumers needs, presented in Appendix XXI - Customer needs. Each criteria is given an importance factor. This importance have been rated together with the security guards at the airport and the costumers statements.

The ideas are rated from 0-2, according to the existing security check:
0: Worse than reference
1: Same as reference
2: Better than reference

Criteria	Importance	Ideas																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	2	2	2	2	2	0	2	2	0	1	1	2	2	1	1	1	1	1
2	5	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1
3	5	2	2	1	2	2	1	1	1	0	2	1	2	2	1	1	1	2
4	5	2	2	2	1	2	2	0	0	2	1	2	2	2	1	0	2	2
5	4	2	2	2	2	1	2	1	1	2	2	1	2	2	1	0	2	2
6	3	1	1	1	2	1	1	2	1	2	1	1	2	2	2	0	2	2
7	5	1	1	2	2	1	1	1	1	1	2	1	2	2	2	0	2	2
8	2	0	2	2	2	2	2	1	1	2	1	2	2	1	1	2	2	2
9	4	2	2	2	2	2	1	1	1	2	1	2	1	2	1	2	1	1
10	4	2	2	2	2	2	0	1	2	0	2	1	2	2	1	1	0	2
11	2	0	0	2	2	2	2	1	1	2	1	2	2	2	2	2	2	2
12	1	0	0	2	1	1	2	1	0	1	1	0	1	1	1	1	1	1
13	4	2	2	2	2	2	0	1	1	0	2	1	2	2	2	1	1	2
14	4	2	2	2	2	1	0	2	1	2	1	0	2	2	2	0	2	2
15	3	2	2	1	2	1	0	2	1	0	1	1	2	0	2	2	0	2
16	4	2	1	1	1	1	1	2	1	1	1	2	1	1	1	1	1	1
17	3	1	1	1	0	2	0	0	1	0	2	1	2	0	0	0	0	2
	Total	94	94	92	87	87	58	68	56	65	85	69	106	94	78	47	75	104
	Ranking	**3**	**3**	**4**	5	5	12	10	13	11	6	9	**1**	**3**	7	14	8	**2**

Table 37.1. Evaluation of ideas

DESCRIPTION OF CRITERION:

1. Uses the boarding pass to check in
2. Allows carry-ons(bag) to be security checked
3. A more pleasant security check
4. Allows for separations of on-body items (i.e. phone, wallet, etc.)
5. Helps the passenger to understanding of procedure
6. Allows for passengers to go through, without security guard accept, if nothing are detected
7. The passengers are not allowed into the airport without an accepted security check
8. Reduce the time spent for transporting hand-in items container back and forth
9. Allows the passengers to handle a big amount of items (three trays and one carry-on bag)
10. Reduce stress for the passenger
11. Easy identification for the passengers own items
12. Informs the passenger to remember all items in the hand-in items container
13. Allows passengers to use the time they need
14. Reduces the numbers of necessary security guards
15. Fastens the passenger flow through security (passengers / hour)
16. Creates a smooth transition between check-in, security and duty free
17. Allows passengers to be responsible for kids, handicapped, passenger with extra needs, to be together in the security check

* Keep price for implementation in mind
** What do the airport gain? Why will the airport invest in the system?
*** What experience do the idea create and who does it involve?

XII - TEST OF THREE CONCEPTS

The following section is a description of the test set-up,feedback and evaluation of the three interaction test from the selected three ideas.

Models and informations screens are made, for making the test of the concepts. The concepts main principle is tested with participants which are in the Create building. The list below describes the tasks which needs to be made before during the test.

Concept Luminous:
Test if the people understand what to hand-in in the different steps
Test the use of icons and words
Test if the people understand they have been approved by the floor lighting up

Concept Indiscan:
The silhouette on the screen shows the passenger where they have items
The silhouette changes according to the items taken off
The screen under the silhouette shows icons+text for the most basic things to hand-in

Concept Cartish:
The passenger hand-in items in a cart
The screen on the cart changes
First shows the general items to hand-in. In the bottom there is a button which the passenger pushes when they have handed in all items
The screen changes and shows a map and the name of the security station the passenger must walk to
The passenger walks to the scanner, how will the passenger use it?

CONCEPT LUMINOUS	
Participant 1	• It was easy to understand the light on the floor • A conveyor could transport the items to the end • A combination of icons and text is the best
Participant 2	• The table could be a conveyor which follows the passenger • The passenger emptied his pockets at the first step, and did not hand-in items at the other steps
Participant 3	• The participant understood what to do • Thinks it is cool and nice to get feedback from the floor • It is fast to read the icons • In a international airport everyone understand the icons, and do not need to know the language to understand what to hand-in

Participant 4	• How do the system respond to a knife? • The participant would like if the items were handed into a tray which follows you while you walk • It is nice to have a combination of text and icons • How much should there be on the screen to still keep it understandable? Maybe the different screen could get headline some fx electronic, organic, metal, etc. • Make it clear that it is allowed to hand-in an entire bag/carry-in, so the passenger do not start to empty the bag
Participant 5	• The first screen could be named electronic • It is easy to understand a combination of icons and text • The focus are on that you need to hand-in the items, and color and light on the floor are not really something the passenger looks at
Participant 6	• The passenger hand-in all items at the first step, which results in the passenger do not hand-in other items at the next steps • The combination of text and icons was definitely the best • The passenger noticed the colors, but it was first when the reached the green color at the end, that he understood that the colors shows the progression • It could have been better if the colors were changes, so the you start at with a dark color and go to a bright green color

Illustration 39.1

Illustration 39.2

Illustration 39.3

EVALUATION OF THE TEST OF CONCEPT LUMINOUS

- Not all participants did it in the steps which were shown, they knew what to do, so they just handed all their stuff in a once
- The participants imagined their luggage/items follow them to the end by the use of a conveyor or trays
- There is a need for information/reminder of taking the current items off
- The participants did not really get the appearance of light - this might be a source of error for the test setup
- Most participants through the screen containing icons and text where easiest to understand
- Maybe the concept could inform the passenger about which areas to empty (fx pockets, jacket, etc.) instead of informing about the precise products

CONCEPT INDISCAN	
Participant 1	• Is the system safe enough? It is possible to trick the system? • It is easy to understand
Participant 2	• Easy to understand
Participant 3	• The passenger easily understand for empty the pockets • He do not use the icons • When the pushed the "help-button", he thought a menu would appear, which would explain what to do
Participant 4	• Thought the "help-button" opened a menu • There needs to be a screen which shows when you have been approved • The icons are not used, it was more the areas shown on the screen which were used • It is easy to understand - the person are used to do it in the airport today • There needs to be a screen showing what to do afterwards
Participant 5	• The icons are not really used, it was enough with the silhouette and the shown areas • It is easy to see where there is items which needs to be removed
Participant 6	• It is understandable and fairly easy to understand • He did not use the icons, but he thinks they can be helpful if you doubt about what to hand-in • You stand still and only focus on hand-in the items, you are not thinking about where to go afterwards

Illustration 40.1

Illustration 40.2

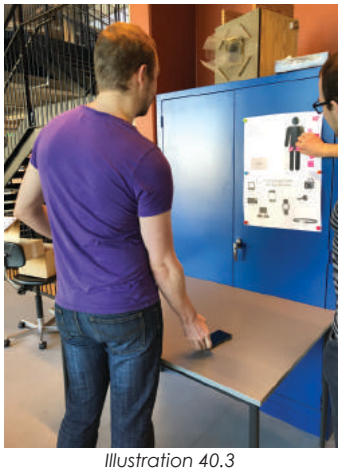


Illustration 40.3

Illustration 40.4

EVALUATION OF CONCEPT INDISCAN

- The participants generally understood how to read the silhouette
- There is a need for a feedback to tell the passenger that they have been accepted, and are allowed to collect their items again
- In general the participants through that the help-button would open up a menu for further information, and not call a security guard
- Non of the participants used the icons under the silhouette
- One participant mentioned that he could focus on just hand-in the items and not move forward
- Source of error because the participants had just handed their stuff in at the previous concept, so they were aware of the items they carried

CONCEPT CARTISH	
Participant 1	• It is easy to understand how to use the cart • The cart needs to come after check-in
Participant 2	• -
Participant 3	• The person does it in the sequence from left to right • First scans the boarding pass and afterwards goes through the scanner, before the cart have been handed in • Do people dare to hand-in their wallet or phone in the cart?
Participant 4	• It is confusing - in some airports today you scan your boarding pass as one of the last steps, why should you then do it as one of the first steps now? • The person first place the cart in the box, afterwards scans the person and at the end the boarding pass are scanned • Show the precise way to do it • It is easy to understand how to hand-in items in the cart • Children can stick to the cart as they do to shopping carts in supermarkets
Participant 5	• The person was unsure if it matters where to place the items • He forgot his cart when walking to the scanning station • The person first scanned the boarding pass • The person though that it was possible to walk in the scanner together with the cart, so it is scanned at the same time • He follows the steps from left to right - first scanning of boarding pass, then placing the cart in the middle - this makes the most sense for him • Maybe the use of a conveyor to transport the cart could be a possibility
Participant 6	• He did not take the cart with him, because he thought a guard would take care of it - like they hand-in the trays today and another takes care of the transport of the trays • You need to take care of your cart at all time • The solution might be useful for passengers which are in a hurry, and thereby can go faster through and pass by other passengers

Illustration 41.1

Illustration 41.2

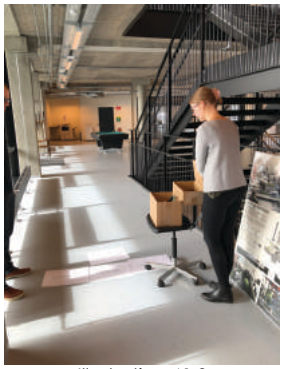


Illustration 41.3

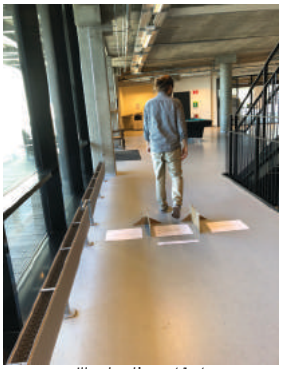


Illustration 41.4

- **EVALUATION ON CONCEPT CARTISH**
- All the participants understood how handed-in their items and pushed the button on the screen
- Some of the participants were positive about the map and the instruction on where to go
- All of the participants had a hard time understanding how to interact with the scanning station - source of error: The station were only presented with paper on the floor, which resulted in the participants having a hard time imagining how the system looked and where to interact - there were not physical walls
- Some of the participants forgot to bring the cart to the scanning station, and just left it at the place where they stood while emptying their pockets
- Most participants had a hard time knowing in which order to go through the steps - they scanned the boarding pass and afterwards did not know what to do with themself and the cart
- What do the passenger when they have forgotten something and are in the scanner?

REFLECTION OF THE TEST

- The three concepts were not presented in the same way
- Concept Luminous and Indiscan focused more on the participants understood the information on the screen and if they knew what to hand-in
- Concept Cartish focused on how to read the screen on the cart, hand-in the items, and transport the cart to the scanning station where they need to understand what to do with the boarding pass, the cart, and them as a passenger.
- This resulted in concept Cartish been the entire experience, while the other two concepts mostly focused on the presentation of the information.
- Maybe the concept could inform the passenger about which areas to empty (fx pockets, jacket, etc.) instead of informing about the precise products
- The participants were not the real target group. The target group might have other problems/ trouble than the participants we tested. (But when this concept (in some years) hits the market they will probably be our target group)

- All concept needs to be further developed according to the procedure if there is a false positive.
- We still do not know if it is possible to scan multiple passengers at the time. And is it possible to scan the passengers without having to instruct them in how they should stand?

XIII- MOOD BOARD FOR AESTHETIC AND FUNCTIONS




Combination of colored light and white materials





Illustration 43.1




The combination of materials and shapes to create depths

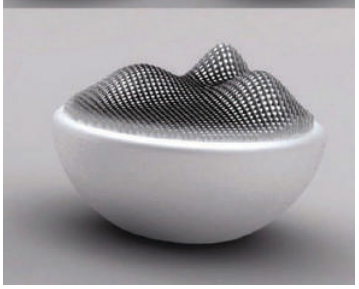
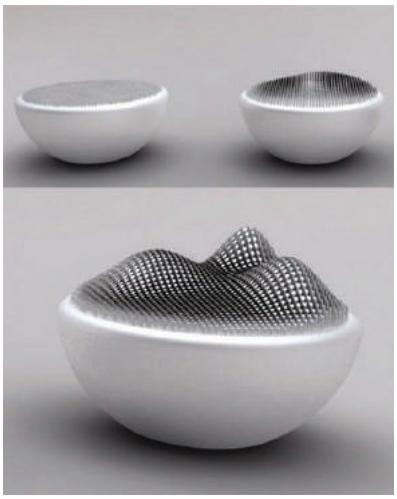
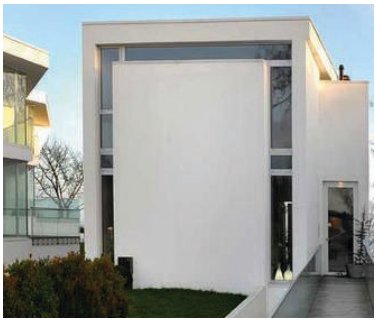




Illustration 43.2





Minimalistic shapes and material combination

Illustration 44.1

The expression change from one to another, depending on if the product is on or off

Illustration 44.2

The general shape - organic & round shapes

Illustration 44.3

XIV - FRAMING OF THE TWO CONCEPTS

The purpose is to get a common understanding of the two concepts and what they are trying to accomplish. Framing the two different concepts: Luminous & Cartish. The concepts will be framed by using the Product Reasoning Model (Haase and Laursen, 2017).

CONCEPT LUMINOUS

Key features in bullets:

- Privacy
- Using the time you need
- Show progression
- Gives indications of what to hand in
- Families do the security together
- The product learn the passengers how to do the security check

	Insight	Aspired value	Frame metaphor / Oneliner	Working principle
Main paradox	Families are stressed through the security check, because there are many things they have to handle: - Their children - Separating hand-in items - Taking off on-body items	Give families the time and space they need to ensure that they feel less pressured through the security check		CT-scanner: Removing the need to separate hand-in items by implementing CT-scanning.
Experience	There is a lot of different things happening around the family and there is pressure from the other passengers. The kids are often unpredictable.	Creating a calm and quiet atmosphere	Like a caravan	Isolate the family in an enclosed area to create calmness and control the kids.
Interaction	The passengers often forget to hand-in on-body items, because they are stressed and distracted.	Creating clarity about which items to hand in.	Like getting ready for the shower	Use a silhouette to create clarity about which body part they need to focus on when handing-in on-body items. Use icons to show precise examples of what to hand in.
Expression	Children do not like small and enclosed room like an elevator	Create an open and welcoming room which do not frighten the children.		Use semi transparent materials and light colors. Lessen the enclosed feeling by opening the "ceiling "

CONCEPT CARTISH

Key features in bullets:

- Prepare for the security check
- Creates clarity of what to hand in
- Guides the passenger the right way
- The family helps each other during all processes - including the kids
- The family and the cart follows each other
- The family have control over the security check for the entire family

	Insight	Aspired value	Frame metaphor / Oneliner	Working principle
Main paradox	Families are stressed through the security check, because there are many things they have to handle: - Their children - Separating hand-in items - Taking off on-body items	Give families the time and space they need to ensure that they feel prepared before entering the security check.		Provide the passengers with a cart which allows them to prepare before entering the security CT-scanner: Removing the need to separate hand-in items by implementing CT-scanning.
Experience - Parents	Families see the airport as a part of the traveling experience, but there is not thought about the experience as a part of the travel in security. There is a lot of different things happening around the family and there is pressure from the other passengers.	Give all family members a possibility to help and do the security check and preparation together. Make the kids be entertained, to ensure they stay around the parents.		Give the parents information about what to hand in.
Experience - Kids	The kids are often unpredictable when they are bored. When they are bored they try to do something entertaining	Give the kids a feeling of being a part of the security check by helping Make the kids get a sense of accomplishment	Helping set the table and get a compliment from the parent	The kids are occupied interaction with the cart - this could be by helping the parents or playing a game.
Interaction	The passengers often forget to hand-in on-body items, because they are stressed and distracted	Create clarity for the parents for what to do and help them prepare.	Like a GPS in a car	Give information and indication of what to hand-in using a screen on the cart
Expression	Passengers check in their mind with their luggage and have a hard time interpreting what to do in the different steps	It is aspired to create a cart which is both welcoming for the parent and the kids. There needs to be clear indications on how/where to interact.		Using lights and colors to indicate the interaction points

XV- PRESENTATION OF CONCEPTS FOR THE FAMILIES

The development of concept Luminous and Cartish have been presented for the families at the airport. The presentation will be on a A1 Poster, and contain user scenarios, a big render, and a small text for both concepts. The purpose is to get feedback on the concepts from the users and get their point of view.

Comments from the families:

1. Mor, far, 2 børn 2 og 4 år: De synes det lød spændende. Og at det kan fjerne panikken. Han kunne se fordele og ulemper ved begge koncepter. Holder mest med cartish, .
2. Mor, far og søn på 2år: lumninous er meget stor og implementerer og kan sikkert skabe meget kø i højsæsonen. Men det er rart at man kan stå uforstyrret og det er en læringsproces hvordan man kommer igennem. Cartish er smart fordi man kan forberede sig før og tage sig tid. De kan bedst lide Cartish.
3. Mor med 3 børn, i alderen 2-6 år. Hun er til luminous fordi man kan være derinde som familie og er samlet.
4. Mor, far, 2 børn i alderen 4 år og 6 år. Cartish var trøls fordi man skal slæbe rundt på noget. De havde intet med dem nu, og synes det ville være trøls at skulle slæbe rundt på en vogn. De synes luminous var smart, fordi man kun skal gøre noget inde i system og ikke andet.
5. Mor, far og datter på 1 år: De havde 3 stykker håndbagage med. Cartish kan være begrænset i den størrelse til at håndtere alt ens ting. Luminous er mere fleksibel. De hælder mest til luminous fordi den mest fleksible.
6. Mor, far, 3 børn i alderen, 2,4,6 år. De havde 5 styk håndbagage med. Luminous vil være dyre og svære at implementerer, men den er mere fleksibel fordi den kan håndtere alle ens genstande og tasker. De er meget i tvivl om man vil indlevere sine ting åbne i en vogn, ved at ligge værdigenstandene i vognen. Der er ikke plads til alle tingene, og hvad vil der ske når man har en klapvogn ved siden af? De foretrækker luminous.
7. Mor, far, 2 børn i alderen 1-3 år. Luminous kan være svær at finde ud af, og folk kan komme til at bruge meget tid på at finde ud af hvad de skal gøre. Cartish er nemmere for folk at forstå. De foretrækker cartish
8. Mor, far, barn på 2 år. De foretrak cartish fordi de havde noget at bære deres ting i. De ved ikke helt om de vil kunne forstå hvad man skal gøre i luminous fordi den er mere kompliceret.

