Improving the airport landside connectivity through the Internet of Things

02. Design report

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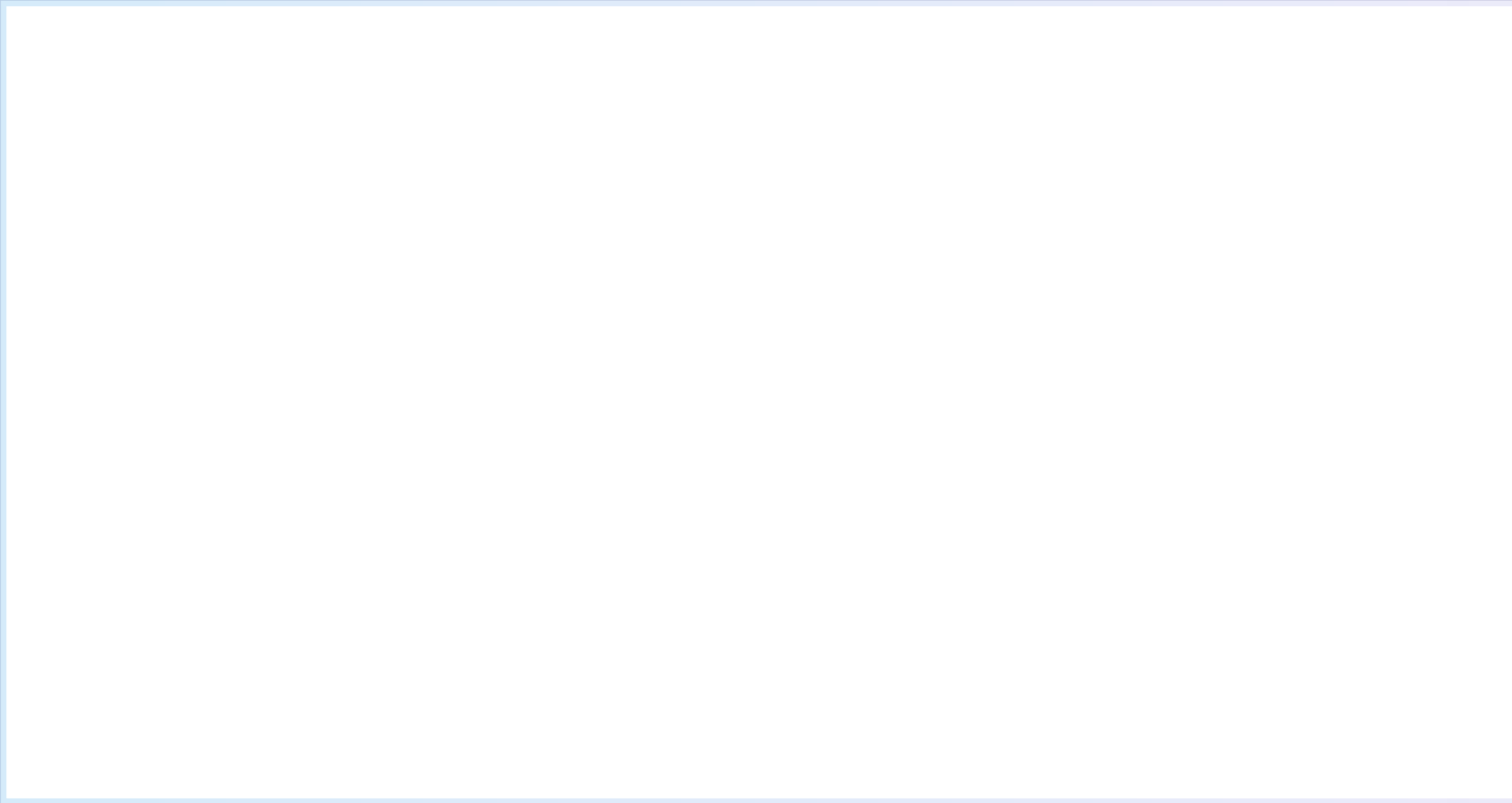
CONTENTS

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.

Ministery 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.

ACKNOWLEDGEMENTS

EXECUTIVE SUMMARY

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 "Seamless user-centered Mobility Services" at the IDE faculty of the Delft University of Technology.

Schiphol is the third largest airport of Europe, with 326 direct destinations. The number of passengers keeps increasing, which requires Schiphol to expand in order to keep facilitating the passengers as good as possible. A new terminal and pier is developed and realized in 2023, which will result in even more passengers.

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. Also, in case of delays passengers want to make sure they can still be on time, since they need to catch their flight. The airport is responsible for offering the best services to support the passengers in their journey. This includes the provision of products and services for easy and reliable landside connectivity.

The research phase of the project covered the analysis of the technologies, current landside situation at Schiphol and the passenger journey. This phase is discussed in the analysis report. From this report it is derived that the main bottlenecks at landside is the lack of capacity. The growing number of passengers result in more capacity problems. This report, the second part of the project, describes and develops the connected system for congestion problems at the Kiss and Ride at Schiphol.

Results show that in case of congestion, departing passengers can become stressed. The level of stress increases with an increase in insecurity. In case of disruptions, Schiphol also lacks efficient tools to manage the traffic. Therefore, a dynamic wayfinding system has been developed.

The system exists of two main parts, the dynamic traffic signs and sensors. The sensors measure the number of cars and travel speed of the cars to provide an indication of the congestion level.

Subsequently, the content on the dynamic signs changes accordingly to redirect the driver to alternative locations.

The main benefit of this system is that the operation at Schiphol can take control in case of congestions/contingencies. As a result, unsafe situations can be prevented. Indirectly, the insecurity levels of the passengers will be reduced, because they are presented with alternative routes to arrive at their end destination.

The presented connected system is in line with the ambitions of several initiatives at Schiphol, this thesis contributes to the development of these initiatives by developing and evaluating the different elements of the system.

1

INTRODUCTION

This design report is part of the graduation assignment about improving the landside connectivity through the use of the Internet of Things. The project is carried out at Schiphol Airport in Amsterdam and is part of the Expertise center "Seamless user-centered Mobility Services" at the IDE faculty of the Delft University of Technology.

The analysis report, explored and researched the possibilities of the Internet of Things, the bottlenecks and challenges regarding landside connectivity and the passenger experience and journey. The findings of that report are used in this design report for concept development and validation.

1.1 PROJECT PROGRESS

In this chapter, the main findings and conclusions of the analysis report are presented. The research and conclusions are divided in three categories: the technological analysis, internal analysis and passenger analysis.

1.1.1 Design process

The project is divided in four phases: discover, define, develop and deliver (figure 1). The analysis report covered the discover phase where the project on a broad scope has been explored and researched.

