



Improving the airport landside connectivity through the Internet of Things

01. Analysis report
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GLOSSARY AND ABBREVIATIONS

AAS

Amsterdam Airport Schiphol

Airside

The area after security, such as all the infrastructure for aircrafts and gates in the terminal.

Biometrics

Unique features of people such as fingerprints and facial measurements.

BOA

Stands for 'buitengewoon opsporingsambtenaar' which are people enforcing public safety.

Ceintuurbaan

The connecting road between de Kiss and Ride and the highway A4/A9.

DAP

Digital Airport Program.

IPO

Integrated Process Control Operations. A dashboard to support and provide information about the KPI's. The goal is to make sure everyone has the same data and is able to draw conclusions from the dashboard to use in order to meet the KPI's.

IoT

Internet of Things. This is a collection of different things (sensors, actuators, data) that are connected to the Internet and with each other.

Kmar

Koninklijke marechaussee. The Dutch military police.

K&R

Kiss and Ride.

Landside

The area before security. Hence, public areas in and outside of the terminal.

Maaiveld

The area at level 0, facilitating taxi, bus and hotel shuttle processes.

MaaS

Mobility as a Service.

Ministry IenW

Ministerie van Infrastructuur en Waterstaat.

NS

Nederlandse Spoorwegen. The Dutch railways.

Obi4wan

Platform that collects all to Schiphol directed social media messages.

O/D passengers

Origin destination passengers. All passengers that start or end their journey at Schiphol.

P1

Parking garage at Schiphol Centrum. Also known as short parking, where the garage can only be used for 0-48 hours.

PAX

Passengers.

PRM

Person with reduced mobility.

PoCs

Proof of Concepts.

ProRail

The owner of all rails in the Netherlands.

RTHA

Rotterdam The Hague Airport.

Schiphol Plaza

The area at the entrance of Schiphol on level 0.

STC

Stichting Taxi Controle.

Uber

Ordered taxi.

Wilbur

Dashboard used by the control room at Schiphol.

EXECUTIVE SUMMARY

Flying comes with many responsibilities for both the airport and the passenger. One of the responsibilities for the passenger is to be on time at the airport. There are many modalities to choose from in order to travel to and from the airport, whereby each type of modality comes with its own service and process. Consequently, passengers can have difficulty when trying to find the most efficient and easy route. Using different services by different companies can make it difficult to choose the most efficient and easy route. Also, in case of delays passengers want to make sure they can still be on time, since they need to catch their flight. Hence, not being provided with solutions and predictions when things go wrong, can be stressful for passengers.

Besides, the airport is responsible for offering the best services to make sure the passengers can catch their flight on time. This includes the provision of products and services for easy and reliable landside connectivity.

This master thesis studies how to improve the airport landside connectivity through the Internet of Things. The project is carried out at Schiphol Airport in Amsterdam and is part of the expertise center "OV-betalen" at the IDE faculty of the Delft University of Technology.

In this analysis report the first part of the project is presented, in which the technology, current situation at landside Schiphol and the passenger experiences are explored and studied. Consequently, the findings from this report are used for the ideation and design phase (design report).

The technology, Internet of Things (IoT), is chosen for this project. The Internet of Things is the collection of things that are connected to each other and to the Internet, where things can be sensors, actuators and software. This technology can be applied in many domains, such as mobility, healthcare, energy, agriculture and retail.

Three levels of IoT products are found; the first with sensors that collect data in order to provide the users from data input, the second also with sensors that collect data in order to act and generate patterns from the data and the third level, the autonomous products that can individually make decisions.

In an airport, IoT can add value by improving the passenger experience and achieving operational efficiency. Schiphol recognizes the trend of becoming smart, and initiated the Digital Airport Program (DAP).

Within this program Schiphol is working on digital and smart solutions in different fields.

IoT can also be used for smart mobility solutions, such as developing a platform with all services of all modalities included and easy payments. In this way, the user can personalize his/her journey in an easy way.

Schiphol landside can be divided in the departure area, Schiphol Plaza, Maaiveld, parking garages and the train platforms. Within these areas the largest segments are the train and car travelers. Hence, the respective areas (departure area, Schiphol Plaza and the train platforms) face capacity problems. Due to the growing number of passengers at Schiphol, the capacity problems can increase as well. Lack of capacity can result in longer waiting times and unsafe situations. In return, the passengers will experience more insecurities and stress while traveling to the airport.

Capacity problems can be reduced by increasing the efficiency of processes or motivating passengers to travel differently. However, there is a chance that other modalities also experience capacity problems. Therefore, it is valuable to be able to have real-time information about the situation on the way and at Schiphol.

To understand more about the motivation of passengers a diary study has been done. It was found that passengers base their choice of modality on factors such as time, price, comfort, reliability and earlier experiences. For these factors, time efficiency is the most relevant. Again, we can link to the responsibility of being on time in order to catch the flight.

The findings about the current situation at landside connectivity can be categorized in the passenger experience and the operational efficiency. From the operational perspective, Schiphol wants to offer fast and reliable processes. Efficiency can be increased by applying IoT to monitor and control the processes more. This will provide more insights and opportunities to learn and improve the processes. The passenger experience can be improved by using IoT to monitor and provide input about the processes in order to reduce insecurities while traveling.

The next phase of this project is presented in the second report, the design report.



INTRODUCTION

This analysis report is the first part of the graduation assignment of the Master Integrated Product Design at the Delft University of Technology. The thesis is carried out at Schiphol Group, which is the organization that runs Amsterdam Airport Schiphol and other regional airports. The assignment is about the use of the Internet of Things for improving the landside connectivity at the airport.

The first report describes the research done for creating an understanding the current situation of the context and passengers. The results and findings derived from this report are used as input for the further ideation and realization of the thesis. The first chapter describes Amsterdam Airport Schiphol and the context in more detail.

I.1 AMSTERDAM AIRPORT SCHIPHOL

Amsterdam Airport Schiphol (AAS or simply Schiphol) is a busy airport with 326 direct worldwide destinations and 68.5 million passengers in 2017, this makes Schiphol the 3rd largest airport in Europe (Vliegveldinfo, 2017). The number of passengers increased with 7,7% with respect to 2016 (Schiphol Group, 2017c). The summer of 2018 was the busiest summer at Schiphol with 220.000 passengers a day (Schiphol, 2018). The number of passengers is not only rapidly growing at Schiphol, in 2035 the number of worldwide passengers is expected to double (IATA, 2016).

I.1.1 Mission and ambition

The mission of Schiphol is 'Connecting the Netherlands', with the goal to provide links from the Netherlands with the rest of the world to achieve social and economic value (Schiphol Group, 2017a).

In addition to their mission, Schiphol has the ambition to become Europe's preferred airport by providing high quality services. The strategy with five themes is based on achieving this ambition, which are as follows.

Top connectivity: providing excellent networks within Europe and intercontinentally.

Excellent visit value: provide attractive and quality processes for travelers, airlines and businesses.

Competitive marketplace: provide high quality work places, accommodation, accessibility and convenience for 24 hours every day. Hence, working on the AirportCity concept.

Development of the group: this theme is focused on strengthening the organization in staying innovative and distinctive.

Sustainable & safe performance: providing a safe and healthy environment for employees, passengers and residents.

The continuous growth of passengers increases the capacity problem around Schiphol. In order to keep providing capacity and quality, a new area will be developed. This new area, Area A will consist of a new terminal and pier and is planned to be finished in 2025. Based on the mission and strategy, five ambitions are defined for this project.

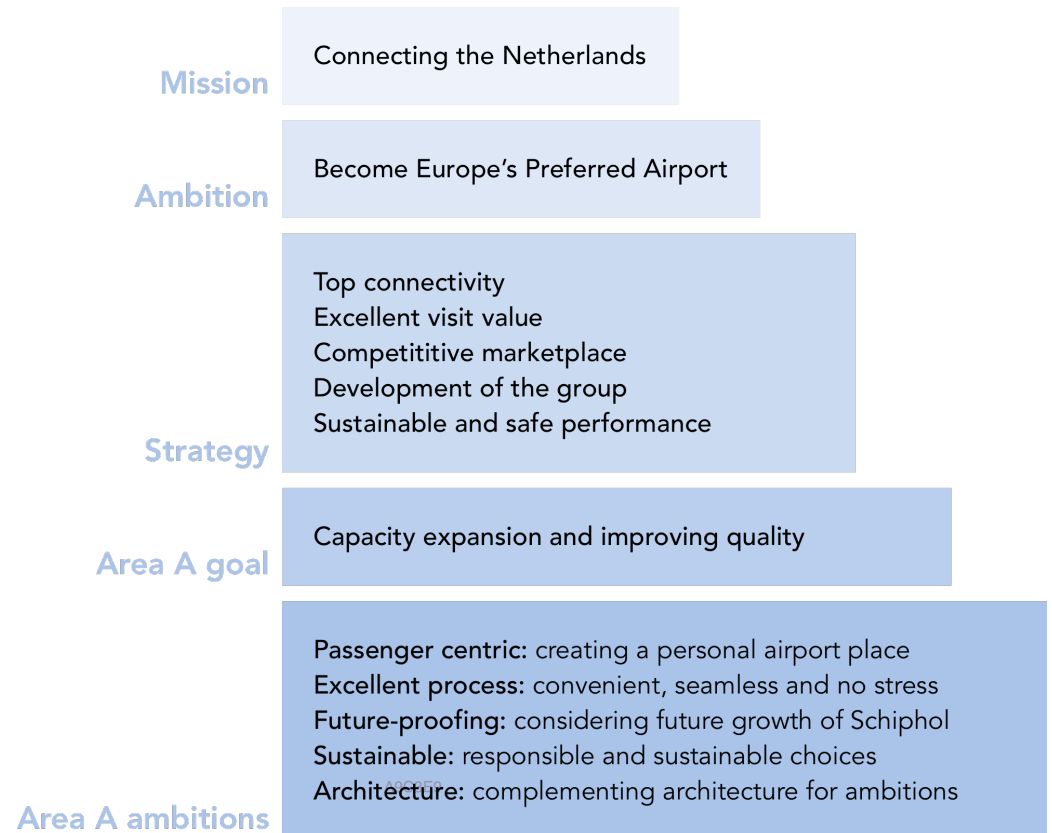


Figure 1: an overall image with the mission, ambition and strategy of Schiphol.

1.1.2 Digital Airport Program (DAP)

Next to becoming Europe's preferred airport, Schiphol also wants to become the world's best digital airport in 2018 (Overgoor, 2016). Therefore, Schiphol initiated the Digital Airport Program (DAP) in 2015. The program consists of the following value streams: seamless flow, personal relevant information, airport control, smart airport data, connected airport and airport planning & forecasting (Schiphol Group, n.d.)

The focus of this program is to provide a seamless passenger journey and become a smart airport (Veen, 2017). In addition to improving the passenger experience, the program also considers smart solutions for airlines and employees (figure 2, Schiphol Group, 2016).

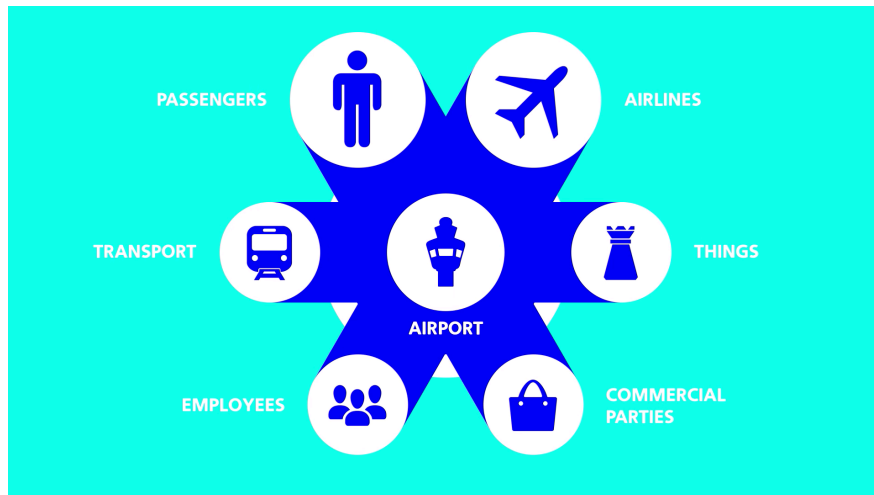


Figure 2: the six topics that Schiphol wants to cover within the Digital Airport Program (Schiphol Group, 2016)

1.1.3 Concept of Operations

To keep improving and providing the best services, different initiatives and programs are introduced at Schiphol. In 2018 the Concept of Operations (CONOPS) has been initiated, whereby the goal is to optimize the Operational Excellence at Schiphol to make sure the airplanes leave on time with all the passengers and their luggage on board (Schiphol Group, 2017g).

Analyzing the current situation shows that passenger delays can cost a lot of money for the organization (Schiphol Group, 2017g). In addition, delays have a large influence on the passenger experience. Delays can be caused by both the processes and passengers that arrive late to Schiphol (time-critical passengers). Therefore, providing quality and efficient processes are important. Furthermore, high quality and efficient processes will result in better passenger experience and in less time-critical passengers (Schiphol Group, 2017g).

The current processes/moments within the passenger and aircraft journey have been mapped out by Schiphol. In this overview, the predictability of these processes/moments are visualized (figure 3). The unpredictable moments mostly take place during the preparation and unloading of the aircraft. Other interesting moments are the arrival and departure to/from Schiphol by the passengers, where the unpredictability is caused by the lack of influence Schiphol has on these processes. How early do passengers decide to arrive at Schiphol? When do passengers leave Schiphol?

Five development paths have been defined to indicate the required developments in order to achieve Operational Excellence (figure 4, Schiphol Group, 2017g).

The development paths vary from passenger-oriented developments to process management developments. The descriptions and examples are derived from CONOPS (Schiphol Group, 2017g) and from the Business Partner Passengers at the airport (personal communication).

1. Independency: the first area focuses on developing services that can be used by the passengers independently. How can self-service desks be expanded to E-self-services to carry out tasks prior the journey as well as prepare the passengers before the journey? A good existing example is the online check-in that can be done at home.

2. Process capacity: the second area focusses on how areas and assets can be commonly used. For instance, equipment for aircraft stands that can be used commonly by different handlers.

3. Spatial capacity: due to the growing number of passengers, the terminal is getting more and more crowded. Is it possible to decentralize processes off the airport, to take pressure off the terminal? For instance, remote solutions for baggage drop-off to reposition processes further from Schiphol Centrum. Or planning in buffering moments to prevent waiting lines.

4. Process simplicity: there are many steps in both the passenger and aircraft journey (figure 3). Instead of carrying out every step individually, is it possible to integrate processes for simplifying both journeys?

5. Managing: as can be seen in figure 3, there are several steps in the journey that have a little predictability. How can Schiphol have more influence on some processes by guiding and steering? Interesting ideas within this area would be a Just-in-Time (JIT) systems for passengers, aircrafts and baggage to prevent early or late arrivals.

To initiate projects for the improvement of the operation, Proof of Concepts (PoCs) have been developed. PoCs are projects that fit into at least one of the development paths to validate and evaluate ideas with regard to Operational Excellence (Business Partner Passengers at the airport, personal communication).

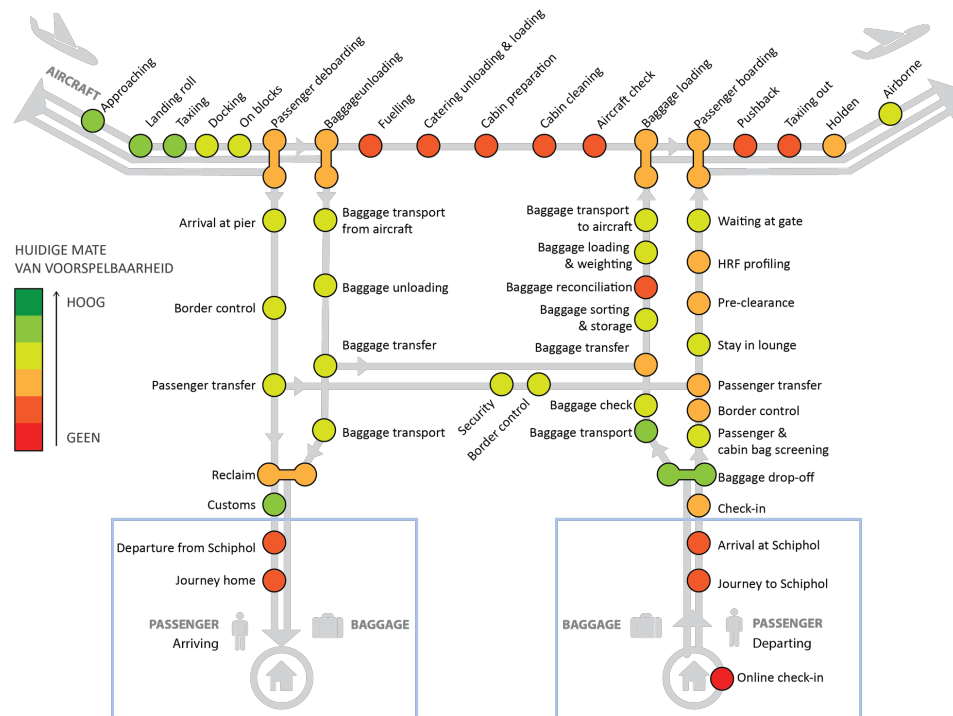


Figure 3: predictability of processes/moments Schiphol Group, 2017g). The scope of the project is appointed with the rectangles.