Table 47.1 shows the pros and cons which the families pointed out for both concept Luminous and concept Cartish.

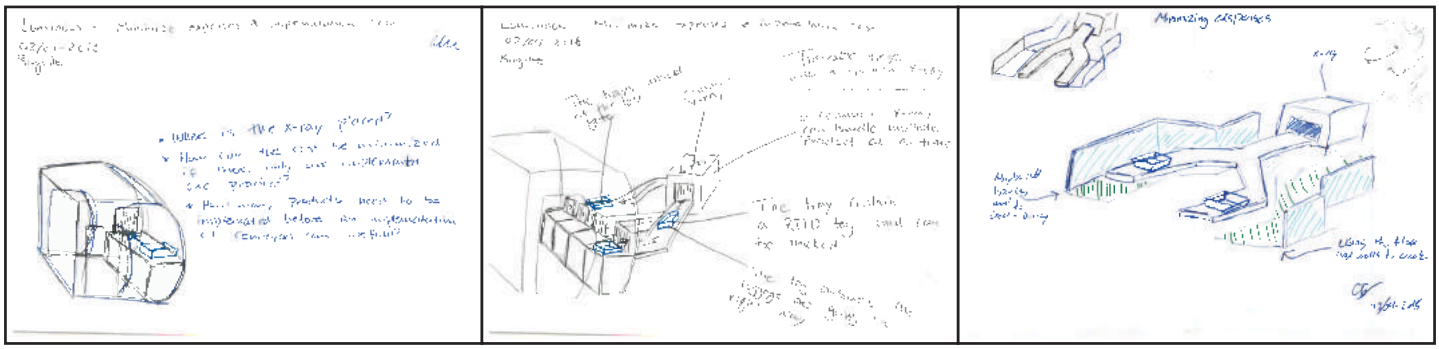
	Pros	Cons	Favorite choice
Concept Luminous	• Rart at man kan stå uforstyrret • Man lærer hvordan man kommer igennem ved brug af produktet • Man kan være samlet som en familie • Man skal kun gøre noget når man står inde i systemet • Fleksibel og kan håndterer større mængder bagage	• Ser dyr ud at implementere • Kan sikkert skabe meget kø i højsæsonen • Kan være svær at forstå og finde ud af hvad man skal gøre - Kompleks at finde ud af	4
Conceot Cartish	• Virker nemmere at implementere • Man kan forberede sig før • Tage sig den tid man har brug for • Nemmere for folk at forstå • Kan bære rundt på en samlet vogn med alle ens genstande i	• Man skal slæbe rundt på vognen, selvom man har få genstande med • Størrelsen begrænser hvor meget der er plads til • I tvivl om passagerne vil indlevere værdigenstandene • Hvordan kan produktet bruges sammen med en klapvogn?	4

Table 47.1 - Presenting the pros and cons which the families highlighted

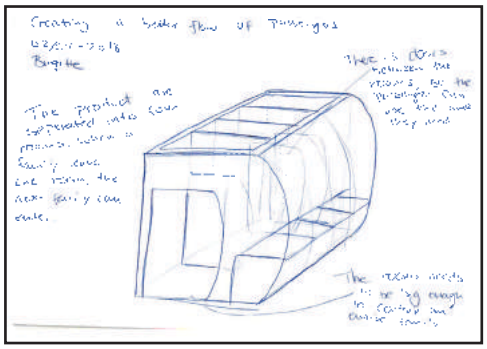
XVI - IDEATION ON CONS

CONCEPT LUMINOUS

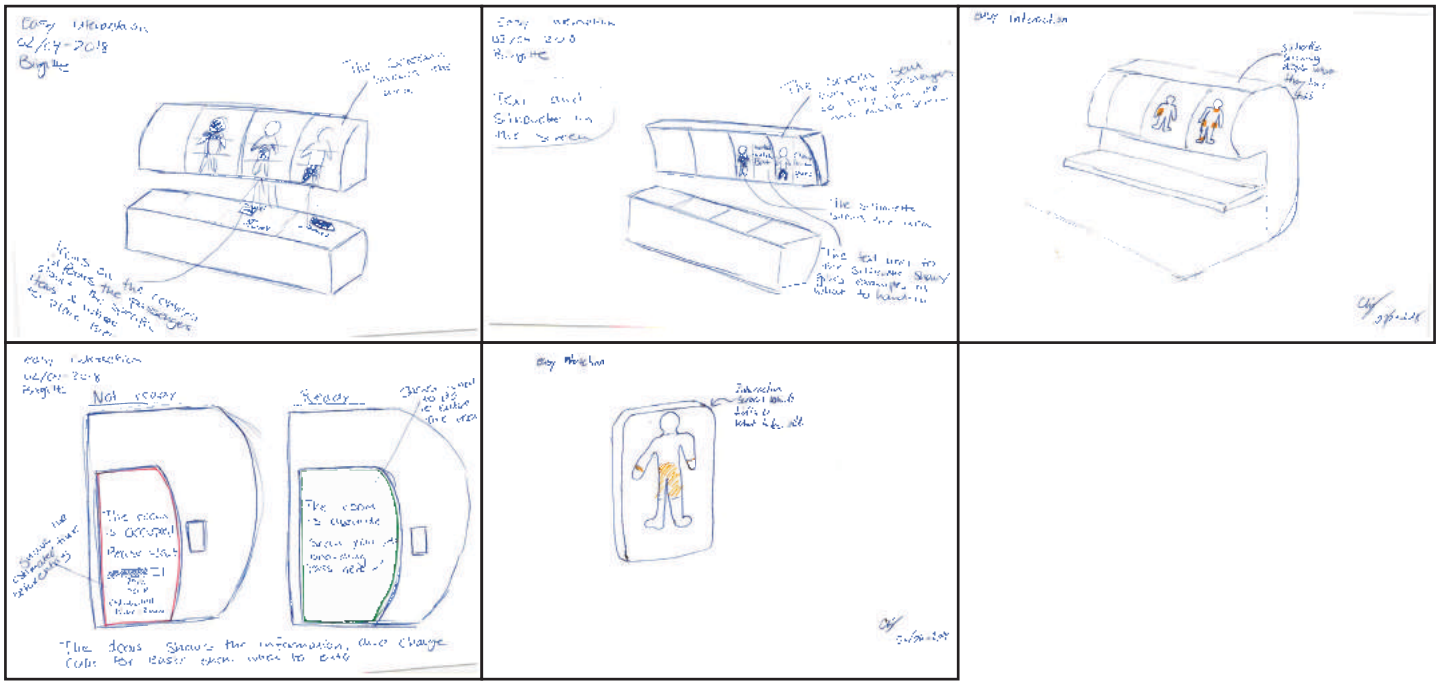
Minimize expenses



Creating a better flow of passengers

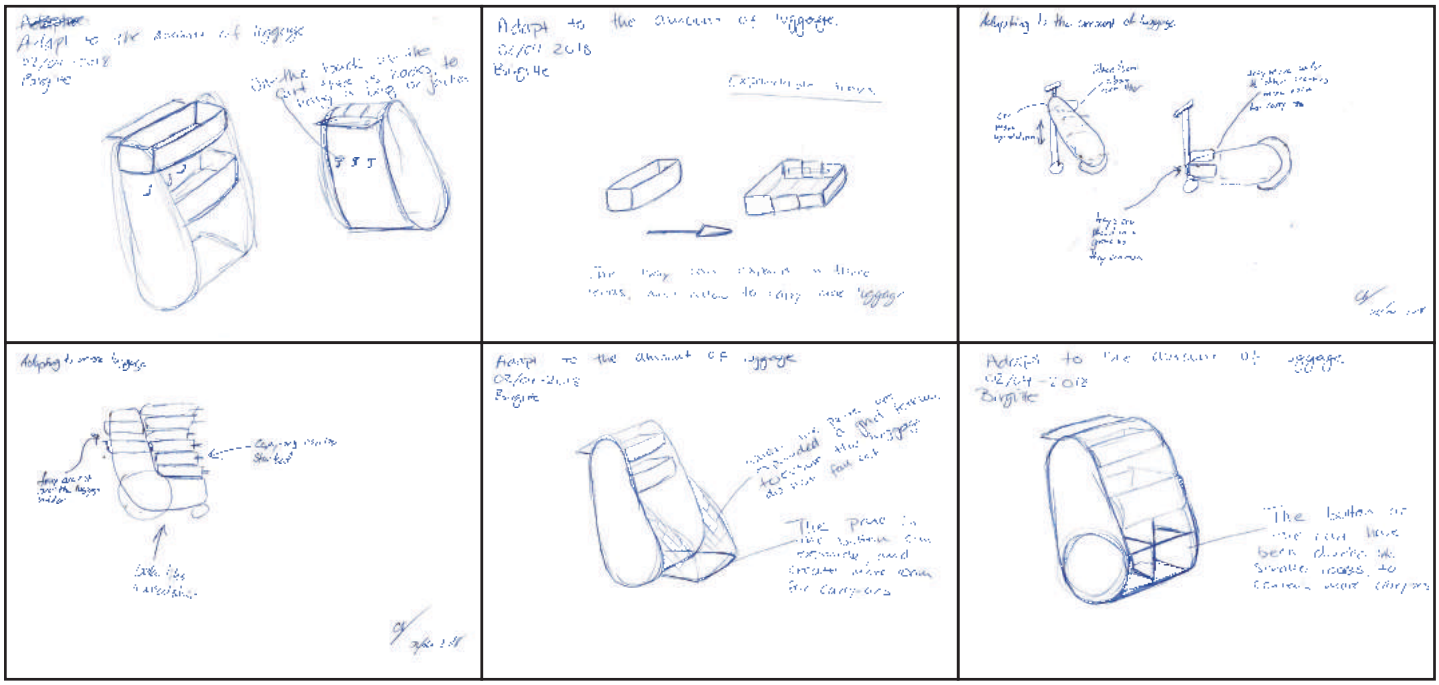


Easy interaction

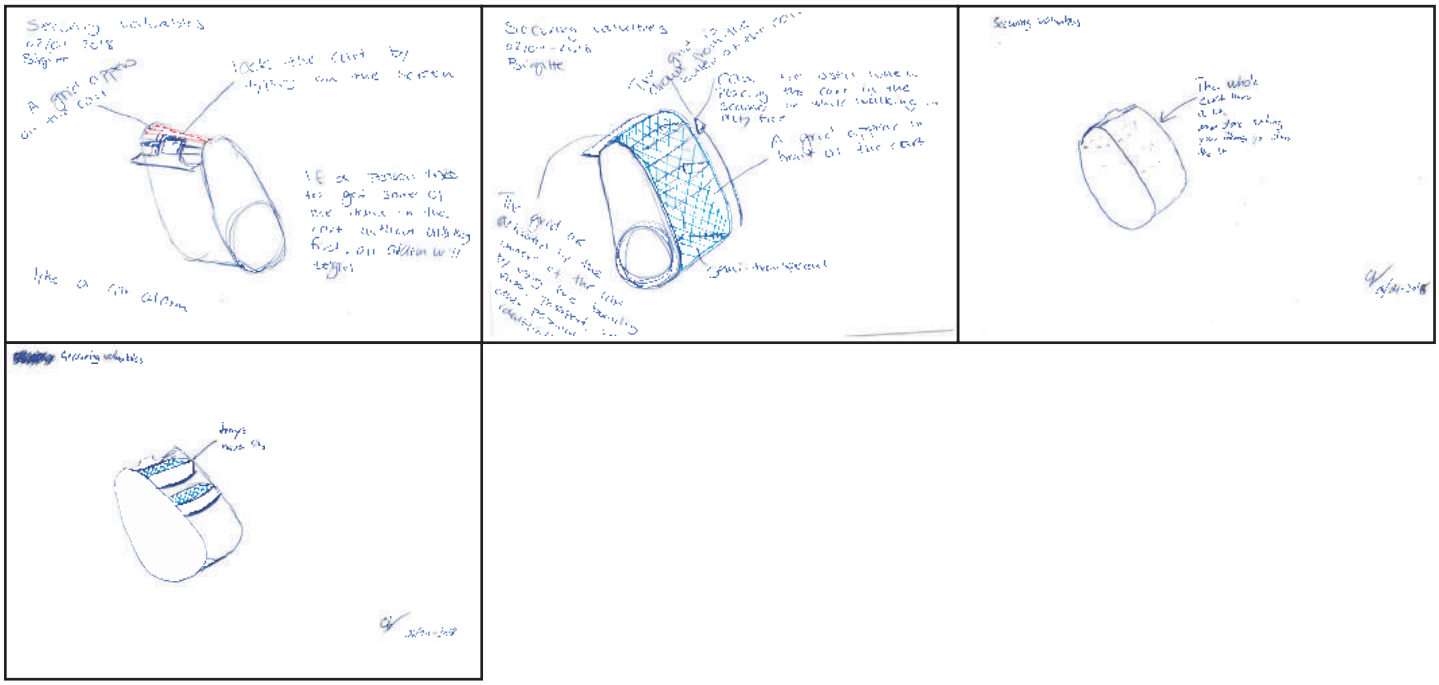


CONCEPT CARTISH

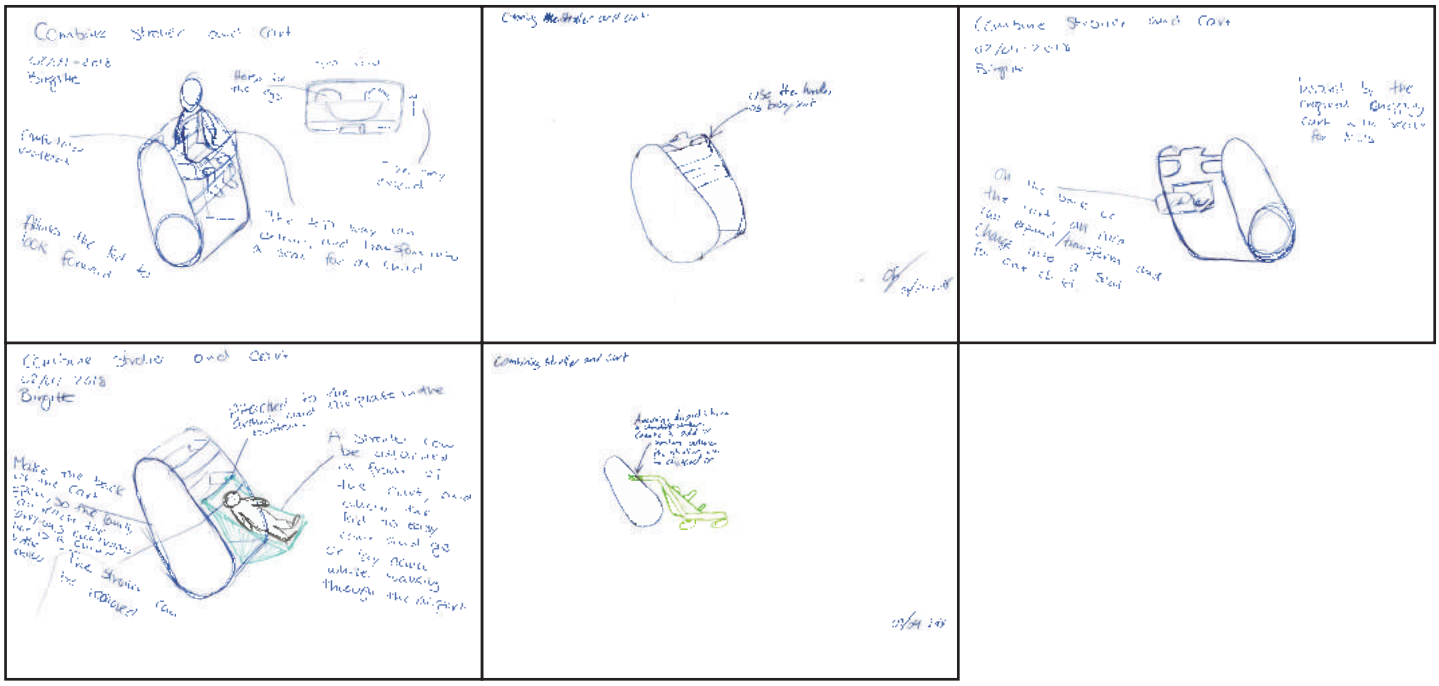
Adapt to the amount of luggage



Securing valuables



Combine stroller and cart



XVII - EVALUATION OF CONCEPTS

The two concepts will be rated based on the same parameters. The parameters are based on statements, research, needs, and demands, which have been found during the process.
The parameters are rated from 1-5 according to its importance. 1 is least important, while 5 most important.
Each concept are rated from 0-10. 0: worse than reference. 5: same as reference. 10: better than reference.

