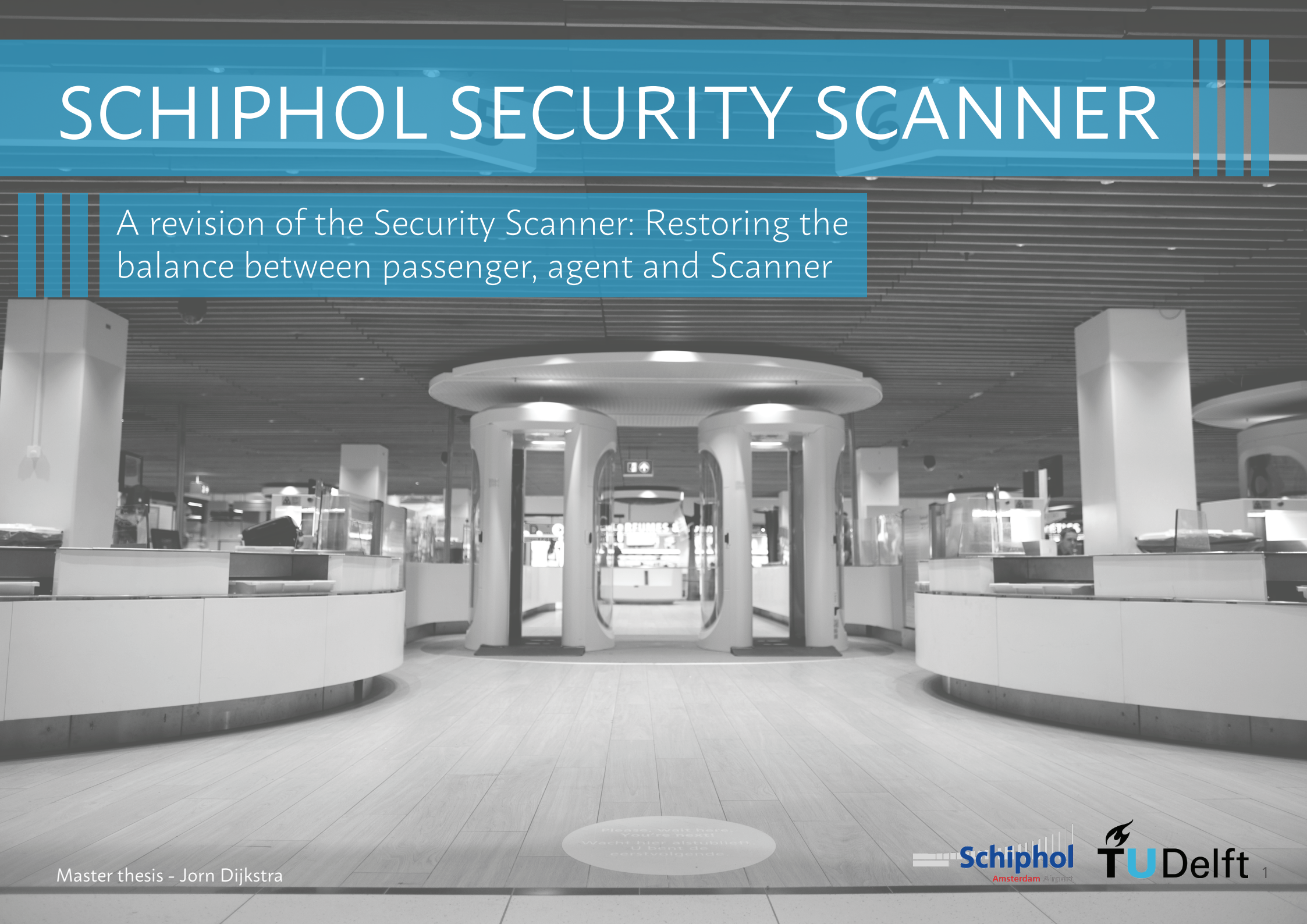
SCHIPHOL SECURITY SCANNER

A revision of the Security Scanner: Restoring the balance between passenger, agent and Scanner



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Preface

This master thesis is produced as a final deliverable for the graduation project, to conclude the Design for Interaction master at Delft University of Technology. This project that was executed in collaboration with Schiphol's Security Policy - R&D department.

The origin of this thesis stems from a request from Schiphol to the faculty of Industrial Design Engineering (IDE). They were looking for a graduate student who was interested in doing an assignment about solving the usability problems of the Security Scanner.

At the time, I was specifically looking for an assignment that focusses on design for usability. I came to hear about this assignment via Ir. Katinka Bergema, who is part of the Aviation Design Team at IDE. She brought me into contact with Pierre Kemmere, who is the Strategic Advisor Aviation Security at the SP - R&D department. After a pleasant meeting at the Schiphol offices, I received a phone call next day from Pierre that I was granted to do the assignment.

The collaboration entails a Graduate Internship via the Luchtvaartcollege Schiphol. I was offered a workplace at the SP - R&D department in Terminal West - tower A (Fig. 0.2), where I was allowed to make full use of the company's resources.

The supervisory team for this project consists of Rene van Egmond (chair), Rebecca Price (mentor), Jurgen Staal (company mentor) and Ivar van Cuyk (company mentor).

TU Delft

Luchtvaart College Schiphol

Schiphol Amsterdam Airport

Fig. 0.1 | Security Policy and Security Operations Department

Fig. 0.2 | Schiphol Offices - Terminal West

LEGEND

- Discover chapters
- Ideate chapters
- Evaluate chapters

GLOSSARY

A.A.S. = Amsterdam Airport Schiphol
ASM = Airport Security Management department
A.T.D. = Automatic Target Detection
DF (1-3) = Departures Filter (1-3)
EDS = Explosives Detection System
ESM = Engineering Systems & Management department
ETD = Explosives Trace Detection
Non-SRA = Non-Security Restricted Area
SAM (jr.) = Security Area Manager (jr.)
SRA-CP = Security Restricted Area - Critical Parts
SSL = Schiphol Security Lane
SSM = Schiphol Security Management department
PV2 = ProVision-2 Security Scanner

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Chapter 1 | **Introduction**

In this chapter the project domain is introduced, along with the initial assignment provided by Schiphol. Furthermore, the project scope, aims and objectives and the structure of the report are discussed.

1.1 | The domain

'Incredibly rude security staff'

'We've had to wait for hours!'

'A nightmare'

Remarks not unfamiliar for passengers who travelled via Schiphol recently. Since the introduction of centralised security at Schiphol airport, passengers may experience a rough start of their holiday. Long queues at security due to summer crowdedness, having to arrive extra early to not risk missing your flight, and a set of complicated security procedures. A lot of passengers who have endured this burdensome process not only complain about the waiting time, but also about the attitude of security staff, which is found to be rude and impersonal (see Facebook reviews in **Fig. 1.1**. All in all, not the result Schiphol aimed for when installing the Schiphol Security Lanes (SSL) (Schiphol, 2015).

Their cutting edge technology has been criticised from the start, initially with complaints about privacy issues with the body scan (Valkenburg and van der Ploeg, 2015). As addressing this issue by updating to the Provision-2 Security Scanner seems to have put the general mind at ease, the system is still far from perfect. The lack of clear instructions in this high volume and high pace environment confuses the passenger, which results in unnecessary pat downs and re-checks, and consequently in unnecessary delays.

At the moment, security staff has to compensate for the shortfall of the system as they have taken on the role of instructor on top of their regular job: ensuring aviation security. Above quotes indicate, while necessary, their attitude is generally not appreciated.

One focal point of these issues is the Security Scanner, which is far from intuitive in its usage. The passenger does not know when to enter, what posture to take, how long to take this posture and when to exit. On top of this, many errors occur: passengers walking through the scanner, positioned reversely or pressing themselves against the glass.

Because of the lack and quality of clear instructions, the security agent has to provide the instructions and perform corrections. In a high volume and high pace environment this is exhausting both physically as mentally. However, the agents are also part of the problem as passengers are distracted from the Scanner's use cues, and do not even get the opportunity to figure it out for themselves.

While the security staff is criticised on their attitude, it is easy to empathise with the challenges they face on a daily basis.

Sine the switch to centralised security, agents complain about the extreme working pressure (FNV, 2016). Most agents compare working at the SSL to working in a factory: It is warm, noisy, the work is heavy and repetitive, but above all they are literally stationed at a belt line. Moreover, agents are the victim of corporate pressure. Cost cuttings, unattractive hours and short breaks, while not being allowed any mistakes, result in lots of stress, anxiety and the occasional burnout. Last year's protests emphasise this matter (NOS, 2016).

This discontent lead to an unpleasant work environment, which is transferred onto the passenger. While there are many improvements to be made in the centralised security system, this issue will be the focal point of this thesis. A repetitive task that is now executed by pressured employees can be replaced by an automated and more intuitive design. Such an intervention defuses the tension between passenger and agent, and makes it possible for the agents to focus on their actual job. Finally, this provides a more pleasant security experience for everyone involved.

Fig. 1.1 | Facebook reviews about Schiphol security

1.2 | The request

The assignment written out by Schiphol originates from a problem identified with the Provision-2 Security Scanner, which is an active millimetre-wave scanner used to detect anomalies on passengers' bodies.

According to Schiphol there are a number of key-issues that cause the passenger check to be 'sub-optimal'. These issues are:

- There is no clear trigger for the passenger to enter the Scanner
- The passenger does not know what to do once inside the Scanner
- There is no clear trigger for the passenger to exit the Scanner
- There is a high alarm rate (65 - 75%) which results in unnecessary pat downs

These issues causes the passenger check to be an increasing bottleneck, because they tend to decrease the overall throughput dramatically. In an ideal situation where all users are completely knowledgeable about the process, the maximum capacity is 10 passengers per minute, while the current average is 2,5 passenger per minute.

Currently, 'acceptable performance' is achieved by the security agents who manage this 'imperfect process', by giving instructions and demonstrating all required steps. This results however, in agents performing these repetitive tasks over and over again.

Influence of Clearscan
Additionally, Schiphol foresees this problem will grow even larger in the nearby future. Schiphol has plans to implement new baggage-scanning technology, which will increase baggage throughput significantly. This will result in the passenger check being an even larger bottleneck.

Therefore, the goal of the assignment 'Auto in & out flow Security Scanner' is defined as follows:

'Design a solution to facilitate intuitive usage of the Security Scanner, resulting in a throughput of at least 8 passengers per minute, whilst positively influencing the passenger experience.'

Schiphol would like to see the following outcome regarding this project:

1. A solution that facilitates an automated in- and outflow of passengers
2. A solution that instructs passengers on taking and keeping the right posture
3. Increasing the throughput to a minimum of 8 passengers per minute
4. Overall, provide pleasant use for the passenger

This outcome should eventually lead to a better passenger experience. Additionally it should lead to a more pleasant experience for the security agents, since the occurrence of regular repetitive tasks will be prevented.

'Design a solution to facilitate intuitive usage of the Security Scanner, resulting in a throughput of at least 8 passengers per minute, whilst positively influencing the passenger experience.'

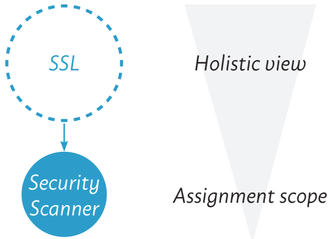
- Schiphol, 2016

Fig. 1.2 | A passenger being scanned in the ProVision-2 at Departures Filter 1

1.3 | Project Scope

The main goal for this project is to improve the usability and user experience of the Security Scanner for passengers, and for the security agents. To do this however, first an understanding of the Schiphol Security Lane as a whole needs to be developed. The SSL can be viewed as a complex living system, where all elements interrelate to each other. Therefore, a *holistic view* will be applied initially in order to discover the properties, relations and dynamics of all separate elements.

The time frame for the solution to be implemented is from 2017 - 2020. Furthermore, the solution should be compatible with the current system rather than being a complete redesign. In 2015 Schiphol Group has purchased 64 ProVision-2 Security Scanners and is not looking to invest in a completely different solution on a short term basis.



1.4 | Aims & Objectives

For Schiphol, the aim is to deliver a grounded design proposal that addresses the current usability problems around the Security Scanner. This design proposal should facilitate the autonomous use of the Scanner regarding the following points:

1. The in- and outflow of passengers
2. Taking the correct posture

Moreover, the design should eventually lead to a better user experience for both passengers and security agents.

1.5 | Report structure

The report is divided into three stages:

1. Stage I - Discover
2. Stage II - Ideate
3. Stage III - Evaluate

These stages are based on the initial project approach, which is visualised in an infographic, and can be found in **Appendix A.**.

STAGE I - DISCOVER

The Discover stage entails the analysis of the current state of play at Schiphol security. Field observations were executed to get acquainted with the SSL, and to identify issues in an early stage. For a more thorough insight, user research with both passengers and agents were executed, followed by a thematic analysis. Based on the analysis the macro problems at the SSL could be established.

After narrowing down the scope to the Security Scanner, additional field observations are executed at the passenger check to deconstruct the process and to identify the usability problems.

Finally, based on all previous research, a design vision is established. The problem definition is defined followed by a design goal, interaction vision and list of criteria, which serve as the foundation for the Ideation stage.

STAGE II - IDEATE

The core goal of the Ideate stage was to create a design that answers the problems defined in the previous stage. In the first ideation cycle, a free approach was applied to get the initial ideas on paper and to start thinking about the implications of certain interventions. In the second cycle, the three concept building blocks are established followed by a more focused ideation. A creative session with the R&D department was held after which the decision was made to solely focus on passengers taking the correct posture.

A Responsive Animations concept was developed and tested in operation. The goal of these prototyping tests was to assess the effectiveness, iterate on the design and to record the agent's experiences.

This stage concludes with a final animation design proposal, which will be evaluated in the final stage.

STAGE III - EVALUATE

In the final stage, an implementation suggestion is provided. Two tests were executed with an Xbox Kinect 2.0 skeletal tracking system in order to draw conclusion about the feasibility of motion tracking i.c.w. the Scanner. The tests are followed by an embodiment suggestion, and calculations for dimensioning the concept.

Finally, the concept is evaluated in relation to the design vision and the initial assignment, and recommendations for Schiphol are provided. The thesis concludes with a reflection on both the project as well as the internship at Schiphol.

STAGE I - DISCOVER

Chapter 2 | **Schiphol Security**

In this chapter Schiphol's security policy and centralised security layout are discussed. Furthermore, field explorations at the EF filter have been done to get acquainted with the Schiphol Security Lane, and to identify issues in an early stage. Additionally, a storyboard depicting the passenger checking process gives insight in the passenger experience at the security check.

2.1 | Security Policy Schiphol

Vision

Aside from providing a safe and secure airport conform regulations, Schiphol Group is a company with commercial interests. Schiphol has defined the Access Policy based on the following values:

1. Safe and secure
Restricting access to critical areas increases the security level at Schiphol. Access to secured areas is only allowed to individuals who have a valid reason to be there, especially in higher-risk areas such as the baggage area, the platform and runway.

2. Hospitality
Schiphol wants to provide an optimal service to its passengers and to airline companies. They think carrying out a hospitable image is key in this process.

3. Efficient
For each company, it is important to reduce unnecessary costs as much as possible. Schiphol wants to realise this by making security processes as efficient as possible.

Fig. 2.1 | Schiphol Group headquarters

Legal structure

Being the operator, Schiphol Group is responsible for executing the security activities at the airport conform the international and national regulations. Fig. 2.2 shows the legal hierarchy of the parties involved in creating these regulations (Van Cuyk, 2015).

Schiphol Security Departments

Within Schiphol Group, there are three departments involved in creating and executing the access policy of the airport:

- **Security Policy (SP)**, who are the policy makers (and where this project is being executed)
- **Security Operations (SO)**, who are the access providers
- **Airport Authority Office**, who are the upholders.

All departments are part of the overarching Safety, Security and Environment (SSE) department.

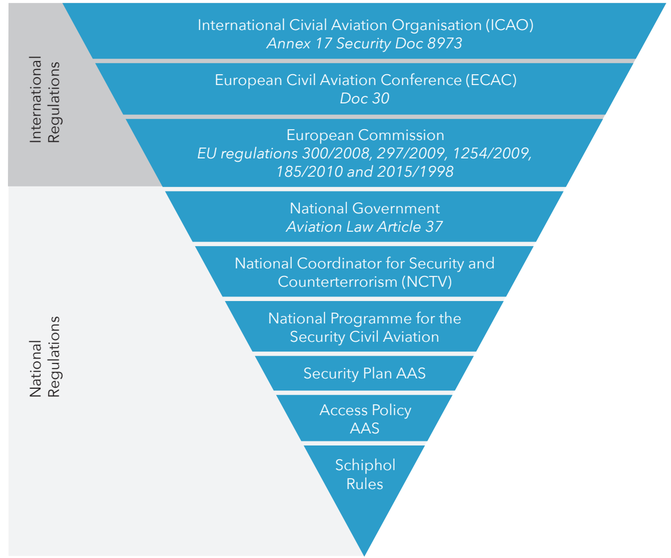


Fig. 2.2 | Regulatory hierarchy for aviation security (respective documents in italic)

2.2 | Security Areas

According to EU regulation 300/2008 (Pöttering and Lenarcic, 2008), Schiphol has classified the security level of each area at the airport into one of the following classifications:

- **Airside Security Restricted Area - Critical Parts**
- **Airside Non-Security Restricted Area's**
- **Airside Demarcated Area's**
- **Landside Secured Premises by A.A.S.**

For this project however, the security areas will only be distinguished between landside and airside.

Landside

The landside area is the public area of the airport. Everyone is allowed to be there, with exception of a few areas. For instance, Schiphol Plaza, the train and bus stations and the car park are labeled as landside premises. Although not as heavily as on airside, the landside area is a (partially) secured area. The landside basement for instance, which is used for transporting and storing goods for the shops, is a landside secured premises. In order to get access to these areas, one must be in the possession of a Schipholpas (Fig. 2.4).

Additionally, The Koninklijke Marechaussee or 'KMar' (Royal Dutch Military Police) does regular patrols around the airport to check for suspicious activity (**Fig. 2.3**).

The landside area is located within the border of The Netherlands. Therefore, all persons who are on landside are considered to be on Dutch soil.

Fig. 2.3 | KMar agents patrolling on landside

Airside

The airside area is the non-public area of the airport (**Fig. 2.5**). Access to airside is exclusively provided to passengers, and airport staff in possession of a Schipholpas (**Fig. 2.4**). For instance the boarding gates, the tax free shops, the baggage areas, the airplane platforms and airstrips are all airside premises.

Every time someone needs access to airside, he or she must undergo a personal security check. For passengers this will happen at one of the five central security filters. Staff has to go through one of the personnel filters. In both cases, both the person and his/her belongings will be checked for forbidden items. The security check is executed by one of the external security companies, which are G4S, I-Sec and Securitas.

The KMar is also active at airside, more specifically at the border passage checkpoints. If a passenger needs to move from a Non-Schengen to a Schengen area (or the other way around) his passport will be checked. Once you are at airside, you are in international terrain.

Fig. 2.5 | Passengers and KLM staff at airside

Fig. 2.4 | Personal orange Schipholpas

2.3 | Centralised Security

Traditionally at Schiphol, all passenger security checks were performed at the departure gates. This meant security had a decentralised character since the checks were all performed on different locations. On the night of 2 to 3 June 2015 however, Schiphol switched to a centralised security structure (Schiphol, 2015). From this moment on, all passengers have to go through one of the five central security filters.

These five security filters consist of three Departures Filters (1, 2 and 3) and two Transfer Filters (EF and GH). **Fig. 2.6** depicts a schematic overview of the security filter placement across the terminal.

Clean Airside

The large advantage of centralised security over decentralised security is that it provides a 100% clean airside area. Until 3 June 2015, only the security checks for Schengen flights were centralised at Departures Filter 1. This meant the airside area consisted of a mix of checked Schengen passengers and unchecked passengers with other destinations. This meant it was merely impossible for Schiphol to exactly know which passenger was 'clean' and who wasn't. With centralised security all passengers are checked before being provided access to airside, thus providing a higher security level.

Employee costs

Another advantage for Schiphol is that with centralised security less security staff is required. With exception of a few gates, there is no security staff required anymore at the departure gates. This allows Schiphol to cut on employee costs.

An advantage for the security agents is that they do not have to run from gate to gate anymore in between shifts.

Passenger assessment

Every flight generally has a distinctive type of passenger, each with its specific behaviours and characteristics. The advantage of security checks at the gate is that the security agents were able to anticipate on the flight and thus the type of passenger they would need to check. This meant agents were able to pay more specific attention to regular occurring issues for each passenger type, and adapt their instructions accordingly.

With centralised security, the distinctiveness between passenger types is harder to make since there always is a mixture of flights at each filter.

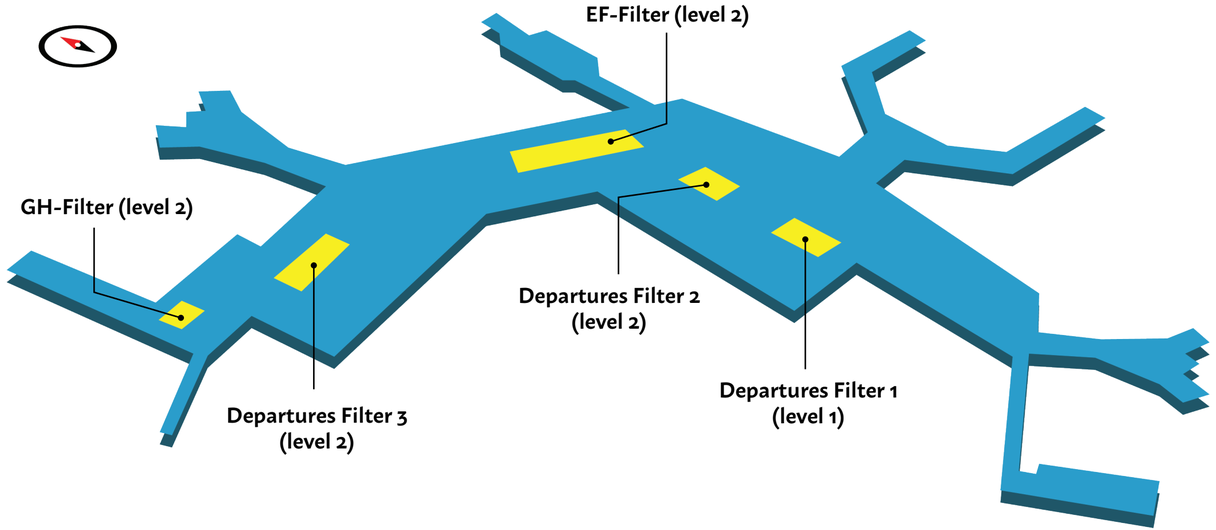


Fig. 2.6 | Security Filter locations across terminal

2.4 | Schiphol Security Lane

In order to achieve a centralised security infrastructure, a new type of security check configuration was required. Together with Scarabee Aviation Group (Fig. 2.7), Schiphol developed the Schiphol Security Lane (SSL) (Fig. 2.8). Each security filter consists of an even number of SSL's, depending on the size of the filter. The largest filter is the EF-filter, which contains twenty SSL lanes.

