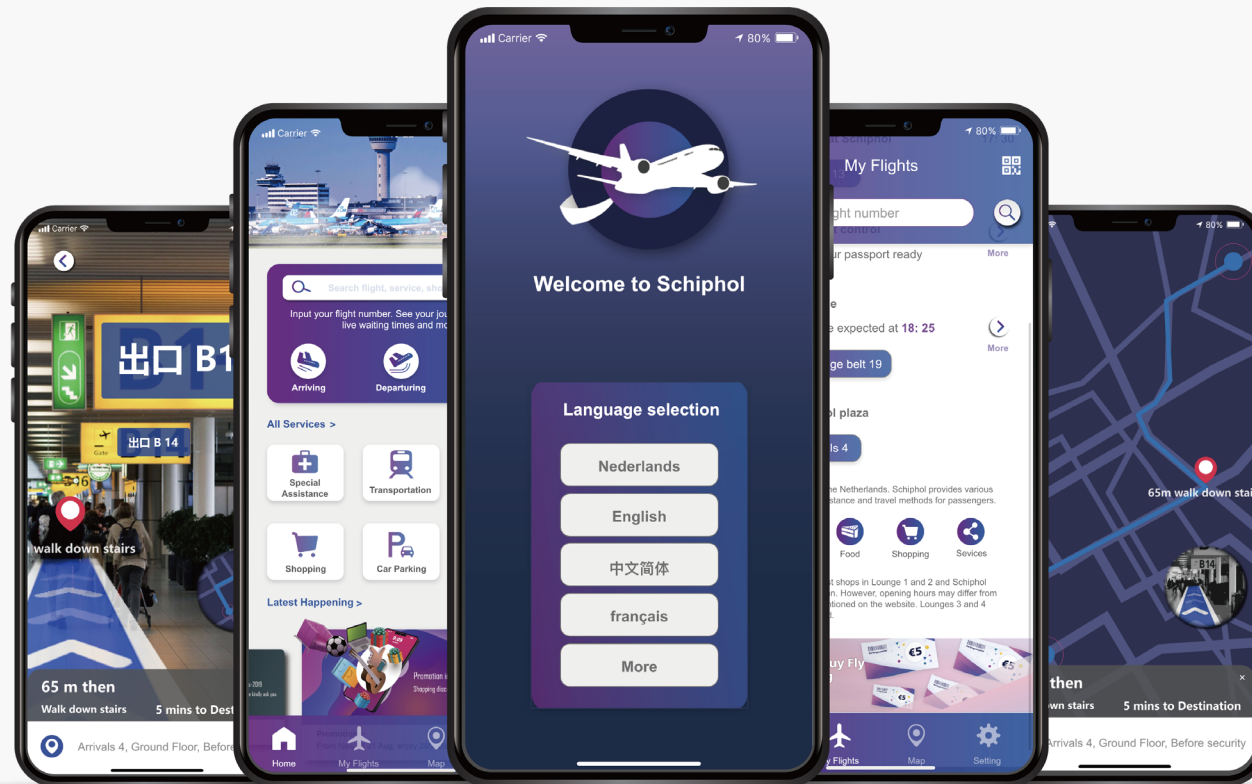


Schiphol indoor navigation application

Master thesis
jianghui Li



Schiphol indoor navigation application

Master thesis

Delft, 2020 3.06-8.24

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Executive Summary

Base on the preliminary research results, the design goal of this project is defined: Providing departing, arriving and transferring travellers a seamless experience, which makes them feel confident and relaxed during the whole process of their journey in Schiphol, including wayfinding, searching information, learning of the Dutch transport system, check-in and even passing border control, Etc. This can be achieved by facilitating the Schiphol information providing and wayfinding to help travellers understand the Schiphol service, wayfinding and transportation system and meet all their varying needs. The emphasis of this project is not to improve the Schiphol's service system or add new service in Schiphol, but to help travellers understand and utilize Schiphol's current service system by building a new efficient app information architecture and AR navigation system.

This project explores which information structure is more suitable for Schiphol (Public transport system). Through continuous testing and iteration, the information architecture of the new Schiphol app is confirmed, which would combine with the liner pattern and Hub and spoke information structure to build the underlying information architecture of the app. Choosing the Hub and spoke as the primary parent pattern and applying liner pattern for subsections.

In the user testing phase, it was discovered that functionality, ease of learning, and fun are all essential factors that affect user performance with the new Schiphol app. The focus of the second iteration is to ensure that users can understand and use the app. Make the layout of each interface and visual elements of the app more familiar to all users. The third iteration mainly focuses on

the ease of use and fun of the new app. More attractive visual elements and dynamic effects are added to enhance the app's interest. After three rounds of testing, the new Schiphol app can meet the needs of all participants and combines functionality and fun.

Overall, the new app can help travellers quickly obtain the information they need and learn about Schiphol (Schiphol wayfinding system, Schiphol service system, Dutch public transportation system). At present, only about one per cent of passengers will download the Schiphol app in advance, so how to help them realize this app and download it is still an issue that Schiphol needs to consider in the future.

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Chapter 1 | Introduction

This chapter includes:

- 1.1. Project background
- 1.2. Design vision
- 1.3. Design structure

1.1 project background

Schiphol is one of the largest transportation hubs in Europe, With the number of passengers continuing to increase in the coming years according to CBS (2018), Schiphol and the TU Delft has established a cooperation to improve the efficiency of Schiphol and experience of all kinds of passengers.

There has been consistent growth in the number of passengers, which would cause the capacity of Schiphol terminal will become too small in the near future. A good flow of people is essential in improving passengers' experience and making Schiphol more efficient. When looking at where problems arise in terms of people flow, Schiphol found travellers to have problems with wayfinding and to understand the Dutch public transport system and Schiphol service system, decreasing the people flow. So how to help passengers understand the Netherlands transportation system and Schiphol service system and improve their wayfinding experience have become the main direction of this project.

“At Schiphol, the traveller’s experience is of high importance with safety, enjoyability, sustainability and seamlessness as core terms” according to the CEO of Royal Schiphol Group D. Benschop (2019). For this project, the primary assignment left by Schiphol is “**Design a multi-modality transport hub; an efficient and inclusive service HUB for personal mobility. Improve the user experience of international travellers arriving at Schiphol Airport during their first encounter with the Dutch public transport system by developing a user-centred product-service solution to provide travellers with a seamless travel experience**”. -Schiphol (2019).



Figure 1: Schiphol plaza (jianghui li, 2019)

1.2 Design vision

“The ambition of Schiphol is connecting the Netherlands with the whole world and make all kinds of passengers have a safe, seamless, enjoyable and sustainable Schiphol experience” (D. Benschop, CEO Royal Schiphol Group). “Schiphol wants to differentiate itself in the market by having fluent processes, the best service and a broadly appealing restaurant and shopping offer” (Royal Schiphol Group, 2019c). Based on the clients’ demands, the following is the design vision of this project.

The design vision of this project

Making Schiphol be the preference European airport for departing, arriving and transferring travellers by providing seamless and comfortable user experience. Helping passengers, especially the first time travellers to understand Schiphol and make full use of Schiphol service efficiently by providing personal guidance and thoughtful and personalized user experience.

1.3 Design structure

This report is structured in three phases that roughly reflect the design process: 1. research phase, 2. Concept phase, and 3. From concept to design.

1.3.1. Research phase

The primary purpose of the research phase is to define the design goal of this project. First, discovering and defining problems through user research, including journey maps, interviews and persona, then combining context analysis and stakeholder analysis to reevaluate the main problems in users’ journeys. Finally, the design goal, function list and requirement list of this project are obtained by analysing all the investigation and research results.

1.3.2. Concept phase

In the concept phase, the final concept of this project is obtained. This process includes competitive product analysis, ideation, model making, and product iteration.

1.3.3 From concept to design

The main task of this stage is to realise the relevant functions of the concept and complete the testing and iteration through functional prototyping.



Research phase

Chapter 2: User research

Chapter 3: Context & Stakeholder Analysis

Chapter 4: Design goal



Chapter 2 | User research

This chapter includes:

2.1. Current passenger journey analysis

2.2. Interview

2.3. Persona

2.4. Conclusion

Abstract

The primary purpose of this project is to improve the passenger experience in Schiphol. In this chapter passengers' experience in Schiphol, their emotions are analysed, and their demands are explored. This chapter mainly consists of three subjects: current passenger journey, interviews and Personas of typical passengers. First, the passenger journey is described, and passengers journey maps are created. Then, to understand their psychological changes and personal needs, base on the journey map, different types of travellers are invited to take part in an interview. Finally, combine with the interview results, the persona of typical users will be made.



Figure 2: People flow in Schiphol plaza (jianghui li, 2019)

2.1. Current passenger journey analysis

The passenger journey focuses on the experience and current situations for passengers at Schiphol. Passengers' current experience in Schiphol is mapped to show their routes for arrival, departure and transfer. The passenger journey analysis is comprised of the existing passenger flows, the specific interactions between Schiphol and the passenger and the experience of different types of travellers in Schiphol. There are different types of travellers at Schiphol, and they have their journey and experience to, from or at the airport. Different passengers have various travel and wayfinding at airports is a common problem that is influenced by multiple aspects like the architecture of the building, signs, interior design features and even by the type of traveller and the reason of their visit. (Fewings, 2001). The different types of passengers at Schiphol would be described in the last part of this chapter: Persona. Here, in order to get a good understanding of the current passenger flows at Schiphol, passenger journey maps are done for the arrival, departure and

transfer journey. A passenger journey is defined as the trip they make from home to their destinations or leaving Schiphol by train or bus.

Method

Customer journey mapping is applied to learn current travellers journeys in Schiphol. It is a framework to get a grip on different aspects of the travellers' experience. In this graduation project, customer journey mapping is used as an analysis method of the journeys that different kinds of travellers currently go through at Schiphol terminal. Here, as shown in figure 3, taking the journey map from Schiphol annual report as a reference, the Schiphol service, and the specific travel methods are added to the journey map. Combined with the previous research, observation and subsequent interviews, three journey maps were created and improved continuously. Tester tries to make it include all activities for passengers in Schiphol.

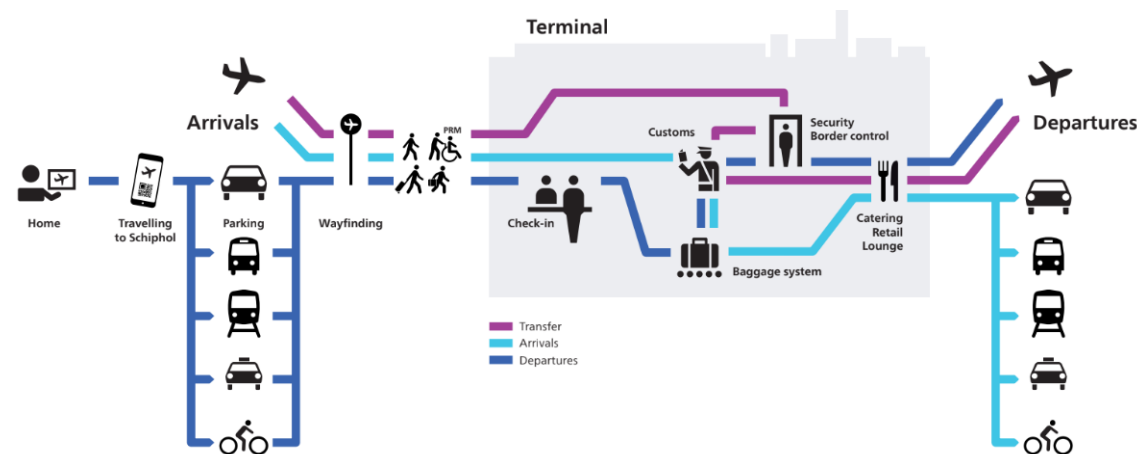
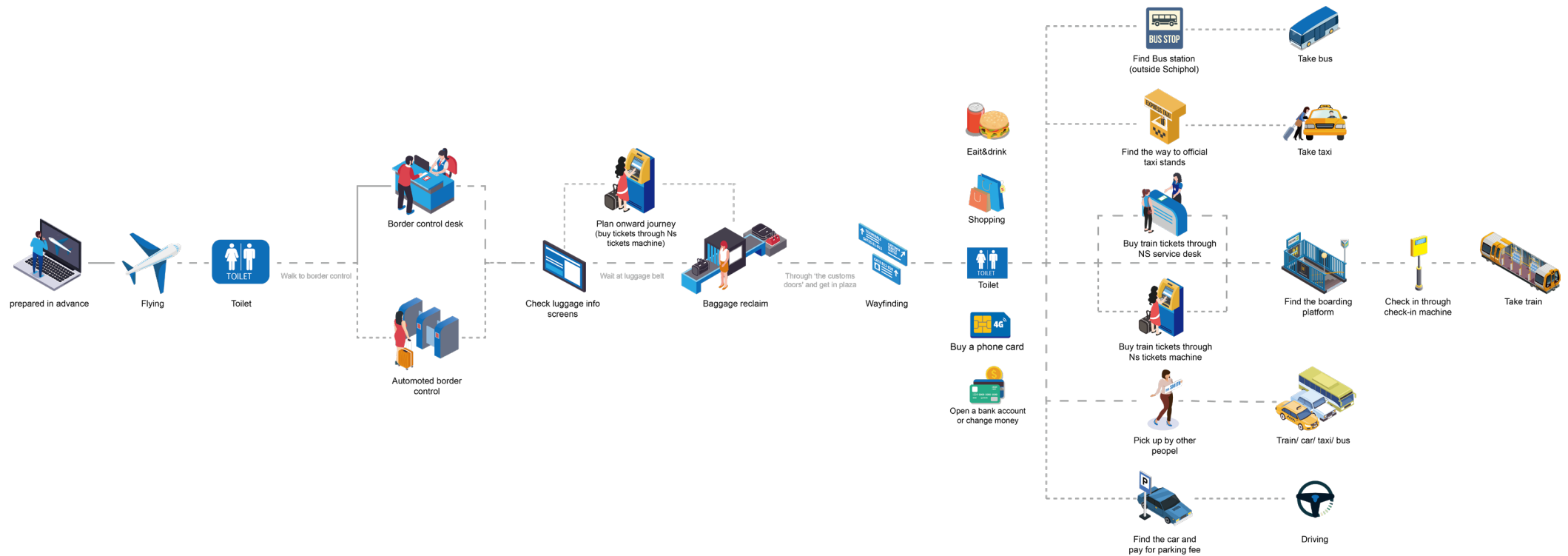


Figure 3: Users' journey map (Schiphol annual report 2018)

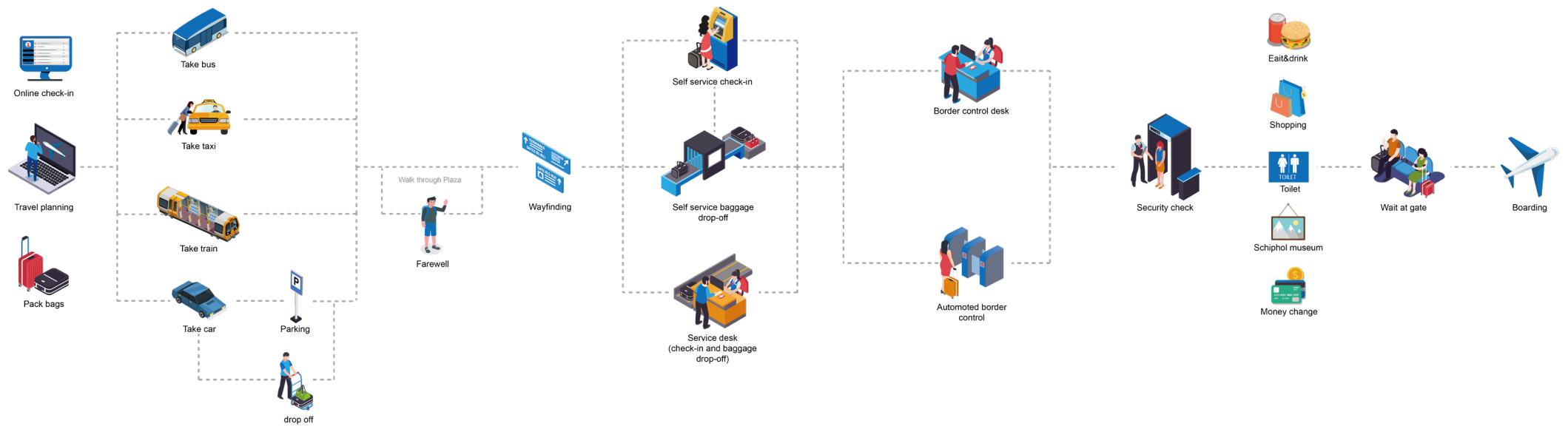
Journey maps of the current stages with Passenger Flows

Here, in order to develop passenger journeys at Schiphol, all possible steps of passengers are analyzed and described in passenger flow. The journey maps and all the passenger experience is based on the Schiphol annual report 2018 and observation and interview results. The steps are mapped for each stage in the passenger flow and visualized below. For specific details, please refer to appendix-1.

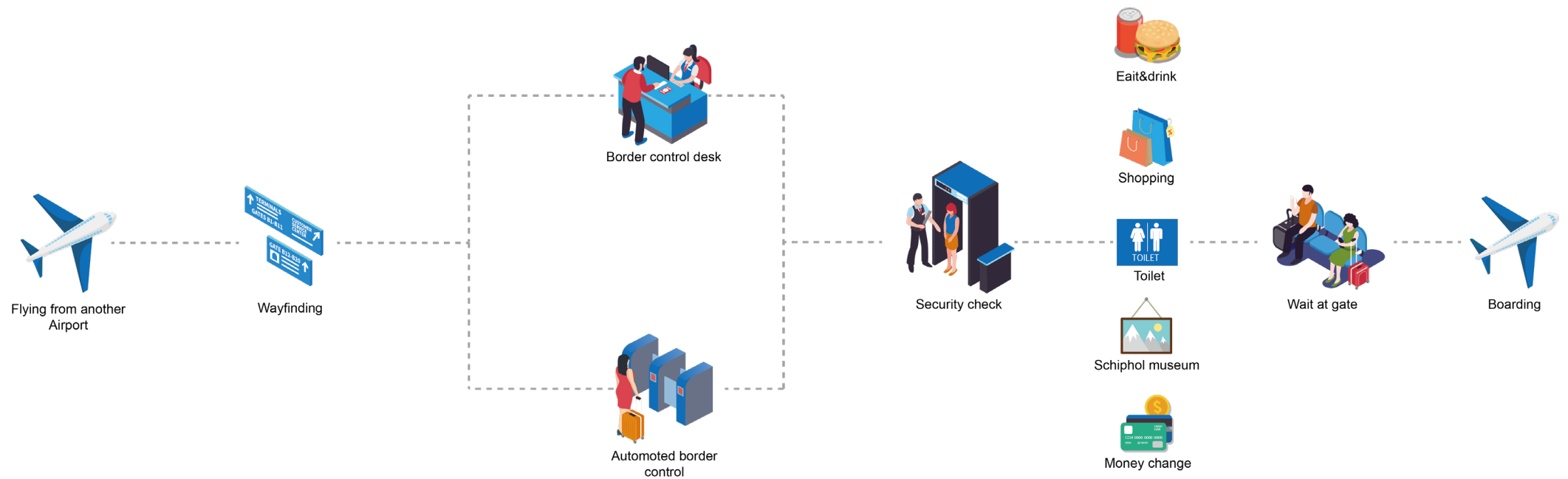
Arrival journey map



Departure journey map



Transfer journey map



2.2. Interview

In the previous chapter, the passengers' journey and experience are described. This chapter would focus on passenger emotions in each step of their journey in Schiphol and their demands. Different travellers have different needs. For example, international travellers always have language barriers, while local travellers would worry about parking in Schiphol. The primary purpose of this chapter is to understand the core needs of different users through interviews and the main obstacles encountered by different travellers at Schiphol.

Research question:

1. what are the main obstacles encountered by different travellers at Schiphol?
2. How did different passengers solve problems throughout the whole journey at Schiphol, especially wayfinding problems and missing information?
3. What are the demands of diverse travellers in Schiphol?

Method

Interviews were conducted through teleconference and telephone.

Participants

Ten travellers partook in the interview, from which three were male, and seven were female. The age range from 21 to 55, and nationalities represented were: French, Dutch, Spanish and Chinese. Seven participants had no prior or little experience with Schiphol and the Dutch public transport system, and 3 participants are local or frequent travellers to Schiphol. Participants include four students, one engineer, one retiree, one housewife, two doctors, and one businessman. They came to the Netherlands for different purposes: travelling, immigration,

working, visiting family and studying.

Procedure

Participants were asked questions based on a map showing their customer journey to recall memories. Here, the term customer journey is defined as the physical routes participants pass through in Schiphol terminal.

At the beginning of the interview, the tester will ask the interviewee's overall impression of Schiphol compared to other airports. Then show them passenger journey maps and record their specific routes in Schiphol. Then for each step of their journey at Schiphol, the tester would ask them the following questions.

1. What did you feel at this step?
2. Why do you have this emotion, and what happens to you at this step?
3. If you encounter some problems at a specific stage, how did you finally solve it?
4. Do you know where to go next or do you have some wayfinding problems in this step and what information you need and missed?

All views of the participants and insights will be recorded in the notes.

Result

See appendix 2 for 9 journey maps for all participants with the results of interviews. Below are some insights from the interviews.

Arrival at Schiphol

1. For passengers who come to Schiphol for the first time, 6 out of 7 participants, except for a Spanish girl, decided at home what type of transportation method they were going to use after arriving at Schiphol. Participants used Google/the internet (n= 2) and information provided by their hotel (n= 1) as sources to prepare. The left 5 out of 10 participants were picked up by others.
2. Almost all passengers will feel relaxed when they get off the plane. Here some Chinese girls need to go to the toilet to fix their make-up. And a Spanish girl mentioned air pressure. A Dutch girl said that she never used the toilets on the plane because of the sanitation problems.
3. For travellers from non-European countries, they cannot choose automated border control. They have to wait in line for the border control desk, and when communicating with marshall of the border control in English, 5 out of 6 non-European travellers felt nervous due to language barriers. For European travellers, a Dutch traveller complained that because the sign was unclear, he did not know where to queue when he passed the custom. A French traveller who even didn't realize that he could pass the customs through the automated border desk and complained that the service desk took too long to queue.
4. Almost all participants would not buy train tickets while waiting for their luggage. They pay more attention to their luggage and stare at the baggage belt because they are afraid of missing that. Moreover, one participant felt the baggage information on the electronic screens is unclear and another participant was informed that her luggage was delayed(1.7% of delayed baggage in Schiphol).
5. 8 out of 10 participants can successfully pass the plaza and find the exit or Ns ticket machine without any wayfinding problems. 2 participants feel confused and difficult to find the parking slot because

the signs in Schiphol is unclear and insufficient.

6. For passengers who come to Schiphol for the first time and choose public transportation, 5 out of 6 this kind of participants feel anxious and confused when they use the NS ticket machine and feel it is hard to learn the Dutch public transportation system. Furthermore, only one participant had no problems with buying tickets. Reasons for this mentioned by her were a clear interface of the ticket machine. Moreover, a Spanish girl prefers human service and buy a ticket from the NS service desk when she came to Schiphol the first time.

7. 3 out of 7 participants who had no prior or little experience with Schiphol and the Dutch public transport system found it is hard to find the train station boarding platforms which are located below Schiphol plaza. 4 out of 7 first time travellers did not realize the check-in machine and missed it.

Departure from Schiphol

1. Most participants would prefer to check-in online, which is time-saving and efficient.
2. For travellers who drive to Schiphol, 1 participant do not know that they can reserve parking spaces through the Schiphol application. They complained about the insufficient parking spaces and high parking fees.
3. 2 out of 10 participants have had the experience of forgetting to check out.
4. 3 out of 10 participants feel it is hard to find the departure hall due to the unclear signs. One participant emphasized that she can not realize the departure hall is located on the first floor due to the lack of signs of departure in Schiphol plaza.

5. Two participants found it hard to find the first-class lounge because of the unclear signs.

Transfer at Schiphol

1. 2 of 5 transfer passengers do not understand the extra security check-in Schiphol and feel annoyed about that.
2. One participant complained about the long queue of border control.
3. Two participants have complained that it is hard to realize VIP lounge for transit passengers is different from the VIP lounge for passengers departing from Schiphol.

Discussion and Conclusion

To elaborate on the research question: **what is the main obstacles encountered by different travellers at Schiphol?** The following finding was done.

Language barriers: For non-European travellers who come from non-English and non-Dutch speaking countries, they cannot understand the text on the signs and even cannot communicate with Schiphol staff and ask for help. Here language barriers are also a problem during the process of passing customs, and they need to answer the questions asked by marshall at the border control desk.

Unclear signs and critical information were missing: The majority of the participants found Schiphol signs are clear, and they can easily find exits and gates base on that. But the signs for the parking lot, first-class lounge and service desk, etc. are insufficient and unclear. Many travellers even complain that they cannot find the departure hall. The specific cause of this situation is related to the design principle of the Schiphol signs system, which would be discussed in the next chapter-Schiphol context. Moreover, missing information is also a severe

problem. For example, in this interview, a French traveller wanted to avoid the potential crowds at border control. When he got off the plane, he walked directly to the border control desk. But he finally found that he still had to line up and felt upset. He did not realize that as European passengers, he can pass the customs directly through automated border control without queuing. Furthermore, for participants driving to Schiphol, most of them complained about the long time spending on parking and few parking places. No participant, even Dutch here, did not know that parking spaces can be reserved in advance through the Schiphol app. Such essential information missing directly affects and constrains travellers journey at Schiphol.

Complicated transportation system: For first time users, because of the lack of knowledge about the Dutch public transportation system, frequently problems related to NS ticket machine, payment of the train tickets, check-in through NS check-in machine and wayfinding of the boarding platform were encountered, these issues start the experience of passengers with the Dutch public transportation system negatively. From the interviews, it was clear that to most of our participants, there were lots of problems in understanding the OV-chipcard system and check-in. Here a Chinese girl said that when she used the NS ticket machine to buy train tickets, the OV-chipcard system confused her and she didn't know if she needed to apply for an OV card before buying a train ticket. Moreover, missing check-in is also a common problem, and even frequent travellers will forget to check-in.

Findings on research question two; **How did different passengers solve problems throughout the whole journey at Schiphol, especially wayfinding problems and missing information?** are following.

Most of the international participants were already looking for information on public transport or connecting with people who pick them up before arriving at Schiphol. That seems to improve the

wayfinding compared to travellers who did not prepare because they know what to do next clearly. Two participants did not prepare their travel in advance, and the location where they both started to think about what transportation to choose is Schiphol plaza. One possible reason might be that travellers look for information based on previous experience of airports, and most of them are reluctant to buy train tickets and distract attention from the baggage belt in the luggage reclaim hall. During the process of leaving Schiphol, the majority of participants found it is clear for them that which was the best option and how to buy tickets. However, most people who thought it was clear had to actively search for information using the internet, contacting the information desk or pick up by others. Participants who felt it was unclear stated that there was no clear overview of options. Conclusions from this indicate that the information presented by Schiphol at the airport today is insufficient for the traveller to be able to make a confident decision.

When travellers encounter wayfinding difficulties or other problems, especially buying train tickets, How they solve it? The participants were advised via the internet/Google, had been in contact with the information desk and received clear instructions from Schiphol staff or someone more experienced with Schiphol and the public transport system. Here it is found that most travellers preferred to have personal contact and guidance when asking for information instead of the non-personal digital version. Here a Chinese girl encountered difficulties in buying tickets through an NS ticket machine. She asked another Chinese girl close to her to help her purchase train a ticket. Another Spanish girl went directly to the service desk to buy train tickets. Moreover, when faced with the problem of wayfinding, people always tend to ask others for help. But many participants here complained that when they need help, it is difficult to find the Schiphol staff in time.

On the other hand, recognition and missing key information were mentioned in the interviews as one of the reasons why people think their personal demands are not met. For example, a Chinese mother in the

interview claimed that she wants someone to help her take care of her two-year-old child while waiting for check-in. But she didn't recognize the baby care lounge in Schiphol. Fewings (2001) also highlights recognition as a critical factor in the traveller's wayfinding process and experience in the airport.

Findings on research question three; **What are the demands of different travellers in Schiphol?** are following.

Different travellers have different demands which are influenced by the type of traveller and even their visitation reason. From the interview results, It is found that When each passenger different personal needs cannot be met at Schiphol, strong negative emotions will appear. For example, for French business people, efficiency is the priority, and they do not want to waste time at Schiphol. He feels anxious and disappointed when he finds that he needs to spend a long time in line. For Chinese travellers, their main demands at Schiphol are shopping and tax refund. For them, the shopping experience is their focus. For this project, understanding the different needs of users and their concerns are also a meaningful direction. This topic would be discussed in 2-3 persona.

Limitations

Some participants have not been to Schiphol in a long time, and it is hard for them to keep the fresh memory of their experience, which would lead to errors and distortions in remembering. Thus might have had an impact on the validity of the result of the interview. The small number of participants that were interviewed would also affect the result of the interview. It is hard to define how common those problems are, though the establishment of their presence is essential. During the discussions, it was also realized that not all questions were applicable to all participants, which resulted in a different amount of participants per question.

2.3. Persona

The main purpose of this chapter is to understand and even classify the personal demands and goals of each passenger at Schiphol. Here in order to understand users' individual needs, experiences, behaviours and purposes, the persona is created.

Method

"A user persona is a representation of the demands, goals and behaviour of a hypothesized group of users. It can help the designer to recognize that different people have different demands and expectations. It can also guide ideation processes. In most cases, personas are synthesized from data collected from interviews with users" (Dam, R. F., & Teo, Y. S. (n.d.)). Based on the data of participants from the interview, 9 personas are created. Each persona represents a type of passenger at Schiphol. These 9 personas represent 9 typical passengers at Schiphol, who come from different countries, have different occupations, different purposes to Schiphol, different cultural backgrounds and even different personalities.

Discussion

Nine personas indicate common behaviours, experience, outlooks and personal needs of Schiphol different kinds of passengers. During the later ideation process, proposed concepts and ideas should be evaluated by how well they meet the requirements of the above nine personas. Functions of the final solution would be prioritized refer to how well they address the needs of the nine personas. In these nine personas, the personal needs of all typical users are related to the lack of crucial information, language barriers, non-user-friendly Dutch transportation system and wayfinding. Combined with the analysis and discussion of the interview, the two studies were performed at the landside area

of Schiphol. What would be interesting to investigate is: How to improve the Schiphol wayfinding process for passengers? How to help international travellers solve language barriers? What information do different travellers need and how to help them filter information effectively? How to assist international travellers in understanding and using the Dutch transportation system.



Aarav
About
age: 29
occupation: Software engineer
status: single
nationality: Indian
language: English and Hindi

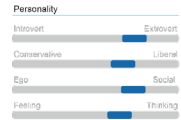
Bio
Aarav is a software engineer from India. He was invited by a local computer company to be a technical consultant and will stay here for one year. This is his first time here. Because he is not familiar with the local transportation system, he has seen the introduction video of the train system and installed the schiphol app in advance.

Like	Dislike
Photography	Poor communication
Open source software	Slow internet connection
Watching movie	Unclear signs

Personal needs

Find out where to buy an anonymous or chipkaart
Find information about the train in an efficient way, the train timetable, boarding location, departure time
Buy a local SIM card and charge it to connect with the internet

Frustration
Lack of knowledge about how and where to buy a chipkaart and a SIM card
It's hard to find the right staff to ask for help.



Preferred wayfinding solution



- Internet and app
- Personal contact (service desk and personnel)
- Signs and physical maps in schiphol

Motivation



Theresa
About
age: 33
occupation: Housewife
status: Married
nationality: German
language: English and German

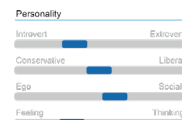
Bio
Theresa is a housewife. She moved to the Netherlands with her two-year-old daughter due to her husband's job change. After she came to Schiphol, her husband drove to pick her up. This was the first time she came to Schiphol with her little daughter.

Like	Dislike
Soap opera	Poor communication
Reading	Unfamiliar environment
Online shopping	Awkward situation

Personal needs

When she arrived at Schiphol, she had to find the parking lot. Her husband is waiting for her there.
When the departure from Schiphol, she wanted to find a quiet place to wait. The noisy and crowded environment of the Schiphol main terminal made her daughter irritated and burst into tears.

Frustration
Due to the signs for the parking lot are insufficient and unclear, she felt confused and stressed during the wayfinding process.
Her daughter's crying and yelling in the public area make her feel embarrassed and stressed.



Preferred wayfinding solution



- Internet and app
- Personal contact (service desk and personnel)
- Signs and physical maps in schiphol

Motivation



Dennis
About
age: 70
occupation: Retiree-history teacher
status: Married
nationality: French
language: French and a little English

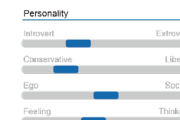
Bio
Dennis used to be a junior high school history teacher. Now he is retired. He and his wife traveled to the Netherlands for the first time. Because of the language barriers, he can only rely on icons on the signs to find his way. He has booked a hotel in Amsterdam in advance, but he has no idea about Dutch public transportation system.

Like	Dislike
Reading	Noisy environment
World history	Overcrowdedness
Museum	Impatient service

Personal needs

Find a place to sit and rest
Find someone who know French to help him and find out the way to get to the hotel

Frustration
Due to language barriers, he could not understand most of the signs and don't know how to communicate with the others.
The crowded and noisy environment makes him feel tired. He even couldn't find any place to sit.



Preferred wayfinding solution



- Internet and app
- Personal contact (service desk and personnel)
- Signs and physical maps in schiphol

Motivation



Liang
About
age: 22
occupation: International students
status: single
nationality: Chinese
language: English and Chinese

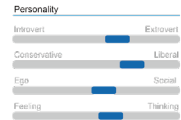
Bio
Liang is a graduate freshman of TUD. She came to the Netherlands for the first time. The strange environment and language barriers made her feel anxious. She prepared in advance by asking other TUD students for information about Dutch public transportation and travel suggestions. After arriving at Schiphol, she knew what she was going to do next.

Like	Dislike
Design	Poor communication
Shopping	Unplanned journey
Fashion	Complex system

Personal needs

Find out where to buy an anonymous OV chipkaart.
Buy a local SIM card and charge it to connect with the internet

Frustration
Lack of knowledge about how and where to buy an OVchipkaart and a SIM card
Non-user-friendly Dutch public transportation
The complex and confusing user interface for NS ticket machine



Preferred wayfinding solution



- Internet and app
- Personal contact (service desk and personnel)
- Signs and physical maps in schiphol

Motivation



Zhang & Wang
About
age: 55&53
occupation: Doctors
status: Married
nationality: Chinese
language: Chinese

Bio
Zhang and Wang are a middle-aged couple. They came to the Netherlands to visit their daughter, who studies in TUD. They don't speak English. When they came to Schiphol, their daughter was waiting for them at the train station platform below Schiphol plaza.

Like	Dislike
Cooking	Unplanned trip
Reading	Rude and impatient service
Watching movie	Noisy environment

Personal needs

Find out where is the train station platform.
Tax refund when departing from Schiphol

Frustration
When passing through customs, due to language barriers, they did not understand the question asked by the custom controller.
Due to language barriers and insufficient signs at Schiphol, they did not find the train station below Schiphol plaza.

Personality

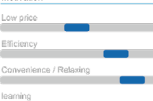
Introvert	Extrovert
Conservative	Liberal
Ego	Social
Feeling	Thinking

Preferred wayfinding solution



- Internet and app
- Personal contact (service desk and personnel)
- Signs and physical maps in schiphol

Motivation



Albert
About
age: 30
occupation: Designer
status: single
nationality: Spanish
language: English and Spanish

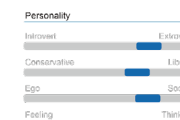
Bio
Albert is a designer and has a long history of smoking. This is his second visit to the Netherlands. He came here to reunite with his family. He would like to immigrate to the Netherlands because his wife is Dutch.

Like	Dislike
Photography	Poor communication
Smoking	Overcrowdedness
Design	Unclear signs

Personal needs

Find out where to buy a train ticket.
Find information about the train in an efficient way, the train timetable, boarding location, departure time.
Find Smoking area.

Frustration
The complex and confusing user interface for NS ticket machine and it is hard to find the right staff to ask for help.
Long queue for the NS service desk.
He spent a long time to find the smoking area and finally was informed that smoking is forbidden in Schiphol.



Preferred wayfinding solution



- Internet and app
- Personal contact (service desk and personnel)
- Signs and physical maps in schiphol

Motivation



Simon
About
age: 44
occupation: Businessman
status: Married
nationality: French
language: French and English

Bio
Simon came to the Netherlands on a business trip. The local company sent a driver to pick him up. He is busy with work every day and when he was at the airport, he always wanted to find a quiet place to work. Every time he travels, he would buy some souvenirs for his family. This is his sixth time in the Netherlands, and Schiphol is no stranger to him.

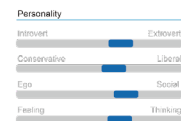
Like	Dislike
Real-time information	Poor communication
Mountain climbing	Long waiting time
Museum	

Personal needs

While waiting for check-in, find a quiet place to work.
When leaving Schiphol, buy souvenirs for his family.
Leave Schiphol efficiently.

Frustration
Waiting for luggage can feel endless.
It took too long to queue through customs and he did not realize that passengers with European passports can pass customs through automated border control without queuing.

When he left Schiphol, it was difficult to find souvenirs in duty-free shops

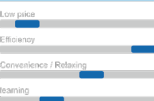


Preferred wayfinding solution



- Internet and app
- Personal contact (service desk and personnel)
- Signs and physical maps in schiphol

Motivation



Mathias
About
age: 60
occupation: Engineer
status: Married
nationality: Dutch
language: English and Dutch

Bio
Due to the need for work, Mathias often travels from Schiphol to other countries. He is already familiar with everything about Schiphol. Every time the company will arrange the first class for him. And his wife will drive him to Schiphol every time and pick up him when he arrived.

Like	Dislike
Reading	Noisy environment
Gardening	Unclear signs
Antique collection	Long waiting time

Personal needs

Find the first class lounge.
Parking at Schiphol.
Buy some snacks in Schiphol.

Frustration
Parking in Schiphol is difficult due to limited parking spaces.
Since the unclear and insufficient signs, it is difficult to find the first-class lounge. When he transferred from Schiphol, he did not realize that the first-class lounge for transfer passengers was different from the first-class lounge for departure passengers.

Personality

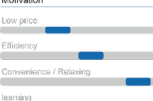
Introvert	Extrovert
Conservative	Liberal
Ego	Social
Feeling	Thinking

Preferred wayfinding solution



- Internet and app
- Personal contact (service desk and personnel)
- Signs and physical maps in schiphol

Motivation



Lisa
About
age: 21
occupation: International student
status: single
nationality: Korean
language: English and Korean

Bio
Lisa studied in the UK, this is the first time she came to the Netherlands. She came here to travel. She booked the hotel in Amsterdam in advance, but she hadn't thought about how to leave Schiphol. At Schiphol plaza, she knew through google maps navigation that she had to go there by train.

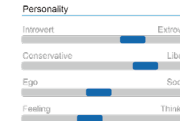
Like	Dislike
Traveling	Overcrowdedness
Shopping	Slow internet connection
Watching movie	Unclear signs

Personal needs

Find out where to buy a train ticket.
Find information about the train-the train timetable, boarding location, departure time.
Temporarily store your luggage at Baggage Storage or in a locker

Frustration
Lack of knowledge about how and where to store her luggage.
It is hard to find the NS train station and she did not realize that the NS train station was just below Schiphol plaza because of the unclear signs.

Missed check-in.



Preferred wayfinding solution



- Internet and app
- Personal contact (service desk and personnel)
- Signs and physical maps in schiphol

Motivation



Figure 4: Nine personas (Please refer to appendix-3 for the big picture)

2.4. The general conclusion of study1&2&3

The study aimed at finding out what is the main obstacles encountered by different travellers and points out where improvements are needed based on the passenger experience, which could indicate the directions of this project. The research investigated how and when a traveller is looking for information and personal needs of different type of passengers. The following is the possible development direction of this project.