Parameters	Importance		Concept Luminous		Concept Cartish	
	Rate	Description	Answer	Rate	Answer	Rate
In which context is it used?	-	The context in the airport i.e. Check-in, security, duty free	The security check	-	The check-in and security. Possibility for use in duty free.	-
Which tasks in the security flow does it relieve?	-	The tasks are based on the description on page 16.	It relieve the tasks for scanning the boarding pass(step 1), hand in the items (step 3 & 4). The collection of scanned items(step 7) are eased because the passenger are not feeling pressured by other passengers. The passenger still needs to stand in the queue (step 2) before entering the security.	-	It relieve the tasks scanning the boarding pass (step 1). The passenger can prepare their hand-in items (step 3), before going into the security check, which will minimize the queue(-step 2). The passenger only need to hand-in one cart, and not multiple trays (step 4). The collection of scanned items(-step 7) are eased because the they only need to collect one cart.	-
Who can use the product?	-	A description of which family members can be involved and help using the product. If the product were expanded to multiple segments, which segments can then be a potential user of the product?	The parents are the main user of the product, because conveyor and screen are placed in a certain height, which makes is difficult for the kids to help. The kids might be using the products as an experience, as the floor lights up as they progress. The high tech interface sets a limit for passengers with a less technical abilities. The user segment can increase to handle young and business passengers.	-	The placement of draws allows the kids to be an active part of handing in items. The handle on the side of the cart, allows the kids to grab while transporting the cart. The parents are the main user for transporting the cart. The cart can be used for segment as elderly and young, because they all see the airport as a part of the travel experience. The elderly might find it helpful to have a cart for transporting their items.	-
Does it create an experience for the family?	-		The family are together in the hand-in process and they progress in the steps together. The closed scanner creates privacy for the family, and let them use the time they need.	-	The concept makes it possible family prepare for the security before entering the security area, and thereby creating a more calm hand-in process. The family members are together in the hand-in process and progress together to the security area.	-
How does it inform the passenger about the procedure?	-	The importance have not been rated because ít is a need which needs to be fulfilled. The concepts solves it in different ways.	It informs the passenger about the procedure by utilizing screens to show which areas on the body to focus on. The lightening floor gives indication to the passenger about when they are allows to continue.	-	The screen gives information to the passenger. The screen changes when the passenger interact with it.	-
Is it possible to reduce the number of security guard?	3	Compared to if the airport were going to implement a new lane. The rating 3 is given because of it is not necessary for the concept but would increase the value (business)	No need for a security guard informing the passenger about what to hand in. The rating 7 is given because it have a high tech interface. It is not a need for security guards because of the security level, but because the passengers can have a hard time understanding the procedure. One guard can handle multiple stations at the same time.	7	No need for a security guard informing the passenger about what to hand in. The rating 7 is given because one guard can handle multiple stations at the same time. A guard might be needed to explain the procedure for the passenger.	7

How high is the production price?	2	The rating 2 is given because the airport are willing to invest in expensive solution to optimize the flow or make the security experience better	The product are sharing a CT-scanner with another unit. The station requires lightening floor, walls, and screen above the conveyor. Furthermore, multiple scanner are needed though the entire product.	3	The station have an individual CT-scanner and an individual body scanner. The passengers need to have a individual cart, which requires multiples carts to be implemented. Each cart has a screen and a chip for positional recognition. The cart replace the original trays and conveyors.	4
How much is the running cost?	4	The rating 4 is given because it needs to be cheap to have the product running because the first time investment were high. The system needs to run all day.	The rating 1 is given because it uses more equipment and technologies than the existing security check.	1	The rating 4 is given because security stations are similar with the existing security equipment. The cart uses more power than the original trays and conveyors.	4
Ability to increase the speed of passenger flow	5	Increase in passengers going through per hour. The rating 5 is given because the more passenger the airport can get through security, the more flight routes they can get. For the airport it is a business, and it is important they can earn money at the same time as they gives a good service.	Creates a faster flow in the regular security lane, because the families are removed. The rating 2 is given because the concept combine step 1, 2, 3, 4, into one. This results in one family needs to be done with all steps, before a new family can begin.	2	Creates a faster flow in the regular security lane, because the families are removed. The rating 7 is given because the concept makes it possible to remove step 3, to an area which do not slow down other passengers. It enables passengers to go through the security check prepared.	7
How invasive is the implementation of the system?	3	The importance 3 is given because the airport are willing to implement new product. But the check-in and security area are often limited on space, which can be difficult to expand	The rating 4 is given because the implementation of two system will take up the same space at the regular security flow. If there is implemented multiple systems, they will be more invasive to implement.	4	The security scanner are easier to implement and removes the existing conveyor system. Different stations for picking up and deliver the cart needs to be implemented in the entire airport, which results in a bigger implementation. The concept can be used in multiple areas in the airports, which makes the implementation bigger. Due to that the team found it difficult to compare it with the current solution. Based on that the rating 5 is given.	5
How does it handle a varying family sizes?	4	The importance 4 is base on the framing which is to create a family experience. Kids cannot do the security check them self so they need a parent/guardian to be around.	The concept gets the rating 3. The concepts creates a room for families in different sizes. The size of the system, can limit the maximum numbers of passengers going in together.	3	The rating 8 is given because the family members can hand-in their items at the same time. The area around the cart limits the numbers of passengers who can interact at the same time. For big families it is possible to take multiple carts, and thereby adapt to the varying family size. The security scanner are similar to the existing system - one passenger walking through at a time.	8
Does it allow for handling a varying amount of carry-ons and on-body items?	5	The importance is 5 because it needs to handle all amount of carry-ons and on-body items because everything needs to be scanned.	The rating 6 is given because the moving conveyor makes it possible to handle an unlimited amount of luggage. The passenger are not limited by the sizes of the trays. The delivering of items after scanning, have not been developed, and can limit the amount of luggage handled.	6	The rating 5 is given because the cart limits the amount of carry-ons and on-body items, because of the dimensions of the cart. The families have the possibility to take multiple carts.	5

Can it ease it process for separating items?	5	The importance 5 is given because of the research shows that the biggest problem in the security check is the separation of items.	The rating 10 is given because the families gets indications and information about which areas and items to hand-in, at the screens.	10	The rating 8 is given because the cart give the families the time they need to separate the items. The screen shows examples for items to hand-in.	8
Can the product use data to create extra value for either the passenger or the airport?	1	Is it possible to use date to either earn money or another monetary gain for the airport. Or can it be used to create a better and more personal experience for the passengers. The importance 1 is given because it is a feature which could be nice to implement, but it is not a need.	The rating 5 is given because currently there is no use of data. But further development could implement the use of data, adapting to the numbers of passengers who scanned their boarding pass before entering the scanner.	5	The cart tracks where passengers are in the airport, providing the airport with a flow map over the airport, which can be used to optimize the airport. The map shows the different shop tempting passengers to buy. The map also guide the passenger to the their destination.	9
Does it allow the passenger to use the time they need?	4	The importance 4 is given because when passengers are pressured they make mistakes in step 3. But the airport want the passengers through security fast.	The passengers are isolated from the other passengers and can take the time they need when inside the room, because they do not need to think about other passengers.	9	The passenger can use all the time they need while handing in their items and preparing for the security check, because they are not standing in a queue. When the family arrives at the security area, they are affected by the passengers behind.	8

The result is:
Luminous: 186 point
Cartish: 233 point

XVIII - IMPLEMENTATION LEVELS

This section explores the different implementation levels of the solution, with focus on when it is implemented and which technologies are in use. Create a list of pros and cons for each of the level.

Level 1:
Direct implementation in existing security. The cart is developed with removable trays which can be placed on the existing conveyor. Carry-ons still needs to be sorted, this can either be done in security or outside security if a place for sorting items is added. The latter solution will require the cart to handle a higher number of tray. X-ray technology.

Level 2:
CT scanners have been implemented by are not dedicated for the trolley. Trays are removable and are placed on the conveyor before scanning. Carry-ons no longer need to be scanned. CT technology
Level 3:
Dedicated line for the cart and a scanner which is able to scan the whole cart. They line is added into the existing security check area. Trays are not removable and carry-ons are can be scanned on the wagon without having to sort the items in them. CT technologies

Level 4:
The solutions is added when a new terminal is taken into use. The solutions is the main security check with a whole terminal dedicated to families. Other passenger group are introduced to the system and smaller cart might be developed to suit their needs.

	Stage 1	Stage 2	Stage 3	Stage 4
Scanning technologu	X-Ray	CT	CT	CT
Implementation price	Low - only investment in carts	Low - only investment in carts	Medium - Investment in both couple of scanners and Carts	High - Investment in both high numbers scanners and carts
Estimated launch date	Today	5-10 years (Depending on the development and approval of CT scanners)	7.5 - 12.5 years Ct scanners need to be mature to ensure it can scan multiple carry-on at the time.	15+ years Ct scanners need to be mature to a level were stability to secure that it is not needed to have the other systems as back up. And a new terminal needs to be build.
Invasiveness	- Requires installation of tracking system - Cart charging stations - Storage space for carts	- Requires installation of tracking system - Cart charging stations - Storage space for carts	- Requires installation of tracking system - Cart charging stations - Storage space for carts - Extra lines for scanners	- Requires installation of tracking system - Cart charging stations - Storage space for carts - Extra lines for scanners - New Building

Experience in the security check	Families can prepare before the security check in their own space. After preparing the familie goes into a line resembling the regular line. Families will still need to separate their carry-on items when arriving at the security area. Families still have many trays to handle before and after the security check.	Families can prepare before the security check in their own space. After preparing the familie goes into a line resembling the regular line. Families will have to move trays and carry-ons onto a conveyor. The carry-on items do not need to be sorted.	Families can prepare before the security check in their own space. When the family is ready, they move to the scanner where the family pushes the cart into a scanner and walk through a scanner of their own. If the family is cleared in the security check they can proceed to the duty free zone, if not a security guard will provide them with assistance.	Families can prepare before the security check in their own space. When the family is ready, they move to the scanner where the family pushes the cart into a scanner and walk through a scanner of their own. If the family is cleared in the security check they can proceed to the duty free zone, if not a security guard will provide them with assistance.
Flow improvement	Improvement in the regular line, because the families are removed. Incremental improvement in their line because they are ready and have prepared before security but the still have to handle a lot of trays.	Improvement in the regular line, because the families are removed. Improvement in their line because they are ready and do not have to sort items.	Improvement in the regular line, because the families are removed. Improvement in their line because they are ready and their do not have to take of their. (Assumed they can figure it out and if the scanner is not slower in it self)	Improvement in their line because they are ready and the do not have to take of their. (Assumed they can figure it out and if the scanner is not slower in it self)
Security guards	The security functions as the regular security check which means the check would require as many guards as normal.	The security functions as the regular security check, but the guard giving instructions to the passengers are no longer present. - 1 guard	The security check functions as a self-service, guards would be present at the scanner but less than the regular security check as people will not be let through if something is detected.	The security check functions as a self-service, guards would be present at the scanner but less than the regular security check as people will not be let through if something is detected. Here there would be less guards than anywhere else, because of the elimination of the regular security check.

EVALUATION

Each of the levels have pros and cons. Level one and two are cheaper than three and four, and can be implemented fairly quick. Level one allows for preparation but the family still have to separate everything ending up with multiple trays. Level one and two require the family to take out the trays to scan them. But even though trays are being scanned the cart cannot pass the security line without getting check or scanned. This would result in the cart having to be scanned or the family to deliver the cart before the check and then providing them with a new cart. Level three and four scans the cart which means the family can have the same cart through the whole airport. Level three and four are similar. The difference between three and four is that four is the only system and targets everybody, not only families.

XIX- FUTURE TECHNOLOGIES - ARTIFICIAL INTELLIGENCE

This section takes a look into how one of the leading countries in public monitoring is looking at the future and how they use Artificial Intelligence (AI) and big data about the criticizing to increase public security. The section will then related back to how the such technology and data is used in todays society. This section is based on: Desktop research.

The age of big data is over us, we live in a world where our daily activities are monitored and analyzed, whether it is searching on Google, liking a page on Facebook, or shopping online. Sites as Facebook and Google are the most known users of big data collection and they likely know you better than your own family and friends. (Quenqua, 2015) In 2014 the Chinese government published a document called the "Planning Outline for the Construction of a Social Credit System". The document describes an idea of a national rating system for its citizens based on their online activities, who your friends are, what content you watch online etc. The system is currently being tested with voluntary participants, but the system is set to launch nationwide by 2020. (Botsman, 2017)
The government have giving eight companies license to come up with such system. One of these companies is Alibaba, which rates it users. The way the system functions is accumulating data about the user. The score is based on users action and each action is given a score, depending on whether it is a good or bad action. The scoring system gives each user a score based on that. Depending on the users score they receive certain benefits, such as smaller financial loans. (Botsman, 2017)
The first implication of the system have started to show already, and have had consequences. The first step in the direction of the use of social credit scores happen in February 2017 when the Chinese supreme court banned 6.15 million citizens from taking flights for four years. The ban were based on social misdeeds committed by the citizens. Another 1.65 million have also been banned from trains. (Botsman, 2017)

The Social Credit System is not the only initiative the Chinese government have tried to implement AI in their government structure. Police forces have started to use facial recognition technology to identify passengers and potential troublemakers at train station. Officers are wearing glasses with a camera in it. The glasses are connected to the police database where passengers are compared with their criminal history. The glasses can identify criminal suspect on-sight. The government is working together with multiple tech companies in order to improve their facial recognition technologies and their facial recognition database. They are aiming to store data about the country's 1.3 billion citizens and hope to be able to identify passengers within three seconds. (Bhandari, 2018)

The Chinese government is moving towards using AI and big data as a part of their security systems around their transport systems. But it is not only in china there is a step towards using biometric technologies as identification of persons. Private tech companies, such as Apple and Samsung, have already implemented biometrics to identify users for years. First finger prints and now Facial recognition in Iphones and Iris recognition in Samsung phones. These features can already be used to access government controlled applications such as e-boks. (e-Boks.com, 2016) The trend seems to move towards a world where biometrics are becoming more normal. It can be postulated that in the future ID will no longer be necessary. Your body will be your ID.

XX - DEVELOPMENT OF FORM

The following section will describe the development of the aesthetic of the cart. Multiple iterations of form and expression were developed through the use of mock-ups, mood boards, CAD and 3D print.

A sketching round focused on creating a lifting part and a lifted part. A aesthetics which is present in strollers. The sketching resulted in six different expressions. The different expressions can be seen on illustrations 58.1 to 58.11. Out of the six expressions four were evaluate on pros and cons.

FORM 1

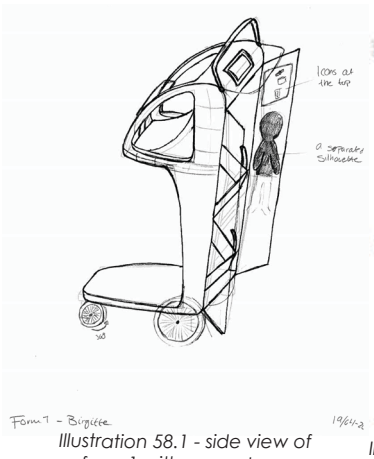


Illustration 58.1 - side view of form 1 with open doors

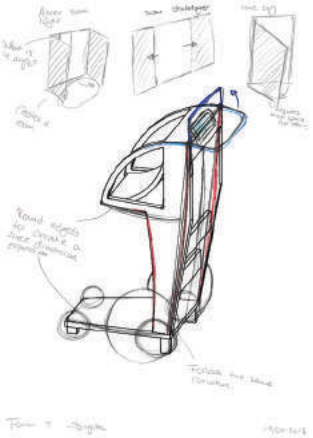


Illustration 58.2 - Side view of the form 1 with closed door

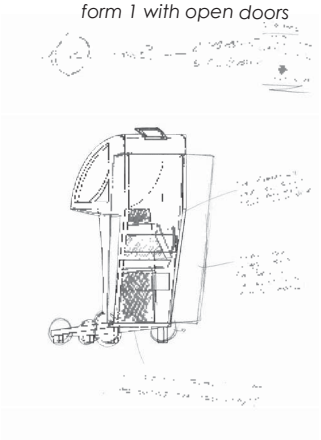


Illustration 58.3 - back view of the form 1 with open doors

FORM 2

Illustration 58.4 - Form 2 side view with one door open

FORM 3

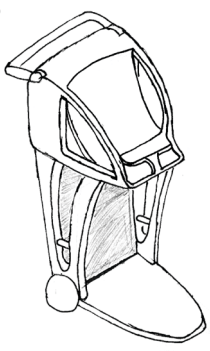


Illustration 58.5 - Form 3 front view with closed doors

FORM 4

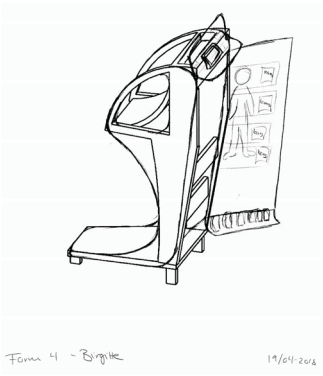


Illustration 58.6 - Form 4 side view with one big door open

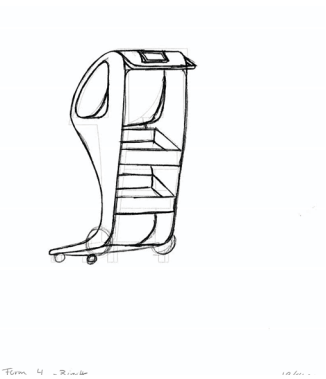


Illustration 58.7 - Form 4 back view with sight to trays

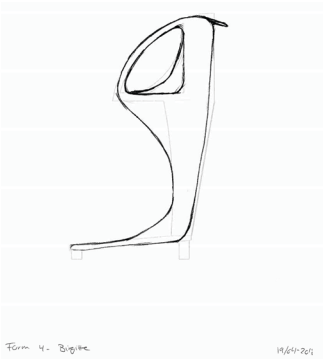


Illustration 58.7 - Form 4 side view

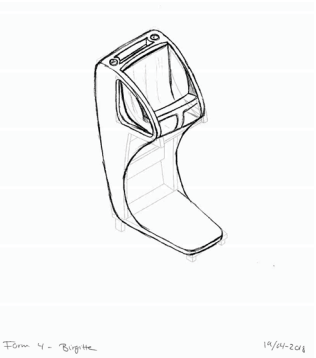


Illustration 58.8 - Form 4 front view

FORM 5

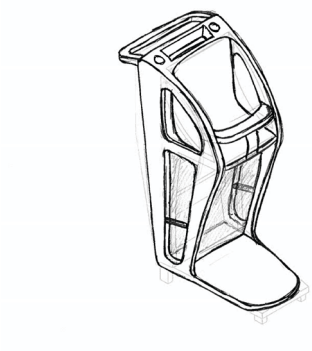


Illustration 58.9 - Form 5 front view

Illustration 58.10 - Form 5 side view

FORM 6

Illustration 58.11 - Form 6 side view

FORM 1
Pros:
The overall shape of the top part makes it look soft, because it have rounded edges

Cons:
The upper part where the child is seated look heavy
There is a misplay between the top part and the bottom part
The screen is to curved
It can be difficult to place draws in the body because it is to thin
Problems with the top part to be stacked
There is no child handle

FORM 4
The form is plain/simple looking
Pros:
Top and bottom are combine and it looks like one
Possibility for the luggage to be supported and the bottom
good room for the draws
Round edges making it look welcoming
Cons:
The expression of something lifting and something being lifted is lost
Curved screen
Problems being stack - The body is sticking out alongside the top, meaning the backplate which needs to flip inside is large making less room for the trays
There is no child handle

FORM 5
Pros:
It looks like a whole product
There is a child handle
There is some light structure elements create by the depth in the material
Cons:
The expression of something lifting and something being lifted is lost because of the heavy body strucktion
The relation between the on-body items storage and the carry-on storage is wrong. might not be room enough for carry-on.
Problems being stack - The body is sticking out alongside the top, meaning the backplate which needs to flip inside is large making less room for the trays

FORM 6:
Pros:
Have a light structure and lifts the top part
It has room between the wall to ensure luggage do not fall out to the sides.
There is a handle for the child
Cons:
It look like the parts are separated
Problems being stack - The body is sticking out alongside the top, meaning the backplate which needs to flip inside is large making less room for the trays
The screen is not integrated

The after evaluating the team decided that it needed to see the shape in 3D to really gain an understanding of the shape so it was decided to mock the forms up in SolidWorks and 3D print them. The 3D printed shapes were compared to each other. The 3D printed forms can be seen on illustrations 59.1 - 59.4

FORM 1

Illustration 59.1 - Form 1 3D print convex shape and curved child seat

FORM 4

Illustration 59.2 - Form 4 with flat side and a continues curvature on the side profile

FORM 5

Illustration 59.3 - Form 5 straight side with a indentation in the middle for a child handle

FORM 6

Illustration 59.4 - Form 6 straight side with a hole in the middle for a child handle

The models were discussed based on the expression the had. Form 1 had some speed in its shape which made it interesting but lacked a connection between the top and lower part. Form 4 were way to solid, it looked heavy and stationary.