Function

The SSL is a security passage where passengers and baggage are separately checked. Passengers have to place their baggage and belongings on the belt line which are screened with an X-Ray machine. The passengers have to proceed to the Security Scanner, which uses millimetre-waves to detect anomalies on the passengers' bodies. After both passenger and baggage have been (re-)checked and approved, the passenger can reclaim the baggage and proceed to Airside.

Shape

The SSL has a characteristic shape. It is a straight belt line that transitions into an inwards hooks on both ends. Schiphol staff sometimes refers to the 'dual lane' which are the two lanes that together form the typical 'dog bone' shape. All security agents are positioned inside the dual lane, with exception from the Lane Assigner and the Searchers (Fig. 2.9).

SSL touch points

The SSL can be divided into eight touch points:

1. Filter queue;
2. Preparation;
3. Baggage scan;
4. Passenger scan;
5. Baggage reclaim;
6. Baggage re-check;
7. Reorganisation;
8. Visitation

Each touch point has its own purpose, which will be discussed in the next paragraph: SSL Overview.

Aesthetics

Besides a typical shape, the SSL also has distinctive aesthetics. It looks clean and modern through *simple geometric volumes, smooth surfacing* and the use of a *broken-white colour*. Furthermore, the environment in which the SSL's are placed are lit with a warm yellow colour and contains wooden elements. Altogether, the new security filters give a passenger-friendly impression unlike the typical industrial airport security checkpoints.

Passenger flow vs. baggage flow

For the security check, the passengers are separated from their baggage, resulting in two different flows: a passenger flow and a baggage flow. Each flow is subjected to a different checking process, each with its specific criteria. At the passenger check the focus is mainly on checking for (potential) weapons such as stabbing weapons and firearms. At the baggage check, the focus is mainly on finding (potential) explosives. This is the reason why all electronics and liquids, aerosols and gels (LAG's) need to be removed from the baggage.

SCARABEE
TECHNOLOGY AT HEART

Fig. 2.7 | The SSL is designed by Scarabee

Fig. 2.8 | Front of the Schiphol Security Lane

2.5 | SSL Touch Points

The SSL touch points and security agents are mapped in the schematic overview in **Fig. 2.9**, and are discussed below.

1. Security filter queue
After checking in, the passengers are guided to the security filter where they often encounter a queue of fellow passengers. This queue is managed by the Lane Assigners (agent a.), who have to efficiently distribute the passengers over the available lanes.

2. Preparation
At the Preparation, passengers are asked to put their hand luggage and personal belongings in the plastic trays, which will then go through the Baggage Scan. Emphasis is put on unpacking LAG's since these form an explosives risk. The Installer (agent B) gives instructions to the passengers about what items they should put in the trays. There is space for three passengers to unpack at the same time.

3. Baggage scan
A backscatter X-Ray scanner is used to scan the passenger's hand baggage and personal belongings. The Observer (agent c.) analyses the X-Ray images from a random lane (multiplexing). When he suspects a forbidden item or material, he can highlight the suspicious area by marking it with a red frame. In this case the luggage is disapproved (see red 'X' in image x] which then proceeds to the Unpacker (agent E) at the Baggage re-check (touch point 6). In case the baggage is approved, the passenger may retrieve it at the Baggage reclaim (touch point 5).

4. Passenger scan
The Security Scanner scans for anomalies on the passenger's body, using millimeter-wave detection. The passenger takes position inside the Scanner whereafter the Searchers (agents D) press the button to scan. In case of detection, the passenger has to undergo a physical pat down at the areas that are marked by the Scanner (e.g. zone pat down). There is always a male and a female Searcher, since law requires passengers to be searched by the same sex. When the agent decides the passenger is 'clean' the passenger may proceed to reclaim his hand baggage at the Baggage Reclaim (touch point 5). If the passenger is not considered 'clean', Visitation is required (touch point 8).

5. Baggage reclaim
In the case the passenger's hand baggage is approved, the tray will be transported to the Baggage Reclaim area. At this touch point the passenger can retrieve his baggage and personal belongings. A table is placed in between the two dual lanes for passengers to reorganise (touch point 7).

6. Baggage re-check
The belt line is split in order to separate the disapproved baggage from the approved baggage. The disapproved baggage will be transported to the agents' side of the SSL behind a glass wall. The hand baggage will still be in sight but out of reach for the passenger. The Unpacker (agent E) will open the suitcase and checks the areas marked by the X-Ray watcher (agent C). Swipes for explosives traces are made occasionally, and there is also the possibility to do another X-Ray scan. Once the baggage is approved, the passenger can reclaim his baggage at this point.

7. Reorganisation
There are two areas where the passenger can reorganise his baggage and personal items again. The reorganisation table in between the lanes is often used by passengers coming from the Baggage Reclaim. The furniture in the back is often used by passengers coming from the Baggage Recheck.

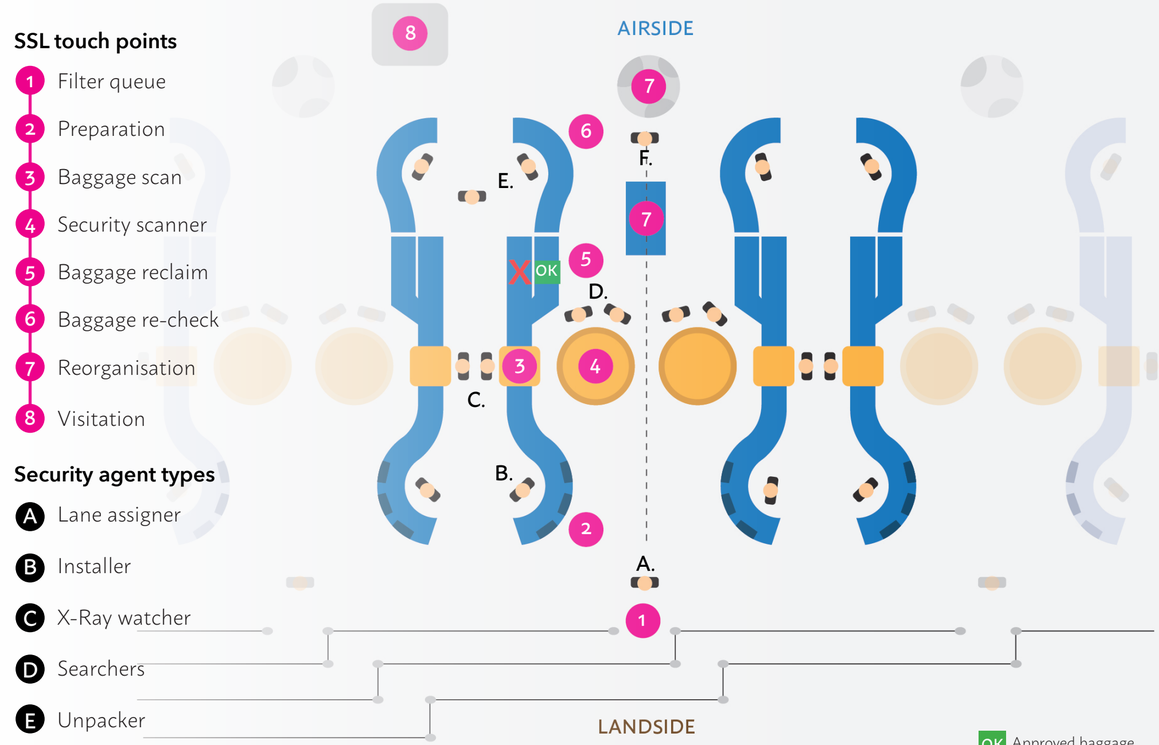
8. Visitation
A visitation is executed whenever the security agents decide a passenger requires a more thorough check after the Passenger Check. This happens in a sheltered area at location, where said passenger is separated from the view of other passengers.

SSL touch points

1. Filter queue
2. Preparation
3. Baggage scan
4. Security scanner
5. Baggage reclaim
6. Baggage re-check
7. Reorganisation
8. Visitation

Security agent types

- A Lane assigner
- B Installer
- C X-Ray watcher
- D Searchers
- E Unpacker
- F ECBS



OK Approved baggage

Disapproved baggage

Fig. 2.9 | Schematic overview of the SSL (top view)

2.6 | Early explorations

Multiple field observations were done at the EF transfer filter, to identify issues in an early stage. In this section the issues per touch point are discussed briefly.

1 *Filter queue*

Fig. 2.10 | Information banner at filter queue

Identified issues
Most passengers don't read the information banners (**Fig. 2.10**) at the filter queue due to:

- Poor visibility and readability, as opposed to the effective *black on yellow* wayfinding signs in the terminal (Waller, 2007)
- Passengers are moving or occupied

2 *Preparation*

Fig. 2.11 | Passenger unpacking his suitcase at the preparation table

Identified issues
- Passengers throw baggage directly on the belt instead of using a tray
- Passengers do not take (all) electronics and LAG's out of their bags
- Passengers do not take everything out of their pockets
- Passengers take their shoes and belts off while this is often not necessary
- Passengers and agents appear rushed and stressed; high paced touch point
- Instruction stickers on the preparation table are not readable

4 *Passenger check*

Fig. 2.12 | Passenger being scanned by the Security Scanner

Identified issues
- There is no clear entrance cue for the passenger
- Some passengers walk through the Scanner, like with the traditional metal detection gates
- Passengers still have items in their pockets or in their hands, mostly passports, boarding passes, coins and handkerchiefs
- In rare cases, passengers are positioned reversely in the Scanner
- Passengers move (their heads) during the scan
- There seem to be occasional communication issues between passengers and agents
- Some passengers want to proceed directly after exiting, but are stopped to be patted down

5 *Baggage reclaim*

Fig. 2.13 | Passenger cleaning up her tray at the baggage reclaim

Perceived issues
- Passengers do not (know they have to) put the empty trays away. This regularly causes a congestion on the reclaim belt, stagnating the whole process.
- Some passengers reach for their disapproved bags over the glass separation wall. This triggers a penetrating alarm, to the frustration of agents.

2.7 | SSL security staff

Schiphol does not have its own operational security staff, but instead hires external security companies. These external companies are G4S, I-Sec and Securitas (Fig. 2.14). Employees of these companies man the security filters and perform the daily operations. However, they are supervised by the Security Area Managers (or SAM) from Schiphol.

As stated before, the Kmar is also active at airside but not specifically at the security filters. They supervise the border passage checkpoints where they perform the passport control for passengers moving between Schengen and non-Schengen areas.

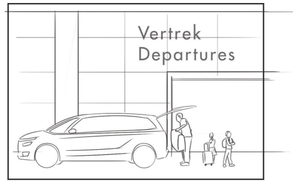
Fig. 2.14 | Security companies working at the security filters

Fig. 2.15 | I-Sec agent unpacking baggage at re-check station

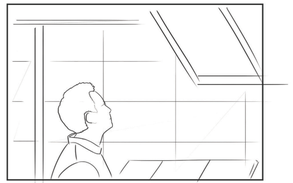
Fig. 2.16 | Back end of SSL

2.8 | Storyboard: Security experience

A storyboard was created to give an impression about a typical user experience at Schiphol security. Additionally a few usability issues are already introduced.

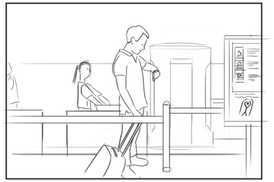


1. The passenger arrives at Schiphol and parks his car at the valet parking spot

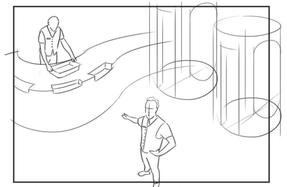


2. Once inside, the passenger looks at the information screen to find his check-in desk

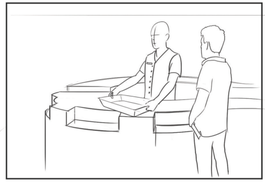
3. Checking in and dropping off baggage



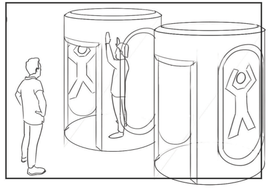
4. The passenger is afraid he'll miss his flight due to the long queues at the security check



5. The passenger is guided to an available Preparation spot by a security agent

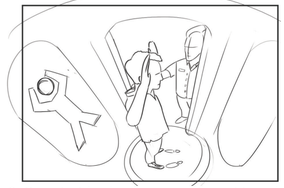


6. The passenger takes his belt off, while the agent indicates this is not necessary

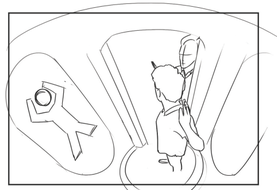


7. Waiting before the Security Scanner, while the neighbouring Scanner is free to use

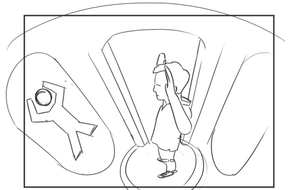
8. The passenger does not know whether he may enter, so tries to make contact with the agent



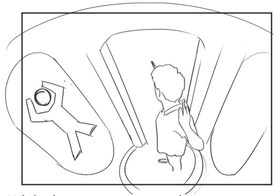
9. Once inside, the passenger is positioned backwards, after which the agent corrects him



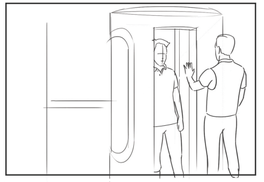
10. The agent demonstrates the posture by raising his arms: 'like this'



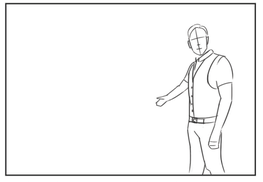
11. The passenger wants to exit as quickly as possible to check on his baggage



12. While the antennas move, the passenger turns his head questioning how long he should hold this pose

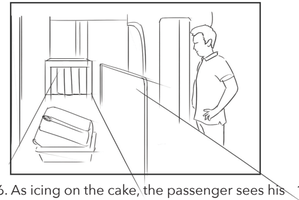


13. The passenger wants to exit the Scanner but he has to wait because a pat down is in progress

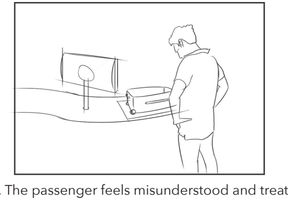


14. When finally guided out, the passenger is surprised he has to undergo a pat down

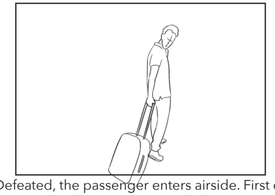
15. 'Why do you have to search me? I just went through that thing!'



16. As icing on the cake, the passenger sees his baggage is located behind the glass, out of reach



17. The passenger feels misunderstood and treated badly by the security staff



18. Defeated, the passenger enters airside. First order of business: get a drink.

Chapter 3 | **User Research**

After the initial field observations at the EF filter, user research was conducted with both passengers and agents. Passenger probing was done to get insight in passenger's experiences along the passenger journey. Agent research was conducted to explore the SSL issues in more depth and to record the agent's experiences as well. A thematic analysis on the results was done to obtain a summarised overview of the core issues at play at the SSL. At the end of the chapter, the scope is narrowed down to the scope of the assignment: the Security Scanner.

3.1 | Passenger probing

A passenger probing survey was conducted at the waiting area at the gates, in order to map passengers' experiences along their journey.

The survey depicts a timeline with touch points ranging from 'preparing' the journey to the 'departure' of the airplane(**Fig. 3.2**). Passengers were asked to assign an emotion to each touch point. These emotions are represented by either male or female PAM figures (Desmet, Vastenburg et al., 2012), depending on the gender of each passenger (**Fig. 3.1**). Afterwards, the results were discussed briefly with the passenger, with specific focus on the security touch points. The questionnaire format can be found in **Appendix C**.

Nationality, age and Schiphol travel experience were recorded for each participant to find out whether a relation exists between demographics and emotions per touch point.

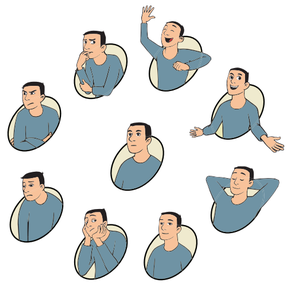


Fig. 3.1 | PAM emotions (male version)

Results

No clear trends were observed between the surveys. A clear dip in emotions at the security checkpoints was expected to be seen, considering the security check is often found to be the least enjoyable part of the journey.

Interesting though is that the response at the security touch points varied between very negative (8) to very positive (2), while most passengers actually did not have a strong opinion about it during the discussion. On the contrary, the consensus was actually moderately positive, even with passengers who assigned negative emotions on the security touch points on the survey.

This response is in sharp contrast with the Facebook reviews about Schiphol security (**paragraph 1.1**).

> *"Very good, very smooth operation*

> *"I didn't encounter any problems at all. Worked perfectly fine in my opinion.*

Limitations

The sample size of this probing survey was relatively small. Moreover, the samples were taken randomly at different departures gates. No clear differentiation between passengers has been made which means no clear conclusions can be made in relation to demographics.

Additionally, the survey was taken at the gate where passengers had a moment to relax. This means the emotions they had at previous touch points might be harder to recall.

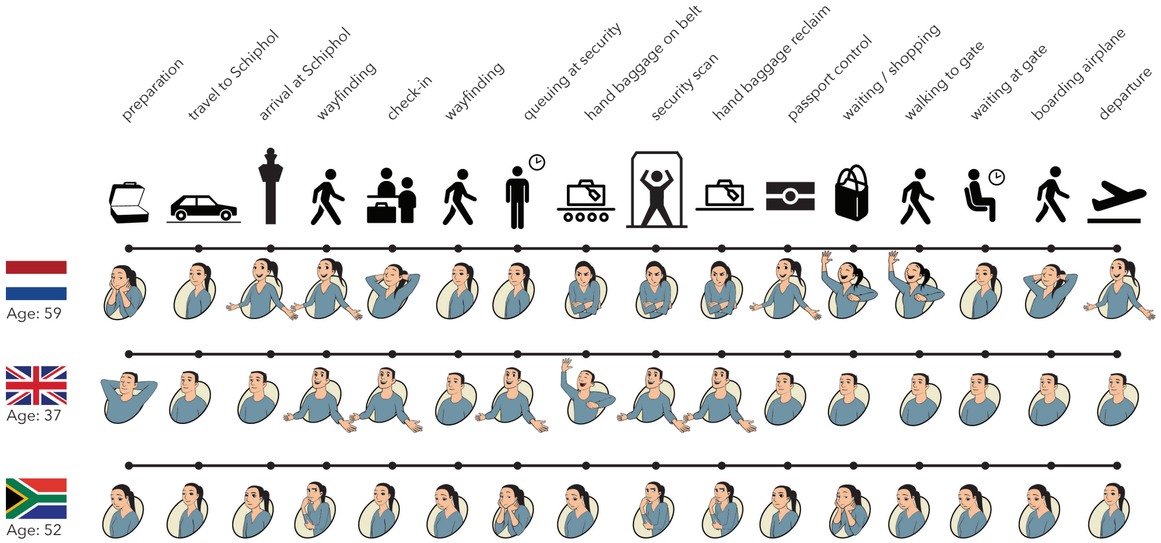


Fig. 3.2 | Three different samples from the probing survey

3.2 | Security agent research

In order to get a more thorough insight on what issues are at play at Schiphol security, user research has been conducted with the security agents.

The user research with the security agents consists of two parts: *questionnaires* and *semi-structured interviews* in operation.

The security companies G4S and I-Sec agreed to take part in the research for the project.

1. Questionnaires

In the questionnaire the agent's opinion about centralised security, the SSL touch points and job satisfaction was asked. Moreover, agents were asked to report regular occurring issues and to give suggestions for improvement. Both a hardcopy and a digital version was created, which can be found in **Appendix D** and **Appendix E.**

2. Semi-structured Interviews

The semi-structured interviews were executed at the EF filter and recorded using field notes (**Appendix G.**). These interviews served as additional support for the questionnaires, which provided more in depth information about the issues in the operation.

Analysis

The results from the questionnaires were analysed by applying a thematic analysis.

The focus was on finding frequently occurring themes between questionnaires and between interviews. This was done by highlighting statements made by the respondents, which were then gathered and clustered into themes (**Fig. 3.3**). All statements were counted to determine the occurrence rate and thus the relevance of each theme.