Wayfinding:

Spatial orientation is an essential element affecting the seamlessness and efficiency of travellers' journeys. For this project, it would be crucial to investigate how to combine traditional Schiphol signs system and digital navigation system with helping passengers to find their destination and service in Schiphol effectively and directly in the Schiphol environment?

Searching Information:

Passengers are continually searching for information related to their journey and their personal needs. However, different travellers have different needs. But their individual needs missing are more or less related to the lack of information. Knowing where to find the information that they need, understanding the information provided and having an overview of Schiphol service and the options available can impact their experience in Schiphol. For this topic, it would be interesting to explore how to distinguish and classify the needs of passengers and provide real-time information with passengers to make up for their knowledge gap in Schiphol.

Dutch public transportation:

"Most of the international passengers, especially first time users, currently feel that public transport in the Netherlands is non-user-friendly" (NBTC, 2014). Lehr (2016). Lehr (2016) analyzed four areas of improvement concerning the Dutch public transportation system at Schiphol: find the public transportation information, wayfinding (like finding the train station, bus station, official taxi stands and NS ticket machine & service desk), payment of the train tickets. For this project, how to provide passengers with relevant information and instruction about understanding and to use the public transportation system will become the focus of this topic.

Language barriers:

Image recognition, real-time translation and AR-translated digital images would be exciting to explore. The primary purpose is to help international travellers read Schiphol signs and maps.



Chapter 3 | Context & Stakeholder Analysis

This chapter includes:

3.1. Context analysis

3.2. Stakeholder analysis

Abstract

The Previous chapter has posed opportunities for improvement during the next phase of the project-Wayfinding, Searching information, Dutch public transportation, Language barriers. In order to study current problems, the system has and develop the user-centred solutions in Schiphol environment, the context of Schiphol and the needs of all stakeholders in this project should be understood. This chapter includes two parts-Context analysis of Schiphol & Stakeholders analysis.

3.1. Context analysis

To know how does the context of Schiphol influence travellers, especially international travellers and how Schiphol helps them solve their problems encountered at Schiphol, the current setting of Schiphol is analyzed.

A general overview of Schiphol

Schiphol is the leading international airport of the Netherlands with 70 million travellers annually, 200 000 every day. These are numbers which have quickly been increasing over the years.

Schiphol terminal building has three levels and is mainly composed of the arrival hall (plaza) on the ground floor, departure halls on the second floor, the main terminal and gates on both 2nd floor and 3rd floor. "The one-terminal concept is applied in Schiphol, where all facilities are located under a single roof, radiating from the central plaza" (Schiphol.nl, (n.d)). Here Schiphol context analysis will be divided into three parts according to functional characteristics and building structure-arrival hall, departure hall and the main terminal and gates of Schiphol.

3.1.1. Schiphol plaza: arrival hall

In general, as can be seen in figure 5, Schiphol Plaza is a triangular-shaped building and a combination of an airport arrival hall and a train station. There are also lots of shops and restaurants in the plaza. In this chapter, the wayfinding system in Schiphol plaza, service that Schiphol provided, working staff and public transportation system in Schiphol are discussed.

Wayfinding system

The Schiphol wayfinding system is complemented by sign system, maps, service desks and digital information systems-Schiphol app and electronic screens. Schiphol wayfinding system helps passengers find their way independently.



Figure 5: Map of Schiphol Plaza (Schiphol.nl)

Sign system

Amsterdam Airport Schiphol distinguishes itself with an international and consistent sign system throughout the airport. Over 3.000 clear and very recognizable signs show the passengers the way to their destination.

Schiphol signs are followed by an international trend (International Union of Railways), which is similar to the signs system of Dutch Railways (NS). After the Schiphol Plaza combined with the NS train station, they have decided to share symbols of signs system, which could align different sign systems to reduce cognitive load and learning cost for travellers (Mijksenaar, P. (2012)). Here, different from the NS station sign system, Schiphol applies a colour-coded scheme that colours are coupled to specific types of information. Yellow signs refer to arrivals and departures, for instance. In contrast, blue signs offer information on wayfinding of restaurant-café facilities and shopping in Schiphol terminal, anthracite to indicate other airport service and facilities in Schiphol, and green to escape routes (Mijksenaar, P. (2012)). The main colours of Schiphol signs are yellow with dark grey lettering or the opposite, which create a sharp visual contrast and make the symbols and words stand out. As shown in figure 6, all signs in Schiphol are displayed in English or Dutch and featured unambiguous, often big and black arrows in white circles. The layout of wayfinding signs in Schiphol was simplified to the bare essentials: direction and destination (Mijksenaar, P. (2012)).

In addition to hanging signs, there are other types of signals in Schiphol. First, in Schiphol plaza, there are lots of official taxi stickers on the floor (figure 7), which was added to avoid travellers getting swindled by unofficial taxi drivers asking too much money. It is found here that signs on the ground sometimes conflict with signs in the air. Passengers don't know which one to follow. Second, there are many signposts in Schiphol plaza (figure 7), which is located in front of the arrival gate.

The primary colours of the Schiphol signposts are blue with white lettering. Different from the hanging signs, signposts are less obtrusive and show travellers the direction of the most popular restaurant and some facilities in Schiphol.



Figure 6: MSchiphol hanging signs (jianghui li, 2019)



Figure 7: Schiphol signpost and taxi sticker (Jianghui Li, 2019)

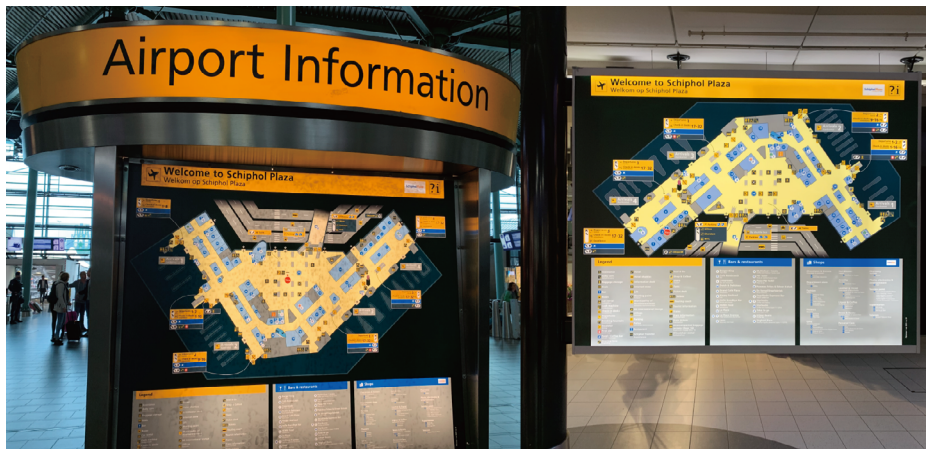


Figure 8: Schiphol maps (Jianghui Li, 2019)

Maps

Besides signage, travellers could also find the location information from the Schiphol map post (2D bird's eye view). Schiphol Maps could give visitors an overview of specific areas, which is located at each arrival gates and exits of Schiphol plaza. The Schiphol map provides passengers with the location information of all facilities and service in Schiphol plaza and even official taxi stands, bus station and parking area outside Schiphol Plaza. However, compared to digital maps in Schiphol app, such a map cannot show the users their location and direction.

Digital information system

Schiphol airport was ranked top spot of the Mijksenaar digital airport index Europe 2019 (Mijksenaar Digital Airport Index, 2019). Schiphol ranked high because of the Schiphol application providing real-time information and digital map. Nevertheless, for Schiphol app, a problem has been that only a small percentage of travellers who have been to Schiphol download and use this application. In total, only 18% of passengers use an application on their phone to navigate at Schiphol (Schiphol Group, 2017). However, unlike Google map, Schiphol app is a separate platform. Its applicability for users is not extensive, so it is hard to promote it. The main functions of this software are helping users to track their flight (stay updated about gate change, delays or cancellations), book official Schiphol parking spots and providing with a Schiphol digital map.

Service desk

Another form of general wayfinding at the airport is using airport staff and service desks to be suggested and guided personally. As shown in figure 9, Schiphol has some service desks, information points and staff members of the different transport systems at the Plaza that are available to ask any questions. Similar to the Schiphol sign system, English and

Dutch are the main languages for communicating, the International Civil Aviation Organization (ICAO, 2001) require all working staff in airports should be able to communicate in English.



Figure 9: Schiphol service desk and airport staff (jianghui li, 2019)

Main takeaways

Schiphol has its own clear and unique wayfinding system and offers travellers different kinds of tools to help with their wayfinding. For signs in Schiphol, consistent symbols and layout make that easy to recognise and follow. Nearly all symbols and pictograms are international (Mijksenaar, P. (2012)). Three thousand hanging signs with arrow stickers on the grounds, signposts and even maps in Schiphol make users can get a lot of wayfinding information in any corner of Schiphol. In an interview, Mijksenaar, who has been responsible for sign system at Schiphol since 1990, said that signs in Schiphol could be summed up in the four principles. Continuity: meaning repeating the information until the destination is reached. Conspicuity: meaning the signs should catch the eyes. Consistency: meaning consistent terms and symbols. Clarity: message on the sign should be lucid and clear. A large number of repeated signs with various information posts did help Schiphol quickly improve their wayfinding system but also make Schiphol plaza to be a visual overloading environment for travellers, with lots of signs.

Various information post, people and objects are blocking the line of sights and walking path. Schiphol wayfinding developer J. Elzas also confirmed this observation. He stated that "it would be interesting to see how the introduction of new sensory ways of providing information could add value to the travellers' wayfinding experience". Besides the visual overload, there are no clear walking routes defined in Schiphol, which is decreasing the flow of people and the efficiency of Schiphol. On the other hand, a variety of information appears together in front of travellers. Travellers need to spend much time reading and filtering considerable information and have to make a choice which signs to follow (hanging signs, signpost, sticker on the ground).

Schiphol wayfinding system is more and more shifting towards digital information systems. It is found that the main function of Schiphol app is to help travellers track their flight and offer indoor navigation for passengers. However, due to the lack of public transportation information and outside navigation, for passengers arriving at Schiphol, they usually rely on Google Maps or other navigation software to help them leave Schiphol and reach their destination.

Service in Schiphol plaza

Schiphol Plaza is a transfer area also for entertainment and relaxation. Schiphol offers a variety of services in the plaza to help travellers adapt to new environments and resolve some emergencies or personal problems, like lost and found desks and pharmacy stores.

All Service in Schiphol plaza



Shops and Restaurants

Huge amount of shops and restaurants are located at Plaza, including supermarkets, café and bars.



Baggage Storage

Temporarily store passengers' baggage at Baggage Storage or in a locker.



ABN AMRO Financial Centre

ABN AMRO Financial Centre help travellers with standard banking services, currency exchange or just general questions.



Airport Telecom Shop

Airport Telecom helps travellers to connect their smartphone, tablet and laptop to a Dutch mobile network. Many shops in Schiphol offer travellers pre-paid SIM cards without any formalities.



Lost & Found

Reunite travellers with their lost property.



Pharmacy Plaza

Schiphol pharmacy plaza here to fill prescriptions and help with basic medical, health and travel supplies.

Figure 10: Service in Schiphol plaza (all information and pictures come from the Schiphol official website)

Staff

Staff in Schiphol are responsible for the safety of passengers and help them with the wayfinding and using Dutch public transportation system. In addition to Schiphol staff, employees from NS train station will also help passengers with the payment of train tickets at the plaza and guide them through the process of using the public transportation system.

Travellers use these different parties to ask questions mainly about wayfinding in Schiphol, using train ticket machine and other personal demands. Due to the massive number of passengers, it is difficult for Schiphol staff to help all passengers with their needs. Moreover, during the user interview, passengers stated that because of the inconsistent uniforms (figure 11), they could not identify the different staff in the plaza and find the right person to ask questions.

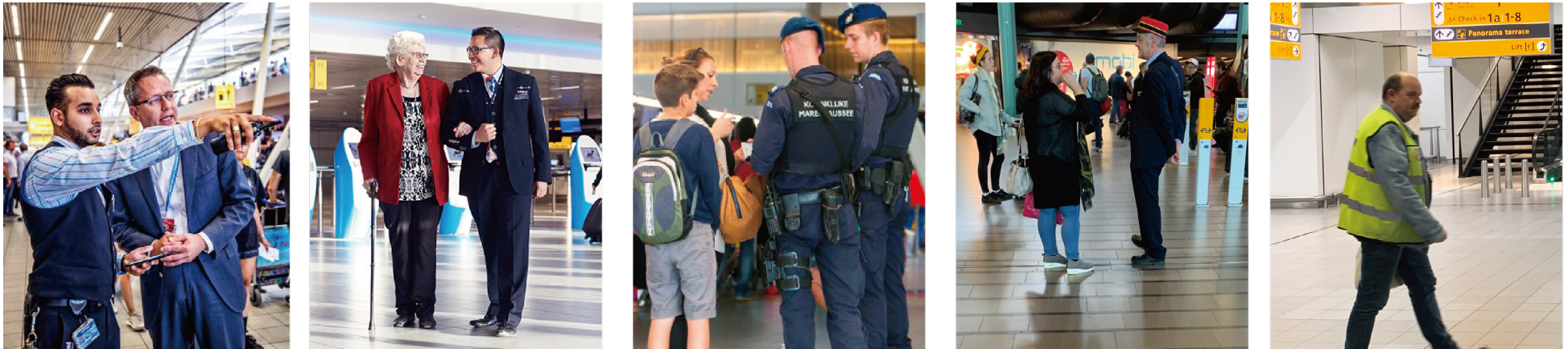


Figure 11: Schiphol staff (This group of pictures comes from the Schiphol official website or shoot by the author)

The public transportation system in Schiphol

Schiphol has excellent transport links to Amsterdam and the rest of the Netherlands. Passengers could take the train, catch a bus or rent a car to leave Schiphol (Schiphol.nl, (n.d)). Following is the introduction of different transportation methods leaving Schiphol.

Train:

NS train Station is located below Schiphol plaza. Passengers could

plan their journey online and buy train tickets from the NS railway ticket machine or NS service desk. Except for paper tickets, travellers could also open a public transport card called the 'OV-chipkaart'. After recharging this card, travellers can use that to take almost all public transportation in the Netherlands. Below figure 12 shows the process of passengers taking the train.



NS service desk



Train ticket machine



Check-in machine



Take the escalator or lift downstairs and board the train.



Buy train tickets



Check-in



Boarding

Figure 12: Process of taking the train (jianghui li, 2019)

Bus

The Bus station is outside Schiphol and just a few minutes' walk from Schiphol terminal. There are city and regional bus lines, and also shuttle buses that can take passengers to some hotels, which can be seen in figure 13 (Schiphol.nl, (n.d)).



Figure 13: Bus station outside the Schiphol plaza(get your guide. com)

Taxi

The official taxi stands are located outside the departure and arrival halls. People could follow the taxi sticker and Schiphol hanging signs to find it. Schiphol provides different kinds of taxi for travellers- a regular taxi, a luxury Schiphol Business Taxi or a Schiphol Travel Taxi minibus (Schiphol.nl, (n.d)). Below, figure 15 would show the difference between those kinds of taxis.

Rent a car

Passengers could pre-book online or go to the car rental service desk (figure 14) in Schiphol plaza. There are many car rental companies in Schiphol.



Figure 14: Schiphol car rental service desk (Schiphol.nl)

Schiphol travel taxis



Schiphol Travel Taxis are ideal for groups of no more than 8 travellers. People can also save money by sharing costs with other travellers.

Advantage: **Low price**

Standaard taxis



The official taxi stands located in front of Schiphol Plaza. From there, passengers can catch a metered taxi.

Advantage: **Convenience**

Business taxis



Professional drivers, luxury cars and everything arranged perfectly. Make an easy online booking and the taxi will arrive.

Advantage: **Luxury**

Figure 15: Different kinds of taxis(Schiphol.nl)

Main takeaways

Schiphol provides users with multiple modes of transportation, leaving Schiphol. However, there is no channel for passengers to know what different types of public transportation methods there are in Schiphol. It is hard to choose the right way to travel and the right tickets for passengers at plaza because of the lack of information about the Schiphol transportation system. According to previous user research, even frequent travellers and locals do not wholly understand the transportation system in Schiphol. For example, almost no one knows Schiphol travel taxis-car sharing service. For first time travellers, some of them complain about the complicated Dutch public transportation system, especially the payment of the train tickets, which was also confirmed by TUD alumni Larissa Q (Lehr 2016). Here for the first time user, they lack relevant ticket purchase information to help them understand the OV-chipkaart system. Like a single, disposable paper ticket is the optimal option for passengers who only plan to use the Dutch public transportation once or twice. The OV-chipkaart is more suitable for travellers who plan to use the public transportation system more frequently and over a long period (Schiphol.nl, (n.d)).

3.1.2. Schiphol: departure hall

Schiphol departure hall(figure 16) is a space for check-in, and security and it also contains other services for passengers who departure from Schiphol. Below the process of check-in and drop-off baggage in Schiphol, passport control, security check and service in departure hall would be discussed.

Check-in and baggage drop-off

Passengers could check-in for their flight in several ways—check-in online at home, check-in by using the self-service kiosk and check-in desk in Schiphol departure hall.

Online check-in

Most of the airlines in Schiphol allow online check-in and passengers could print their boarding pass from a printer (Schiphol.nl, (n.d)).

Self-service kiosk

Passengers could check themselves in at a self-service check-in kiosk in the departure halls. The kiosk would print out a boarding pass for them. There are also self-service baggage drop-off kiosks at Schiphol. Passengers could follow the on-screen instructions to print their baggage tag. Then the self-service baggage drop-off machine will check the weight, size, safety of their baggage (Schiphol.nl, (n.d)).

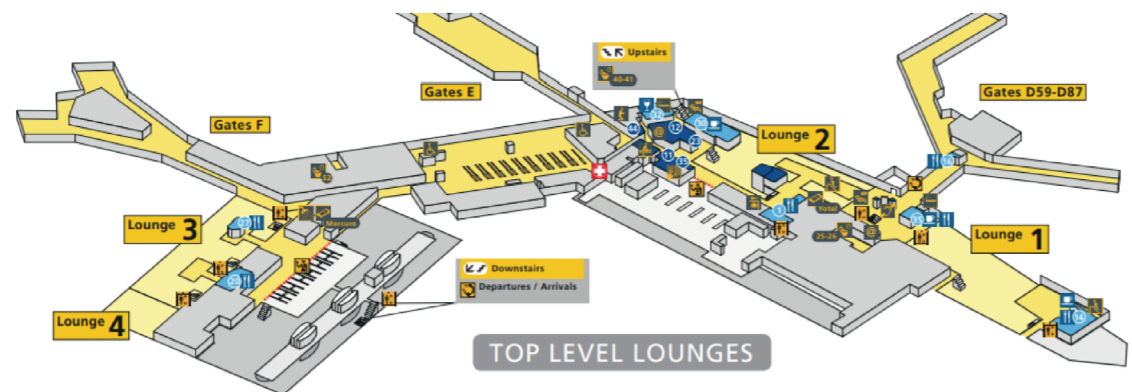


Figure 16: Map of Schiphol departure hall (Schiphol.nl)

Check-in desk

Travellers could go directly to their airline's check-in desk. The airline representative would help them check-in their baggage and print their boarding card (Schiphol.nl, (n.d)). However, usually, travellers need to spend extra time queuing, and self-service check-in is more time-saving, especially for passengers with hand baggage only.

Passport control

For most travellers except those from Schengen countries, they need to pass through the passport control with their identity card or passport before the security check in Schiphol departure hall (Schiphol.nl, (n.d)). For passengers travelling to and from non-Schengen countries, there are two ways to pass customs. First, for people who hold an EU passport that contains a microchip, they could pass through the border control through an automatic self-service border checkpoint(figure 17). Second, for travellers without an EU passport, they have to line up in front of the border control desk to pass through the passport control.



Figure 17: Schiphol automatic self-service border checkpoints (Schiphol.nl)

Security check

The Schiphol departure hall contains multiple security checkpoints and a transfer security checkpoint. During peak hours, passengers usually have to queue up to pass through security (figure 18).

Service in the departure hall

In the departure hall, Schiphol offers some service to help travellers to satisfy passengers' individual needs, like tax refund and seal baggage. Below all the service in the departure hall can be seen in figure 19.



Figure 18: Schiphol security checkpoints (NOS.nl)

All Service in Schiphol departure hall



Seal and go

For an added sense of security for baggage, passengers can have it sealed in shrink foil. With this foil, their baggage is sealed and protected against opening by strangers.



Privium Club Lounge

Privium Plus members (first-class) can work or relax in the Privium club lounge with lightning-fast WiFi, free catering and a wide array of reading material.



Tax refund

There are lots of tax refund partners in Schiphol departure hall. With them passengers can claim back the VAT of their Dutch purchases.

Figure 19: Service in Schiphol departure hall (Schiphol.nl)

Main takeaways

Schiphol offers passenger different ways of check-in and passing passport control. As airport passenger flow increases, Schiphol Airport needs to create more space for security and check-in. However, instead of more check-in lanes, Schiphol programme manager Peter Flierman and process developer Janny Postma decided to add self-service check-in methods in Schiphol, like self-service kiosk and the online check-

in. "The plan is for everyone flying economy to do their check-in and baggage drop," says Janny (Schiphol.nl, (n.d)). The border control is the same, like eGate-the Schiphol automatic self-service border checkpoints. Faced with the contradiction between limited space and increased passenger volume, Schiphol has added more self-service facilities to help the airport to improve the efficiency of Schiphol.

3.1.3. Schiphol main terminal and gates

After the security check, passengers would enter the main terminal of Schiphol. The main terminal of Schiphol includes approximately 165 boarding gates and four airside lounges. The main terminal of Schiphol is a waiting area and passengers could use different hospitality and amusement facilities before boarding. Below the various service in this area would be discussed.

Service in the main terminal

As shown in figure 20, Schiphol provides various services to passengers to meet even almost their personal needs.

Main takeaways

There are different kinds of service in Schiphol airside area. Services range from passenger rest, food service to family entertainment, child care and even religious habits. Compared with other airports, Schiphol services can be considered comprehensive and human-centred. Combine with previous chapter conclusions-user research, and it is found that services offered by Schiphol can meet most of the personal needs of users. For example, the businessmen can work in the internet centre before boarding and families with children can go to the museum or baby care lounge to have a rest. Schiphol main terminal and gates are currently not only a transfer area like many airports but also a place of entertainment with different kinds of facilities (the range from tax-free shops to the science museum).

All Service in Schiphol main terminal



Eat & Drink

The main terminal of Schiphol has different kinds of restaurants, bars and even food markets.



Duty-Free Shops

Passengers can buy luxury brand products at low prices here, like cosmetics, clothes, jewellery, watches, high-end wine, etc.



Schiphol Rijksmuseum

Schiphol museum is a small version of the Rijksmuseum. Passengers can enjoy a selection of famous 17th-century Dutch paintings, which regularly rotate with the main museum's collection.



Baby Care Lounge

The Baby Care Lounge offers private spaces where passengers can bathe, feed and even let their baby sleep in one of the bed cabins.



Nemo Science Museum

There are interactive test setups and experiments for young and old, as well as a playground for toddlers. At each setup, passengers can learn more about technology and science by performing experiments.



Meditation centre

The Meditation Centre is a non-denominational and interfaith space, where people can pray, meditate, or just relax in silence.



First aid

Medical assistance is available anytime day or night at Schiphol.



Internet centre

In the internet centre, PCs all have a strong and secure Internet connection and usage is free. People could work here during the waiting time.



Privium Airside Lounge

Privium Plus members can enter at any time on the day of their flight, and enjoy comfortable chairs, high-speed internet access or the free buffet.



Sleep at Schiphol

Whether people would like to sleep, rest or just freshen-up with a hot shower, pay a visit to either the Mercure Hotel or YOTELAIR.

Figure 20: Service in Schiphol main terminal (Schiphol.nl)

General discussion

research question:

How does the context of Schiphol influence travellers especially international travellers.

How Schiphol helps travellers solve the general problems they encountered at Schiphol?

Figure 21 shows how Schiphol solve general problems.

First, in order to help passengers improve their wayfinding experience, Schiphol uses traditional sign systems and digital applications to help users to find their way. Schiphol traditional sign system performs well in displaying information because of its consistent symbols and layout. Nevertheless, Schiphol is perceived to be a visual overloading environment for travellers, with too much information including signs, stickers on the ground, electronic screens and even commercials. Due to Schiphol complex and huge service system, it is difficult for traditional

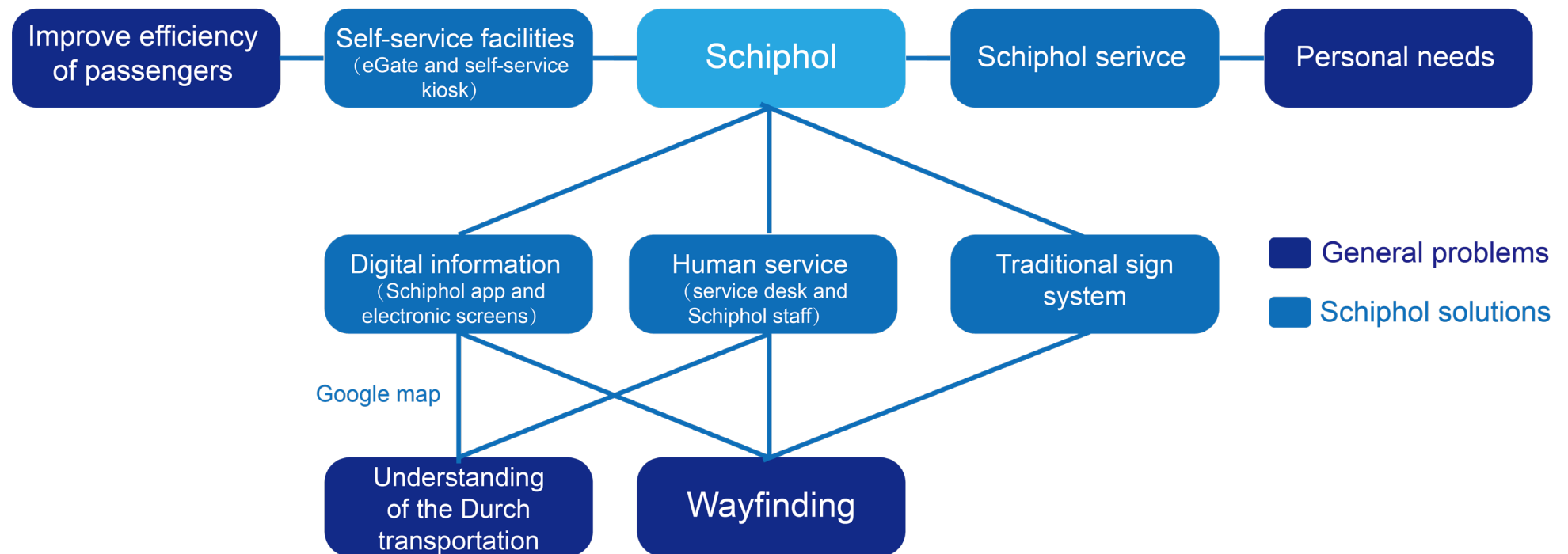


Figure 21: How Schiphol solve the general problems

sign system to display all information to users. Here the Schiphol wayfinding system is complemented by Schiphol digital information system, like the Schiphol application. However, it is reported that only a few users are using it to track their flight. For arrival travellers, the Schiphol app does not meet their core needs-learn what different types of public transportation methods there are and make a confident choice between the options. For departure passengers, this application could help them to get real-time flight information. Because it lacks public transportation information and serves as a separate platform, few passengers use it as a navigation software.

Second, for the public transportation system, Schiphol currently mainly relies on human services to help passengers understand and use the complex Dutch public transportation systems. Some self-service machines are generally considered to be challenging to use by first users due to lack of related instructions. Moreover, Schiphol lacks the aggregation of information about different types of public transportation methods and passengers need to complete the information collection process by themselves, which increased the difficulty for travellers to make the right choice.

Third, in order to improve the efficiency of check-in, Schiphol added online check-in and self-service kiosk. For European travellers, they can even pass customs directly through eGate. Self-service with artificial intelligence is the main way of Schiphol currently improves passenger flow in the departure hall.

Finally, Schiphol provides various services for travellers to meet their personal needs, including religious habits, diet, working, rest, child care, cultural needs and even accommodation. In conclusion, Schiphol service system is comprehensive and people-oriented.

3.1.4. Conclusion

Combining previous user research conclusion and Schiphol current context, the following four directions would be re-examined and explored.

Wayfinding:

The traditional wayfinding system has been unable to meet the basic navigation needs due to Schiphol complicated service system and causes visual overload (too many signs). The digitization of information will be the focus of this project. Combined with the traditional sign system, the new solution should filter the vast wayfinding information in Schiphol base on passengers' needs and display useful information to them.

Searching Information:

In this chapter, it is found that Schiphol service system is varied and complete, which could almost meet all travellers' personal demands. Although in previous user interviews, many participants stated that their personal needs were not being met at Schiphol. However, the main reason is lack of information. For this topic, it would be interesting to explore how to distinguish and classify the needs of passengers and recommend to them related services and facilities in Schiphol rather than a collection of all information. For check-in and passport control in Schiphol, information provision is also essential. Here how to guide passengers to choose the best way to check-in and pass customs will affect passenger experience and also Schiphol efficiency.

Dutch public transportation:

Dutch public transportation system is complex. For how to use and learn

the Dutch public transportation system for first time users, Schiphol currently lacks relevant instruction and a summary of transportation information. Schiphol app also does not help users with understanding the Dutch transportation system. Here the new solution should show passengers information about different types of public transportation and also offer relevant instructions to help them make the right choice between all the options.

Language barriers:

Schiphol currently only provides English and Dutch versions of signs. For non-English and non-Dutch speaking travellers, Schiphol still has no measure to help them overcome language barriers. Here digital information or phone application would be a breakthrough in solving this problem.

3.2. Stakeholders analysis

The primary purpose of this chapter is to understand the needs of stakeholders. Afterwards, the design goal and function list of this project are obtained by analyzing the demands of stakeholders combining with the previous analysis results.

"Stakeholder analysis is a process of identifying people who are involved in this project or can either affect or be affected by the project; they are divided into four categories based on their levels of participation-interest and influence in the project" (investopedia.com, (n.d)). All stakeholders of this project are shown in Figure 22. The following analysis will focus on the key players for this project.

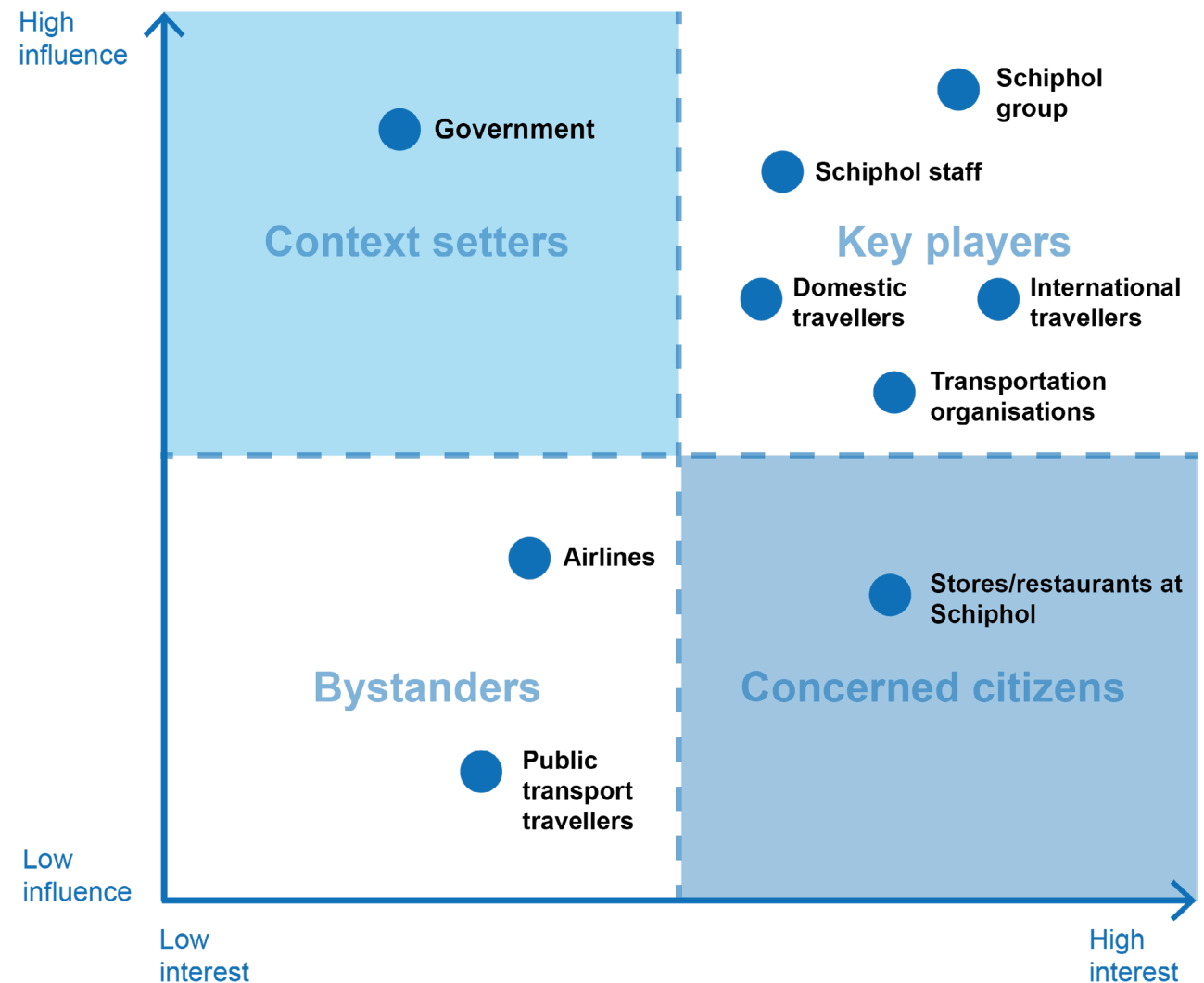


Figure 22: Stakeholders power&interest grid

3.2.1. Travellers

Addressing the demands of travellers and improving their experience in Schiphol is the focus of this project. The passengers' group is divided into international passengers and domestic passengers. The journey of all kinds of travellers and all touchpoints that they interact with Schiphol are illustrated in user research. In this chapter, in order to define the user group more objectively and gain an overview of all kinds of travellers in Schiphol, data related to Schiphol travellers will be collected and analyzed. The annual report 2018 published by Royal Schiphol group is used as the main source to offer the information of Schiphol travellers.

Passengers are the core users of this project. They come from different countries and have different cultural backgrounds. To understand this complex user group, the facts about travellers from Schiphol annual report provide an overview on their different cultural background, languages, the purpose of arriving the Netherlands and even how they interact with the transportation system. Below the eight most relevant facts about travellers in Schiphol are selected from Schiphol annual report 2018 (facts 1,2,3,5,7), the General Report 2014 Inbound Tourism Survey published by NBTC (fact 4) and Schiphol mobility 2017 publish by Schiphol group (facts 6,8).



1. 67% of the travellers in Schiphol are international travellers and most of them come from Europe (excl. the Netherlands, 43%). Most European visitors are from Germany, the United Kingdom and Italy. Thus, 24% of visitors in the Netherlands is not European.



2. Most travellers, about 46% travel to the Netherlands for leisure, followed by 33% of travellers who travel to the Netherlands for business matters. 20% of travellers visit the Netherlands for visiting friends or relatives and the resting 1% of travellers have other purposes.



3. 36% of travellers stay within a period of one to three nights. One-third of travellers stay for a period of four to seven nights and the rest travellers (32%) stay over 8 nights.



4. Most passengers travel as a pair (34%). 23% of travellers travel alone and 26% are multiple adults. 16% of travellers travel with children aged between 0 and 12 years old (9%) and aged between 13 and 18 years (6%). The resting 2% are other compositions.



5. 17% of passengers are under 30 years old, and more than 50% of passengers are between 30 and 50 years old. Travellers aged between 30 and 50 years make 18% of the total and the resting 5% are elderly travellers.



6. For international arriving travellers, 75% are looking for public transportation to their final destination on Schiphol page and 11% of non-Dutch arriving travellers are looking for a taxi. "How to get to my hotel" is the number 1 question at the information desk.



7. For departing passengers, 46.3% travel to Schiphol by public transportation, 19.8% are dropped off by car. 10% travel by car and also park their car in Schiphol. 12.7% use taxi, followed by 7% of travellers who use group transportation, leaving 2% of travellers using other transportation means.



8. Passengers don't see Schiphol app as the logical starting point for planning their route. They prefer a dedicated navigation system like NS.nl, 9292-OV & Google maps. Here Google maps has the largest market share with 70%.

Main takeaways

Conclusively, those eight facts provide an overview of the main stakeholder-travellers in Schiphol. Fact 1 that most Schiphol travellers are international indicate the importance of this specific user group. According to the data from Schiphol user database 2018, 33% of travellers were found to be from the non-English and non-Dutch speaking countries. This fact once highlights that language barrier is a common problem for Schiphol. Fact 6 and fact 7 indicate that NS train system takes in the main transportation and more and more travellers take the train to Schiphol. Helping passengers understand and use the NS railway system is a crucial point of this project.

Moreover, the fact that most people use google maps as their navigational tools instead of Schiphol app highlight the need to improve the Schiphol app based on other navigation software. Here the report named Schiphol mobility (Schiphol group, 2017) also mentioned that "use of app-based navigation systems is growing since it provides real-time traffic data and the maps are always up-to-date. Schiphol should make sure Google Maps is always up-to-date when changes to the infrastructure happen".

3.2.2. Schiphol staff

Within the travellers' journey, passengers also meet Schiphol staff, who serving airlines and guiding passengers. They have direct contact with travellers and have an intuitive impact on their experience. These stakeholders are:

Marshall at customs: They check the travellers' identity by checking their passport or resistant card. They will talk with travellers to know their purpose of coming to the Netherlands. For European travellers, they could pass the custom by self-service channel (the automated border control machine).

Security officials: They check passengers' belongings for prohibited items and ensure passenger safety. They have direct physical contact and language communication with passengers during the process of security check.

Information desk: Their primary responsibility is to help travellers with their wayfinding process and solve general problems at Schiphol. However, due to the limited number, the Schiphol information desk is not always available for all passengers. On the other hand, they only provide consultation in English and Dutch.

NS service desk and NS staff: In Schiphol plaza, NS staff help travellers to learn the public transportation system and buy a train ticket. Travellers could line up at the NS service desk or find NS staff in the Dutch railway ticket corner.

Royal military police: They are responsible for passengers' safety and are constantly walking around in Schiphol. Travellers could also ask

them questions about wayfinding at Schiphol.

Schiphol other employees: There are lots of people also working in Schiphol, like cleaners at Schiphol, shop assistance and waiters. Sometimes they help travellers with their wayfinding process and even support the essential operation of the Schiphol terminal.

Main takeaways

All these different kinds of Schiphol employees have their role with different interests in Schiphol. Passengers ask questions to those different parties about how to get to their destinations at Schiphol. Moreover, due to the massive amount of passengers in Schiphol (79.2 million passengers in 2018), human service is not adequate to meet the current demands of all passengers. Furthermore, it is found that all human services in Schiphol are available only in English and Dutch. For travellers from the non-English and non-Dutch speaking countries, they are almost unable to communicate with Schiphol staff and seek bits of help.

3.2.3. Transportation organisations

As previously mentioned, travellers can choose multiple kinds of transportation, like train, bus, taxi and renting a self-drive car in Schiphol. As an international transportation hub, Schiphol has cooperation with lots of Dutch transportation companies, including national (NS) and regional public transportation companies. NS (Dutch Railways) is the closest company to Schiphol among those companies. After the NS railway station was added to Schiphol, they have decided to share symbols of signs system, and there are lots of NS staff working in Schiphol plaza to help passengers buy train tickets.