Form 5 and 6 both had the child handle incorporated. Form 5 were stationary and resembled a high chair. Form 6 were also stationary and resembled a high chair but had a lightness to it and the lifting part and a lifted part were clear in it. The team tried out quick render on the 3D models to try out different styling possibilities.

FORM 1

FORM 4

FORM 5

FORM 6

The team made a new sketch round combining form 1, form 5 and form 6. The speed from form 1 should be combined with a mixture of form 5 and 6. Were a mixture of the light structure of 6 were combined with the indentation of form 5. The sketching round also focused on increasing the niceness of the product. The team took inspiration in car design and looked at some of the features in sports cars. The team took inspiration in the vents and lines used on cars to create speed in the expression. See illustration 60.1.
The sketches can see on illustrations 60.2 - 60.5.

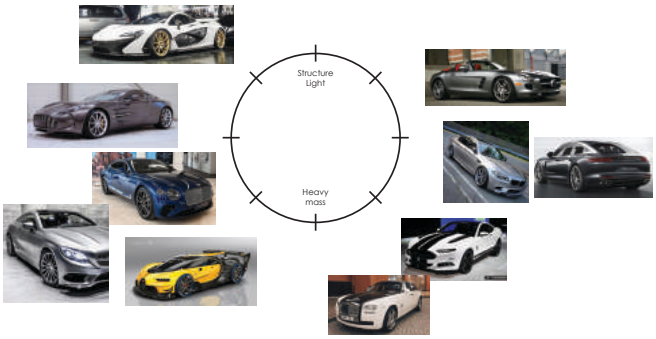


Illustration 60.1 - Circle of form with sport cars

Illustration 60.2 - Sketch of the combination 1 and 5

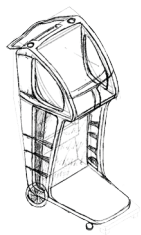


Illustration 60.3 - Sketch of the combination 1 and 5

Illustration 60.4 - Sketch of the combination 1 and 5

Illustration 60.5 - Sketch of the combination 1 and 5

The sketching round gave the team an idea of how the cart should look. The overall shape should be convex to create speed and for stacking capabilities. The children's handles in the side of the cart should be used the same way as the ventilation in sport cars to create speed and direction on the product. The shape will change depending on the features added to the cart-

XXI - NEEDS& DEMANDS

INTERPRETED NEEDS

Question/ Prompt	Source	Customer Statement	Interpreted Need
Regulations	(Trafik-, bygge og boligstyrelsen, 2018)	The boarding pass must be scanned before passengers can leave security	The boarding pass must be scanned before leaving the security
	(Trafik-, bygge og boligstyrelsen, 2018)	Carry-on items must be scanned before permitted inside the airport	Carry-on items must be scanned before permitted inside the airport
	(Trafik-, bygge og boligstyrelsen, 2018)	The passengers must go through a security screening before leaving security	The passengers must go through a security screening before leaving security
General user*	Supervisor	The security flow are designed with the same structure in all airports, because it is the best way with the existing products	
	Security guard	"I think the passengers feel like shit while going through security"	Make the journey through security more pleasant for the passengers
	Security team	The passengers do not see the signs hanging in the security area	Information needs to be easier for the passengers to see and understand
	Supervisor	The machines and equipment there have been implement needs to be approved by EU	The equipment needs to be approved by EU
	Interview with security team and observation	The security flow through the metal detector stop, when a passengers are pulled inside the ProVision. The flow starts again when the passenger have been searched. There can be added an extra security guard to eliminate the stop.	There occur a stop in the flow as a result of using the ProVision, because the passengers can not walk through without the accept from a security guard.
	Security guard and observations	Used trays are transported from the end of the conveyor to the beginning multiple times per hour, and result in a security guard wasting time for transport the trays	Reduce the time used for transporting the trays to the beginning of the conveyor

General user*	Observation	Passengers needs more than one tray when going through security to carry and separate all of their carry-on items	Passengers need more space for their carry-on items
	Observation	Passengers have a hard time carrying more than one or two trays	Passengers need a way to transport their trays
	Interview with passenger	It can be very stressful to put all your things in a tray. You stand and wait in line and then suddenly you have to hurry and put all your stuff in a tray while people are standing behind you and waiting	More time/less pressure to sort your items
	Observation	If passengers overloads a tray, their items can fall out	Ensure that the passengers items do not fall out of the tray
	Observation	When the passengers are collecting their stuff at the end of the conveyor, they are confused and result in the passenger taking the wrong phone, tablet or computer	Needs to make it easy for the passengers to identify their luggage/items
	Observation and interview	The passengers are often in a hurry and stressed while collection their items, which can result in them forgetting some stuff and items in the tray	Make a reminder for the passenger to ensure they have remembered all their items in the trays
User specific: Elderly	Observation	In situation with many people and the pressure is high, the elderly get stressed and start loosing the overview	Need time and space to keep an overview of the situation
	Observation	The elderly have a hard time interpreting the signals from the metal detector and ProVision	Need clear directions for how to interact with the metal detector and ProVision
	Observation	The elderly seems timid towards the different technologies in security and afraid of doing something wrong	A need for the solution to have a low-tech interface
	Observation	An elder passenger had trouble putting the items inside the trays and at the same time focus on the cane did not tip over	Indication on movement impaired passengers have trouble sorting their items
User specific: Family	Observation	Parents are often occupied by keeping an eye on the children. Resulting in that their head is in another place than security.	Need time and space to keep an eye on the children
	Observation	Parents are often distracted from the sorting of items in security because they need to keep an eye on the children. This results in forgetting to put items in the tray	Need a reminder/way of knowing what needs to be sorted

User specific: Business	Observation/interview	Business people are experienced travelers, if they are in line behind someone inexperienced they are slowed down	Need to be able to avoid/get past slower passengers
	Observation	The business travelers often carry different types of electronic (phone, tablet, computer, etc.) which all needs to be separated in the trays and often requires the use of multiple trays	Needs to be able to contain all types of electronic without separating the stuff into different trays
User specific: Young	Observation/interview	Young people are quick to learn the steps and are not afraid of making mistakes. But they often do it quickly which can result in them not being thorough	There is a need for pacing to ensure steps are followed correctly
	Observation	Young passengers think they are fast enough to get their stuff after security to do it on the conveyor, but they are not which results in creating a queue	There is a need for getting the passengers away from the conveyor

*General user: The general user needs are the needs which goes across all user groups.

CUSTOMER STATEMENTS AND INTERPRETED NEEDS - 2. EDITION

The second edition of the interpreted needs are updated after the choice of the family segment. Most other users needs have been removed, the ones left are those who align with the segment in focus.

Question/ Prompt	Source	Customer Statement	Interpreted Need
Regulations	(Trafik-, bygge og boligstyrelsen, 2018)	The boarding pass must be scanned before passengers can leave security	The boarding pass must be scanned before leaving the security
	(Trafik-, bygge og boligstyrelsen, 2018)	Carry-on items must be scanned before permitted inside the airport	Carry-on items must be scanned before permitted inside the airport
	(Trafik-, bygge og boligstyrelsen, 2018)	The passengers must go through a security screening before leaving security	The passengers must go through a security screening before leaving security
Security employees	Security guard	"I think the passengers feel like shit while going through security"	Make the journey through security more pleasant for the passengers
	Security team	The passengers do not see the signs hanging in the security area	Information needs to be easier for the passengers to see and understand
	Supervisor	The machines and equipment there have been implement needs to be approved by EU	The equipment needs to be approved by EU
	Security guard and observations	Used trays are transported from the end of the conveyor to the beginning multiple times per hour, and result in a security guard wasting time for transport the trays	Reduce the time used for transporting the trays to the beginning of the conveyor
General user*	Observation	Passengers needs more than one tray when going through security to carry and separate all of their carry-on items	Passengers need more space for their carry-on items
	Observation	Passengers have a hard time carrying more than one or two trays	Passengers need a way to transport their trays
	Interview with passenger	It can be very stressful to put all your things in a tray. You stand and wait in line and then suddenly you have to hurry and put all your stuff in a tray while people are standing behind you and waiting	More time/less pressure to sort your items
	Observation	If passengers overloads a tray, their items can fall out	Ensure that the passengers items do not fall out of the tray
	Observation	When the passengers are collecting their stuff at the end of the conveyor, they are confused and result in the passenger taking the wrong phone, tablet or computer	Needs to make it easy for the passengers to identify their luggage/ items
	Observation and interview	The passengers are often in a hurry and stressed while collection their items, which can result in them forgetting some stuff and items in the tray	Make a reminder for the passenger to ensure they have remembered all their items in the trays
User specific: Elderly	Observation	In situation with many people and the pressure is high, the elderly get stressed and start loosing the overview	Need time and space to keep an overview of the situation

User specific: Family	Observation	Parents are often occupied by keeping an eye on the children. Resulting in that their head is in another place than security.	Need time and space to keep an eye on the children
	Observation	Parents are often distracted from the sorting of items in security because they need to keep an eye on the children. This results in forgetting to put items in the tray	Need a reminder/way of knowing what needs to be sorted
	Desktop Research	Families see the airport as a part of the travelling experience.	Make the security check a more family friendly experience
	Observation at Aalborg airport.	Most families had a stroller for their kids with the through from check-in, through security, and in tax-free	Implementing a stroller for kids
Airport	Interview	We want people to get through security as fast as possible to increase the time they have in the duty free area.	Increase passenger flow through the security
	Interview - Thomas Bruun Pedersen, Sektionschef SPS at Copenhagen Airport A/S	The equipment the security guards uses today for operating the X-ray machine have two bottoms. New equipment needs to be operated as simple, so they do not use more time on training the security guards.	New scanning equipment needs to be operated with a simple interface.
	Interview - Thomas Bruun Pedersen, Sektionschef SPS at Copenhagen Airport A/S	CPH airport will test CT-scanners instead of X-ray machines, and change the technology to add up with the future threats in airports.	CT-scanning is the future and needs to be implemented.
	Interview - Thomas Bruun Pedersen, Sektionschef SPS at Copenhagen Airport A/S	Airports are subject to strict laws that can be changed very suddenly. Even through the airport are autonomous, they need to fulfill regulation.	Possibility to adapt to future regulations
	Interview - Thomas Bruun Pedersen, Sektionschef SPS at Copenhagen Airport A/S	Separate some of the security lanes into segments, to utilize them better. CPH airport have tried making family lanes, but families do not use it because it is slower and more troublesome.	Make a family lane which makes the families want to be separated from the other segments
	Interview - Thomas Bruun Pedersen, Sektionschef SPS at Copenhagen Airport A/S	We do not want to control the passengers, but we want to guide them, to separating the passengers into different lines and thereby optimize the productivity and passenger flow	Guide passengers through the security check to get a consistent flow through all lines
	Interview - Thomas Bruun Pedersen, Sektionschef SPS at Copenhagen Airport A/S	We use image technology to look of the passenger flow and how they are moving. This makes it possible for them to predict queues for the coming 30 minutes.	Tracking technology to get an understanding of the passengers pattern predict queues
	Interview - Thomas Bruun Pedersen, Sektionschef SPS at Copenhagen Airport A/S	The future in airport security is about the passenger flow	Optimize the passenger flow

	Interview - Thomas Bruun Pedersen, Sektionschef SPS at Copenhagen Airport A/S	It is not allows to separate the segments in to slower passengers, because it will create "slow lanes". The transport authority requires that 95% of all passengers are going through security in less than 5 minutes.	The separating of passengers can not result in the security lane being slower than the rest of the lanes.
	Interview - Thomas Bruun Pedersen, Sektionschef SPS at Copenhagen Airport A/S	Combining the solution so multiple passenger segments can use it, when it is not used by the families - this can reduce the resources for implementing the system	Include other passenger to use the product, when it is not used by families
	Interview - Thomas Bruun Pedersen, Sektionschef SPS at Copenhagen Airport A/S	It takes a long time to get a scanning technology approved.	Incorporate technology which is used/known for scanning - so the launch of the product is not delayed because of the technology.
	Interview - Thomas Bruun Pedersen, Sektionschef SPS at Copenhagen Airport A/S	A test with the passenger and their response on information given by a security guard or a screen, resulted in a significant bigger amount respecting the information given by the screen.	Passengers are more likely to follow information given by a screen
	Interview - Thomas Bruun Pedersen, Sektionschef SPS at Copenhagen Airport A/S	There are different security standards (C1, C2, C3), which describes the different security levels. The equipment needs to be approved for the different levels	The product must fulfill the highest security level for adapting to the future in airport security.

*General user: The general user needs are the needs which goes across all user groups.

CUSTOMER NEEDS - 1. EDITION
The customer statements and interpreted needs are change into more specific customer needs.

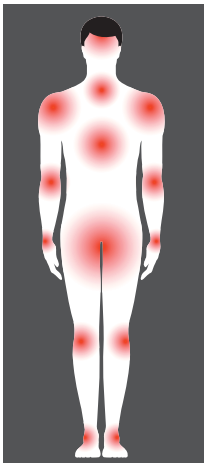
Needs					
No.	To who		Criteria	Imp.	Finding
1	Airport	The concept	ensures the boarding pass are scanned before leaving the security		
2	Airport		ensures carry-on are scanned in the security check (security scanner)		
3	Airport		ensures passengers are scanned in a security screener before leaving security (security scanner)		
4	Airport		are approved by international organizations		
5	Security guard		reduces the time used for transporting trays back and forth		
6	Passengers		informs what to hand in through icons and silhouettes		
7	Passengers		guides the passenger through security		
8	Passengers		can contain all on-body items at once		
9	Passengers		allows the passenger to prepare for the security		
10	Passengers		have a seat for one child		
11	Passengers		informs to collect all items after scanning		
13	Airport		Increase passenger flow		
14	Airport		fulfil the highest security levels		
16	Airport		can be used by other passenger segments		
17	Airport		tracks the passenger flow to predict queues		

XXII - DESIGN OF SILHOUETTES

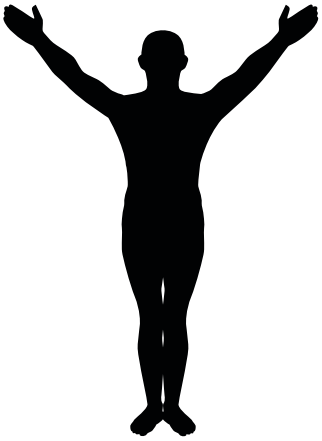
The section below are showing different types of silhouettes, to find the best for showing and inform both the parents and the kids on where to search on the body.

TRADITIONAL SILHOUETTE

Silhouette 1



Silhouette 2



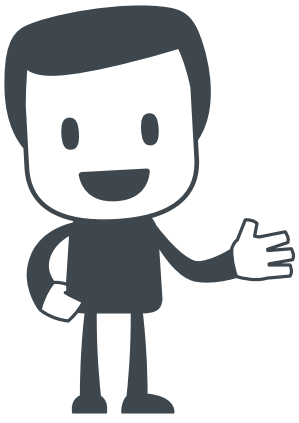
Silhouette 3

Silhouette 4

The traditional silhouette is easy to identify and get a precise position of some of the items. The silhouette can in proposal 1 and 2 be difficult to cut into two pieces. While proposal 3 are easier because the centerline of the body is above the waste line. Proposal 4 is a more abstract version of the human silhouette. Proposal 2 are showing the precise areas to focus (it is e.g. used in public swimming pools to ensure the users are getting clean in the right areas on the body).

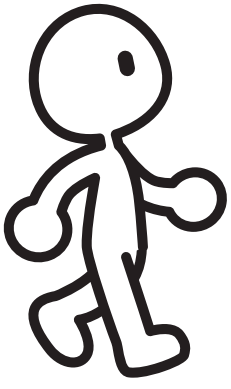
A MORE CARTOON DESIGN OF THE HUMAN SILHOUETTE

Silhouette 5

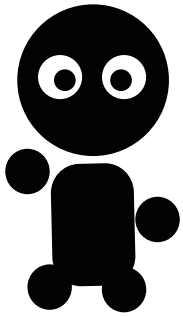


Silhouette 6

Silhouette 7



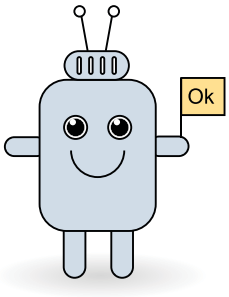
Silhouette 8



Silhouette 9

The silhouettes which have a more cartoon look are still having the overall dimensions of a human silhouette. Proposal 5, 6, and 7 still contain the overall look of a human, with hair, fingers, and clothes. It is easy to see where the different areas are separated. Proposal 8 and 9 are simplifying the human more. The silhouettes are not wearing clothes, hair or have fingers. All four proposal (5-9) are creating a more interesting and fun expression to look at, instead of the first four silhouettes (1-4).

A CARTOON FIGURE FOR SHOWING THE SILHOUETTE:



Silhouette 10

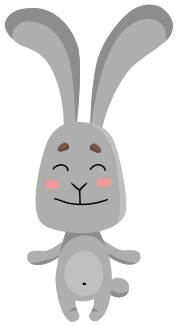
Silhouette 11

Silhouette 12

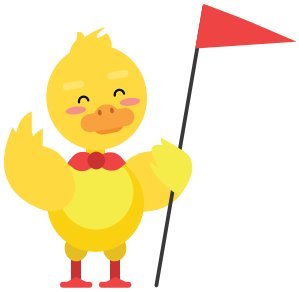
Silhouette 13

Silhouette 14

Silhouette 15



Silhouette 16



Silhouette 17

Proposal 10-17 contains different cartoon silhouettes, which still contain the basic body propositions. The different airports could have a individual mascot which represented their airport, and thereby get the kids more involved in the airport experience. Proposal 10 are a robot while proposal 11 looks like a friendly monster. Proposal 12-17 are animals which the kids know. All proposal are having a friendly and welcome expression, with smiles and open arms.
The use of cartoon silhouette can make the kids to be more focused and get them to be a part of the preparing. But it could also result in being to childish for some kids, and other passenger segments.