This design report will use the findings from the discover phase to define the design direction for the assignment. Consequently, ideas are developed and tested in order to deliver a final concept. Figure 1 can be used as a reading guide to understand which chapter belong to the respective phases.

1.2 CONCLUSIONS FROM THE DISCOVER PHASE

In this section the findings and conclusions from the analysis report are described.

1.1.2 Technological analysis

<u>Internet of Things</u>

Derived from the assignment topic, an understanding about the Internet of Things (IoT) is required. Therefore, the definition, challenges and possibilities with IoT have been analyzed through literature research. As defined by (Morgan, n.d.), IoT is the collection of 'things' that are connected to each other and to the Internet. These things can be for instance sensors, actuators, software and the users. By connecting things to each other and to the Internet networks such as smart homes, smart cities, smart infrastructures can be created (Mahmoud, Yousuf, Aloul, & Zualkernan, 2015).

Cila, Smit, Giaccardi, & Kröse (2017) indicate that IoT is not only about making products smart, but also about understanding the impact of smart products on people's lives. They identify three behavior types to interact with these products: 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).

Discover
Technological analysis
Internal analysis
Passenger analysis
Findings and insights

Analysis report

Define
Design direction: chapter 2
Schiphol infrastructure: chapter 3
Idea generation: chapter 4
Idea selection and evaluation:
chapter 4

Develop
Idea development: chapter 5
Conclusions: chapter 5

Design report

Deliver
Final design: chapter 6
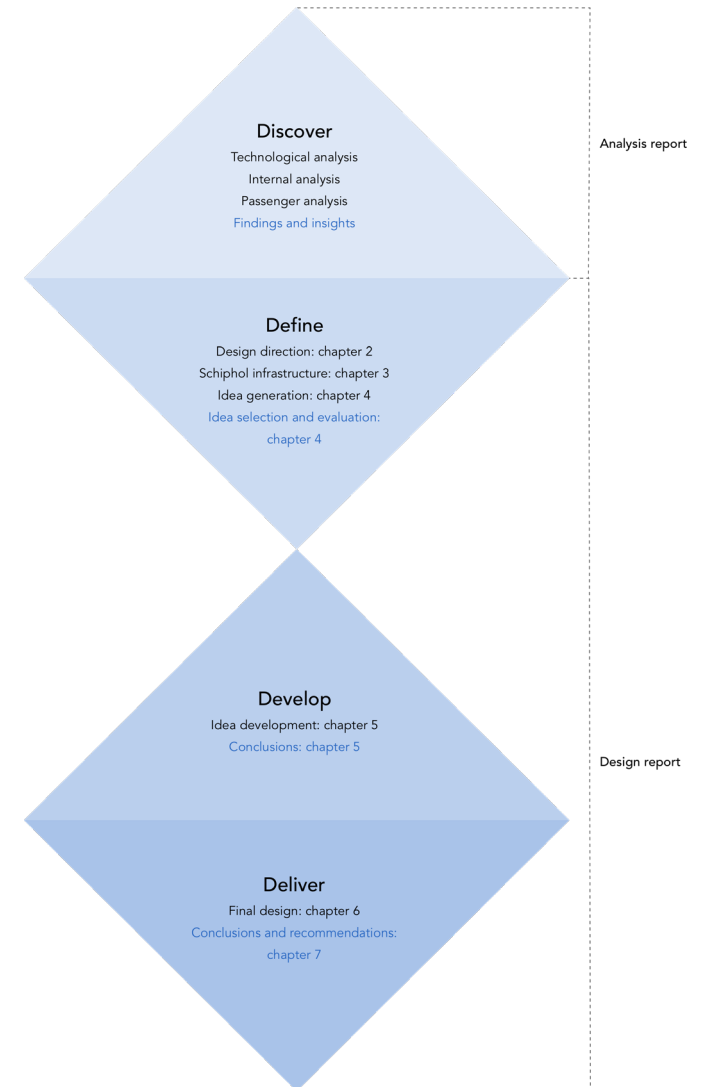Conclusions and recommendations:
chapter 7

Figure 1: visual of the design approach

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).

The Creator is the novel behavior type with autonomous and self-aware products that live amongst people (Cila et al., 2017).

Implementing artificial intelligence (AI) can achieve products in the Actor and Creator role, since the combination of AI with IoT can generate insights and patterns from all the data that is being produced. (Schatsky, Kumar, & Bumb, 2017).

Challenges
It is predicted that by 2020 50 billion devices will be connected to the Internet (Evans, 2011). However, the more things become connected to the Internet, the more products will become vulnerable for hackers and cyber-attacks (Lee & Lee, 2015). Therefore, 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 help in creating reliable products, since all information will be decentralized (Guinard, 2018).

Nowadays, IoT exists out of separate networks, but to become smarter and more interconnected, the separate networks need to become connected into a "Network of Networks" (Evans, 2011). However, devices and data should be able to share information with each other by becoming interoperable.

The last of the three challenges discussed in the analysis report is the scalability of networks. If everything becomes connected and interoperable, a significant amount of data will be generated. To support all the data, new powerful systems are required to manage, interpret and compare the data for useful outputs (Chen, Xu, Liu, Hu, & Wang, 2014).

Internet of Things for airports
In context of the project, IoT can be a valuable tool for improving the passenger experience and to achieve operational efficiency (IoT Innovation, 2017). Due to the Digital Airport Program (DAP), different initiatives at Schiphol are creating digital solutions in different airport processes. In order to monitor the generated data, two dashboards have been developed; IPO and Wilbur.

IPO serves to analyze data in relation to the performance of a KPI, whereas Wilbur is used for managing day-to-day operations (appendix M and X.A).

Only a small part of the generated data is communicated with passengers. One example that is being communicated are the real-time waiting times at security.

Mobility trends
In line with the assignment to improve the landside connectivity, smart mobility plays a role as well. Therefore, relevant trends are explored in the analysis report.

Mobility as a service (MaaS)
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.
MaaS (Mobility as a Service) is one 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 door-to-door journey according to its preferences. However, this concept is quite novel and therefore can come with some challenges. Li & Voege (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. Nowadays, several examples available of multi-model journey planners such as Whim, Tranzer and Wegfinder. However most of these solutions come with limitations and are therefore not fully integrated with all modalities and on-off payments possibilities.

Car sharing
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. 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. Providing more services for sharing modalities can reduce the capacity problems that people are facing daily.

Autonomous vehicles
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.
Another concern are the legal issues. For instance, who will be responsible in case of an accident, 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. Nonetheless, Deloitte (2016) expects the autonomous cars to be introduced in 2020 and personally owned by 2022.