Figure 23: NS railway station below Schiphol (Schiphol.nl)

3.2.4. Schiphol group

For this project, the Schiphol group is an important stakeholder. As the main client of this project, they are kept up-to-date throughout the whole project and will directly or indirectly participate in this project. Schiphol Group is an airport company and responsible for the operation of Schiphol Airport. The main goal of the Schiphol group is connecting the whole world: “Facilitating optimal links with the rest of the world in order to contribute to prosperity and well-being in the Netherlands and elsewhere” (Royal Schiphol Group, 2019b).

As the owner and leading operator of Schiphol airport, currently, five departments are mainly responsible for the operation and development of Schiphol-operations department, asset management department, safety, security and environment department, IT department and Consumer Products and Services department. For this project, it is important to understand the key players' core needs and leverage their expertise. Below is the introduction of the five departments.

Operations department: Schiphol operations department are responsible for the whole airport operation and management. Such as passenger flows and wayfinding in Schiphol, baggage reclaims and even development of Schiphol terminal (Schiphol.nl. (n.d)). The operations department is also the main partner of this project that supports the project by offering a primary contact, like experts interview and meeting. According to the meeting with Schiphol wayfinding developer Danckaerts, Carolien (2020), the operations department currently is focusing on the traditional sign system and also working on the future-field solutions to improve the Schiphol wayfinding. Carolien also stated Schiphol is currently not considering applying the advanced technology in their wayfinding system, like artificial intelligence and augmented

reality.

Asset management department: The asset management department maintains, manages and develops all of the assets in Schiphol and ensure all assets are both safe and used safely. They are also responsible for Schiphol business control (Schiphol.nl. (n.d)).

Safety, security and environment department: The main task of this department is optimising safety and Identifying and eliminating potential hazards in Schiphol (Schiphol.nl. (n.d)). The safety, security and environment department direct the royal military police to ensure the safety of everyone at Schiphol. Moreover, they will provide safety-related advice and expertise to other Schiphol departments.

IT department: They are responsible for providing reliable and innovative digital solutions(Schiphol application) and also support the data analysis and information exchange in Schiphol. Currently, they work on designing and building the new version of Schiphol application.

Consumer Products and Services department: Their main job of them is improving the travellers' experience in Schiphol. They are responsible for various items related to the passenger journeys, like advertising in Schiphol, exclusive service(VIP centre) for frequent travellers, parking in Schiphol and commercial facilities at Schiphol.

3.2.5. Conclusion

The main purpose of stakeholder analysis is finding out the core needs of the key player of this project. Here, for passengers, the significance of this project is to help them understand the Dutch transportation system and provide real-time information about the airport through translated information. For Schiphol employees, the final solution should help them reduce workload by allowing more passengers to find their way in Schiphol independently. For Schiphol group, the new solution needs to be combined with the current Schiphol service and wayfinding system to help passengers improve travel efficiency. Finally, according to the needs of different stakeholders, the function list of the final solution will be derived in the next chapter.

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Chapter 4 | Design goal

This chapter includes:

4.1. Design brief

4.2. Function list

Introduction

In this chapter, in order to define the goals and scope of this project, a design brief is produced. This chapter is mainly composed of a design brief and function list of this project. The design brief will connect the previous research phase and concept phase. First, the design brief would integrate the previous research results and summarize them into the design goal and objectives. Second, It is also the starting point of the concept phase and acts as the roadmap to guide the project to the right goals. After that, a function list of this project is made. For the function list, it would show what functions of the final solution should have and how to achieve the design goals and objectives. The function list is created based on the wants and needs of the target audience (Schiphol travellers) and clients (Schiphol) and even the analysis of Schiphol context. In the ideation stage, the function list would serve as a checklist to ensure the final design to meet the design goal. Finally, after the function list and requirements of the final design have been defined, the final concepts of this project could be developed, evaluated, and selected in the ideation stage (Pfeifer, M. (2009)).

4.1. Design brief

"A design brief is a project management document that helps with identifying the scope, goals, and core details of the design project" (Heaton, S., & Simon. (2016)).

Problem review

According to the preliminary research, the problems of travellers at Schiphol can be summarized in four directions.

Wayfinding: Due to Schiphol complicated service system, the traditional wayfinding system has been unable to show passengers all information that they need, and too many signs causes visual overload. Passengers need to read and filter much information about wayfinding in Schiphol, which is decreasing the flow of travellers.

Opportunities: The digitization of the wayfinding system maybe could solve the limitations of traditional sign system in Schiphol.

Searching information: Travellers are continually searching for information related to their journey and their personal needs. Different passengers have different needs. However, their personal needs missing are more or less related to the lack of information because there is no channel for passengers to know where to find the information that they need and have an overview of Schiphol service and the available options.

Opportunities: It would be valuable to explored how to distinguish and classify the needs of passengers.

Dutch public transportation: Most of the international passengers, especially first time users, feel that public transport in the Netherlands is non-user-friendly and hard to learn and use. On the other hands,

Schiphol currently lacks relevant instruction and a summary of transportation information about what different types of public transportation methods there are including buying process.

Opportunities: Providing relevant instructions to help travellers to learn and use the public transportation system.

Language barriers: For non-English and non-Dutch speaking travellers, they can not understand the signs in English or Dutch and also can not communicate with staff or ask for help in English.

Opportunities: Image recognition, real-time translation and AR digital images would be interesting to explore.

Main stakeholders

Schiphol Group: From Schiphol perspective, it is important to improve the efficiency of passengers, because of the increasing amount of travellers. Moreover, Schiphol tries to differentiate itself in the market by having fluent processes and providing the best service and travellers' experience during departing, arriving and transferring travellers (Royal Schiphol Group, 2019c).

All kinds of travellers: Travellers will generally pay attention to the efficiency, comfort and service of their journey in Schiphol. Nevertheless, different passengers have different demands, and their personal needs are more or less related to Schiphol information provision.

Design objectives

According to the four types of issues in Schiphol, the following are the design objectives corresponding to each issue.

Wayfinding

Object 1: Help passengers to filter the enormous wayfinding information

in Schiphol base on their needs and display and emphasize useful information to them.

Object 2: Improve the user's wayfinding experience more intuitively and effectively.

Object 3: Ease or at least not aggravate the visual overload of the current Schiphol environment.

Searching information

Objective 4: Distinguish and classify the needs of passengers. Then providing real-time information and recommending to them related services and facilities in Schiphol to guide them make full use of Schiphol service rather than a collection and display of all information.

Dutch public transportation

Objective 5: Showing passengers information about different types of public transportation and also offering relevant instructions to help them use the dutch public transportation and make a confident choice between all the options.

Language barriers

Objective 6: Help travellers read the Schiphol sign system by real-time translation.

Design goal

Base on the six design objectives, the design goal of this project is produced.

Providing departing, arriving and transferring travellers a seamless experience, which makes them feel confident and relaxed during the whole process of their journey in Schiphol, including wayfinding, searching information, learning of the Dutch transport system, check-in and even passing border control, Etc. This can be achieved by facilitating the Schiphol information providing and wayfinding to help travellers understand the Schiphol service, wayfinding and

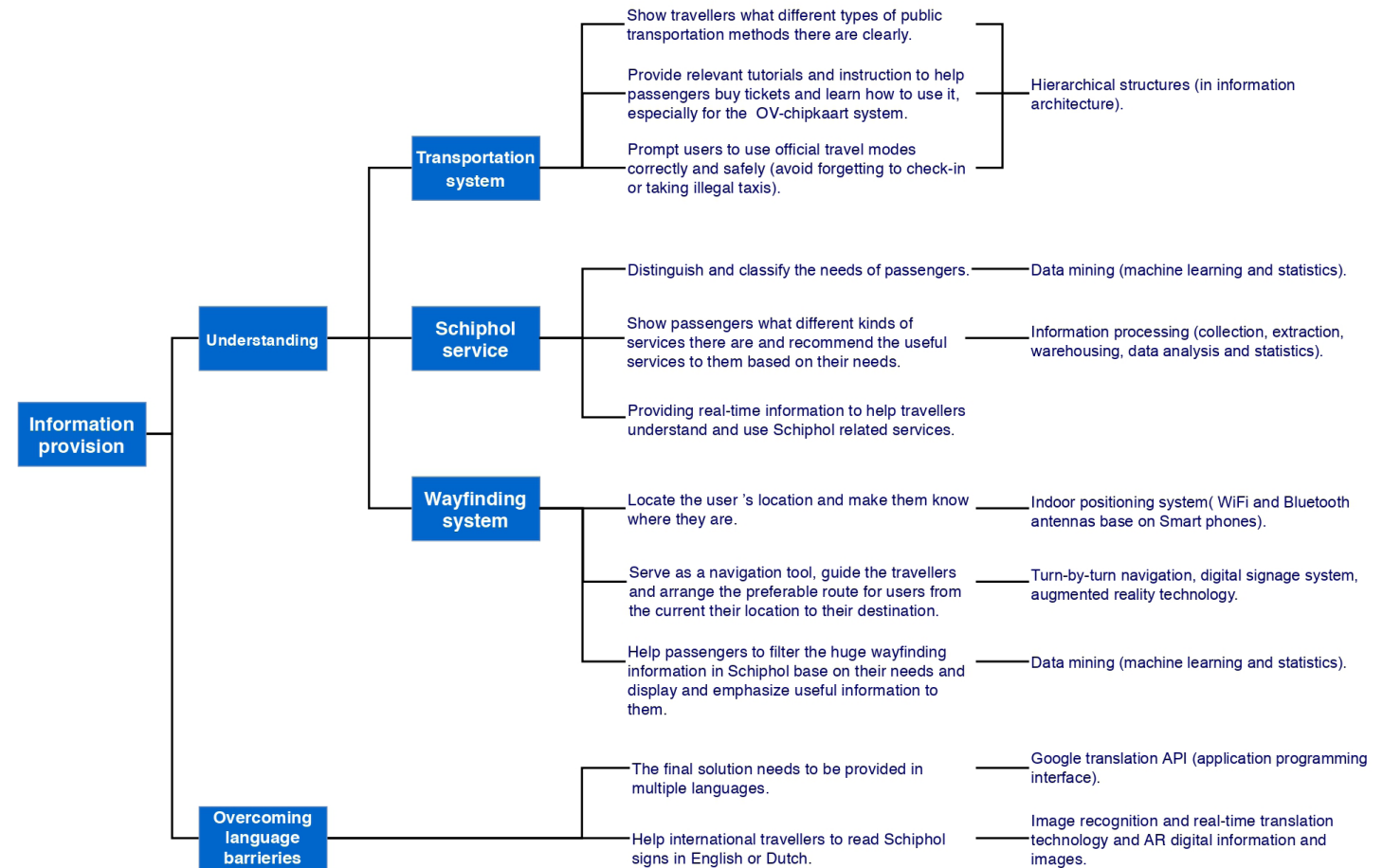
transportation system and meet all their varying needs.

Project scope

It is difficult and costly to provide portable and recyclable equipment for nearly 79.2 million passengers every year based on the clients meeting. Mobile phone navigation application development does not have these limitations, and the digitization of information is also the focus of Schiphol IT department. Moreover, The design scope of this project covers the user's entire journey, including departing, arriving and transferring in Schiphol rather than a single link, like check-in or baggage reclaim. So the new solution needs to accompany the user all the way in Schiphol and provide personal and general guidance. The mobile application also meets this requirement. Therefore, in the concept phase, this project will focus on developing the mobile indoor navigation application for Schiphol.

4.2. Function list

Base on the design goal of this project, the main function of the final solution is providing information and guidance to help travellers understand the Schiphol service, wayfinding and public transportation system and even overcome the language barriers. The following function list would show what functions of the final concept of this project that ensure the concepts of the project could meet the design goal should have and its corresponding technologies.

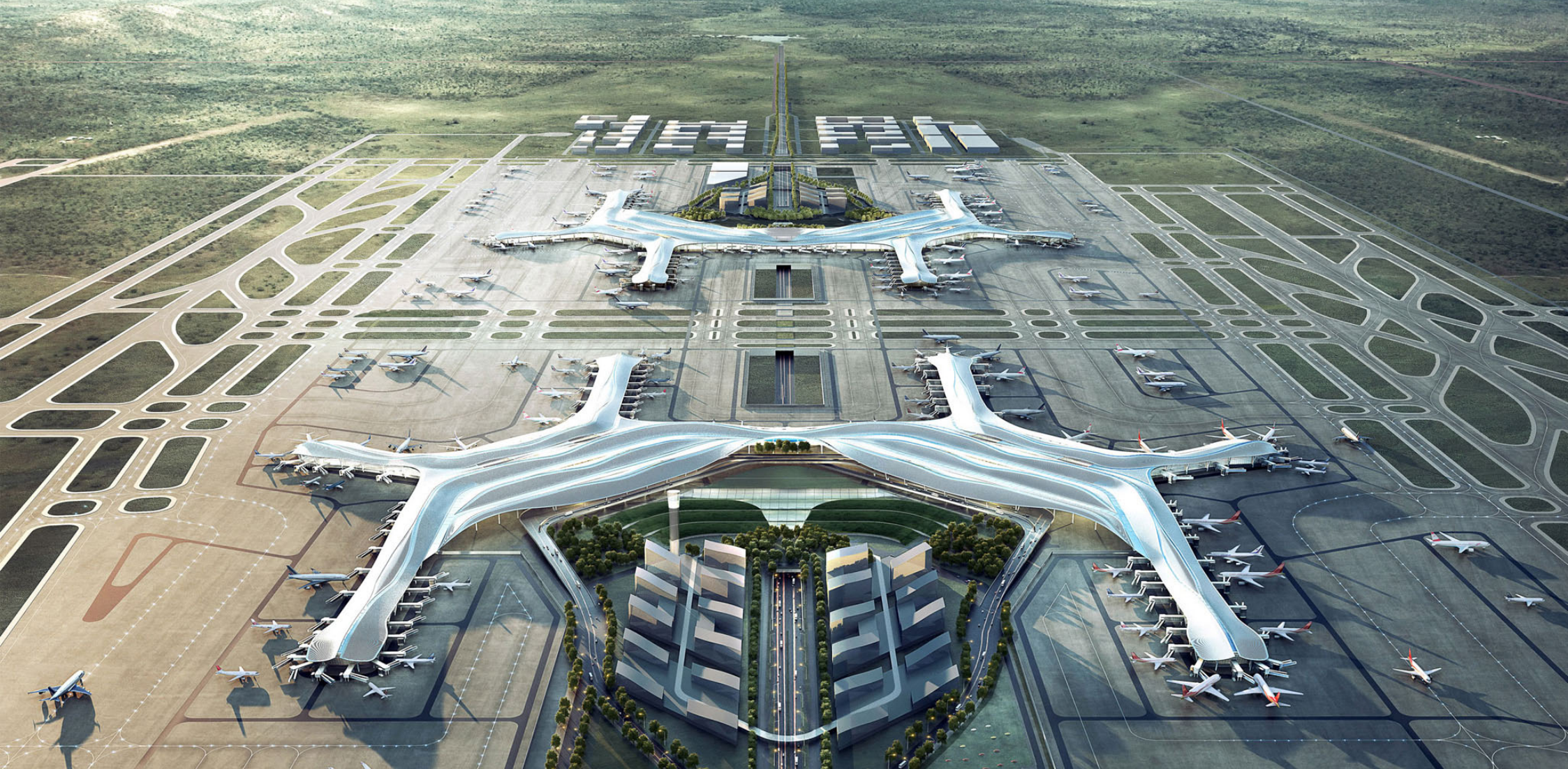




Concept phase

Chapter 5: Competitive product analysis

Chapter 6: Ideation



Chapter 5 | Competitive product analysis

This chapter includes:

- 5.1. Schiphol app analysis
- 5.2. Other airport application analysis
- 5.3. Museum guiding system

- 5.4. Other technologies applied in airports
- 5.5. Emerging new technologies
- 5.6. Conclusion

Introduction

In this chapter, comparison and analysis amongst different guiding solutions in other airports have been made. The main purpose of this chapter is to analyze and learn related similar products on the market. Competitive product analysis would provide reference and guidance for ideation and developing solutions for current problems in Schiphol.

According to the recommendations of some users in previous user interviews and online surveys, the following is the analysis of Schiphol app, some well-known airport applications, other technologies applied in airports and emerging new technologies.

5.1. Schiphol app analysis

As previously mentioned, unlike the google map, the Schiphol app is a separate platform. The primary function of the Schiphol app is helping travellers track all departing or arriving flights and receive updates about gate changes, delays and airport updates (Schiphol.nl. (n.d)). Below figure 24 has shown the interfaces of the Schiphol app. First, it is found that the main menu of the Schiphol app contains three options, which are flight tracking, parking reservation and Schiphol map. The information priority of these options is relatively high, and the user can easily find them.

- **Tracking flights:** Users can get real-time information(stay updated about gate change, delays or cancellations) about their flight by flight number.
- **Parking reservation:** Help users reserve parking spaces in advance, and the user could enter the parking lot by scanning their number plate.
- **Map:** Schiphol app offers users the digital map of Schiphol terminal. Nevertheless, here it is found that Schiphol maps can only display the user's location but not the user's direction and cannot arrange a route for the user to help them reach their destination.

Main takeaways

According to the author's personal experience and user interviews, it is found that, for users who departure from Schiphol, Schiphol app can meet their needs and help them prepare their journey in advance by providing real-time information about their flights. For users who

arrival Schiphol, the digital map could help them with their wayfinding process in Schiphol plaza. However, due to the lack of public transportation information and instruction about taking the Dutch public transportation system, the Schiphol app cannot meet travellers' basic needs of leaving Schiphol. There is no channel for travellers to know what different types of public transportation methods there are.

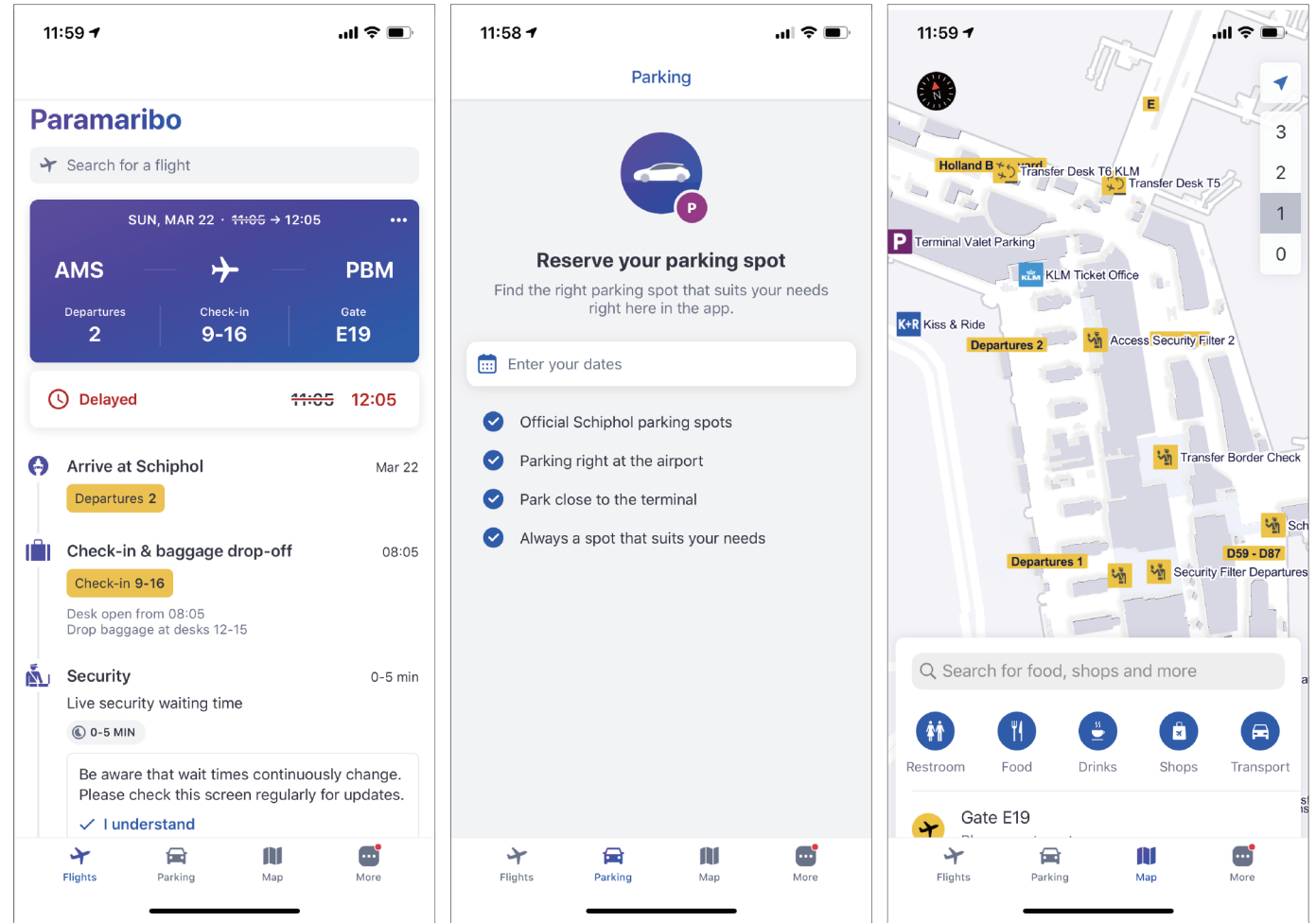


Figure 24: Interfaces of Schiphol app (Screenshots of Schiphol app)

5.2. Other airport application analysis

Several airports recommended by passengers in user interviews, like Changi Airport, Rome airport, Heathrow airport, Incheon International Airport and Hong Kong International Airport. After use and analysis, the following two airport apps is inspiring to this project.

iChangi app

Singapore Changi Airport is one of the largest transportation hubs in Asia. Changi Airport was voted the World's Best Airport for the eighth consecutive year at the 2020 World Airport Awards (SKYTRAX, 2020). iChangi app serves as the primary tool for digital information provision of Changi airport and is highly recommended because of its functional and attractive interfaces. The following are the analysis insights of the iChangi app.

1. iChangi app provides users with real-time information about their flights and parking reservation service. Compared to the Schiphol app, iChangi app provides more service options in their main menu (figure 25), like shopping, individual assistance and booking service, which could encourage travellers to explore the airport and learn the service in Changi. As shown in figure 25, iChangi app learns the users' demands with a gradual process that is from elementary to profound and display specific helpful service to them step by step. Like from "travelling with children" to "Baby milk, family facilities, strollers renting service".

2. iChangi app could arrange the preferable route for users from the current location to a destination in Changi airport. But iChangi app's digital map also cannot show the user's direction.

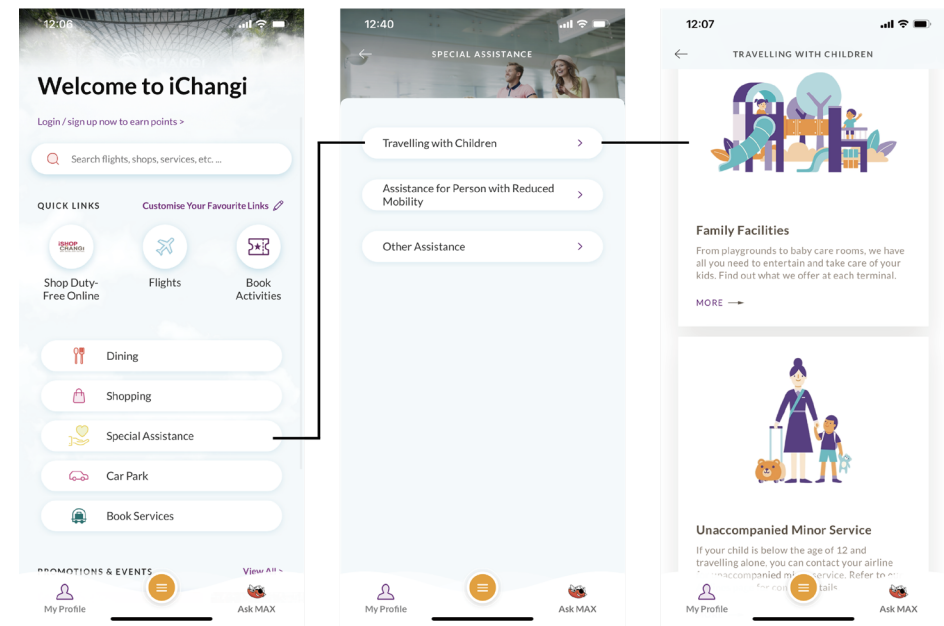
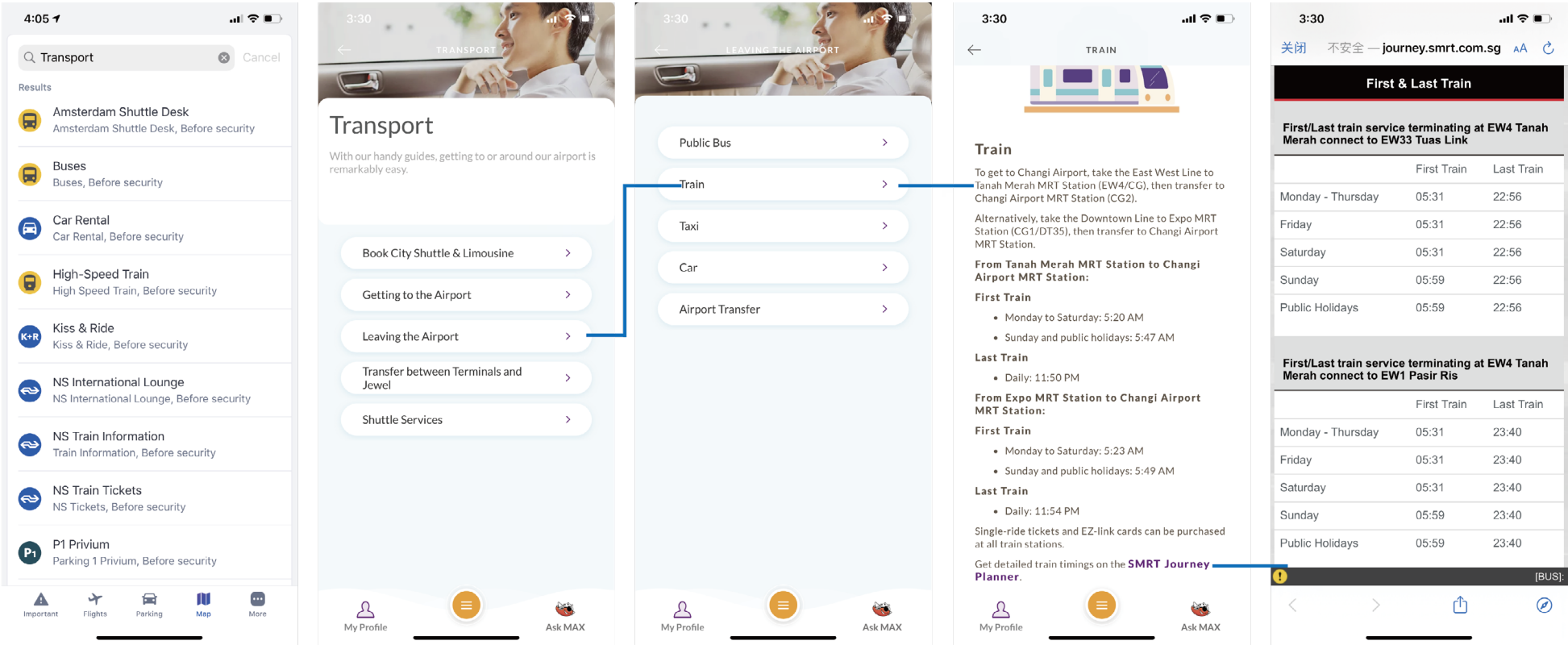


Figure 25: Hierarchical information structure of iChangi app (Screenshots of iChangi app).

3. iChangi app clearly shows all kinds of travel modes to users. As shown in figure 26, iChangi app clearly shown what different types of public transportation methods there are for all passengers and also provide the timeline and instruction of different transportation modalities. Moreover, the iChangi app provides visitors with quick links to other websites (like NS.com or 9292 app) to help passengers with their ticket purchase. Compared with the chaotic information structure in the Schiphol app, the hierarchical information structure of the iChangi app is more straightforward for users to understand and natural.



Public transportation information in Schiphol app.

Public transportation information in iChangi app.

The link of other ticketing website

Figure 26: Public transportation information in iChangi app and Schiphol app (Screenshots of iChangi app).

Heathrow app

Heathrow airport is the major international airport in London and the second busiest airport in the world. Heathrow app serves as the leading digital solution for Heathrow airport and ideal travel companion. The following are the analysis insights of the Changi airport.

1. As shown in figure 27, the main function of Heathrow app is offering real-time flight status information and live flight updates. Secondly, the Heathrow app also provides users with some related service information, such as dining and shopping. Here it is found that passengers can choose the closest service based on their location, such as service area before or after security and different terminals in Heathrow. Compared with Schiphol app that lists and show all the service to passengers

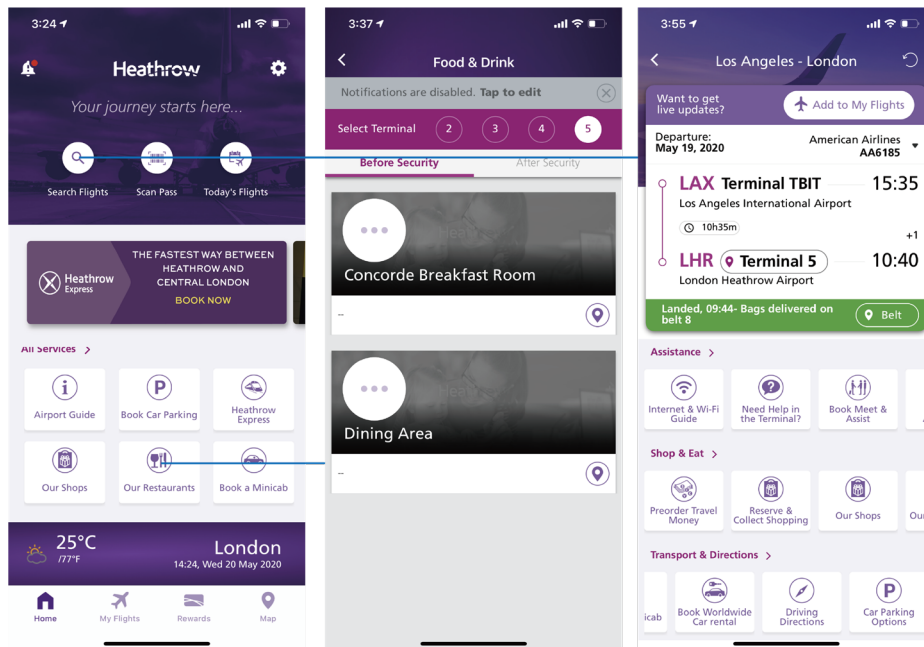


Figure 27: Interfaces of the Heathrow app (Screenshots of Heathrow app).

together, services classified by the region in Heathrow app would help passengers reduce the reading volume and the time for making a decision. Moreover, after the passenger input the flight number, the app will recommend to the passenger all the services and information that the passenger may need, such as travel modes, weather conditions at the destination and assistance provided by Heathrow.

2. Heathrow app would plan the most time-saving route for users and guide them to their destinations (figure 28).

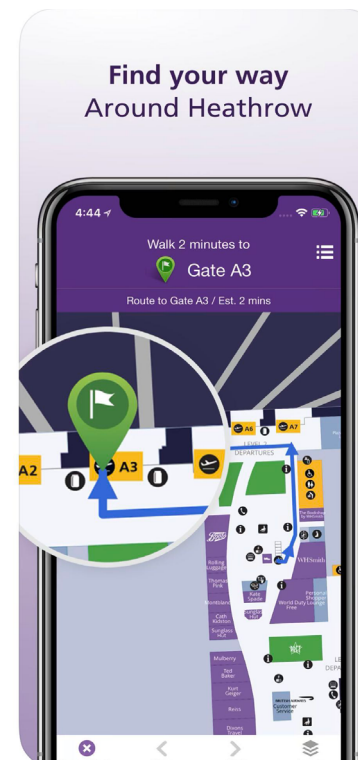


Figure 28: Interfaces of the Heathrow app (Screenshots of Heathrow app).

Main takeaways

According to the above analysis of the three airport apps-Schiphol, Changi, Heathrow airports, the main function of the three apps is to provide real-time information on flights, digital maps and parking reservation service. Compared with Schiphol app, the other two apps are more transparent in service introduction and information provision. For this project, how to understand the varying needs of users and provide them with relevant information and instruction will be the focus of this project. Here iChangi app and Heathrow app have provided two ways of optimizing the information structure.

Refer to the basic knowledge of mobile information architecture, iChangi app follows a linear pattern (figure 29) that "allows users to move from the index page with a general overview of the content to the pages with more details" (n.d, 2018). Here iChangi app learns the passengers' needs step by step and displays relevant information to them with a gradual process that is from elementary to profound and. The advantage of the liner pattern: The information and navigation are perceived to be clear, and users are less likely to get lost in the app's content. Moreover, "the liner pattern is suitable for applications that are focused on one particular topic or some of the closely related ones" (n.d, 2018). For this project, the liner pattern is an excellent choice for providing transportation information and introducing Schiphol service system, which allows passengers to learn about Schiphol step by step. On the other hand, the liner pattern also has its shortcomings, especially the low efficiency of operation. Here it would be inefficient for users to switch between sections if there are many levels in the app (n.d, 2018).

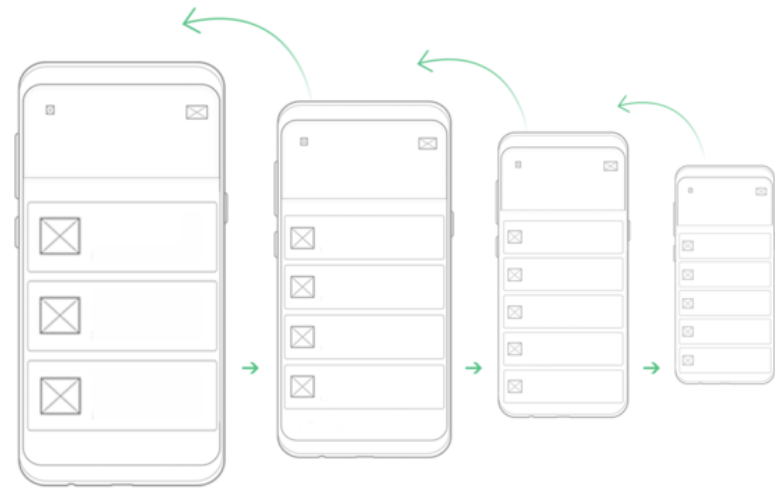


Figure 29: Liner pattern-Mobile Information Architecture Patterns (Applikey Team, 2018)

Heathrow app mainly follows a mobile information architecture pattern, named Hub & Spoke, which is the default for most apps in iPhone. For this pattern (figure 30), after entering the app, users would see an index page (the hub) with spokes to navigate. If users want to switch to another spoke, they should go back to the hub first. This pattern is a good choice for multi-functional apps (n.d, 2018). The advantage of this pattern: The index page provides a general overview of the app contents and functions. Users can understand the specific content of the entire app and purpose of each tool and feature in the app through the index page. The disadvantage of this model is that a large amount of information appears on the index page, which sometimes causes visual overload for users. Compare with the liner pattern, it has less learnability but higher efficiency.

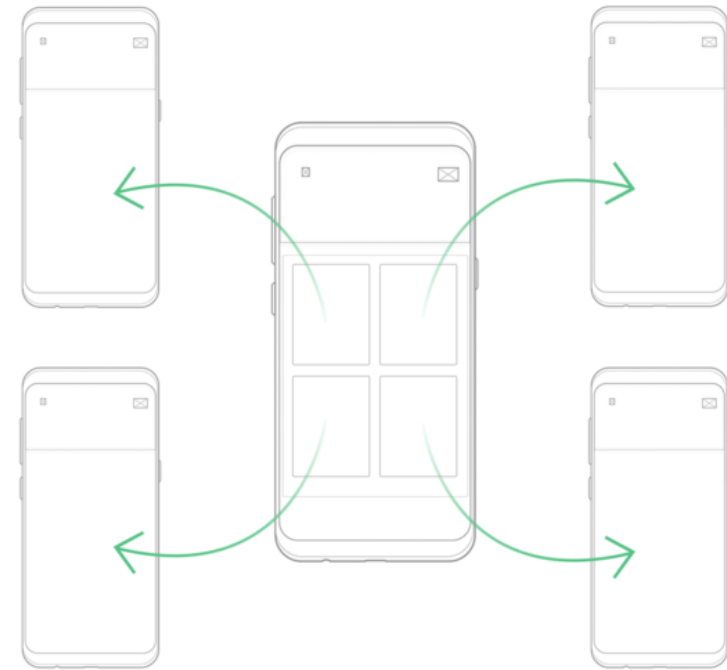


Figure 30: Hub & Spoke-Mobile Information Architecture Patterns(Applikey Team, 2018)

5.3. Museum guiding system

Similar to the airport, public museums are also a place that needs to receive a large number of passengers. Museums have different goals, ranging from serving researchers to serving the general public. With a large number of passengers with different aims, the museum's guiding system not only needs to guide the people flow but also provide information to the tourists. Moreover, museum guiding systems are usually forward-looking and integrated with advanced technologies. So an analysis of modern museum guiding systems can provide a reference and guidance for the subsequent ideation stage. The following are some well-known museums with guiding systems that are both entertaining and informative.

VR web-National Museum of Natural History

The National Museum is located in Washington and features its virtual tours integrated directly onto the web. Using Web VR means that virtual visitors can utilise VR headset or just smartphone to have a virtual tour (Bambury, S. (2017, August 20)). Passengers can remote access the museum for free. As shown in figure 31, virtual tours can be navigated by an on-screen map and interactive arrows on the ground. The VR web tour also provides interpretation and detailed display of all exhibits.

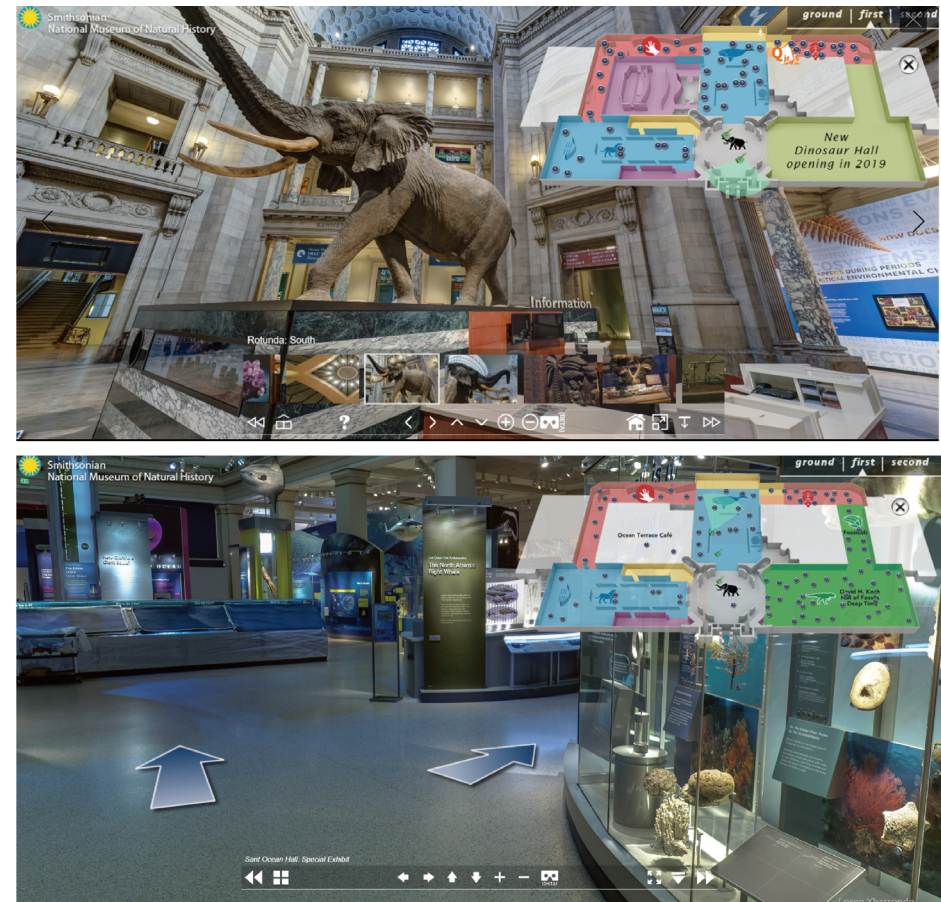


Figure 31: Screenshots of the web VR tours
(National Museum of Natural History official website)

Virtual reality-Cincinnati's Museum of Natural History & Science

"Museum of Natural History & Science has launched a VR experience, Jurassic flight, that allows visitors to explore the prehistoric world and interact with different dinosaurs. As shown in Figure 32, after wearing a VR headset, people could embody a pterosaur and fly amongst different kinds of dinosaurs. Users could have a dinosaur flight experience that takes them back 150 million years" (Coates, C., Rides, S.D., Etc., (2019)). The VR exhibits could provide unique full sensory experiences to visitors and encourage people to learn the relevant knowledge of dinosaurs.