DIVIDING THE SILHOUETTE INTO SECTIONS

The following section shows different ways on how to separate the silhouette into the necessary sections to get the best result. One silhouette from each of the presented types will be chosen, and shown on Illustration 71.1-71.3.

Different ways for showing the icons have been made for the three types of silhouettes.

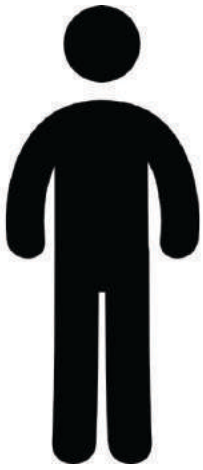


Illustration 71.1 - A traditional silhouette

Illustration 71.2 - A cartoon design of the human silhouette

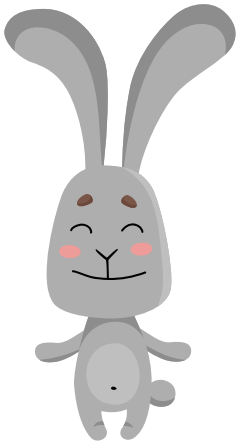
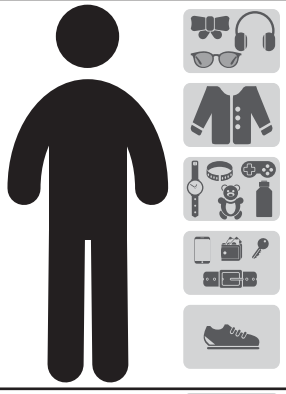
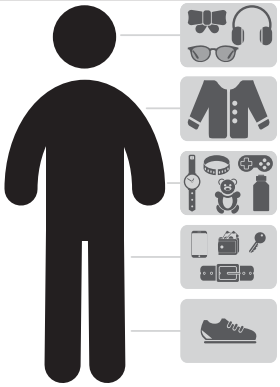


Illustration 71.3 - A cartoon figure as the silhouette

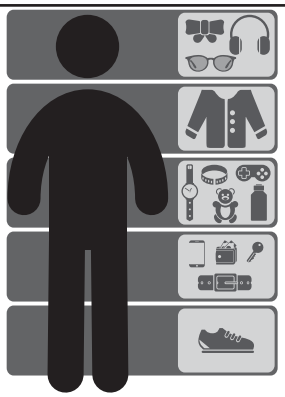
Traditional 1.
The icons are placed next to the silhouette in areas where they normally are placed on the body.



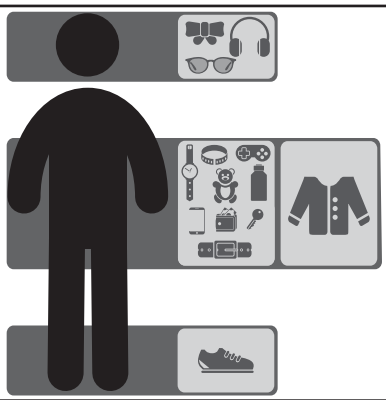
Traditional 2.
The icons are divided into five groups, according to the different areas on the body. They are placed next to the silhouette in the areas where they normally are placed.



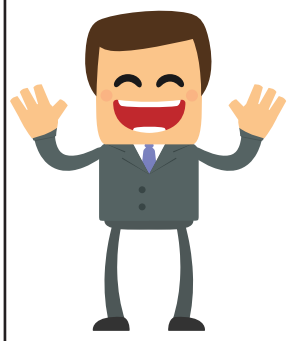
Traditional 3.
The icons are divided into five groups, which are connected to the silhouette with lines.



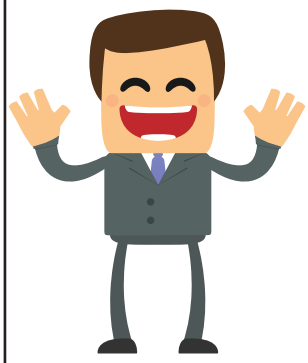
Traditional 4.
The icons are divided into five group. The icons are connected to the silhouette by a background which indicates the place on the body they are placed.



Traditional 5.
The icons are divided into four groups. The use of a background indicated the three main parts of the body where the items are placed.

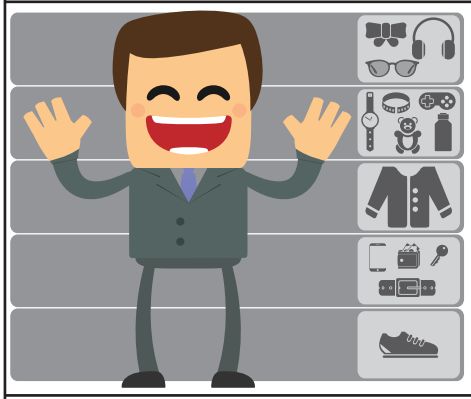


Cartoon human 1.
The icons are placed next to the silhouette in areas where they normally are placed on the body.

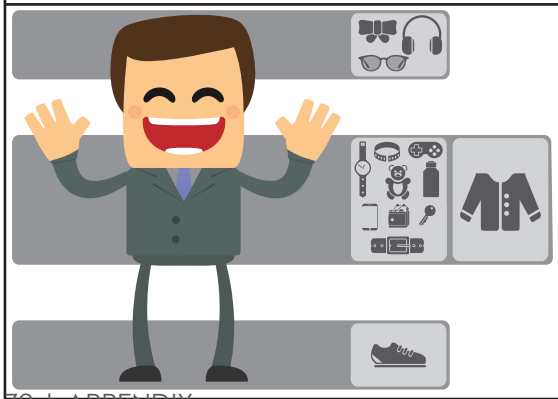


Cartoon human 2.
The icons are divided into five groups, according to the different areas on the body. They are placed next to the silhouette in the areas where they normally are placed.

Cartoon human 3.
The icons are divided into five groups, which are connected to the silhouette with lines.

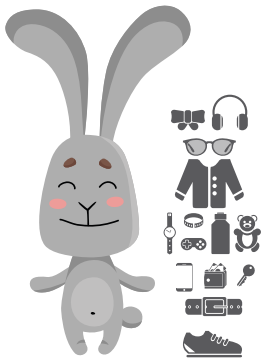


Cartoon human 4.
The icons are divided into five group. The icons are connected to the silhouette by a background which indicates the place on the body they are placed.



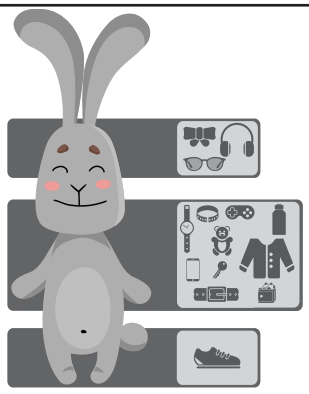
Cartoon human 5.

The icons are divided into four groups. The use of a background indicated the three main parts of the body where the items are placed.



Cartoon 1.
The icons are placed next to the silhouette in areas where they normally are placed on the body.

Cartoon 2.
The icons are divided into five groups, according to the different areas on the body. They are placed next to the silhouette in the areas where they normally are placed.



Cartoon 3.
The icons are divided into four groups, which are connected to the silhouette with a background.

CHOOSE OF ONE SILHOUETTE

To select one silhouette which must be placed inside the cart, the three different types of silhouettes have been presented to different families.

The families choose the cartoon silhouette with a rabbit. One of the families mentioned that animals always attracts the kids focus, and thereby makes it easier to get the kids attention to help handing in the on-body items.

After the selection of the cartoon silhouette, the families were presented for the three different ways to indicate which items to hand-in. They liked the indication with a background which connected the place on the body together with the icons. One of the families mentioned that it could be useful to differentiate the gray colors, so it were three areas were highlighted even more. Another color could also be used instead for gray.

Based on the presentation for the families it is chosen to use the silhouette with a rabbit. Furthermore is the icons with a background which indicates the area on the body selected. The chosen silhouette and indication of items are shown on Illustration 73.1. The colors and sizes of icons will be adjusted one the final model.

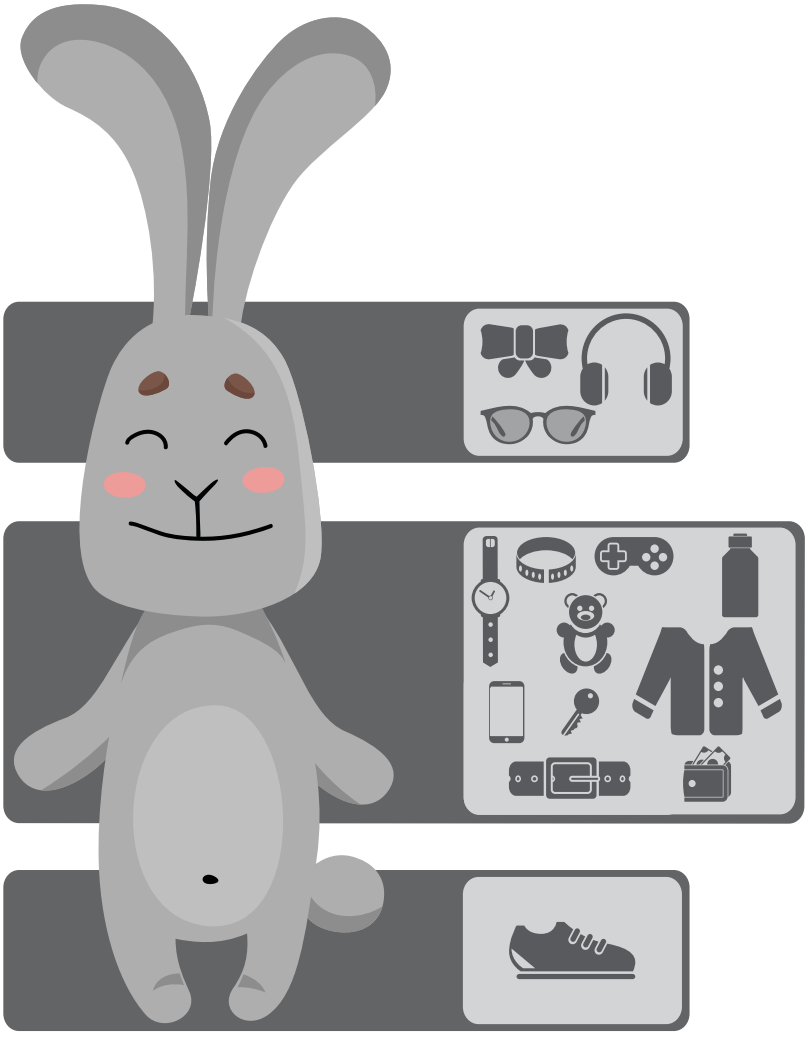


Illustration 73.1 - The chosen silhouette and way for showing the icons

XXIII - INTERACTION TEST - *DESIGN OF TRAYS*

A test of the interaction will be conducted, to get feedback on different types of places to hand-in items.

The purpose is to create foundation for selecting a specific setup for the hand-in items.
The silhouette and the icons will be presented on a model, to get feedback on the information which are given while the participants are during the test.

MODEL WORK
A frame made of wood is made. The frame is stationary.
On the frame different parts are being attached:
The doors with the silhouette and icons - the doors will be placed in one position and can not move or rotate.

TEST
The different setups will be made in a separate parts. This makes it easy to change the setup to different design for handing in the items.

The model are divided into three levels. There is a space on 20cm between the different levels.

The model have three setups:
- Setup 1: The fancy holders are placed in the two top levels, while a regular tray are mounted on level 3.
- Setup 2: All three levels contains a regular tray
- Setup 3: All three levels contains trays which are tilted 20 degrees.

PARTICIPANT 1
Setup 1:
The pockets do not fit his headphones in level 1, but it fits to the items in level 2 because he only carried three items. It would not have worked if he had more items. There were not room enough for the shoes.

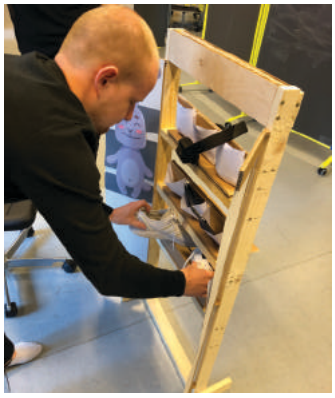


Illustration 74.1 - Participant 1 with setup 1

Setup 2:
There are not enough room for the shoes because the trays are to short. There is a problem to get the jacket to fit into the tray, because there are not much room between the trays.


Illustration 74.2 - Participant 1 with setup 2

Setup 3:
He can see into the tray even through he is close to it. He is very positive about the items are slided forward in the trays, which makes it easier to look at it.


Illustration 74.3 - Participant 1 with setup 3

He would choose setup 3 which changes for the shoes. The participant handed in the items which were shown on the icons next to the tray, which made it difficult to fit all items in level 2. The participant mentioned that it could be useful not separating the icons on the silhouette, and thereby make it up to the single person how they would hand it in.
The participant did not notice the blue markings behind the silhouette, but he saw the connection between the silhouette and the icons.

PARTICIPANT 2

Setup 1:

There are not room enough in the small pockets. There are many items in level 2 which needs to fit into three pockets. There are no room for a jacket. It is very clear with the icons - but they stand in random places.

Illustration 75.1 - Participant 2 with setup 1

Setup 2:

It reminds of how you are hand-in items at the airport today. It was easier. It was easier to get the jacket to fit.

Illustration 75.2 - Participant 2 with setup 2

Setup 3:

It is nice that it is possible to see the items inside the tray. It was faster to hand-in the items.

General comments:

The silhouette was not used. The icons were used in the first setup to see what to hand-in. It is necessary to bend over to get the items into level 2. The participant would choose setup 3.

Illustration 75.3 - Participant 2 with setup 3

PARTICIPANT 3

Setup 1:

The participant placed his keys and wallet in level 1, even through the icons shows something different. He did it because it was the items which had the most value for him. He liked the pockets for his valuables because they are separated.

Illustration 75.1 - Participant 3 with setup 1

Setup 2:

The items and the valuable are rattling - the keys might scratch the phone.

Illustration 75.2 - Participant 3 with setup 2

Setup 3:

Similar with setup 2.

General comments:

It could be useful with a coat hanger for the jacket. He places the shoes on the ground. He did not use the rabbit. He suggest that it could be useful to sort the items according to their value for the passengers.

He would choose a setup where the valuable are places highest, and the rooms under will be bigger.

Illustration 75.3 - Participant 3 with setup 3

PARTICIPANT 4

Setup 1:
Level 2 do not work because he do not carry that many small items. It would have been better with an extra tray.

Setup 2:
It is nice that there are room for the belt. It is easier to see the items in the trays, because they can be hidden when they are in the pockets.

Setup 3:
It works good. There is a problem with the sizes.

General comments:
The participant would choose setup 3. The icons are placed random which makes it difficult to see and figure out. Maybe the icons could be placed on the rabbit or inside the trays. The participant placed his shoes on the ground.

Illustration 76.1 - Participant 4 with setup 1

Illustration 76.2 - Participant 4 with setup 2

Illustration 76.3 - Participant 4 with setup 3

PARTICIPANT 5

Setup 1: The participant emptied his pockets and placed it in that order. He placed the shoes on the ground, and mentioned that it could be useful to have a grid for the shoes. The participant forgot to take out his keys.

Setup 2:
The participant were afraid of forgetting items if they were laying next to the edge and thereby hidden.

Setup 3:
It works better when you can look into the trays and no items can be hidden.

General comments:
The participant would choose setup 3 with a added hook for the jacket and a grid for the shoes.

The participant mentioned that it could be possible to divide the icons into electronic and non-electronic.
He did not use the rabbit and could not connect the rabbit together with the icons. He suggested that the rabbit could be transparent and hidden behind the icons for better communicate the areas on the body.

Illustration 76.1 - Participant 5 with setup 1

Illustration 76.2 - Participant 5 with setup 2

Illustration 76.3 - Participant 5 with setup 3

PARTICIPANT 6

Setup 1:
The participant liked the pockets. The pockets works well for the wallet and the phone. He were confused about the tray in the bottom. Furthermore he missed room for his cap.

Setup 2: It works better with the pockets, but the pockets are limited by the space.

Setup 3:
It works well with the tilted trays which create a better overview of all the items.

General comments:
The participant noticed the rabbit and the icons, but did not use it.
The participant would choose a setup which combines setup 1 and setup 3 - with pockets in level 1 and tilted trays in level 2 and 3.

Illustration 77.1 - Participant 6 with setup 1

Illustration 77.2 - Participant 6 with setup 2

Illustration 77.3 - Participant 6 with setup 3

EVALUATION

None of the participants choose setup 2.

Some of the participants liked the use of small pockets for their basic items, such as phone, wallet and keys. The use of tilted trays created the best overview of all the items.

Two of the participants mentioned that the separation of items could be changed - so instead of placing it according to the body it could be divided into groups containing metal and other pieces.

There were no room for the jacket. One of the participants hung the jacket on the side of the cart. Other participants wrinkled their jacket, to get it to fit into the trays.

There were not enough room for the shoes. Some of the participants placed the shoes on the ground.

There is a need for a test with families about the information given from the silhouette and the icons - we need to connect the silhouette and the icons better.