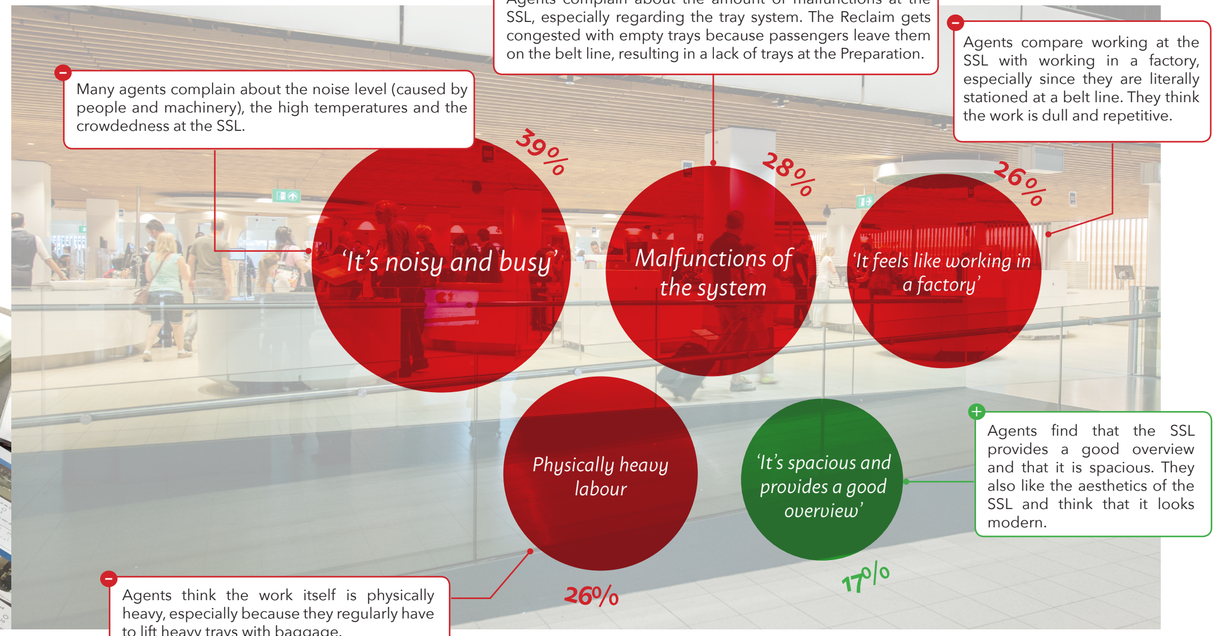
Key results

The key results are visualised by using red and green circles. The red circles represent the aspects that are disliked by the agents, whereas the green circles represent the aspects that are liked. Additionally, the size of the circles correspond with the occurrence rate and thus the relevance of each theme. The occurrence rate is also represented by the percentage attached to each circle. The complete collection of results can be found in **Appendix F.**

Legend

⊕ = Positive response
⊖ = Negative response

Fig. 3.3 | Processing the questionnaire results

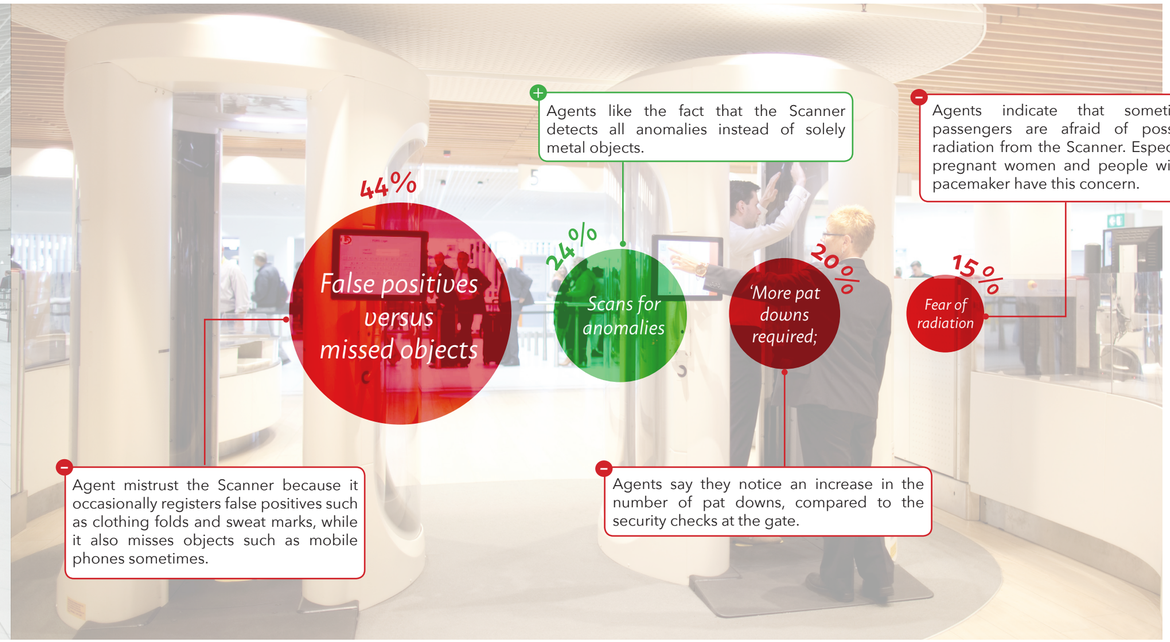


2 Preparation

Most agents think three passengers at the Preparation is too much to handle simultaneously. Agents cannot focus on every individual passenger all the time, increasing the possibility of passengers not being prepared correctly. This leads to unnecessary pat downs and re-checks, and frustration with the agents.

Agents indicate that passengers do not understand what to do, and that they also do not pay attention to the instructions. They complain about passengers just throwing their bags directly on the belt and still having items in their pockets.

4 Passenger scan



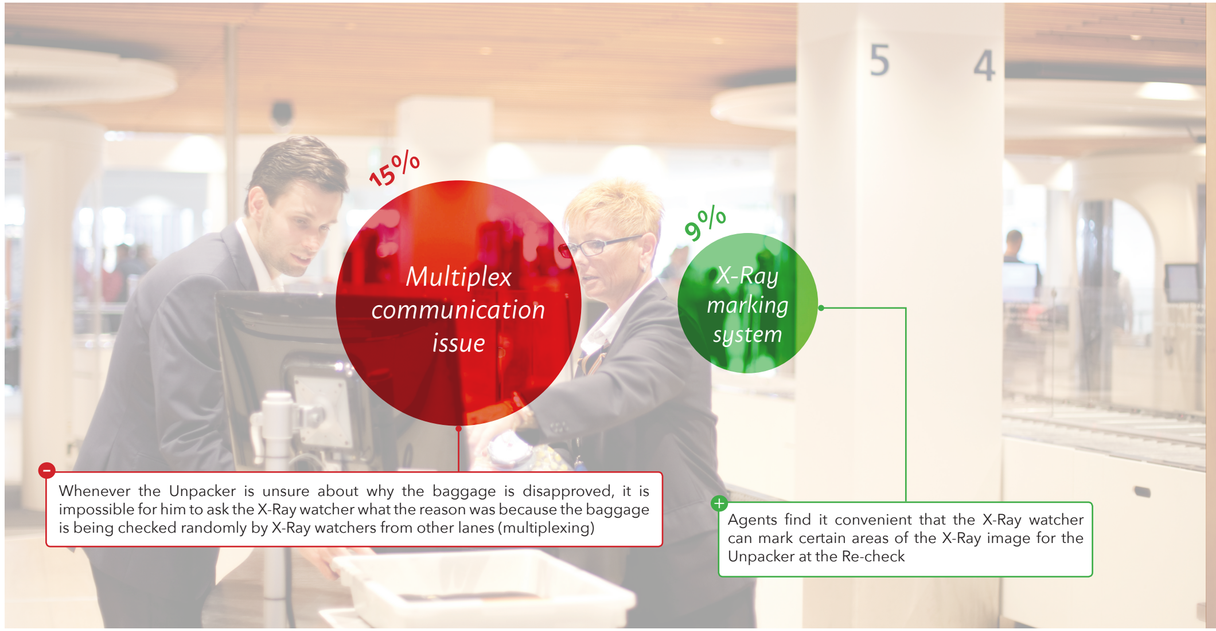
Agents like the fact that the Scanner detects all anomalies instead of solely metal objects.

Agents indicate that sometimes passengers are afraid of possible radiation from the Scanner. Especially pregnant women and people with a pacemaker have this concern.

Agent mistrust the Scanner because it occasionally registers false positives such as clothing folds and sweat marks, while it also misses objects such as mobile phones sometimes.

Agents say they notice an increase in the number of pat downs, compared to the security checks at the gate.

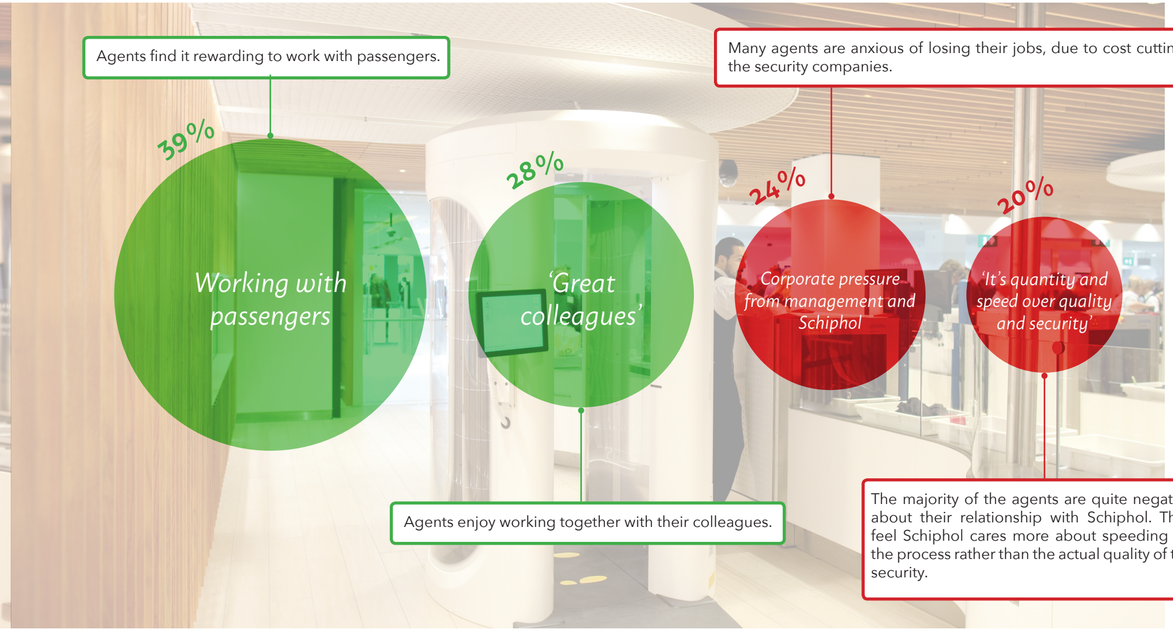
6 Baggage re-check



Whenever the Unpacker is unsure about why the baggage is disapproved, it is impossible for him to ask the X-Ray watcher what the reason was because the baggage is being checked randomly by X-Ray watchers from other lanes (multiplexing)

Agents find it convenient that the X-Ray watcher can mark certain areas of the X-Ray image for the Unpacker at the Re-check

Job satisfaction



Agents find it rewarding to work with passengers.

Agents enjoy working together with their colleagues.

Many agents are anxious of losing their jobs, due to cost cuttings at the security companies.

The majority of the agents are quite negative about their relationship with Schiphol. They feel Schiphol cares more about speeding up the process rather than the actual quality of the security.

After conducting the field observations (**paragraph 2.6**) and user research, a clear view on the macro problems at Schiphol security was obtained. In this paragraph a summarised overview of these macro problems are discussed.

Cumulative characteristics

The key issue that emerged was the influence of ineffective preparation on the passenger check and baggage check.

1. It is common that passengers are not fully prepared because they still have items in their pockets such as mobile phones, coins, boarding tickets and passports. These will be detected by the Security Scanner at the passenger check, whereafter the passenger needs to be patted down.

2. Electronics and LAG's are not unpacked from the baggage. Consequently, these will be detected by the X-Ray watcher at the baggage check, whereafter it will be transported to the re-check area.

Both are cases of an extra checking step that could have been prevented by preparing the passenger and baggage more effectively. Instead, this cumulative effect of ineffective preparation leads to unnecessary delays(**Fig. 3.5**).

Influence of Clearscan

However, Schiphol is currently doing pilots with the Clearscan by L3, which is a new type of baggage scanner that can solve the problem of incomplete baggage preparation (**Fig. 3.4**). The Clearscan scanners use CT screening technology, which facilitates 3D-imaging of the baggage. Section views of the baggage can be made so that passengers do not have to take out electronics and LAG's anymore. This means the preparation will be easier and will go significantly faster. However, this increases the pressure on the passenger check, because the baggage flow becomes quicker than the passenger flow. During Schiphol's pilots, a significant increase in the queue before the Security Scanner was observed.

Fig. 3.4 | Passengers can leave their electronics in their bags with the Clearscan (background)

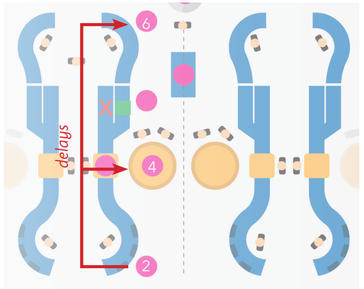


Fig. 3.5 | Cumulative effect from preparation

Technical issues

Security agents complain regularly about the malfunctions with the tray system.

An even more pressing issue is the inconsistent detection algorithm at the Security Scanner. Agent do not always trust the Security Scanner because it occassionally detects false positives such as folds in clothing and sweat marks, while at the same time it misses objects such as mobile phones and keys (see Passenger Scan section in **paragraph 3.2**).

Ineffective communication to passenger

Information about the rules and procedures at the SSL are not communicated effectively, if at all:

Procedural information: Passengers are not fully aware of what actions are expected at each touch point. The information posters in the queue, the stickers on the SSL and the Scanner are not read/ seen by passengers (**Fig. 2.10**).

Safety information: There is no information on the Security Scanner stating it uses non-hazardous millimeter-waves. Sometimes, passengers (especially pregnant women and people with pacemakers) are afraid of being exposed to radiation.

Confusing rules: At most airports, passengers are required to take off their belts and shoes at the security checkpoint. At Schiphol, only belts with 'large' buckles and 'high' shoes have to be taken off. These are very fuzzy definitions. Even more confusing, some agents always ask passengers to take of their belts and shoes. This inconsistency can get very confusing for the passenger.

Agents' working experience

Most agents are not satisfied with the working conditions at the SSL (see Centralised security / SSL section in **paragraph 3.2**). They think it is similar to working in a factory due to the repetitiveness of the work and the high noise level. They also experience the work itself as straining both physically as mentally. Frustrations run high when passengers make mistakes and don't appear to pay attention to the task.

Additionally, the relationship between the agents and Schiphol is cumbersome. The agents feel like Schiphol cares more about increasing capacity, minimising costs and process efficiency than the actual security. Moreover, many agents fear losing their jobs due to corporate cost cuttings.

Many of these findings from the agent research are also mentioned in the FNV report about agents' experiences regarding working at centralised security (FNV, 2016).

All this influences the agents' mood and serviceable attitude in a negative way, which is often outed towards the passenger. Consequently, this results in a bad passenger-agent relationship.

A thorough understanding of the system and its dynamics was gained by first analysing the SSL as a whole. The findings of this analysis serve as a latent knowledge basis for the rest of the project, because possible influences of design interventions can be predicted more accurately.

Most of the problems with the SSL exist on a system level (the cumulative effect) or stem from ineffective communication towards the passenger. While there are many starting points for improvement and quick wins to be made, the scope of the assignment should be respected: improving the usability of the Security Scanner.

The following chapter depicts a thorough analysis of the Security Scanner, as well as a deconstruction of the interactions at the passenger check. Usability issues will be identified, which will serve as a basis for the Design Vision (**Chapter 5**).

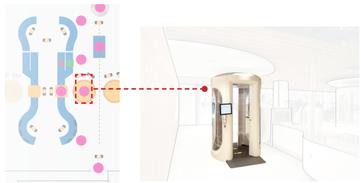


Fig. 3.6 | Assignment scope: Security Scanner

Chapter 4 | **L3 Security Scanner**

This chapter describes the Provision-2 active millimetre-wave scanner, used at the Schiphol security filters. Furthermore, the passenger checking process is deconstructed and visualised in a process timeline, in which the key usability issues are mapped as well. This analysis serves as a foundation for the Design Vision in chapter 5.

4.1 | L3 ProVision-2

The Security Scanner used at the SSL is the ProVision-2 (PV2) active millimetre-wave scanner made by L3 Communications. It uses non-ionising millimetre-waves to detect anomalies on the human body. As opposed to the traditional metal detection gate, the PV2 can detect anomalies of all materials such as plastics, ceramics, powders, gels and explosives (L3, 2017).

Millimetre-waves

Millimetre-waves (MMW) are electromagnetic waves with wavelengths ranging from 10 to 1 mm, corresponding with frequencies between 30 and 300 GHz (Harris, 2012). Within the electromagnetic spectrum, MMW falls between microwaves and infrared waves.

MM-waves are non-ionising, meaning it cannot alter the molecular structure of the recipient and is therefore considered harmless. Moreover, MMW can penetrate only one layer of clothing but cannot penetrate the body.

Detection process

In the PV2 there are two rotating transmitters that emit the MM-waves to the person standing inside the Scanner. Depending on the material, the waves are then partially absorbed and partially reflected back to the emitters. Based on the absorption rate, the Scanner can distinguish between different materials.

The results are then processed according to the Automatic Target Detection (ATD) algorithm (L3, 2017). There is an algorithm for both male and female passengers.

Finally, the found anomalies are highlighted as yellow spots onto a mannequin figure on a screen for agents to see (**Fig. 4.1**). The agent will then proceed to execute a partial pat down with focus on the highlighted areas. In case no anomalies are found, the screen displays a green background with the text 'OK'.

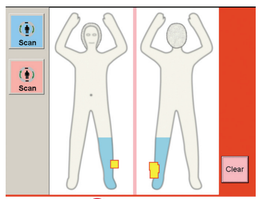


Fig. 4.1 | Detection on right leg

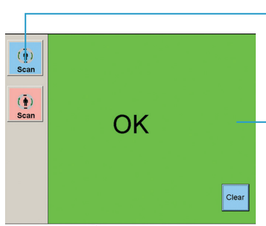


Fig. 4.2 | No anomalies detected

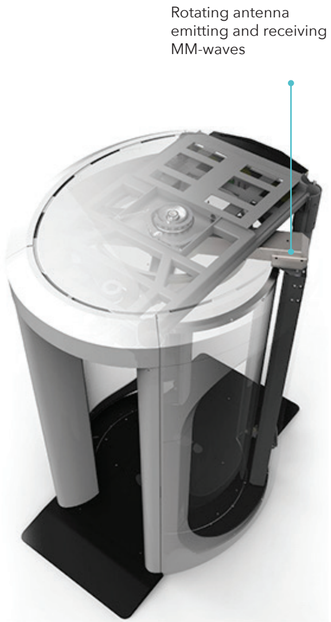


Fig. 4.3 | Cutaway of the PV2 showing the antennas

Taking the correct posture

After the passenger has entered the Scanner, he has to step on the yellow footsteps and raise his arms to take the so called 'ballerina' posture. The arms have to be raised in order to prevent passengers from hiding items under their armpits, and to obtain the most transparent and accurate scan results.

The Scanner contains two use cues to assist the passenger in taking the correct posture. The yellow footsteps on the floor indicate the passenger's feet placement (**Fig. 4.4**), and the mannequin demonstrates the ballerina posture (**Fig. 4.5**).

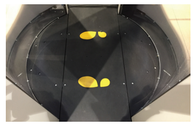


Fig. 4.4 | Use cue: yellow footsteps

Fig. 4.5 | Use cue: mannequin sticker

Standard procedure

1. The agent calls over the waiting passenger to step inside the Scanner
2. While the passenger enters, the agent points at the yellow footsteps and instructs to 'Stand on the yellow footmarks please'
3. After placing the feet correctly, the agent demonstrates the ballerina posture by raising his arms
4. When the passenger's posture is correct, the agent presses either the male or female scan button, depending on the passenger's gender
5. The passenger has to hold the ballerina posture for three seconds, while the antennas rotate around the passenger 'illuminating' him with millimetre-waves
6. After the antennas have rotated, the Scanner takes approximately three seconds to process the results using the ATD algorithms. In the meanwhile, the passenger is either guided out or has to wait inside the Scanner, depending on whether a pat down already is being executed
7. Once the detection is complete, the agent checks the results on the screen.

    - In case of detection: The passenger has to be patted down, which has to be executed by an agent from the same gender
    - In case of no detection: The passenger may proceed directly to the baggage reclaim or re-check (depending on the detection results of the baggage scan)

8. While the first passenger exits the Scanner the next passenger is being called over, repeating steps 1-7

Continuous scanning

Agents always strive to get passengers out the scanner as quickly as possible. There is always a processing time of the Scanner involved, but agents rather have passengers wait on the pat down spot than inside the scanner. This way the next passenger can already step inside the scanner. This is called 'continuous scanning'. However, this is often not possible due to pat downs already being executed, which means the passenger often has to wait inside the Scanner. **Paragraph 4.2** discusses the influence of pat downs on the throughput of the scanner in more detail.

4.2 | Throughput Security Scanner

The throughput of the Security Scanner can be defined as the amount of passengers going through the Scanner per time unit. Throughput measurements were performed on different lanes at the EF filter, by using a tally counter (measurements in **Appendix K.**). The average throughput is approximately **2,5 passengers per minute**. Schiphol claims a throughput of 10 passengers per minute is possible in case all individuals are completely knowledgeable about the process.

The throughput depends on a large variety of factors, which are mapped in the schematic in **Appendix J.**. However, according to measurements and calculations by the R&D department, the throughput is for approximately **80%** defined by the pat down time.

This becomes most apparent whenever two consecutive passengers of the same sex have to be patted down (**Fig. 4.6**, situation B1). The problem is that the whole passenger check runs to a hold, because the second passenger has to wait inside the Security Scanner for the agent to finish patting down the first passenger.
Because the pat downs account for such a significant percentage of the throughput, there are currently two options for increasing the throughput of the Security Scanner:

2,5 pax/min = Average throughput

1. **Decreasing the number of pat downs** This can be done by making a design intervention at the Preparation in order to prepare the passenger more effectively. This will decrease the number of unnecessary pat downs. Another option would be to improve the detection algorithms of the Security Scanner.

2. **A reconfiguration of the pat down area**
   This is more an intervention on the system level. By moving the pat down area further to the back, it is possible to line up passengers that need to be checked. This allows the following passengers to be scanned continuously, thus increasing the throughput. However, this is not really a solution as it causes a shift of the bottleneck. The baggage of the passengers that need to be checked will pile up, causing a bottleneck at the Baggage Reclaim.