Future airport
Not only the mobility trends are important for this graduation, but also trends for airports in general. The trends explained in the analysis report mainly support the seamless flow vision to reduce the capacity problems and improve the passenger experiences.
One development is the use of biometrics for authenticating passengers for faster and more secure self-service processes (SITA, 2018).
Using technologies for easier and more efficient security screening will also contribute to the seamless flow. An example of such a technology is a cart developed as part of the PASSME research program, whereby the cart with all your belongings goes through a separate scanner to scan for prohibited items (PASSME, 2018).

Remote processes will become more relevant in order to facilitate the growing number of passengers worldwide. Online check-in and self-baggage drop-off are existing examples of remote processes. In a few years door-to-door baggage services are expected to become more popular. Hereby, the service ships your baggage before you, which means the passenger is not required carry the baggage to the airport and check-in at the terminal, everything is arranged by a pick-up service (PASSME, 2018).

1.1.3 Internal analysis
The internal analysis with regard to landside connectivity Schiphol consisted of exploring and understanding the current situation at the different areas with respect to the processes. In general, there are four areas over which the different modalities are distributed. Figure 2 gives an overview of the distribution of the processes with their areas.

Processes for departing passengers are mainly located at level 1, where the car travelers can use the K&R and P1. Arriving passengers can use Maaiveld located at level 0 to continue their journey by taxi, bus or shuttle. Train travelers all have to use Schiphol Plaza, since the elevation points to the platforms are positioned in Plaza.

The main findings were the capacity and wayfinding problems. The K&R has reached a limit, which can result in congestion in front of 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 disturbs the process on the K&R, due to their long residence times. To use the K&R as efficiently as possible, the residence time needs to be minimized. 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 might help in using the space and time more efficiently. Just-in-Time means that the touring car can only arrive after the group of passengers is complete and gathered outside.

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 become a problem. Particularly, in cases of disruptions, dangerous situations can occur. In those situation, contingency plans have to be activated. The capacity problem of the train is translated in problems at Plaza. Furthermore, Plaza can be seen as a transition area for different users (arriving/departing passengers, train travelers, employees, visitors of Schiphol), where many services are offered. Due to all the information at Plaza, the wayfinding can be experienced as difficult.

LEVEL 1

Private car
Valet services
Car rental services
Taxis
Hotel shuttles
Touring busses
P3/P4 bus
Government services

LEVEL 0

STA/ official taxi
Hotel shuttles
Amsterdam hotel shuttle
P3/P4 bus
City busses
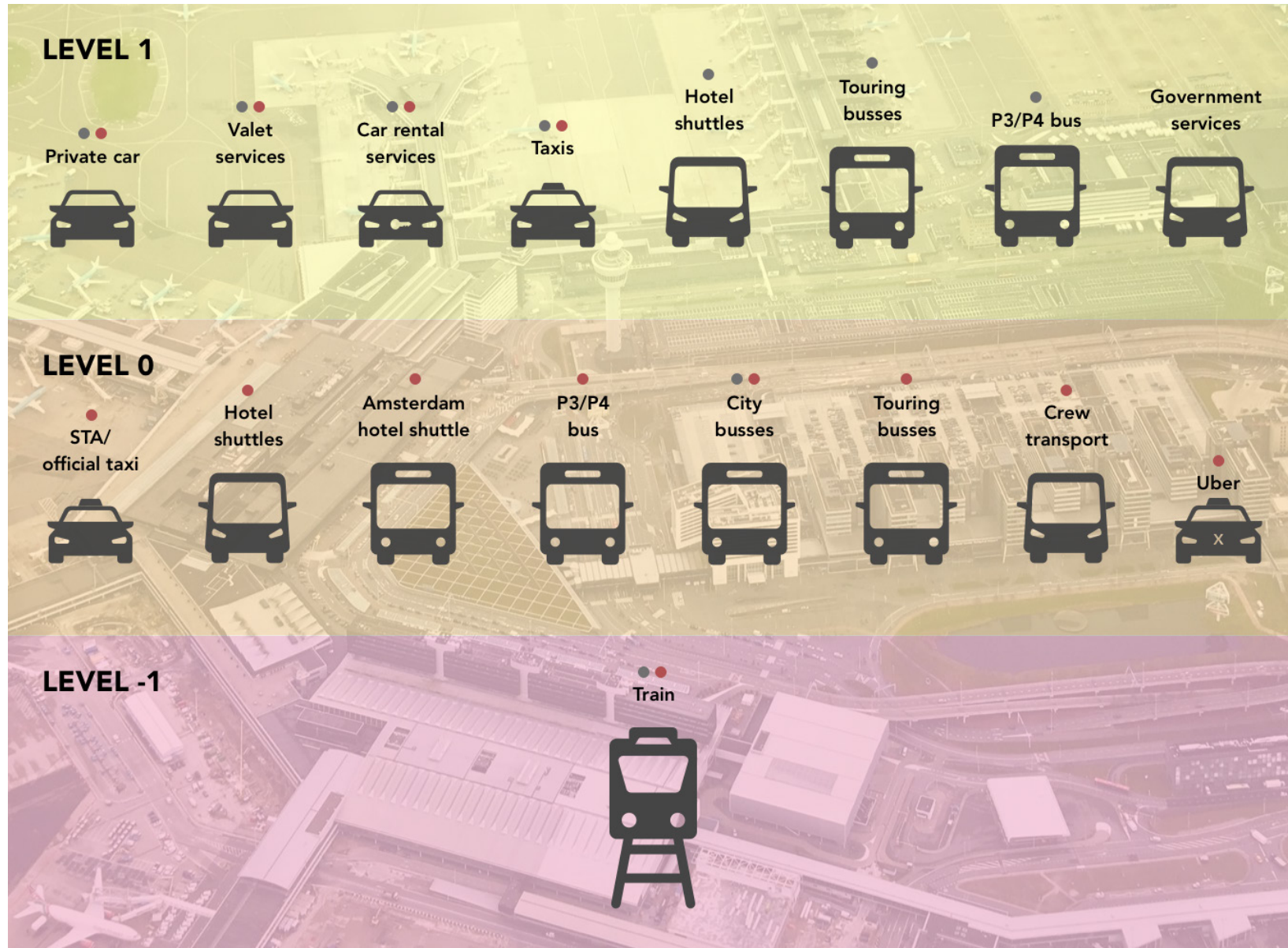Touring busses
Crew transport
Uber

LEVEL -1

Train

Figure 2: all processes at Schiphol landside

1.1.4 Passengers

Passenger profiles and experiences are explored to gather insights about the needs, behavior and wishes of the different passengers.

SITA (2016) defined four personas that are used to understand the type of passengers that walk around at an airport. Within the four profiles, there are prepared and unprepared passengers whereby the prepared passengers want to have control over their journey in order to prevent mistakes and inefficiency. The results of the conducted diary study found different levels in preparation, the passenger that starts planning when it is time to leave, the passenger that looks up information before the journey and the passenger that relies on the travel companions.