*Figure 32: VR experience of the Jurassic flight
(Coates, C., Rides, S.D., Etc., (2019)).*

Augmented reality-National Portrait Gallery

London National Portrait Gallery launched its application with Image recognition technology to help users learn the backgrounds and stories of the different artworks. Users should scan the artworks by their phone camera. Then the app would recognise the images and display the digital labels and text to users (figure 33). It would serve like a personal tour guide.



*Figure 33: National Portrait Gallery in London
(Charlie Fink, 2019).*

"In 2017, the Perez Art Museum Miami launched a fully augmented reality-powered art exhibition. Its digital 3D arts mark the AR museum. Travellers should download the museum application to see and interact with digital artworks. As shown in figure 34, this exhibition provides an immersive AR experience with travellers, where digital 3D images appeared in a space" (Coates, C., Rides, S.D. Etc. (2019)).



Figure 34: Perez Art Museum Miami
(Felice Grodin, 2017)

Main takeaways

The above examples show that augmented reality technology and virtual reality technology could be applied in a variety of innovative ways (webVR, VR headset and AR app) to help users to explore the museums. For this project, using web VR could help people remote access the Schiphol. The 360° images technology allow viewers around the world have a remote visit to Schiphol at their homes. Currently, Google Maps has produced 360-degree images for Schiphol, and users can view them through google map. VR devices could provide users with full sensory experiences and immerse users in some specific scenes. It could make Schiphol more accessible and travellers' experience in Schiphol more enjoyable. Moreover, AR is an effective way for helping users explore the new context in greater detail and adding digital information in reality (Coates, C., Rides, S.D., Etc. (2019)). Here it is found that AR displays both the reality and extra digital information, like sounds, videos, graphic, to users. However, VR replaces reality with an alternate scenario. The difference between AR and VR indicates that AR is more suitable for annotating scenes and providing extra information. On the other hands, VR needs extra individual devices, like smart glasses or a VR headset. AR only requires a smartphone with the AR app (Charlotte Coates, 2020).

5.4. Other technologies applied in airports

Technology is critical to the future of the airport operation efficiency and development. Below are some technologies that applied in well-known airports, which is illuminating for the concept phase of this project.

Artificial intelligence

"AI is rapidly penetrating airports to support a more efficient and seamless journey. Not limited to reporting wait times, AI will power a more personalized travel experience to each customer from the curb to the gate," said Anuraag Jain, founder of Zensors, a cloud-based AI system for the airport. Currently, AI is widely applied in airports, and the application of AI in airports now is focusing on two directions: virtual agents, chatbots and user behaviour prediction.

First, nearly 32% of airports and airline companies in the world are cooperating with AI companies to investigate robotics in the next three years, according to the 2018 Air Transport IT Insights survey. Since the number of passengers increases to grow in Schiphol, the limited number of Schiphol staff can not meet all their needs. Here smart robots could free up airports stuff and serve as the personal assistant to offer that one-on-one service to all passengers. As shown in figure 35, Heathrow Airport has launched the robots service that can communicate with passengers in multiple languages and can provide real-time information and suggestions to help travellers to solve the general problems in airports (Hornyak, Tim, 2020). Second, currently, "AI is widely used to analyzes the big data collected from the airport to anticipate air traffic bottlenecks or traffic slowdowns via predictive software" (Koren, Anat, 2019). AI technology could also be used to predict user behaviour through typical user models and user-related data (user's purchase

history, travel information, personal information). Here predicting the user's behaviour and purpose can help Schiphol improve user experience and efficiency, such as providing useful information and services to travellers in advance.



Figure 35: Chat robots at Heathrow airport (Hornyak, Tim, 2020).

Machine learning

Machine learning now is widely used in airport security check and self-service, like Schiphol self-check-in. For the security check, "the machine learning system could identify threats by collecting and analysing data faster than a human could. For example, some products that needed to be scanned separately, like cameras or laptops, could be kept in travellers' baggage when they pass the security checkpoints" (Baker, Joe, 2020). In addition to security check and self-check-in, machine learning also can be used for maintaining security at the landside area of airports. Oakland International Airport has developed

the Evolv Edge system. Evolv Edge system applying facial recognition and millimetre-wave technologies to scan people passing through a portable security gate. Machine learning techniques are used here to automatically collect and analyse data for potentially dangerous, containing flammable items and even guns, while ignoring passengers' belongings, like keys and wallets (Baker, Joe, 2020).

Augmented reality

The Gatwick airport currently applies AR technology to help travellers to find their way and understand the complex layout of the airport. The new AR application with the installation of locating beacons act as an indoor navigation tool to guide passengers to their destination in the airport in a more intuitive way. As shown in figure 36, the AR app superimposing direction and the arranged routes on the phone screen, rather than just presenting users' location and a 2D map to users. There are also other uses for the AR system, like promotion. Airport retailers can store the promotional information or images in the environment and show it to nearby passengers, advising passengers of ongoing products or benefits. Exploring the AR system could help the airport to develop new real-time services and digital information system to improve passengers experience in the airport (Hills-Duty, R. (2017)).

Main takeaways

Artificial intelligence (AI) and machine learning are typically used for analysing passengers' data and improving security and check-in efficiency in many airports. For this project, how to distinguish users and understand their needs will be the premise of providing effective information to different travellers. Here it is found that AI technology could be used to predict the user purpose and behaviours. However, using AI technology to predict user behaviour may have limitations in technology and regulations, such as the user's data usage rights and data privacy. Moreover, the smart robot could help travellers with their wayfinding and overcoming language barriers.

Using AR technology can provide passengers with extra information, and this digital information will not occupy Schiphol physical space and intensify the visual overload of Schiphol environment. On the other hand, AR technology can guide users more intuitively and effectively through the fusion of digital images and text with reality in Schiphol. So, for this project, augmented reality (AR) is an excellent option to improve passengers' wayfinding experience and information provision in Schiphol. Although there are still some advanced technologies are now growing at some airports, such as autonomous travel, sustainable materials and even blockchain, they are not described and analysed here.



Figure 36: AR indoor navigation application of Gatwick airport (Nikki Gilliland, 2017).

5.5. Emerging new technologies

There are some emerging new technologies which are revolutionizing the travellers' experience in airports. These new emerging technologies will provide more possibilities for the Schiphol future development and exploring the new emerging technologies would also inspire the creation of new ideas and concepts of this project.

Internet of things (IoT)

Internet of things is a system connecting everything in the system through the internet. This technology involves real-time data analysis, machine learning and product sensors. Sensors installed on the product will automatically collect data and upload it to the networks. "The main function of this technology is to serve for the intelligent control system by analyzing and processing the collected object data"(n.d, (2017)). For Schiphol, the internet of things technology could be applied to collect user data, predict user behaviour and build up IOT intelligent system in Schiphol. For the IoT system, all types of equipment in the airport are attached to Schiphol networks, offering real-time data on elements like performance, maintenance Etc. (n.d, (2017)). Moreover, IoT could also collect users' data, such as monitoring users' mood and health status. Then the analysis results of these data will be used to build up customize personalized journeys for passengers.

5G networks

"5G is the fifth generation technology standard for cellular networks. Compare with 4G, the main advantage of the new networks is the higher bandwidth (download speeds up to 10 gigabits per second)" (Hoffman, Chris (January 7, 2019)). High-speed 5G connections would explore and supports lots of new services in airports. The currently promising

application field of 5G networks is automation and IoT (internet of things) applications (Marisa Garcia, (2019)). The ultra-high network speed (5G networks) supports real-time information transmission and users' data collection and analysis, which is the basis of IoT. Moreover, 5G networks would allow users to download Schiphol applications faster.

Main takeaways

IoT(internet of things) and 5G networks would accelerate the growth of smart airports, with the smart equipment and facility in airports. IoT and 5G networks support the development of personalized user experience and real-time data transmission. For this project, the combination of new emerging technologies would accelerate the process of collecting and analyzing data in Schiphol, and the insights from the analysis would help Schiphol improve personalized service for individual travellers in Schiphol. On the other hand, 5G networks will promote the application of other technologies, such as AR and AI. The speed of the network directly determines the quality of the user's real-time interaction with the airport. Taking AR application as an example, the real-time display and feedback of virtual images will significantly affect the users' experience. Although these new emerging technologies cannot be realized in a short time, they suggest the direction and trend of this project future development.

5.6. Conclusion

According to the above introduction of different kinds of solutions that could be used in Schiphol and insights from that, the following would show the comparison of the different solutions and relevant technologies of this project. This result will also guide and inspire the concept stage.

 App information structure	Application information architecture Liner pattern-iChangi app Hub & Spoke-Heathrow app	Advantage ● Clear information structure ● Easy to learn and understand for users ● Higher efficiency ● Strong generality of index page	Disadvantage ● Slow for users to switch between different functions (Lower operation efficiency) ● Visual overload of the index page ● Less learnability
 Museum guiding system	Museum navigation Web VR VR-Virtual Reality AR-Augmented Reality	Advantage ● Remote accessible ● Low requirement for hardware equipment (VR device, smartphone and laptop) ● Full sensory user experiences ● Entertaining ● Suitable for annotating scenes and providing extra digital information	Disadvantage ● Unsmooth interfaces and user experience ● Need exclusive VR equipment ● Low operating efficiency ● Need to download AR app
 New technologies applied in airports	Technology trends Artificial intelligence Machine learning Augmented Reality IoT (Internet of things) 5G networks	Field of application ● Analysing passengers' data ● Predicting user behaviour ● Analysing passengers' data ● Maintaining security automatically ● Indoor navigation ● Digital information provision ● Users' data collection ● Airport smart equipment management ● Real-time data transmission ● High speed download	● Smart robot ● Self check-in



Chapter 6 | Ideation

This chapter includes:

- 6.1. Ideation
- 6.2. Evaluation
- 6.3. Conclusion

Introduction

In this chapter, the knowledge from the previous chapter (Competitive product analysis) is used to generate ideas base on the function list of this project. This chapter mainly includes two parts: Ideation and Evaluation.

6.1. Ideation

After competitive product analysis, analysis of other airports or museum wayfinding solutions, applications, Etc. is used as inspiration for the creation of rough ideas according to the design brief of this project and function list. Base on each design objective and its corresponding functions, ideas are generated. Below is the ideation process.

Method

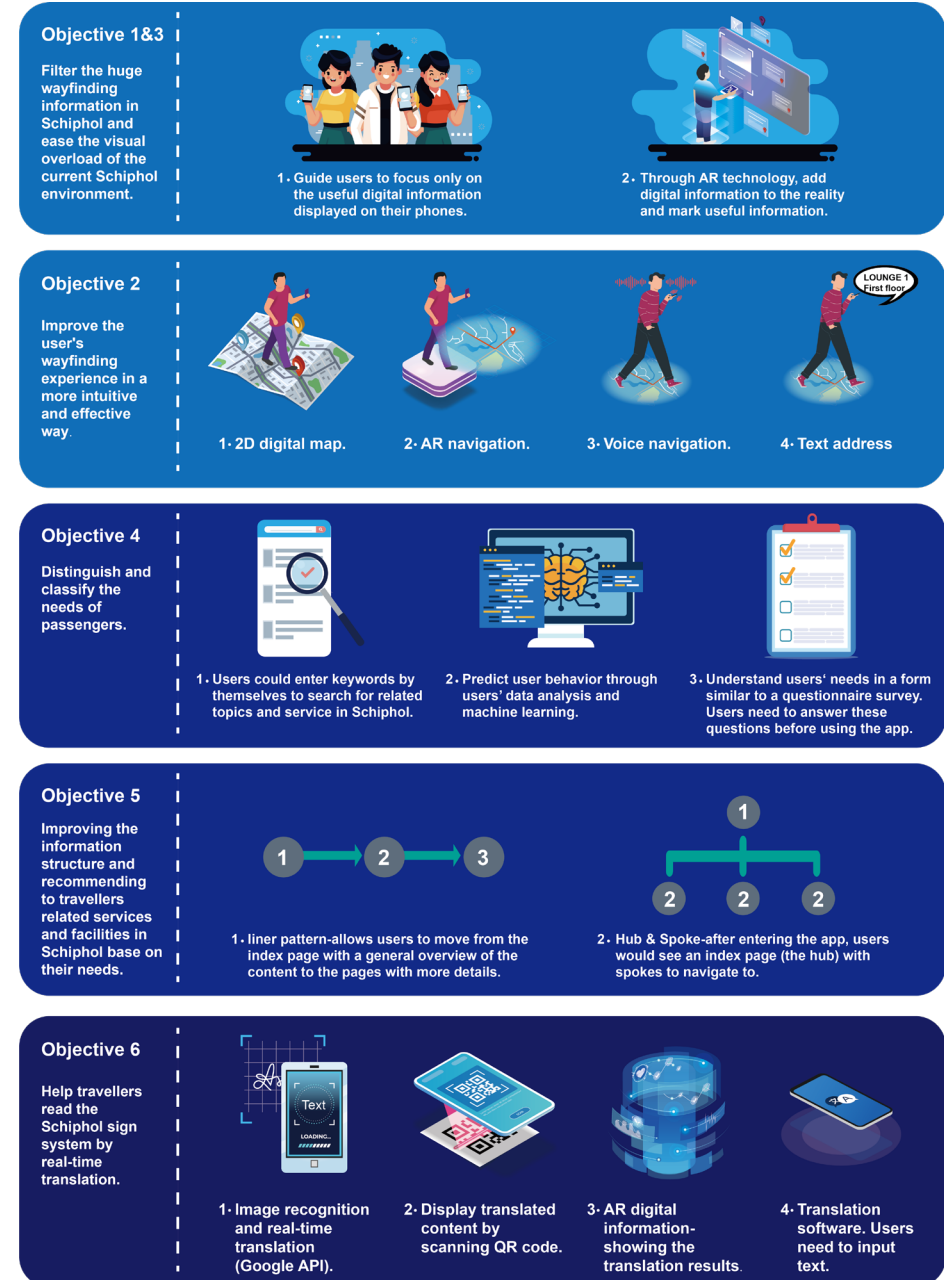
In order to explore more solutions, a creative workshop was organised with four designers from the IDE faculty. They were given a brief introduction of this project and a detailed explanation of the design brief and function list of this project. The design goal indicates that the project scope should cover all passengers' journeys, including departing from Schiphol, arriving at Schiphol and transferring from Schiphol. in Schiphol. Base on the design scope in the design brief, they were required to generate ideas about the mobile application. Here they would brainstorm and generate ideas for each design objective. Then they would share their ideas with others in the workshop and select interesting ideas and iterate on them. Finally, according to the function list and design brief, some unrealistic and less valuable proposals that do not meet the functional requirement are excluded. Below is the results of the ideation.

Result

The following ideas were obtained through discussion and screening in the workshop. These ideas basically meet the functional requirements in the function list.

Discussion and conclusion

After discussion in the workshop, it is found that all ideas for each objective have strengths and weaknesses. The primary purpose of this part is not to select one option for each design objective, but rather try to combine each ideas' strength in an integrated design. These ideas will act as new elements that be combined to produce the final concept of this project. The table on the right is the result of ideation. It would show the corresponding solutions for each design objective.



6.2. Evaluation

The ideas generated in the previous section will be used as new elements to generate the final concept. In this part, for each design objective, the corresponding ideas will be compared and combined to get the final solution. Moreover, the evaluation method and process are different for each design objective here. These methods will include literature research, technical analysis, experiments and expert interviews. Through these methods, the ideas corresponding to each design objective are evaluated and be combined to produce the final concept.

Objective 1&3

For the design objective 1&3, its main goal is the management of the visual or information overload in Schiphol. The focus of this topic is improving the information structure in Schiphol and Schiphol wayfinding system. For this design objective, there are two main directions here. First, base on the previous chapter knowledge, AR technology is a good option for annotating scenes in reality and providing digital information. Moreover, for this project, AR technology can effectively combine virtual information and Schiphol information system (the signs system). This solution means that users need to read the information provided by Schiphol in reality in combination with the virtual information displayed on the mobile phone, which is an effective way to filter large amounts of information and solve visual overload. The second way is to guide users to focus only on the virtual information on their mobile phone. Here base on the previous context analysis, Mijksenaar who has been responsible for sign system at Schiphol since 1990, said that "We should never underestimate the role of traditional signs in the wayfinding system." This idea can't make full use of Schiphol existing signs system. Moreover, another drawback of this method is its limited interactivity with reality. So compared

with relying only on the virtual information on the mobile phone side, applying AR technology to enhance the efficiency of the Schiphol signs system is more in line with the previous research results and design goals of this project.

Main takeaways

The final concept would apply AR technology to annotate scenes, mark useful information for passengers and overlays digital information on top of the existing Schiphol environment.

Objective 2

For this design objective, it is required to guide travellers to find their way in Schiphol effectively. All ideas are concentrated on indoor navigation, and each way of navigation disseminates information differently (visual, auditory, reading text). Here research by Polly Hussman and Valerie Dean O'Loughlin at Indiana University indicated "that people have a strong sense of their learning preferences (visual, auditory, reading/writing, kinesthetic)". Moreover, in this study, it is found that although people have their learning preferences, they would not overly rely on their preferred learning strategy. Like most visual learners did not only rely on visual strategies (like diagrams, graphics) and their learning process also requires reading and sound to acquire knowledge. Compare with providing a single channel for knowledge acquisition, providing learning material in multiple modalities is always more useful for people to learn a new system (Husmann, P. R., & O'loughlin, V. D. (2018)). For the navigation methods in this project, according to the above analysis, the final solution will combine these four navigation methods instead of choosing the best option. To better compare and combine each navigation method, the following are the list

of advantages and disadvantages of each navigation method.



2D digital map.



AR navigation.



Voice navigation



Text address

Advantage

Help users know their location and understand the surrounding environment and building structure.

Augmented reality navigation features add extra information in reality and help to pave the best possible route to the destination for users, which is easy to follow for users. 3D maps are also great at grabbing attention and represent the cool user experience.

Providing voice instructions and free the user's hands and eyes.

Text address intuitively displays the geographic location and supports users to communicate with others and seek help.

Disadvantage

The 2d map is not as clear and intuitive as the 3d map in the display of directions to users.

It is costly to implement and ar navigation cannot help users know their location and their surroundings.

Voice navigation cannot make users know their location and understand their surroundings.

Text information can not guide the user to their destination. It is just an auxiliary tool in navigation software.

After comparison, each navigation method has its advantages. First, 2D static maps can help users quickly understand the surrounding environment and know their location. However, its disadvantage is that it can not clearly show the direction to the user on the two-dimensional plane and its limited interactivity (Harrower, M. (2020)). Here 3D navigation represented by AR navigation makes up for the deficiencies of 2D maps. At present, most navigation software not only relies on one individual navigation method but use them in combination. For example, Google's AR navigation application with flexible mapping tech displays a 2D map at the bottom of the AR navigation interface, and users could also switch between the 2D maps and AR navigation system. For this project, AR navigation combined with 2D maps is a good option not only for annotating scenes and providing digital wayfinding information but also for planning routes for passengers and guiding them to their destination.

Second, the voice navigation system provides turn-by-turn navigation by voice instructions. With voice navigation, passengers will hear wayfinding alerts and suggestions, where to turn, and if there is a better route for them. The most significant advantage of voice navigation is that it guides the user to the destination step by step through the voice instructions and frees their hands and eyes, so this type of navigation is currently commonly used for driving navigation by car. For this project, the Schiphol noisy environment was not conducive to users receiving voice messages. Moreover, according to design objective 1 & 3, liberating the user's hands and eyes is not the focus of this project. On the contrary, the final concept (app) needs to guide users to pay attention to the digital information on the mobile phone interface and help them filter a large amount of information in reality. Third, text address has been widely used in most navigation software. It can facilitate users to communicate with others and seek help from others. For this project, add text address and text information about wayfinding (like the time required to reach the destination) in the navigation system of the app would help the travellers have an overview of their routes to their

destination and the wayfinding process in advance.

Main takeaways

In the wayfinding navigation module, the final concept will apply a combination of AR navigation, 2D maps and text information about wayfinding to guide passengers to follow the planned route.

Objective 4

For this project, learning the needs of different users is the prerequisite and foundation of providing customized service and personalized recommendation with passengers. Collection of passengers' personal information and analysis depends on web mining technology and even machine learning. Here Schiphol needs to collect and analyze the user's personal information to recommend them the corresponding and helpful service. For example, it will recommend opening a mobile phone card service for non-European travellers. However, there are many restrictions on the application of passengers' personal information, such as privacy and security issues and related regulation.

Main takeaways

The final concept would rely on advanced keywords search capability and questionnaire to learn the needs of all users, which means users need to input their needs by themselves or choose service that they need.

Objective 5

The information structure of an app is the outline of the information in it, which will directly affect the effectiveness of information transmission. After ideation and screening, two information architecture patterns are suitable for building the basic app structure of this project (liner pattern, Hub and Spoke). The strategy for designing and building app structures is not to rely on a single information structure but to

combine different information structures according to the functional requirements of the app (Applikey Team, 2018). Base on the previous chapter analysis, liner pattern is more intuitive and straightforward to navigate and be understood by users. The Hub and spoke information structure performs better in information display and operation efficiency. In order to combine the strengths of the two kinds of information architectures, the two information structures would be consolidated and be used in the final concepts. Considering that Hub and spoke information structure performs well in the information display, this structure will be used on the index page and act as the main interface. The advantage of this model is that it can help users have an overview of the app contents and functional structure of the app. On the other hand, the screen of the smartphone is small, so fewer elements and substances can fit into it. Here the liner pattern could be applied to assist the Hub and spoke structure, distributing part of the content to other interfaces. The advantage of this structure is that it can reduce the visual overload of the index page of the app and make the information structure more intuitive and easy to learn by users.

Main takeaways

As shown in figure 37, the final concept will combine with the liner pattern and Hub and spoke information structure to build the underlying information architecture of the app. Choosing the Hub and spoke as the primary parent pattern and applying liner pattern for subsections. The index page of the app (Hub and spoke) that has links to other pages, which in turn

contain links to more subpages (liner pattern).

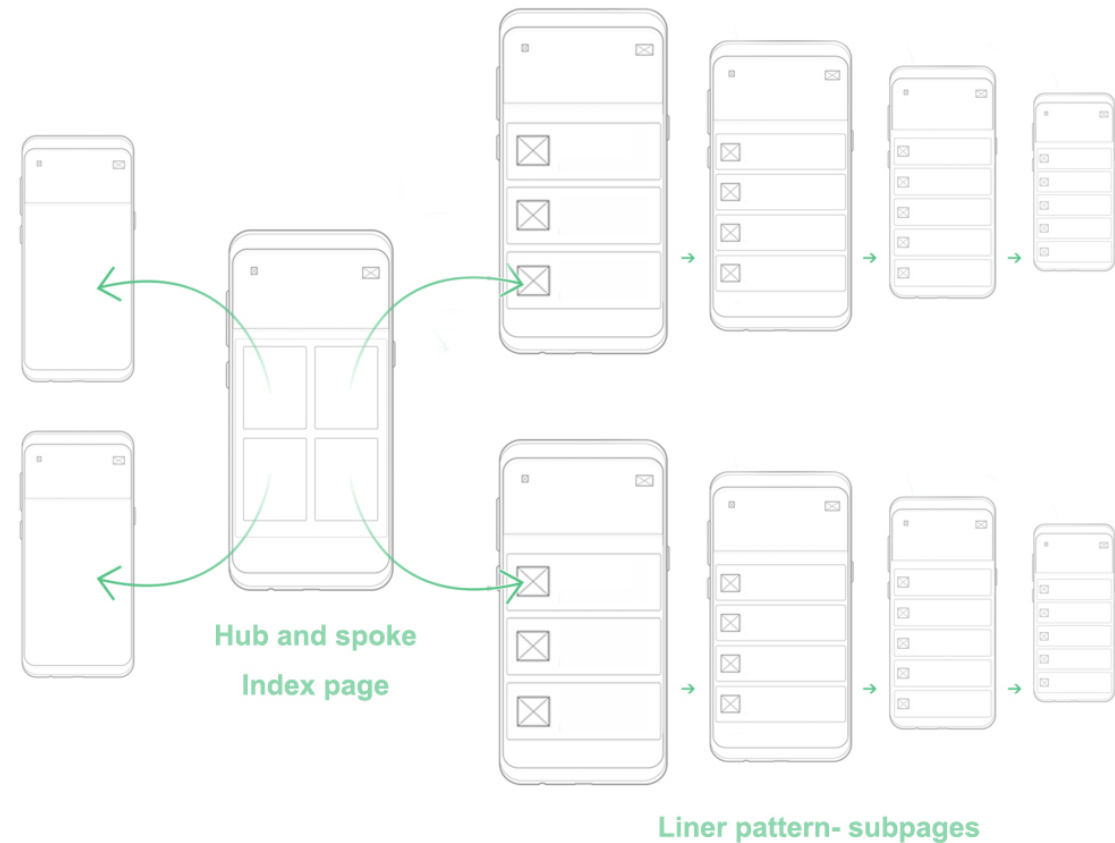


Figure 37: Information structure of the final concept

Objective 6

According to the function list of this project, the final concept should help international travellers to read and understand the Schiphol signs system in Dutch or English. After ideation, four ideas could help travellers to translate Schiphol signs-Google API, AR digital information, QR code and translation software. Before going further, the two opinions, scanning the QR code to see the translation results and making travellers rely on other translation software, are excluded. Because, firstly, there are numerous signs in Schiphol need to be translated during the passengers' wayfinding process. If passengers scan the QR code corresponding to each symbol to view the translation results, it will greatly reduce the efficiency of passengers and cause congestion in Schiphol. Second, if passengers rely on other translation software to read Schiphol signs system, they need to frequently switch between the Schiphol app and translation software, which will significantly affect the user experience and decrease Schiphol efficiency.

For this project, real-time translation is an ideal solution. Real-time translation software can identify and translate the text captured by the mobile phone camera through Image recognition technology. Real-time translation technology suits the translation of large amounts of text information. But, image recognition and translation technology are currently mainly used for the translation of still images. Google translation has developed real-time image recognition and translation and offering API to help other software use these functions for free. Whether this technology can recognize the signs in Schiphol Airport and the limitation of applying this technology in Schiphol have become the main problem of the feasibility of this idea at present. Here base on a field experiment in Schiphol plaza (conducted by jianghui Li on November 22, 2019), it is found that google real-time translation software can accurately identify and translate most of the signs in Schiphol plaza. This experiment includes the extreme distance and angle range measurement of text recognition and brightness requirements

for text recognition. However, in the process of testing, it is found that when users use real-time translation software to translate Schiphol signs, they must stop moving and scan pictures with their phones. If real-time translation software is used on the move, the translation results will be vague and unreadable (figure 38). So the application of real-time translation technology in Schiphol will decrease the flow of people and cause congestion. Because of the immaturity of the development of the real-time translation technology (represented by Google translation), for this project, real-time translation function cannot be implemented in Schiphol now.

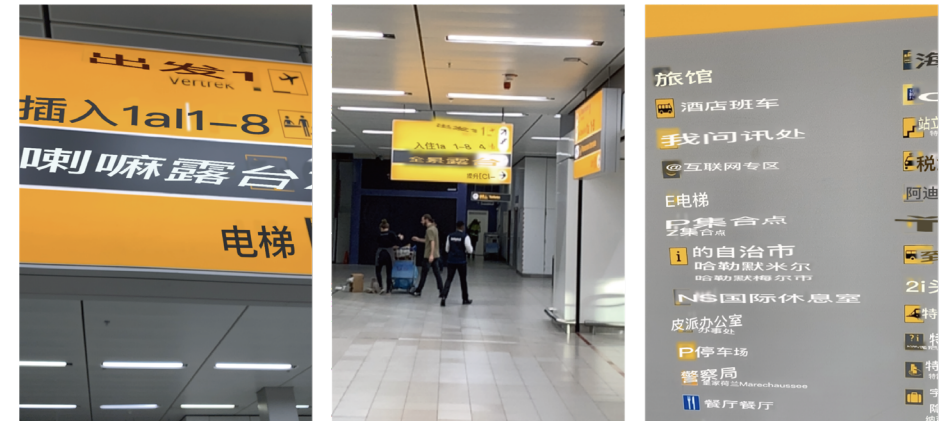


Figure 38: Testing results (Google translation)

For the idea (showing the translation results through the AR digital information), the realization of this idea requires the Schiphol programmer to input and store all the translation results of Schiphol signs in different language version in the Schiphol environment. The app on the user's mobile phone recognizes the user's main language through the program and displays the translation result corresponding to users' native language to the users. Compare with the real-time translation

technology, AR digital information can translate text information in Schiphol is limited; for example, it is only suitable for large hanging signs that are easy to locate. The real-time translation technology is to recognize and translate all the text information in the pictures captured by the mobile phone camera. However, the advantages of applying AR digital information for translation are high translation accuracy and stable display.

Main takeaways

For how to translate the signs system in Schiphol, the final solution will use AR technology to superimpose images or text of the translation results on top of what passengers can see in real-time and store the digital information of translation results in the Schiphol environment. The passenger's mobile phone shows them the translation result of the corresponding signs based on the user's location and direction. It would show passengers an altered version of reality.

6.3. Conclusion

At the end of this chapter, for all the design objectives, the corresponding ideation results will be used as new elements to constitute the final concept. As shown below, the ideation results define the scope of the final concept. The result of ideation will guide the implementation and generation of the final concept. How the new elements are combined and implemented to generate the final concept will be discussed in the next chapter (the final concept).

Objective 1&3

Filter the huge wayfinding information in Schiphol and ease the visual overload of the current Schiphol environment.

Solution

To address the information overload and improve passengers' wayfinding efficiency in Schiphol, the final concept would apply AR technology to annotate scenes, mark useful information for passengers and overlays digital information on top of the existing environment.



Objective 2

Improve the user's wayfinding experience in a more intuitive and effective way.

Solution

In the wayfinding navigation module, the final concept will apply a combination of AR navigation, 2D maps and text information about wayfinding to guide passengers to follow the planned route.



Objective 4

Distinguish and classify the needs of passengers.

Solution

The final concept would use the keyword search system and questionnaire to understand the needs of users.

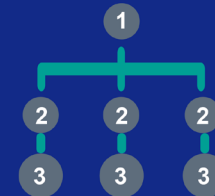


Objective 5

Improving the information structure and recommending to travellers related services and facilities in Schiphol base on their needs.

Solution

the final concept will combine with the liner pattern and hub and spoke information structure to build the basic information architecture of the app. Choosing the Hub and spoke as the main parent pattern and applying liner pattern for subsections.



Objective 6

Help travellers read the Schiphol sign system by real-time translation.

Solution

For how to translate the signs system in Schiphol, the final solution will use AR technology to superimpose images or text of the translation results on top of what passengers can see in real-time and store the digital information of translation results in the Schiphol environment.





From Concept to Design

Chapter 7: Final Concept

Chapter 8: Recommendation



Chapter 7 | Final Concept

This chapter includes:

- 7.1. Prototyping**
- 7.2. Testing and iteration**
- 7.3. Final concept**

Introduction

As above mentioned, the final concept for this project would be an indoor navigation application with AR technology. In this chapter, in order to determine the final concept, interactive prototyping of the app is created for testing and iteration. This chapter includes three sections: prototyping, testing and iteration and final concept. At the end of this chapter, after continuous testing, the final concept of this project is obtained.

7.1. Prototyping

According to the ideation results in the previous chapter and design brief, two concepts are created here. These two concepts each represent a type of app-Utility apps (functional and efficiency) and travel apps (user experience and entertainment). These two concepts will meet the design requirements and follow the design brief. The two concepts display information with different emphasis. One of them is more focused on efficiency and functionality, so it will help users quickly find the information that they need in Schiphol. Its structure would base on the user's journey in Schiphol and guide users to complete tasks through step by step instructions. Another concept focuses on improving the user experience in Schiphol and helps users to better enjoy and explore the services in Schiphol. It will help users fully understand Schiphol and better adapt to the new environment or even overcome cultural differences.

Here both solutions have their strengths and weaknesses. The purpose of this chapter is not to just select one solution as the final concept, but rather combine the advantages of the two solutions and get the final concept through testing and iteration. Interactive prototypes for the two concepts are required here before testing. Below is the process of making interactive prototypes.

Method

To get an interactive app prototype, first, creating the information structure of the concept (new Schiphol guiding application). The information structure is the outline of the information in the app, and it is the structure of the app's content (Applikey Team, 2018). For this project, according to the ideation results in the previous chapter, corresponding solutions were given for problems for each design

objective, respectively. Here the information structure (wireframe) of the app would integrate these solutions. Here, a wireframe below is created to demonstrate the hierarchy of information and contents of the app, which would act as a guide for making prototyping of testing. Second, drawing the app interfaces based on wireframe through quick sketches. Then, based on the drawings, using vector-based digital design software for apps or websites such as XD to create an interactive app prototype for testing. This kinds of software can be used to create and collaborate on everything from prototypes to mockups to full designs (Cousins, C. (2019)). For the navigation interface, static images of the navigation interfaces will be created through PhotoShop, which would be used to simulate AR navigation.

Result

Below are the wireframe and app interfaces of each concept.

Concept-1(Utility app)-wireframe

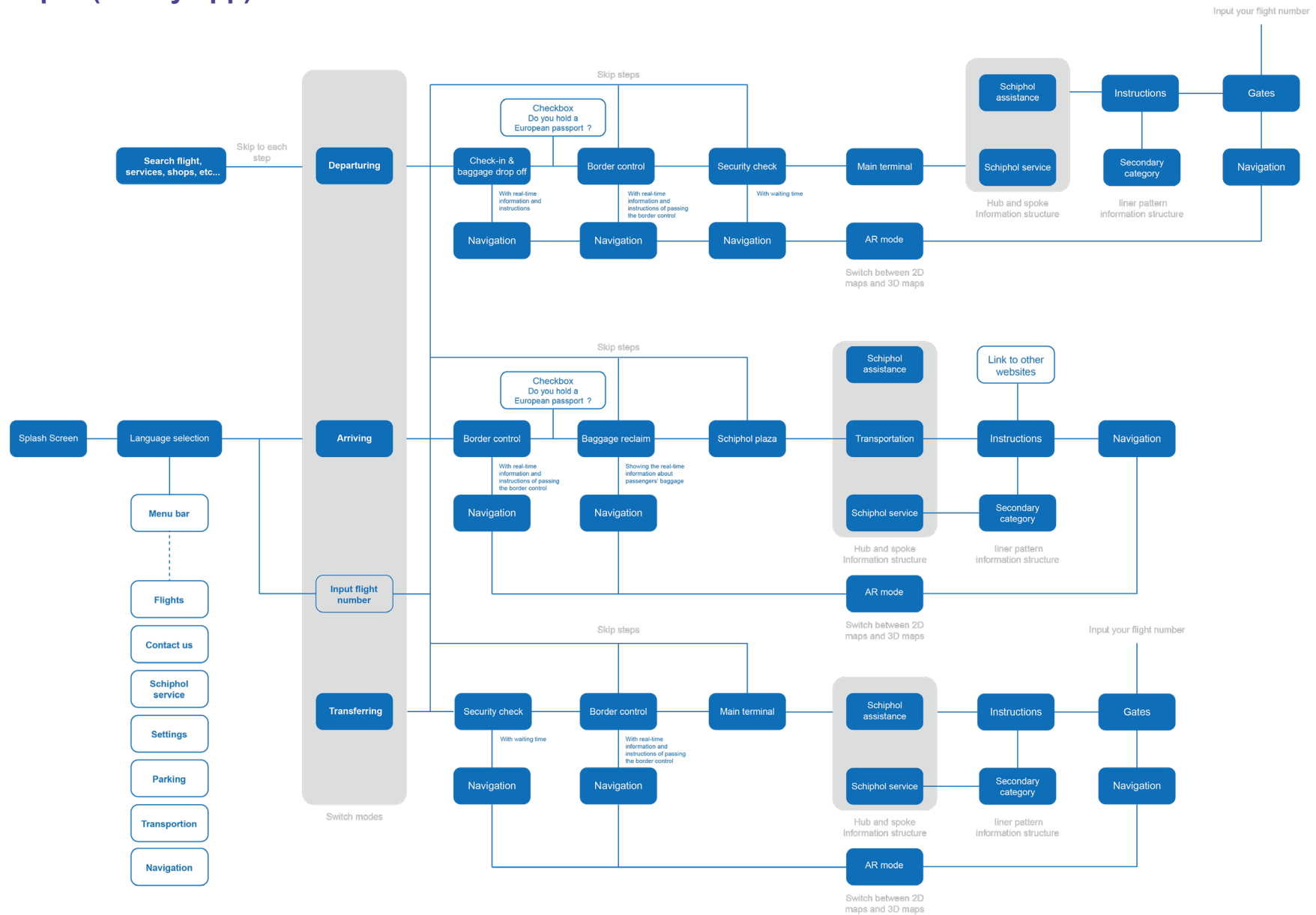


Figure 39: Wireframe of prototype 1

Concept-1(Utility app)