However, since both options fall outside the project scope, **the throughput issue will not be addressed.**

A1: This is the ideal situation, where the Scanner detects no anomalies on the passenger's body. The passenger can proceed to reclaim *(continuous scanning)*.

A2: While the first passenger (male) is being patted down, a second passenger from the other sex (female) is being scanned. There Scanner detects no anomalies which means she can proceed to reclaim *(continuous scanning)*

B1: The first passenger (male) is being patted down, while a second passenger from the same sex (male) is being scanned. The Scanner detects anomalies on the passenger's body which means he also has to be patted down. However, he has to wait inside the Scanner until the agent finished the pat down of the first passenger *(process on hold)*

B2: The first passenger (male) is being patted down, while a second passenger from the other sex (female) is being scanned. The Scanner detects anomalies on the passenger's body which means she also has to be patted down. However, the female passenger and female agent have to wait inside the Scanner until the pat down position is free to use *(process on hold)*

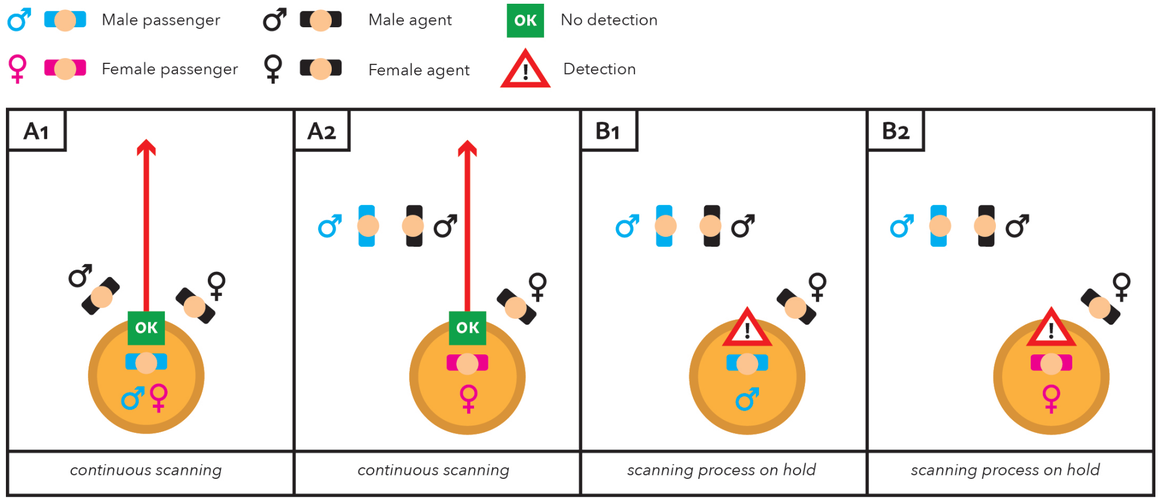


Fig. 4.6 | Possible configurations at the passenger check (also inverted male/female configurations are possible)

4.3 | Process deconstruction

The initial field observations (**paragraph 2.6**) were focused on exploring the SSL. After narrowing down the project scope, focused usage observations were executed at the Passenger Check (4) to get a more thorough understanding about the procedures and concerns. These observations were executed at the EF filter as well.

The insights gathered from the user observations are mapped in a process timeline (**Fig. 4.8**). This timeline shows the activity of the passenger, the agent and the Scanner during a single scanning cycle.

Usability Issues

The main goal of the observations, was to find usability issues related to the Security Scanner (**Fig. 4.7**). These are represented by the red triangles in the timeline. The issues are explained in the next section.

1. Passenger does not know when to enter
2. Passenger walks directly through Scanner
3. Passenger's body does not face blue mannequin
4. Passenger's feet are not placed exactly on footsteps
5. Passenger's face not towards mannequin
6. Passenger's arms not raised (correctly)
7. Passenger moves during scan
8. Passenger does not know how long to hold pose
9. Passenger wants to exit but has to wait for agent
10. Pat down comes unexpected

Fig. 4.7 | Usability issues at the passenger check

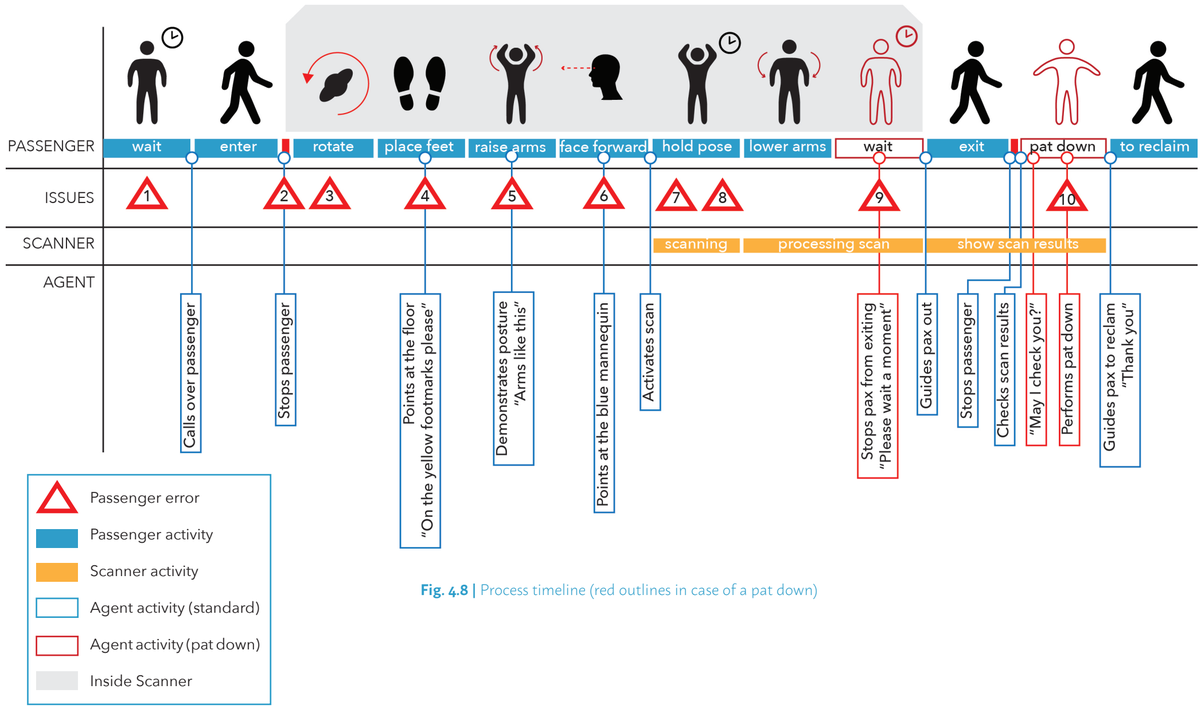


Fig. 4.8 | Process timeline (red outlines in case of a pat down)

Explanation of the usability Issues

1

The passenger does not know when to enter the Security Scanner. While some passengers step in after their predecessor has exited, most passengers wait for instructions from the agent.

Cause: There are no use cues provided by the Scanner at all that indicate the passenger either has to wait, or that he should enter.

Current solution: The agent gives the entrance cue by making a 'come over' gesture, often supported by a nod.

2

The passenger walks directly through the Scanner without being scanned.

Cause: The passenger mistakes the Scanner for a metal detection gate, where walking through is the intended way of use. This behaviour is a result of former experience.

Current solution: The agent blocks the exit, and points at the yellow footsteps on the floor or at the blue mannequin on the glass pane.

3

The passenger does not face the blue mannequin. Instead, the passenger keeps facing the walking direction (towards the agent), or is positioned reversely.

Cause: There is no cue indicating this bodily orientation, except for the feet pointing towards the blue mannequin. Moreover, it is unnatural to stop and rotate, especially while focusing on the agent for instructions.

Current solution: The agent points at the yellow footsteps on the floor or at the blue mannequin on the glass pane.

4

The passenger's feet are not placed exactly on the yellow footsteps, decreasing the accuracy of the scan.

Cause: The passenger does not know exact feet placement is of much importance. Moreover, often he is distracted by the agent or the blue mannequin.

Current solution: The agent points closely at the yellow footsteps, and back and forth at the passenger's feet.

5

The passenger's arms are not raised, or not in the correct position yet. In the latter case, the arms are often not raised high enough or are not aligned with the body in side view.

Cause: The blue mannequin is not clear or visible enough, or the passenger might think his arms are in the correct position already.

Current solution: The agent demonstrates a movement where he raises his arms (higher) or puts emphasis on aligning his arms with his body.

6

The body is in the correct position but the passenger's head faces towards the agent.

Cause: The passenger keeps looking at the agent for confirmation and further instructions. It is unnatural to face away from the person you are having a conversation with.

Current solution: The agent points at the blue mannequin.

7

The passenger moves during the scan, which strongly influences its quality. This often results in a faulty or blurry scan.

Cause: The passenger turns his heads to look at the agent for further instructions / confirmation. Additionally, there is no instruction that the passenger should freeze his posture during the scan.

Current solution: The agent performs a re-scan of the passenger.

8

The passenger does not know for how long the ballerina posture has to be kept. This problem manifests itself in the passenger holding the posture while he is allowed to exit the Scanner. Another possibility is that he tries to exit the Scanner before the scan is finished (resulting in a faulty scan).

Cause: There is no clear communication about whether the scan starts, is in progress or is finished.

Current solution: The agent guides the passenger out when the scan is complete, or sends him back in case of a faulty scan.

9

The passenger does not know when to exit the Scanner. Some passengers wait inside the Scanner for further instructions, while others want to exit but have to wait because the agents are busy with a pat down.

Cause: The passenger thinks he may exit the Scanner after the antennas have moved, and there is no instruction that contradicts this.

Current solution: The passenger is blocked by the agent who makes a 'wait here' gesture.

10

The pat down comes unexpected to the passenger

Cause: Passengers do not understand why a pat down is required after a full body scan. They do not know the passenger check consists of two steps (a body scan and a partial pat down).

Current solution: None, except for when a passenger gets frustrated. In this case the agent tries to mediate and explain the procedure.

Chapter 5 | **Design vision**

A Design Vision is established based on the analysis from the field observations and user research. The design vision consists of a Problem Definition, a Design Goal and an Interaction Vision. The establishment of the Design Vision concludes the Discover stage, and serves as the foundation for the Ideation stage.

5.1 | Problem Definition

In this paragraph, the problem definition is formulated and discussed. It concretely describes the problems that will be addressed, and will serve as a foundation for the Design Vision and Ideation stage.

The problem definition is based on the field observations at the EF transfer filter, the research with the security agents from paragraph (3.2) and the analysis of usability issues with the Security Scanner from paragraph (4.3).

The problem definition is explained using the framework in (Fig. 5.1): The problem not only manifests itself in the user-product atmosphere, but also in the relationship between both users.

The problem definition is comprised of three elements:

1. The incoherent relationship between passenger, agent and Scanner
2. The lack, and the quality of use cues of the Scanner
3. The lack of corrective, confirmatory and informative feedback from the Scanner to the passenger

1. Inconsistent relationship between users and Scanner

Excessive instructions
Both the agent's instructions and the use cues are aimed to guide the passenger through the passenger checking process as smooth as possible. However, the passenger is overwhelmed by having to pay attention to both simultaneously. This overkill of instructions results in confusion.

Distraction from use cues
Passengers do not get the opportunity to manage taking the correct posture by themselves, because agents immediately give instructions upon entering. This means the passenger is distracted from the Scanner's use cues.

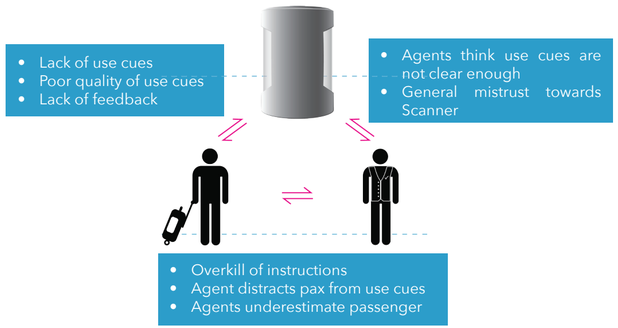


Fig. 5.1 | Problem definition framework

The actual observation of this problem appeared during the reference tests with the prototype (paragraph 9.2)
The reasons the agents immediately starts giving instructions are:

- They are instructed to do so by either management or Schiphol, mostly to give a serviceable impression
- Agents think passengers cannot manage by themselves because:
  - They think the use cues are not clear enough
  - They think passengers are not focused on the task, but more on the whereabouts of their luggage and on getting through of security as quick as possible
  - They underestimate the passenger's autonomous capabilities

2. Lack and quality of use cues

There is a lack of use cues at the Security Scanner.
There are too little instructions to guide the passenger through the whole process as the existing use cues describe only a small part of the required actions. More specifically, there is a lack of:

- An entrance cue. The passenger does not know whether he should enter or wait.
- A cue to trigger a 90° rotation. Aside from the footsteps pointing in the right direction, there is no cue specifically aimed at rotating the passenger towards the mannequin.
- An exit cue. The passenger does not know whether he should wait or is allowed to exit directly after the scan.

The existing use cues are not effective enough and incomplete:

- Yellow footsteps (Fig. 5.2): No emphasis is put on that passengers' feet have to be placed exactly on the yellow footsteps.
- Mannequin(Fig. 5.3): The mannequin only indicates the bodily posture in front view, not in side view. It is important to align the passenger's arms in side view for an accurate scan. Moreover, the mannequin is not visible enough because of the low contrast with the background. Finally, the text is too much to read in such a short amount of time, and is only written in English only.

3. Lack of feedback

The Security Scanner is a static non-responsive object that provides no active feedback to the passenger at all. There is no corrective feedback that attempts to correct the passenger's mistakes, nor confirmatory feedback to indicate the passenger shows the correct actions. More specifically the Scanner does not:

- Notify the passenger to prevent him from walking through the Scanner [corrective]
- Notify the passenger when he is not facing the mannequin [corrective]
- Notify the passenger when his feet are not (exactly) on the yellow footsteps [corrective]
- Notify the passenger when his arms are not raised, or are in an incorrect position [corrective]
- Notify the passenger about the state of the scan: start of scan, scan in progress, scan finished [informatory]
- Notify that the passenger should either go to the baggage reclaim or the pat down area [informatory]
- Notify the passenger should wait inside the Scanner (in case a pat down is in progress) [informatory]

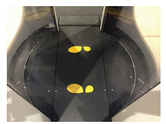


Fig. 5.2 | Passengers do not place their feet exactly on the footsteps

Influence on User Experience

The lack of (proper) use cues and feedback, along with the excessive instructions makes it difficult for the passenger to understand what to do. This results in confusion and increased anxiety with the passenger, and often leads to delays at the passenger check.

Additionally, constantly giving instructions results in strain on the agent's body and mind. This leads to fatigue and frustration, especially when a passenger struggles with performing the desired behaviour (and thus causing delays).

Consequently, this less pleasant attitude of the agent influences the agent-passenger relationship in a negative way, resulting again in a bad security experience for the passenger.

Fig. 5.3 | The mannequin only demonstrates the posture in front view

5.2 | Design Goal

'To enable inexperienced Schiphol passengers to use the Security Scanner autonomously, by providing **responsive guidance** and **real-time feedback** during each step of the way'

The Problem Definition is followed by the Design Goal, which serves as the foundation for the Ideation Stage.

The first problem in the Problem Definition (**paragraph 5.1**) is solved easily: tell the agent to not give instructions anymore. This prevents passengers from being overwhelmed and distracted, allowing them find out for themselves what posture to take. Not giving any instructions also reduces the constant physical and mental strain on the agent.

However, this directly increases the significance of the other two problems since the passenger now has to be able to use the Scanner autonomously. Since the current use cues are incomplete and insufficient and there is no feedback from the Scanner, an alternative type of **guidance** should be provided.

The monitoring and controlling tasks of the agent should be taken over. Therefore, the guidance should be **responsive** to the position and behaviour of the passenger. Furthermore, **real-time feedback** should be provided in order to either correct or confirm the passenger's actions. The design goal is formulated as follows:

'Enable first time users to use the Schiphol Security Scanner autonomously, by providing responsive guidance and real-time feedback during each step of the way'

The guidance should be provided for:

1. Entering and exiting the Scanner
2. Taking and holding the correct posture

The feedback should be provided for:

1. Corrections and confirmations regarding the passenger's posture [corrective and confirmatory]
2. Indicating the status of the scan (start scan, scan in progress, and scan finished) [informative]
3. Communicating whether a pat down is required or not [informative]

Target group and location

This Design Goal is specifically aimed at inexperienced Schiphol passengers because the usability problems stated in **paragraph 4.3** are most significant with this target group. Passengers with former experience at Schiphol Security are more knowledgeable about the process, thus generally require less instructions / corrections.

Most inexperienced Schiphol passengers can be found at the transfer filters. However, with centralised security it remains difficult to target a specific group since it always is a mix of several passenger types. Nevertheless, the expectation is that the largest improvements can be made at the transfer filter. Therefore, the prototyping tests will be executed at the EF filter, just like the earlier observations.

5.3 | Interaction Vision

The Interaction Vision describes the desired interaction characteristics between the passenger and the design intervention:

Friendly: Passengers can perceive security checkpoints as intimidating and impersonal. A friendly interaction can change the passenger's experience into a more personal and positive one.

Captivating: The interaction should be captivating so the passenger will only focus on following the guidance, and will not be distracted by his surroundings

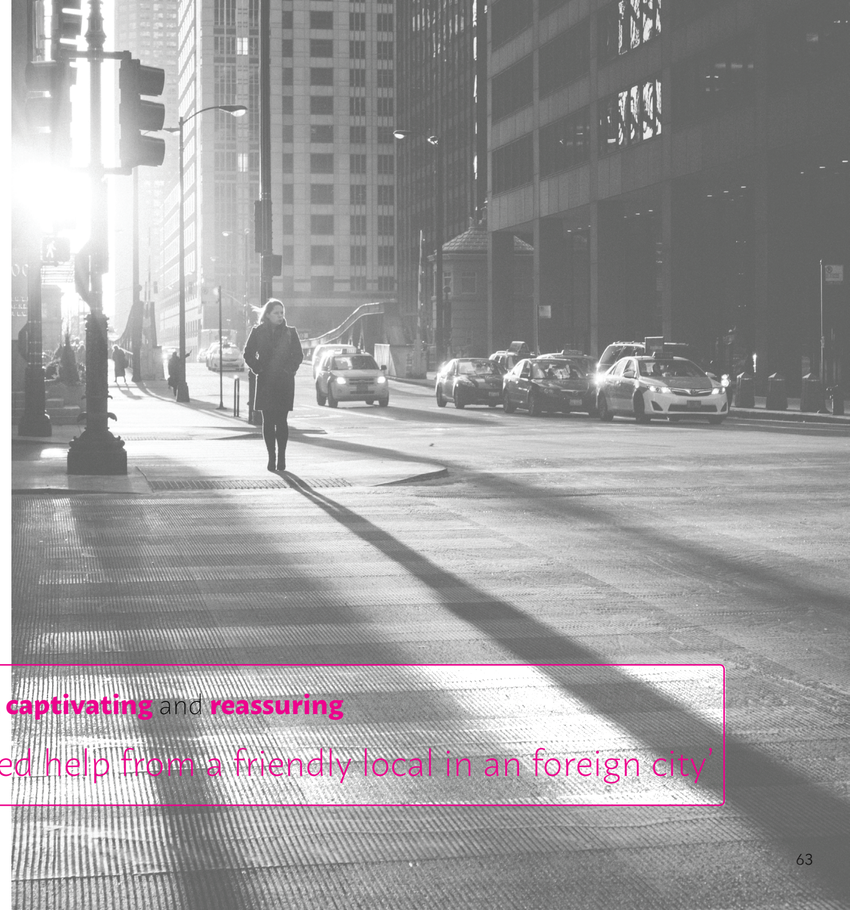
Reassuring: The interaction with the Scanner should also be reassuring, so that the passenger knows he is performing well and feels more secure in his actions.

Like receiving unexpected help from a friendly local in a foreign city

The metaphor is chosen because the passenger might also feel like a stranger lost in an unknown city: intimidated, insecure and slightly anxious. The use of the design intervention should feel like receiving help from a friendly local who takes you under his wing to help you find your way.

The design should feel **friendly, captivating** and **reassuring**

'Like receiving unexpected help from a friendly local in an foreign city'



5.4 | Design Criteria

01. Addition to the existing configuration
The design should be an addition to the Security Scanner, rather than a redesign. Moreover, no physical changes inside the Scanner can be made.

02. Fitting security context
The design should fit the security context. It should be functional and unobtrusive, rather than expressive and overly present (e.g. not a Disney attraction).

03. Safety
- There may be no obstructions in the path between the Scanners
- There may be no hazard of components falling on users, or users tripping over components
- There may be no sharp or protruding parts
- There may be no open electronic circuits
- The design should meet the fire safety regulations

04. Inclusive/universal ergonomics
The dimensions of the design should be based on the P50 anthropometric data of the average EF-passenger, and should also be suitable for the P5 and P95 individuals of this group.

05. Throughput
The design should provide a throughput of at least 2,5 passengers per minute (**paragraph 4.2**).

06. Fitting SSL aesthetics
The design should fit within the SSL aesthetics (**paragraph2.4**)

07. Privacy
The passenger may not get the impression that he is being recorded.

08. Simple and unambiguous design
The design should be simple and unambiguous in order to be most effective and understood quickly.

09. Concise design
The design should be as concise as possible, meaning it should not contain any redundant elements.

10. Honest design
The design should have a valid reason of existence. It should not present itself other than what it is (e.g. trying to make it fun). It should fit the motto 'we cannot make it anymore fun, but we can make it easier'.

11. Level of technology
Low tech and easy to implement solutions are preferred over high tech solutions. Moreover, the technology should be fitting to the purpose, in order to prevent another case of a technology push.

12. Installation / implementation
As little changes as possible should be made to the SSL, regarding the implementation of the design. Moreover, the current (network and power supply) infrastructure should be maintained.

13. Costs
The production/material-, implementation- and operating costs of the design should be as low as possible. Considerations regarding type of technology, power consumption and material use should be made.

14. Manual overruling
The agent should still be able to manually give instructions when required. Also in case of a malfunction, the agent should be able to disable the design.