From the same diary study about the journey to and from an airport, seven factors have been found that influence the choice of modality to travel with (table 1). From these influences, time and costs were the most relevant inluences on the decision making.

Another key insight is the fact that insecurities have to be reduced in order to prevent stress (ACI, 2014). Time plays an important role in the mind of the departing passenger, because the passenger has the responsibility to be on time in order to catch a flight. Whenever there is a disruption and the duration is unknown it can lead to an increase of stress levels.

1.1.5 Next phase

In the previous sections the insights from the analysis report are briefly described. The technological, internal and passenger analysis are required to understand how the landside connectivity can be improved. In the next phase design directions are explored and selected.

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 1: influencing factors for decision making

KISS AND RIDE

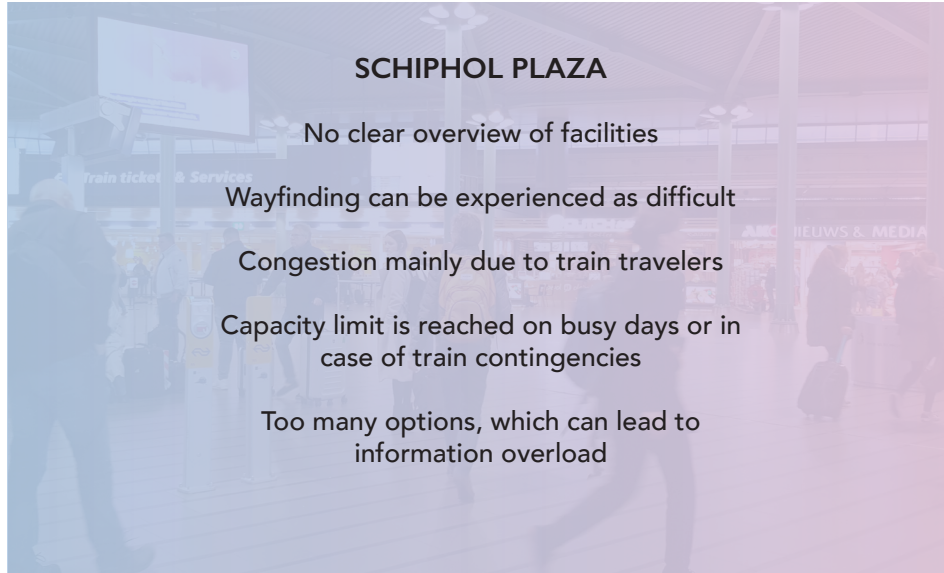Capacity limit is reached on busy days

Third-party services take up space on the K&R

Many arriving passengers are being picked up at the K&R (free)

Departing passengers can experience stress due to waiting lines

No clear overview about free places for the driver

SCHIPHOL PLAZA

No clear overview of facilities

Wayfinding can be experienced as difficult

Congestion mainly due to train travelers

Capacity limit is reached on busy days or in case of train contingencies

Too many options, which can lead to information overload

MAAIVELD

There is no clear overview of all processes at Maaiveld
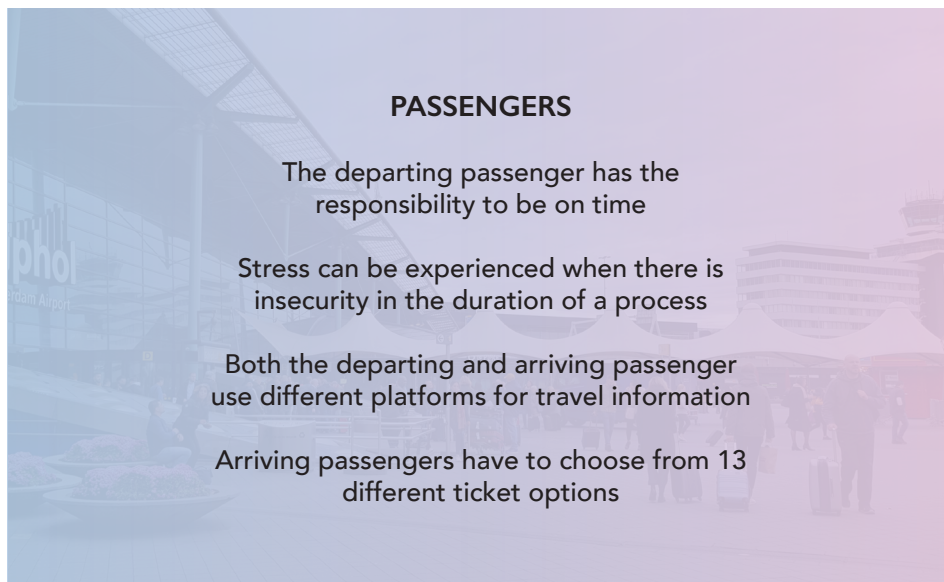
Touring busses take up a lot capacity by waiting inefficiently for all passengers

Dangerous situations due to pedestrian crossings

Official Taxi process is well-regulated with a digital system

Illegal taxi services are provided

PASSENGERS

The departing passenger has the responsibility to be on time

Stress can be experienced when there is insecurity in the duration of a process

Both the departing and arriving passenger use different platforms for travel information

Arriving passengers have to choose from 13 different ticket options

Figure 3: summary of bottlenecks in four categories

2

DESIGN DIRECTION
The findings summarized in the first chapter are used to define several opportunity areas. Subsequently, one of the opportunity areas is selected to start the ideation process.

2.1 INTRODUCTION

Analyzing the findings about the current situation regarding the landside connectivity, there are mainly two categories: the operational efficiency and the passenger experience within the journey to/from the airport. From an operational perspective, Schiphol wants to offer fast and reliable processes, but also reduce capacity problems to prevent dangerous situations from occurring.

On the other hand, the passenger wants to be in control of the processes and have security about what is going to happen next. Currently, stress can be experienced due to insecurity on the way to the airport. Additionally, the significant number of options to travel to Schiphol can make it difficult to choose the best option for that journey. Schiphol can be accessed via train, private car, car sharing, official taxi, shared taxi, touring bus and public transport bus (figure 2).

2.2 OPPORTUNITY AREAS

From the summarized bottlenecks, four focus areas can be defined (figure 3). For the continuation of the project, the bottlenecks are used to define opportunity areas. Each opportunity area is explained with the chosen bottleneck for a specific area and passenger. In order to make a selection, selection criteria have been defined.

The selection of an opportunity area is based on the following criteria:
• The direction should add value to the passenger journey
• The direction should add value to Schiphol operations
• The direction should be able to be improved by IoT
• The direction should be relevant for the scope of 2025
• The direction should be different than the already existing initiatives at Schiphol

OPPORTUNITY AREA 1
STRESSED CAR TRAVELERS IN CASE OF CONGESTION

22,7% of the passengers is being dropped off/picked up by car. The current areas to drop off/pick up are the K&R and P1 – short parking.
In peak hours congestion problems are occurring on the K&R due to the lack of capacity. With the expected growth of passengers, congestions can intensify in a few years.