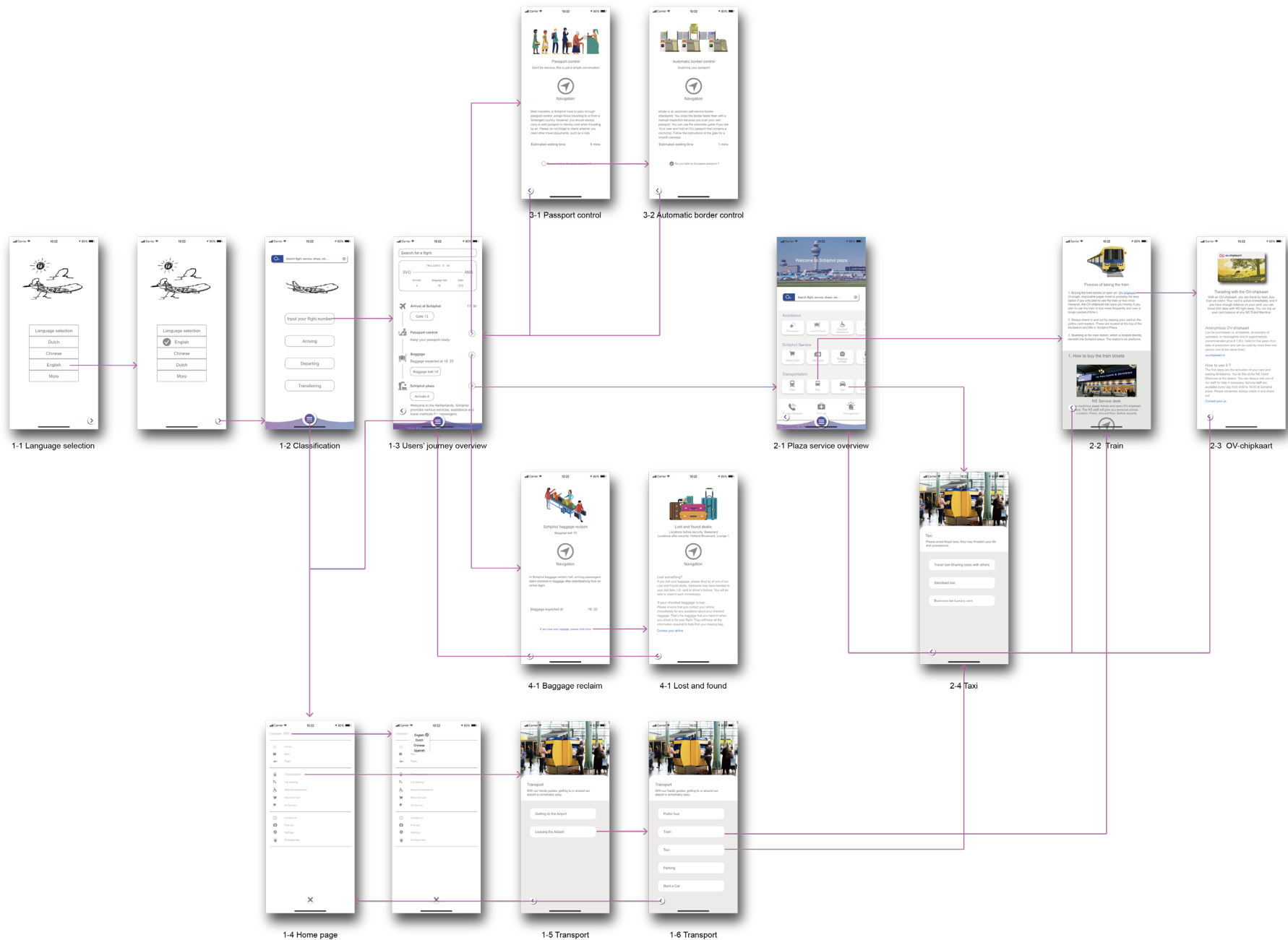
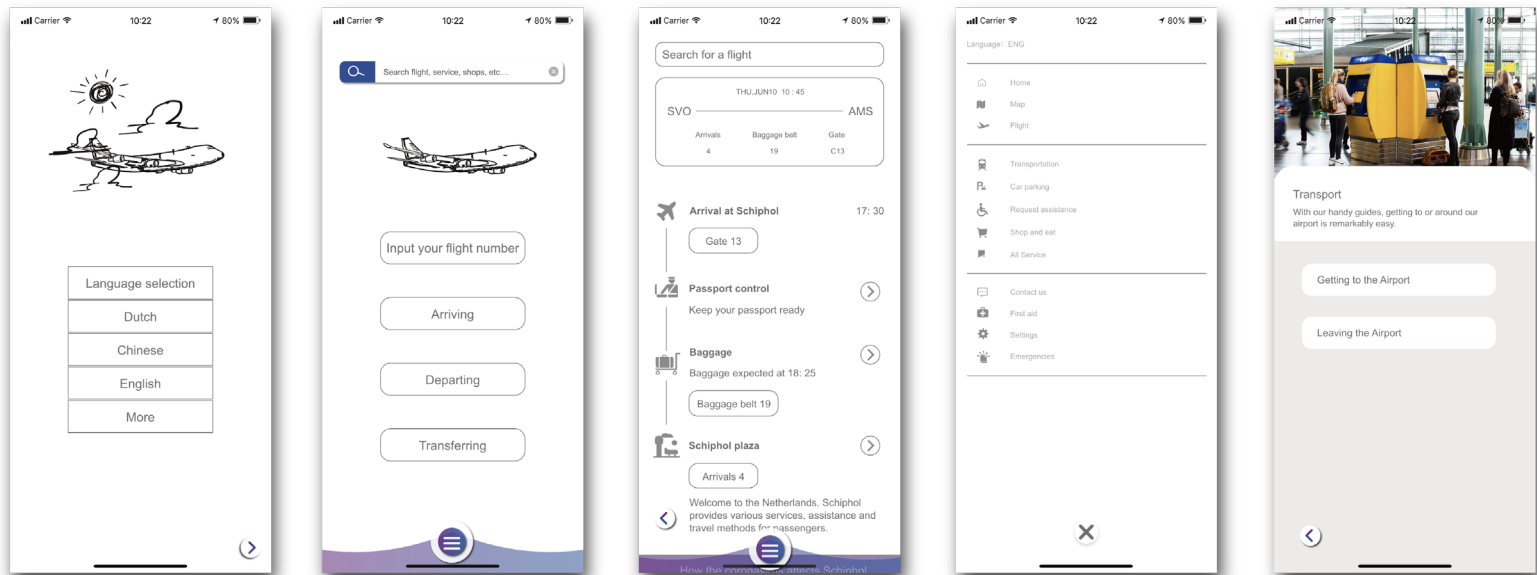
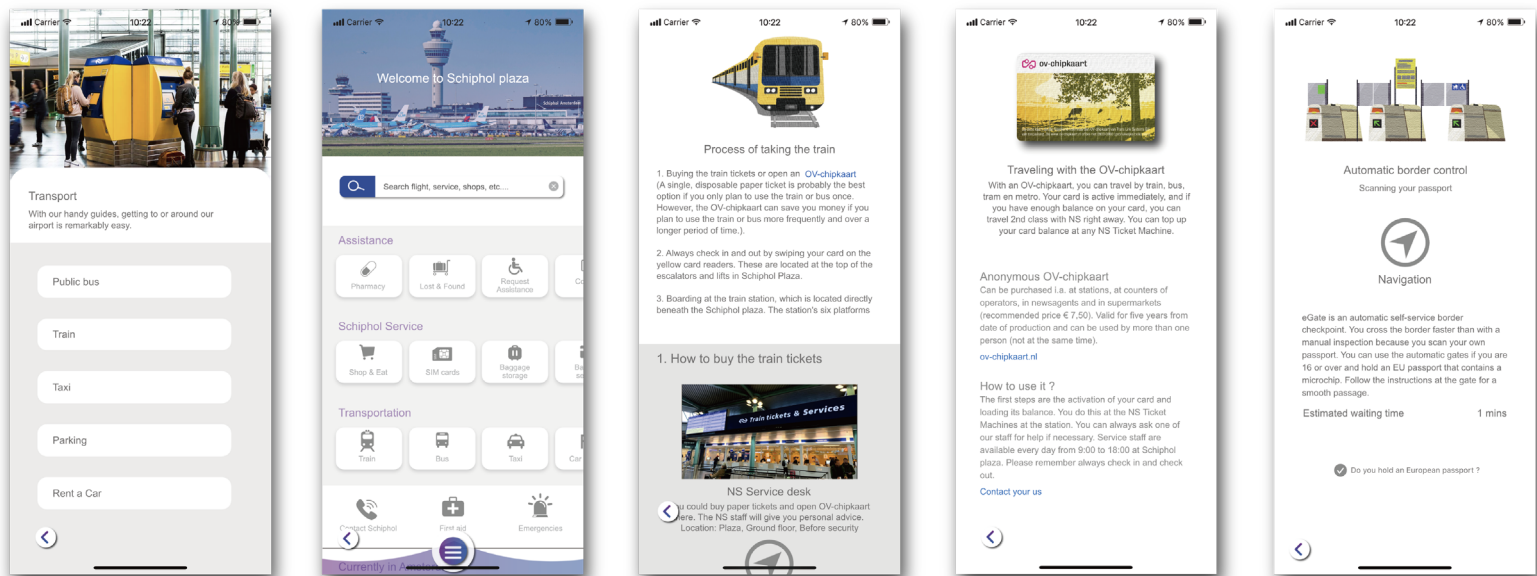


Figure 40: App Interfaces of prototype 1

Concept-1(Utility app)



1-1 Language selection 1-2 Classification 1-3 Users' journey overview 1-4 Home page 1-5 Transport



1-6 Transport 2-1 Plaza service overview 2-2 Train 2-3 OV-chipkaart 3-2 Automatic border control

Figure 41: App Interfaces of prototype 1

Concept-2(Entertainment & travel apps)

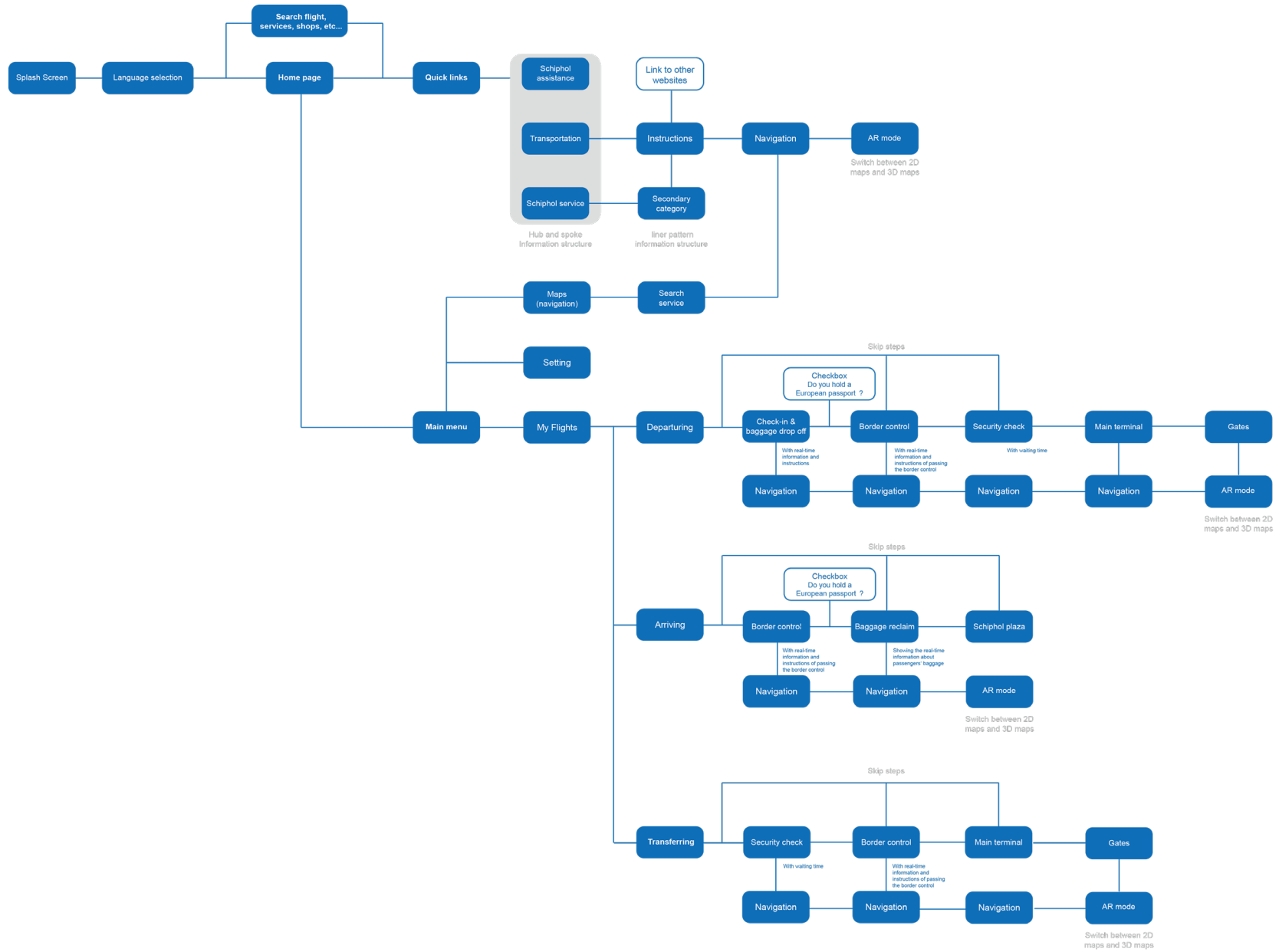


Figure 42: Wireframe of prototype 2

Concept-2(Entertainment & travel apps)

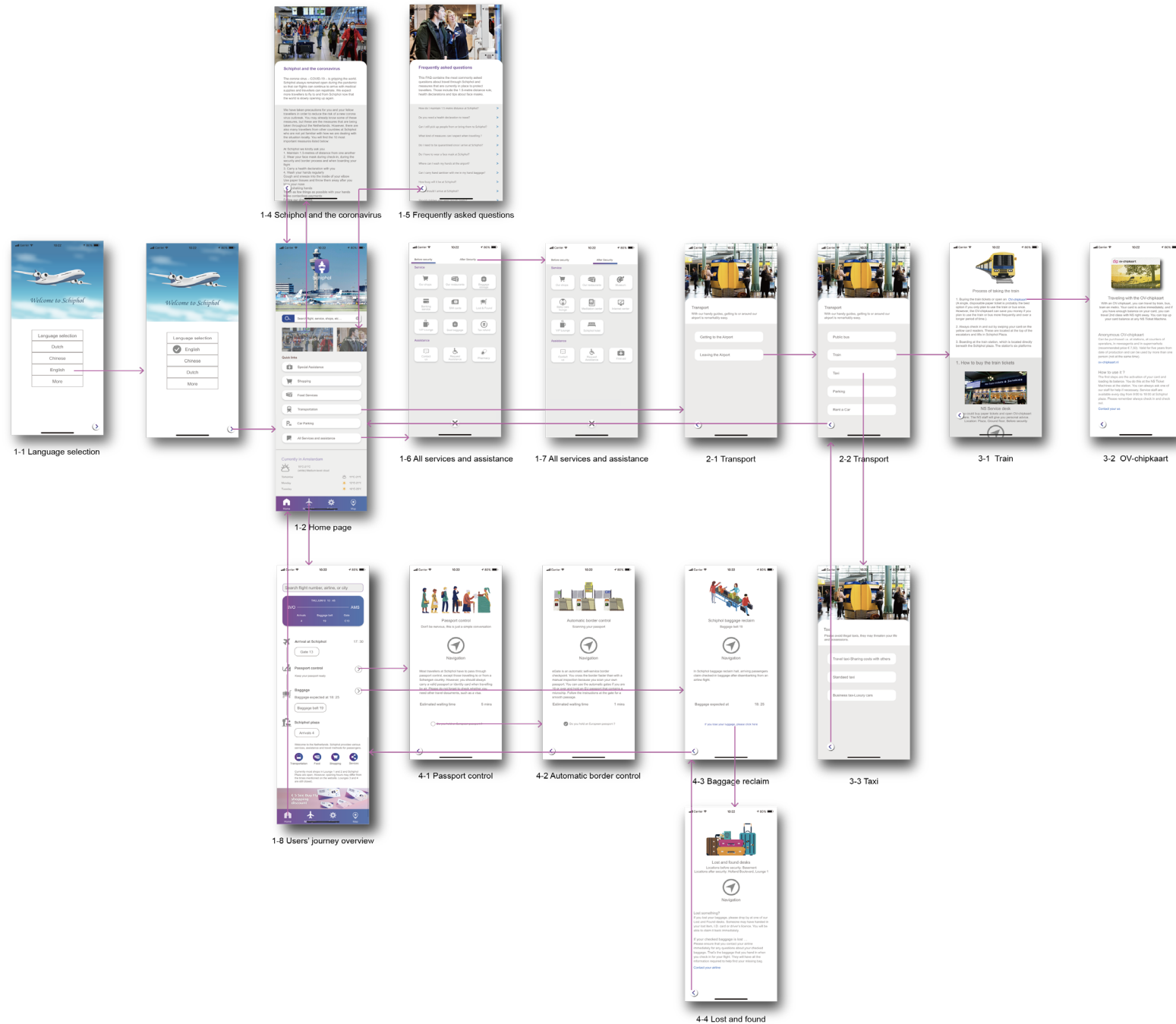
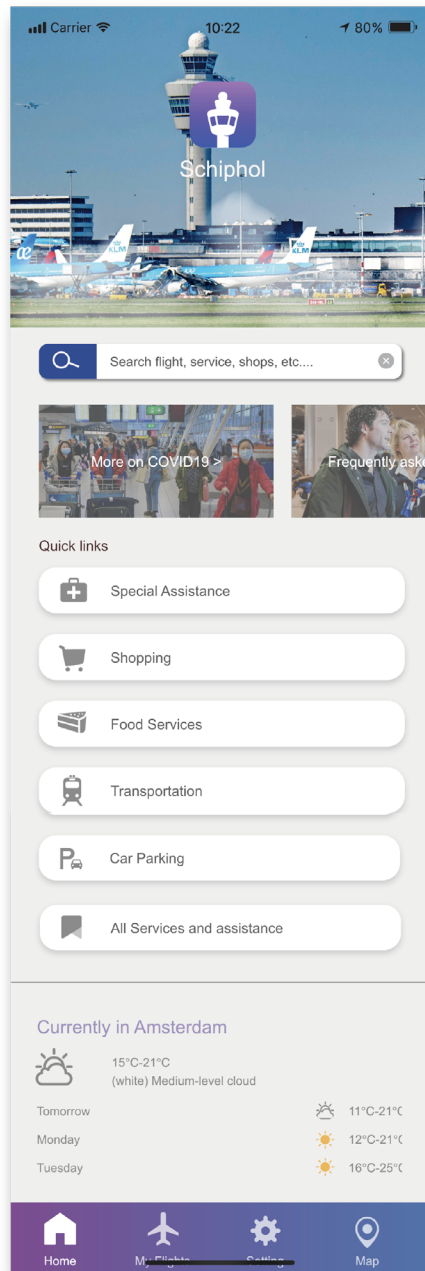
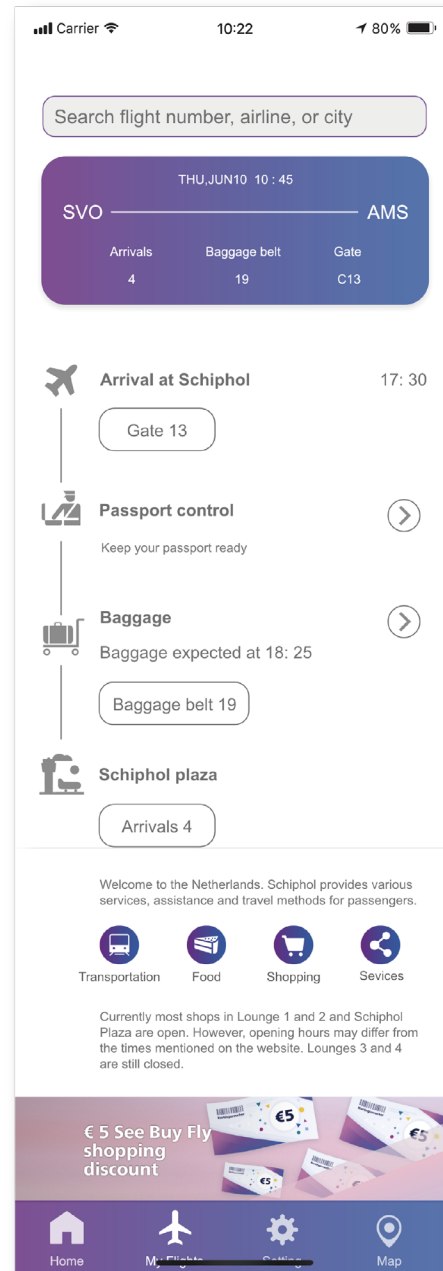


Figure 43: App Interfaces of prototype 2

Concept-2(Entertainment & travel apps)



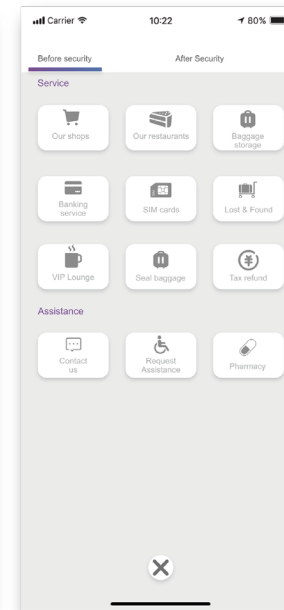
1-2 Home page



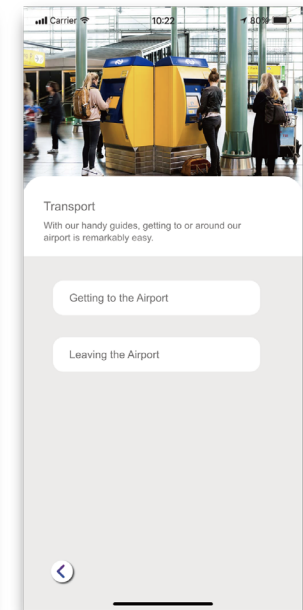
1-8 Users' journey overview



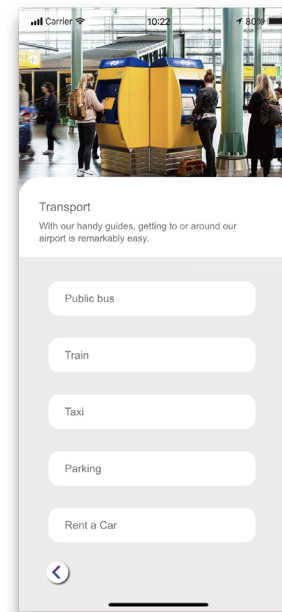
1-1 Language selection



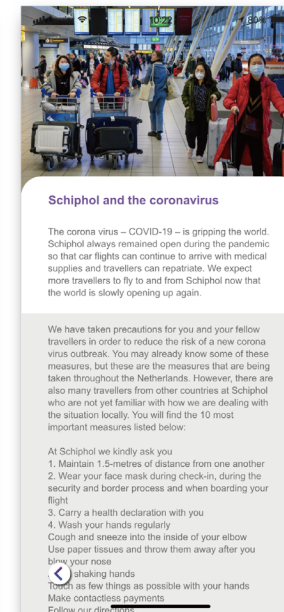
1-6 All services and assistance



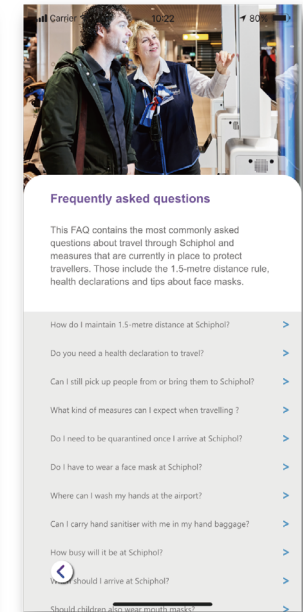
2-1 Transport



2-2 Transport



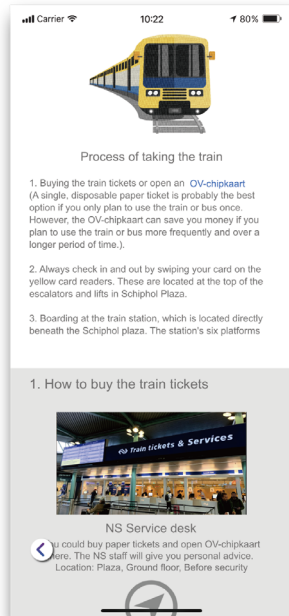
1-4 Schiphol coronavirus



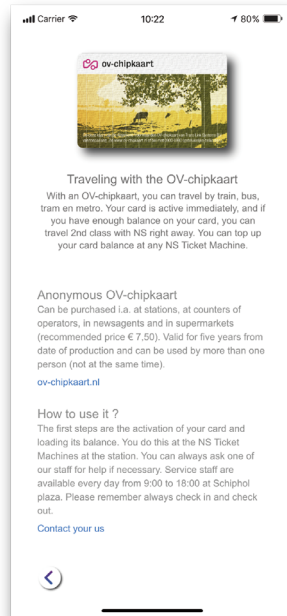
1-5 Frequently asked questions

Figure 44: App Interfaces of prototype 2

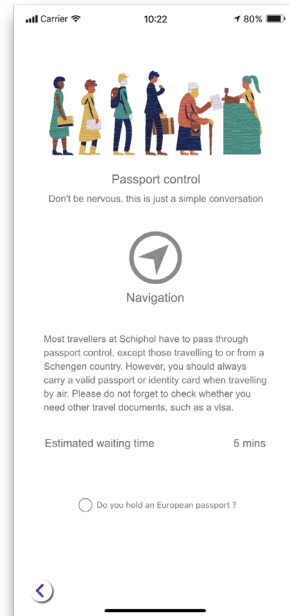
Concept-2(Entertainment & travel apps)



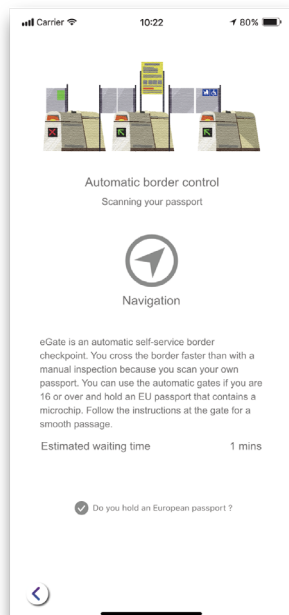
3-1 Train



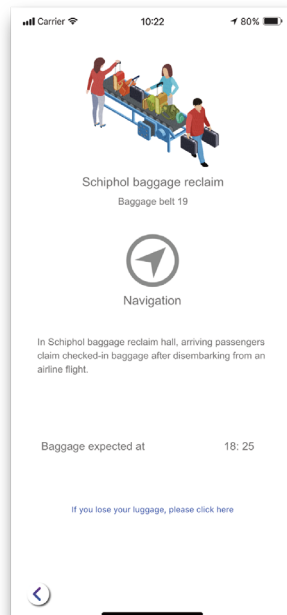
3-2 OV-chipkaart



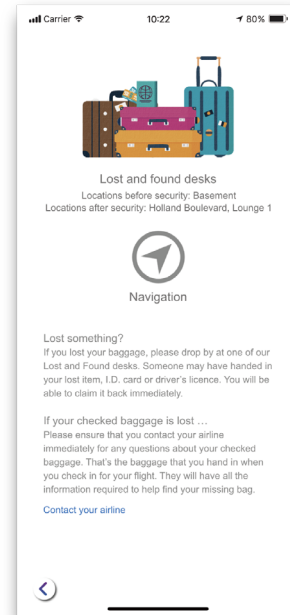
4-1 Passport control



4-2 Automatic border con-



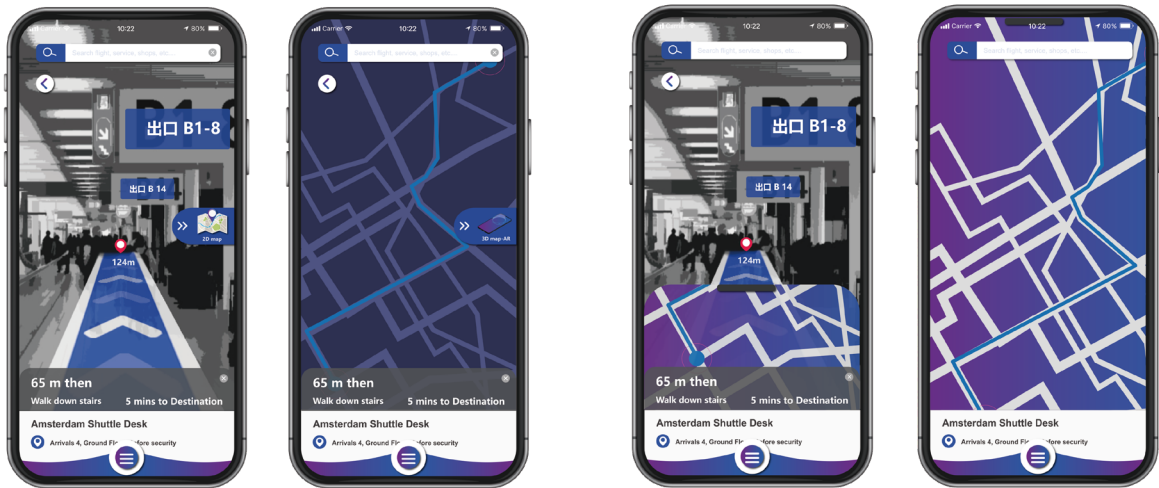
4-3 Baggage reclaim



4-4 Lost and found

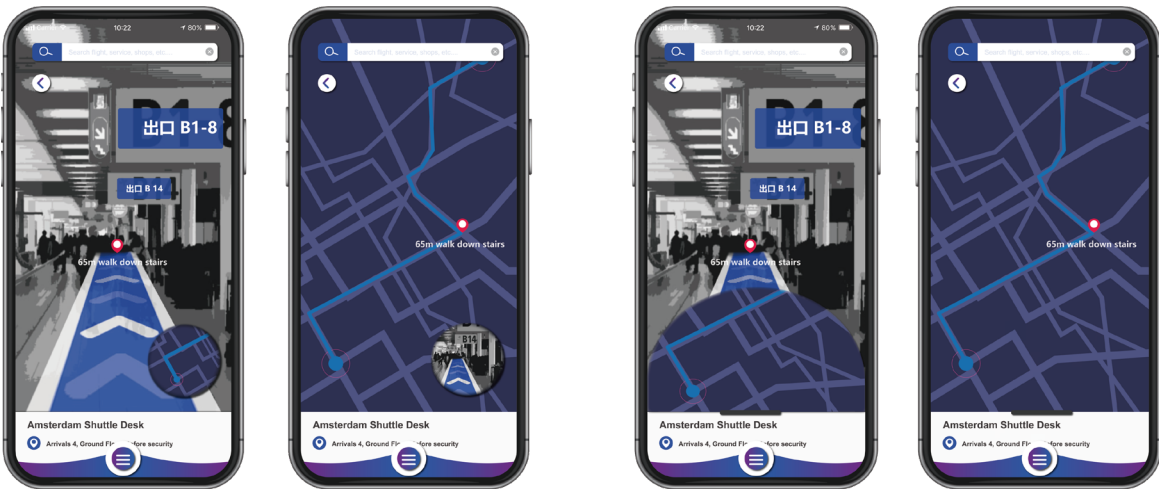
Figure 44: App Interfaces of prototype 2

Navigation interfaces



Scheme 1 (Switch between AR navigation and 2D map with a button)

Scheme 2 (Switch between AR navigation and 2D map by sliding the page from bottom to top)



Scheme 3 (Switch between AR navigation and 2D map with a small radar map)

Scheme 4 (Merging 2d maps and 3d AR maps)

Figure 45: Navigation interfaces

7.2. Testing and iteration

In this chapter, through continuous user testing and product iteration, the final solution of this project will be determined. Here user testing is the process through which the interface and functions of the app are tested by users who perform specific demands and tasks in Schiphol conditions. During the testing process, users' insights and feedbacks, including responses and emotions of different kinds of users regarding the new app, would continuously optimize the final solution (app). The purpose of user testing is to evaluate user experience and the usability of the app, which would help to know where the new app has errors or missing users' demands. Finally, correct these errors by optimizing the information structure.

Method

The test is divided into two stages; the first stage is mainly focused on the information structure of the app. First three international travellers will be invited to partake in the test and use the two apps. In order to better simulate the realistic conditions, according to the previous personas, each of the participants was given different characters and tasks, which is similar to their real status. These three participants will be given different character backgrounds with different personal needs, and they need to complete the assigned tasks to meet the needs of the characters in persona. There are three rounds of this test. After each round, the tester will adjust the prototype based on users' feedback and insights from the analysis. During the trial, ease of use, efficiency and learnability of the app will become the focus of the evaluation. Moreover, during the process of testing, all the participants would not be guided and be allowed to interact with interactive prototypes naturally. To see if the information architecture of the new app is intuitive and efficient enough to use by users who aren't yet familiar with it. In the

first round of testing, users were asked to use and compare two app prototypes, and then the tester will combine the strengths of the two solutions based on users' feedback. Here, to make the testing results more accurate and credible, the test sequence of the two concepts will be changed for each test. In the second and third rounds of testing, participants only need to interact with one app prototype. Second, one interaction designer partook in the test. He will also participate in the three rounds of testing, and the procedure is consistent with the above. The only difference is that he will give more professional advice to optimize the app's information structure and even visual representations.

The second stage is mainly focused on navigation interfaces. All participants were asked to compare and evaluate the above four solutions of navigation interfaces. Based on users' feedbacks, the tester will adjust each scheme and combine their advantages to get the final solution of navigation interfaces.

First-round testing and interview result could be seen in appendix-4.

Insights and suggestions for improvement

1. In some interfaces, excessive contents and text make users feel confused, and they perceived these interfaces in this app to be visual overloading.

Suggestions for improvement: Simplify these pages by highlighting essential information(text links) and adding interactive visual elements(users' journey map). Here the new app could "use some visual features and different font styles and colours to simplify these pages and help users to understand what they have covered, what they are interacting with, and what is next" (Chawla, P. (2020, June 29)).

Furthermore, break a big task into several subtasks. During the testing, it is found that when the user faces a complicated task that contains lots of steps, he would feel confused and anxious. So, it's better to divide a big job into small chunks (Nick Babich (2018, February 12)).

2. Many users think that the interactive buttons in the app are not evident and apparent. The user does not know the function of these buttons, like what they have covered and what is next.

Suggestions for improvement: Adding some descriptions and notes under these app icons or using icons to give a hint of the functionality of each button. Visually make them look more like an interactive button(adding shadow under the figure).

3. Comparing the two prototypes, participants prefer the traditional main menu at the bottom of the page. They are familiar with this model, which could offer an overview of the structure of the app.

Suggestions for improvement: Add the main menu at the bottom of the interface of the final solution to help users effectively understand the functions of the app and switch between the different modules in the app. Following the users' familiar interface arrangement also allows them to use prior experience to interact with the new app, without a learning curve.

4. Many participants complained about the lack of specific information in the app. For example, smoking is prohibited in Schiphol.

Suggestions for improvement: Add missing information to the app.

5. Typing on a small mobile screen is annoying for most users, so user input needs to be minimized and simplified.

Suggestions for improvement: Passengers can scan the QR code of the ticket to obtain flight information instead of entering the flight number.

6. Repeated operations significantly affect user experience and the

fluency of the operation process.

Suggestions for improvement: If the users want to enter the next interface after completing tasks, they always need to return to the home page. To simplify this process, adding a button(like "Next") to guide the user to the next functional interface directly.

7. For the navigation interfaces, most participants prefer Option 3 because the small radar chart in the left corner of the page can make them see the 2D map and AR navigation images at the same time. This form is also convenient for users to switch between 2D maps and AR navigation.

Suggestions for improvement: Using scheme three as the navigation interface and adding the navigation interface to the prototype.

Conclusion

Comparing the information structure of the two prototypes, all participants prefer prototype 2, and there are three reasons for that. First, interaction architecture with too many linear structures makes users feel to be controlled and guided all the time and less autonomous. Second, users prefer the interface mode they are familiar with, which could minimize cognitive load and learning costs for users. Compared with the information structure in prototype 1, prototype 2 applied the Hub and spoke information structure in the main interface, which is the default for the ios-Apple operating system. Third, the main interface of prototype two clearly shows users all the functions of the app. It gives users better operating efficiency and fluency. Moreover, the index page of prototype 2 provides a general overview of the app contents and functions. Here, first, for prototype3 (iteration-1), it will use the information architecture of prototype 2. On this basis, combined with the advantages of prototype 1, the overall structure is optimized. Second, simplify the information structure and interfaces by keeping content and visual elements to a minimum (present the user with the most relevant information). Third, keep the materials and interactive

buttons in the app predictable and familiar to users. Fourth, highlight the essential information by using visual elements to convey importance. For example, in the main interface, highlighting flight tracking and Schiphol users' journey map.

Iteration-1

According to the above modification suggestions, a new prototype was created and be used in the second round of testing. See the appendix-5 for the wireframe and interfaces of prototype 3 (iteration-1).

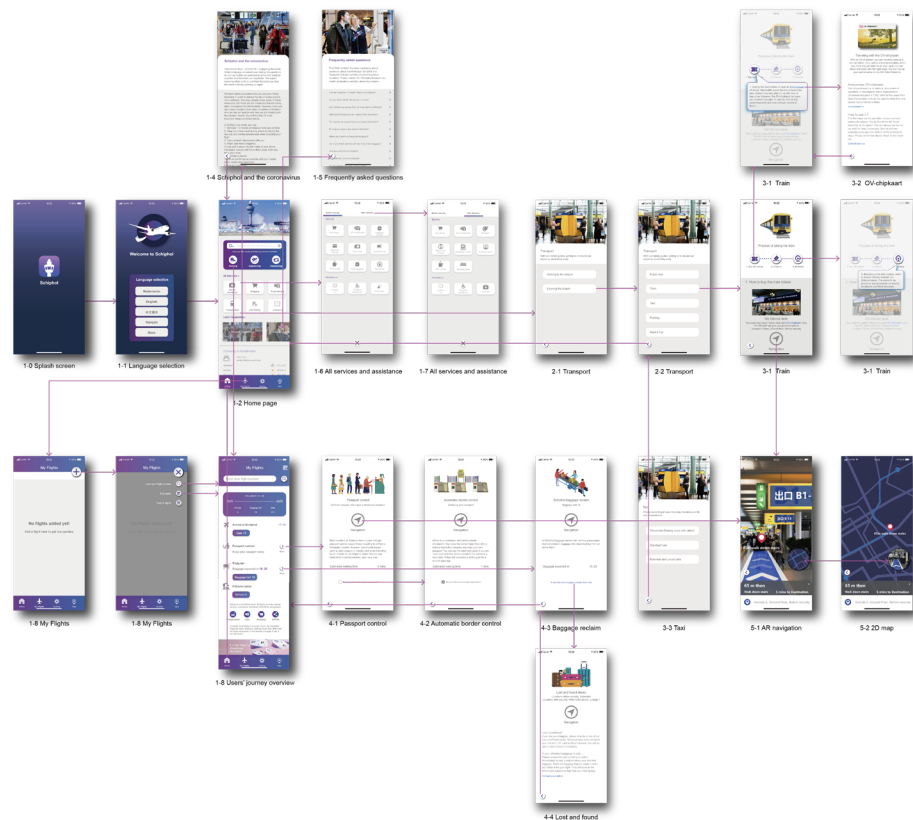


Figure 46: Interfaces of prototype 3(iteration 1)

Second round testing results and interview result could be seen in appendix-4.

Insights and suggestions for improvement

The overall visual style of the app is not uniform, which would exacerbate the user's cognitive impairment and increase learning cost.

Suggestions for improvement: Make the new Schiphol app consistent in visual. Icons, functional buttons and typefaces should be consistent across the new app.

Some details and layout in the prototype are not in line with users' habits and platform guidelines. Each mobile platform (IOS system and Android) has standard guidelines for interface design. Here most users have become familiar with the interaction patterns of the popular mobile system, like IOS or Android, and anything that contradicts the guidelines would cause the cognitive load to users (Nick Babich (2018, February 12)).

Suggestions for improvement: In order to minimize cognitive load, the new app should follow the familiar page layouts and interaction patterns that be used in regular apps.

During the testing, most participants believed that the priority of the information in this app is not clear. They recommended that the new app should highlight the most important information and function in the app.

Suggestions for improvement: Prioritize interactive function buttons and essential information based on users' demands and assign priority levels to all user tasks and services in Schiphol. Give prominence in the icons or typefaces to the functional buttons and critical information with frequent use and high priority levels.

Too much professional terms would increase learning cost for the users. Clear communication is important in mobile app design.

7.3. Final concept (Iteration 3)

According to the above modification suggestions from the third round testing, the final concept(iteration 3) was created. Compared with the previous two generations of prototypes, the most significant feature of the final solution is that it combines functionality and ease of use while simultaneously attracting users visually and enhancing the user experience of the application. The information structure of the final prototype still follows the structure of the previous two generations.