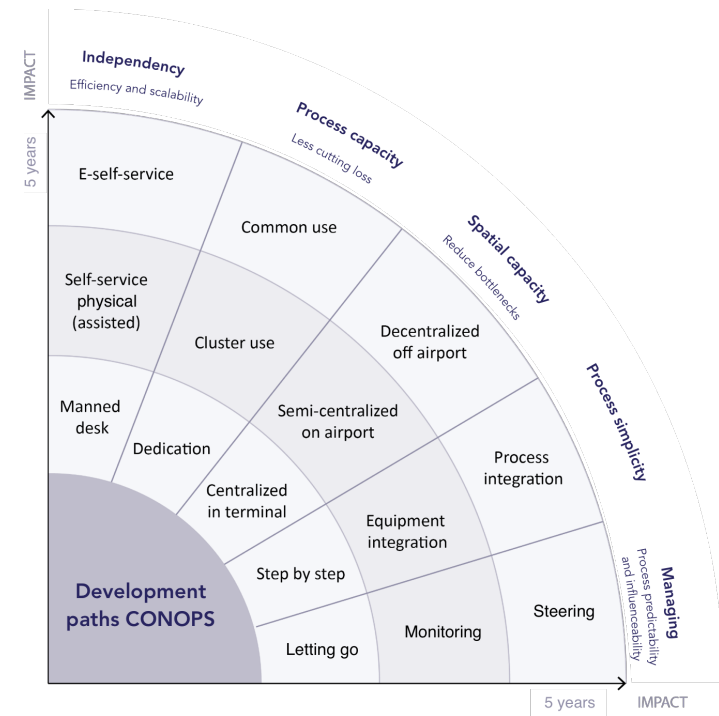


Figure 4: development paths as presented by Schiphol Group (2017g).

1.1.4 Landside connectivity

An airport can be divided in two sides, airside and landside. Airside is the area after security, such as all the infrastructure for aircrafts and gates in the terminal. Landside is the area before security consisting of the public areas in and outside of the terminal.

Schiphol wants to provide a seamless journey for passengers (Veen, 2017).

The journey towards and from the airport is a crucial part in the seamless journey. The thesis explores the different processes and experiences of passengers to create an understanding of the bottlenecks and challenges regarding the landside connectivity.

1.1.5 Stakeholders

For the landside connectivity at Schiphol, many stakeholders are involved. Figure 5 shows an overview of these stakeholders. The outlined blocks are purely informative and are not the stakeholders, hence all stakeholders are represented with filled blocks.

The different stakeholders can be distinguished in seven groups: travelers, Schiphol, airlines, government, infrastructure, tourism organizations and ground transportation organizations.

Travelers include all passengers and employees that travel to and from Schiphol. The passengers can be divided in again two groups, the Dutch and the Non-Dutch passengers. The interest of the passengers within the context of this project will be to receive relevant information and communication for a seamless flow.

The thesis is written at Schiphol within the Operations department. This department is responsible for improving and optimizing processes with a scope of 0-5 years. Their interest will be to learn about an integrated design to provide better connection to and from the airport.

Airlines transport passengers to distant destinations, in the case of Schiphol from the Netherlands to international destinations. The airlines have direct and frequent contact with the passengers to provide information about the flight. Airlines can play a role in the communication about the journey to an airport. In this case, KLM is the main collaborator with Schiphol.

In order to provide the ground transport connections to and from the airport, different organizations are involved. For public transportation, different P.T.O.s (Public Transport Operators) are required for their services. For Schiphol these are Connexion, GVB, NS, R-Net, Sternet, Q-liner and Arrive to provide bus and train services.

In addition to public transport, passengers can travel by taxi, hotel shuttle, touring car or private car.

There are several taxi services, such as the official Schiphol taxi, Schiphol Travel Taxi, Uber or other private organizations. Hotel and touring services are offered by various organizations, such as FlixBus and Hilton. Crew transport can be compared with touring services, thus is also offered by different organizations such as Met&Co.

Tourism organizations are closely linked with the Non-Dutch passengers to provide information about the journey from and to an airport.

All modalities are connected with the (road) infrastructure of and around Schiphol. The involvement of these infrastructures is distributed over several stakeholders. Obviously, Schiphol has ownership of the areas on Schiphol, but the changes are discussed and decided consultation with other stakeholders. For the train station of Schiphol, decisions are made in discussion with ProRail. In addition to the main infrastructure, the municipality Haarlemmermeer has a strong influence on changes with an impact on the road infrastructure. Province has an influence on decisions with regard to the provincial roads connected with Schiphol. Similarly, Ministry IenW has a voice in connections from the freeway to Schiphol (A4 and A9).

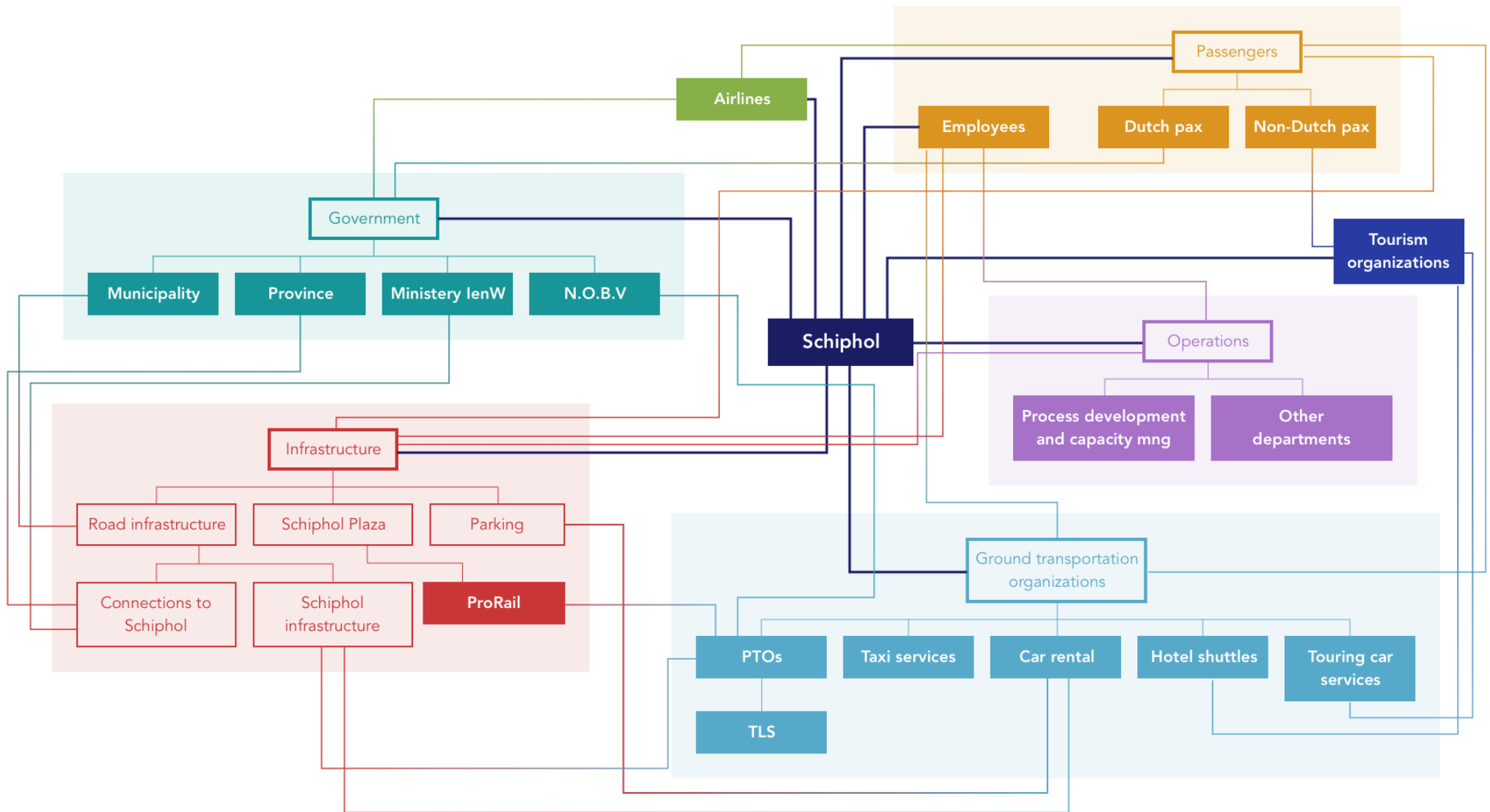


Figure 5: overview of stakeholders regarding the landside connectivity of Schiphol. Outlined blocks are informative, filled blocks represent the stakeholders.

1.1.6 Technology

The assignment is about the use of the Internet of Things for improving the landside connectivity at the airport. The Internet of Things (IoT) is the collection of 'things' that are connected to each other and to the Internet (Morgan, n.d.). These 'things' be objects, services, people and devices (Mahmoud, Yousuf, Aloul, & Zualkernan, 2015). IoT can be applied in many contexts, which also brings possibilities for airport solution.

As already mentioned, Schiphol initiated the Digital Airport Program (DAP) in 2015, recognizing the digitalization need. The goal of this program is to improve the passenger experience and turn the airport into a smart airport.

Developments such as automating the check-in process by using passenger preferences or using beacons for measuring and predicting waiting times (Drinkwater, 2017) or providing real-time transport information are examples of such developments. From an operational perspective, IoT can be used for monitoring and controlling passenger flows through dynamic wayfinding or Just-in-Time systems for picking up passengers.

1.2 ASSIGNMENT

The following section will describe the problem statement and assignment description that will be worked out with this thesis.

1.2.1 Problem statement

The passenger is responsible for being on time to catch their flight. However, the journey to the airport can be influenced by many factors which are not affected by passenger itself. There are many options to travel to and from the airport. However, these means of transportation all have their own services and are not interlinked with each other. Consequently, passengers can have difficulty when trying to find the most efficient and easy route. Using different services by different companies is not user-friendly for the passengers as it is time consuming and not possible to anticipate when delays can occur. There are no guaranteed transfers within the complete journey.

Not being provided with solutions and predictions when things go wrong, can be stressful for passengers.

On the other hand, the vast growth of Schiphol results in capacity problems around landside, in 2025 the expected growth is 50% (Schiphol Group, 2011). The available space is limited and there are limited possibilities to expand infrastructure. Therefore, the increasing demand can result in bottlenecks when the supply is insufficient. Implementing new technologies such as IoT can open up possibilities to solve the bottlenecks.

1.2.2 Assignment description

The assignment is to design a product-service system that supports seamless and personal travel to and from the airport through the use of the Internet of Things (IoT).

Initially, both travel streams to and from Schiphol will be explored and analyzed.

Additionally, the current situation at landside Schiphol will be explored to understand the bottlenecks and challenges that are faced. Subsequently, a specific passenger group and area will be selected to work out in detail.

1.2.3 Design approach

Following the Double Diamond model (Design Council, n.d.), the project is divided into four phases.

1. **Discover:** within this first phase research will be done to gather insights about topics related to the assignment. The insights will be used as input for the definition and direction of the project.
2. **Define:** the second phase focuses on the results and insights generated in the first phase to identify a valuable and feasible direction for the assignment.
3. **Develop:** this phase focuses on the idea generation and concept development which will be tested and iterated.
4. **Deliver:** finally, everything will come together in the last phase to finalize the concept.

This analysis report is the documentation of the first phases where the context, passengers, technology and bottlenecks will be explained. Consequently, the input will be used to define the direction for the project. The define, develop and deliver phase will be presented in the design report.

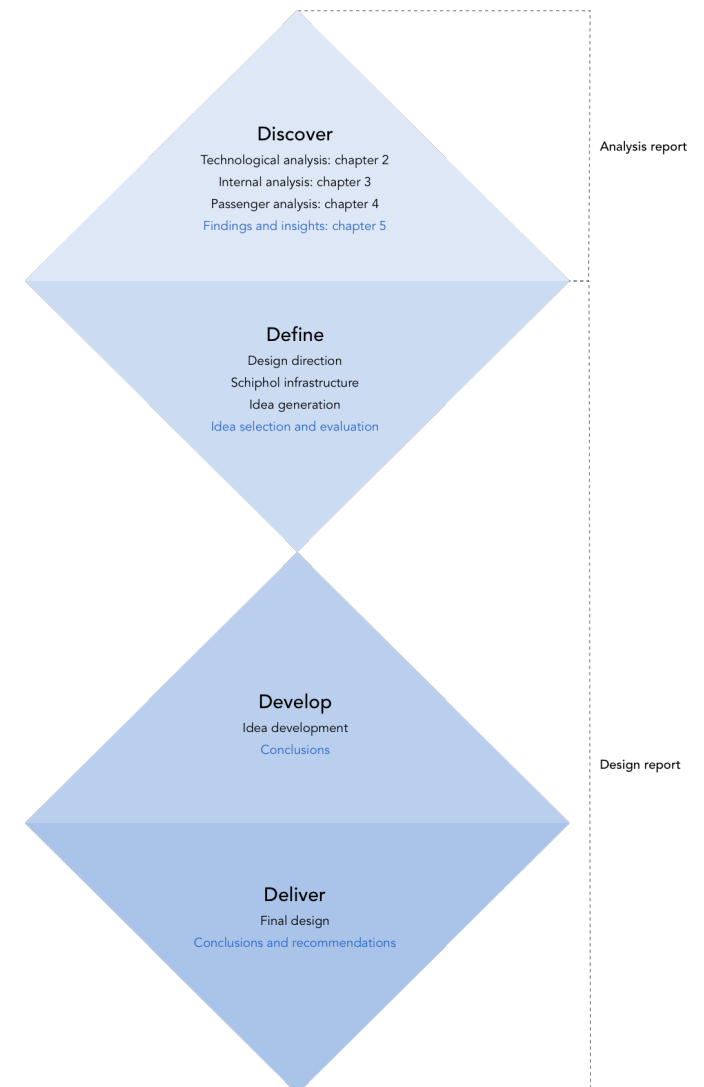


Figure 6: visual of the design approach

2

TECHNOLOGICAL ANALYSIS

This chapter analyzes the technology used within this thesis, the Internet of Things. Moreover, mobility trends and other technological developments in an airport will be explored.

2.1 INTERNET OF THINGS (IOT)

The first section is an explanation of IoT and the main challenges that can be faced.

2.1.1 What is IoT?

In the introduction the definition of IoT has been explained as the collection of 'things' that are connected to each other and to the Internet (Morgan, n.d.). It is predicted that by 2020 50 billion devices will be connected to the Internet, which is equal to 6.58 connected devices per person (Evans, 2011). Eventually, everything can become connected and open up opportunities in different areas.

Imagine everything in your house is connected with each other and the internet. You have a meeting in a few hours, so your alarm clock wakes you up on time and starts the coffee machine to brew your favorite coffee. Your car is connected with traffic data and your calendar. Hence, the car checks if there is any traffic or if there are better options available to make sure you are on time. Scenarios such as these can become reality if everything is connected and communicating with each other.

In addition to these kind of personal experiences, IoT can add value to other domains such as social relationships, mobility, transport, enterprises, monitoring of resources (Abomhara & Køien, 2014) or healthcare, energy, agriculture and retail (Mahmoud et al., 2015).

These smaller domains become part of bigger networks, such as smart homes, smart cities, smart transportation and smart infrastructures (Mahmoud et al., 2015).

Cila, Smit, Giaccardi, & Kröse (2017) state that IoT is more than just making things smart, it is about understanding the impact of smart products on people's lives. Evans (2011) explains this by saying humans transform data into knowledge and wisdom which is important for people to evolve and become more advanced. Since IoT generates large quantities of data it can help people process more knowledge and wisdom to evolve (Evans, 2011).

To understand how these products can interact with people Cila et al. (2017) identify three behavior types: the Collector, the Actor and the Creator.

The Collector consists of sensors and is able to collect and form data to inform their users on the data input (Cila et al., 2017). For instance, smart watches monitor and collect data about the heart rate, sleep and other activities which are communicated with the user to create an understanding of their own activity and behavior.

The Actor collects data such as the Collector, but is also able to act upon the given input and generate behavior patterns accordingly (Cila et al., 2017). For instance, the Nest learning thermostat, which remembers behavior patterns and is able to act upon that (Faggella, 2016).

The Creator is the novel behavior type with autonomous and self-aware products that live amongst people (Cila et al., 2017). Autonomous cars that can bring people from point A to B and return individually to their home or pick up other people to bring them to their destination. Another example, can be a smart air purification system that can individually locate air pollution and is able to communicate with people clean the air around them (Hugen, 2018).