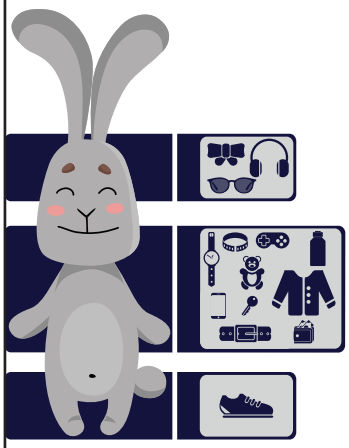
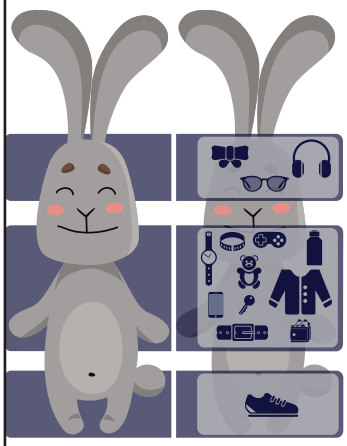
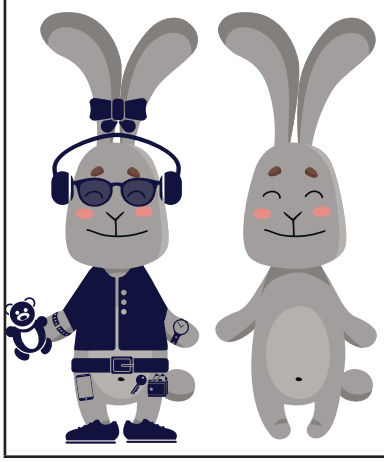
REFLECTION

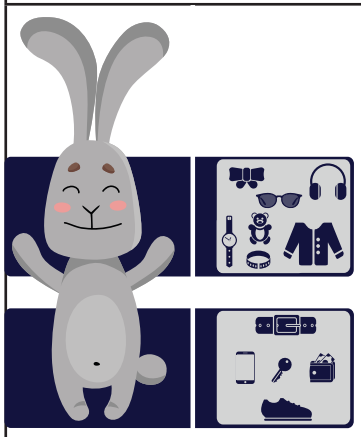
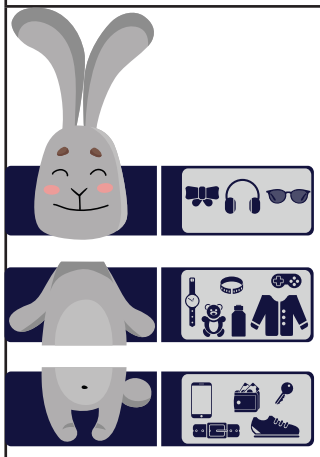
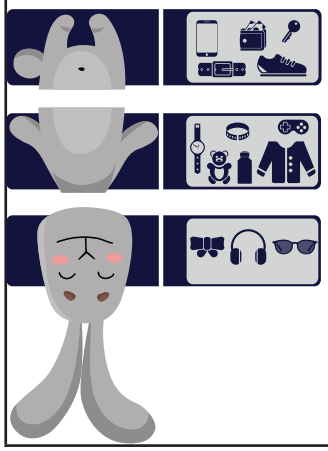
It could have give more information to test the interaction with an entire family, to see how they used it and communicated it to the kids. Furthermore it could have resulted in more information about the amount of items which the families carries.

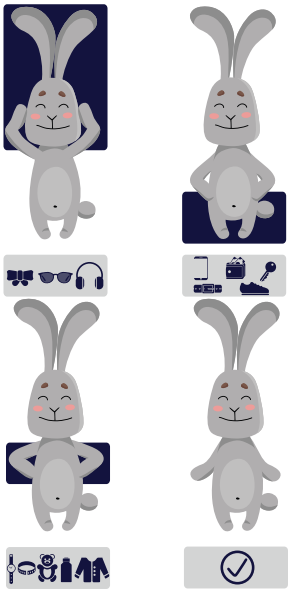
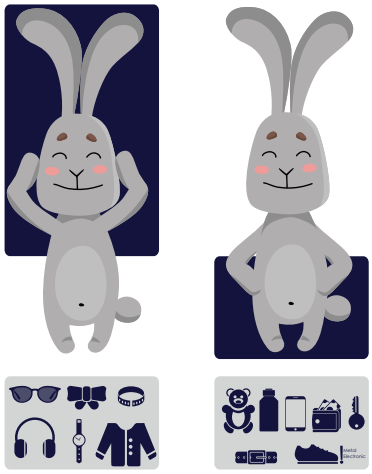
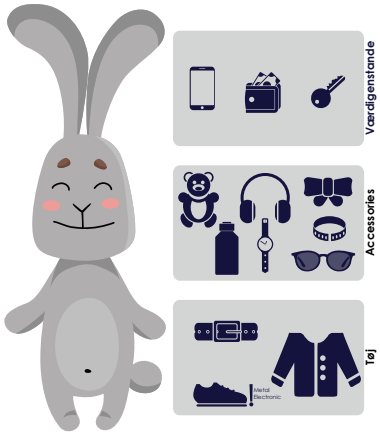
XXIV - LAYOUT OF SILHOUETTE AND ICONS

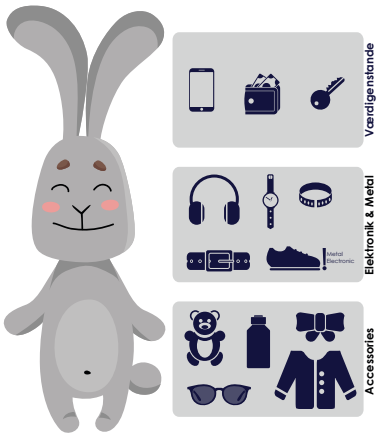
The design of the silhouette and icons are made in different variations. These are presented for families, to get their feedback on how they read the information.

The 10 different silhouette and icons designs are placed on the model. Pros and cons for each version are made.

		PROS	CONS
	VERSION 1	• The trays are still used as a connection between the wings • The icons are related to the place on the body	• The different size of the sections • The lowest section only contains a shoe • Valuable are placed together with the rest of the items
	VERSION 2	• The trays are still used as a connection between the wings • The icons are related to the place on the body • NOTE: Swich the rabbits so the icons are placed on the left wing, while the rabbit without icons are placed on the right. • Use the setup of icons as they are presented and divided in Version 5.	• A lot is going on on the right side of the cart - it is confusing to look at • The rabbit is hidden and it can be hard to see it. • There is still many icons in level 2
	VERSION 3	• The precise position on the body are shown, which highlights what the icons symbolizes • NOTE: It can be possible to color the different icons and color the trays - and thereby connect the icons to the trays.	• It can be difficult to see the connection between the two wings • The valuable (phone, wallet, keys) are the smallest icons on the rabbit

		PROS	CONS
	VERSION 4	• It is easier to see the icons	• The two divided sections on the silhouette do not align with the three trays
	VERSION 5	• The three sections have the same size • uses the trays	• It look like we have decapitated the rabbit • It can be difficult to see the connection between the rabbit and the icons
	VERSION 6	• The three sections have the same size • uses the trays • Valuables are placed in the top tray	• It look like we have decapitated the rabbit • Very confusing that the rabbit are hanging upside down • Shoes are placed in the top tray

		PROS	CONS
	VERSION 7	• Can use the height of each wing • The silhouette follows the storytelling and shows how to search your body • The silhouette and icons are easily digestible • It is optional for the passenger which trays they want to use • It is easy to connect the icons with the precise section • NOTE: Grass can be added so the rabbit stands on the grass and the icons are placed under the ground	• It can be difficult to follow the sequence of how to read the information • The illustration of the rabbit are much similar for step 2 and step 3.
	VERSION 8	• The silhouette follows the storytelling and shows how to search your body • There is a connection between the icons and the silhouette • It is optional for the passenger which trays they want to use • Can use the height of each wing	• It can be difficult to see the icons when they are placed under the rabbit - NOTE: it can be possible place the icons above the silhouette and use a sky, a cloud, or a thought bubble
	VERSION 9	• It is possible to place the section with icons so what they align with the height of the trays • It is possible to get the valuable in alignment with the highest tray	• No connection between the rabbit and the icons • Because we do not reference to the rabbit, it can signal that the icons only shows the items which needs to be handed in • If the icons for shoes and jacket is remove, the separation needs to be different

		PROS	CONS
	VERSION 10	• It is possible to place the section with icons so what they align with the height of the trays • It is possible to get the valuable in alignment with the highest tray	• No connection between the rabbit and the icons • Because we do not reference to the rabbit, it can signal that the icons only shows the items which needs to be handed in

NOTE: the size of the wing can result in making it difficult to connect the trays to the sections on the silhouette

Maybe the jacket and the shoes needs to be removed from the wings, and only informed by the screen in top.

All 10 versions have been given pros and cons. All 10 version were printed out hand hanged on the interaction model, to see how they fitted into the model. This gave a better overview and understanding of the different versions.
Each version is given a color get the versions separated and select a few for further work and use them in the interaction test.
The green color presents a chosen version.
The red color presents a deselected version.

REFLECTION
Previous test of the setup and interaction were made with icons showing the need for handing in the jacket and shoes. It is only in rare cases what the shoes must be handed in - if they contain metal or electronic.
The interactions test about the setup of trays inside the cart showed a problem with the jacket because of the limited space. A developed were afterwards made and resulted in placing hook on side of the cart, so the jacket do not need to fit into the room/cabinet in the back.

The icons which were represented on the ten first versions of the interaction test, all contained icons of shoes and jackets. Because it is so rare that shoes are handed in and the jacket are placed another place, it is decided to remove the icons from the silhouette.

XXV - INTERACTION TEST

LAYOUT OF SILHOUETTE AND ICONS

The five selected layouts were further developed and afterwards printed in full scale.
All five layouts were placed above each other and attached together by the use of clips. This makes it easy to change between all the five setups when we stand in front of the test person / test family.

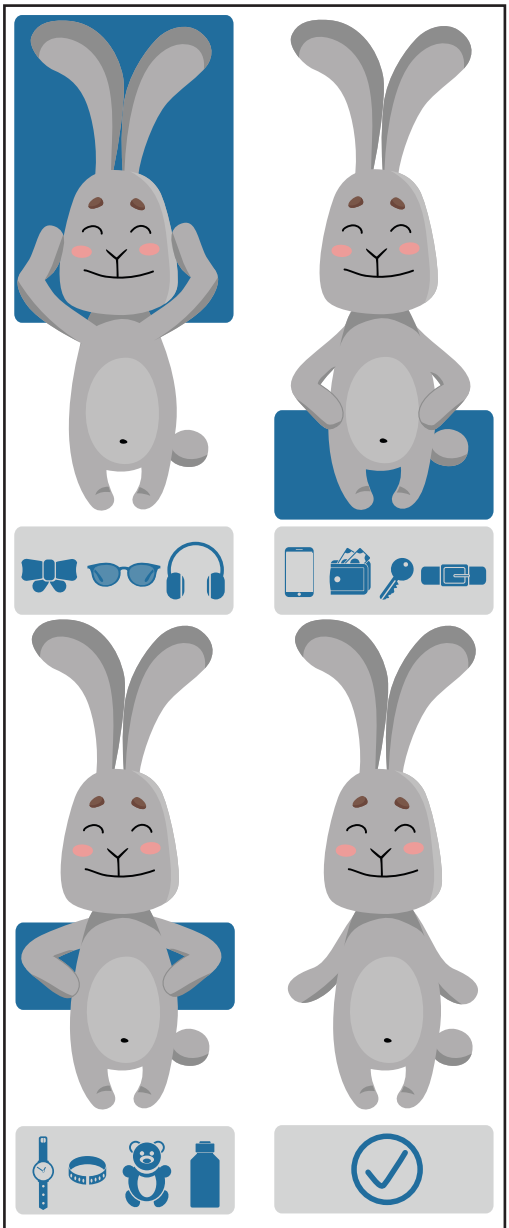


Illustration 82.1 - Setup 1. Shows four different rabbits where the hands changes position and indicates the position for the icons

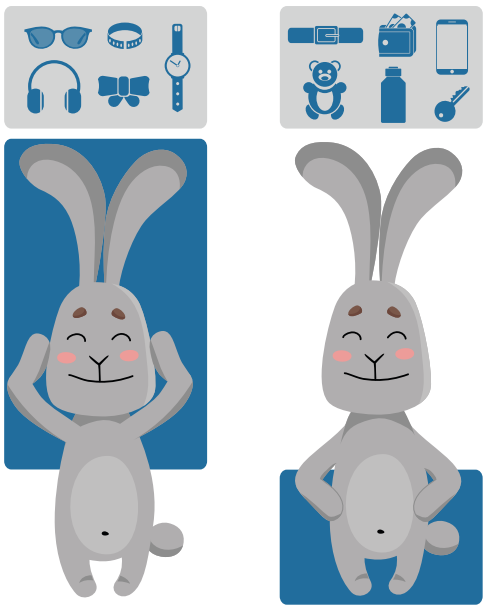


Illustration 82.2 - Setup 2. A more simple version than setup 1, with only two sections

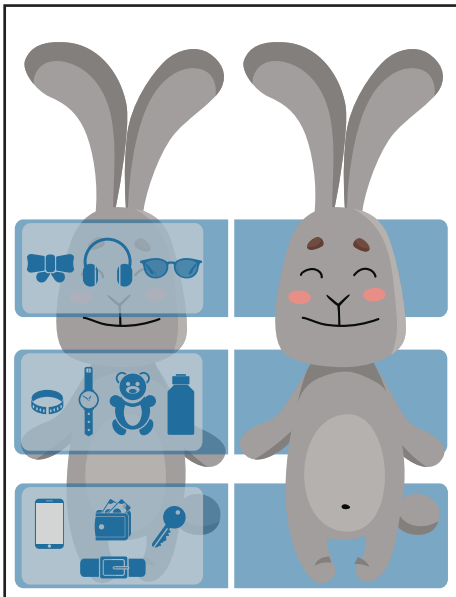


Illustration 82.3 - Setup 3. The rabbit are hidden behind transparent icons.

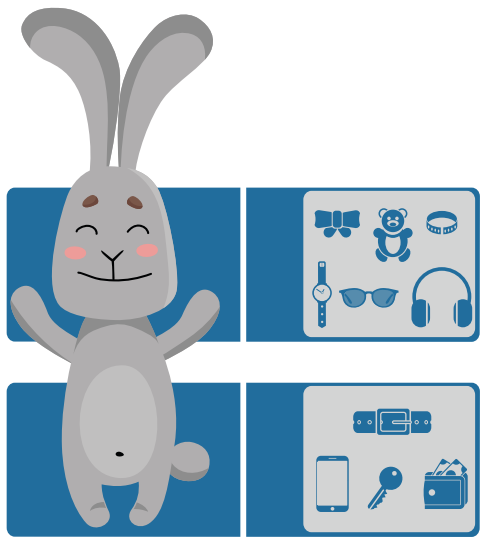


Illustration 82.2 - Setup 4.

Illustration 82.3 - Setup 5.

PARTICIPANT 1

A father with two kids in age 2 and 4 years.

- Setup 1: It functions fine, it is easy to understand.
- Setup 2: The blue background do not work as well as setup 1.
- Setup 3: It become difficult to see the rabbit. Maybe the rabbit can have the icons on the body.
- Setup 4: It is difficult to see the connection between the silhouette and the icons.
- Setup 5: The father explains for his kids what they needs to take off.

He would choose a combination between setup 1 and setup 5.

He suggested the use of nudging - an example is the footprint to a trashcan. Icons could be placed inside the trays. This will make easier for the kids because they are used to place items into different forms in a certain place.

PARTICIPANT 2

A father with a son at the age 1 year.

- Setup 1: It was confusing that it was the same rabbit. The icons was easy to read.
- Setup 2: Make a lot more sense than setup 1.
- Setup 3: It could have been useful if arrows connected the silhouette to the trays. It looks messy with the icons in front. It is difficult to see the connection between the two rabbits.
- Setup 4: It is difficult to see the connection between the rabbit and the icons. The rabbit just stands.
- Setup 5: It is difficult to make a checklist for the parents. It is easier to get the kids attention, but difficult to get an overview.

He mentioned that they often uses a stroller in the airport. He pointed out what bigger kids should do, and thought that it was a good idea with handles on the side of the cart.

The participant would choose setup 2.

PARTICIPANT 3

A mother with a son in an age of 2,5 years.

- Setup 1: It is difficult to see what the bracelet is. Kids do not know the headphones but more inears.
- Setup 2: It become more clear with two pictures. She did not notice the arms.
- Setup 3: Very confusing - to many inputs at a time.
- Setup 4: It is much similar.
- Setup 5: Good and fun to look at.

A combination between setup 1 and setup 5 would be good.

Illustration 83.1 - Participant 3.

PARTICIPANT 4

A mother with a daughter in age 8 years. They came to us because they thought it look fun.

- Setup 1: The mother did at first not understand the setup and what to do.
- Setup 2: It is easier to see.
- Setup 3: The child finds it easier to understand that setup. They can not connect the rabbit together with the icons.
- Setup 4: It is easy.
- Setup 5: The mother thought that the layout was sweet, but the child did not. They thought that the jacket were a sweater.

The mother choose setup 5 because it was the easiest to understand due to the icons were placed on the body.

PARTICIPANT 5

A mother with a daughter in age 1,5 years.

- Setup 1: It is difficult to see what the hair clipis. The rabbit is cute. After a while the mother understands the blue areas shows the areas on the body. She had most focus on the icons.
- Setup 2: It become more clear. Good with the icons in the top.
- Setup 3: The rabbit becomes unnecessary.
- Setup 4: It become unnecessary.
- Setup 5: It is fun. Thinks that is easier to overlook some items, as example the phone.

Setup 2 were the one which created the best overview of what to take off. But setup 5 will attract the kids attention the most. She choose setup 2.

PARTICIPANT 6

A mother with a daughter in age 4 years.

- Setup 1: She separates the icons into other categories than presented, such as electronics. The rabbit catch the attention.
- Setup 2: There are more icons. It gives better sense and it is better with fewer separations.
- Setup 3: Make good sense. Why is the rabbit separated into three segments? It is easy to see how the icons are connected to the silhouette. The graphic expression is bad, and were better in setup 1 and 2.
- Setup 4: It is confusing with three trays but only two segmentations.
- Setup 5: It looks like a tough rabbit. It is much more visual and easy to see the placement of the items.

She would choose setup 5, because it do not matter where the items are placed inside the trays. She suggest to split the items into categories such as electronic and liquid. She see the entire project as good and useful.

Illustration 84.1 - Participant 6

PARTICIPANT 7

A mother with a son in age 1 year.

- Setup 1: She notices in the beginning that the arms indicated the areas where the icons belonged. She thought that the rabbit were to big according to the icons.
- Setup 2: More clear to see and works better.
- Setup 3: It icons drowns in the background and are being hidden - they are difficult to see.
- Setup 4: The rabbit catch the kids attention - it is fine.
- Setup 5: It is fun. It catches the attention even better. It can be difficult to see and keep control over the things which need to be handed in.

She choose setup 2.

Illustration 84.2 - Participant 7

PARTICIPANT 8

A mother with a daughter in age 2 years.

- Setup 1: It is good with the check mark.
- Setup 2: Missing the check mark.
- Setup 3: Very confusing.
- Setup 4: Not as good.
- Setup 5: The minus is good. It can be difficult to see if the teddy bear is as part of the illustration or if it is a part which needs to handed in.