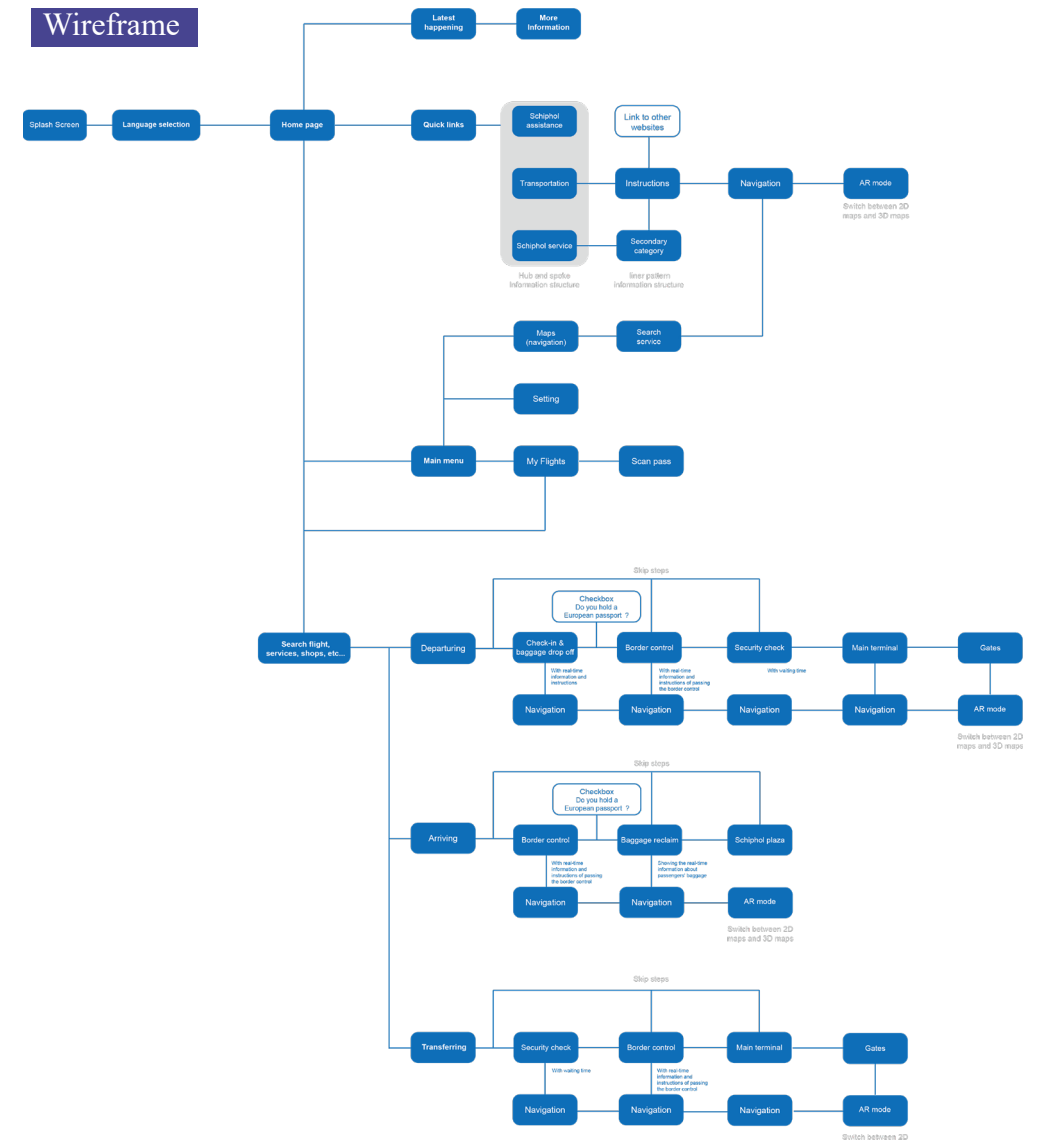


Figure 48: Wireframe of prototype 5 (iteration 3)

Final concept-App Interfaces

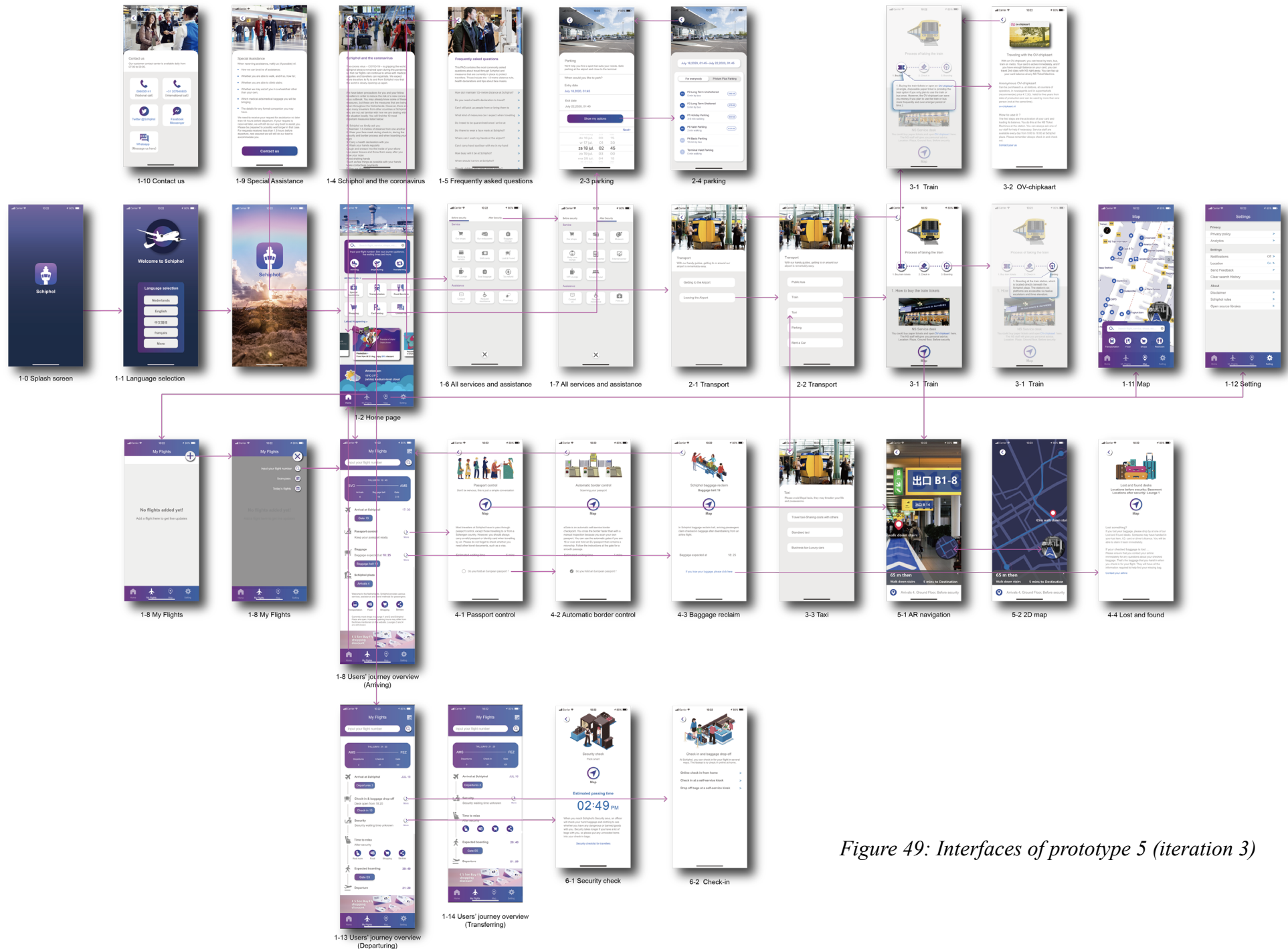
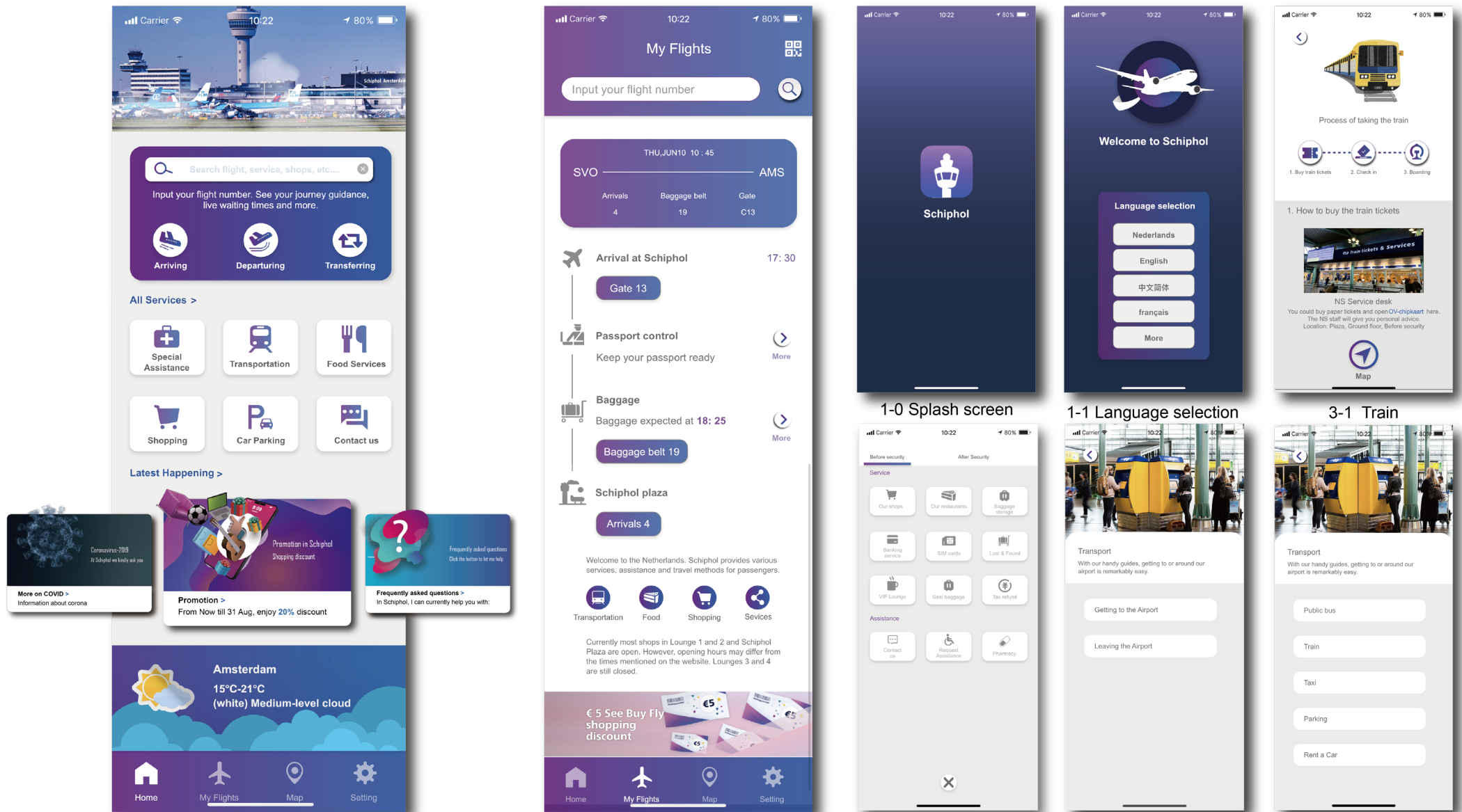


Figure 49: Interfaces of prototype 5 (iteration 3)

Final concept-App Interfaces



1-2 Home page

1-8 Users' journey overview

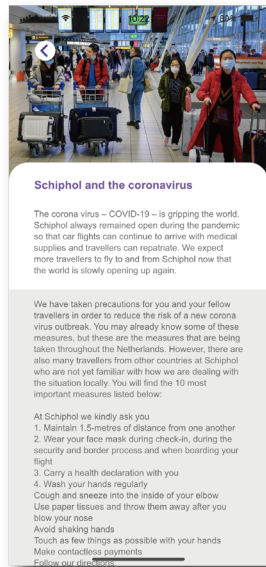
1-6 All services and assistance

2-1 Transport

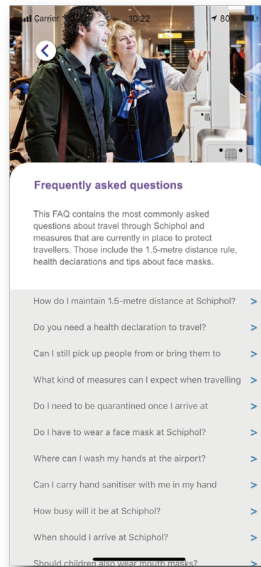
2-2 Transport

Figure 50: Interfaces of prototype 5 (iteration 3)

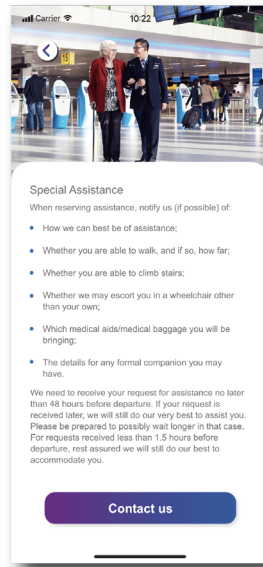
Final concept-App Interfaces



1-4 Schiphol coronavirus



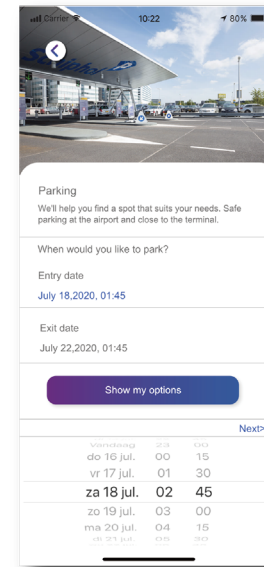
1-5 Frequently asked questions



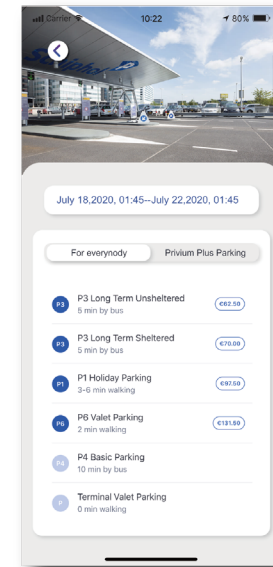
1-9 Special Assistance



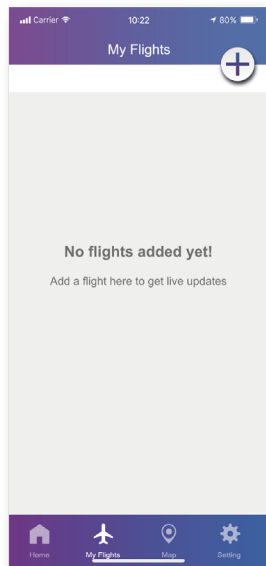
1-11 Map



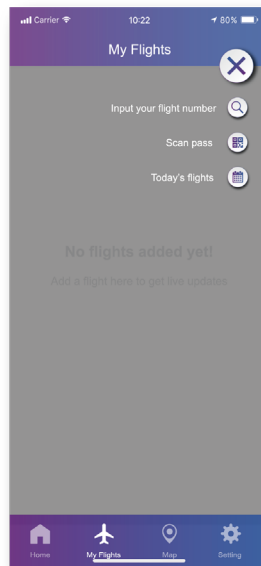
2-3 parking



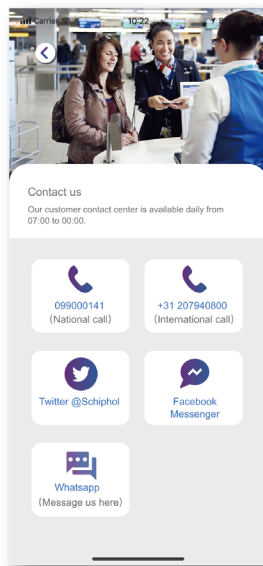
2-4 parking



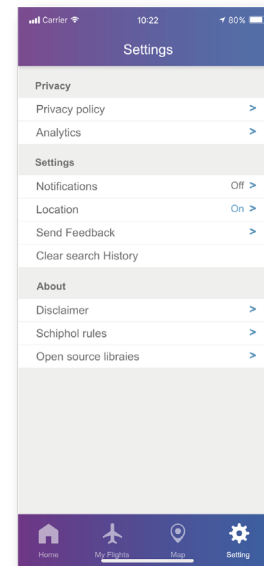
1-8 My Flights



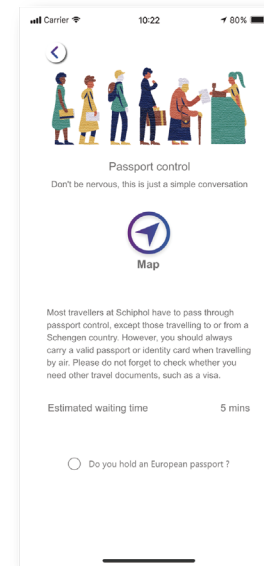
1-8 My Flights



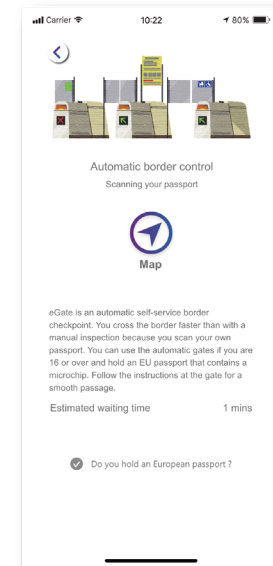
1-10 Contact us



1-12 Setting



4-1 Passport control



4-2 Automatic border control

Figure 50: Interfaces of prototype 5 (iteration 3)

Final concept-App Interfaces

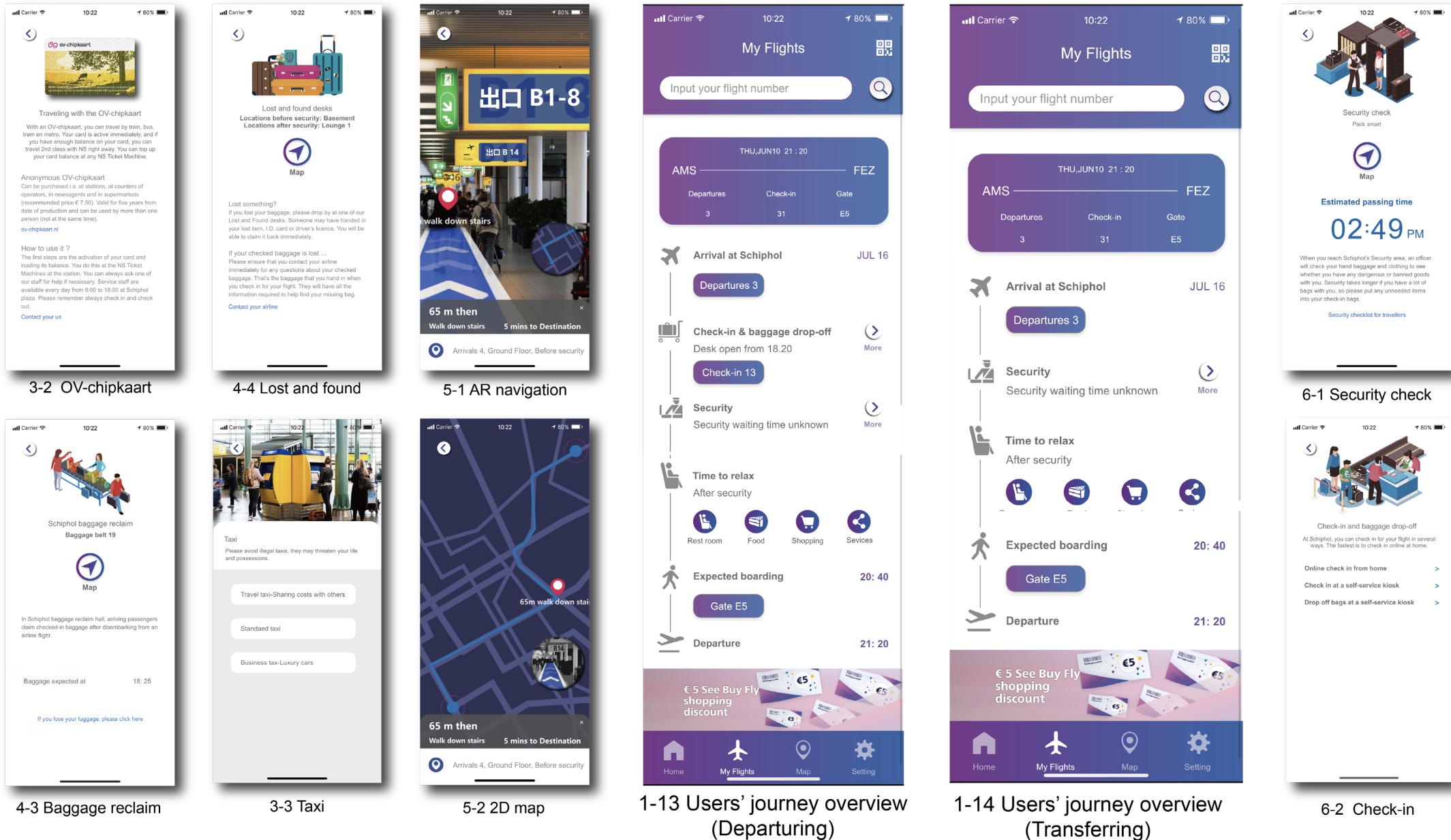


Figure 50: Interfaces of prototype 5 (iteration 3)



Chapter 8 | Recommendation and Discussion

This chapter includes:

8.1. Recommendation for Schiphol

8.2. Reflection of the project & Personal evaluation

8.1. Recommendation for Schiphol

For this project, if Schiphol wants to develop and implement it in-depth, here are some suggestions about technology and information architecture.

First of all, there are two solutions for the realization of AR navigation in Schiphol. First, install trackers in Schiphol signs. When the distance sensor of the tracker detects the user, it will send the relevant digital image to the user's mobile phone. The advantage of this method is high recognition accuracy and stable performance. However, it requires many trackers to be installed in Schiphol. The second way is to create a 3D model of Schiphol terminal and use unity to add AR practical and digital information in it. This method requires the modeller to build up Schiphol's vast and complex three-dimensional building structure. Unlike 2D maps, AR navigation requires modellers to construct Schiphol's internal spatial structure in detail. When the two parameters (distance between the user and the target and the camera angle) meet specific values, the designated digital image is displayed on the user's mobile phone. Both methods of appeal need to be assistant with Schiphol's internal beacon-based positioning system. Here, Schiphol programmers can refer to the above suggestions to build an AR navigation system. Each method requires a lot of time and workforce. For large public spaces, the realization of AR navigation is still challenging at present.

Second, the final concept of this project has built up the information structure of the new Schiphol app. If Schiphol wants to continue this project, additional information interfaces need to be added, like relevant regulations, other website links, and service information such as catering or shopping, that makes the app complete.

Third, for this project, how to promote the new app is still a problem. At present, only a small number of passengers will download and use Schiphol's app. How to help travellers realize that this app is still a problem for Schiphol operation department. Here, considering that international travellers have to connect to wifi when arriving at Schiphol, adding the quick link of downloading the new Schiphol app in the connection page would be effective for users to know that. This question can also become a research topic.

8.2. Reflection of the project

As an industrial designer, this project is the first interactive design project for me. However, the design process and user-centric research methods are not fundamentally different from product design. Nevertheless, in the process of prototype testing and iteration, I learned much professional knowledge of interaction design. On the other hand, this is also the first time that I work with a client alone instead of being responsible for a separate project as a team. In this process, I also learned how to use company resources and how to communicate and negotiate with clients. Designers must learn how to explore and utilize customer suggestions because their suggestions and insights are often very professional and enlightening.

Finally, it is found that design is not only about exploring how advanced technology can help people improve their lives, but also using all feasible means to solve users' problems. Although it is the nature of designers to look to the future, it is also the responsibility of designers to solve existing problems. For this project, I wanted to explore how AR technology can be applied to indoor navigation at the beginning and help Schiphol improve the user experience. But through the research phase, it is found that what users need is not an AR indoor navigation software to help them find their way but to optimize the information structure of the current app to help users understand Schiphol and know what to do next. Here it is also found that product designers can also complete the work of interaction design very well. The two design methods and research process are mostly the same. Related software and prototyping tools about interaction design are not difficult to learn.



Reference and Appendix

Reference

Appendix 1-9

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Appendix | 1-9

Appendix-1 Description of users' journey maps

Steps of the arrival journey

1. Prepared in advance: Many travellers will plan their trips and book hotels in advance.
2. Border control: Passengers need to pass the custom after getting off the plane. For passengers holding European passports, they can choose automated border control. Here they only need to scan their passports and pass. For passengers with non-European passports, they usually have to queue for a long time to reach the border control desk and then they will be asked some questions by a border control officer.
3. Baggage reclaim: In the luggage reclaim hall, passengers find their luggage information through the electronic screen. Then they need to wait for their luggage in front of the baggage belt. While waiting, they can also buy train tickets in the luggage reclaim hall.
4. Wayfinding: Passengers rely on Schiphol sign system, human service and digital maps to find services in Schiphol and ways to leave Schiphol and arrive their destination.
5. Schiphol Plaza: Schiphol plaza is a public areas insight the terminal with retail and hospitality facilities for passengers before leaving Schiphol. Passengers can enjoy all Schiphol services here such as buying train tickets, currency exchange, shopping and eating.

Steps of the departure journey

1. Prepared in advance: The stage that passengers prepare their journey, check-in online and pack bags.

2. Schiphol Plaza: The first public insight the terminal of Schiphol. Passengers can enjoy all Schiphol services here.

3. Departure hall: Passengers could refund tax and check in here. Checking-in is provided in different ways to the passengers and required to do at the airport or at home.

4. Border control and security check: First the identity of passengers is checked automatically or by a marshall. Secondly, all passengers and their carry-on luggage need to be checked, then they can pass the security check.

5. Gate: The gate consists of furniture that allows passengers to sit and wait for their flight. Passengers could go shopping here or could play with their mobile devices.

Steps of the transfer journey

1. Border control and security check: Passenger need to pass the border control and security check again. Then they are allowed to get in the Schiphol terminal.

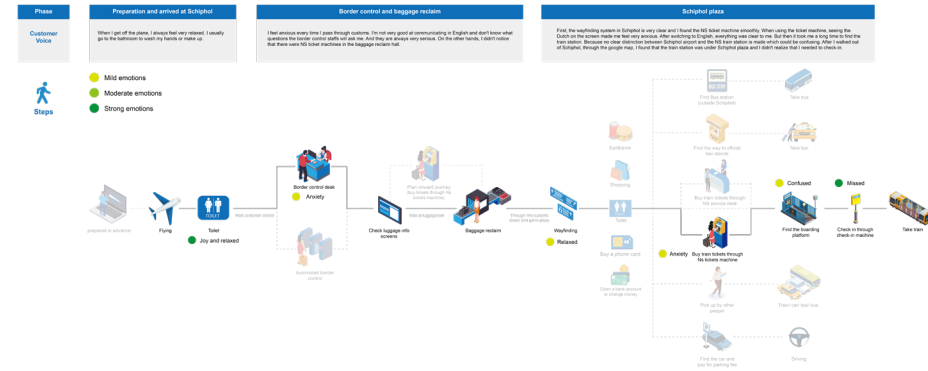
2. Gate: Passengers would sit and wait for their flight. Schiphol also provides them with food and shopping services.

Appendix-2 Results of interviews.

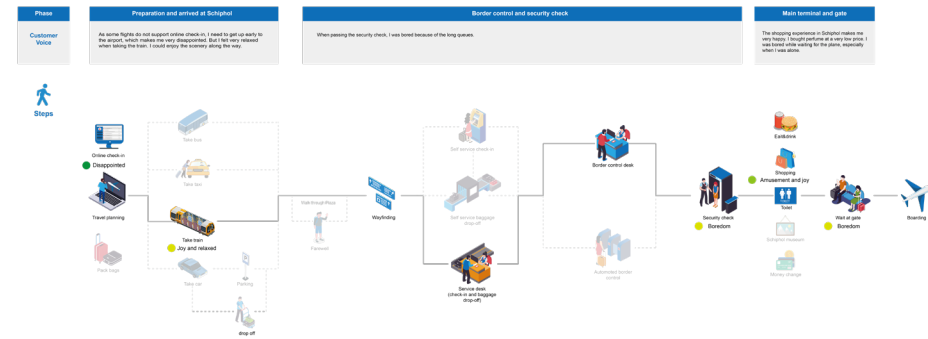
Interview 1-A Chinese girl who live in London

age: 23
Occupation: International student
Purpose of coming to the Netherlands: Traveling
Personal needs in Schiphol: Shopping in tax-free shops

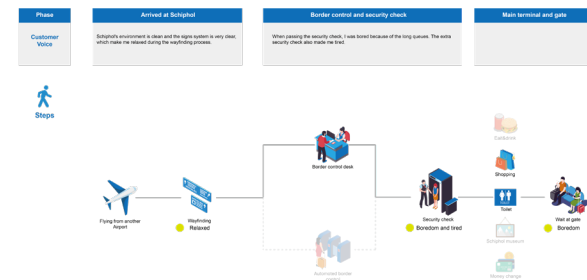
Arrival journey map



Departure journey map



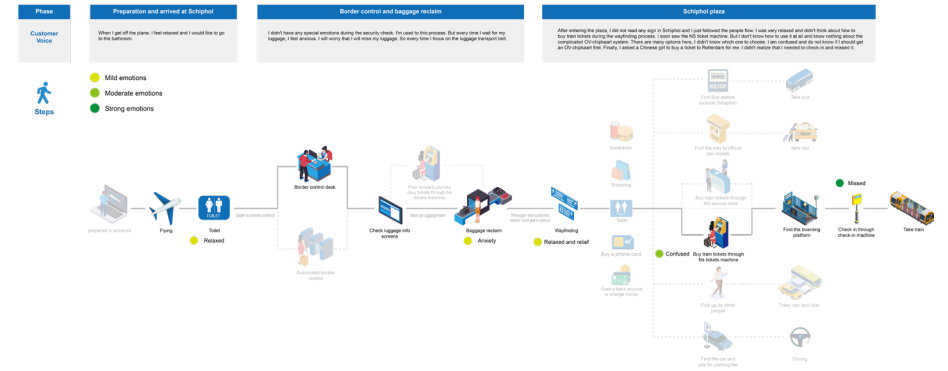
Transfer journey map



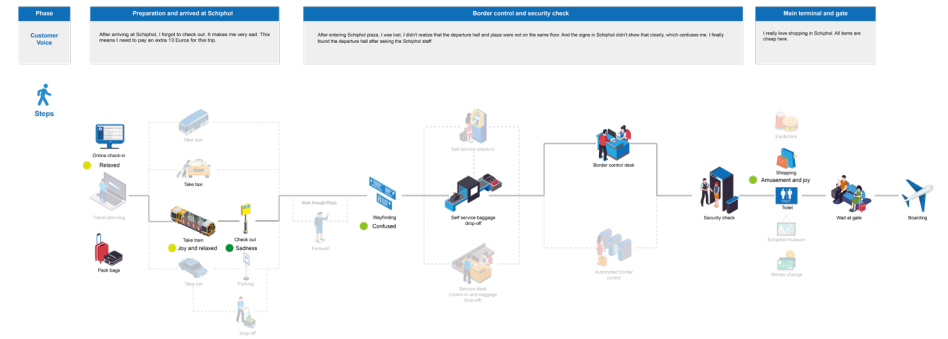
Interview 2-A Chinese girl who study in Rotterdam

age: 25
Occupation: International student
Purpose of coming to the Netherlands: Long-term residence and studying
Personal needs in Schiphol: None

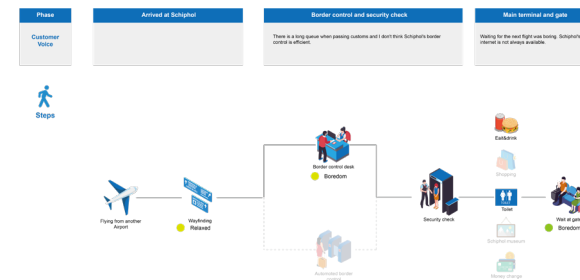
Arrival journey map



Current passenger departure journey map



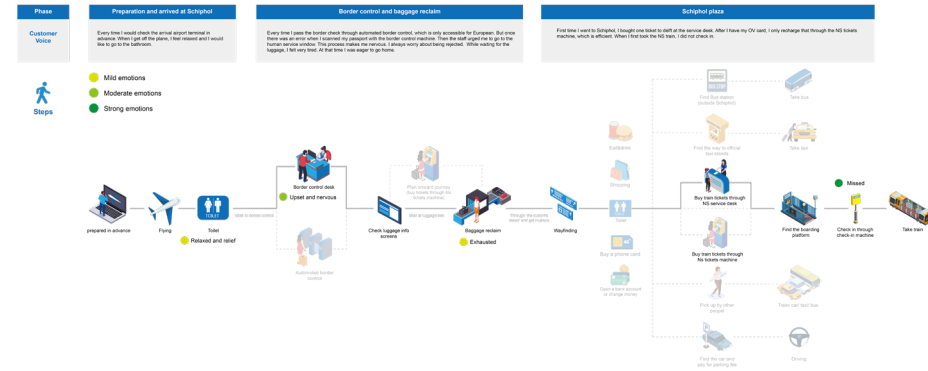
Current passenger transfer journey map



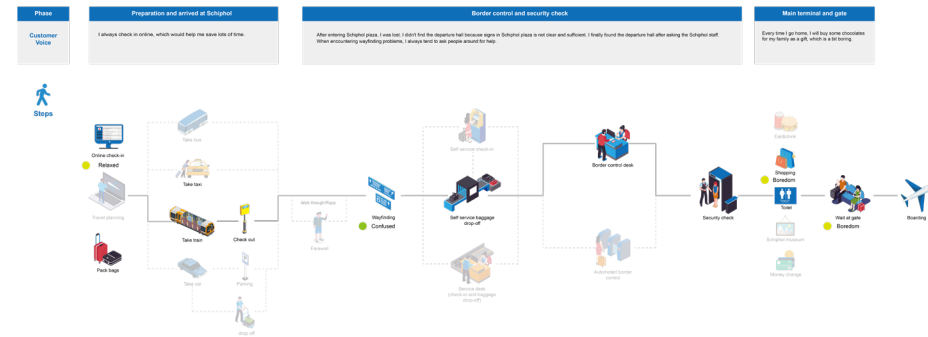
Appendix-2 Results of interviews.

Interview 3-A Spanish girl who study in Netherlands
age: 21
Occupation: International student
Purpose of coming to the Netherlands: Long-term residence and studying
Personal needs in Schiphol: Buy gifts for family

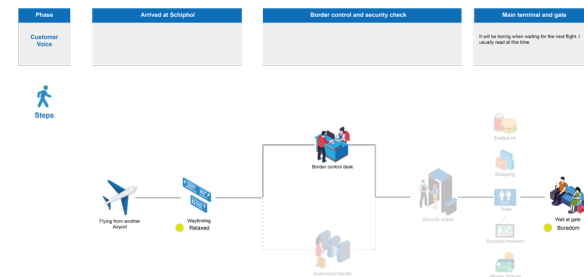
Arrival journey map



Current passenger departure journey map

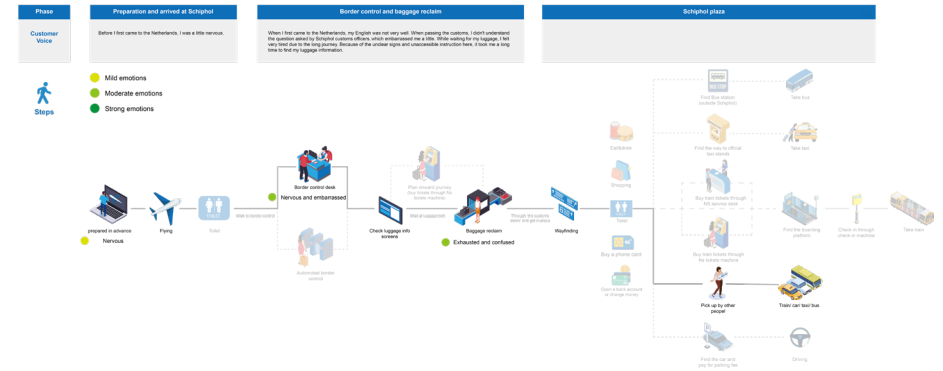


Current passenger transfer journey map

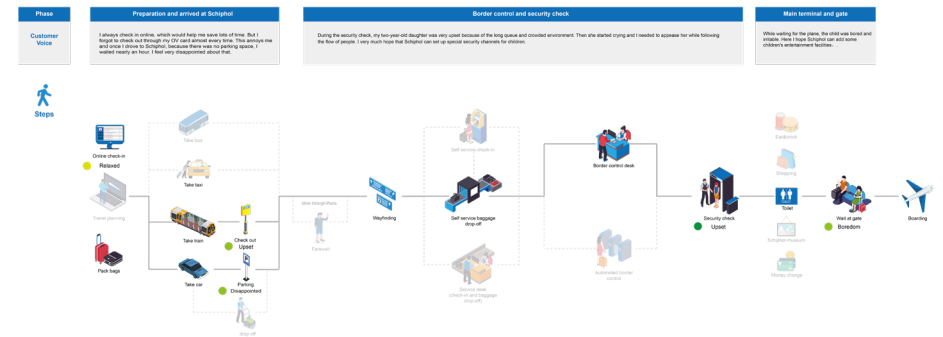


Interview 4-A Chinese mother
age: 32
Occupation: Housewife
Purpose of coming to the Netherlands: Long-term residence
Personal needs in Schiphol: Take care of her two-year-old daughter

Arrival journey map



Current passenger departure journey map



Appendix-2 Results of interviews.