OPPORTUNITY AREA 2
WAYFINDING SCHIPHOL PLAZA

Schiphol Plaza is a multifunctional area where train travelers, arriving and departing passengers and employees can change modality at Maaiveld or continue their journey in Schiphol. The largest group using Schiphol Plaza is the arriving passengers. Arriving passengers can continue their journey by train or other modalities located at Maaiveld. With the different options available, arriving passengers can experience difficulty in finding their way.

OPPORTUNITY AREA 3
PROCESS DIGITALIZATION

The area connected with Schiphol Plaza and the Jan Dellaert square facilitates most processes are for arriving passengers. Taxi, bus, hotel shuttle, ordered taxi, touring bus, shuttle bus and crew transport processes are distributed over four lanes. Lane C is the only public area that is free to use by transport companies. Here the main bottleneck is the touring cars that take up a lot of space due to long residence times. In this case, Schiphol is the facilitator and not the executor, thus there are no monitoring systems available. For Schiphol it will be valuable to create more insights in these processes to take more control and use the area more efficiently.

OPPORTUNITY AREA 4
JOURNEY INFORMATION

Departing passengers have their own responsibility to be on time at the airport in order to catch their flight. Insecurities in the journey result in stress as a consequence. Traveling to Schiphol can be done in many ways (figure 2), where each modality comes with its own service. It is interesting to look at how the insecurities in the journey can be reduced by improving the information provision to keep updated about the processes.

2.2.1 Selection opportunity area
Opportunity areas 1 and 4 have the most potential when evaluating the criteria. Both of these areas are valuable for the passenger journey and for the Schiphol operation. All areas have the possibility to be improved by IoT.

In 2025 the new terminal and pier will already be in use, which results in an expected growth of 50%. However, due to the developments at Schiphol some areas may be different than today (appendix X.D and appendix X.E)

The K&R is an interesting area, because there is an extra user group, the drivers. A customer journey is created to understand the activities for both of these user groups (figure 5 and 6). The future of the K&R at Schiphol is quite fuzzy and decisions are made/changed regularly. To create a valuable proposition for both the passengers and Schiphol it is decided to focus on the opportunity area 1, congestions for the car travelers, and contribute to the discussions regarding the K&R at Schiphol.
Besides, congestions result in insecurities and therefore increase the stress levels for the passengers. Therefore, it is interesting to explore ideas for contributing to the reduction of stress levels in case of congestions. The departing passenger experiences more stress when traveling, because the passenger has to catch their flight.

Figure 4: low intensity on the K&R

2.3 ELABORATION OPPORTUNITY AREA
In the analysis report the K&R has been discussed to some extent (figure 3). However, to get a more in-depth understand of the effect of congestions for Schiphol and the passengers both insights from the enforcers and passengers have been gathered.

2.3.1 Enforcement on the Kiss and Ride
The enforcement on the K&R is done by the BOA's (Buitengewoon opsporingsambtenaar) at Schiphol. Their responsibility is to send drivers away that are parking on the K&R or misusing the area. With the intention of understanding the situation on the K&R from the perspective of the enforces, a few observational meetings have been organized. During those meetings, the briefing of the enforcers was attended and informal conversations have taken place while driving around with an enforcer.

The main thing the enforcers have discussed during the briefing was the difference between being strict and hospitable. There is a clear difference in opinion divided in a group that wants to be friendly and provide a hospitable environment with high service, whereas the others plead for more enforcement to prevent long residence times on the K&R.

"*Writing fees will result in one unhappy customer and ten happy customers after that*" (enforcer 1, informal conversation).

"*We represent Schiphol with the service on the K&R, therefore it is important to be hospitable and customer friendly*" (enforcer during briefing)

Their main complaint was the third-party valet and car rental services and the collectors on the K&R. Since it is their responsibility to make sure the traffic keeps flowing, they have to discuss with the drivers and send them away. However, with no proof about the residence times it can become their word against the drivers.

On the 7th of November 2018 around 3 p.m. observations were done by driving around with the BOA. It was a Wednesday, and around 3 p.m. the intensity on the K&R is low (figure 4).
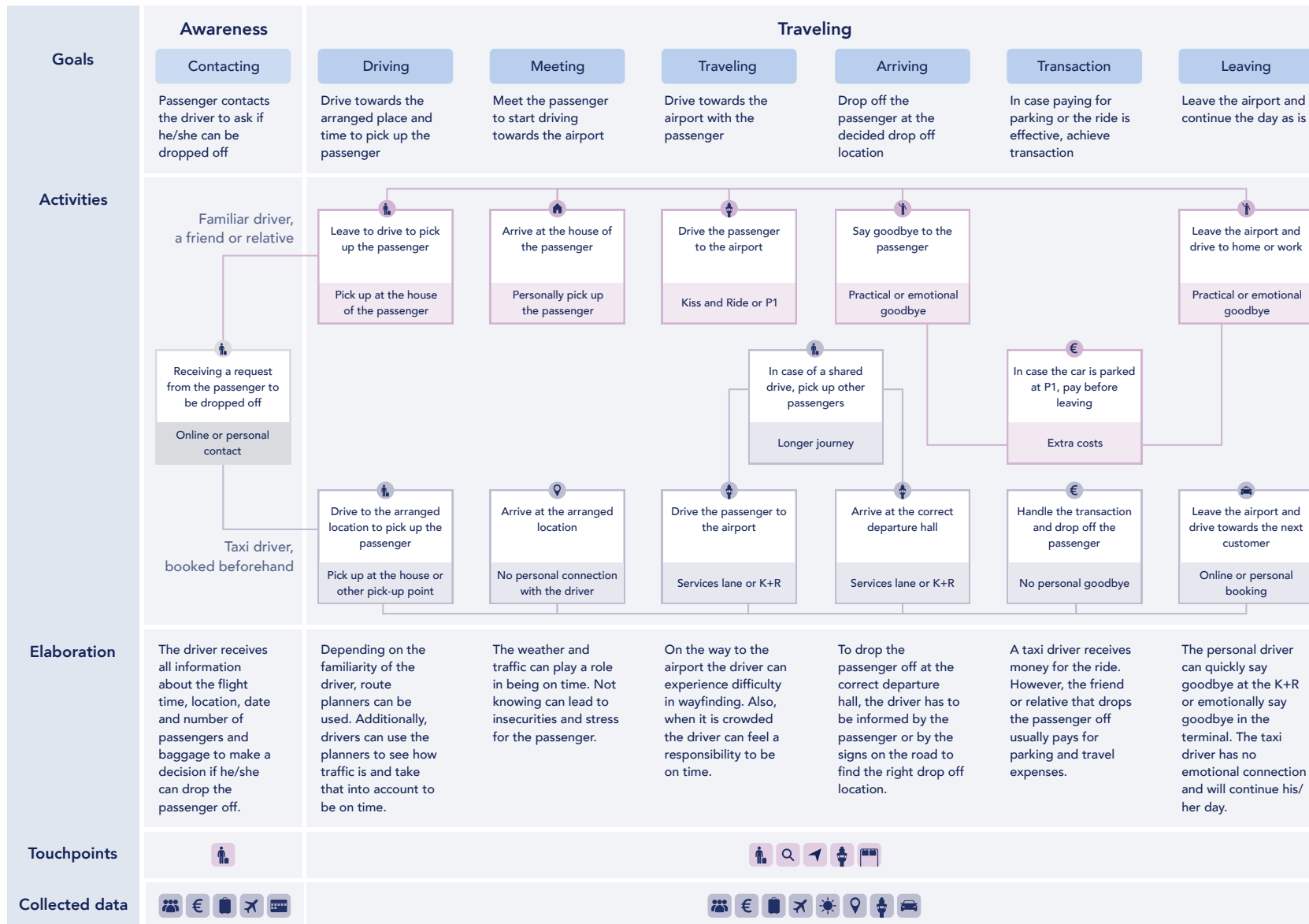
	Awareness	Traveling					
Goals	Contacting	Driving	Meeting	Traveling	Arriving	Transaction	Leaving
	Passenger contacts the driver to ask if he/she can be dropped off	Drive towards the arranged place and time to pick up the passenger	Meet the passenger to start driving towards the airport	Drive towards the airport with the passenger	Drop off the passenger at the decided drop off location	In case paying for parking or the ride is effective, achieve transaction	Leave the airport and continue the day as is