15. Life span
The design should be able to operate for 18 hours a day for a minimum period of 5 years.

16. Accurate monitoring
The design should be able to track the position and movements of the passenger accurately in order to provide effective guidance and feedback. Moreover, it should be able to distinguish between passengers.

STAGE II - IDEATE

Chapter 6 | **Ideation cycle I**

The establishment of the Design Vision concludes the Discover stage, and is the foundation of the Ideation stage. This stage is comprised of two ideation cycles, a concept design phase and a prototyping phase.

In this first cycle, the ideation style is still very loose and free. Sketching ideas freely allowed the mind to be cleared of obvious directions, and stimulates thinking more thoroughly about the practical implications of certain ideas. Additionally, two probing experiments were executed in operation to get a feeling on how passengers would react to certain interventions.

6.1 | Early ideation

In this paragraph, the free ideation sketches are explained briefly and evaluated using the PMI method from the Delft Design Guide on page 145 (van Boeijen, Daalhuizen et al. 2014).

1

Informing the passengers about the security procedures beforehand, could be a more effective way of preparing them. Especially when it is a moment they can pick themselves, for instance during the **flight** or through the **Schiphol App**. Passengers will be more at ease which offers them the possibility to study the security procedures more carefully.

- ⊕ Choose your own moment to study the procedures (not stressed)
- ⊖ Passengers are not actively looking for this information (not interesting)
- ⊖ Collaboration with airline companies required (in case of info on plane)
- ⊖ Passengers may forget the information
- ⊖ Poor fit with design goal (not responsive)

- ✳ Possibilities for gamification (e.g. smartphone security game)

2

An **information screen** on the security filter could be a more effective way to communicate the security procedures. A screen with animations is more noticeable and expressive than an instruction poster.

- ⊕ More noticeable and more expressive than a poster
- ⊖ Another extra stimulus in an already busy environment
- ⊖ Aimed at group, rather than individuals
- ⊖ Not responsive

3

The Scanner contains very static use cues. By adding **interactive elements** the instructions can be made more expressive and intuitive. For instance, for the enter and exit cue, a **traffic light** or a gate can be used. For the posture, flashing footsteps in combination a **live projection** of a moving mannequin can be used.

- ⊕ Expressive and intuitive (universal)
- ⊕ Good fit with design goal (responsive)
- ⊖ Possible interference with detection

- ✳ Basis for many types of ideas

4

A preparation tray with **compartments for specific items** could be a more effective way to make sure passengers unpack everything. The shape of the compartment can serve as an affordance, or stickers can be used to indicate which item should be placed where. This decreases the possibility of passenger not unpacking everything, thus prevents unnecessary pat-downs and re-checks. It can be made even more effective by adding visual, auditory or even haptic feedback.

- ⊕ Simple, intuitive and effective
- ⊕ Prevents unnecessary pat downs
- ⊖ Outside design scope (aimed at Preparation)

- ✳ Can make agent's job easier

5

By using Augmented Reality technology through either **AR glasses** or a **smartphone**, the passenger can see instructions / demonstrations as a digital overlay when looking at a specific touch point.

- ⊕ Position based instructions aimed at each individual passenger
- ⊕ Live information
- ⊖ Electronics not allowed
- ⊖ Impractical

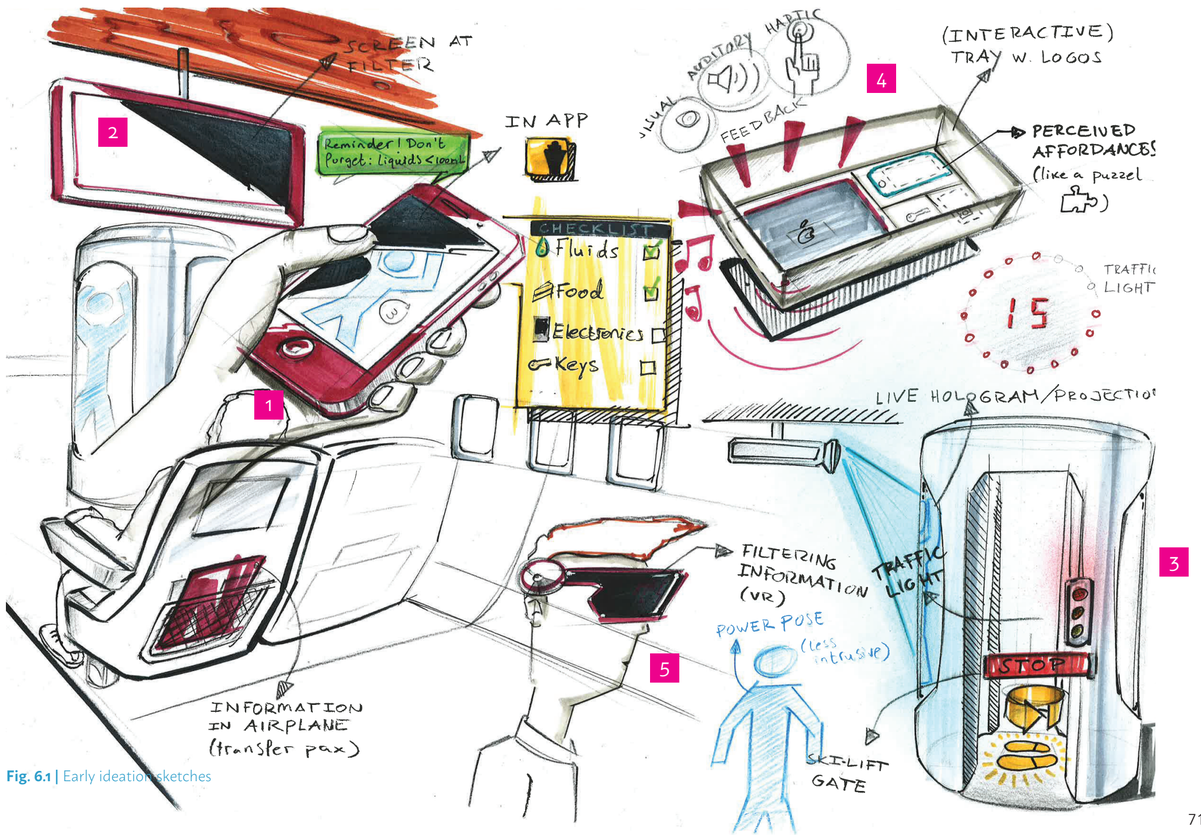


Fig. 6.1 | Early ideation sketches

6

Another way of making sure passengers are fully prepared for the security check is to create a **threshold**. Passengers cannot proceed if they still have items on them. In this example, the passengers first has to throw his water bottle in the bin before the gate is opened.

- ⊕ Prevents unnecessary pat downs
- ⊖ Extra step (decrease in throughput)
- ⊖ Occupies extra space

7

Instead of sending a signal to the passenger that he has to enter the Scanner, the passenger can also be the initiating factor. Implementing a button which the passenger can press to 'open' a door or gate (as seen in public transport) to the Scanner, solves the problem of not knowing whether to enter or not.

- ⊕ Effective solution to the problem of not knowing when to enter
- ⊕ Lights around button have communicative function
- ⊖ An extra door / gate is not aesthetic and adds to the claustrophobic experience

- ⊛ Interesting take on security to let passenger take control, instead of agent

8

A suit for the agents to wear, containing small vibration engines for **haptic feedback**. This suit vibrates at the points where the passenger needs to be checked, so the agent does not have to look at the screen of the Scanner anymore.

- ⊕ Very intuitive
- ⊕ Original
- ⊖ Might get annoying after a while
- ⊖ No fit with design goal at all (does not help passenger)

- ⊛ Interesting possibility to improve agent's workflow and work experience

9

Passengers are allowed to use the Scanner of the neighbouring lane when it is not in use. However, most passengers are not aware of this.

Rotating the Scanners inwards and/or **intuitive wayfinding** are ways to communicate that both Scanners can be used. It triggers the passenger to pick the Scanner based on availability rather than solely sticking with their own Scanner. No differentiation between lanes is made anymore, which results in a funneling effect of both lanes and increases the overall throughput.

- ⊕ Cheap and simple
- ⊕ Quick to implement
- ⊖ Line cutting possible
- ⊖ Not much exit space
- ⊖ Not directly fitting design goal

- ⊛ Interesting to see whether this could be a quick fix for increasing throughput

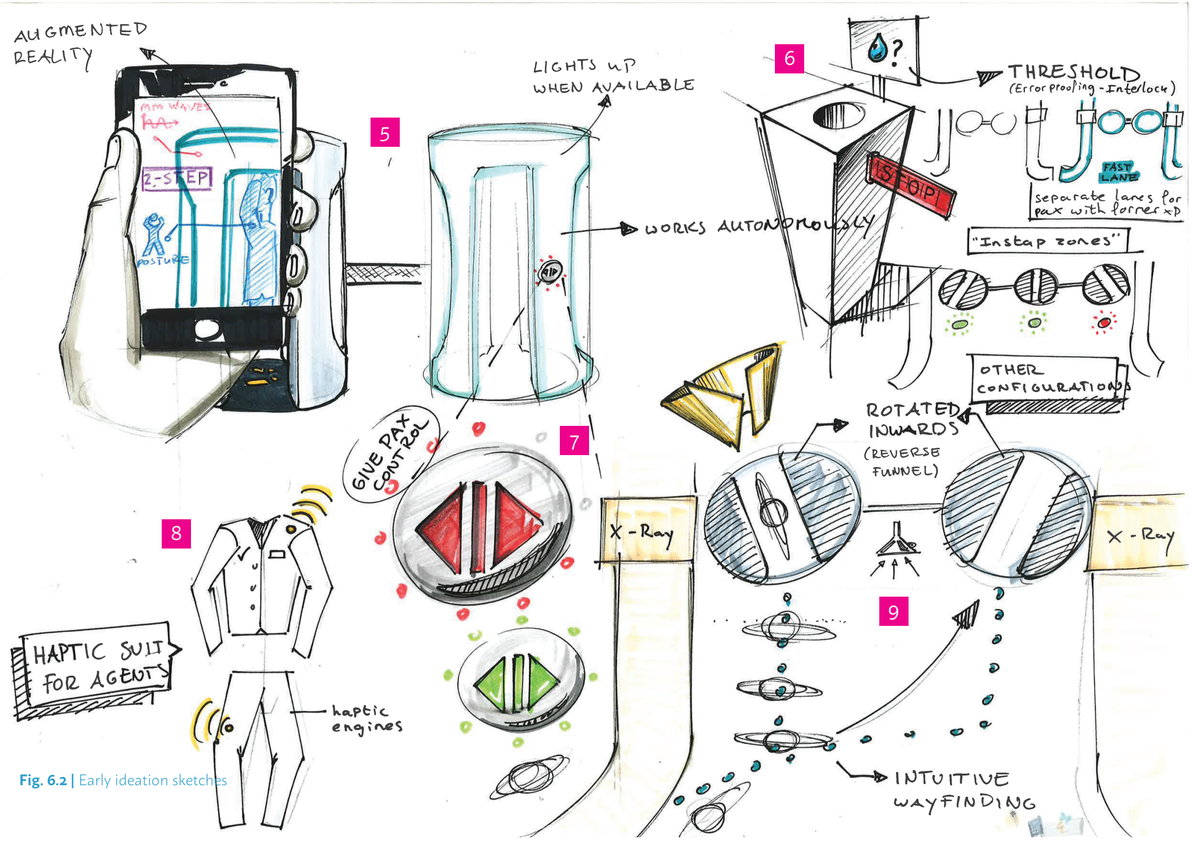


Fig. 6.2 | Early ideation sketches

6.2 | Probing experiments

In parallel with the initial ideation, two probing experiments at the EF filter were executed to get a feeling for how passengers would respond to design interventions at the passenger check.

Experiments were executed with:

I. A waiting line before the Security Scanner
II. A LED strip on the entrance of the Security Scanner

The results of the tests can be found in (**Appendix O.**), and will be discussed briefly in this section.

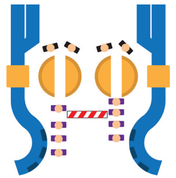
Experiment I - waiting line

Experiment: Creating a waiting line in several configurations by sticking barrier tape on the floor.

Goal: To see if the throughput of both lanes can be improved by funneling passengers into single queue. The hypothesis was that passengers then might choose a Scanner based on its availability, rather than sticking to their own lanes. This should ideally prevent passengers from waiting before their own scanner, while the neighbouring scanner is free to use.

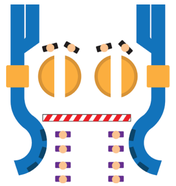
Results:

1. Narrow waiting line



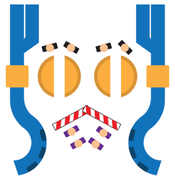
- Passengers do not respond to the line at all

2. Wide waiting line



- Passengers form two queues behind line
- Results in a blockade at preparation

3. 'Funnel'



- Passengers form two queues, perpendicular to the lines
- Results in a clash of passengers

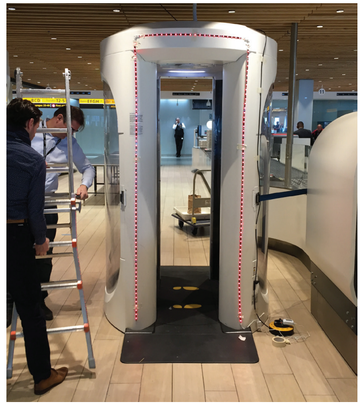
Discussion:

- Passengers keep forming two queues because it is unnatural to move away from their own lane
- Passengers do not tend to use the neighbouring scanner because they want to stay close to their baggage
- Funneling passengers is not desirable:
  1. The 'other' scanner is rarely available
  2. Appearance & Behaviour issue*
- This idea focuses on distributing passengers and improving throughput which is not part of the design goal. Therefore, this idea falls outside the project scope.

Experiment II - LED strip

Experiment: Using a remote controlled RGB LED strip on the front of the Security Scanner to trigger passengers to either wait, or enter the Scanner.

Goal: To see if a LED strip could work as an entrance cue: see if passengers are triggered to enter the Scanner when the LED strip is green, and wait when the LED strip is red.



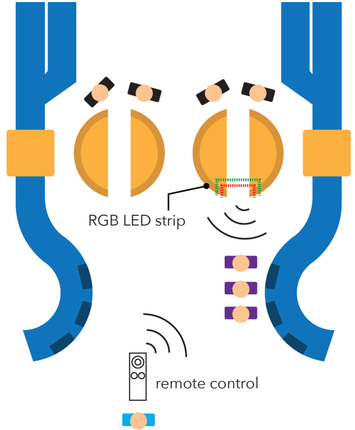


Fig. 0.3 | Test configuration of LED strip experiment

Results:

- Passengers did not respond to the LED strip at all
- Passengers still looked for instructions from the agent

Discussion:

- There are three possibilities the passengers did not respond to the LED strip:
  1. Passengers did not know what the function of the LED strip was, or whether it was aimed at them
  2. The agent is deemed to be more important and authoritative than instructions from a machine (e.g. the human interaction overrules machine interaction).
  3. Passengers did not see the LED strip, although it was very noticeable, especially when it was switched between red and green
- This is not a suitable option for an entrance cue

Chapter 7 | **Ideation Cycle II**

The second ideation cycle depicts a more focused ideation following the design goal and interaction vision. In this chapter the concept structure is established to determine what elements the design should entail. Principle solutions were generated individually, and reviewed together with the R&D department to decide on the final concept direction.

7.1 | Concept Structure

After the first ideation cycle, which entailed a more freestyle approach, a more focused ideation was required. In order to start generating principle solutions, the concept building blocks were established first which are depicted in **Fig. 7.1**.

The building blocks are based on the design goal to provide responsive guidance for both 1. Entering/ exiting the Scanner and 2. Taking and holding the correct posture (**paragraph 5.2**).
To indicate when the passenger should enter and exit the scanner, an Enter and Exit cue is required.

For taking the correct posture, an element of Demonstration is required. However, both should be based on the element of Responsiveness, which is the core building block of the concept.

Based on this concept structure, principle solutions were generated which are discussed briefly in the next two paragraphs.

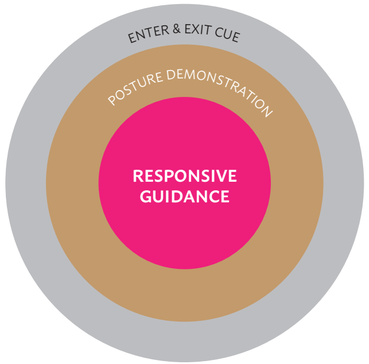


Fig. 7.1 | Responsive guidance as the core building block for the concept

7.2 | Principle solutions Enter & Exit Cue

The principle solutions depicted in this paragraph focus on triggering the passenger to either wait or enter the scanner.


A1. Traffic Lights


A2. Interactive Path


A3. Moving Floor Projections

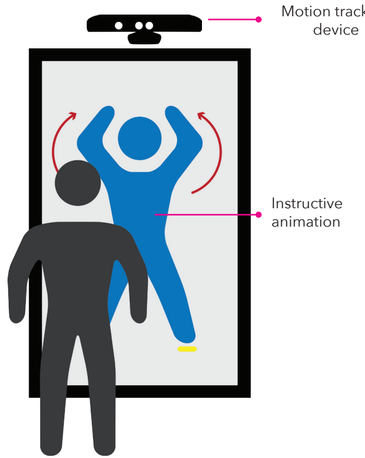

A4. Scanning Progress Bar


A5. Matrix Signs


A6. Occupation Lights

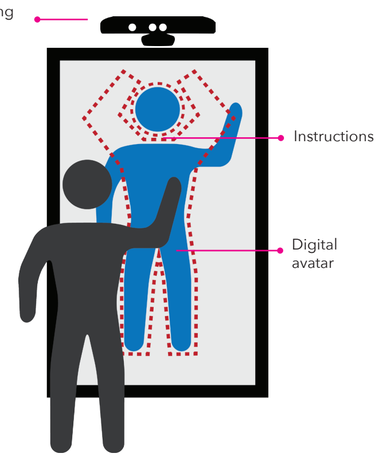
7.3 | Principle Solutions Posture Demonstration

The principle solutions depicted in this paragraph focus on instructing the passenger to take the correct posture.



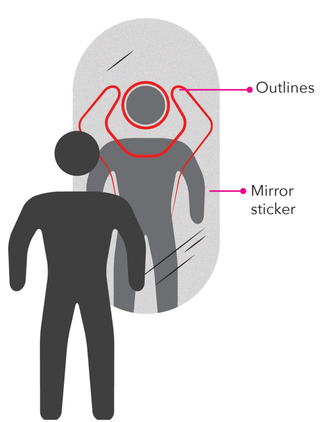
B1. Responsive Animations

- A set of animated instructions, depending on the passenger's current posture
- The current posture is monitored by a motion tracker



B2. Digital Avatar

- A digital representation of the passenger using a motion tracker
- Additional instructions on screen



B3. Outlines on mirror

- A mirror sticker with outlines of a mannequin
- The passenger has to fit his body within the outlines

7.4 | Creative session R&D

In addition to the individual ideation, a creative session with the R&D department was organised. The goal of this session was to discuss the existing ideas, generate additional ideas, and to decide what concept what would be the best concept direction to proceed with.

Session structure

The session was executed with five members of the R&D department, and structured as follows:

1. Discussion of existing ideas
2. Brainwriting to generate more principle solutions
3. Clustering and discussing results
4. Synthesis into the 'ultimate concept'
5. Discuss plan to proceed with

Fig. 7.2 | Discussion of results during creative session with R&D department

Key conclusions

1. Entrance cue
The R&D department decided an entrance gate just like the NoCue (**Fig. 7.3**) would be most effective as a principle solution for the Entrance Cue. A gate opening works very intuitively because it triggers people to walk through, while a closed gate communicates very clearly the passenger may not proceed. Moreover, an entrance gate is a universally known principle. However, using an entrance gate should not induce a claustrophobic feeling by 'locking' the passenger in.

An additional idea worth mentioning depicted a walkthrough Scanner concept which can be found in **Appendix S.**.

2. Posture demonstration
Using a motion tracking device in combination with animations or an avatar would be the most effective for guiding passengers to take the correct posture. Gamification suggestions were also made (**Fig. 7.4**). However, the security context is not suitable as it would be 'forced 'gamification, and it is not in line with design criteria **02** and **10**.

Integration of principle solutions
The initial aim of the assignment was to design a single integrated solution to achieve autonomous in/out-flow and the passenger taking the posture autonomously. However, it became clear that both are very different design problems that need to be addressed separately. By attempting to synthesise both into one coherent solution, unnecessary compromises have to be made which will diminish the quality of each solution. This would be a typical case of trying to focus everything, which results in solving nothing. Earlier synthesis attempts were made which can be found in **Appendix Q**.

Fig. 7.3 | NoCue gate at border passage

Fig. 7.4 | Kinect fitness game

Narrowing down: passenger's posture
Because a coherent synthesis was not possible and because the design scope would become too large by focusing on both design problems, the collective decision was made to narrow down the project scope to passengers taking the correct posture. The Enter & Exit cue were therefore excluded from the scope.

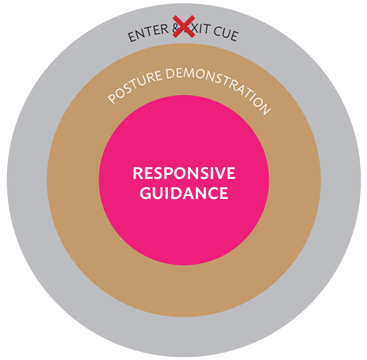


Fig. 7.5 | Excluding Enter and Exit cue from scope

Chapter 8 | **Concept Design**

After the collective decision to narrow down the design scope to guiding passengers taking the correct posture, the Responsive Animations concept was chosen as the appropriate concept to proceed with. This chapter describes the design considerations, as well as the composition and functionality of five initial animations. Moreover, the interaction structure is provided, indicating the order and conditions for displaying the animations.

8.1 | Concept choice

The choice for the Responsive Animations (**B1**) as a final concept direction is explained by using the Harris profile in **Fig. 8.1**. The criteria in the Harris profile are based on the design criteria in paragraph **5.4** and are discussed below:

Functionality
Animations are more demonstrative and directive than a responsive Avatar. Moreover, the Avatar might even distract the passenger which is an undesired effect. Another side effect is that the passenger does not immediately realise that he is being represented by the Avatar.