To achieve products within the Actor and Creator role, artificial intelligence (AI) plays an important role. Gartner believes this role will become vivid in 2022, where 80% of IoT projects will have an integration with AI (Pemberton, 2017). Combining AI with IoT will add intelligence in order to generate insights and patterns from all the data that is being produced (Schatsky, Kumar, & Bumb, 2017). These patterns can be used for adapting the product to the fit the user accordingly, such as the example given earlier; the Nest thermostat. Looking further than smart homes, AI can add the same values to companies by translating all the data into important insights which can be act upon.

All things considered, IoT opens up many possibilities in different fields. However, it is important always consider the added value to improve people's lives.

2.1.2 Challenges of IoT

IoT is starting to grow rapidly. In order to become successful, it is important to be aware of the challenges that come with it. The major challenges will be described within this section.

Security and Privacy

Connecting everything to the Internet can make products vulnerable for hackers and cyber-attacks (Lee & Lee, 2015). A study done by Hewlett Packard (2014) unfolds that 70% of IoT devices will be exposed to attacks. A significant consequence of these attacks can be the privacy of data, which can include data about one's location or preferences (Lee & Lee, 2015).

In order to prevent security threats, it is relevant to use authorized software and verifications prior connecting devices to the network (Mahmoud et al., 2015). Implementing other technologies such as Blockchain can verify data and create reliable products (Guinard, 2018). Blockchain is a decentralized database where the information is not stored at one place, but distributed over millions of computers. This makes it impossible to hack or corrupt. The information is only accessible and changeable by one owner, but can be viewed by everyone (Blockgeeks, 2018).

Interoperability

IoT today exists out of separate networks, but to become more powerful it is important to connect these networks with each other and create a 'Network of Networks', as mentioned by Evans (2011). By connection networks to other networks, more data and patterns can be generated. To achieve interoperability, devices and data should be able to share information with each other (Gazis et al., 2015).

Scalability

As soon as everything becomes connected and interoperable all the 'things' will generate a significant amount of data. To support all of the data, new systems will be required to manage, interpret and compare data for useful outputs (Chen, Xu, Liu, Hu, & Wang, 2014). In this situation Blockchain can be implemented again to safely decentralize some of the data (Guinard, 2018). Blockchain is able to exchange data from machine to machine and thus can be used for machine to machine communication (Zuidam, 2014).

2.1.3 Internet of Things for airports

The airport is a dynamic and complex environment where many processes for different user groups are offered. The airport never stops running, it is accessible 24/7.

The growing number of worldwide passengers creates an even more complicated situation where it becomes challenging to make sure all flights, passengers and their luggage leave on time.

Furthermore, experiences at an airport can become quite stressful since passengers have a need to complete all their tasks on time in order to catch their plane (Caves & Pickard, 2001). Hence, IoT can be a valuable tool for achieving excellent experiences for both the operators and the passengers (Drinkwater, 2017).

With the involvement of retailers, airlines, government and safety organizations, airports can be seen as a small version of a city (IoT Innovation, 2017). Schiphol describes this as the AirportCity. Hereby the goal is to provide high quality work places, accommodation, accessibility and convenience for 24 hours a day (Schiphol Group, 2017a).

Considering the airport as a condensed city, it is interesting to examine the values of smart cities. There is not one definition for a smart city but different interpretations (Nam & Pardo, 2011). Smit (2017) describes several concepts for smart cities as social-driven, data-driven or urban-focused, where the key factor is the relation of the city with the user. Or as de Waal & Dignum (2017) state, a group of human and non-humankind actors in one environment. Added values of IoT in a smart city can be efficiency, safety, healthcare and socialization (Smit, 2017).

Making an airport smart will have a two-fold goal. One, improving the passenger experience before the journey and in the terminal. Two, achieving operational efficiency in the airport (IoT Innovation, 2017).

In line with DAP, different initiatives at Schiphol are creating digital solutions in different airport processes. For instance, a department focused on IoT works on smart solutions for the aircraft stand (Product Owner at the airport, personal communication, 2018). Schiphol NeXt explores smart mobility solutions such as 'Mobility as a Service (MaaS)' to provide an end-to-end seamless journey.

The stream 'Smart Roads', focuses on the digitalization of roads through the placement of sensors (Junior Developer at the airport, personal communication, 2018).

In order to monitor the available data, two dashboards have been developed; IPO and Wilbur.

The function of IPO is to analyze data in relation to the performance of a KPI. Hence, the user groups are the process and service owners who can examine the performances of their processes. The data is uploaded the day after measuring and means it is not real-time.

The second dashboard is Wilbur, the objective of this dashboard is to use the data for managing day-to-day operations. Unlike IPO, this dashboard does provide real-time data. Wilbur is used by the directors in the control centers, who can control the situation and act if necessary. More information about the dashboards can be found in appendix M and X.A.

The current data in these dashboards are mostly in and around the terminal. Little information is communicated with passengers. Information that is being communicated are the real-time waiting times at security. It is interesting to see how this can be extended to further regions and be used for the passengers.

2.2 MOBILITY TRENDS

The scope of this thesis is the improvement of landside connectivity through the use of IoT. Within IoT, there are many possibilities for smart mobility. Relevant trends will be explained in the following sections.

2.2.1 MaaS

Traveling from point A to point B can be done by different modalities. Nowadays, there are various journey planning apps available for both public transport and private transport. Ideally, these planners will come together into one common platform for an improved user experience (Goodall, Dovey, Bornstein, Bonthron, & Daberko, 2017).

Next to providing a multi-modal platform, it is valuable to improve the way people pay for their transport. Payment of transport also exists of many options,

especially if one changes modality.

Earlier, public transport operators have worked on single-tickets solutions usable for all public transport services (Li & Voegelé, 2017). In the Netherlands, the OV-Chipkaart was developed to use for all public transport modalities. However, other trends such as car and bike sharing services, require other payment methods than these single public transport cards.

MaaS (Mobility as a Service) is a platform with all means of transportation and one-off payments (MaaS Global, n.d.). With this service, the user will be provided with a personalized journey according to its preferences.

Since it is a novel concept, there are some challenges that can occur. Li & Voegelé (2017) listed several potential challenges; the public transport system can be inadequate, e-ticketing cannot be possible, stakeholders are not willing to share data or stakeholders don't accept e-payment.

Nonetheless, there are several examples of MaaS in the world, with Whim being the world's first to include more than public transport; the app covers taxi, car rental and bike sharing (Whim, n.d.). The payment can either be done per ride or on a monthly basis. Other examples of MaaS and integrated planners are shown in table 1.

App	Modalities	Region	Payment	Remarks
Whim	Taxi Car rental Bike sharing	Helsinki, Finland Birmingham, England Antwerp, Belgium	Per journey Monthly	Shows prices and time
Tranzer	Train Tram Bus Taxi	Netherlands	Per journey	Shows prices and time
Wegfinder	Train Tram Metro Bus Uber Taxi Bike sharing Scooter sharing Car sharing	Austria	Per journey (only for public transport)	Shows prices and time
Wienmobil	Train Tram Metro Bus Car sharing Bike sharing Taxi	Austria	Per journey (only public transport and in Vienna)	Shows prices and time

Table 1: overview of known MaaS applications

App	Modalities	Region	Payment	Remarks
GoAbout	Car Bike Train Tram Bus Metro	Netherlands	No payment	Only information is being provided. Shows time and no price.
Moovel	Train Bus Car sharing Bike sharing Taxi	Stuttgart, Germany Hamburg, Germany, Berlin, Germany Portland, USA	Per journey	Route planning is worldwide. Booking and paying in Germany
UbiGo	Train Bus Metro Car sharing Car rental service Taxi Bicycle	Stockholm, Sweden	Monthly subscription	Pilot has been done in Gothenburg, will be launched in Stockholm
Go Denver	Train Bus Metro Taxi Car Car sharing Bike sharing	Denver, USA	No payment	Only information is being provided

It can be seen that many of the apps do not provide all services needed for MaaS. Some are limited to a small region, some don't include payment methods for all modalities. Other apps don't include all available modalities and several apps only show the possibilities and link the services to their original apps (e.g. Car2Go). There are many things that can be improved within this area.

More importantly, can MaaS go beyond a region or country, and provide end-to-end journeys worldwide?

App	Modalities	Region	Payment	Remarks
Car2Go	Car	28 countries	Per minute, per 2 hours or per day	User drives privately
ViaVan	Van	Amsterdam London Berlin	Per ride	Shared transport service with driver
MoBike	Bike	Several countries	Per ride or per number of days	User cycles alone
OV-bike	Bike	More than 200 train stations in the Netherlands	Per 24 hours	User cycles alone
Felyx	Scooter	Amsterdam Rotterdam	Per minute	User drives alone
Greenwheels	Car	Netherlands	Per ride and monthly	User drives privately
UberPool	Car	Several countries	Per ride	Shared transport service with driver

Table 2: overview of modality sharing apps in the Netherlands

2.2.2 Car sharing

Nowadays many people drive in their own personal car. However, in recent years a new trend, car sharing, has started to become more popular. In addition to car sharing, sharing of other modalities also became more popular; bike, scooter, taxi sharing for instance. Table 2 gives an overview of sharing services in the Netherlands. Sharing can mean that the owner shares his/her own car when it is not in use. Or, it can mean that the car is owned by the company and shares it with everyone, hence there is no personal ownership over the car.

The sharing trend goes further than the Netherlands. In 2017 there were 10 million members worldwide. This is expected to increase to 35 million members by 2025 (Waszkowski, 2018).

2.2.3 Autonomous vehicles

Together with the vehicle sharing trend, self-driving vehicles are expected to become part of traffic as well. Deloitte (2016) expects shared autonomous cars to be introduced in 2020 and personally owned by 2022.

The technology of autonomous vehicles already exists. There are a number of examples of autonomous metros in for instance Seoul and Copenhagen. However, for vehicles that have to participate in traffic and be driving amongst people, the technology has to be tested to solve safety issues (figure 6). Another concern are the legal issues, in case of an accident, who will be responsible, the software or the passenger?

When introduced, autonomous vehicles can make a big impact on the way people travel, the infrastructure of cities and roads. However, there are quite some challenges that need to be solved before introducing the autonomous car.

2.3 FUTURE AIRPORT

Airports keep innovating and integrating new technologies for the best operation and passenger experience. Some of the innovations are explained in the following sections.

2.3.1. Biometric sensors

Seamless flows at airports is a hot topic. One development for the seamless flow is the use of biometrics for authenticating the passenger for faster and more secure self-service processes (SITA, 2018). Biometrics are unique features of people such as fingerprints and facial measurements.

2.3.2. Security

Security is an important step in the journey where passengers are screened if they can be of any harm or carry prohibited items (ARUP, 2016). Caves & Pickard (2001) state that screening is one of three most stressful experiences. To both improve the passenger experience and reduce the security waiting times a security cart has been developed as part of the PASSME research program. This cart can be used to seamlessly walk through security without any stuff that needs to be unpacked and checked. The cart, with all your belongings on the cart, goes through a separate scanner which scans for prohibited or dangerous items (PASSME, 2018).



Figure 7: articles with accidents. From left to right IOL (2018) and Guardian (2018).

2.3.3 Remote processes

With the growth of worldwide passengers, repositioning processes will become relevant in a few years.

Moving tasks earlier in the journey already proved to help. For example, the online check-in and speed baggage drop-off significantly reduced the waiting times in the terminal. Creating more remote processes can help reduce the waiting times even more. A nice example is the door-to-door baggage service that ships your baggage before you. This means the passenger is not required carry the baggage to the airport and check-in at the terminal, everything is arranged by the a pick-up service (PASSME, 2018).

2.2.4 End-to-End journeys

When travelling abroad, there is a tendency to think about smaller journeys that are part of larger journey; home to airport, airport to airport, airport to hotel. With blooming technologies as MaaS and biometrics it can become accessible to go towards end-to-end journeys whereby the airport is just a 'station' to change modality (Innovatie Manager at the airport, personal communication, 2018).

2.4 CONCLUSIONS

In this chapter, technologies and trends relevant for the context of this thesis have been explored. The position of Schiphol within IoT has been explained and further in this thesis the possibilities will be explored. By means of the two dashboards Schiphol measures the passenger flows and waiting times by means of Blip sensors. Some of these measurements are being translated to waiting times and communicated to the passengers with screens and on the website. The information is real-time and the next step is to use the system for predicting waiting times and mass of passengers. Other data is used for generating insights about the capacity of a specific area.

The two dashboard IPO and Wilbur are a good start of generating data, but how can this data be used for a better

passenger experience and operation efficiency? What other information is required for creating an integrated system for both passenger and airport?

Trends in connected devices and mobility can be valuable for airports to develop integrated smart systems. As explained, these smart systems can be distinguished in three behavior types, the collector, the actor and the creator.

Translating this into mobility can be beneficial for the operation of an airport by creating patterns in behavior and data to get a better understanding of the flows and capacity. In return, the patterns can be used to predict situations beforehand.

For passengers, integrated smart systems can be used for personalized advice and information at any time.

3

INTERNAL ANALYSIS

For day-to-day operation of the airport, all activities are managed with their own processes. The department Operations (OPS) is responsible for improving and optimizing these processes with a scope of 0-5 years. Their vision is reflected in the CONOPS initiative where the aim is to improve the passenger experience by achieving operational excellence. Processes can be divided in four areas; airside, landside, passenger and baggage. For this assignment, the focus will be on landside connectivity processes.

Landside connectivity can be divided in four areas; departure area, Schiphol Plaza, Maaiveld and train platforms. Of these four areas, the train platforms are not owned by Schiphol, but belong to ProRail.

This chapter explores the current situation of these areas to create an understanding of the present bottlenecks that occur.

3.1 INTRODUCTION

The first section is a description of the used methods for the analysis and an introduction of the explored areas. The research aimed on understanding the current and future challenges that Schiphol can face.

3.1.1 Current infrastructure

Most processes are carried out at Schiphol Centrum, the area in front of the terminal (figure 8). All the processes result in a complex situation. Therefore, the research will focus on this area. Within the first section an explanation will be given of the relevant areas at Schiphol Centrum.

The areas at Schiphol Centrum can be divided in three levels: plus one, zero and minus one. Figure 9 gives a first impression of these three levels.

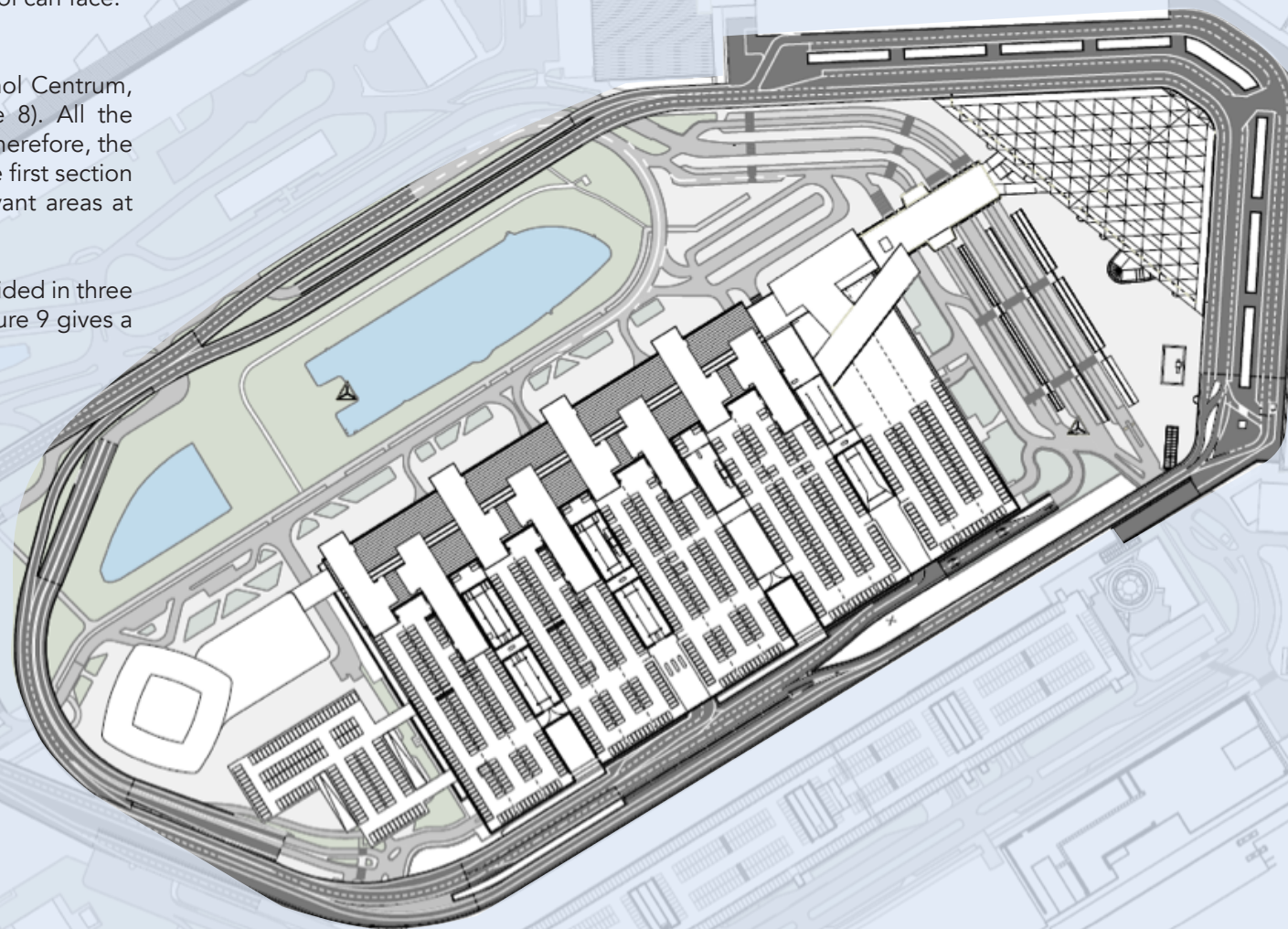


Figure 8: 2D visual map of Schiphol Centrum (Schiphol Group, 2017d)

Figure 9: photos of the three levels: +1, 0, -1. Left to right: level one, two of level 0 and level -1.