Activities

Familiar driver, a friend or relative

Leave to drive to pick up the passenger — Pick up at the house of the passenger

Arrive at the house of the passenger — Personally pick up the passenger

Drive the passenger to the airport — Kiss and Ride or P1

Say goodbye to the passenger — Practical or emotional goodbye

Leave the airport and drive to home or work — Practical or emotional goodbye

Receiving a request from the passenger to be dropped off — Online or personal contact

In case of a shared drive, pick up other passengers — Longer journey

In case the car is parked at P1, pay before leaving — Extra costs

Taxi driver, booked beforehand

Drive to the arranged location to pick up the passenger — Pick up at the house or other pick-up point

Arrive at the arranged location — No personal connection with the driver

Drive the passenger to the airport — Services lane or K+R

Arrive at the correct departure hall — Services lane or K+R

Handle the transaction and drop off the passenger — No personal goodbye

Leave the airport and drive towards the next customer — Online or personal booking

| **Elaboration** | The driver receives all information about the flight time, location, date and number of passengers and baggage to make a decision if he/she can drop the passenger off. | Depending on the familiarity of the driver, route planners can be used. Additionally, drivers can use the planners to see how traffic is and take that into account to be on time. | The weather and traffic can play a role in being on time. Not knowing can lead to insecurities and stress for the passenger. | On the way to the airport the driver can experience difficulty in wayfinding. Also, when it is crowded the driver can feel a responsibility to be on time. | To drop the passenger off at the correct departure hall, the driver has to be informed by the passenger or by the signs on the road to find the right drop off location. | A taxi driver receives money for the ride. However, the friend or relative that drops the passenger off usually pays for parking and travel expenses. | The personal driver can quickly say goodbye at the K+R or emotionally say goodbye in the terminal. The taxi driver has no emotional connection and will continue his/her day. |

Touchpoints

Collected data

Figure 5: Customer journey of the passenger

Goals

Awareness | **Traveling**

Contacting	Driving	Meeting	Traveling	Arriving	Transaction	Leaving
Passenger contacts the driver to ask if he/she can be dropped off	Drive towards the arranged place and time to pick up the passenger	Meet the passenger to start driving towards the airport	Drive towards the airport with the passenger	Drop off the passenger at the decided drop off location	In case paying for parking or the ride is effective, achieve transaction	Leave the airport and continue the day as is

Activities

Familiar driver, a friend or relative

- Leave to drive to pick up the passenger — Pick up at the house of the passenger
- Arrive at the house of the passenger — Personally pick up the passenger
- Drive the passenger to the airport — Kiss and Ride or P1
- Say goodbye to the passenger — Practical or emotional goodbye
- Leave the airport and drive to home or work — Practical or emotional goodbye

- Receiving a request from the passenger to be dropped off — Online or personal contact

- In case of a shared drive, pick up other passengers — Longer journey
- In case the car is parked at P1, pay before leaving — Extra costs

Taxi driver, booked beforehand

- Drive to the arranged location to pick up the passenger — Pick up at the house or other pick-up point
- Arrive at the arranged location — No personal connection with the driver
- Drive the passenger to the airport — Services lane or K+R
- Arrive at the correct departure hall — Services lane or K+R
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Elaboration

Contacting	Driving	Meeting	Traveling	Arriving	Transaction	Leaving
The driver receives all information about the flight time, location, date and number of passengers and baggage to make a decision if he/she can drop the passenger off.	Depending on the familiarity of the driver, route planners can be used. Additionally, drivers can use the planners to see how traffic is and take that into account to be on time.	The weather and traffic can play a role in being on time. Not knowing can lead to insecurities and stress for the passenger.	On the way to the airport the driver can experience difficulty in wayfinding. Also, when it is crowded the driver can feel a responsibility to be on time.	To drop the passenger off at the correct departure hall, the driver has to be informed by the passenger or by the signs on the road to find the right drop off location.	A taxi driver receives money for the ride. However, the friend or relative that drops the passenger off usually pays for parking and travel expenses.	The personal driver can quickly say goodbye at the K+R or emotionally say goodbye in the terminal. The taxi driver has no emotional connection and will continue his/her day.

Touchpoints

Collected data

Figure 6: Customer journey of the driver

Coincidentally, while observing that day a cloth came loose on the Ceintuurbaan, and subsequently blocked one lane. In total there are two lanes on the Ceintuurbaan, so it was important to get rid of the cloth to keep the traffic flow optimal.

Together with the fire department and the KMar the cloth has been removed. The process of solving this was quite spontaneous. The enforcer mentioned that there are no procedures for situations like that (informal conversation).

While removing the cloth, drivers were informed to switch lanes by using the dynamic screens on the car (figure 7). Although it was a quiet moment on the day, quickly the traffic piled up on the Ceintuurbaan (figure 8).

"*The Ceintuurbaan is the heart of the K&R, whenever something happens on the Ceintuurbaan, we have a big problem*" (enforcer informal conversation).