Responsiveness
While animations can be made responsive, an interactive Avatar is the highest level of responsiveness that can be obtained.

Fitting security context
Animations on a screen is an appropriate fit for the security context, whereas an Avatar might radiate a high gamification or 'Disney' caliber.

Throughput
While the influence on the throughput is hard to predict, the possible distraction of the passenger with the Avatar can result in a significant decrease in throughput.

Feeling of privacy
With the Animations, passengers might not directly draw the conclusion that they are being monitored. An Avatar mimicking the passenger's movement though, immediately makes clear the passenger is being monitored.

Originality
Animations on a screen is a very well-known principle and is not very original. A moving Avatar based on the passenger's movements however is still quite a new concept. It offers many interesting possibilities.

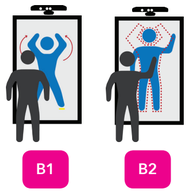
Raison d'être
The use of animations is a logical step for providing guidance to passengers, whereas the use of an Avatar feels a bit unnecessary and redundant. It would just be another form of a Technology Push. It could also radiate the impression of Schiphol trying to make things fun, which again would not fit the security context.

Feasibility
While the motion tracking technology does not differ between concepts, the integration of the passenger monitoring with the Avatar is harder to realise.

In conclusion, while the Avatar concept is the most original one and offers the most interesting possibilities, the Responsive Animations concept is the most suitable for providing effective guidance to the passenger. Animations are more demonstrative and to the point, while the Avatar might actually distract the passenger from the task. Furthermore the Responsive Animations concept is more appropriate for the security context, has a more valid reason of existence and is easier to realise.

	1. Responsive Animations					2. Responsive Avatar			
	- -	-	+	++		- -	-	+	++
Functionality			■	■			■		
Feasibility			■	■				■	
Fitting security			■			■	■		
Throughput		■				■	■		
Feeling of privacy			■			■	■		
Originality		■						■	■
Raison d'être			■				■		
Responsiveness			■					■	■
Score	+6					-3			

Fig. 8.1 | Harris profile to choose between concepts



8.2 | Animation Design

After deciding on the Responsive Animations concept, the decision was made to make five initial animations:

1. Instruction animation: Raise Arms
2. Instruction animation: Freeze
3. Instruction animation: Exit Scanner to A. Pat down or B. Reclaim
4. Correction animation: Feet Placement
5. Correction animation: Arms higher

Design considerations

Before actually designing the animations a list of considerations was formulated:

Colour
There is a preference for cool colours such as blue and grey to give a calm and friendly impression. Nevertheless, the choice of colours should be based on the function of the elements involved. Warm and energetic colours should be used for instructive elements so that they stand out. Green and red colours should be used to communicate something is either OK or NOT OK.

Furthermore, the colours should be adjusted to each other (hue and contrast) to create a clear distinction and hierarchy between elements. Moreover, the composition should forms a clean and integrated whole.

Natural movements
The movement of the mannequin should give a natural impression. Instead of a robotic and linear movement, the movements should be 'popping' by using acceleration and deceleration effects.

Icon-based design
The design of the animations should be icon-based so that the message can be conveyed quickly and unambiguously. Moreover, applying icon-based design ensures the passenger focuses on its meaning rather than the aesthetics. The icons should be based on universal semantics.

No language involvement
To make the design universal and inclusive, it may not contain any elements of language. Especially at the transfer filter, one cannot assume every passenger is able to read English.

Friendly visual language
The elements in the design should contain round shapes in order to give a friendly impression.

Coherent set of animations
There should be coherency among the different animations. They should be perceived as a set of animations.

Feedback: level of communication
For security protocol's sake, the exact detection results of the Scanner should not be communicated to the passenger. Otherwise passengers may check these spots themselves which may interfere with the results. The agents should be the evaluating party.

Composition

The blue mannequin (Fig. 8.2) is the foundation for all animations. The mannequin is based on the universal icon of a person. The colour is based on the blue colour in the Schiphol house style palette. The platform beneath represents the floor of the Scanner.

On top of the mannequin layer, an instruction layer is applied which contains (supporting) elements for the instructions (Fig. 8.3).

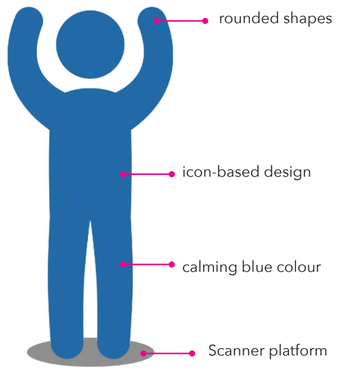


Fig. 8.2 | Blue mannequin

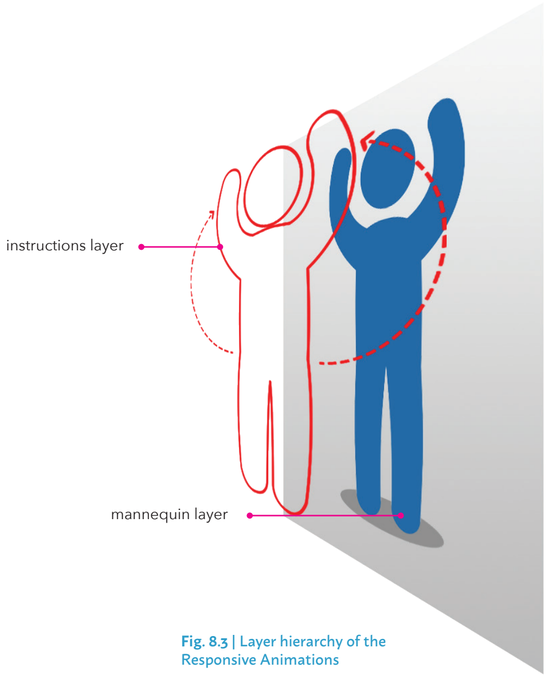
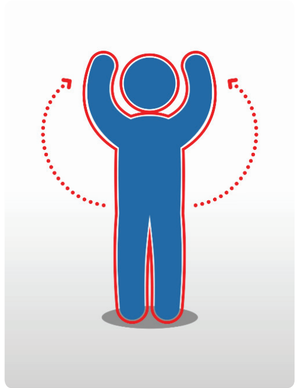


Fig. 8.3 | Layer hierarchy of the Responsive Animations

8.3 | Animation concepts

In this paragraph the animations are described, as well as the conditions they will appear under:



1. Raise Arms

Main posture instruction

- Mannequin raising his arms until positioned within the red outline
- Movement is supported by red arrows

2. Freeze

Once passenger is in position

- Outline and platform turn green
- Green clock starts ticking for 5 seconds (includes process time of Scanner so passenger remains inside for Exit animation)
- When the clock is full, the green frame and platform start flashing as a confirmation

3A. Exit to Pat Down

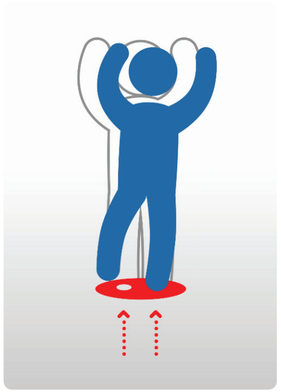
In case the passenger needs to be patted down

- Passenger (blue) being patted down by an agent (black)
- Moving arrow triggers exit

3B. Exit to Pat Down

In case no anomalies are detected

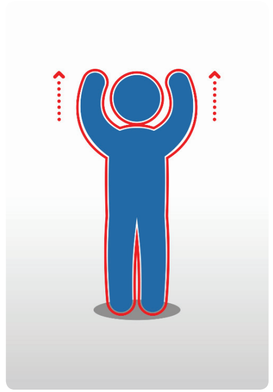
- A blue suitcase depicting baggage
- Moving arrow triggers exit



4. Feet Correction

In case passenger's feet are positioned incorrectly

- Mannequin stepping aside on the two footsteps
- Arrows emphasise feet placement



5. Arms Correction

In case passenger's arms are not raised high enough

- Mannequin starts with arms slightly raised
- Mannequin raises arms until correct position supported by red arrows

8.4 | Interaction structure

The interaction structure in Fig. 8.4 depicts the order and conditions for the animations to be displayed. A clear distinction is made between instructive animations and corrective animations.

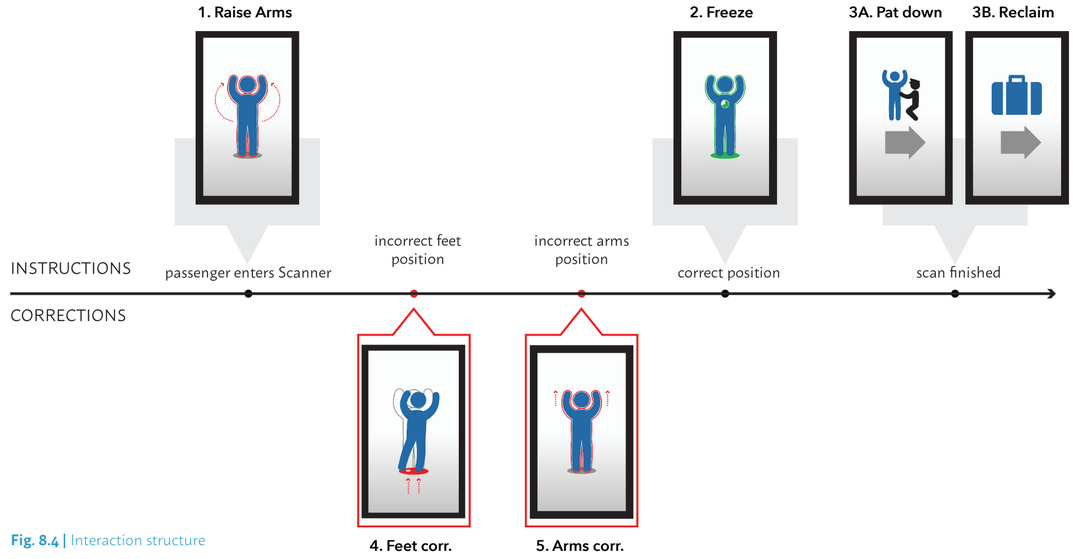


Fig. 8.4 | Interaction structure

Chapter 9 | **Prototyping**

A series of prototyping tests in operation was executed with the initial set of animation concepts. The main goals were to assess the effectiveness of the animations, to optimise the design based on the observations and to record the agent's experiences with the prototype. Based on the results the final design proposal could be made.

9.1 | Animation prototyping

A prototyping tests series was executed in a live security operation, using the animation concepts from **paragraph 8.3**. The series was executed by using a *mixed method approach*: Both qualitative and quantitative data was collected (**Fig. 9.1**).

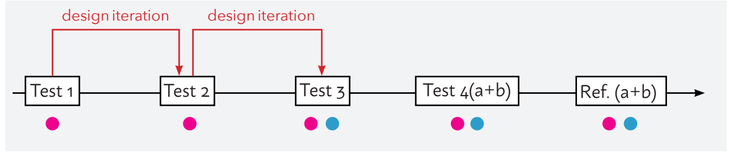
The goal of the *qualitative tests* (1 and 2) was to:

1. Assess the effectiveness (e.g. level of autonomous use) of the design by doing observations;
2. Make iterations based on the observations to optimise the design;
3. Record the agents' experiences by conducting semi-structured interviews afterwards;

The goal of the *quantitative tests* (3, 4 and Ref.) was to:

1. Measure the process time per passenger by timing each step;
2. Measure the frequency of manual interventions by the agents through tallying;
3. Compare the results with a reference test;

The emphasis was on the qualitative tests to assess the effectiveness and optimise the design. Quantitative testing is generally more suitable as verification for a near-finished product, as a concept can still be altered significantly during following iteration cycles. However, these quantitative tests were still executed to provide an indication about the potential influence on throughput and manual intervention rate. The approach and results of the quantitative tests can be found in **Appendix V.**.



● = qualitative (observations; semi-structured interviews)
● = quantitative (timing; tallying)

Fig. 9.1 | Timeline of the test series (mixed method approach)

Fig. 9.2 | TV in portrait mode connected to a laptop with digital soundboard

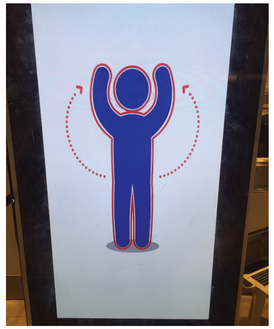


Fig. 9.3 | View from inside the Scanner

Materials & apparatus

1) TV
The animations were displayed on an 80' flat screen TV (**Fig. 9.2**), which was mounted on a frame in portrait mode so it would cover the surface area of the window of the Security Scanner (**Fig. 9.3**).

2) Laptop with soundboard
A laptop with a digital soundboard was used to activate the different animations, based on the actions of the passenger. The soundboard application was Resolume Avenue v4.

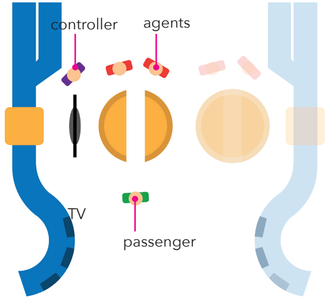


Fig. 9.4 | Testing layout in top view

Location and testing layout

Location
The test series was executed at the EF filter, which is the same location the initial observations (**paragraph 2.6** and **4.3**) and agent interviews (**paragraph 3.2**) were executed.

Moreover, the target group of inexperienced Schiphol passengers is best represented at the transfer filters.

Layout
Fig. 9.4 shows the top view of the testing layout. The TV is positioned between the Security Scanner and X-Ray machine. The controller of the animations is positioned slightly behind the screen while still being able to observe the passenger inside the Scanner. Based on what the passenger does, the researcher can decide what animation to activate.

Glass pane
The inner glass pane of the Scanner, which normally contains the mannequin, was replaced by a blank pane. This way the passenger was able to see the screen without any obstruction, and the controller was able to clearly observe the passenger's behaviour inside.

Organisation
A detailed description on the organisation of the tests, the testing protocol, and alterations made after the pilot test can be found in **Appendix T.**.

Instructions for agents

The main goal of the tests was to assess whether passengers were able to take the correct posture without agent interference. Therefore, agents were asked not to give their usual instructions and retain from correcting passengers immediately (**Fig. 9.5**). The agents were only allowed to call over the passenger to step inside the Scanner. Manual intervention by the agents was allowed whenever passengers did not respond within 5 seconds, or whenever they walked through the Scanner without being scanned.

During the quantitative reference tests, which were executed without the animations, agents were given the same instructions. This means passengers only had the existing use cues as guidance for taking the correct posture.

Fig. 9.5 | Briefing the agents before the tests

9.2 | Results: Overall response

In this paragraph, the overall response to the animations is discussed. A clear distinction is made between results (■) and interpretation of the results (◆). The results are numbered and correspond with the numbers of the discussion.

Response to the screen

Results

1 With exception of passengers walking through the Scanner, all passengers noticed the screen.

2 There was an observable decrease in passengers turning their heads to look for confirmation from the agents during the scan.

Interpretation

◆1 The screen probably draws the attention through its size and the amount of light it emits. The screen was also visible from the queue before the Scanner which probably already made passengers aware of its presence before entering the Scanner.

◆2 The animations are captivating enough to keep passengers focused on to the screen. Moreover, this would indicate that the animations are clear enough that assistance from the agent is not required.

Effectiveness

■ **Results**

The effectiveness varied per animation, which will be discussed in detail in **paragraph 9.2**. The Raise Arms and Freeze animations were the most effective.

The effectiveness also varied per flight. Especially passengers from South-American, Mexican, Israeli, Japanese and Korean flights performed well overall.

One specific flight performed relatively poorly though. The animations were least effective with passengers from Indian flights. Either they tended to walk straight through the Scanner, stood still and stared to the screen, or looked back and forth to the agent and screen.

◆ **Interpretation**

At this point it would be speculation why the results vary so much so much between different flights. However, two possible reasons would be:

- The interpretation of icons and symbols is culturally dependent.
- There is a certain reluctance towards following instructions, based on how hierarchical the culture is.

Findings during reference test

■ **Important observation: disruption by agents**

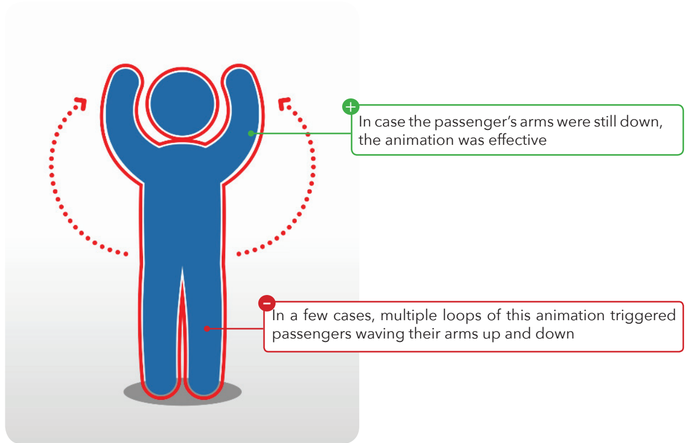
An important qualitative observation during the quantitative reference tests, was that most passengers actually were quite capable of taking the correct posture by themselves. The agents only had to perform the occasional feet correction, but otherwise most passengers were able to take the posture autonomously. After scanning, most passengers waited in the Scanner for further instructions from the agents.

◆ **Interpretation**

This indicates that the initial instructions given by the agents actually contribute to the overall problem (**paragraph 5.2**). It appears that a lot of passengers are quite capable of taking the posture by themselves. However, they seem overwhelmed and distracted by the agent giving instructions during their own attempt. This is quite the paradox since the agents are trying to help, but in reality unknowingly slow down the process in most cases.

9.3 | Results: Animations

1. Raise arms



Results

1 Most passengers already raised their arms by themselves after stepping inside.

2 In case passengers still had their arms down: Passengers raised their arms after the animation being displayed.

3 One of the agents waited relatively long with pressing the scan button, causing the animation to loop multiple times. A few passengers imitated this looping motion, by waving their arms up and down.

Interpretation

◆1 Waiting passengers pay attention to their predecessors, and learn they have to raise their arms inside the Scanner.

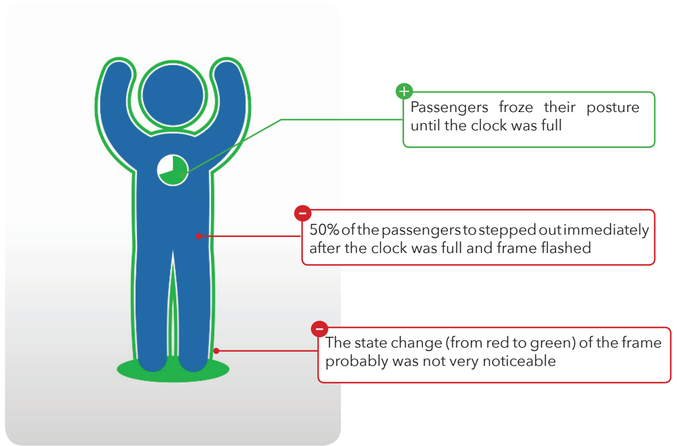
◆2 The raise arms animation is effective in case passengers still have their arms down.

◆3 The waving phenomenon shows that passengers imitate the mannequin on the animation. Although this is an undesired effect that needs to be addressed, it still shows that passengers respond to it.

Suggested improvements

Display only a single loop of the mannequin raising his arms to prevent passengers waving their arms up and down.

2. Freeze



Results

1. During the 'Freeze' animation, passengers froze their posture until the clock was full and the frame started flashing.

2. Additionally, about half of the passengers stepped outside after the frame flashed, the other half waited inside for further instructions.

Interpretation

1. This indicates that passengers understand they have to keep this posture until the clock is full. The clock in combination with the freezing mannequin seems to be effective. Additionally, this could mean they understand that the clock represents the scanning process which means the semantic value of the clock is clear.

2. Passengers who exited after the frame flashed, probably realised the scan was finished and that this was a cue to exit the scanner. However, this resulted in passengers not waiting long enough to see either of the Exit animations, which meant they were uninformed regarding the outcome.

Suggested improvements

Excluding the flashing confirmation frame in order to prevent passengers from exiting the Scanner before seeing one of the Exit animations. This ensures that passengers know whether they have to proceed to the pat down or reclaim area.

3A. Exit to pat down + 3B. Exit to reclaim

Results

1. About half the passengers waited inside the Scanner upon seeing either of the animations, the other half exited.

2. After the scan was complete, the agents stepped aside as usual. Additionally almost all agents said 'Thank you' after the scan finished, also as usual.

3. Some agents found that the symbols in the Exit to Pat Down animations displayed a certain 'posture' and 'activity' that could be interpreted as explicit.

Interpretation

1. The moving arrow is an effective element within the animation, as it triggers passengers to step out.

   The reason the other half of the passengers did not step out yet, is probably because they waited for further instructions from the agents. Another explanation would be that they did not have the chance yet to step out by themselves because the agents (un)intentionally intervened (see point 2). Therefore the passenger might not have gotten enough time to actually 'read' and understand the symbols.

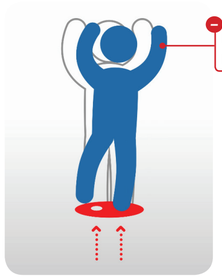
2. It is very likely the passengers were intuitively triggered to step out after either the gesture or the remark from the agent, making it harder to assess the effectiveness of the Exit animations.

3. It is clear what the agents meant with this remark. This animation requires an updated design.

Suggested improvements

Making the Exit to Pat Down animation less explicit by creating an animation where the agent is moving a traditional hand detector up and down. Although such a detector is not used, it probably will communicate better that the animation depicts a pat down.

4. Feet correction (version 1)



Passengers only pay attention to the mannequin's posture, instead of the feet movement

Results
Passengers raised their arms but did not reposition their feet.

Interpretation
Passengers do not focus on the feet correction movement the mannequin makes, but instead solely focus on the posture of the mannequin. This means it is not clear the instructions are aimed at correcting the feet position, making this animation ineffective. It does however show that passenger respond to the posture of the mannequin.