Departure area (+1)

The departure area is located on the first floor in front of the departure halls. Within this area the Kiss and Ride (K&R) and services lane can be found (figure 9).

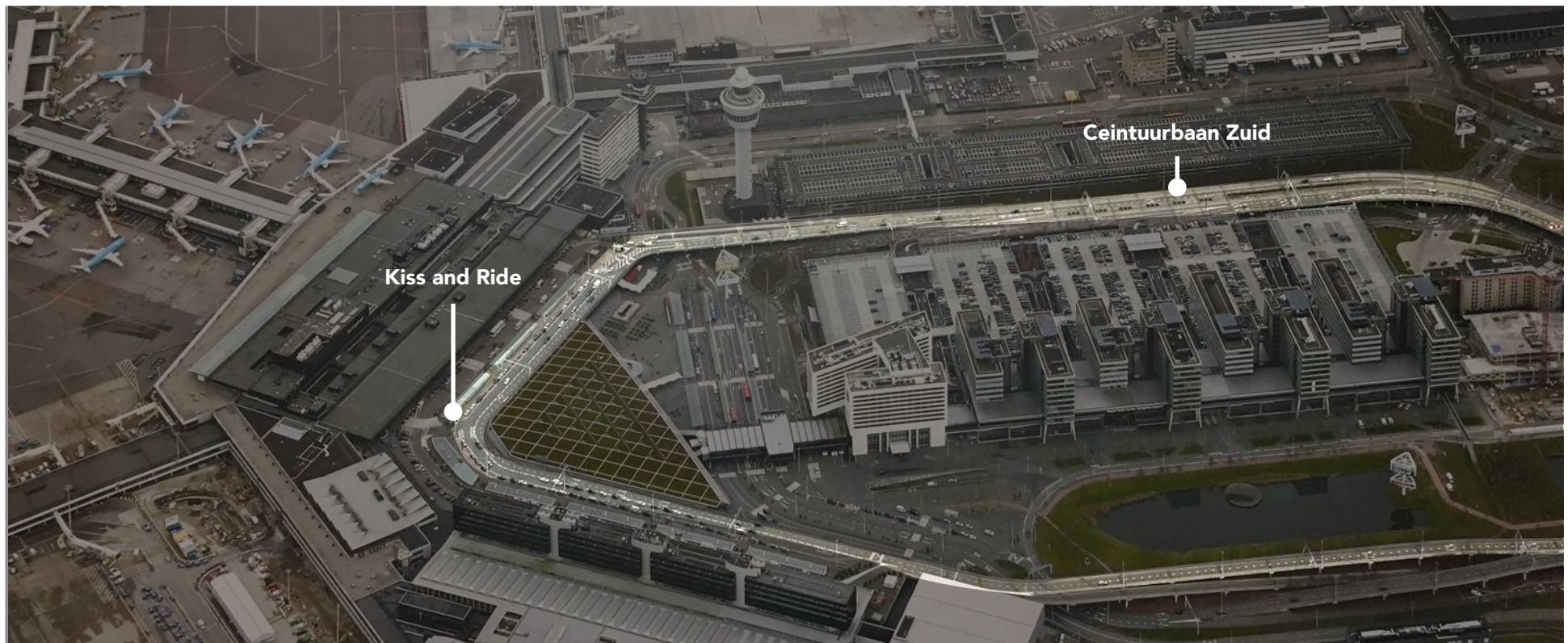
The K&R is a public space and free of charge. It is the only free process at Schiphol to drop-off passengers.

The services lane is only accessible with authorization. Thus, services such as taxis, Schiphol valet parking, hotel shuttles and touring cars can use that lane.

The purpose of the K&R and the services lane is to drop-off passengers only, picking passengers up is not allowed. An overview of the purposes of this area can be seen in figure 10.

An important connection to the K&R is the Ceintuurbaan Zuid (figure 10). This is the road from the highway to the departure area. As soon as something happens here, the congestion can intensify till the highway.

Figure 10: departure area existing of the Kiss and Ride and Ceintuurbaan Zuid.



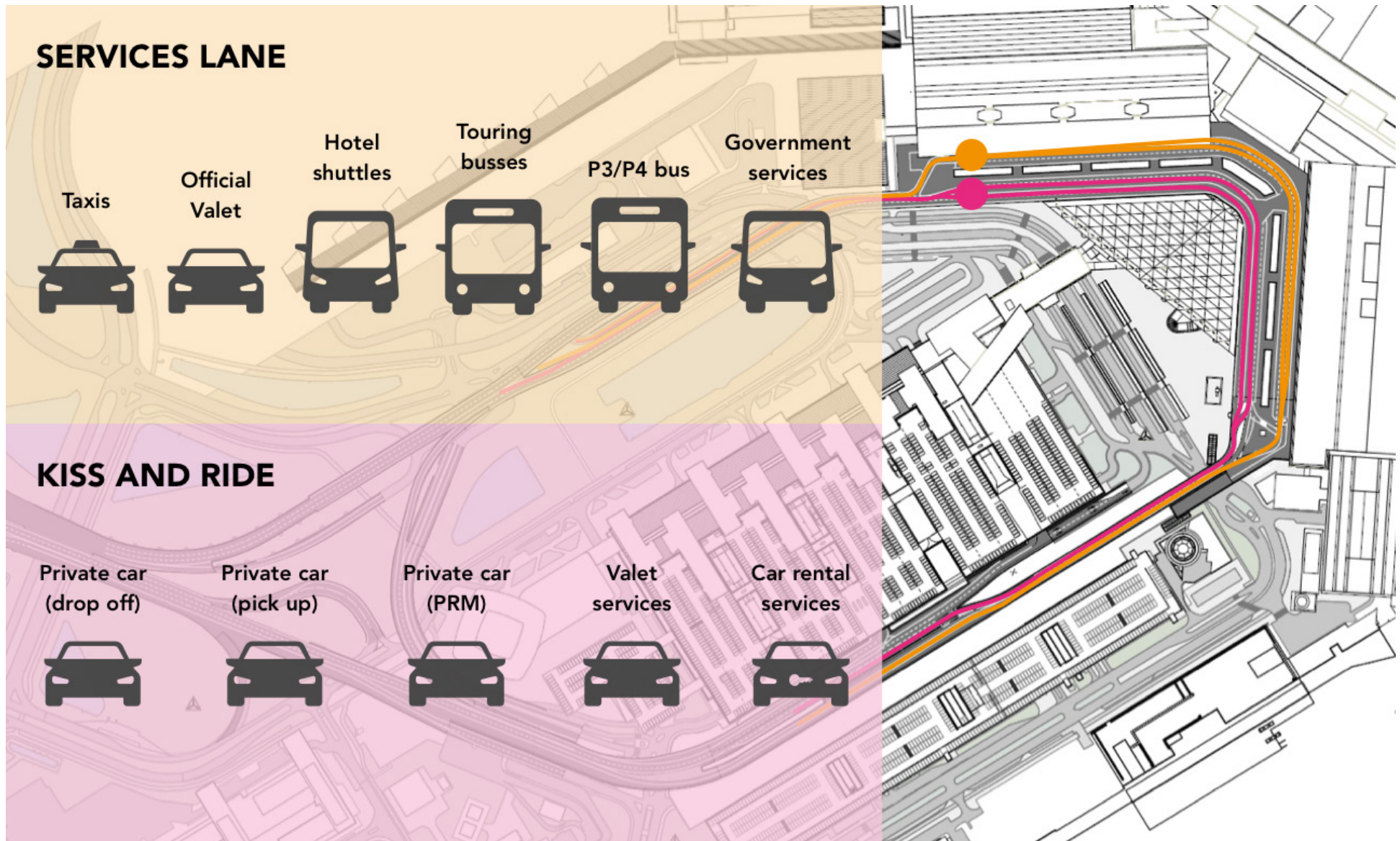


Figure 11: overview of processes at the departure area (Schiphol Group, 2017e)

Schiphol Plaza (0)

Schiphol Plaza is located in the terminal with many facilities such as stores, restaurants, bars and transport information. Passengers can find services such as ticket vending machines, stores, baggage carts, disabled wheelchairs, car rental, seating and phone cells.

Plaza is located on the ground floor of Schiphol and is a public space. It is an area where different flows come together. Passenger/employee flows from the train, bus, taxi, arrival halls and offices come together in Plaza (figure 12).

Schiphol Plaza facilitates many services within that one area. See figure 12 for a more detailed map of Plaza.

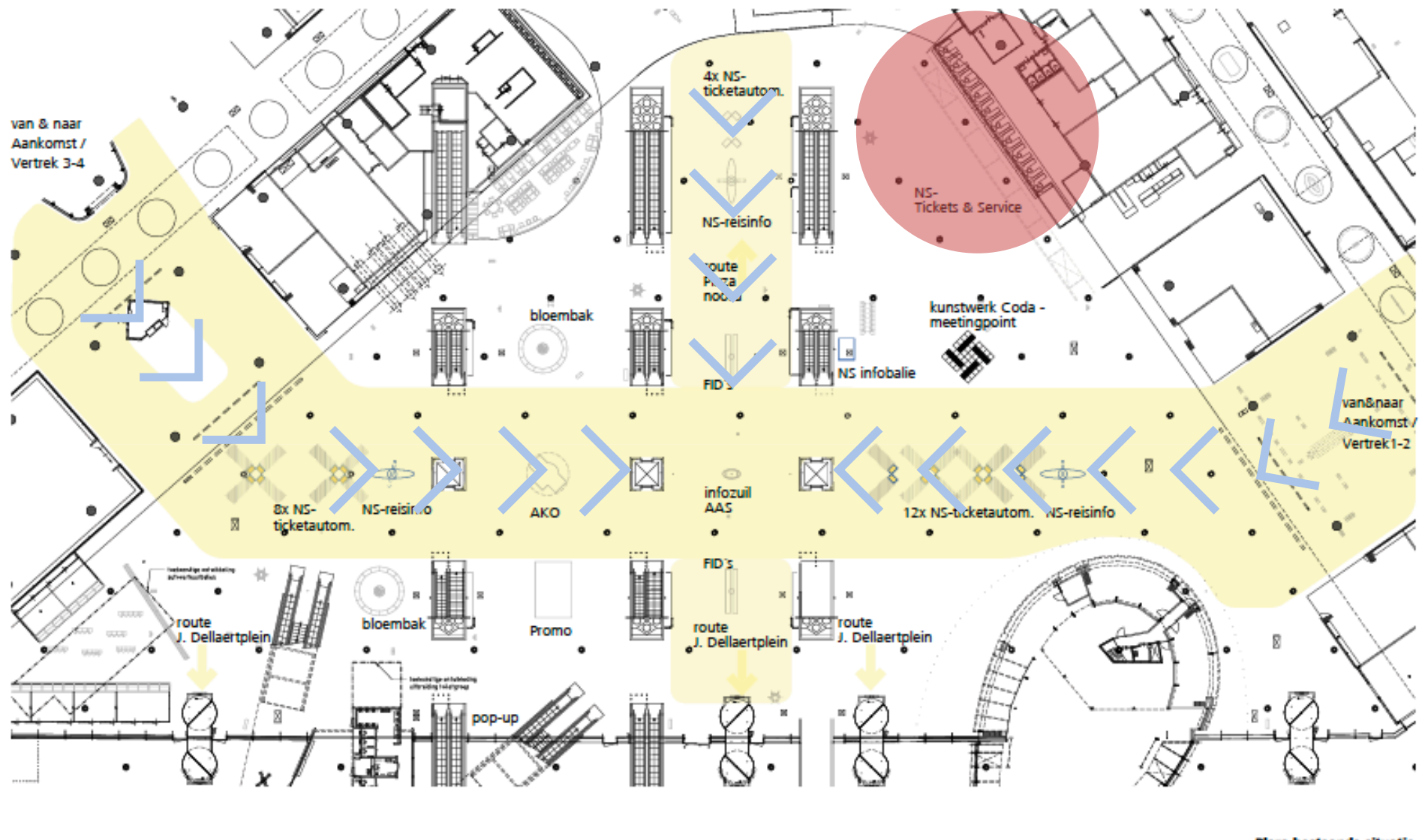
The image is not up to date with the situation in October 2018, the meeting point has been removed due to the re-organization of this area. Subsequently, a new meeting point has been placed between platform 5/6 and 3/4 (figure 12).

Schiphol Plaza can be accessed by arriving passengers that go from the arrival hall to the trains or outside (figure 13). In addition, departing passengers can enter Schiphol Plaza from the outside or the train platforms. Outside the terminal the Jan Dellaert square at Maaiveld can be found.



Figure 12: 2D map of level 0 where Plaza is in the middle, connected to all the arrival halls. All the blue blocks represent the stores and other services.

Figure 13: the flow from the arrival halls to Plaza (Crouwel, 2017)



Arrival area (0)

The arrival area can be divided into the Jan Dellaert square and Maaiveld. The square connects Plaza with Maaiveld where all the processes for picking up take place.

Maaiveld can be divided into four lanes (ABCD lanes), where each lane has its own function. Figure 14 visualizes all the processes for Maaiveld. All lanes are forbidden for individuals.

Lane A and B are only accessible by the therefore authorized vehicles, these are the taxis, hotel shuttles and public transport busses respectively. Lane C is accessible for all modalities with transport purposes (touring cars, Ubers, crew transport). Lane D is only accessible for the Sheraton hotel. However, the Ubers use a small part of this lane to get to the dedicated Uber parking space (Service Owner Passenger at the airport, expert interview).

Train platforms (-1)

On level minus one, the train platforms can be found. The exit of these platforms ends in Schiphol Plaza, which provide an easy connection to the arrival and departure halls. There are 3 platforms with four elevation points for each platform (figure 15).

Parking

In addition to the areas on Schiphol Centrum, there are other locations to travel to or from Schiphol, the parking areas. There are several parking options around Schiphol.

The closest to the terminal is Terminal Valet Parking, here passengers can park their car on the services lane in front of terminal 2 and 3. In addition to the Terminal Valet, there is also P6 Valet, which gives the option to park for longer than 3 days in P1.

P1 – short parking. The main purpose of this garage is for short stay parking (0-48 hours parking allowed). Therefore, it is also used to pick up passengers. In addition, car rental companies rent some places to store their cars and as mentioned before the P6 Valet offers places for the passengers.

The parking garages are not all close to Schiphol Centrum, there are two official remote areas; P3 and P4. These two parking places are accessible by a free bus offered by Schiphol. P3 is only a few minutes away by bus, whereas P4 is around 10 minutes.

Moreover several parking places are available for employees, these are also remote (P30 and P40).

In addition to the official parking services, many third parties provide services such as valet and remote parking. However, these services are handled on the K&R.