She choose setup 1.

CONCLUSION

Only one participant understood the blue boxes. For the other 7 participant we needed to explain the function.

The families which did not have time to talk with us, their kids look interested at the rabbit.

7/8 participants thought that setup 2 were better than setup 1.

Many of the participant think that setup 3 become confusing and contained to many informations. The rabbit became furthermore unnecessary.

Setup 4 resulted in spited opinions. Some thought that the rabbit were unnecessary and they could not combine the rabbit and the icons. Other participants thought the setup were fine.

All the participants thought that setup 5 were cute or easier for the kids to understand. In addition, many mentioned that the setup became messy and confusing for the parents to keep check on all the items which needs to be handed in.

REFLECTION

The interaction test was not conducted in the context, which could have affected the participants mindset and clarity about the situation.

All the participants were a single parent with one of maximum two children. It could have been interesting to see how the parents interacted if they did it together as couple.

Many of the kids were shy and hesitant to participate or answer the parents questions when they tried to include them.

The order which the setup were presented meant that the first setup were the most unknown entity. The rest of the setups follows some of the same principles as setup 1, so after figuring about setup 1 the participants found it easier to decode the other setups.

The rough model made it difficult for some of the participants to understand the overall setup. A more detailed model could have resulted in different results and feedback.

XXVI - DETAILING OF INTERACTION PARTS

HANDLE - FOR PARENTS

Research of different type of handles for the cart have been elaborated.

Illustration 86.1

Illustration 86.2

Illustration 86.3

Illustration 86.4

Handle 1, is a flexible handle which can adjust to the passengers wishes.
Handle 2, are separated into two, and are often used on umbrella stroller.
Handle 3, uses a regular tube for the parents to grab. The tube is a cheap solution, and well known at shopping carts.
Handle 4, is bend upwards. This is often seen on stroller or baby carriage which is designed for parents to walk around with. The bend of the handle can maybe make it easier for the parent to push the stroller around and get a good grip.

There are mostly used different colors or materials on the handles to indicate where to interact, and make the interaction more nice.

It have been chosen to implement handle no. 4. The handle makes it possible for the user to adjust the grip. It have furthermore been decided to cover the handle with a comfortable material.

HANDLE - FOR KIDS

Research of different type of handles for how the kids can interact with the cart, have been elaborated.

Illustration 86.5

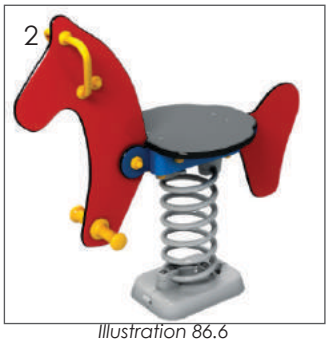


Illustration 86.6

Illustration 86.7

Illustration 86.8

Handle 1, the color differentiation on the interaction area, clear round shape which resembles a handle they know.
Handle 2, is a different handle but same color difference between the toy and interaction point. The shape of the handle allows the children to keep different holding positions.
Handle 3, is also having a clear indication on the interaction area by creating a “wall” on each side of the handle.
Handle 4, is a handle which the child can push and get support when walking.

The use of color for separating the interaction points from the rest of the product, are used in all four presented products. This results in the use of colors on the handles where the kids interact.

POSITING OF HANDLES

The research are made by taking inspiration of existing strollers and shopping cart on the market and the height of the different handle.

Illustration 87.1

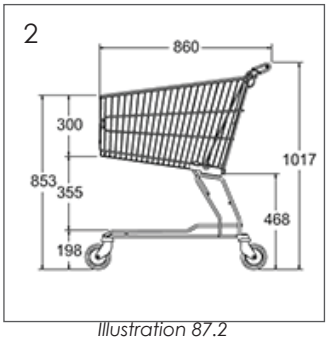


Illustration 87.2

Illustration 87.3

Illustration 87.4

Illustration 87.1 and 87.2 presents a regular shopping cart. The illustrations show the handles being at a height of 102cm and 109cm.
Illustration 87.3 is an example on a stroller which has a handle height on 104cm. Illustration 87.4 have an adjustable handle, which can change from a height from 102cm to 108cm.

The handle which are used for the cart are changing in height, as presented on the previous section. The presented shopping carts and strollers are varying in height from 102cm to 109cm.
It is decided to use a handle have a height of 102cm at the lowest point, and 108cm at the heights point.

Research about the handle height for kids are made, to get an indication on different heights.
Research about the children heights were made, to get an better understanding of the height according to the ages.
Research took inspiration in the handle height which are used for children's scooters. The scooter showed on Illustration 87.6, suites for children in ages from 3-12 years. The illustration presents the handle in four different heights; 54cm, 63cm, 70cm, and 77cm.

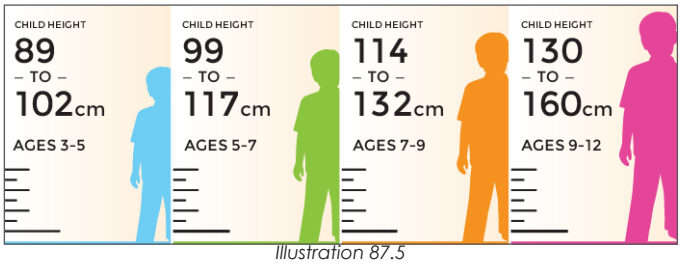


Illustration 87.5

Illustration 87.6

DIMENSION OF HANDLE SIZE

Different sizes of handles have been tested to find the best size for the handlebar on the cart for the parents to use. The different handles varied in diameter size from 2,8cm to 5cm.
The test of different handles resulted in a handle size with a diameter on 3cm.

The handles on the side of the cart which the kids use have also been tested, to find the best size. The kids which uses the handle on the side various in ages, and thereby have different preference for the diameter of the handle. It is selected to place a handle which change in the diameter and have a maximum diameter on 3cm.

SEAT DIMENSIONS

Research are made to know the size for the seat. The research are inspired in existing strollers and car seats on the market.

The research are based on the strollers and car seats presented on Illustration 89.1-89.5. The research showed the child seat changed dimensions according to the age of the child, and had a range from 30,5cm to 45cm. The car seats were bigger than the strollers, due to they need to protect the child if an car accident happens.

At the visit at CPH Airport two types of seats for the child were available for the passenger to walk around with in tax free, as presented on Illustration 89.6 and 89.7. The stroller on Illustration 89.6 were big and designed for the kids to lay down. While the shopping cart with a seat, Illustration 89.7, were designed for traveling both the child and carry-ons. The shopping cart with a child sitting in the seat are shown on Illustration 89.8. The dimension on the seat used on the shopping cart are shown on Illustration 89.7.

Illustration 89.8 - Shopping cart with seat from CPH Airport

The strollers and car seats from the research and the seat from CPH airport, created the basis for the dimensions of the seat. The final dimensions are shown on Illustration 89.9.

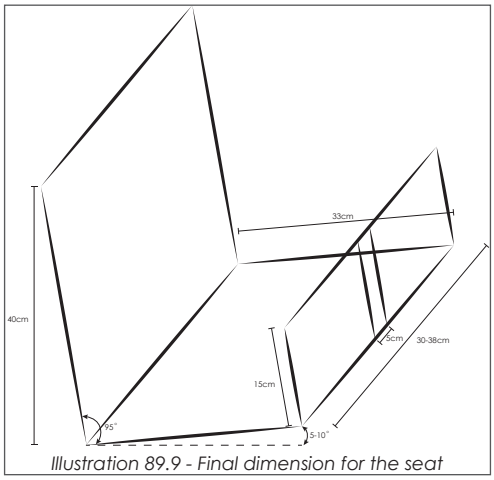


Illustration 89.9 - Final dimension for the seat

Illustration 89.6 - Stroller at CPH Airport

Illustration 89.7 - Shopping cart with a seat for a child, at CPH Airport

Illustration 89.1 - Thule chariot cross bike trailer - Width 40,6cm
https://www.twowheelingtots.com/thule-chariot-cross-bike-trailer-review/

Illustration 89.2 - Stroller, Carry cot - Width 38cm
https://www.pinterest.dk/pin/543387511271750232/

Illustration 89.3 - Stroller - Width 30,5cm

Illustration 89.4 - Car seat - Width 38cm
http://mobilnimarketing.me/car-seat-dimensions-chart/car-seat-dimensions-chart-radian-convertible-car-seat-review-features-car-seat-height-chart/

Illustration 89.5 - Car seat - Width 45cm
https://www.britax-roemer.co.uk/car-seats/toddler/duo-plus/1060.html

WIDTH OF CART

To get insight in the dimensions of the cart, it is decided to research into the width of existing strollers and shopping cart on the market.

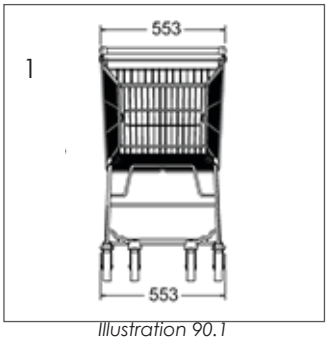


Illustration 90.1

Illustration 90.2

Illustration 90.3

Illustration 90.1 presents a regular shopping cart with a width on 55cm. A shopping cart can be difficult to drive, because it being so big.

More research were made on strollers. Illustration 90.2 and 90.3, presents two strollers, which had a width on 52cm and 45cm.

Based on the research it is decided to aim for a total width of the cart on 50cm. The width makes it possible for easier to move around with the cart.

XXVII - LOCKING MECHANISM FOR DOOR AND WHEELS

In the following section a description of the development of the locking mechanism for the door and the brake mechanism for the wheels are described. This section is based on: Mock-up and desktop research

The cart is constructed with two door on the back. In order to keep the doors close when the cart is moving it was decided to create a looking system for the door. And to keep the cart from moving when separating items a brake for the wheel is needed. As the two functionalities needs to be activate and deactivated at the same time the team developed a brake and lock system in one. The mechanism is controlled through the through the handle on the cart. See illustration 91.1.

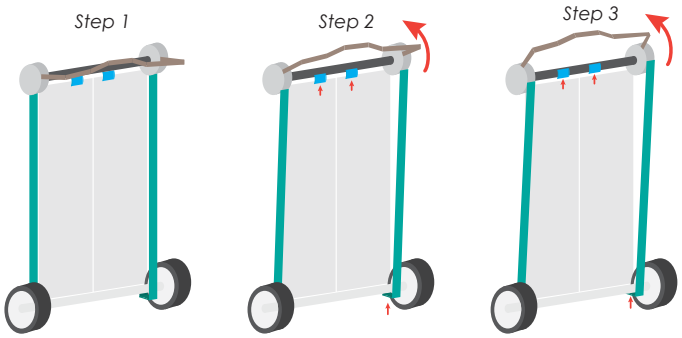


Illustration 91.1.
Step 1: The handle is in drive position keeping the doors locked and wheel unlocked.
Step 2: The handle is pushed up the doors unlock and the wheels start to lock
Step 3: The handle is in lock position keeping the wheel locked and the doors unlocked.

The lock functions by having two pistons mounted on a axle on the handle. At the end of the axle a disk is mounted with a wire going down to the wheels. When in driving position, the pistons holds the door locked and the wire is loose around the wheels. When the handle is pushed up the pistons move out of the door unlocking them, and the wire is pushed up locking the wheels. A mock-up test of the principle were made and showed the principle was functional, see illustration 91.2.

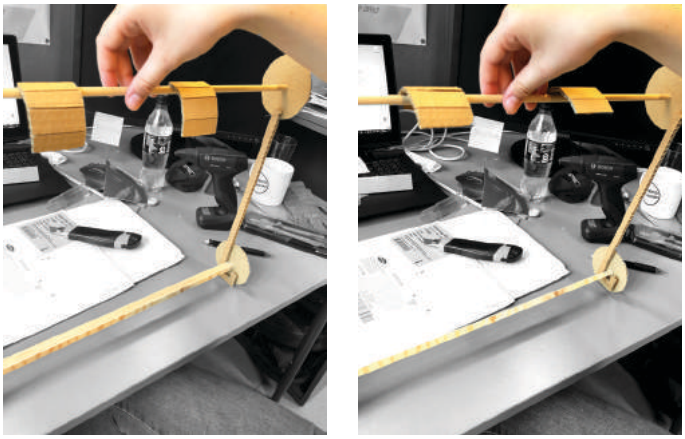


Illustration 91.2 - Mock-up test of principle showing "pistons" going up and "wire" lifting the wheel when turned

Under the construction of the solutions and implementation of the multiple unexpected problems became apparent. The distance from the axle to the door ended up being far greater than expected meaning both pistons and the space required for the movement became greater. Another unexpected challenge were the wire placement in relation to the hinges of the door and positioning of the wheels. In order to make the lock fit the more space needed to be in the top of the cart, in an already limited space. Multiple subsequent processes needed to be made on the side and bottom part of the construction to fit the lock for the wheels.

In the end it was decided to scrap the idea and work further with a standard lock attendant wheel lock and a tension lock for the doors. This locking mechanism for the wheels is known from strollers and wheelchairs. The lock functions by stepping on a peddle which pushes a rod which blocks the wheel.

Illustration 91.3 - Example on attendant lock

The door lock is functions by added a plastic knob on the door, a he part, and a corresponding she part inside the cart, Illustration 91.4. The she part is produced to small with the intention of using the plastic elastic properties to deform the she part when the he part is pushed into it.

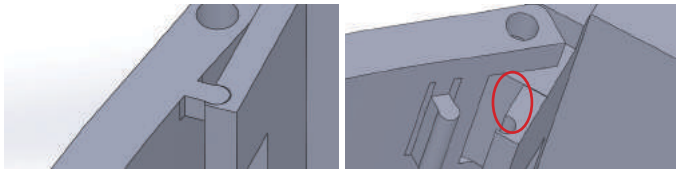


Illustration 91.4 - A he part and a she part used as the brake

XXVIII - COAT HANGERS

The interaction test showed a need for a place to hang or place the jacket. This section will elaborate different solution on where to place a room for the jackets and which attachment to use.

Research about existing hangers for the jacket are made, to gather information and open the solution space. Quick illustrator drawing will be made above a screenshots from the SolidWorks model, to present different positions on where to place the hanger

Illustration 92.11- Coat hanger

Illustration 92.12 - Coat hanger

Illustration 92.1- Coat hanger

Illustration 92.2 - Coat hanger

Illustration 92.13 - Coat hanger

Illustration 92.3- Coat hanger

Illustration 92.4- Coat hanger

The different solutions presented ideas on how to make the hook a part of the design or a separate part. With inspiration in the presented ideas, the team looked at the placement of the coat hangers. Each of the solution were evaluated.

Illustration 92.5- Coat hanger

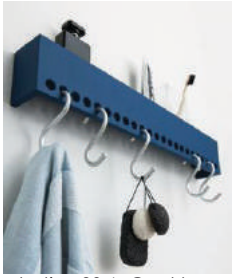


Illustration 92.6- Coat hanger

Solution 1:

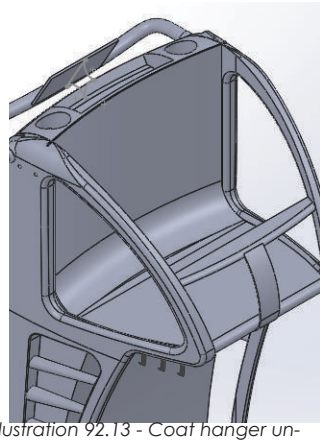


Illustration 92.13 - Coat hanger under the seat turning outward

The solution allows three jacket to be attached on hook in the front of the cart. If the jacket are big, it can create problem for the child which are walking next to it. The same hooks can be attached to the other side of the model, and create space for up to six jackets. A test with Christoffer jacket showed the problem of it touching the ground - even though it was placed in that height.

Illustration 92.7 - Coat hanger

Illustration 92.8- Coat hanger

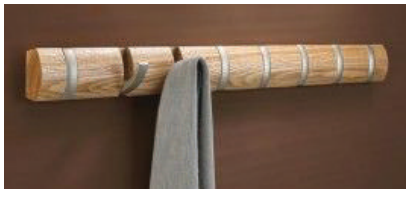


Illustration 92.9- Coat hanger

Illustration 92.10- Coat hanger

SOLUTION 2

The hooks are placed on the bended top part, and allows the jackets to be placed higher. A problem can occur if the jackets are heavy, and thereby creates more stress for the beam.
A test with Christoffer jacket showed the problem of it touching the ground.

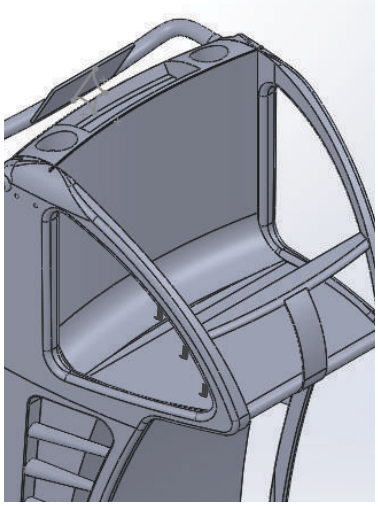


Illustration 93.1 - Coat hanger on the side of the seat turning outward

SOLUTION 3

Two hooks are placed in the top of the cart. They covers the holes where the top tray are mounted. The height of the hooks allows for carrying long jackets. The jackets can irritating the child walking on the side of the cart.
The placement of the hooks can be an integrated part in the interaction while handing in the on-body items.
A test with Christoffer jacket showed the problem of it touching the ground - even though it was placed in that height.

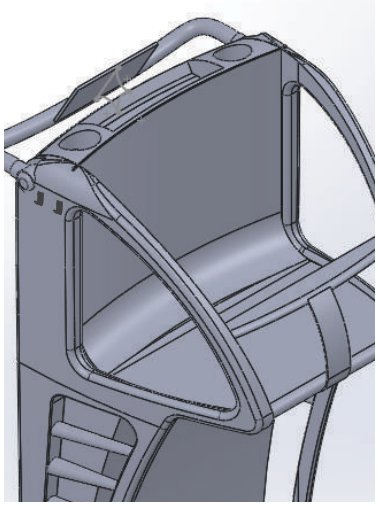


Illustration 93.2 - Coat hanger on the side of the seat turning outward on the highest position

SOLUTION 4

Three hooks are placed under the side of the cart but under the child seat - similar place as Solution 1. The difference is that the hooks are turned. This allows long jackets to be supported by the bottom plate, and not touching the ground.
A problem can occur if the passenger carries many carry-ons, and thereby limits the area for the jackets.