Suggested improvements
Not using a mannequin at all for this correction. Instead, only show a pop-up of two shoes being placed on the yellow footsteps in top view. This will communicate the focus is on readjusting the feet, instead of on taking the ballerina posture.

Two variations of this improved animation were made in between tests (see Feet correction v2). A description of both designs can be found in **Appendix U.**.

Feet correction (version 2)

Variation 1

The feet movement in this animation is too linear and not natural

Variation 2

The movement in this animation is physically relatable to passengers

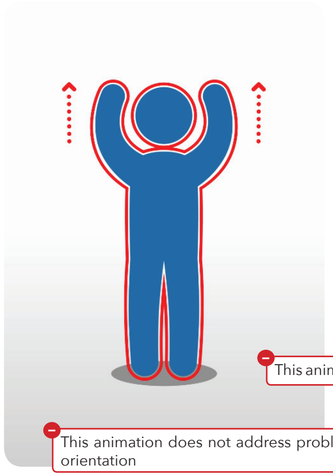
Results
Variation 2 triggered more passengers to adjust their feet than variation 1.

Interpretation
Variation 2 is more effective is because it depicts a movement that is more relatable to passengers than variation 1. The movement made in variation 1 (moving two feet at the same time) is not possible in reality.

Furthermore, the starting position of the feet in variation 2 is more realistic than with variation 1.

Suggested improvements
Making the shoes stand out more by choosing a more contrasting colour, and by making them opaque instead of transparent.

5. Arms Correction



This animation was not required once

This animation does not address problem of arms in wrong orientation

Results
This animation was not displayed a single time, because the passengers' arms were never too low.

Interpretation
When the passenger's arms position is not correct, it is usually because their arms are in the wrong orientation rather than too low. A more frequent issue is when passengers tend to aim their arms towards the glass (diagonally) so they are not aligned with the body. Therefore, a new animation should be created to address this issue.

Because this animation was never used it is hard to assess its effectiveness.

Suggested improvements
No improvements to this animation can be made yet because it has not been tested. Instead, a new animation should be created to address the issue of the arms being in the wrong orientation.

9.4 | Results: Agents' responses

After each session the test was reviewed with the agents manning the lane to discuss their experiences. Several quotes from the conversations are shown and discussed in this section.

The overall response of the agents was very positive. Initially they were very sceptical about its effectivity, but their opinion was completely changed after the tests.

The agents mainly liked the fact that the animations worked as a mediator, defusing the tension between them and the passengers.

Moreover, they experienced a significant decrease in workload because they did not have to demonstrate the posture over and over again.

'When will it [the animations] return to the filter?'

*'Yeah it works **de-escalating**. Passengers don't like orders being barked at them'*

'Passengers would rather follow instructions from a screen than listen to us.'

The agents found the animations to work **de-escalating**. They indicate that most passengers do not like being told what to do, and think that they would rather follow instructions from an animation than listen to the agents.

This is probably true to a certain extent, but expectedly also largely depends on the agent's attitude. When the agent is very strict and agitated, the interaction will be less pleasant. When the agent is friendly and receiving, the passenger will probably respond more positively as well. Nevertheless, the animations works as a mediator reducing the tension between passengers and agents.

'There is less contact with the passenger though'

'Great that there is less contact with the passenger'

During the tests, agents noticed a significant **decrease in contact with the passenger**. Most agents actually found this pleasant because of the decrease in physical and mental strain. However, some agents were less enthusiastic about this aspect because they really enjoy the contact with the passenger. They were also afraid it could give a distant, harsh and impersonal impression to the passengers.

'OK again! I think it really has impact when the posture is exactly correct!'

During Test 2 and Test 4 a few agents thought they noticed a decrease in the detection rate. The process data of the Scanner from Test 2 did not indicate a significant decrease in detection though.

'I've seriously gotten chronic pain in my shoulder since we started working with the SSL. I've constantly got a cracking shoulder joint because of it.'

'Great that it [posture taking] goes automatically!'

'After 10 times you think: help yourself'

Agents were happy that they did not have to give instructions during the test. They often complain about the **constant physical strain** because of the repetitive movement of raising their arms, which is exhausting. There was one particular agent who indicated she even developed problems with her shoulder since Schiphol switched to the SSL. She was very positive about the Responsive Animations taking over the instructive part of the job.

Additionally, agents appreciate that they do not have to talk as much as they normally do. They complain about getting thirsty because of all the talking, while they're not allowed to have a break.

Finally, also the animations **reduce the mental strain** on the agents. They do not constantly have to pay attention to the posture of the passenger, which is very exhausting and tiring. Instead, they can focus on the actual safety and screening of the passengers.

'Where can I sign?'

'People really respond to it! You can see that it works!'

'It's so simple, but so effective!'

'You really see passengers adjust their feet correctly!'

'They [animations] are very effective I would say. Usually it's a mess'

Most agents had the impression the animations were effective. Initially some agents were very sceptical but completely revisited their opinion during the tests.

'You know what I still miss? An animation where the mannequin does this [arms in line with body]'

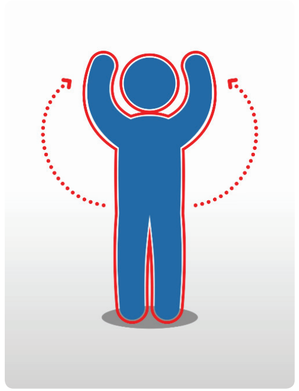
As stated in the previous paragraph (**page 103**), agents indicated that it would be useful to have an animation for correcting an incorrect arms position in side view. Passengers not having their arms in line with their body occurs more frequently than passengers' arms not being held high enough.

[About adding auditory feedback] 'Please no! It's already so loud in here!'

The agents were opposed to the idea of adding auditory feedback to the animations (which was an initial consideration). The agents think it is already too noisy at the security filters and would not like an additional sound source.

9.5 | Updated animations

Based on the results from the prototyping tests the animations were updated, which are described in this paragraph. Moreover, a suggestion for a new animation is provided, that addresses the issue of passengers not having their arms aligned with their bodies. The updated animations can be found via: http://tinyurl.com/yajgafpx



1. Raise Arms

Adjustments:

- The animation loops only once, to prevent passengers from waving their arms up and down

2. Freeze

Adjustments:

- The green outline + platform do not flash anymore to prevent passengers from exiting before seeing the Exit animation

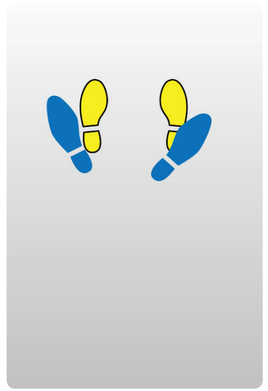
3A. Exit to Pat Down

Adjustments:

- The agent starts in a standing position and uses a hand scanner to indicate a pat down. This gives a less 'explicit' impression
- The arrow is excluded so that passengers do not exit the scanner in case a pat down is in progress

3B. Exit to Reclaim

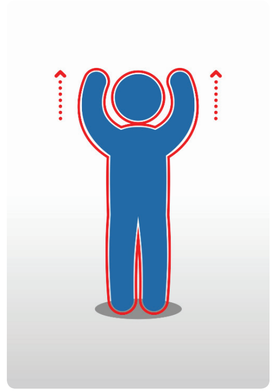
No adjustments made



4. Feet Correction

Adjustments:

- Shoes are made more visible by applying blue colour and making them opaque
- Yellow feet are made more visible by stroking the outlines



5. Arms Correction

Adjustments:

- The animation loops only once, to prevent passengers from waving their arms up and down

New animation: Arms aligned

In this section a suggestion for a new animation is proposed (Fig. 9.7), which addresses the issue of passenger not having their arms aligned with their bodies.

This new animation depicts the mannequin starting with his arms in the incorrect position: arms slightly raised and aimed diagonally towards the glass of the Scanner (1).

The mannequin then moves his arms backwards until the arms are in the correct position (2). This movement is supported by red arrows on each side as well.

The challenge with this animation is to create a suggestion of depth. In this case this is done by:

Making a distinction between upper arms, lower arms and hands, and by creating a foreshortened effect (hands size > lower arm size > upper arm size). The arrows are foreshortened as well. The distinction is emphasised by subtle shading, which also adds to the suggestion of depth.

For the sake of consistency, this animation also depicts the mannequin in front view.

One could argue that an animation in side view would be more effective. However, this may cause additional issues: the passenger rotating sideways to match the orientation of the mannequin.

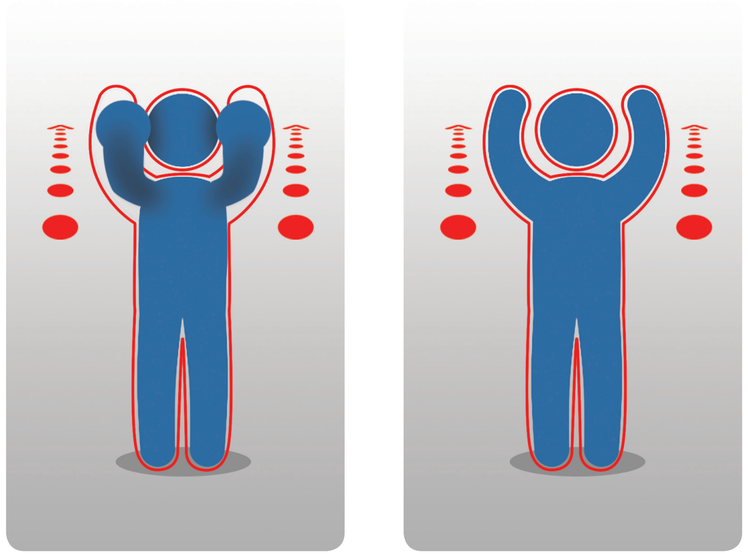


Fig. 9.6 | Suggestion for arms alignment animation

9.6 | Updated interaction structure

In Fig. 9.8 the updated interaction structure is shown:

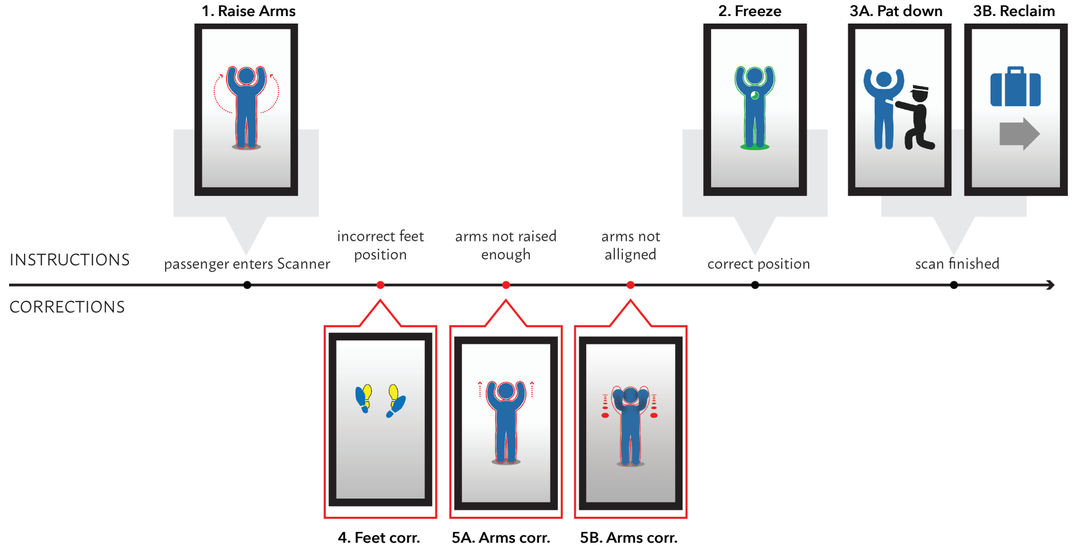


Fig. 9.7 | Updated interaction structure

STAGE III - EVALUATE

Chapter 10 | **Implementation**

This chapter depicts a materialisation suggestion for implementing the Responsive Animations concept. Motion tracking possibilities of passengers standing in the Security Scanner were explored with an Xbox Kinect 2.0. Two tests were executed to verify whether skeletal tracking still worked through the glass of the Scanner, and to discover whether the detection qualities of the Scanner would be influenced. Additionally, the dimensions of the concept were established by using anthropometric data from DINED.

10.1 | Motion tracking

In order to draw conclusion about the feasibility of motion tracking of passengers standing inside the Scanner, two tests were executed with an Xbox Kinect 2.0.

The Kinect 2.0 is a motion tracking device developed for the Xbox One, which provides gesture control for gaming purposes (**Fig. 10.1**). Motion tracking works through projecting a speckle pattern of infrared dots on the room, which the Kinect then captures and processes to determine the position and posture of the users (e.g. skeletal tracking).

For the feasibility of the concept, it was essential to know whether:

- The infrared skeletal tracking still works through the double sided glass of the Scanner
- The infrared dots interfere with the mm-waves of the Scanner, thus influencing the detection

For both tests, an Xbox Kinect 2.0 sensor was used which was connected to a laptop running the Kinect Software Developers Kit (SDK).

Fig. 10.1 | Kinect 2.0 sensor

Test 1 - skeletal tracking

This test was executed in the R&D lab in the basement. The Kinect sensor was positioned on a cabinet and aimed at the Security Scanner. Next, a subject stood inside the Scanner trying out a variety of different postures.

Results: The skeletal tracking still worked for all postures when positioned inside the Scanner.

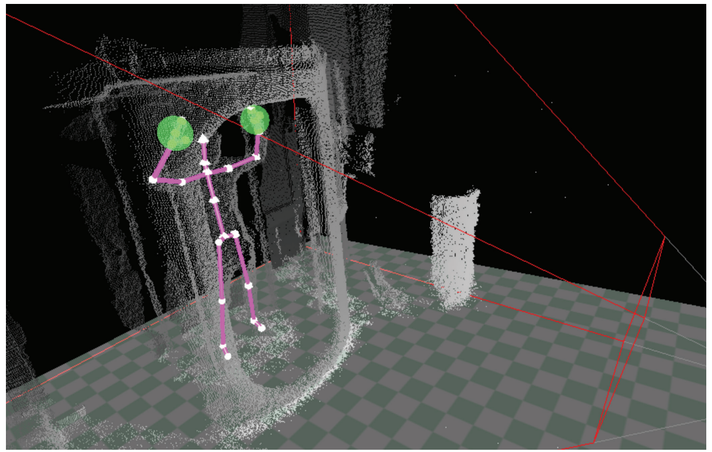


Fig. 10.2 | Motion tracking test through Security Scanner with XBOX Kinect 2.0

Test 2 - detection test

This test was executed at the EF filter on a close lane. The Kinect sensor was positioned on a ladder in the path between two Scanners. Next, the subject stood inside the Scanner under two different conditions:

1. Empty pockets
2. Mobile phone in left pocket, and wearing a key cord with a Schipholpas

Five scans were made for each condition.

Results: Under both conditions the detection was accurate during all scans. Under condition 1, there was no detection. Under condition 2, the mobile phone and Schipholpas were detected every time.

Fig. 10.3 | Subject being scanned with Kinect aimed at Scanner

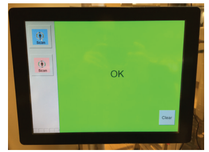


Fig. 10.4 | Pockets empty

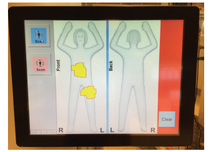


Fig. 10.5 | Phone and pass

Conclusion

Infrared motion tracking, such as the Kinect uses, has potency to be used as a way to monitor the passengers' posture and position inside the Security Scanner. The skeletal tracking still works through the glass of the Scanner, and seems to have no influence on the detection by the mm-waves.

However, more thorough experiments have to be executed in order to draw conclusions about possible refraction and distortion of the infrared pattern by the glass of the Scanner. This can be done by using an infrared camera. Moreover, interference tests with the mm-waves need to be executed by analysing the raw scans of the Scanner, and by doing them in high quantity.

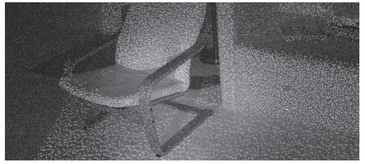


Fig. 10.6 | Infrared dots projected by Kinect

10.2 | Embodiment

In (Fig. 10.7), a suggestion of the concept embodiment is provided. The design consists of a screen and a motion sensor mounted on a steel frame, embodied by steel metal housing. The housing has a broken white colour to match the aesthetics of the SSL.

The screen is positioned in the path between the X-Ray machine and the Security Scanner. The screen and the Scanner are connected through wiring under the floor. The following communication has to take place:

- Once the passenger's posture is correct, a signal has to be sent to the Scanner to start the scan
- Once the Scanner has completed the detection process, a signal has to be sent to the screen to either display the proceed to pat down or proceed to reclaim animations

The ideation process of the embodiment can be found in **Appendix W.**.

Fig. 10.7 | Embodiment suggestion of Responsive Animations concept in context

10.3 | Dimensions

In order to determine the dimensions of the concept, both the screen size and the placement of the motion sensor had to be determined.

Screen dimensions

The dimensions of the screen are based on the anthropometric data from DINED (2017) and the dimensions of the Scanner at the SSL. A combined population of several nationalities was created to include the measurements of transfer passengers.

The screen size is based on the stature and eye-height of a P50 transfer passenger, while it can still be used comfortably by the P5 and P95 of this population (**Fig. 10.8**). This is according to design criterium **04**.

A verification test was done by sticking tape on a wall, after which the decision was made to decrease the distance of the screen with the floor by 100 mm (**Fig. 10.10**).

Motion sensor placement

The placement and tilt angle of the motion sensor is based on the properties of the Xbox Kinect 2.0 and the stature of a P50 transfer passenger, while still being able to track P5 and P95 passengers (**Fig. 10.9**).

For exact details and measurements, consult **Appendix X** and **Y**.

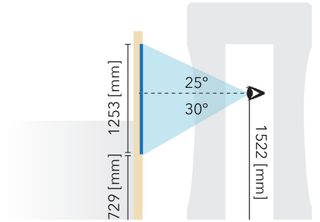


Fig. 10.8 | Calculating screen dimensions based on P50 transfer pax (side view)

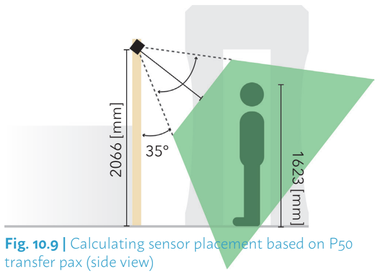


Fig. 10.9 | Calculating sensor placement based on P50 transfer pax (side view)

Fig. 10.10 | Verification test

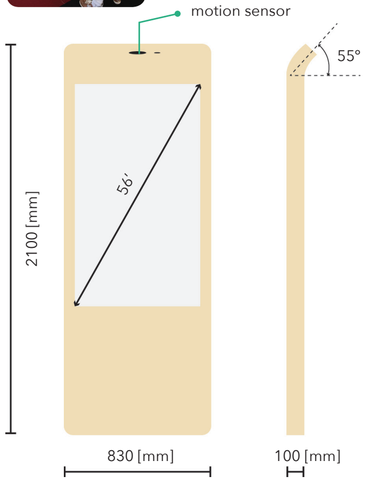


Fig. 10.11 | Final concept dimensions

Chapter 11 | **Concept Evaluation**

In this chapter the concept is evaluated in relation to the usability issues, the design vision, and the assignment as provided by Schiphol. Finally, the value of the concept for Schiphol is discussed, which concludes the project.

11.1 | Usability problems

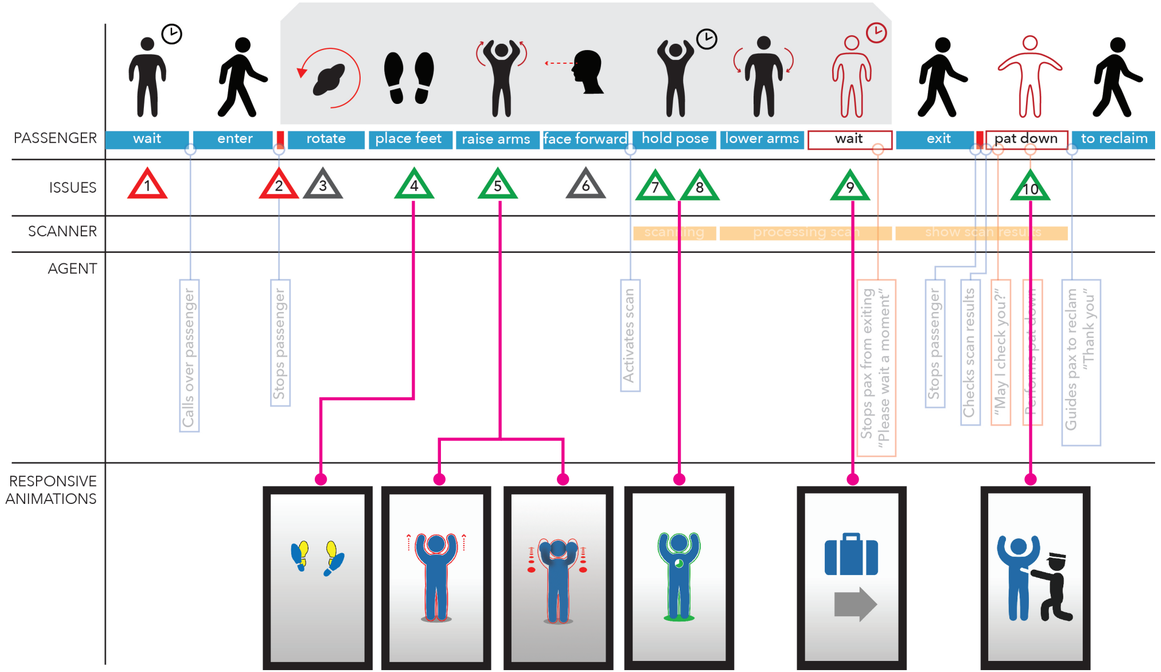


Fig. 11.1 | Concept plotted in process timeline

In this paragraph the concept is evaluated on to what extent the usability issues from Process Timeline in paragraph 4.3 are addressed:

1 The passenger does not know when to enter: **[not addressed]**

This issue is not addressed because it falls outside the adjusted project scope (**paragraph 7.4**). The partial solutions focusing on the Entrance Cue (**paragraph 7.2**) could be used as a starting point for further ideation and prototyping.