Figure 7: dynamic sign on the car

Figure 8: congestion on the Ceintuurbaan

2.3.2 Passenger input

In peak hours, the K&R is overcrowded and insecurities can become problematic for the passenger. In order to explore the passenger experience, messages from the Internet have been collected. The messages are collected via Obi4Wan, a platform used by Schiphol to collect, manage and reply to questions from passengers asked via social media platforms.

A lot of messages are questions or comments about picking up on the K&R. In October 2017, the free Collect & Ride (C+R) has been closed, which was the only free location to quickly pick passengers up. From the messages it can be concluded that many people are not aware about this and don't know what their options are. Consequently, they ask online where to pick passengers up or they go to the K&R (since it is the only free option) and get send away.

Customer service of Schiphol often comments that it is not allowed to park on the K&R, however there is no concrete information available about the allowed residence time. What is the difference between standing still and parking? For both the drivers and the enforcement it will be beneficial to set concrete rules about the residence time.
It is interesting to see that after almost one and a half year many people are not aware about the changed situation at Schiphol with regard to picking up.

In addition to the complaints about not being able to pick up for free, many people commented on the news about paid K&R. This has caused a lot of negativity around the K&R area.

f Amsterdam Airport Schiphol Amsterdam Airport…
🕐 04-09-2018 14:31 📖 ✓ Voltooid

Facebook conversatie: Hello,   Thank you for your message. Since last year, the Kiss & Ride at Arrivals has been closed off to ensure the accessibility of the airport by car. You can always drop someone off at the 'Kiss & Ride', but parking is prohibited here so you must be quick (hence the name). It is not allowed to pick someone up from this spot or to park here, as that would defeat the purpose of the Kiss & Ride. If you wish to pick s
for €1

🕐 17-07-2018 20:34 ↩ Gereageerd

Hallo @Schiphol eerst de 'ophaal' route sluiten, vervolgens is het te druk bij het 'weg brengen'.... (dan kan je €€€€'s vragen). Te gek, je kan ook van de 'aankomst' naar het 'wegbrengen' lopen om 'opgehaald' te worden....hoezo gek dat het daar te druk word...

🏷 Klacht ✕ 🏷 Parkeren ✕

f Amsterdam Airport Schiphol Amsterdam Airport…
🕐 22-07-2018 19:39 📖 👤 ✓ Voltooid

Bedankt voor je terugkoppeling. Je kunt vertrekkende reizigers snel afzetten bij 'Kiss & Ride' voor de vertrekhallen. Let op! Parkeren is hier verboden. Daarom kun je hier geen mensen ophalen. Zoals je op de foto ziet in dit artikel (https://www.schiphol.nl/nl/projecten/pagina/makkelijker-wegbrengen-op-schiphol/) hangt er een bord met -Wegbrengen Alleen Direct Uitstappen-. Heb je dat bord gezien?

Om Schiphol klaar te maken voor de toekomst, moet ook op de grond veel gebeuren. Meer vluchten en meer passagiers betekent namelijk ook meer behoefte aan parkeerplaatsen en faciliteiten. Daarom zijn we sinds 1 oktober 2017 verschillende parkeerlocaties aan het afbreken, verplaatsen, of op- en aan het bijbouwen. Op deze pagina (https://www.schiphol.nl/nl/projecten/pagina/project-parkeren/) houden we alle ontwikkelingen op Schiphol Parking bij.

2.4 CONCLUSIONS

In conclusion, these insights and the earlier done analysis reported in the analysis report indicate that the K&R is an important product for the passengers because it is a comfortable and free area to use and to efficiently drop someone off/pick someone up. In case there are train disruptions, the K&R is also used for drop off/pick up, because it is seen as an efficient and comfortable solution.

From the perspective of Schiphol, it is not allowed to pick passengers up from the K&R, because the collectors have a long residence time. They take up too much space, which can result in congestions. However, quite some passengers are not aware of this rule. The segment that is aware, deliberately uses the K&R, because the enforcement is not always enough to send everyone away.

It was also found that the Ceintuurbaan can easily lead to problems on the K&R due to small disruptions. In case that something happens on the Ceintuurbaan, the enforcement personally drives to the location to redirect the cars from the disruptions.
Congestions can result in an increased stress level for departing passengers. In these situations, the passenger loses control over the journey and doesn't know what will happen next (ACI, 2014).

This chapter explored four opportunities areas and described the selection and elaboration of the selected area. Opportunity area 1 is selected: the stressed car travelers in case of congestion. In this context car travelers are the passengers and drivers that use the K&R. The following chapter will explore the drop off/pick up alternatives in more detail.

04-10-2018 19:03   ✓ Voltooid

@Schiphol K&R wordt eeuwen ook gebruikt voor het snel ophalen van reizigers. Moet ik mijn dochter, die met de trein reist, 'betaald' ophalen vanuit P1, terwijl ik op 8 min afstand woon. Dit beleid lijkt eerder ingegeven, door jullie almaar teruglopende verlies- en winstrekening.
QUOTE @Schiphol: Dat klinkt er vervelend. Gebruik van de Kiss & Ride is en blijft gratis; deze is echter enkel bedoeld voor het snel afzetten van de reiziger(s), zoals de naam aangeeft ('afscheid nemen en wegrijden'). Parkeren op de Kiss & Ride is niet toegestaan.

02-10-2018 11:11   ↩ Gereageerd

@Schiphol   mag wel zomaar de ophaal locatie gesloten worden? Moet de kids&ride dan niet worden aangegeven als ophalen/brengen?

Vraag ✕   Parkeren ✕

3

SCHIPHOL INFRASTRUCTURE

It has become clear that the capacity on the K&R and Ceintuurbaan Zuid is not sufficient for the demand. With the growing number of passengers this will become an even bigger problem. In order to keep facilitating the passengers that are being dropped off/picked up, an additional location might be needed. Therefore, a study is done to explore which aspects passengers, drivers and the organization consider for dropping off/picking up.

3.1 KISS AND RIDE ALTERNATIVES

The current drop off locations are the K&R and P1 at Schiphol Centrum. The users of these drop off are the passengers and drivers. Van Heeswijk (2017) states that there are two types of drivers in the drop off/pick up process; the emotional and the practical driver. The emotional driver wants to go inside the terminal to properly say goodbye/welcome, where on the other hand the practical driver quickly wants to drop off/pick up and leave the airport.

It is found that the areas at Schiphol Centrum (the K&R and Ceintuurbaan in particular) are facing congestion problems. The growing number of passengers can increase these problems more. In order to keep facilitating the users of these respective areas, an additional K&R and/or C&R will be necessary. At Schiphol Centrum no capacity is left, which means the additional location needs to be remote.