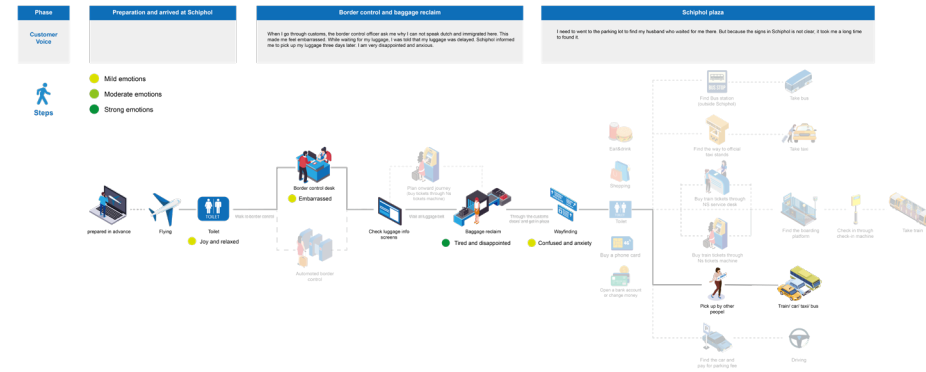
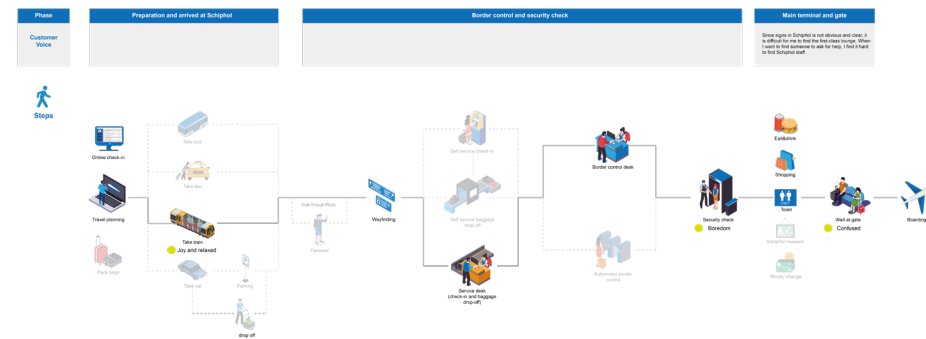
Interview 5-A Chinese woman

age: 52

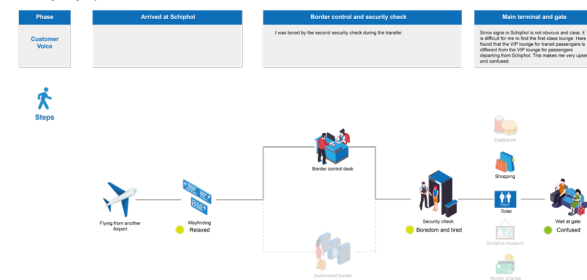
Occupation: Retiree

Purpose of coming to the Netherlands: Family reunion and immigration
Personal needs in Schiphol: None

Arrival journey map

[Departure journey map](#)

Transfer journey map



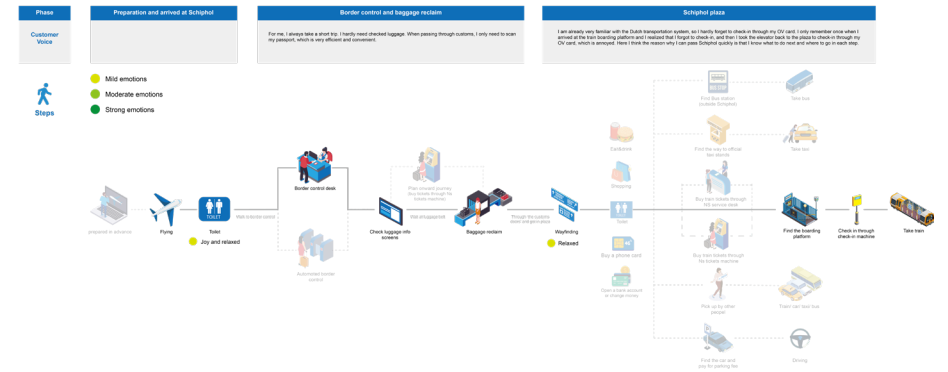
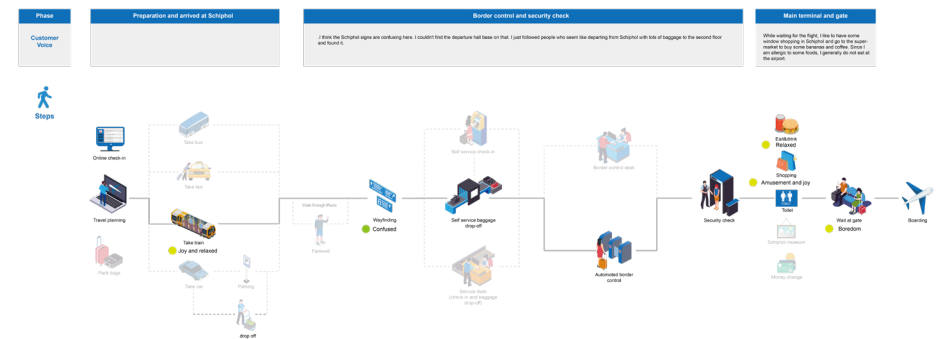
Interview 6-A Dutch girl

age: 23

Occupation: Student

Purpose of coming to the Netherlands: Native
Personal needs in Schiphol: Special demands for food, due to allergies

Arrival journey map

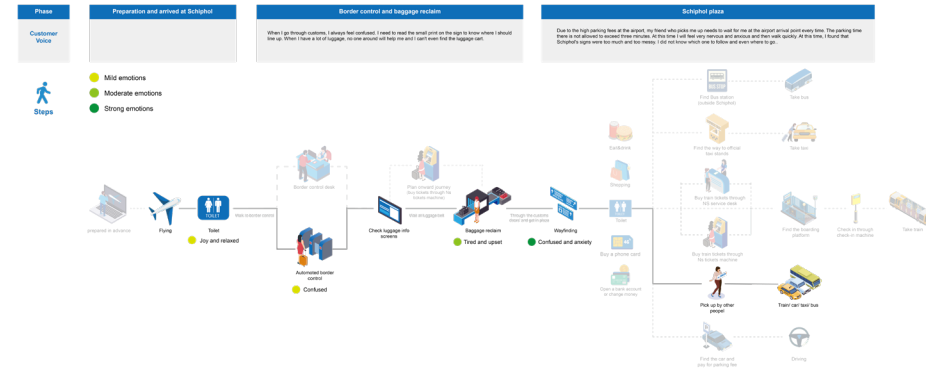
[Departure journey map](#)

Appendix-2 Results of interviews.

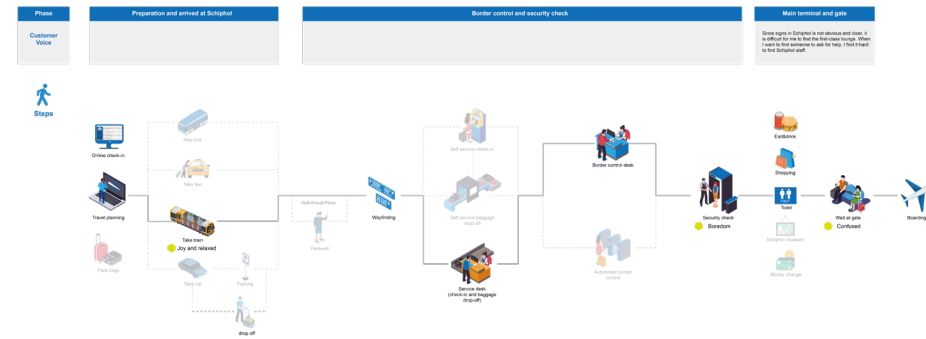
Interview 7-A Dutch man

age: 55
Occupation: Engineer
Purpose of coming to the Netherlands: Native
Personal needs in Schiphol: None

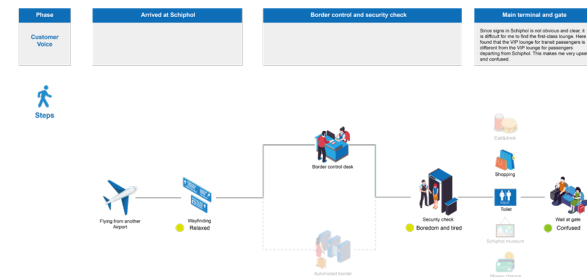
Arrival journey map



Departure journey map



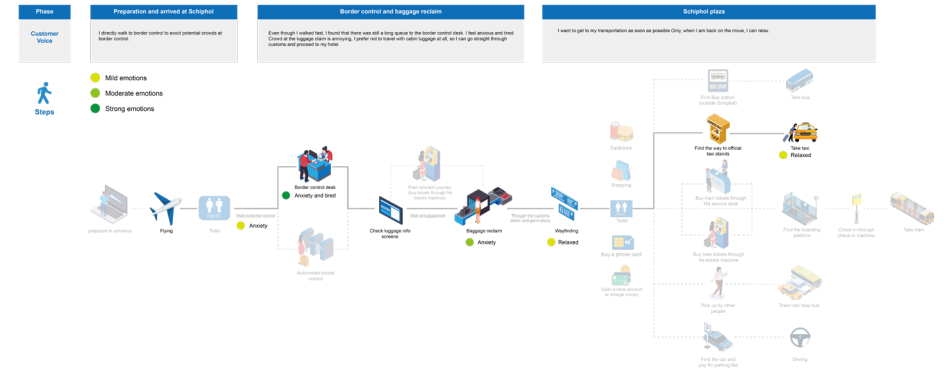
Transfer journey map



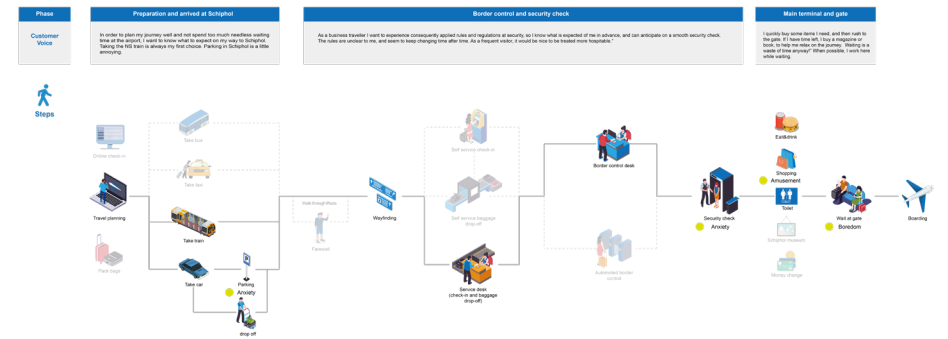
Interview 8-A French Business man

age: 40
Occupation: Business man
Purpose of coming to the Netherlands: Business
Personal needs in Schiphol: Working while waiting

Arrival journey map



Departure journey map



Appendix-2 Results of interviews.

Interview 9-A pair of Chinese parents

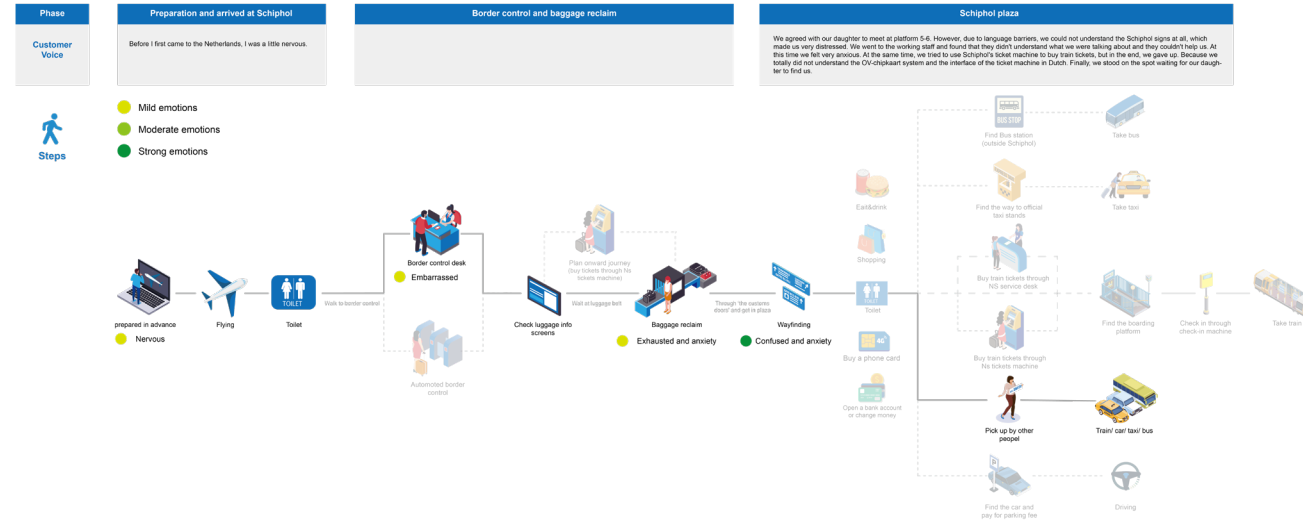
age: 53&50

Occupation: Doctors

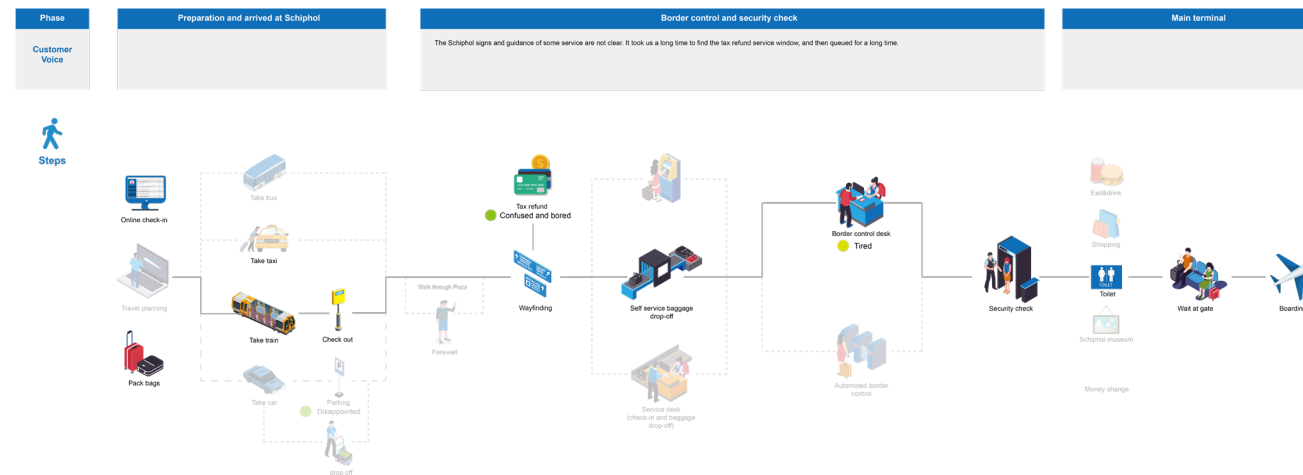
Purpose of coming to the Netherlands: Visiting their doctor

Personal needs in Schiphol: Tax refund

Arrival journey map



Current passenger departure journey map



Appendix-3 Persona.



Aarav

About

age: 29
occupation: Software engineer
status: single
nationality: Indian
language: English and Hindi

Bio

Aarav is a software engineer from India. He was invited by a local computer company to be a technical consultant and will stay here for one year. This is his first time here. Because he is not familiar with the local transportation system, he has seen the introduction video of the train system and installed the schiphol app in advance.

Like

Photography
Open source software
Watching movie

Dislike

Poor communication
Slow internet connection
Unclear signs

Personal needs

Find out where to buy an anonymous ov chipkaart

Find information about the train in an efficient way, the train timetable, boarding location, departure time.

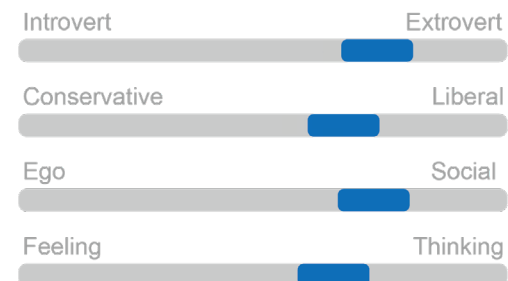
Buy a local SIM card and charge it to connect with the Internet.

Frustration

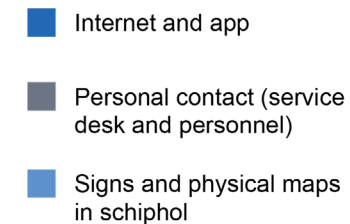
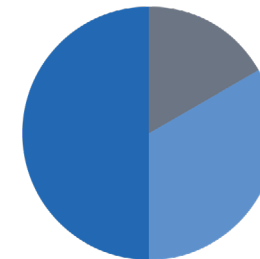
Lack of knowledge about how and where to buy a OV-chipcard and a SIM card.

It is hard to find the right staff to ask for help.

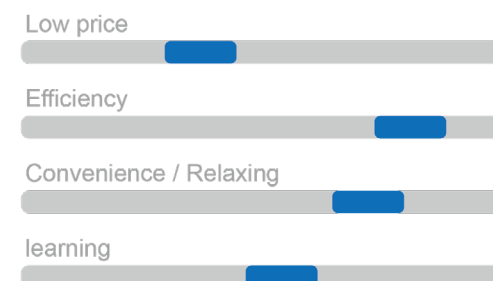
Personality



Preferred wayfinding solution



Motivation



Appendix-3 Persona.



Theresa

About

age: 33
 occupation: Housewife
 status: Married
 nationality: German
 language: English and German

Bio

Theresa is a housewife. She moved to the Netherlands with her two-year-old daughter due to her husband's job change. After she came to Schiphol, her husband drove to pick her up. This was the first time she came to Schiphol with her little daughter.

Like	Dislike
Soap opera	Poor communication
Reading	unfamiliar environment
Online shopping	Awkward situation

Personal needs

When she arrived at Schiphol, she had to find the parking lot. Her husband is waiting for her there.

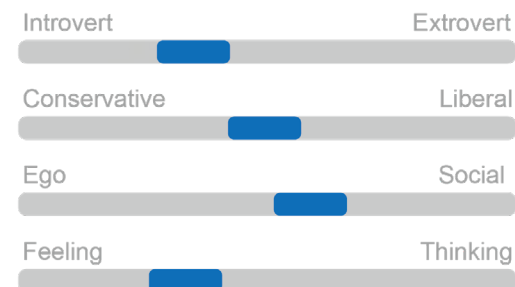
When she departure from Schiphol, she wanted to find a quiet place to rest. The noisy and crowded environment of the Schiphol main terminal made her daughter irritated and burst into tears.

Frustration

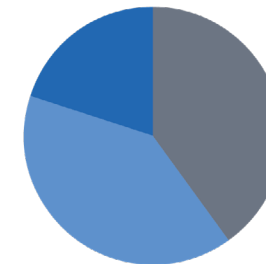
Due to the signs for the parking lot are insufficient and unclear, she feel confused and stressed during the wayfinding process.

Her daughter's crying and yelling in the public area make her feel embarrassed and stressed.

Personality

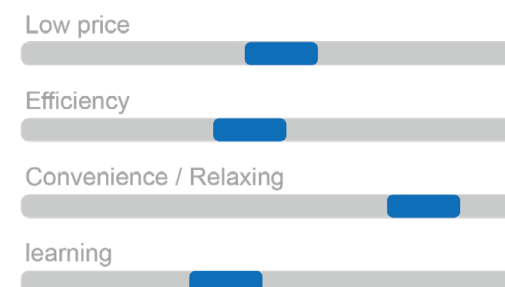


Preferred wayfinding solution



- Internet and app
- Personal contact (service desk and personnel)
- Signs and physical maps in schiphol

Motivation



Appendix-3 Persona.



Dennis

About

age: 70
 occupation: Retiree-history teacher
 status: Married
 nationality: French
 language: French and a little English

Bio

Dennis used to be a junior high school history teacher. Now he is retired. He and his wife traveled to the Netherlands for the first time. Because of the language barriers, he can only rely on icons on the signs to find his way. He has booked a hotel in Amsterdam in advance, but he has no idea about dutch public transportation system.

Like

Reading
 World history
 Museum

Dislike

Noisy environment
 Overcrowdedness
 Impatient service

Personal needs

Find a place to sit and rest

Find someone who know French to help him and find out the way to get to the hotel.

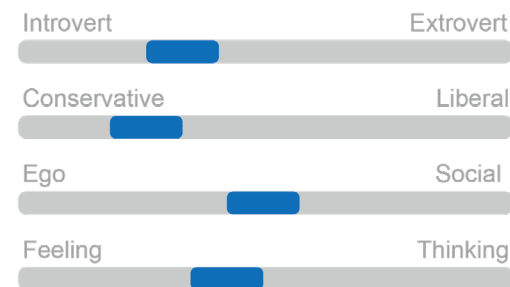
Learn how to use the Netherlands public transport system.

Frustration

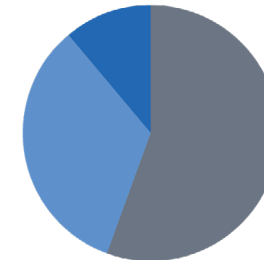
Due to language barriers, he could not understand most of the signs and don't know how to communicate with the others.

The crowded and noisy environment makes him feel tired. He even couldn't find any place to sit.

Personality



Preferred wayfinding solution

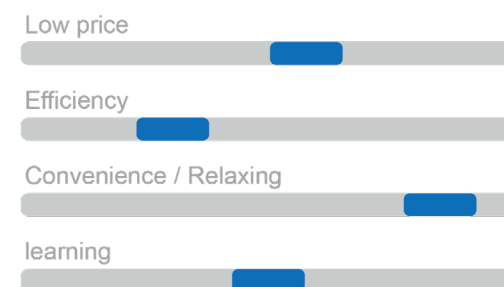


Internet and app

Personal contact (service desk and personnel)

Signs and physical maps in schiphol

Motivation



Appendix-3 Persona.



Liang

About

age: 22
 occupation: International students
 status: single
 nationality: Chinese
 language: English and Chinese

Bio

Liang is a graduate freshman of TUD. She came to the Netherlands for the first time. The strange environment and language barriers made her feel anxious. She prepared in advance by asking other TUD students for information about Dutch public transportation and travel suggestions. After arriving at Schiphol, she knew what she was going to do next.

Like	Dislike
Design	Poor communication
Shopping	Unplanned journey
Fashion	Complex system

Personal needs

Find out where to buy an anonymous OV chipcard.

Buy a local SIM card and charge it to connect with the Internet.

Shop at the airport duty-free shops, when departure from Schiphol. Buy some perfumes and cosmetics.

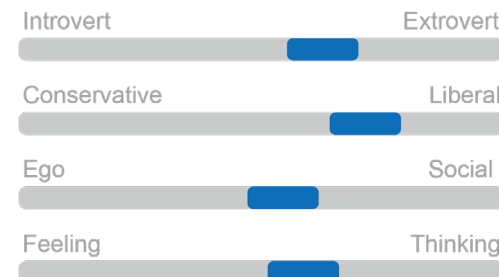
Frustration

Lack of knowledge about how and where to buy an OV-chipcard and a SIM card.

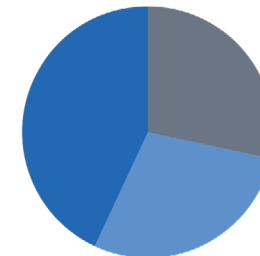
Non-user-friendly Dutch public transportation

The complex and confusing user interface for NS ticket machine

Personality

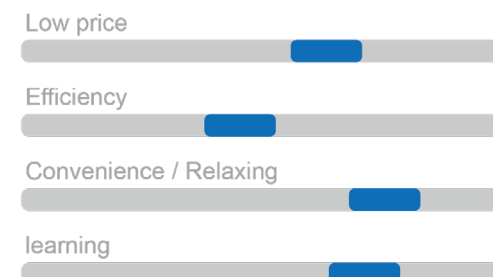


Preferred wayfinding solution



- Internet and app
- Personal contact (service desk and personnel)
- Signs and physical maps in schiphol

Motivation



Appendix-3 Persona.



Zhang&Wang

About

age: 55&53
 occupation: Doctors
 status: Married
 nationality: Chinese
 language: Chinese

Bio

Zhang and Wang are a middle-aged couple. They came to the Netherlands to visit their daughter, who studies in TUD. They don't speak English. When they came to Schiphol, their daughter was waiting for them at the train station platform below Schiphol plaza.

Like	Dislike
Cooking	Unplanned trip
Reading	Rude and impatient service
Watching movie	Noisy environment

Personal needs

Find out where is the train station platform.
 Tax refund when departing from Schiphol.

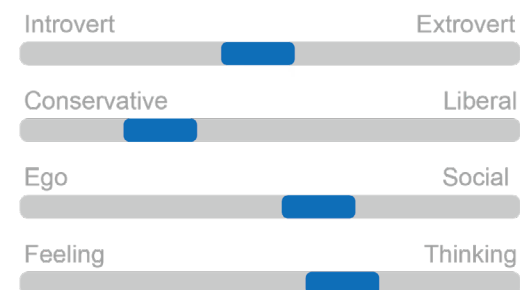
Frustration

When passing through customs, due to language barriers, they did not understand the question asked by the custom controller.

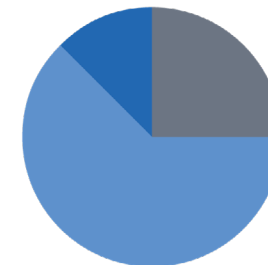
Due to language barriers and insufficient signs at Schiphol, they did not find the train station below Schiphol plaza.

Tax refund service is difficult to find due to unclear and insufficient signs.

Personality

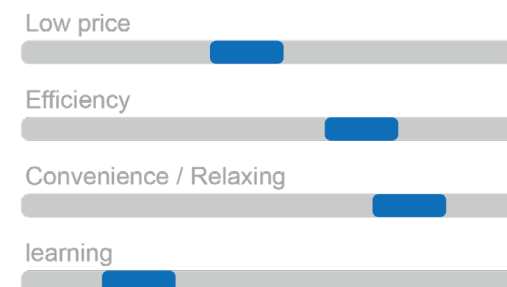


Preferred wayfinding solution



- Internet and app
- Personal contact (service desk and personnel)
- Signs and physical maps in schiphol

Motivation



Appendix-3 Persona.



Albert

About

age: 30
occupation: Designer
status: single
nationality: Spanish
language: English and Spanish

Bio

Albert is a designer and has a long history of smoking. This is his second visit to the Netherlands. He came here to reunite with his family. He would like to immigrate to the Netherlands because his wife is Dutch.

Like	Dislike
Photography	Poor communication
Smoking	Overcrowdedness
Design	Unclear signs

Personal needs

Find out where to buy a train ticket.

Find information about the train in an efficient way, the train timetable, boarding location, departure time.

Find Smoking area.

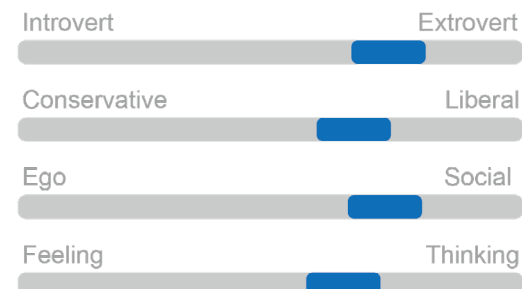
Frustration

The complex and confusing user interface for NS ticket machine and it is hard to find the right staff to ask for help.

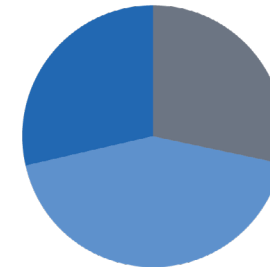
Long queue for the NS service desk.

He spent a long time to find the smoking area and finally was informed that smoking is forbidden in Schiphol.

Personality

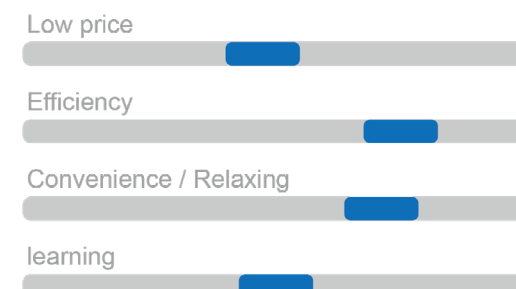


Preferred wayfinding solution



- Internet and app
- Personal contact (service desk and personnel)
- Signs and physical maps in schiphol

Motivation



Appendix-3 Persona.



Simon

About

age: 44
 occupation: Businessman
 status: Married
 nationality: French
 language: French and English

Bio

Simon came to the Netherlands on a business trip. The local company sent a driver to pick him up. He is busy with work every day and when he was at the airport, he always wanted to find a quiet place to work. Every time he travels, he would buy some souvenirs for his family. This is his sixth time in the Netherlands, and Schiphol is no stranger to him.

Like	Dislike
Real-time information	Poor communication
Mountain climbing	Long waiting time
Museum	

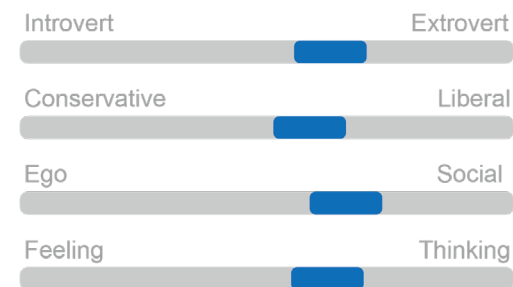
Personal needs

While waiting for check-in, find a quiet place to work.
 When leaving Schiphol, buy souvenirs for his family.
 Leave Schiphol efficiently.

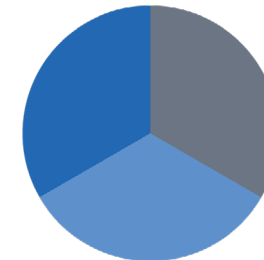
Frustration

Waiting for luggage can feel endless.
 It took too long to queue through customs and he did not realize that passengers with European passports can pass customs through automated border control without queuing.
 When he left Schiphol, it was difficult to find souvenirs in duty-free shops

Personality

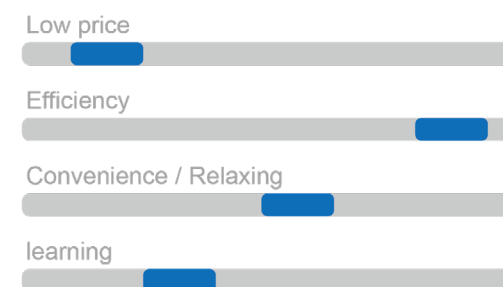


Preferred wayfinding solution



- Internet and app
- Personal contact (service desk and personnel)
- Signs and physical maps in schiphol

Motivation



Appendix-3 Persona.



Mathias

About

age: 60
 occupation: Engineer
 status: Married
 nationality: Dutch
 language: English and Dutch

Bio

Due to the need for work, Mathias often travels from Schiphol to other countries. He is already familiar with everything about Schiphol. Every time the company will arrange the first class for him. And his wife will drive him to Schiphol every time and pick up him when he arrived.

Like	Dislike
Reading	Noisy environment
Gardening	Unclear signs
Antique collection	Long waiting time

Personal needs

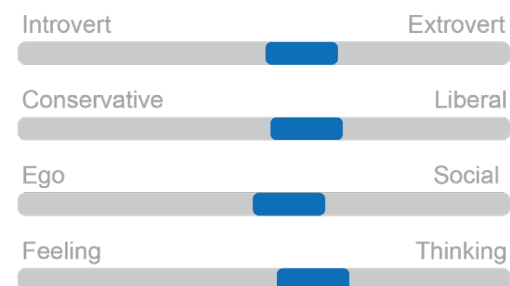
Find the first class lounge.
 Parking at Schiphol.
 Buy some snacks in Schiphol.

Frustration

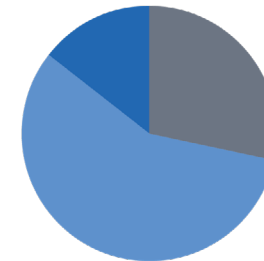
Parking in Schiphol is difficult due to limited parking spaces.

Since the unclear and insufficient signs, it is difficult to find the first-class lounge. When he transferred from Schiphol, he did not realize that the first-class lounge for transfer passengers was different from the first-class lounge for departure passengers.

Personality

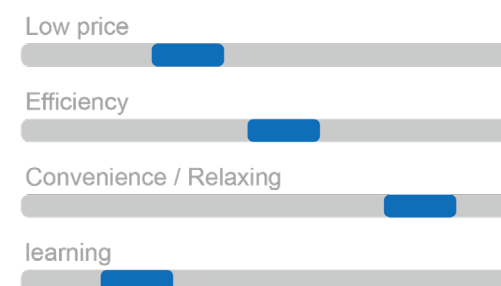


Preferred wayfinding solution



- Internet and app
- Personal contact (service desk and personnel)
- Signs and physical maps in schiphol

Motivation



Appendix-3 Persona.



Lisa

About

age: 21
occupation: International student
status: single
nationality: Korean
language: English and Korean

Bio

Lisa studied in the UK, this is the first time she came to the Netherlands. She came here to travel. She booked the hotel in Amsterdam in advance, but she hadn't thought about how to leave Schiphol. At Schiphol plaza, she knew through google maps navigation that she had to go there by train.

Like

Travelling
Shopping
Watching movie

Dislike

Overcrowdedness
Slow internet connection
Unclear signs

Personal needs

Find out where to buy a train ticket.

Find information about the train-the train timetable, boarding location, departure time.

Temporarily store your baggage at Baggage Storage or in a locker.

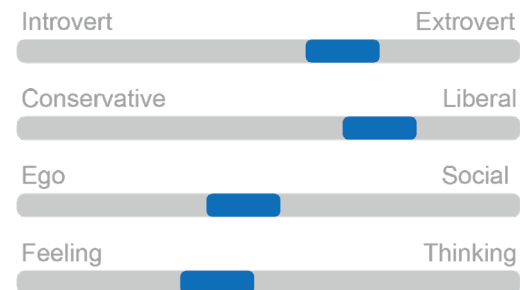
Frustration

Lack of knowledge about how and where to store her baggage.

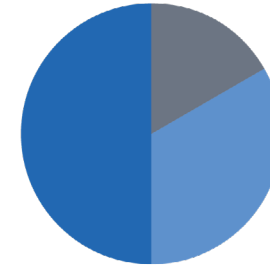
It is hard to find the NS train station and she did not realize that the NS train station was just below Schiphol plaza because of the unclear signs.

Missed check-in.

Personality

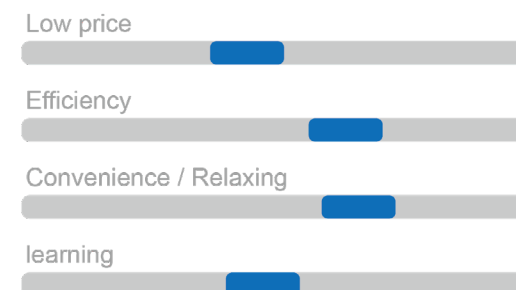


Preferred wayfinding solution



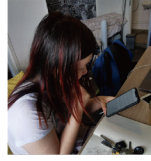
- Internet and app
- Personal contact (service desk and personnel)
- Signs and physical maps in schiphol

Motivation

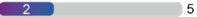


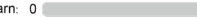
Appendix-4 First-round testing results.

 Participants: Fu zengyu Age: 23 Nationality: Chinese Occupation: International student She has never been to Schiphol	
Concept-1	Concept-2
Insight-1: The buttons on pages 1-3 are not obvious, and the user dose not know which buttons are interactive. Insight-2: In the 3-1 and 3-2 interfaces, users have cognitive barriers to "Do you have a European passport". The user expressed the desire to make it a button instead of a question. Insight-3: The user does not know what the arrow buttons on pages 1-3 represent. Insight-4: Too much content on some pages makes users unwilling to read. Insight-5: On page 1-2, "input your flight number" makes users feel confused. Users do not understand the difference between it and "input your flight" in the search bar.	Insight-1: The information structure is not intuitive enough for users. Users said that they could not quickly find the information they need.
Ease of use : 0 5 Efficiency : 0 5 Easy to learn: 0 5	Ease of use : 0 5 Efficiency : 0 5 Easy to learn: 0 5
Comparison of concept1 and concept2	
For this user, she said she prefers the second concept. Because compared to the first concept, the content in the second app is more vibrant and productive for her. The first app is more like an airport guidance tool, guiding passengers step by step out of the airport. The second app is more comfortable to use and will make her want to explore Schiphol instead of leaving Schiphol quickly. But for an international traveller who came to Schiphol for the first time, the first app displays the most critical information more intuitively. If she comes to Schiphol for the first time, she tended to look for information vital to her. The second concept here has no priority in the information display, which will make her somewhat confused.	
Comparison of the four navigation Schemes	
For the navigation interface, the participant prefers the first solution. Because the first one looks more concise. Too much information and visual elements make her feel confused.	

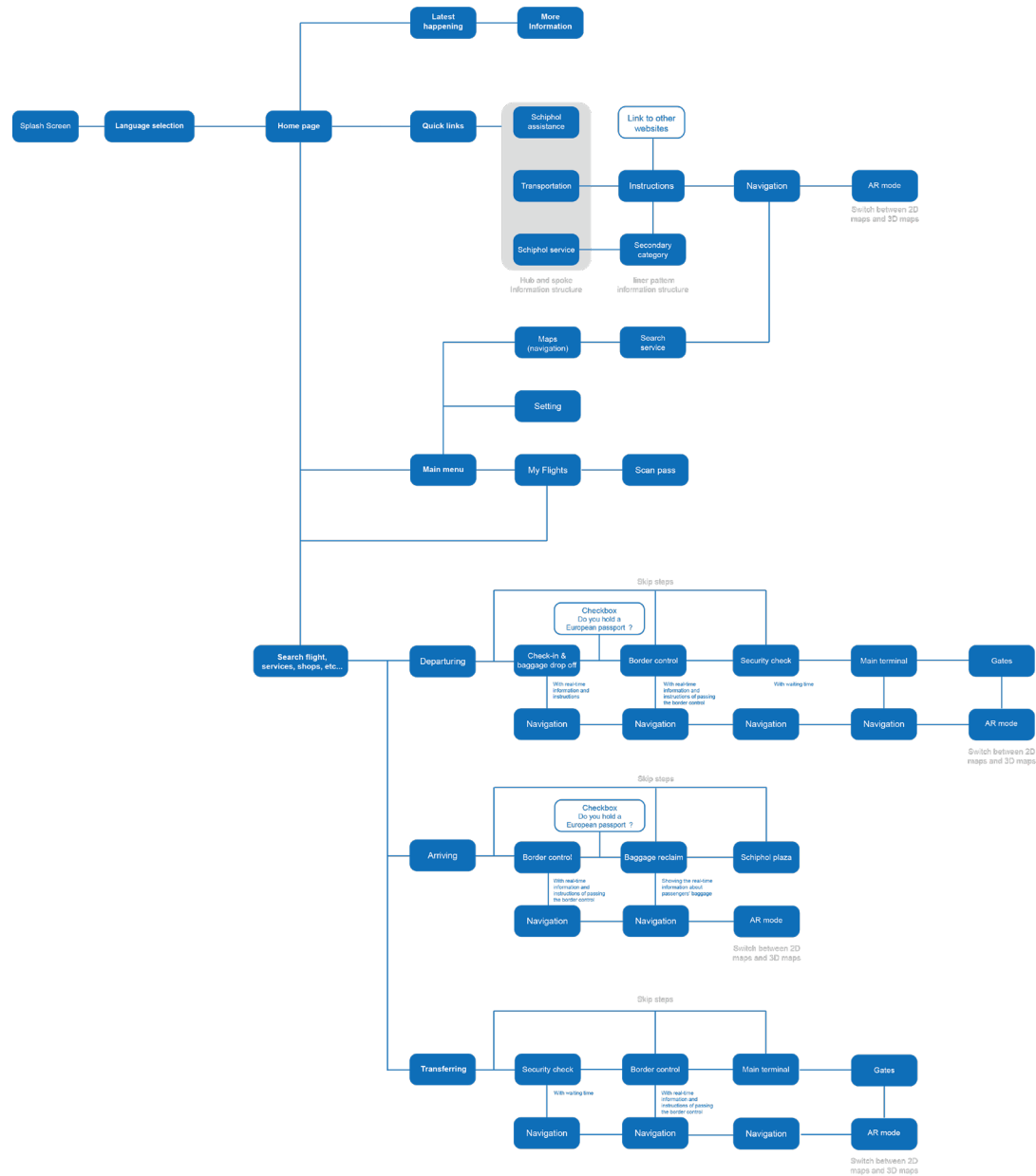
 Participants: Liu yiling Age: 22 Nationality: Dutch Occupation: Designer She immigrated to the Netherlands at the age of 15.	
Concept-1	Concept-2
Insight-1: On page 1-2, the user did not understand why she had to enter her flight number. For her, she would choose to ignore this option. Insight-2: The text on some pages is too small to read. Insight-3: The user does not know what the arrow buttons on pages 1-3 represent. Insight-4: The user believes that many interactive buttons are not visually noticeable.	Insight-1: In the interface 1-5, the problem list is too long, making it difficult for users to find useful information from that.
Ease of use : 0 5 Efficiency : 0 5 Easy to learn: 0 5	Ease of use : 0 5 Efficiency : 0 5 Easy to learn: 0 5
Comparison of concept1 and concept2	
For this user, she said she prefers the second concept. Because compared to the first concept, the second concept is more transparent and intuitive for the user and let her know the main structure and function of this app through the index page. Although there are many options in the index page of the second concept, the grouping and layout of these options are clear. For the prototype one, after entering the app, the user will be confused because she doesn't know its function, which caused her to lose interest in exploring this app. On the other hand, step by step guidance is a bit tedious for her, and the user does not like the feeling of being controlled.	
Comparison of the four navigation Schemes	
For the navigation interface, the participant prefers the third solution. Because in the third navigation interface, the user can see the 2D map and the real environment with digital information at the same time. Compared with other solutions, the 2D radar chart does not obscure too much of the AR navigation interface.	

Appendix-4 First-round testing results.