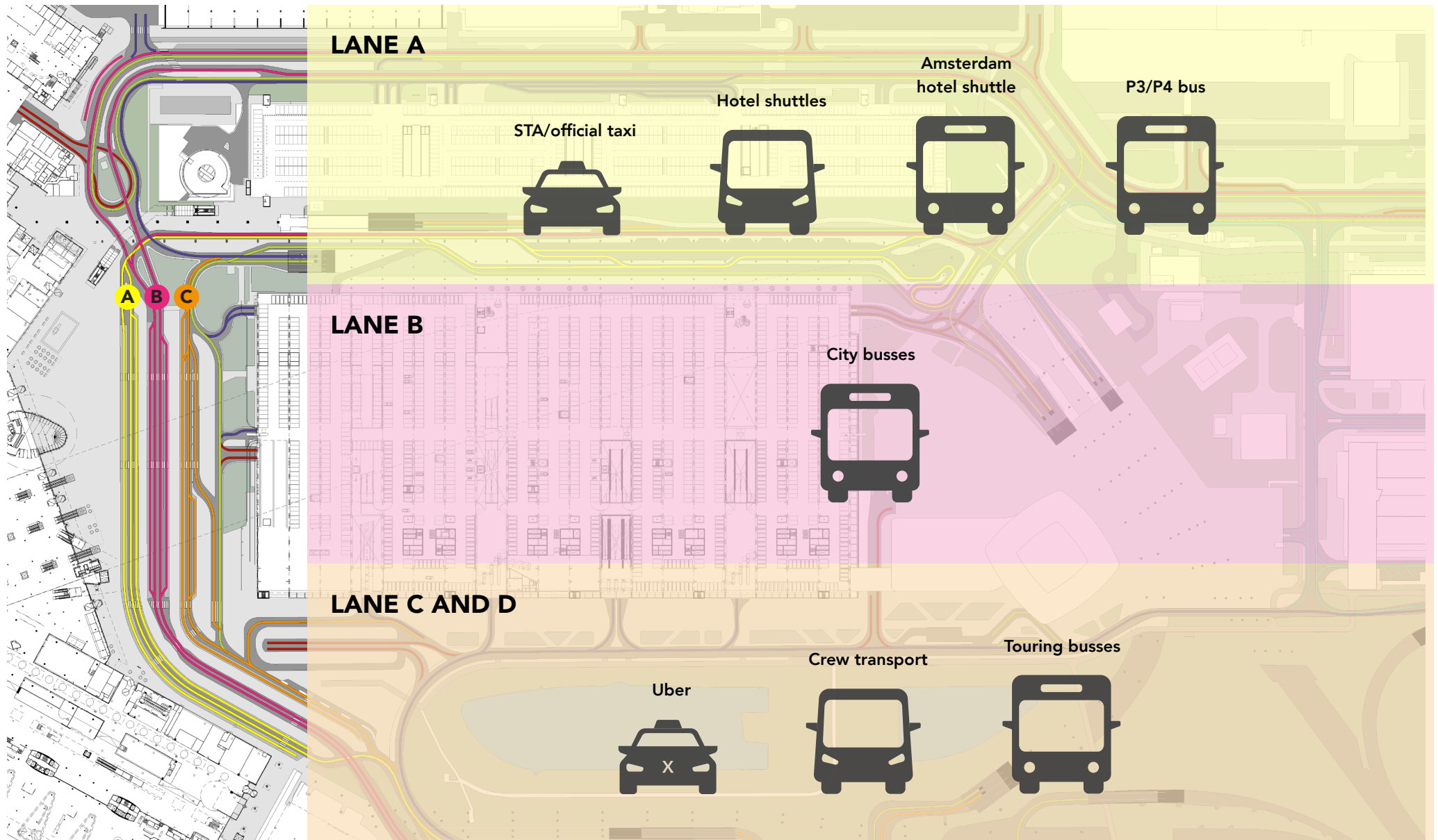
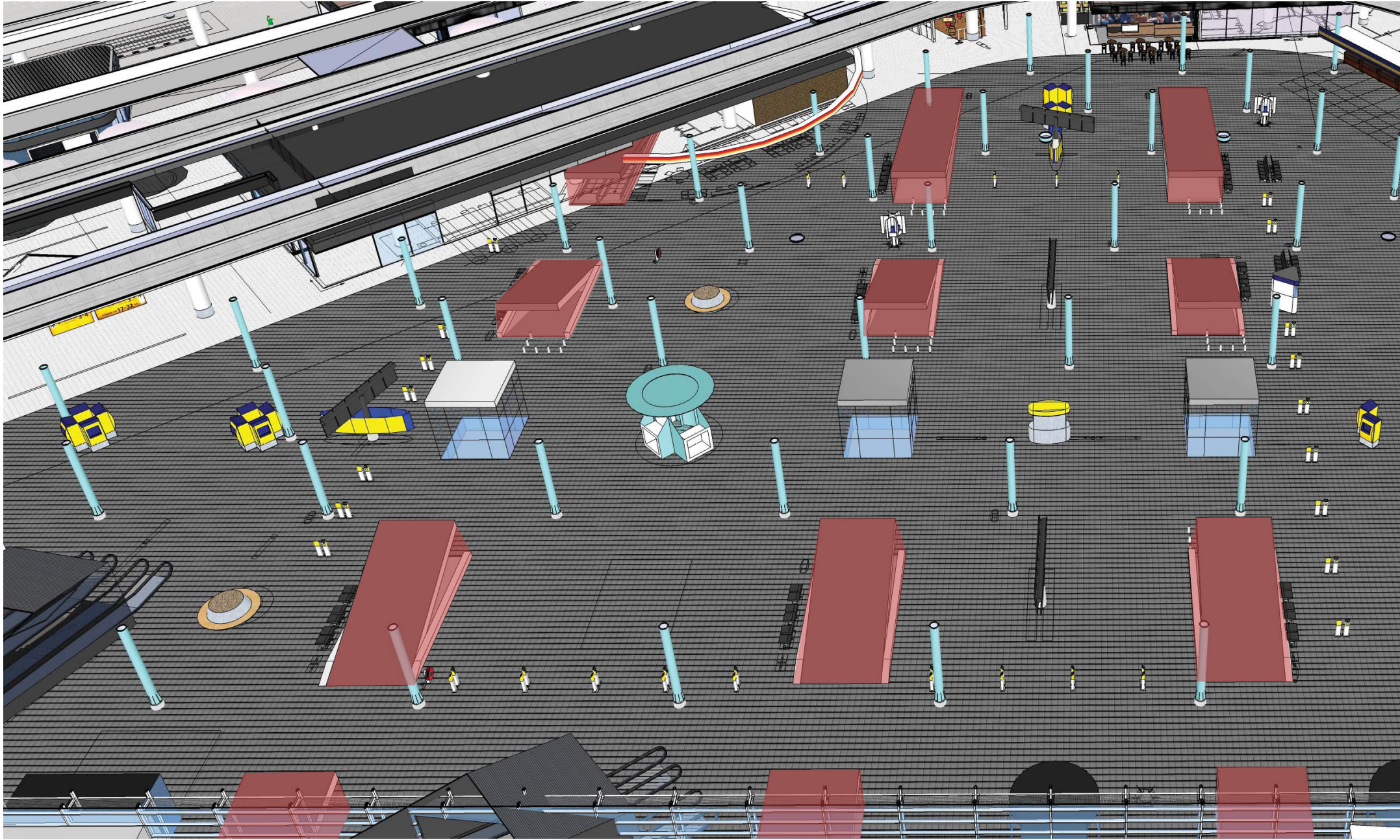
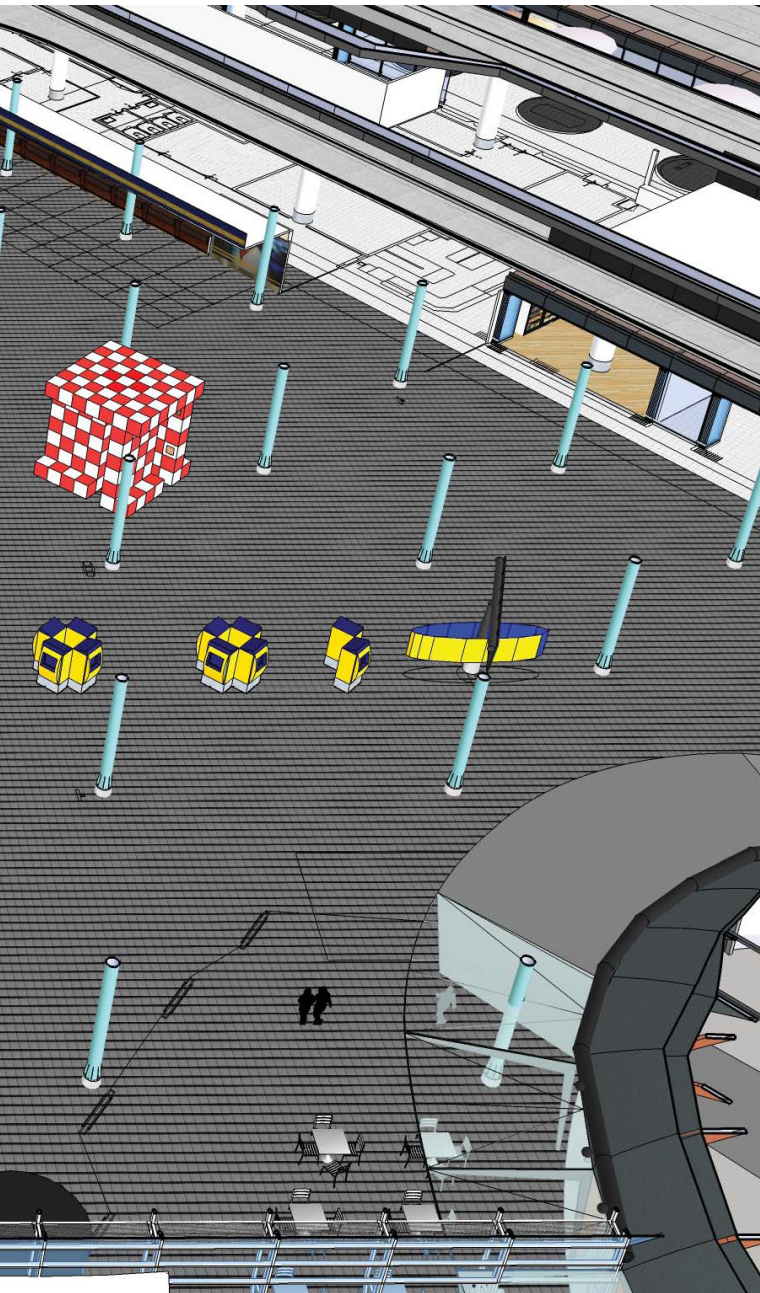


Figure 14: overview of processes at Maaiveld

Figure 15: all elevation points to go from Schiphol Plaza to the train platforms are highlighted in red (Crowel, 2017)





3.1.2 Methods

The different processes and areas at landside result in a complex situation. In order to gather insights about the current situation different methods have been used. The aim of the research was to understand which processes are carried within the four areas. Additionally, the goal was to recognize the current and future challenges that can be faced.

Expert interviews

To gather insights about situation at landside interviews have been conducted with internal and external stakeholders.

The aim was to create an understanding about the current and future challenges regarding processes connectivity, see appendix E for the setup. Process owners, service owners and developers have been interviewed to gather insights about their experiences and worries. Process and service owners are responsible for the overarching and more specific processes respectively. (appendix X.B for transcriptions).

Literature study

Scientific literature and internal Schiphol documents have been collected for understanding the infrastructure and division of landside processes.

Observations

Several observations have been done at Schiphol Plaza and Maaiveld to experience how passengers act and how the processes are actually being carried out (appendix F for setup).

3.2 CURRENT BOTTLENECKS

The second section will use the results of the methods described earlier for identifying the bottlenecks in the current situation. See table 3 for the distribution of passengers with regard to the choice of transport to and from Schiphol. As can be seen, the two largest groups are passengers travelling by train and car. Table 3 gives an overview of the percentages per modality.

Table 3: overview of percentages per modality and the according area (2017).

Modality	Percentage	Area
Train	39,0%	Schiphol Plaza
Dropped off/ picked up by car	22,7%	Kiss and Ride and P1
Taxi	13,4%	Maaiveld and services lane
Parking car	11,3%	Parking places
Bus	3,9%	Maaiveld
KLM-hotelbus	2,4%	Maaiveld and services lane
Taxibus	2,2%	Maaiveld and services lane
Other	1,2%	All areas

3.2.1 Departure area

A large segment of the passengers (22.7%) is being dropped off at Schiphol. The K&R is the only free location to drop passengers off. Therefore, it attracts many people to use the K&R for dropping off and picking up as well. The fact that people use the K&R for picking up is that there is no other free option. The official pick-up location is short parking in P1, for which the costs are €1 per 10 minutes.

After closing the free pick-up area in October 2017, the number of collectors on the K&R has increased by 30%. As long as short parking remains paid and the K&R free, people will use the K&R to pick-up passengers.

Maintaining the rule not to park and pick-up passengers is quite difficult, because there is no clear view over the K&R. Especially not in peak hours. Also, many collectors avoid being caught by driving circles and thereby prevent to park the car.

As mentioned earlier, the K&R is the only free option at Schiphol for dropping off and picking up passengers. Involving money with the K&R is a sensitive topic, making it paid will result in a lot of dissatisfaction (figure 16). What is interesting about this topic is the fact that Schiphol never worked this idea out in detail. A rumor somewhere, resulted in a lot of fuss and negativity around Schiphol.

To get a better understanding about the intensity, capacity and residence time on the K&R, license plate recognition systems have been placed in May 2017 (Service Owner Passenger at the airport, expert interview). This system generates the average residence time and capacity on a monthly basis (Junior and Senior Developers at the airport, expert interview). The data shows that in peak hours, the capacity is at the limit. With the new terminal and pier in 2025, the expected growth of passengers is expected to be around 40-50%, this will intensify the capacity problem, because the number of peak hours can increase (Schiphol Group, 2011). During peak hours 1200 cars pass the K&R in one hour on the K&R. It is expected that the maximum is around 1250-1300 cars, assuming everyone only drops passengers off. Currently, the data shows that in the busiest weeks (f.i. week 34 2018), the intensity was too high for 43 hours. On average this means 6 peak hours a day. However, it is also important to note than on less crowded days, the number of intensify hours per week can be reduced to 1 peak hour per day or even 1 peak hour a week (appendix X.C).

Figure 16: articles about the K&R. (From left to right: LINDA (2018), NOS (2018), GeenStijl (2018), Metro (2017), Lemkes (2018) and NPO Radio 1 (2018).

LINDA NIEUWS
WS SNACKS LIFESTYLE LINDA.TV ALLES O
KISS AND RIDE
DAT WORDT EEN KOSTBAAR KUSJE: IEMAND AFZETTEN OP SCHIPHOL GAAT GELD KOSTEN
Even snel iemand afzetten bij Schiphol maar voor die vluchtige kus en knik betalen. Dat bevestigt Schiphol nu in de Telegraaf.
17.07.2018 | 12:00 uur | Martine Schut
Hoeveel het gaat kosten, en wanneer het nog niet duidelijk.
SMAK (GELD)
Volgens ingewijden gaat het gaat om de wegbrenger. De reden dat de 'kiss & ride' bij Schiphol wil hiermee de milieuvriendelijke passagiersstromen van en naar de luchthaven. "We denken er serieus over na om het Schiphol duurzamer te maken en de passagiers te verbeteren", meldt een ingewijde.
HALEN EN BRENGEN OP SCHIPHOL NIET MEER GRATIS
De verkeersstoren op Schiphol. Foto: ANP
ELS ANKER 30 SEP 2017
Ga je binnenkort naar het buitenland of haal je een vriend of familielid op vanaf de luchthaven? Voor reizigers wordt het allemaal anders vanaf volgende week. Schiphol heeft meer ruimte nodig om de groei van het aantal passagiers te kunnen vangen. Daarom wordt er begonnen met de bouw van een nieuwe pier en een

NOS
71 km 8°
Kiss & ride bij Schiphol gaat mogelijk geld kosten
© DI 17 JULI, 8:07 AANGEPAST DI 17 JULI 2018
ECONOMIE
Iemand met de auto vlak bij de terminal op

U hoeft geen mensen meer af te zetten op Schiphol. Dat doet Schiphol zelf wel
326 reacties
Goedemorgen is het al 1 april? Nee, het is 17 juli en dat is geen 1 april: je gaat op Schiphol moeten betalen om iemand af te zetten. En zo is de allergruotste afzetter in dit verhaal toch weer gewoon Schiphol zelf.
Echt alles, maar dan ook alles, in dit land moet knaken kosten. Dan hebben ze dus zo'n vergadering en dan besluit de financiële pijp van het stel: laten we voor de lol maar eens geld vragen aan mensen

metro
IN HET NIEUWS VIDEO
Zoeken
In het nieuws
'SCHIPHOL WIL BETAALDE KISS & RIDE'
DRUKTE EN MILIEU ALS EXCUUS
68
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uur vc
Opinie & Commentaar
'Schiphol is hypocriet: zelfs Kiss & Ride gaat geld kosten'
dinsdag 17 juli 2018 | BNNVARA | Redactie De Nieuws BV
De grootste vervuiler van allemaal, Schiphol, komt op voor het milieu door de kleine vervuiler te beboeten. Volgens ingewijden gaat Kiss & Ride vijf euro kosten. Druktmaker Marcel van Roosmalen vindt het ronduit hypocriet, zegt hij in De Nieuws BV.
Druktmaker Marcel van Roosmalen - Schiphol

Auto Week
'SCHIPHOL WIL BETAALDE KISS & RIDE'
DRUKTE EN MILIEU ALS EXCUUS
JAN LEMKES
17 JULI 2018 10:18
Schiphol zou plannen hebben om geld te gaan vragen voor het afzetten van passagiers op de zogeheten 'Kiss & Ride'-strook, dus het gebied voor de vertrekhal.

Moreover, the data shows it takes approximately 1.5 minutes to drive from the beginning till the end without stopping in between. Additionally, it shows an average residence time of 7-8 minutes, which means dropping someone off takes about 5.5-6.5 minutes (Service Owner Passenger at the airport, expert interview). However, other factors can influence this data, such as the third-party parking services and the PRM (person with reduced mobility) parking spaces.