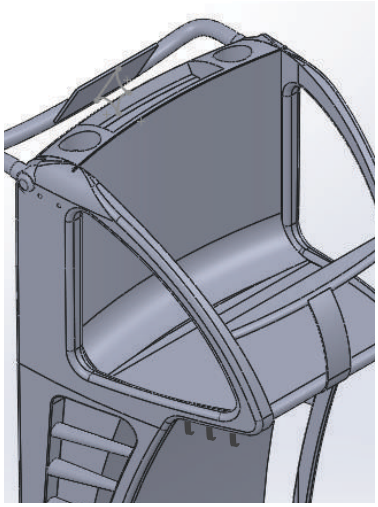


Illustration 93.2 - Coat hanger under the seat turning inward

BACK OF THE CART

SOLUTION 5

his solution have three hooks in the side of the cart - it is similar to Solution 3.
A test with Christoffer jacket showed the problem of it touching the ground - even though it was placed in that height.

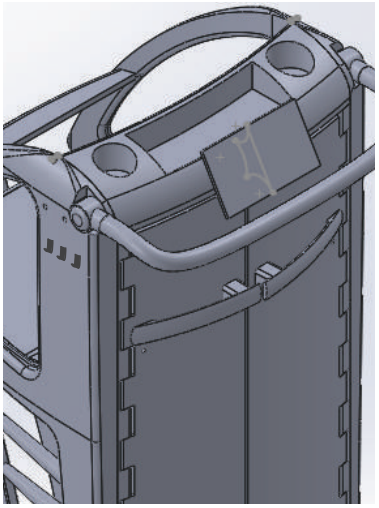


Illustration 94.1 - Coat hanger on the side of the seat turning outward

SOLUTION 6

The hooks are placed on the doors on the back of the cart. If the jacket are big it can result in the passengers are walking into the jacket. It can furthermore be difficult open the doors. A test with Christoffer jacket showed the problem of it touching the ground.

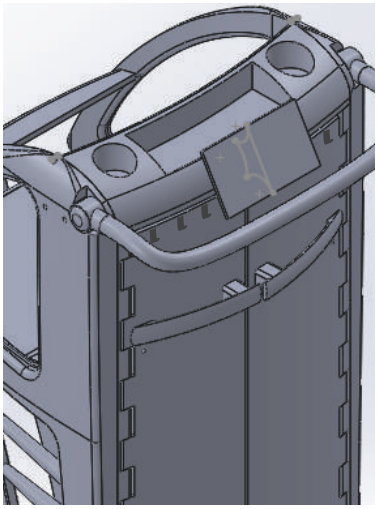


Illustration 94.2 - Coat hanger on the back of the cart

CONCLUSION

It is selected to work further on with the attachment method presented on the illustration to the right.
The attachment will be positioned as presented on Solution 4, underneath the child seat with the opening for the hook inside the cart. This was the only solution which solved the problem will long jackets, because the jacket are supported by be bottom plate.
The hook and the cart are mounted together by a rivet, as presented on the illustration below.
he interaction while handing in the items are affected by the place of the hook, and the passenger needs to move away for accessing the placement for jackets.

The design of the hook will take inspiration the in form of the cart, so it fits the cart the best as possible,

Illustration 94.3 - Example on the way the coat hanger will be fastened

XXIX- FEM ANALYSIS ON THE CART SIDES

The side on the cart will be analyzed by FEM to get an understanding of the deflection, strain and stress. The FEM will help for selecting a material for the side, to ensure it can handle the force from a child.
The material which are being tested is PUR(Plastic). The FEM analysis will contain of solid PUR. But because the form of the side have different thickness, it is necessary to add wood inside PUR, to get the same thickness all over the model. Wood have a higher modulus of elasticity than PUR(around 5 times higher), and will add to a more fixed and stable structure. The FEM analysis only contain PUR, and by adding wood inside it, will only add extra strength to the construction.

The purpose is to see how the side of the cart react when a force is added, and thereby find out if the use of PUR is strong enough to stabilize a child placed in the seat.

The FEM analysis will be made on
- Displacement
- Strain
- Stress
- Bulking

The setup for the FEM analysis are shown on Illustration 95.1.
The material PUR have been added on the entire structure.

Two fixed fixtures have been added;
- One in the bottom, because the side are attached to the bottom plate
- Another fixture have been added in the top, because the side are fixed to the top tray.

One force have been added, and shown with the brown arrows. The force have been attached to the seat of the product.
The force represent the force from two kids (30kg (6years) + 16kg(4years)=46kg), and is the worst case which the cart can be exposed for.
The weight gives a total of 451N. The force is separated onto the two side, and thereby each side handles a force on 451N/2=225,5N.

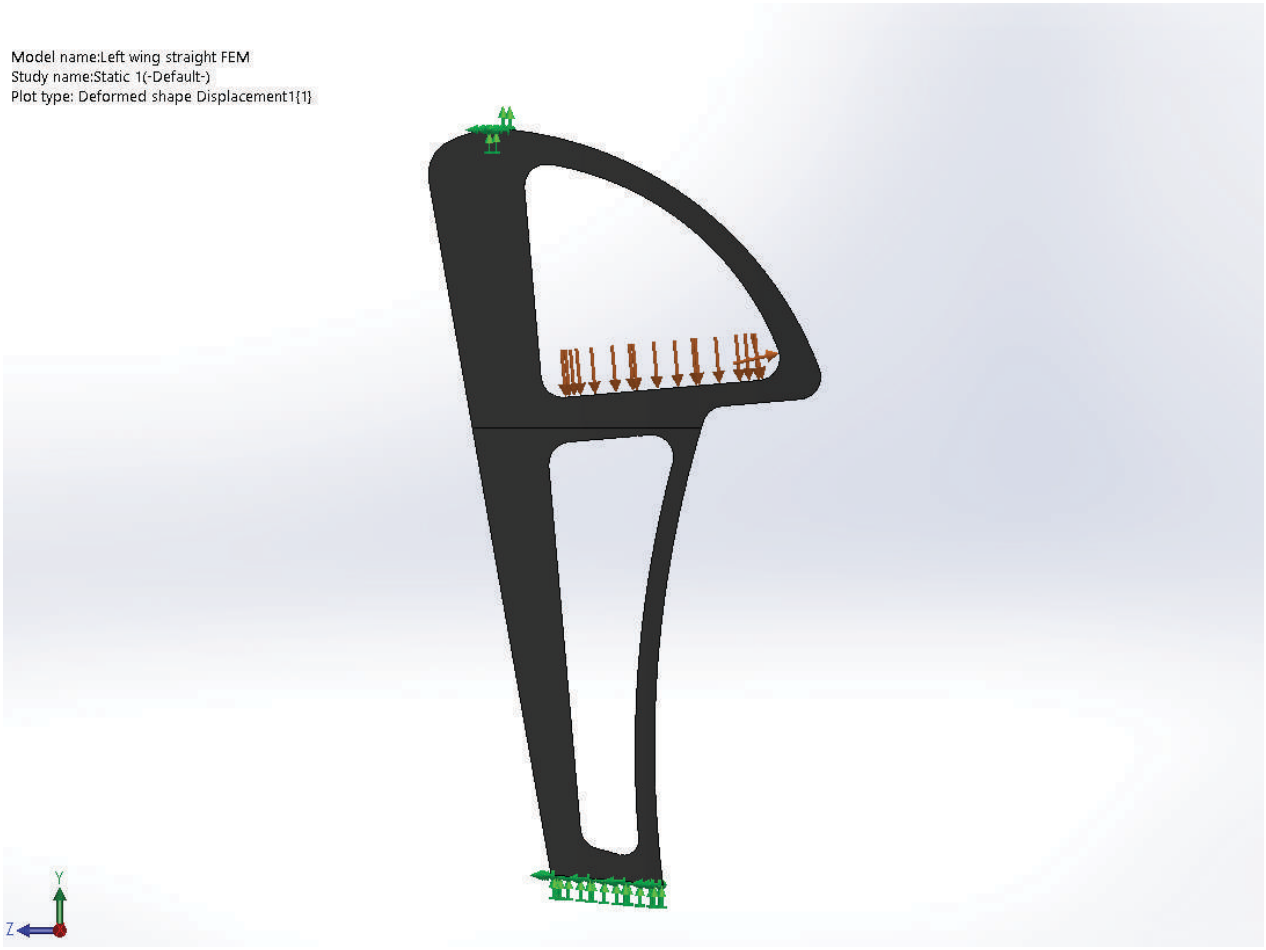


Illustration 95.1 - Setup for FEM analysis

DISPLACEMENT

Illustration 96.1 and 96.2 shows how the side on the cart reacts when a force is added.
The front of the cart (red area) are replaced with 1,376mm. The picture which shows the front on the side, shows that the front have moved both downwards and sidewards. This indicates when a force is added, the font of the cart will expand in the width.
IMPORTANT! We need to ensure the seat are attached to the sides at all time, even through the cart are displaced to the sides.

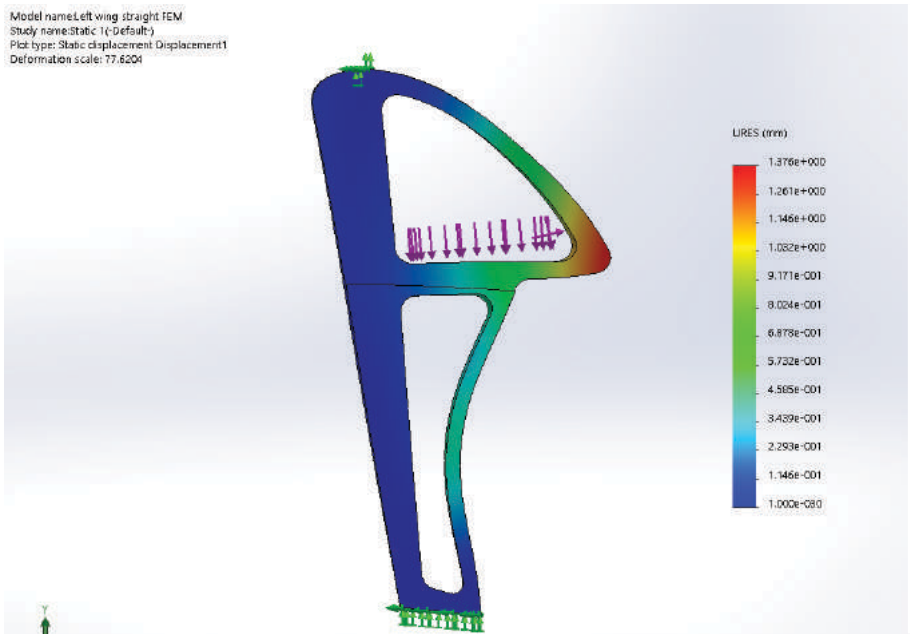


Illustration 96.1 - Displacement of cart

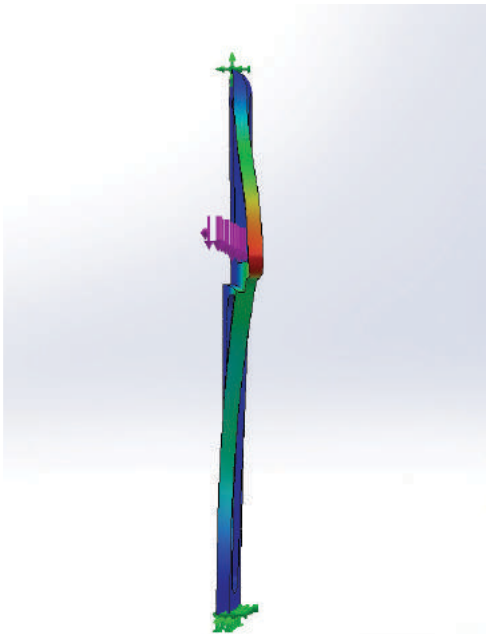


Illustration 96.2 - Displacement of cart

STRESS

Illustration 96.3 shows the displaced form, and shows the places where stress appears. The model are all covered with blue. A light blue are shown in the right corner in the bottom hole. It indicates a small amount of stress in the structure.

STRAIN

Illustration 96.4 shows how the model deplaces according to the strain. The entire model are covered with blue, either light or dark blue. The light blue are shown on the poles which are attached under the seat. Furthermore are the pole which are attached from the end of the seat to the top tray also affected by strain.

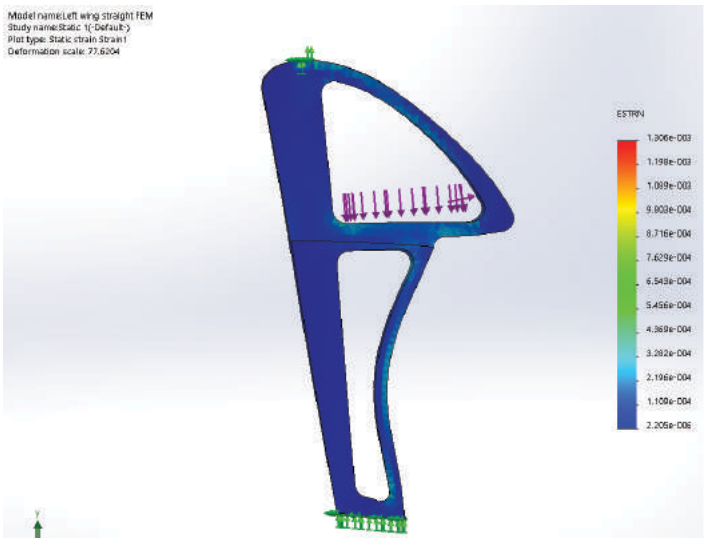


Illustration 96.3 - Stress of cart

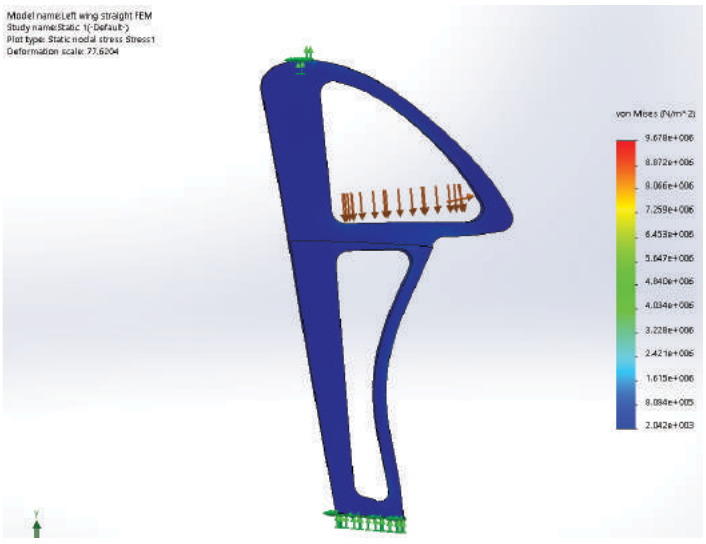


Illustration 96.4 - Strain of cart

EVALUATION We need to ensure the seat are attached to the sides at all time, even through the cart are displacing to the sides. The overall structure of the side can support if two kids(total weight on 46 kg) are sitting in the seat at the same time. A drop test which represent a carry-on which are being dropped into the seat needs to be tested in a FEM analysis.

XXX - MATERIALS

Wood will be used inside the side on the cart, for creating stability for the plastic which are attached on it.
Three types of wood have been discussed:

BALSA:
Is a very soft material which easily can be cut with basic craft tools. Balsa is used in speedboats and water sport equipment such as surfboards. Balsa is very light, and weight 40 kg/m^3 (from the book) - The internet shows the that it can have a density from 80-150< kg/m^3. (alilibaba,-.) (Lefteri, 2014)
Michael from VELUX have presented this material to be an more light solution compared to the Douglas fir.

BAMBOO:
Is a fast grown material and flexible material. It is used in many industries such as musical instruments, furniture, and architecture. Bamboo has a weight on 300-400 kg/m^3 (Lefteri, 2014)

DOUGLAS FIR:
Have a high stiffness and high bending strength. It is important to have a sharp saw for cutting into the wood. Douglas fir is often used as fittings and furnitures. It has a weight on 530 kg/m^3. (Lefteri, 2014)
VELUX uses dried douglas fir in their frames and sashes.

XXXI - ESTIMATION OF NEEDED CARTS FOR FAMILIES

The estimation will be split into two. One estimation is for a test in higher scale which involved test in the two biggest airports in Denmark, which are Copenhagen and Billund.

To get an understanding of the amount carts needed for both airports, research are made.

In normal days up to 46.000 passengers are going through the regular security check in CPH airport - Brian Cilinder-Hansen
During busy days, about 7.000 passengers are going through the security check in Billund (page 11 in the report) .
This gives a total of 53.000 passengers each day.

Research shows that families fits into the segment Experience and Selection (page 21 in the process report). The group which we aim for are the families which fits into the Selection area. Data shows that 23% of all passengers fits into the Selection area. It is decided to use the 23% and estimate that all of them are families, to create an understanding of the needed amount of carts.

23% of the 53.000 passenger gives 12.190 passengers. The number are separated into the family sizes, so one family contain of 3 passengers are sharing one cart, which give a total of 4.063 carts needed each day. The passengers travels at different hours, from early morning to late night. In addition, the passengers needs to check-in about two hours before their flight. A rough estimation resulted in a needs for 1.000 carts for both Copenhagen and Billund airport, to ensure that there is enough carts for the maximum peak for families at the busiest day.

Billund airport will receive: 13,2% which is 132 carts -which results in 150 carts for Billund + 50 Carts in reserve.
Copenhagen airport will receive 86,8% which is 868 carts - which results in 850 carts for CPH. + 150 Carts in reserve.
A total of 1.200 carts.

XXXII - STANDARD COMPONENTS

The following section will present the standard components used in the production.

WHEELS - BIG WHEELS
Research into the unit price for the big wheels, shows that an order on 5.000 units will result in a unit price on 1,53€. (Ideal Chemical & Hardware Co., Ltd., -)

WHEELS - SMALL WHEELS - 360°
Research into the unit prices showed that an order on 100 units will result in a unit price on 0,85€. (Finehope (Xiamen) Polyurethane Products Co., Ltd., -)

10" TOUCH SCREEN
Research about the touch screen resulted in using the unit price for a tablet. A tablet contains more components necessary, but it gives the best estimation for a total price. Research shows that a unit price for one tablet with a 10" screen is 47,75€.

SUMMERY - UNIT PRICE:
- Big wheels: 1,53€
- Small wheel: 0,85€
- 10" touch screen 47,75€

Gives a total unit price on ***50,13€.***

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