2 The passenger walks through the Scanner: **[not addressed]**

This issue is not addressed since there is no active cue that indicates the passenger has to stop and rotate. There is also no preventive measure that keeps the passenger from walking through the Scanner.

3 The passenger is not rotated **[partially addressed]**

There is no active cue aimed to rotate the passenger towards the screen. However, the amount of light produced by the screen is a way to draw the passenger's attention.

4 The passenger's feet are not placed exactly on the footsteps **[addressed]**

The Feet Correction animation triggers the passenger to correct his feet.

5 The passenger's arms are not raised, or not in the correct position yet **[addressed]**

Both Arms Corrections animations trigger the passenger to correct his arms until these are in the right position.

6 The passenger is not facing forward **[partially addressed]**

Although passengers stay focused on the animations, there will always passengers that look at the agent for confirmation.

7 The passenger moves during the scan **[addressed]**

The Freeze animation triggers the passenger to hold his position until the clock has run full.

8 The passenger does not know how long to keep the ballerina posture **[addressed]**

The Freeze animation communicates how long the passenger should keep the ballerina posture.

9 The passenger does not know when to exit the Scanner **[addressed]**

The Exit animations trigger the passenger to exit the Scanner to either the Reclaim or Pat-down area. In case the agents are occupied (e.g when a pat down is in progress), the passenger can exit to Reclaim or understands he has to wait to be patted down himself.

10 The pat down comes unexpected to the passenger **[addressed]**

Although the passenger is not informed that the passenger check is a two-step process, he is informed by the Exit to Pat Down animation whenever a pat down is required.

11.2 | Design Goal and Interaction Vision

Design Goal

The Design Goal was to enable inexperienced Schiphol passengers to use the Security Scanner autonomously, through responsive guidance and real-time feedback (**paragraph 5.2**).

This goal is partially fulfilled. Responsive guidance and real-time feedback are provided through the Responsive Animations concept.

However, full autonomous use is not possible with the design in its current state, mostly because it does not entail the complete process. It only focuses on passengers taking and holding the correct posture, whereas entering the Scanner is discarded in the adjusted project scope.

Additionally, not all usability issues within this adjusted scope are addressed. Especially issue 2 and 3 (passengers walking directly through the Scanner, and passengers not rotating) requires a solution still.

However, despite the fact that the design intervention does not provide full autonomous use yet, it remains to be discussed whether this is actually possible and even desirable. During the Prototyping phase, it became clear that the presence of an authoritative figure (the agent) remained very important. Passengers still often look for confirmation from the agent, despite the fact they would rather follow instructions from a screen. Moreover, no matter how automated the process will be, there will always be (unforeseen) issues that can only be addressed by humans.

Finally, for security purposes an authoritative figure is simply required to make sure the passenger checks are performed accordingly.

Despite this fact, the Responsive Animations proved to be very valuable with inexperienced Schiphol passengers. The animations offer more effective guidance because they are internationally oriented, respond immediately and are continuous regardless of whether the agent is otherwise engaged.. More importantly, the design acts as a mediator, resulting in a better agent-passenger relationship. This will be discussed in more detail in the Problem Definition section.

Interaction Vision

The qualities of the product and passenger interactions should be friendly, captivating and reassuring: Like receiving unexpected help from a friendly local in a foreign city (**paragraph 5.3**)

The movements and rounded shapes of the mannequin succeed well in giving a friendly impression. Furthermore, the animations are unobtrusive and lively. Although they serve as instructions they do not provide a forcible impression.

During the prototyping tests, the passengers were focused on the screen. The animations generally draw the interest of people, perhaps strengthened by their responsive nature. The concept is very much captivating, without being overly present.

Especially the Freeze animation is reassuring, as it indicates the passenger's posture is correct and because passengers can anticipate on the scan being finished. For the other animations the choice was made to not add extra confirmatory elements though, in order to maintain a concise and lean design.

Finally, the design also fits the metaphor: The Responsive Animations concept acts as a friendly local offering unexpected guidance in the foreign environment of Schiphol Security.

11.3 | Problem Definition

The design will be discussed in relation to the three elements as described in the Problem Definition paragraph (**5.1**).

1) The incoherent relationship between the product and its users is solved by letting the Responsive Animations take over the initial instructions and corrections. It is advised for agents not to intervene initially, unless the passenger asks them or if there is a correction required that cannot be addressed by the animations. This prevents the passenger from being overwhelmed and confused with excessive instructions. The agent is only allowed to call the passenger over to enter the Scanner.

2) Compared to the original use cues, the concept offers more effective and more complete guidance for taking the correct posture. Nonetheless, the final concept still lacks an entrance cue, and a correction to have the passenger rotate 90° when the footsteps and screen fail in triggering this.

3) The concept itself is based on the principle of responsiveness, that can offer informative, corrective and confirmatory feedback to the user when required. Currently, the only type of corrective feedback that is not addressed is when the passenger tends to walk directly through the Scanner.

Influence on User Experience

The Responsive Animations are a more complete and clear way for passengers to take the correct posture, resulting in less confusion. However, the largest impact is made with regard to the passenger-agent relationship:

• The design works de-escalating:

The design works like a mediator, as it decreases tension between agents and passengers, which contributes to a more pleasant relationship and a better overall atmosphere.

• The design improves the agents' working experience:

The design results in a decrease in physical and mental strain, because it takes over the instructive part of the agents' job. Agents do not have to constantly raise their arms anymore, nor keep repeating the same thing over and over. This is especially important in a high volume and high paced context such as at Schiphol Security. During the prototyping phase, agents were relieved once they did not have to give instructions anymore.

It makes the working experience more pleasant and improves the overall mood of the agents. This further affects the agent-passenger relationship in a positive way. Moreover, agents can now focus on the actual job (instead of serving as a puppet), which is providing and maintaining security.

Implementation of the design results in less contact with the passengers, which could be both positive and negative depending on the agent. Some agents prefer having as little contact with the passengers as possible, whereas others find this to be the most enjoyable part of their jobs. However, the passenger contact will never completely disappear due to pat downs.

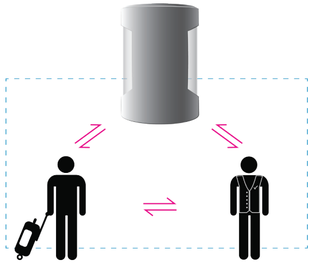


Fig. 11.2 | The interaction framework used for the problem definition

11.4 | The Assignment

Lastly, the concept is evaluated in relation to Schiphol's expectations, as stated in **paragraph 1.2**.

1) A solution that facilitates an automated in- and outflow of passengers
The concept does not facilitate the autonomous in- and outflow of passengers. After adjusting the project scope, the focus was solely on providing guidance for taking and holding the correct posture (**paragraph 7.4**).

2) A solution that instructs passengers on taking and keeping the right posture
This goal is achieved, but as stated before, it is not possible to have the passenger take the posture fully autonomously. There will always be passengers requiring human assistance with the current version of the Security Scanner.

3) Increasing the throughput to a minimum of 8 passengers per minute
This goal is not achieved because the throughput issue stems from a problem on a system level, rather than a product level. The overall throughput is for approximately 80% comprised of pat down time. So in order to make a significant impact on increasing the throughput, an intervention should be made aimed at the pat downs. Two suggestions:

- Decrease the number of pat downs by preparing the passenger more effectively, resulting is less 'bad'(?) scan results. This can be obtained by creating a design intervention for the Preparation (like the interactive preparation tray idea in **paragraph (6.1**).
- Move the pat down spot backwards. Passengers that need to be patted down can line up, while other passengers can move on after being scanned. This also means the agents have to move backwards. However, this also poses new challenges, since the results of the individual
- scans have to be communicated to the agents somehow (over a distance).

4) Provide intuitive and pleasant use for the passenger
This goal is achieved since the Responsive Animations are more expressive and intuitive than the current use cues. Moreover, the pleasant use comes mainly from the improved passenger-agent relationship.

11.5 | Conclusion

Security Scanner

The Responsive Animations concept is aimed at solving the usability issues with regard to taking the correct posture. It does so by providing responsive guidance and real-time feedback.

By providing effective guidance, it addresses the use cue (2) and feedback (3) problems as stated in the Problem Definition (**paragraph 5.1**). It provides a more thorough instruction for taking the correct posture, compared to the yellow footsteps and the mannequin. Additionally, corrective feedback is provided when the passenger is positioned incorrectly. Informative and confirmatory feedback is provided for a better user experience.

More importantly, with this solution the agents do not have to give instructions anymore initially. The agents only have to perform corrections that cannot be addressed by the animations, or whenever the passengers request assistance. This provides a more coherent relationship between the users and the Scanner (1) which has several benefits:

- The passenger is not overwhelmed anymore by the excessive instructions. He only has to focus on the animations. The passenger will not be distracted anymore by the agent which consequently results in confusion compared to the original situation.
- The relationship between passenger and agent is stabilised because the concept works as a mediator. The passenger rather follows instructions from the animations than from the security agent.
- The agent experiences less mental and physical strain, because constant instructions are not necessary anymore. This results in a more pleasant working experience for the agents, and contributes to the agent's mood. This again positively influences the passenger-agent relationship.

Unaddressed issues

Although the design mainly improves the user experience for both passenger and agent, there are several issues that are not addressed in this project:

Usability issues 2,3 and 6 (paragraph 11.1)
Although the Responsive Animations concept is a better integrated approach towards passengers taking the correct posture, there are still some unresolved usability issues. There is no solution yet for passengers tending to walk directly through the Scanner, nor for passengers not being rotated.

Passenger in- and outflow
The concept does not address the issue of the passenger not knowing when to enter the Scanner. The decision to solely focus on assisting the passenger taking the correct posture was made collectively (**paragraph 7.4**). The initial design scope was simply too large for this project, which is discussed in more detail in **paragraph 12.1**. Moreover, it was difficult to synthesise the partial solutions into a coherent integrated design. It is a separate issue that needs to be addressed otherwise. The partial solutions in **paragraph 7.2** form a solid starting point for an entrance concept. For now, the agent has to keep calling over passengers to enter the Scanner.

Throughput
The throughput issue was not addressed during this project because this is mainly a problem that finds its roots in the number of pat downs. By preparing the passenger more effectively, the number of unnecessary pat downs can be decreased. Also the detection algorithms of the Scanner can be improved in order to improve the detection accuracy, decreasing the amount of unnecessary pat downs. Moreover, it is a problem that needs to be solved on a system level. By moving the pat down spot backwards, the passengers that need to be patted down can line up (see suggestions in **paragraph 11.4**). This allows other passengers to proceed through the Scanner.

Autonomous use
Schiphol desires the Security Scanner to be used fully autonomously by the passenger. The design does not provide full autonomous use, but rather serves as a support for the passenger to take the correct posture. However, full autonomous use is not desirable as there will always be unforeseen issues that cannot be addressed by only using animations. An authoritative figure is always required to be present to solve these issues, and to keep monitoring and controlling the security area.

Product Experience
Although the concept aims to improve the user experience at the passenger check, the original product experience issues with the Scanner remain. Passengers can still feel disarmed because of the 'hands up' posture and still have fear for radiation. However, since no changes to the Scanner could be made these issues falls outside the scope of this project.

11.6 | Recommendations

'What improvements could be made to the concept?'

Further user testing should be done in order to optimise the design of the animations. However, in terms of effectiveness it would be interesting to explore the possibilities of integrating auditory feedback. Adding auditory feedback could especially add to the user experience by implementing confirmatory sounds, providing an even more friendly and reassuring interaction.

'What quick changes can Schiphol make to improve the current situation?'

An easy improvement for increasing the user experience for both agents and passengers, is to prevent the agents from giving the initial instructions. Agents should only be allowed to perform corrections, or when the passenger asks for assistance.

This way the passenger can figure out for himself what posture to take, without being overwhelmed and distracted with excessive instructions. This prevents unnecessary confusion with the passenger.

Consequently, the agents experience less mental and physical strain because they do not have to constantly give instructions anymore. Especially in a high volume context this is significant. This prevents fatigue and frustration and improves the mood and working experience. Finally, this positively influences the way the agents interact with passengers.

'Should Schiphol proceed with the concept and invest in a solution using Responsive Animations?'

Schiphol should realise that the Responsive Animations are aimed to assist the passenger with taking the correct posture, in a friendly and unobtrusive way. Its effects are mainly improving the user experience for both passengers and agents. It works de-escalating in relation to the tensions between passengers and agents because it functions as a mediator. Additionally, it improves the agents' working experience because they undergo less mental and physical strain, by not having to give as many instructions anymore.

It is not however, focused on improving the overall throughput of the passenger check. In order to do so, Schiphol should focus on developing a solution to obtain more effective passenger preparation, or a reconfiguration of the lane to move the pat down area backwards (as stated in **paragraph 11.4**).

In conclusion, if Schiphol wants to improve the user experience for both passengers and agents they should proceed with the development of the concept. If Schiphol wants to put more emphasis on throughput and efficiency, an intervention on system level is more suitable. Personally, I highly recommend Schiphol to keep the agents' work experience in mind, as they are the backbone of the Security area and can make or break its efficiency and experience.

'Should Schiphol aim to make the use of the Security Scanner completely autonomous?'

Schiphol prefers to make the use of the Scanner fully autonomous. However, it is not advisable to actually do so. There will always be issues with taking the correct posture that cannot be solved by solely using Responsive Animations. Especially inexperienced passengers are prone to be needing support. For them the SSL is an unknown environment where they are not aware of the exact procedures. Not providing this support inevitably leads to delays.

Moreover, despite the prototype being promising, human interaction still proved to be very important. Passengers still look for confirmation from the agent, making human interaction leading over product interaction.

Furthermore, for security purposes there should always be an authoritative person to monitor and control the environment.

Finally, if Schiphol still desires to make the passenger check fully autonomous, the entrance cue issue has to be addressed. The ideas from **paragraph 7.2** can serve as a starting point.

'If Schiphol decides to proceed with the concept, what are the next steps?'

1) First of all, more prototyping tests have to be executed to make additional iterations in optimising the animations. Only after having optimised the design, a quantitative test is valuable to analyse the effect on the throughput and the system as a whole. Based on these measurements, the R&D department can decide whether to make a business case for investing in this type of solution or not.

2) In case Schiphol does decide to proceed, the consideration has to be made to only implement this solution for the transfer filters or across all security filters. Passengers at the departures filters are generally more experienced than passengers at transfer filters, thus require less assistance. Additional testing has to be done in order to conclude whether such a solution could add value to the user experience the same way.

Furthermore, different filters provide different passenger types and thus different problems and behaviour. If Schiphol decides to implement the animations across all filters, the concept may need to be tailor made to each filter, especially regarding the semantics of the animations. Additional user research and prototype testing is required for this.

Chapter 12 | **Reflection**

In this chapter a reflection is given on both the project as well as the internship.

12.1 | Project Reflection

While the main goal of the Graduation Project was to obtain my certificate for the MSc. Design for Interaction, it was also the final learning opportunity as a student at the TU Delft. My main learning goal was to explore the role of being a designer at a large corporation.

In this chapter, I will evaluate on both the project and on my experience as an intern at Schiphol Security Policy. I will also explain how operating as an intern for Schiphol influenced my design process.

Scope

The main problem was that the project scope remained too broad for too long. The assignment was to obtain autonomous in/out flow, having passengers take the posture autonomously, and to obtain a throughput of 8 pax per minute. First of all, it is very hard to solve all three problems with one integrated solution. That is because each of these are issues on its own that need to be addressed individually. This is the reason why no synthesis into a coherent concept has taken place. Secondly, the initial assignment was too large to be addressed by a single graduate student. However, I was able to provide Schiphol with some ideas on how to address the in/out-flow (**paragraph 7.2**) and throughput issues (**paragraph 4.2**). Developing concepts and doing prototyping tests for all of them was impossible within this time frame though.

Next time I would narrow down earlier in the process, and focus on a very specific problem rather than trying to solve everything with one ubiquitous solution.

Target group: inclusive design

The main difference with the projects I did before, was that the target group for this project was very broad. I chose to design for 'inexperienced Schiphol passengers', which is still a very fuzzy definition. Usually, I pick a very specific target group with clearly defined characteristics, which can serve as a basis for the design requirements. This project however required a more universal design approach aimed at the masses, which is something I had not done before.

Moreover, with a centalised security layout it would have been challenging to conduct user research with a specific passenger type. This would have required picking out passengers from the mix of flights that would perhaps fit the profile. Moreover, I would have to stop passengers in the middle of the security check which passengers nor agents really would have appreciated.

Screen based design

From the start of the project, I wanted to avoid designing a screen based concept. I wanted to explore the possibilities of using tangible interaction design, through applying a more experimental mindset. Interfacing a Neopixel LED strip with an ultrasonic sensor (**Appendix Q.**) was a manifestation of this initial plan. However, the plain reality was that Schiphol was looking for a practical and directly implementable solution. Therefore, a screen based concept was simply the most logical decision. This emphasises the difference of the experimental freedom I had as a design student in an academic environment, versus the requirements and necessities in a commercial context. I will discuss this in more detail in the next paragraph.

Literature study

I started the project with an elaborate literature study (see **Appendix Z.**). However, I struggled with finding literature that was directly relevant to the topic. It was a very practical assignment, where most valuable information was obtained from field observations and user research. Apart from a paper about the privacy implications of the Security Scanner (Valkenburg and van der Ploeg, 2015) and a union report from the Schiphol security staff (FNV, 2016), there was no literature that was directly applicable.

Next time, I would immediately start with field observations and user research, in order to find knowledge gaps that I could fill with relevant literature along the way. However, in this case this was not possible yet due to the delay of obtaining a Schipholpas.

12.2 | Internship Reflection

Challenges within corporate structure / security domain

Operating within the Schiphol security context means dealing with a complex company structure, procedures, rules and restrictions. At the start of the project I had problems with obtaining the Declaration of No Objection (VGB) from the Marechaussee, which I needed to apply for a Schiphol pass. It took almost three months before I received this document, which meant that until September I did not have access to airside. This restricted me from doing field observations and interviews until that time, and caused me to diverge from my original planning.

However, the biggest obstacle for me was to find my way through the corporate structure of Schiphol. Especially organising the prototyping tests in operation was very challenging. It took me quite a while to figure out which departments I had to contact, it being a complex system of multiple departments and people who needed to approve all plans. It took even more time and persistence to convince those departments and to get them to agree with each other. At a certain point, my main occupation was calling, emailing and filling out forms to get the permission for the tests. In previous projects, this would have been valuable time to be spent on the project itself. The reality of a multinational influenced the design process in a way I had not experienced before, as students usually receive a lot of freedom without being bothered by hierarchy and red tape.

There were some unforeseen issues as well during the organisation of these tests. It became clear that additional working permits were required. Due to the Christmas period, this permit was delayed until the end of January. Finally, some minor issues with major impact arose. A discussion about which wall socket I was allowed to use delayed the testing further, changing my initial intentions of designing through quick iterative testing.

These issues delayed the start of the prototyping tests until February. My backup plan of conducting tests at the IDE faculty was met with hesitation and scepticism by Schiphol, who doubted the validity of testing in a different environment to quickly iterate on a first concept (a method we have commonly used in design courses). Again a key difference between this internship and my education so far.

However, I do realise that bureaucracy is an inherent part of operating within the Schiphol security context. Operating in this context means complying with a vast amount of national and international safety regulations.

In conclusion, the key difference I noticed with my former projects was the freedom I had as a design student, versus the limitations and challenges of doing a real project for a large commercial organisation. This internship provided me with a lot of insight on how to organise things within a large bureaucratic corporation. I learned that if you want to get things done within a large company, you'll have to keep pushing because no-one else will do it for you. Additionally, I also realised it is fine to sometimes outsource certain regulatory tasks, especially if these tasks can be solved by someone more experienced and connected in the company.

My plans versus the client's demands

During the project, there was some discrepancy between my intentions and Schiphol's desires regarding the prototyping tests.

Although I prefer doing tests in context because these are the most valuable, organising them did cause a lot of delay in my project. At a certain point, I decided it would be more time efficient to conduct the prototyping tests at another location, and to conduct a final test in operation. This way I could make the planned iterations to quickly improve the design, and do a final verification test at the security filter. However, Schiphol clearly emphasised that they would like to see all tests being executed in operation. Abiding with these wishes kept me from making the iterations I planned to do.

Additionally, Schiphol stressed the importance of conducting quantitative tests to analyse the potential influence of the design on the throughput and process time. They indicated this is important for convincing the Schiphol management in order to justify investing in this project. Although I understand the need to convince upper management, in my opinion it was too early to conduct quantitative testing. The prototype was in a very early stage and still needed lots of adjustments which could greatly influence the quantitative data. I think it is a logical step to do a verification test with a prototype in a final stage, but a design that still has to undergo many iterations for improvement benefits more from qualitative testing. Furthermore, qualitative testing in this moment in the process can also be used to verify whether a concept is promising enough to pursue further. Therefore, I believe the data obtained from the quantitative testing is not very meaningful in this stage.

I think the root of these discrepancies is that large corporations apply a different approach than the typical designerly approach we are taught at IDE. This again is a manifestation of the freedom we have as design students in an academic context, versus the necessity of a solid business case in the commercial context. I gained a lot of experience by operating in the latter, and I realise the importance of fighting for your case with convincing arguments, especially within large corporations.

On the other hand, I also realised the importance of believing in my personal judgment and experience as a designer. In hindsight, too often I let my judgment be overruled by external input, even when my ideas were well-grounded. I will definitely take this experience to the heart, and use it in my further career as a designer.

Final conclusion

Although it was quite a challenge with Schiphol's corporate structure from time to time, I am very grateful for the possibility to do my graduation project here. I really enjoyed working in such a dynamic context, and I especially enjoyed doing the prototyping tests in operation. I am especially grateful to the security agents, who took me into their world and provided me with so much meaningful input. Additionally, their positive responses to the concept were very motivating and empowering, and I am glad I was able to make a contribution that benefited their working conditions.

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Images

All security related photos are courtesy of Schiphol Brandportal (2016).