Passengers that use the official Valet Parking service of Schiphol can use the services lane for dropping off and picking up their car. However, third-party Valet Parking services are competitors of Schiphol and use the K&R to collect and inspect the cars that are being dropped off. It is not possible to send those companies away since it is a public space (Junior Developer at the airport, expert interview). In addition to valet parking competitors, other parties use the K&R for car rental services. Hence, the car is dropped off and picked up on the K&R. It is not allowed to park the car on the K&R, but only to drop someone off in a few minutes and drive away. However, the processes of valet parking services can require the driver to park the car and thus stay longer on the K&R than allowed.

Another influencing factor is the PRM parking spaces. There are 8 parking spaces for PRM where signs indicate an allowed parking time of maximum 1 hour. If these spaces are full, it is legally allowed to use any free space on the K&R with a valid disability card for a maximum of 3 hours. Unfortunately, people are misusing their disability cards and take up the space for unnecessary means (Service Owner Passenger at the airport, expert interview).

In addition to systems on the K&R, Blip track sensors have been placed on the Ceintuurbaan Zuid, which is the road from the highway to the K&R (figure 10).

Confidential

Driving up from Ceintuurbaan Zuid, people tend to stop at the first empty space they see. This causes the K&R in front of the departure hall 1 to be more crowded than in the back at departure hall 3. To distribute the flow on the K&R evenly, new signs have been placed to separate the flow to departure hall 1 from the flow to departure hall 2 and 3 (figure 17).



Figure 17: new signs prior the K&R

The current procedure for providing access on the services lane is done manually. Hence, a person pushes a button to open the barrier when he/she authorizes the driver. This is not an efficient and reliable process, because it is not always clear who is authorized to use the services lane. Therefore, it is planned to add new authorization systems that only allow vehicles with a registered license plate to use the services lane.

3.2.2 Schiphol Plaza

39% of passengers use the train to travel to/from Schiphol. In addition to the passengers, 20% of the employees also use the train to go to or leave their work (Meijering & Van de Werken, 2014). All train travelers use Plaza to get on/off the train. Additionally, Plaza can be seen as a transition area where people can change modality and find many options. Hence, Schiphol Plaza is an important area within the journey for both the passenger and employee.

Considering Plaza as a transition area, there is not a lot of information available about the possible modalities. Ticketing information is little, whereas there are many ticket options. Connexion provides, in collaboration with other organizations, many options for tickets to Amsterdam (appendix G). The placement of their ticketing machine however, is an interesting decision. Relative to the center of Plaza, the ticketing machine is placed in the back, in front of arrival hall 3 (figure 18). The machine has only four options, whereas there are quite more than four Amsterdam ticket options available. On the side panel of this machine, a map with the routes to touristic locations in Amsterdam is shown. It is a nice idea, but the placement is again unfortunate (figure 19).



Figure 18: location of the ticket machine in relation to Plaza (Schiphol24, n.d.)



Figure 19: the obstruction



Figure 20: crossing in plaza with signs in every direction.

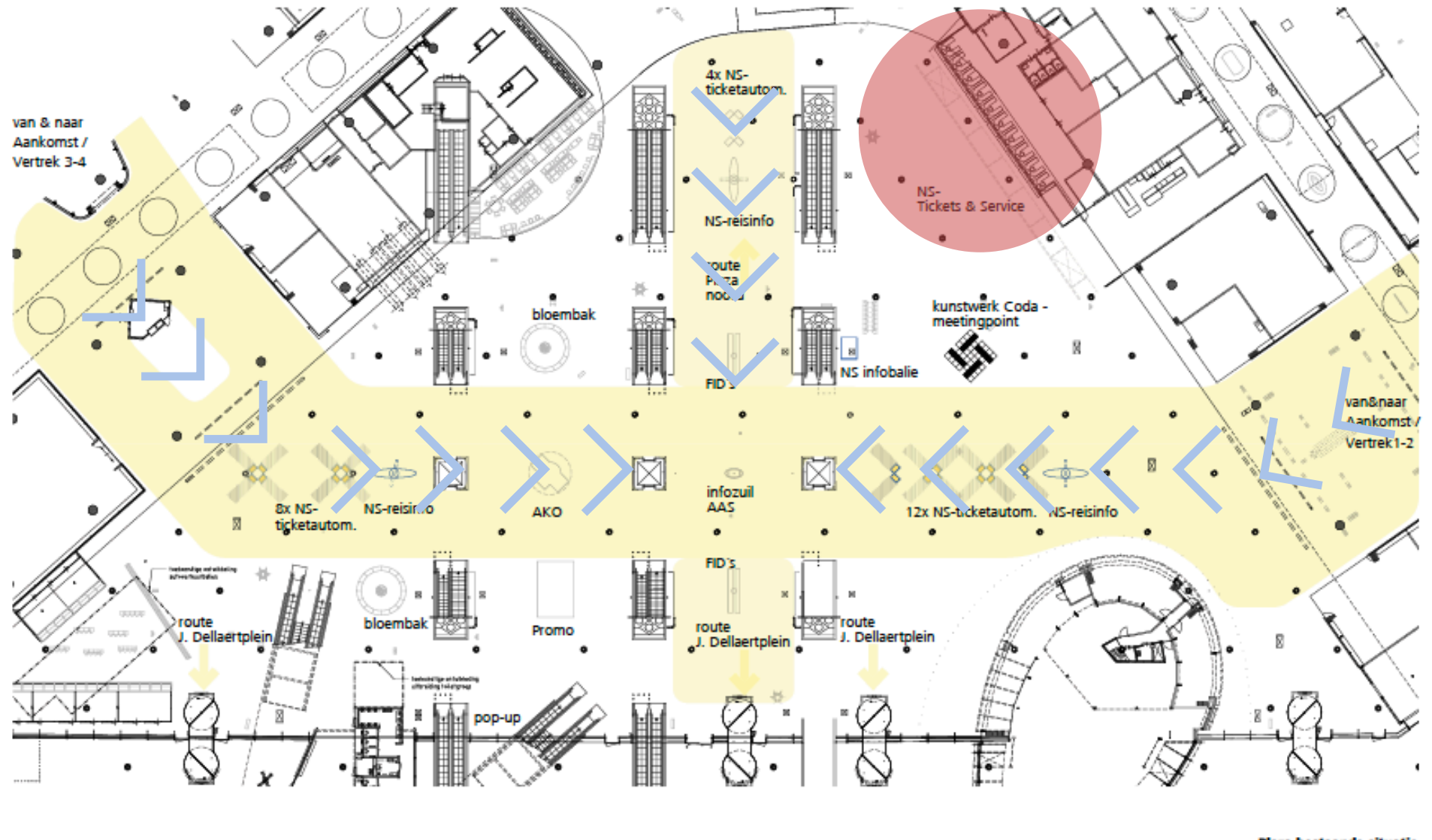
Most given information at Plaza is static and not always up to date. Moreover, crossroads in Plaza show a lot of information, which can lead to information overload (figure 20). Passini (1996) explains that people are able to ignore information they do not need, however the more information the more time it will take to do so. Train assets and train related information is attracting most attention at Plaza. There are 24 ticket vending machines, many check-in poles, an information points and a service desk (figure 15). Looking at the demand it is required to facilitate all those assets, however information about other modalities can be missed by the passengers.

The large screen on the wall (figure 21) provides information about the train schedules/platforms, bus platforms and time schedules. This information is only relevant for arriving passengers. However, arriving passengers walking from the arrival halls towards the train and bus won't see this because it is positioned towards their back (Kuijk, 2017, figure 22). At the same time, the arriving passenger is the largest group using Schiphol Plaza (Schiphol Group, 2018a).



Figure 21: the large screens with train and bus information.

Figure 22: visual of the main flow from the arrival hall towards Plaza (Crowel, 2016). The highlighted circle shows the position of the service desk.



While observing in Plaza it has also been noticed that the smaller screens in front of the train platforms experience quite some disruptions and don't show the correct times/trajectories at all times (figure 23). This causes confusion before getting on the train, since it is not clear which train one is boarding.

The ticketing machines are placed within the main flow from arrival hall 3-4 and 1-2, so when it becomes crowded at those points, other flows are being obstructed (figure 22). If the ticketing machines are placed somewhere else and not in the pathway, the line might not obstruct the view (Crouwel, 2016). There is an initiative to rearrange the position of the ticketing machines, whereby the goal is to remove them away from the main flow (Crouwel, 2017). It has been proven that by already removing one object in Plaza, the view can become much clearer. In September 2018, the iconic red-white meeting point has been removed and a new one has been placed between platform 5-6 and 3-4 (figure 24). However, passengers that are familiar with this meeting point are confused when arriving at Plaza, since there is no wayfinding point towards the new meeting point. Moreover, the new meeting point is placed within the main flow of the passengers as well, this obstructs the flow towards the platforms.

A good flow can also be influenced by wayfinding. Wayfinding design involves spatial layouts, architectural and graphic communication (Passini, 1996). The layout of a building can positively influence the ease of wayfinding (Baskaya, Wilson, & Özcan, 2004). Plaza is a large open space with services spread out. The wayfinding is both being obstructed by congestion as well as by the presence of many signs. In addition to the older signs, new signs are being added for new services. An example of such a new sign, is the arrow on the floor pointing towards the official Schiphol taxi (figure 25). This sign is placed underneath an older sign point towards STA – Schiphol Transfer Assistance (figure 25) Those two taxi services are offered by different companies and located in different places. Showing too much information at one spot can result in confusion.



Figure 23: wrong information on the screens



Figure 24: obstruction in the flow due to the long line at the new meeting point



Figure 25: signs that are similar can cause confusion in the wayfinding

Another important topic is the number of train travelers to/from Schiphol. As mentioned, many passengers and employees use the train to go to/leave Schiphol.

However, passengers are not the only train travelers at Schiphol. Non-flying travelers use Plaza as a transition area to go to the next step of their journey. This intensifies the crowd even more.

In cases of disruptions and delays in the train schedule, the travelers have no other option than to wait in Plaza or to use alternative modalities departing from Maaiveld.

Currently, information about disruptions are communicated via the NS-app and via auditory messages on the platforms. No visible information is provided in Plaza for the passengers waiting. Instead, passengers stand in line in front of the service desk asking how to continue their journey.

Schiphol wields a capacity norm for flow areas (Schiphol Group, 2017f). Exceeding the norm can result in large groups of people that have a low walking space. In extreme situations, crowd management can get out of hand (Schiphol Group, 2018c). For that reason, Schiphol is constantly working on contingency plans together with involved stakeholders such as NS and ProRail to create plans for delays or disruptions with a big impact.



Figure 26: waiting times information at security (Veovo, 2018)

3.2.3 Arrival area

From Schiphol Plaza passengers can walk to Jan Dellaert square to go to Maaiveld. As mentioned, Maaiveld facilitates picking up processes for arriving passengers.

One of the well-regulated processes is the taxi process of the official Schiphol Taxi (figure 25).

The system works with a remote taxi buffer and a Taxi Regulation System (TRS) which makes sure the taxi stand is never empty. The remote taxi buffer facilitates parking spaces for 184 taxis (Service Owner Passenger at the airport, personal communication). On Lane A at Maaiveld there are 14 positions for taxis. 10 of those 14 are always used by one of 3 companies that have a contract with Schiphol. The 4 other positions are available for the open market, also called: additional transport. Schiphol is responsible for monitoring the quality and the process of the buffer and taxi stand. To provide quality the companies have to meet several requirements such as being sustainable. This is the reason that most of the taxis are fully electric. The process is well-regulated, but the communication about the taxis can be improved. The screen in front of the line is static and does not provide information about the waiting times or other destinations than Amsterdam. Blip sensors have been placed, but not connected. After these sensors are connected, the goal is to provide information about the waiting times, just like at security (figure 26).



Figure 27: the official taxi stand on lane A, Maaiveld

On the same lane the Schiphol Transfer Assistance (STA), hotel shuttles and P3/P4 bus depart as well. These are all means of shared transport. The STA is not an official Schiphol service, but has a contract to use part of the lane at Maaiveld. Passengers can order a taxi prior to their journey and be picked up at the arrival hall. It is mostly shared transport, so by combining routes of different people, the taxi will bring everyone to their end destination separately. VIAVAN, a taxi sharing organization, collaborates with STA as well. A Service Owner Passenger at the airport (personal communication) however, mentioned that STA is mostly being used for private rides and not for shared rides. Due to the lack of marketing and trust of the company it did not become a major success.

Hotels that are within a range of 10km of Schiphol Centrum are allowed to pick passengers up on lane A. There are 11 hotels that use this lane. There are no arrangements, but only a few rules that for instance it is not allowed to use more than one bus per hotel. The timeslots are all arranged by the hotels and communicated via a board (figure 28). Information about the timeslots are not provided by Schiphol, but are left to the communication of the passenger with the hotel.

As can be seen from the infrastructure of Maaiveld (figure 12), there are a lot of different bus services available; hotel shuttle, touring cars, city bus, P3/P4 bus and Amsterdam shuttle bus. These busses are spread out over three lanes and lack the clear overview of which bus to take where. In order to find the right bus passengers have to cross lanes to walk around, which result into dangerous situations). Information about which bus to take from which bus stop is not easily found. For instance, the screens for public transport busses are facing one direction what results into a lack of visibility of the information (figure 29).

The city busses on lane B are offered by different companies (Connexion, GVB, R-Net, Snetnet, Q-liner and Arrive). There are two main bus flows; busses that drive around Schiphol (mainly for the employees) and busses that go beyond Schiphol towards other regions. There are also direct lines with Amsterdam City Center. From all these options, only 2.9% of all passengers use the bus for their journey to/from the airport.



Figure 28: board with information about the timeslots of hotel shuttles



Figure 29: screen with information pointing one direction

Not choosing the bus can be caused by the lack of comfort or simply not knowing that there are busses to the city center. As explained before, the information passengers are confronted with in Plaza is mainly focused on train information.

One of the other bus services are the touring cars. Touring cars use lane C, which is the only public area that is free to use by transport companies. Since it is free and there are no monitoring systems available, the touring cars take up a lot of space on lane C because they wait for the bus to be full. Some busses pick up large groups of passengers that are part of a tour, other busses (i.e. FlixBus) wait for individuals that booked their ticket in advance. It can occur that the passengers are arriving with other flights, which results in long waiting times for the busses. There is a lack of capacity, and touring cars that wait for a long time don't help in releasing some pressure on the capacity. To solve this, it is interesting to explore the possibilities of a Just-in-Time system for these touring cars (Junior Developer at the airport, personal communication).

As mentioned, lane C is the public space where transport modalities can pick up their passengers. This is also the border for taxi recruiters that stand there to pick up passengers (especially foreign passengers). These recruiters ask double the price for a single ride to Amsterdam. Unfortunately, there are no warnings about these kinds of activities, so it does occur that passengers are being scammed. This can be prevented by providing information about these activities in Plaza or someplace else.

For gathering and monitoring data, Schiphol developed the dashboard IPO, which stands for Integrated Process Control Operations. The goal is to make sure everyone has the same data and is able to draw conclusions from the dashboard to use in order to meet the KPI's. Currently, GOVI data (data from busses) is added in this dashboard, which helps monitor the timeslots and changes (appendix M). However, this is purely based on process management and achieving the KPI's. Data and information monitored in IPO is not yet used for communication with the passenger. Blip data from the taxi stand is in progress and will be used for communication purposes towards the passenger.

3.2.4 Train platforms

On level minus one the train platforms can be found. Most passengers use the train to travel to and from Schiphol airport. The operator is the NS, Dutch Railways, and the owner and manager of the tracks and station is ProRail. ProRail is responsible for the traffic control and time slots of the routes. "There is not capacity anymore", a statement made by ProRail that already shows the capacity problems regarding trains in the Netherlands (figure 30). The same problem occurs at Schiphol.



Figure 30: article about the capacity problem around the train tracks (NRC, 2018)

Together with the growing number of passengers this results in congestion on the platforms and Plaza. There are sensors on the train platforms to monitor the number of pax/m². As soon as it becomes too crowded and thus dangerous it is possible to take action to prevent accidents (Development and Policy expert at railway company, expert interview).

Because the elevation points are centered on the platform the passengers stay centered. Therefore, staff is present to distribute the passengers over the platforms on a daily basis (Development and Policy expert at railway company, expert interview).

The most crowded tracks are 1 and 2, the train towards Amsterdam Central Station. Simultaneously, these are the smallest platforms, which results into even more congestion.

Congestion is caused by passengers that are not equally distributed over the platforms. ProRail and NS provided large screens on top of the platform to distribute the passengers. However, this has not been proven to work. The content on the screens is too static and does not show other information than the placement of the doors (figure 31). The placement of the screen itself is not optimal either, the vertical range of people is approximately 15 degrees (Schultz, Schulz, & Fricke, 2007). The platform is quite narrow, so to see the screen, passengers are required to look up.

Confidential

3.2.5 Parking

Distributed over Schiphol several parking places can be found, differing from distance and price. The official parking services have their own dedicated areas. However, the third-party parking services, in other words the competitors of Schiphol, use other areas for their services. The bottlenecks around these services have been discussed earlier.