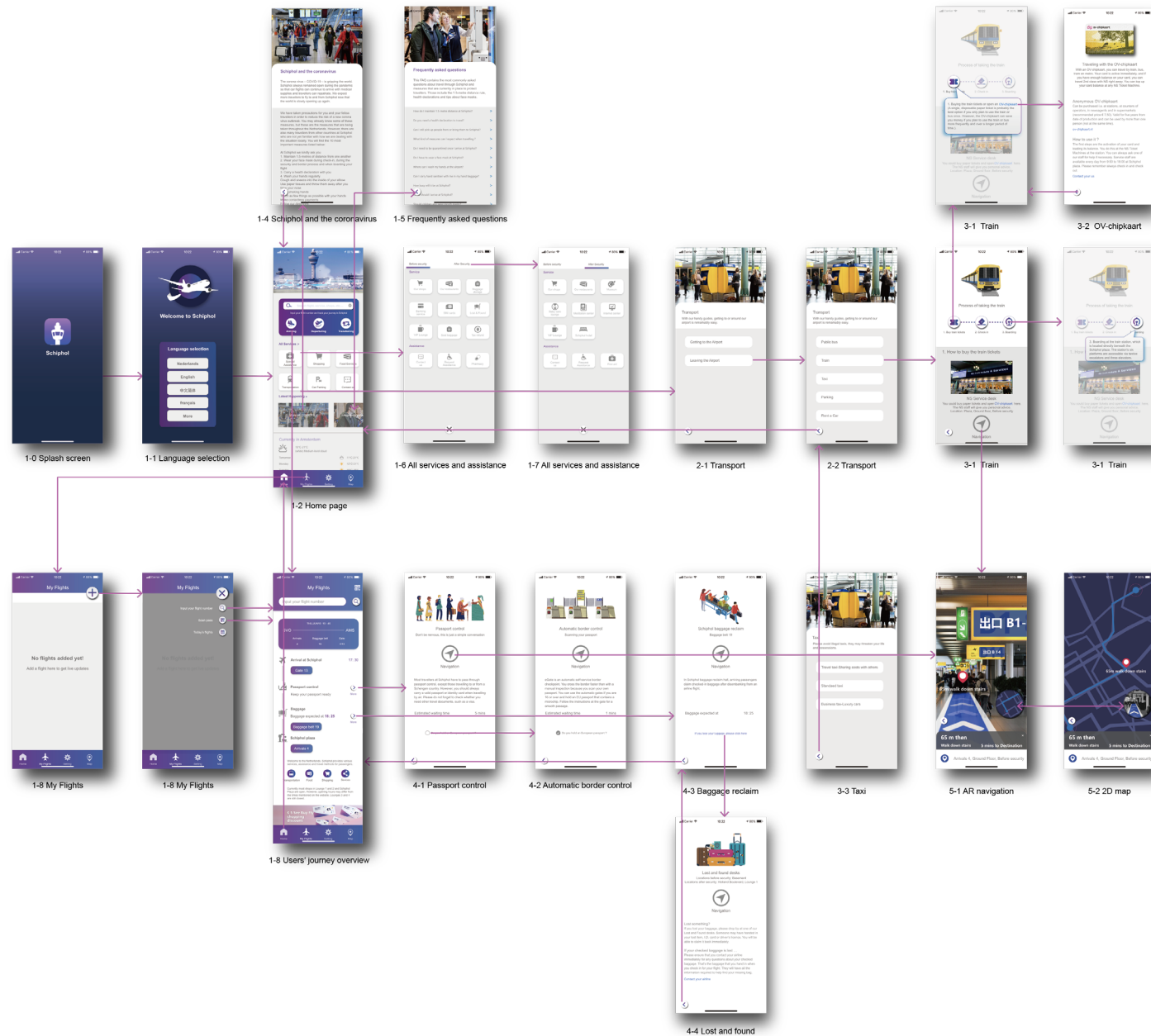
 Participants: Yan Shu Age: 22 Nationality: Chinese Occupation: International student She has lived in the Netherlands for two years.	
Concept-1	Concept-2
Insight-1: The buttons on pages 1-3 are not obvious, and the user does not know which buttons are interactive. Insight-2: Because of the cognitive barriers, users do not like this main menu in prototype one, which is different from the main menu in most apps in form. Insight-3: The user does not know what the arrow buttons on pages 1-3 represent. Insight-4: On page 1-2, "input your flight number" makes users feel confused. Users do not understand the difference between it and "input your flight" in the search bar.	Insight-1: In the main interface, too much content causes visual overload, and there is no priority in the display of information, which makes the user feel confused.
Ease of use : 0  5 Efficiency : 0  5 Easy to learn: 0  5	Ease of use : 0  5 Efficiency : 0  5 Easy to learn: 0  5
Comparison of concept1 and concept2	
For this user, she said she prefers the second concept. Because compared to the first concept, the second app can intuitively show her all the services she needs. The first prototype is very inflexible to use and has no autonomy, which made the user feel she has to follow this pattern.	
Comparison of the four navigation Schemes	
For the navigation interface, the participant prefers the first solution. Because the first one looks more concise. Too much information and visual elements make her feel confused.	

 Participants: Long jizhou Age: 25 Nationality: Chinese Occupation: UX designer He has lived in the Netherlands for two years.	
Concept-1	Concept-2
Insight-1: Entering the flight number is a bit tedious. The UX designer suggested that adding the option of scanning QR codes. Insight-2: Switching between Schiphol app and other navigation software will affect the user experience. The UX designer suggests adding links to other navigation software, like Google Map or 9292, in the app. Insight-3: Repeated operations significantly affect user experience and the fluency of operation.	Insight-1: Missing information, such as smoking areas and toilets. Insight-2: There are many functional buttons in the index page, and the UX designer did not understand what they have covered, what they are interacting with, and what is next.
Ease of use : 0  5 Efficiency : 0  5 Easy to learn: 0  5	Ease of use : 0  5 Efficiency : 0  5 Easy to learn: 0  5
Comparison of concept1 and concept2	
For the UX designer, he said he prefers the second concept. Because compared to the first concept, the information structure of concept 2 is clear. On the other hand, the operational flexibility and efficiency of the linear information structure in prototype 1 are low.	
Comparison of the four navigation Schemes	
For the navigation interface, the participant prefers the third solution. Because in the third navigation interface, the user can see the 2D map and the real environment with digital information at the same time.	

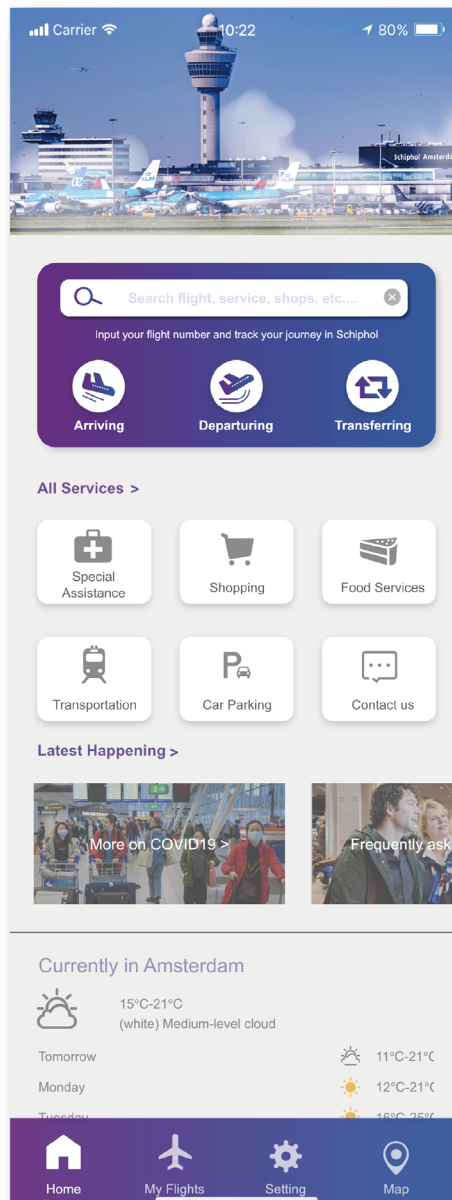
Appendix-5 Wireframe of iteration1



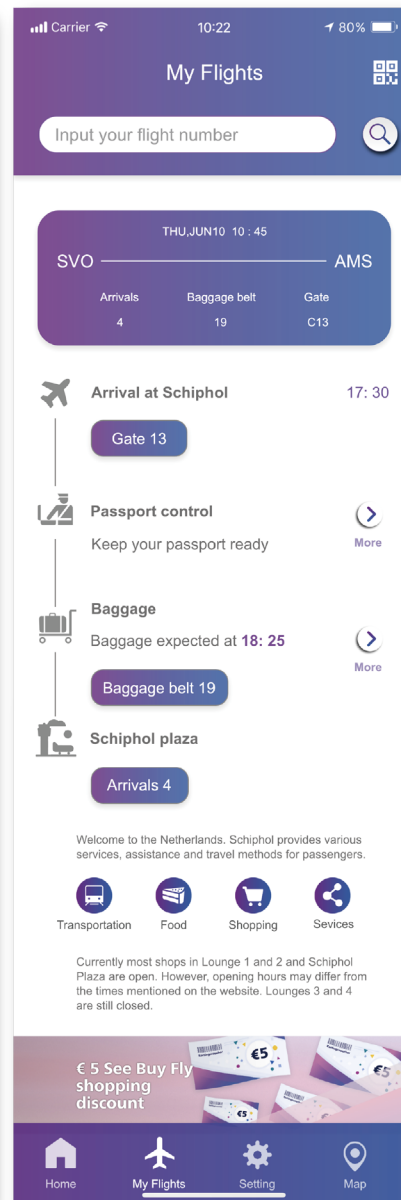
Appendix-5 Interfaces of iteration1



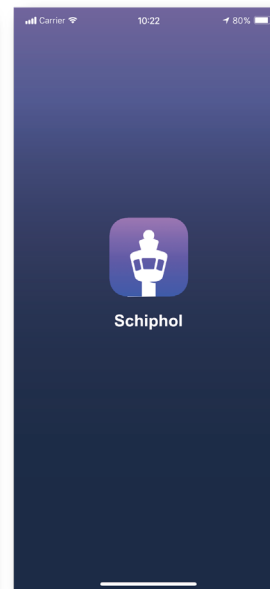
Appendix-5 Interfaces of iteration1



1-2 Home page



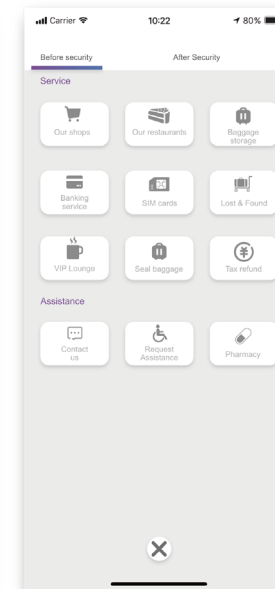
1-8 Users' journey overview



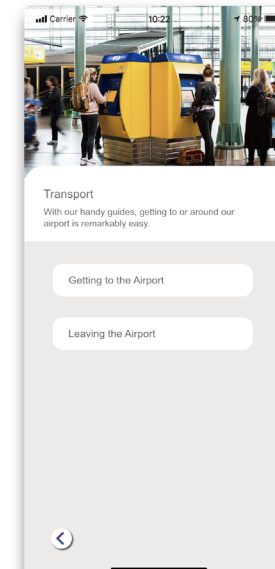
1-0 Splash screen



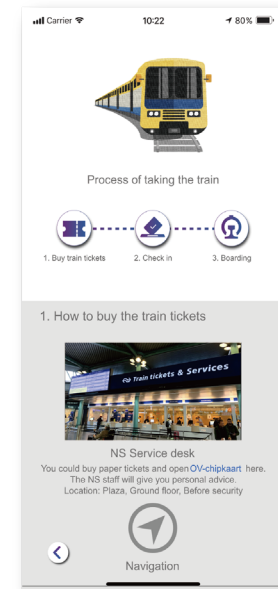
1-1 Language selection



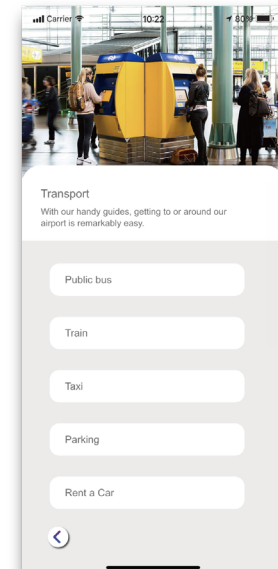
1-6 All services and assistance



2-1 Transport

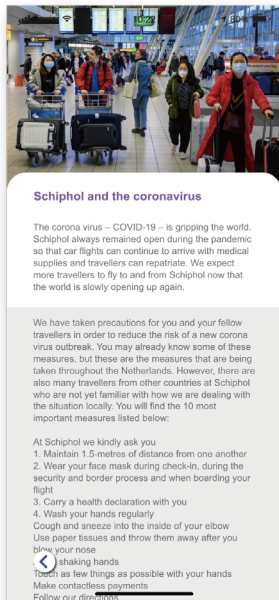


3-1 Train

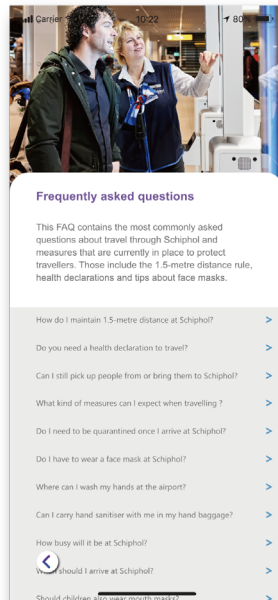


2-2 Transport

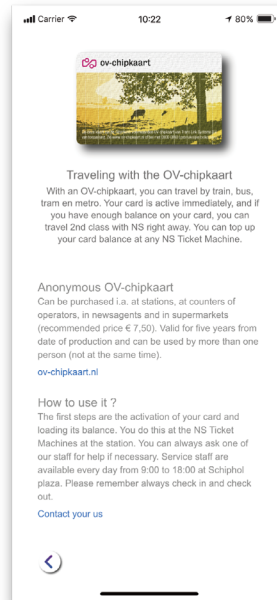
Appendix-5 Interfaces of iteration1



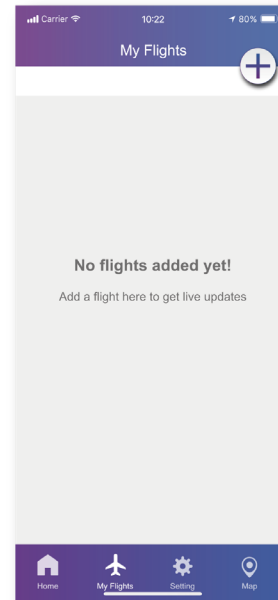
1-4 Schiphol coronavirus



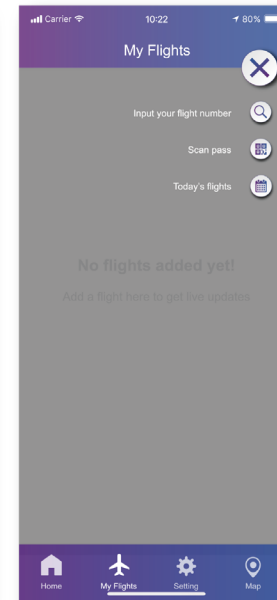
1-5 Frequently asked questions



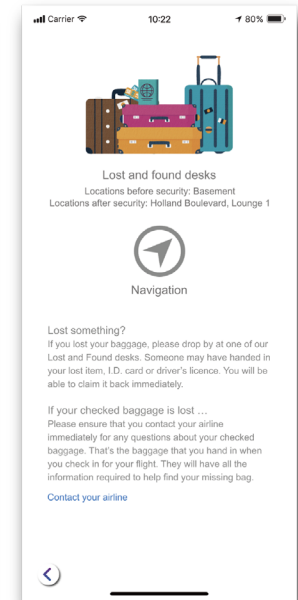
3-2 OV-chipkaart



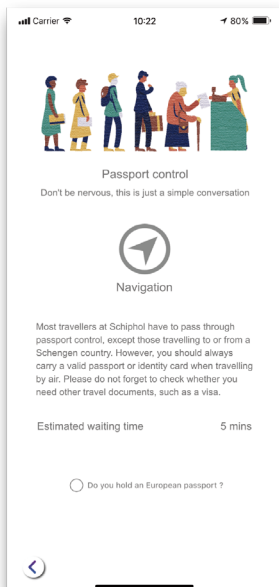
1-8 My Flights



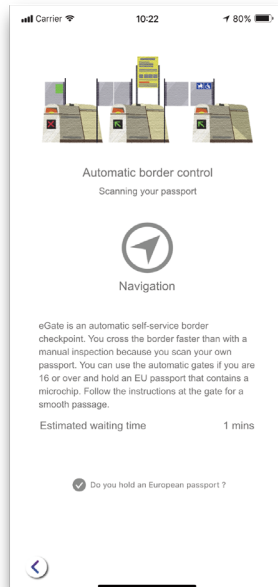
1-8 My Flights



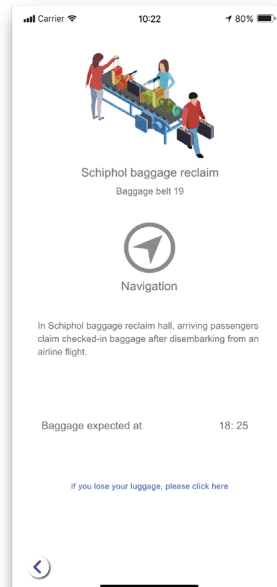
4-4 Lost and found



4-1 Passport control



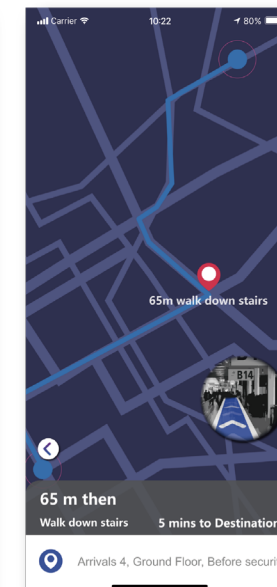
4-2 Automatic border con-



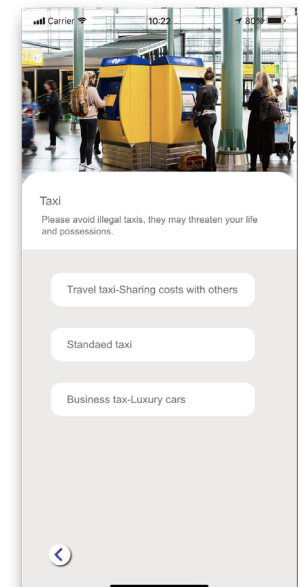
4-3 Baggage reclaim



5-1 AR navigation



5-2 2D map



3-3 Taxi

Appendix-6 Second-round testing results.



Participants: Zhu xingyue

Age: 24

Nationality: Chinese

Occupation: UX designer

She has never been to Schiphol. She is currently working as a UI designer at VIVO Mobile.

Iteration-1

Insight-1: Designing interactive products need to follow the user's habits and minimize cognitive load. In this app, the return key should be placed in the upper left corner instead of the lower-left corner.

Insight-2: The homepage picture is too large, which will attract the user's attention.

Insight-3: The overall visual style of the app is not uniform.

Insight-4: The priority of the information in this app is not clear for users. She recommends using different fonts, colours and visual elements to distinguish different types of functions in this app.



Participants: Fu zengyu

Age: 23

Nationality: Chinese

Occupation: International student

She has never been to Schiphol

Iteration-1

Insight-1: The font of some pages is too small to read.

Insight-2: The homepage picture is too large, which will attract the user's attention.

Insight-3: The priority of the information in this app is not clear for users.



Participants: Long jizhou

Age: 25

Nationality: Chinese

Occupation: UX designer

He has lived in the Netherlands for two years.

Iteration-1

Insight-1: In the home page, the "My flights" option is not clear for this user, and he does not know what will happen after clicking this button. He recommended that add description under this option to explain that.

Insight-2: The homepage picture is too large, which will attract the user's attention.



Participants: Liu yiling

Age: 22

Nationality: Dutch

Occupation: Designer

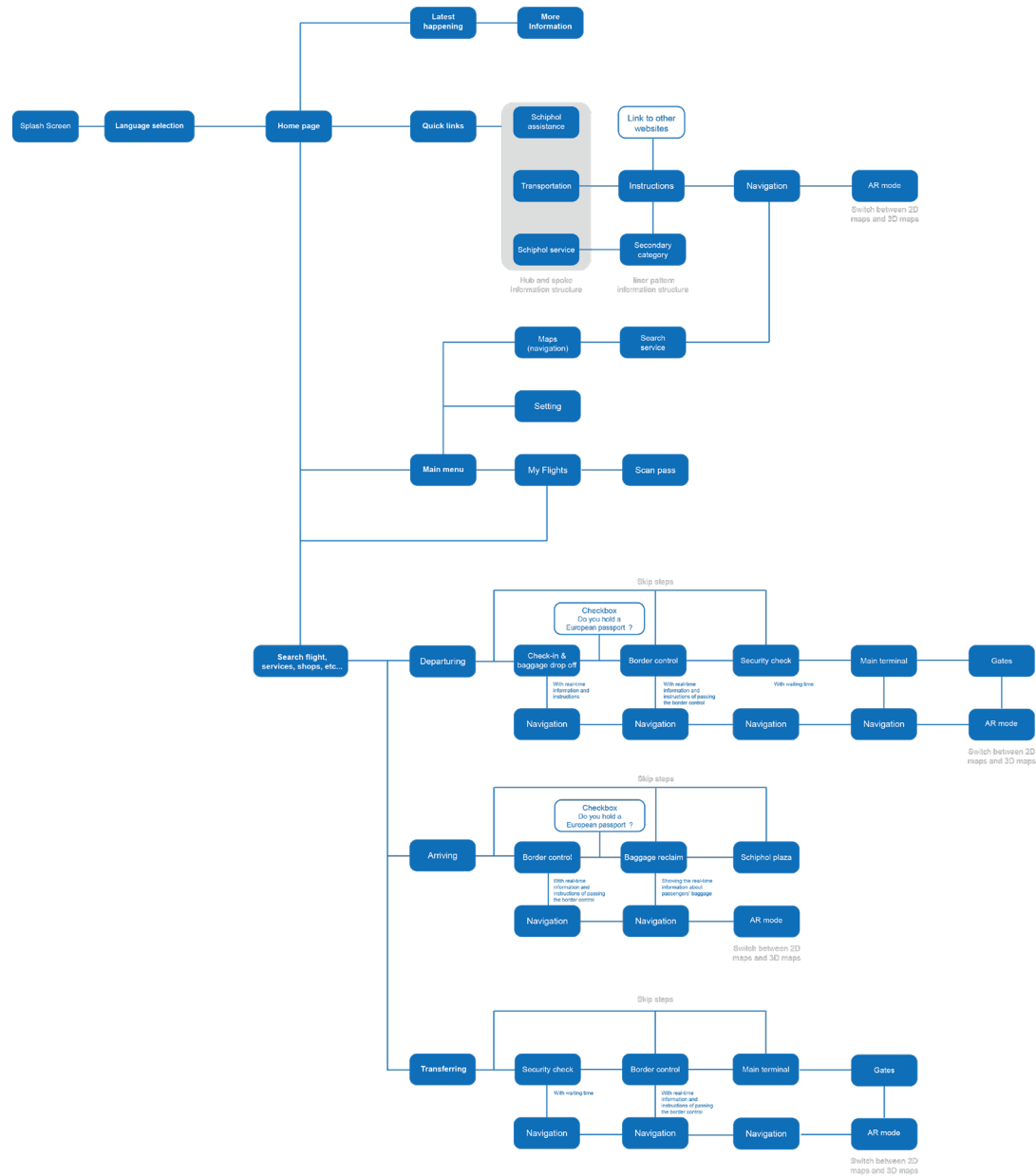
She immigrated to the Netherlands at the age of 15.

Iteration-1

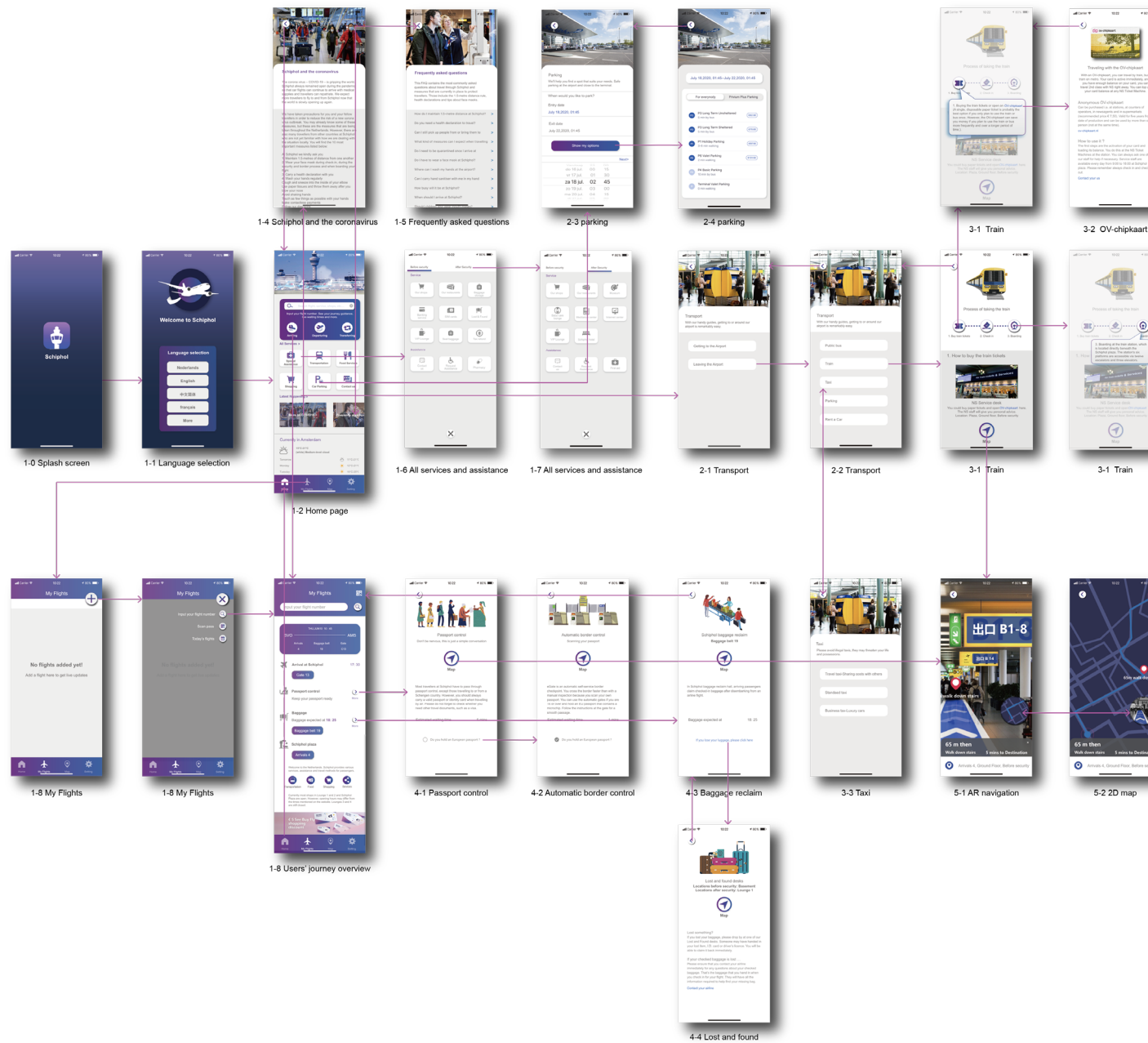
Insight-1: Too many professional terms are used in the App, such as navigation. She suggested replacing these professional terms with better-understood words for users.

Insight-2: The homepage picture is too large, which will attract the user's attention.

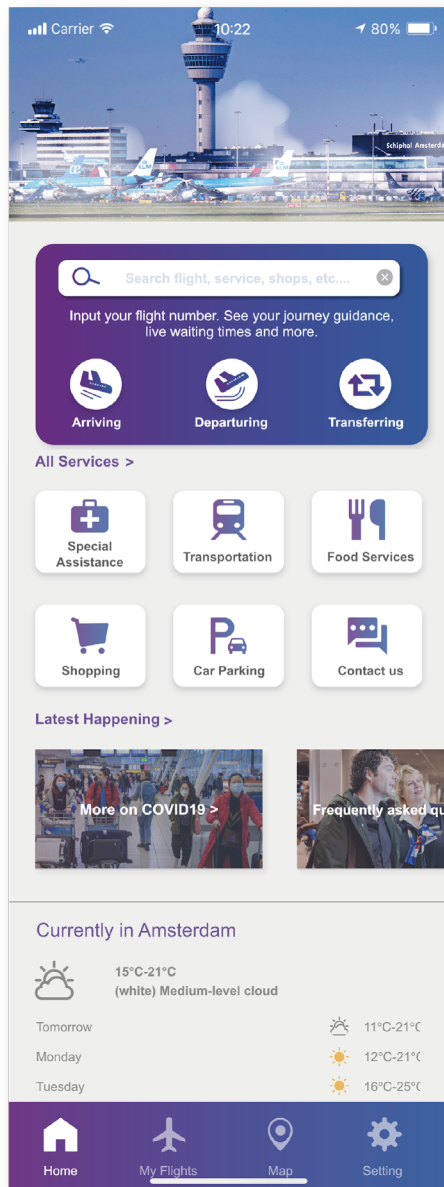
Appendix-7 Wireframe of iteration2



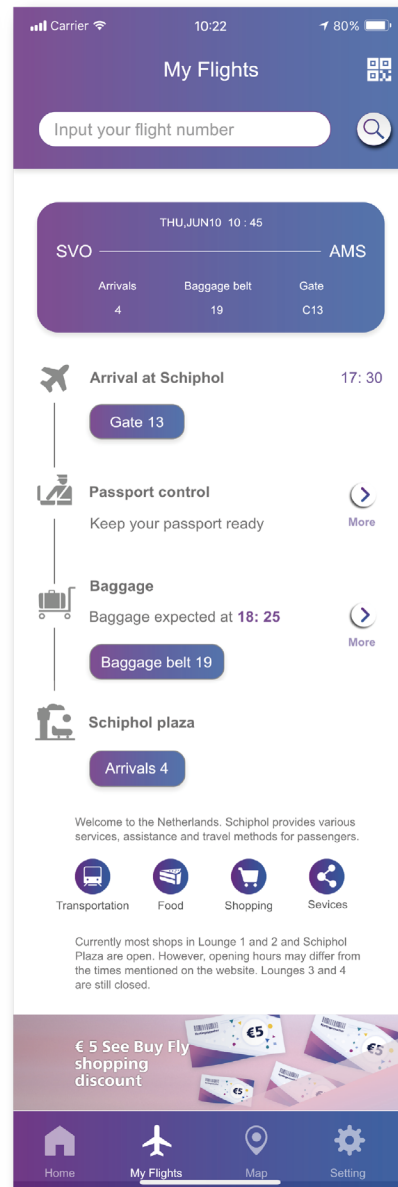
Appendix-7 Interfaces of iteration2



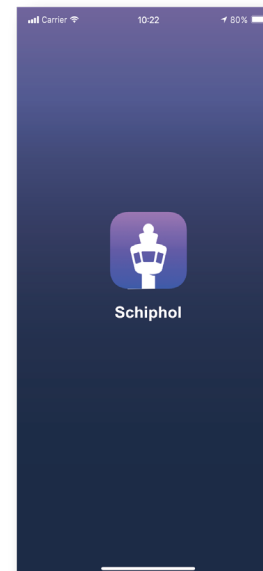
Appendix-7 Interfaces of iteration2



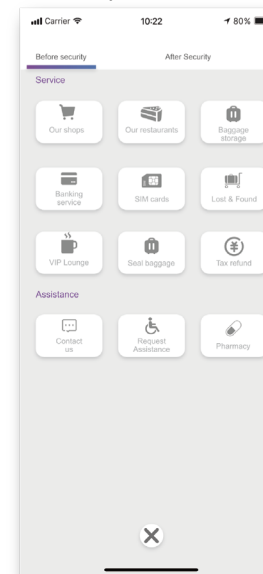
1-2 Home page



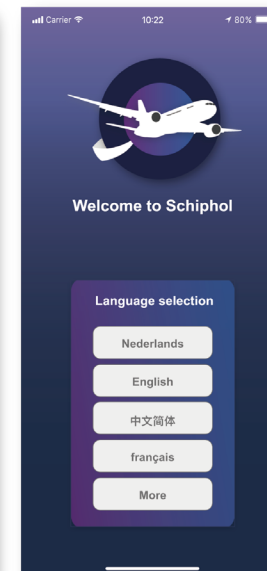
1-8 Users' journey overview



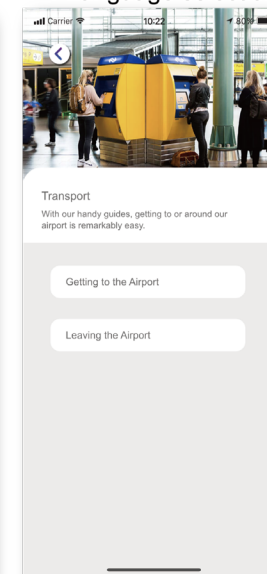
1-0 Splash screen



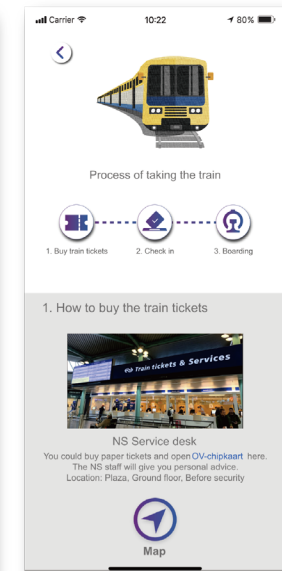
1-6 All services and assistance



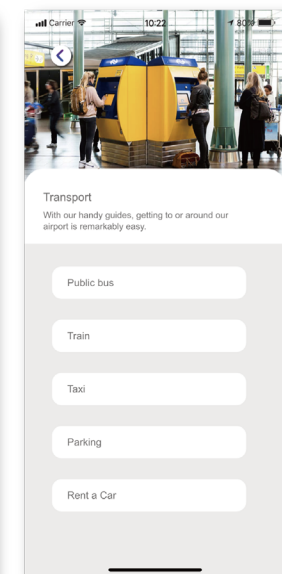
1-1 Language selection



2-1 Transport

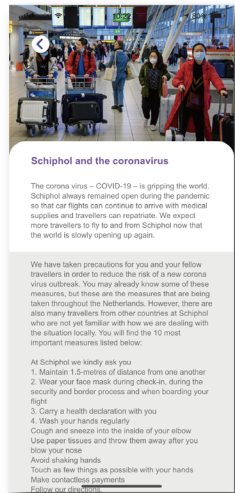


3-1 Train

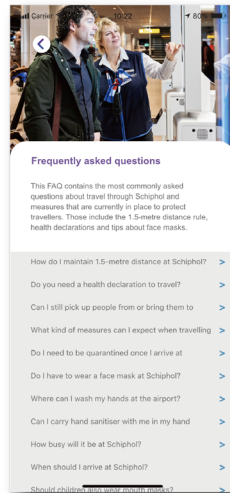


2-2 Transport

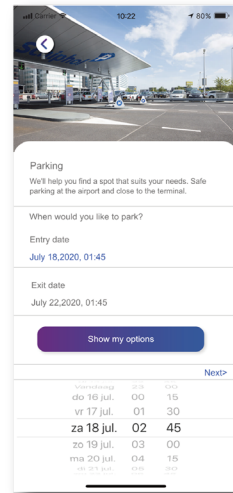
Appendix-7 Interfaces of iteration2



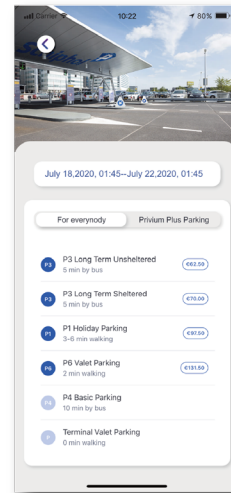
1-4 Schiphol coronavirus



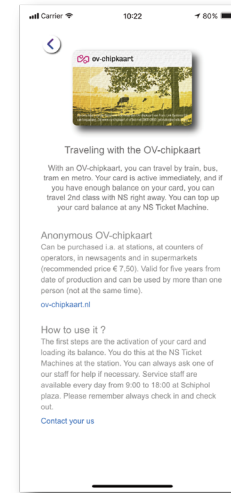
1-5 Frequently asked questions



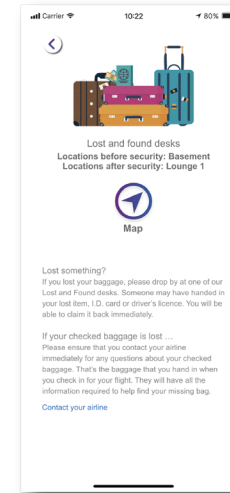
2-3 parking



2-4 parking



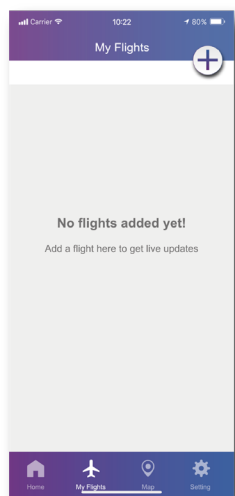
3-2 OV-chipkaart



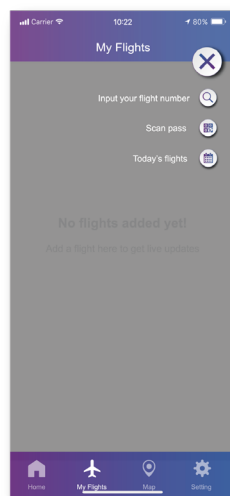
4-4 Lost and found



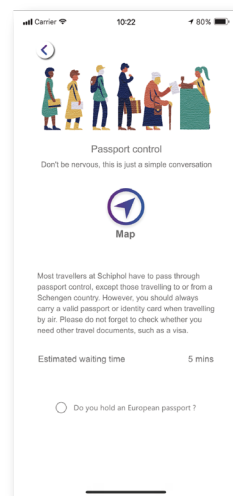
5-1 AR navigation



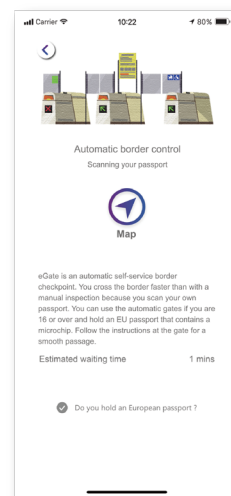
1-8 My Flights



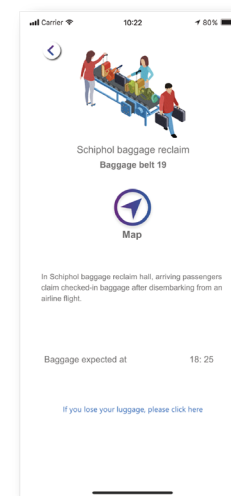
1-8 My Flights



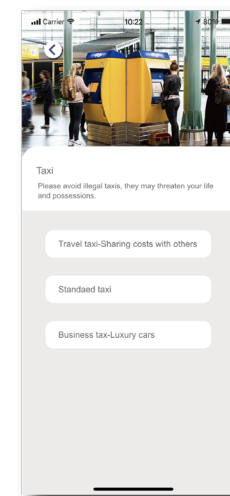
4-1 Passport control



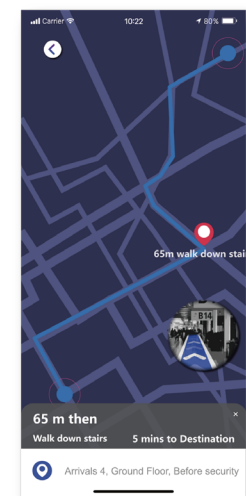
4-2 Automatic border control



4-3 Baggage reclaim



3-3 Taxi



5-2 2D map

Appendix-8 Third-round testing results

	Participants: Zhou Ming Age: 51 Nationality: Dutch Occupation: Housewife She immigrated to the Netherlands at the age of 40.
	Iteration-2
	Insight-1: This app is easy to understand and learn for the user. Insight-2: The homepage picture is too large, which will attract the user's attention.

	Participants: Peter Zeevaarders Age: 61 Nationality: Dutch Occupation: Engineer He was born in Netherlands.
	Iteration-2
	Insight-1: This app is easy to understand and learn for the user. Insight-2: This app is very suitable for users who come to the Netherlands for the first time and users who are flying for the first time.