An important garage is P1, in this garage there are different services offered. The purpose of this garage is for short stay passengers (0-48 hours parking allowed). Therefore, drivers are also sent to this parking garage to pick up

passengers. However, the high price makes it unattractive for passengers to park there. As mentioned earlier, as long as P1 is paid, most passengers will use the K&R. There are discussions about making the first 15 minutes free or relatively cheap in order to attract more collectors to go pick up their passengers from the garage. However, if more passengers go to P1, capacity problems can arise. In P1 parking places are reserved for other services such as car rental and Valet. This means, not all parking places can be used fully.

Furthermore, competitors offering services are attractive to passengers due to the high prices of Schiphol. If there is a cheaper option available, there will always be passengers using that option. Even if it is not as reliable as the official service.

Furthermore, competitors offering services are attractive to passengers due to the high prices of Schiphol. If there is a cheaper option available, there will always be passengers using that option. Even if it is not as reliable as the official service.



Figure 31: the screens on platform 1 and 2

3.3 INFRASTRUCTURE DEVELOPMENTS

Together with the new terminal and pier, Schiphol also has plans for the infrastructure. Some of these plans are required for better connectivity to the new terminal. Other plans are there to provide more capacity for all the processes with regard to landside.

Unfortunately, not all of these plans are guaranteed to be realized. One day it can be decided to discontinue the plan or plans. However, it is good to take them into account in order to know what can be expected in five years.

One development that is certain is the oval shaped roundabout. This will be placed at the entrance of Maaiveld. This roundabout will have four entrances and six exits (Service Owner Passenger at the airport, expert interview).

Confidential

See appendix X.D for other developments at Schiphol landside.

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3.4 CONCLUSIONS

Schiphol wants to keep the arrival and departure processes separated. Most processes for arriving passengers are located at Maaiveld, where the departure area is the location for departing passengers. In Plaza both the arriving and departing processes take place. In order to communicate the distribution of processes to the passengers, communication and wayfinding are key.

Next to the different areas concerning landside connectivity, this chapter provided insights in the wayfinding issues. Due to the significant amount of facilities in Plaza and Maaiveld, the wayfinding can be difficult. In a large space with assets blocking the view, the overview is not clear. The signs provide information about all facilities, but can lead to information overload due to the amount of information.

In addition to the wayfinding, capacity is a serious problem. The K&R has reached a limit, which can result in congestion before the K&R. Factors that play a significant role in the capacity are the collectors, the third-party car rental and valet services. The collectors are the largest group that disturb the process on the K&R. However, the only other option is a paid option, which makes the K&R attractive to use since that is free.

Maaiveld experiences capacity problems around lane C, where touring busses have no restrictions to stand. Therefore, the drivers wait on lane C for the group to be complete, whereas a Just-in-Time system can help in using the space and time more efficiently.

Another modality that has reached a limit is the train. The train, the platforms and the rails are full. With the growing number of passengers this can be a problem. Particularly, in cases of disruptions dangerous situation can occur. In those situation, contingency plans have be activated.

4

PASSENGER ANALYSIS

In order to understand the experiences and needs of the passengers, a passenger analysis has been conducted. This chapter describes the research and analysis done regarding the passengers.

4.1 INTRODUCTION

Within the first section the different types of passengers will be introduced.

4.1.1 Passenger profiles

The number of passengers keep growing, each year Schiphol reaches a new record. In the summer of 2018, Schiphol facilitated 220.000 passengers a day (Schiphol, 2018). In 2025, Schiphol expects a growth of 50% of passengers (Schiphol Group, 2011).

Of all passengers, 32% is travelling for business purposes and 68% for leisure. Most of the departing passengers are starting (or ending) their journey at Schiphol. The other 37% are transfer passengers (Schiphol Group, 2017b).

The airport is an international context, so the way passengers behave and what they want can be different from each other. Schiphol identified 5 groups of passengers: the Asians, Generation Einstein, Business/Premium, Elderly and Groups/Families. These five profiles have different needs and expectations. A detailed description of these personas can be found in appendix L.

In addition to the personas of Schiphol, (SITA, 2016) defined four personas for which the behavior with regard to technology is taken into account as well (figure 34).

The careful planner wants to prepare everything beforehand in order to prevent something going wrong. The hyper-connected wants to have an efficient journey by having full ownership of the journey. Pampered passengers use premium services in order to enjoy their journey. The open-minded passenger does this by trying out new things in order to create new memories (SITA, 2016).

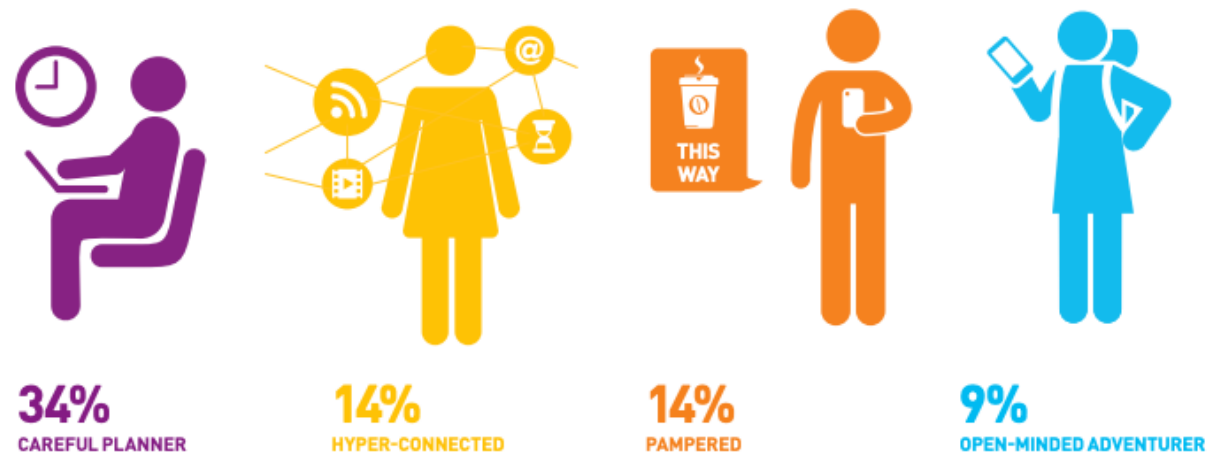


Figure 34: the personas as created by SITA (2016)

4.2 PASSENGER EXPERIENCE

The second section describes the experience and stress levels of the passengers throughout the journey.

4.2.1 Passenger journey

The passenger journey starts from the moment the passenger decides to travel and starts orienting for a destination. From that moment, the passenger has to carry out many tasks. As described by Popovic, Kraal, & Kirk (2009), these activities can be divided in process activities and discretionary activities. Process activities are obligatory activities before entering a plane, such as check-in, screening and boarding (Popovic et al., 2009). For each of these moments, different stress levels can be experienced (figure 33). The colors green, orange and red in the figure indicate the low, middle and high stress levels.

Most stressful experiences take place at moments where insecurity plays a role, such as the baggage reclaim, the long waiting times at security or the duration of the journey towards the airport.

Time is an important factor in the passenger journey. Passengers continuously wonder if they will catch their flight, if they are too early and have to pass time and how long the waiting times will be (Beautiful Lives, 2016).

In addition to and in relation to the stress levels, the experience level can alternate as well. Figure 34 shows the latest results of the passenger experiences at Schiphol (Schiphol Group, 2018b). The experiences are low for several waiting moments and easy of wayfinding.

Passenger experience can be divided in three expectation levels; the required, expected and valued services (ACI, 2014). Required services are the basic and mandatory processes. The expected services are also basic, but define the image of the airport if provided with good quality, whereas the valued services can enhance the experience by providing surprising and unexpected experiences (ACI, 2014).

These three levels can be compared to the Kano Model, where the levels are the Must-be requirements, one-dimensional requirements and attractive requirements with respect to the earlier mentioned levels (Sauerwein, Bailom, Matzler, & Hinterhuber, 1996).

Over time the attractive requirements can become one-dimensional and thus decrease the satisfaction level if not present (Fahy & Jobber, 2012). This means, if the airport introduces a new service (or experience), it is important to keep meeting the expectations every day of this service. Furthermore, Hagen (2015) describes the pyramid of customer needs by distinguishing the qualities in dissatisfiers and satisfiers (figure 35). Again, the dissatisfiers and satisfiers can be compared to the Must-be requirements one-dimensional requirements of the Kano model.

Derived from Maslow's hierarchy, the dissatisfiers are the basic needs such as reliability, safety, speed and ease whereas comfort and experience are the satisfiers (Hagen, 2015). This explanation creates an understanding in the expectations of travelers. Hence, the provision of a safe, fast and easy process to prevent dissatisfaction. Moreover, Hagen (2015) explains that when customers are in move in stations, speed and ease are essential, while comfort and experience are important when travelers have to wait.

Overall, there are two ways that people judge their experiences. Referring to Kahneman (1999) Coglode (n.d.) explains the peak-end rule where the complete experience is based on the judgement of a peak moment and the ending. On the other hand, the primacy and recency effect describes that the judgement of a complete experience is based on the beginning and ending of the experience (Morrison, 2015).

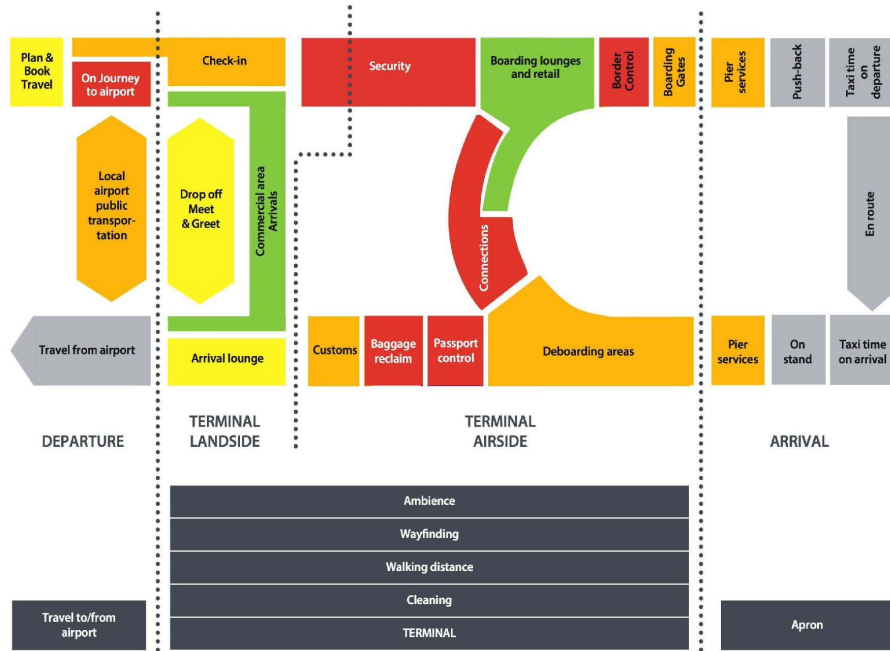


Figure 35: stress levels in the journey (ACI, 2014)

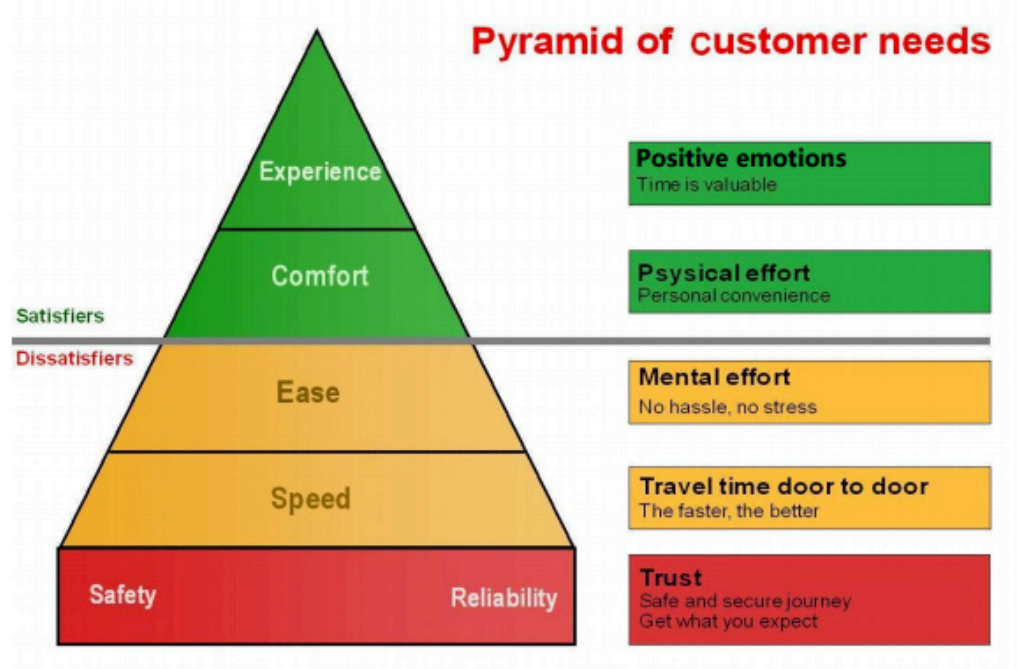


Figure 37: pyramid of customer needs (Hagen, 2015)



Figure 36: experience levels in the journey (Schiphol Group, 2018b)

4.2.2 Diary study

The overall journey has been explained in the previous section. This section will focus on the scope of the project, the journey to/from the airport.

The experience grade of this journey is quite high for Schiphol (Schiphol Group, 2018b). However, in general passengers have a higher risk of experiencing stress during this journey (figure 34).

The passengers have several options to travel to/from Schiphol (figure 38). According to survey results of Schiphol, the satisfaction scores for the modalities alternate between 81 and 61 (Customer Insights Consultant at the airport, personal communication). The lowest scores are for the parking and dropping off satisfaction (appendix H). The highest is for train travel.

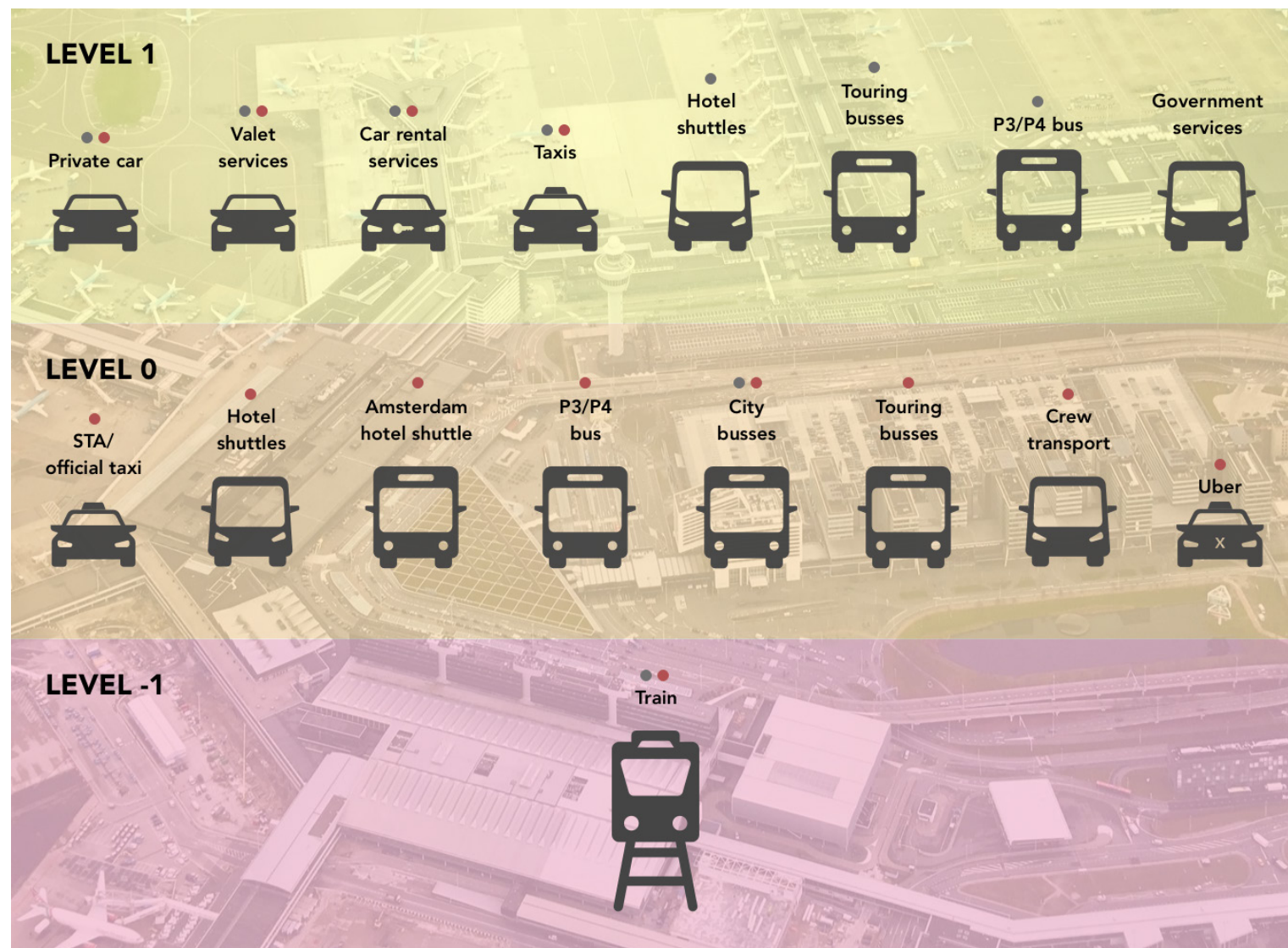


Figure 38: overview of all transport possibilities to and from Schiphol

In order to gather insights about the behavior and decision moments of passengers in the Netherlands and abroad a diary study has been conducted. The purpose of a diary study is to gather insights about the way people behave or interact with the surroundings they find themselves in (UserTesting, 2018). For this study, passengers were asked to document their journey to and from an airport and send the documentations via WhatsApp.

The research questions were as follows:

- What are important decision moments?
- How do people make the decisions?
- What factors are considered for the choice of modality?
- How do people prepare for a journey?

Procedure

Prior the study, information about the flight of the participants was gathered. See appendix I with a list of all participants and their flight information. A few hours before the flight a reminder with instructions was sent to the passengers. The instruction explained to document the decision and important moments while travelling from the starting point till the check-in counters. The instructions deliberately did not inform what specific moments needed to be documented, so the participants could determine what moments were important enough for them to document or describe.

The same procedure was followed for after arriving participants, this time the documentation would cover the journey from the baggage reclaim till the end destination.

After finalizing the documentation phase, a semi-structured interview has been conducted. Hereby, the motivation of their decisions and preparation of the journey were discussed.

Participants

In total 19 participants (18 female, 7 male) voluntary participated in the study. Three participants travelled prior the study and only participated with the interview to discuss their experiences.

The participants consisted of seven Schiphol employees, who have another perspective on the processes and situation at Schiphol. This division in the group

provided a good combination of having participants with a lot of knowledge about the processes and possibilities around Schiphol and the average traveler to Schiphol. The largest group of age (9/19) was between 20-30 years old. Five participants participated more than once, which resulted in a total of 23 journeys and documentations.

Analysis

The interviews have been analyzed with the tool ATLAS.ti 8.3.9 in order to create codes and clusters to find relations in order to answer the research questions.

Results and discussion

The insights of this diary study are gathered from both the interviews and the send information on WhatsApp.

Unfortunately, not all passengers were able to be interviewed. Therefore, several participants answered some questions digitally. All the transcriptions and answers to the questions can be seen in appendix J. All static documentation (images and text from Whatsapp) can be seen in appendix K.

Most participants were O/D travelers of Schiphol, some traveled from Eindhoven and RTHA. The majority of the group traveled for leisure purposes (14/19). Other participants traveled for business. The nationality of the participants was mainly Dutch. The additional participants live or have lived in the Netherlands and were also familiar with the transportation services around the Netherlands. In their decision making this could be noticed, since they referred to earlier experiences.

"Because the bus in Eindhoven is pretty bad, I would rate it 0. I arrived pretty late, around 11.10 pm. And the bus would come around 11.30 pm. So I had to wait for 15 minutes and then the bus would bring me to another 15 minutes from my house, so I chose to get a taxi". – Participant 11, Eindhoven to home.

"I always travel by car [to and from the airport]. I used to take the train, but I experienced trouble and don't want to depend on the train anymore." – Participant 3.

Another interesting finding was that earlier experiences of other travelers can influence the decision making as well. Participant 1 mentioned changing her choice of transportation after talking to an experienced tourist. Additionally, another participant received instructions from her parents to avoid the longer road.

Earlier experiences are considered for taking the decision. In addition to earlier experiences, Psychology Today (n.d.) mentions that decisions are formed by opinions that are influenced by preferences, emotions and reasoning.

With regard to emotion, there are decisions influenced on emotions. Welcoming friends and family after a long vacation is an emotion that influences the choice of picking someone up at Schiphol. However, having expectations can lead to disappointment. One participant said *"I hoped someone would pick me up as a surprise"* (Participant 1, Schiphol to home), but no one came.

Another participant was picked up by his parents, because they wanted to see their grandchildren (participant 7).

Time is an important factor for travelling. Going to the airport it is crucial for the passenger to catch their flight and traveling from the airport, passengers want to be at their end destination as easy and fast as possible. Having a delay or long waiting times in the journey can influence the experience.

In order to get an impression of how satisfied participants were of the journey, they were asked to grade the journey to or from on a scale of 1-5, where 1 is really bad and 5 really good. The grade has been used to create an understanding of the experience of the passengers.

"We ordered a taxi to go to the airport since the metro was no option. We were stuck in traffic for around 1 hour, whereas it should take 25 minutes normally. [I would grade it a] 3 (out of 5), because we had to leave earlier due to traffic. There is room for improvement." – Participant 2, hotel to JFK (figure 37).



Figure 39: documentation participant 2, journey to JFK

Not only time with regard to duration of the journey is considered in the choice, the arrival time is taken into account as well.

"If I can easily travel by train in the morning, but I arrive at Sunday morning 1.a.m, I will travel by car." (Participant 3, home to Schiphol).

Together with time, stress can be experienced on the way to the airport, because there is a specific flight the passenger needs to catch. And the journey to the airport can be influenced by many independent factors, such as disruptions in the train or bad weather circumstances.

"The locals use some apps to check traffic and constructions on the way. The information can be linked with your travel information and is reliable." – Participant 10, Guarulhos to factory (figure 38).

Comfort has been mentioned frequently, but was not always of influence on the choice.

Often, comfort is in relation with money. Thus, if a comfortable ride is chosen, private transport by taxi is probably the solution. An important note with regard to this study is that in the Netherlands the participants had the option to be picked up or dropped off by relatives and friends. Hence, money did not play a role since it is a free ride to the K&R. Nonetheless, with the option to be dropped off for free, it was noticed that participants didn't want to bother their relatives or friends. Especially, if the flight was early, the traveler would rather choose an uncomfortable ride than asking someone to drop off. A nice example is the quote of participant 5:

"...the flight was really early. If they [parents] had to be at my house at 4.30 a.m., they had to leave at 4.00 a.m. Then I will rather take the bus. [The taxi] was expensive, which I didn't want to pay for (...) We were in the bus with drunk people who were going back home. It was really bad, we had to stand, because it was full of drunk people". – Participant 5, home to Schiphol.

Participants that didn't mind paying more for efficiency, used the taxi and parking options in the both Netherlands and abroad.

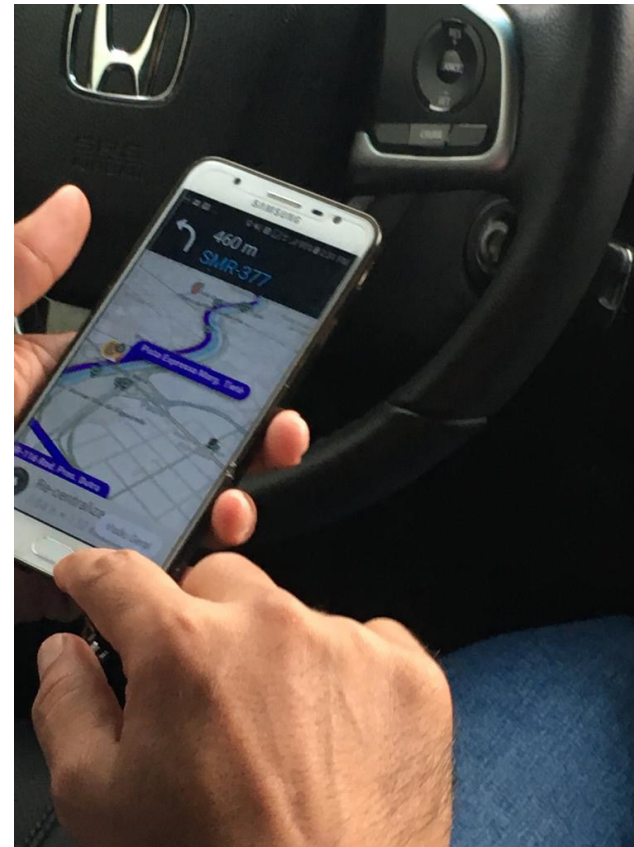


Figure 40: documentation participant 10, journey to Guarulhos

Taxis can have a reliability issue. It is known that fraud can occur with regard to taxis.

"...I could have taken the taxi, but I don't prefer that in Curaçao, because I think it is unreliable." - Participant 4.

However, trust in other areas are also of influence in changing modality. One participant decided not to take the metro, the fastest and cheapest option, because of an unsafe feeling.

"We didn't feel comfortable in the neighborhood [in New York] and it was rush hour, so it is difficult to get through with the luggage, so we chose the taxi." – Participant 2, hotel to JFK.

Moreover, parking at the remote parking garages at Schiphol have been mentioned by several participants. Business travelers don't mind the bus to get to the parking garage, because they don't have a lot of baggage. However, some leisure travelers mentioned the extra time that is required to get to the terminal. Additionally, some participants experienced long walking distances from the closest parking garage to the terminal. Especially with a lot of baggage.

Preparation to go to the terminal was based on the flight time. Since the majority of the participants live in the Netherlands, they were aware of what possibilities they had and how long it would take. Six participants traveled by train, for which they used the corresponding NS Reisplanner app were used for information about the timeslots and any disruptions.

In case there was no train transport possible, participants prepared by using other platforms and services to find another modality option. Hence, in the Netherlands the participants had the required awareness for the journey to and from the airport.

For preparing the journey abroad, three types of passengers can be distinguished, namely: the passenger who starts looking for information after arrival, the passenger who looks up information before the journey to know what to look for and the passenger who relies on others to guide them for the journey.

Quotes to illustrate these personas are shown respectively:

"We didn't research anything before, as soon as we got off the plane we looked at Google Maps to figure out how to get to the hotel" – Participant 5.

"In Amsterdam I already searched for the options to go from the airport to the city, this was an express train. (...) I checked the website of the conference and then saw the train option..." – Participant 14.

"The trip organizer also arranged the transfer. It was arranged perfectly, you arrive and they are waiting for you. You register and then the bus drives you to your hotel." – Participant 8

4.3 CONCLUSIONS

Time is an important aspect of flying; passengers are constantly wondering if they will catch their flight, if they have to wait or if they have to hurry.

Traveling to and from an airport also relates to time, where choices need to be made in order to arrive on time at the airport to go through all processes before entering the plane.

The stress level while traveling to the airport is relatively high, however the experience level at Schiphol scores above average (74 out of 100).

The diary study revealed several factors that can influence the choice of modality to and from an airport. These factors and a short description are summarized in table 4.

The way passengers prepare are divided in three types: the passenger who starts looking for information after arrival, the passenger who looks up information before the journey to know what to look for and the passenger who relies on others to guide them for the journey.

Reoccurring themes can be seen between these types and the defined personas. While preparing there are passengers that have full ownership of their journey and are looking for efficient and cheap solutions. Where on the other hand, some passengers want to have things arranged for comfort. Here money mostly does not play an important role.

From the passenger analysis can be seen that the journey is not seamless. Prior and within the airport there are several activities that need to be done in order to enter the plane. For traveling to and from the airport, passengers explore other options through different platforms in case a delay or disruption occurs. When a passenger is in a foreign country, the frequently used service is Google (Maps). The information on Google (Maps) covers most modalities (car, public transport and sometimes Uber). It is interesting, that when passengers are in their own country, they use more than one platform in order to find information about different modalities.

Influencing factor	Motivation
Time	Both the time of the flight and the amount of time required for traveling to the airport were used for choosing the modality.
Comfort	Being comfortable is important, but not the final deciding factor.
Costs	For many participants money is an important factor for making the decision.
Reliability	The reliability of a modality is considered in the decision process as well.
Sustainability	Considering the sustainability of the type of transport can influence the decision.
Emotion	Making a decision based on emotional factors, such as saying goodbye or welcoming passengers can make a difference in the choice.
Experience	Referring to earlier experiences has a probability of influencing the finally taken decision.

Table 4: summary of all influencing factors for decision making

5

CONCLUSIONS

The findings and conclusions of the previously described research will be explained in this chapter. Consequently, the findings will be used for the next phase of the project, the define phase.

5.1 INTRODUCTION

The first phase of the thesis described in this report was to create an understanding about the topic 'improving the airport landside connectivity through the use of the Internet of Things'. The exploration has been done through literature research, observations, interviews and a diary study.

5.2 FINDINGS AND CONCLUSIONS

The landside connectivity of Schiphol exists of several options. The largest segments are the passengers traveling by train and car. In return, these large groups result in capacity problems at the respective areas. In this case, the concerned areas are the Kiss and Ride and Schiphol Plaza on level 1 and level 0.

On the Kiss and Ride the capacity problem is influenced by the wrong usage of the area, where more services than only dropping off take place. Third-party valet and car rental services and collecting processes result in more intensity than expected. Hence, the infrastructure is not big enough to fit all these processes. The main reason that all these processes take place on the Kiss and Ride is the fact that it is the only free area that is publically accessible. Moreover, both the passengers and enforces have no clear overview to find a free place on or judge if someone is parked for too long.

To motivate the groups to go someplace else, such as the short parking area, offering other free alternatives can be an option. Next to being free, the walking distance to the terminal and comfort in the car play a role in choosing to be dropped off/picked up. From the diary study, it was found that long walking/remote distances can negatively influence the experience. This was mentioned by participants that traveled via the remote parking garages, where they had to transfer to a bus to go to the terminal.

In addition to the Kiss and Ride, capacity problems also occur at Schiphol Plaza and Maaiveld. Schiphol Plaza is crowded with train travelers, where Maaiveld experiences problems around lane C. On this lane, the touring busses take up space by waiting for the whole group to be complete. Moreover, there is no clear overview of the offered services and facilities in these areas. Many assets placed at Plaza can block the view of passengers, which can make it difficult to find the way.

Most arriving passengers have to travel via Schiphol Plaza, where their main goal is to continue their journey towards their end destination. Due to the crowded area it is difficult to find concrete information about how to continue the journey.

Likewise, the infrastructure and intensity of processes on Maaiveld, can result in the same lack of overview.

The growing capacity problems around landside connectivity can translate into longer waiting times and more disruptions. Consequently, the passengers can experience more insecurity and stress while traveling to and from the airport. As mentioned, the people judge their experiences in two ways. Considering the primacy and recency effect (Morrison, 2015), the landside connectivity is relevant for the experience, since it is either the beginning or ending of the complete journey for departing or arriving passengers.

Nevertheless, if the journey to and from the airport is experienced as the most stressful moment it influence the complete experience (peak-end rule, (Coglode, n.d.).

To provide a positive experience, the basic needs must be met. As explained by Hagen (2015), moving travelers want a fast and easy experience. In case of traveling to and from the airport, this is while the passenger is in move. However, when waiting the comfort and experience plays a more important role. For departing passengers time is an important factor in the journey. Insecurity about waiting times or reliability of the promised duration can result in stress. In these situations, it can be valuable to provide comfortable and personal experiences to reassure the passengers by offering alternatives or information about the situation/duration of the process to reduce the stress levels.

Furthermore, the diary study provided insights in how passengers decide their mean of transportation to/from the airport. The choice of modality is influenced by factors such as time, price, comfort, reliability and earlier experiences (table 4). For these factors, time efficiency is most relevant, since it is about catching a flight. Reliability is considered by the participants while making a decision. Hagen (2015) explains that the reliability plays an important role for the experience, since it is as basic need to meet the expectations of the passengers. Comfort is not the final deciding factor, but is a satisfier to enhance the experience while traveling.

In general, the findings can be categorized in two groups, the passenger experience and operational efficiency. From the operational perspective, Schiphol wants to offer fast and reliable processes which can be linked to the required basic needs of Hagen (2015). From the passenger perspective, the fulfillment of the basic needs is important. However, comfortable, personal and unexpected experiences can boost the passenger experience to make the journey memorable (ACI, 2014) (Hagen, (2015). Also, passengers base their experiences on the beginning, ending or peak moments of the journey. If a good experience has to be achieved, these moments have to be considered.

Technologies and trends have also been analyzed in this report to understand the current status of Schiphol and analyze the expected mobility trends. Schiphol recognizes the digitalization trend and has started to generate data through two dashboards IPO and Wilbur. The main objective with these dashboards is to improve the operational efficiency of the processes at Schiphol. Considering the value of the IoT, the generated data can also be applied to improve the passenger experience by for instance informing passengers of the waiting times. A real-life example is the information about the waiting times at security (figure 26).

Next to the values and implementations of IoT, several mobility trends have been discussed. It is interesting for Schiphol to consider these mobility trends for the long-term vision, since it can be beneficial for the capacity problems and efficiency of processes.

5.3 NEXT PHASE

The next phase of this thesis will be the define phase. Using the findings of this report design directions will be defined to start ideating ideas and concepts. The following phases of the project will be presented in a second report, the design report.

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