This section describes the study that aims to explore the value of an additional remote K&R. The remote K&R is a conceptual alternative that will be used for research purposes. Now, imagine a situation with three drop off/pick up locations: A) the K&R in front of the terminal, B) P1 (short parking) and C) a remote K&R. Each of the options has different conditions (figure 9). The K&R can facilitate the practical group, whereas P1 and the remote K&R can facilitate the emotional group.
The goal of the study is to gather insights about what aspects passengers, drivers and the organization consider while dropping off/picking up.

3.2 ALTERNATIVES EVALUATION BY PASSENGERS

By using the options explained in the previous section (figure 9) a user study is conducted to validate the preferred options to drop someone off at Schiphol and create an understanding in the motivation of the passengers and drivers. In the same study the experiences on the current K&R and P1 have been studied as well.

3.2.1 Participants

The study was voluntary and required at least 20 participants. The aim was to have a variety in age and flying experience to represent the diversity in passengers at the airport. Moreover, the goal was to ask participants that are familiar with the K&R and/or P1 (short parking).

3.2.2 Stimuli

The three options explained in the previous section were used for the study (figure 9). All options are developed in the same style and were the same size.

3.2.3 Material

Quantitative and qualitative data has been collected by using an online questionnaire (appendix N). The quantitative data was gathered through a combination of multiple choice and 5-point Likert scale questions. The online questionnaire has been send out to the participants and analyzed afterwards.

3.2.4 Results

The questionnaire has been completed by 24 participants (7 male; 17 female) between the age category of 20 to 60 years, of which 87,5% is 20-30 years old. The majority of the participants were frequent flyers, 45,8% indicated to fly two or three times a year via Schiphol on average. The questionnaire was divided in two parts, where the first part focused on the current experience of the passengers and the second part gathered insights about the presented options (figure 9).

Current experience

A small segment of 7 participants had no experience in using the Kiss and Ride and 11 participants never visited P1 (short parking). The participants who don't have any experience in the K&R and/or P1 have provided no input about the questions related to the current K&R and P1. Therefore, the results of this section are less than the total of 24 participants.

The purpose of the visitation has been divided in four categories: driver (dropping off), driver (picking up), passenger (dropped off) and passenger (picked up).

From the total of 17 participants, the majority (15) indicated to use the K&R as a passenger that was being dropped off as well as the driver that was dropping off. Moreover, the second largest group is the passengers that are being picked up on the K&R (9), this is less than the number of picked up passenger at P1 (7).

Option A - in front of the departure hall (outside)

Drop off/pick up in front of the departure hall

No possibility to walk together with the passenger to the departure hall

Residence time of 10 minutes allowed

Minimal walking distance for the passenger
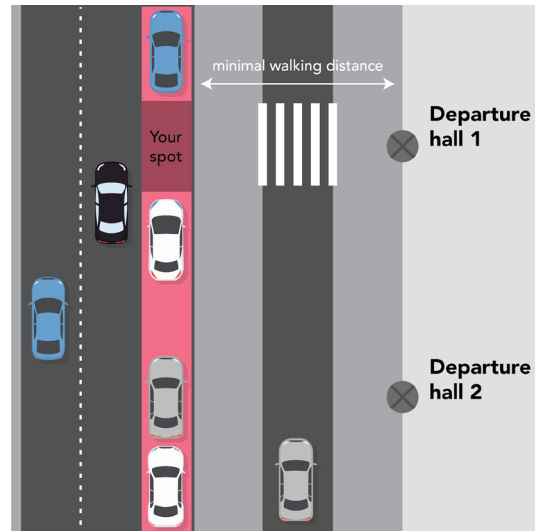
Option C - remote drop off/pick up location (outside)

Drop off/pick up at a remote location

Residence time of 1.5 hours allowed

Driver can drop off/pick up and leave the remote location or park the car and join the passenger to the departure hall to say goodbye/hello

Transfer by bus to the departure halls (approximately 15 minutes)

Minimal walking distance from the bus stop to the departure hall
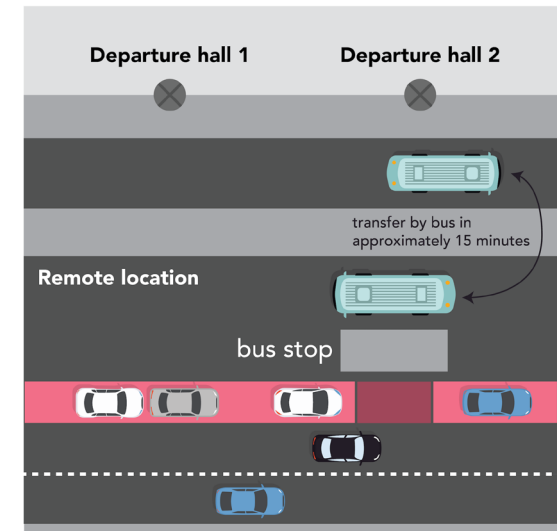
Option B - P1 (short parking) (mostly indoor)

Drop off/pick up in P1

Possibility for the driver to walk together with the passenger to the departure hall

Residence time of 1 hour allowed

Walking distance of approximately 15 minutes
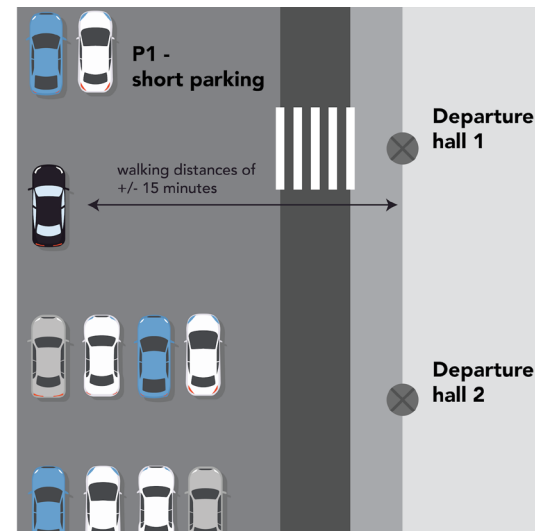
The results of qualitative data about the motivation for choosing (or not choosing) the K&R were in general quite similar to each other. Most participants indicated to use the K&R for its ease of use and the close distance with respect to the terminal. Additionally, costs are mentioned, where participants indicate to prefer the K&R more since it is free. Concurrently, some participants prefer P1 in case the driver wants to stay for a longer time to join the passenger inside the terminal or to have a guaranteed parking spot: "*We don't use it that often, because parking is paid. But you can stay there for a longer time and walk with the passenger inside*" (participant 3, translated from Dutch).

Not using the K&R and/or P1 are simply the consequence of not knowing what it is, not having a car or the case of preferring public transport over the car: "*Train is a faster choice for me*" (participant 22).

Figure 9: three Kiss and Ride alternatives

Explicitly asking what the participants dislike about the K&R and/or P1 has resulted in mainly the high intensity on the K&R.

"*Because it becomes more and more crowded it is difficult to park in front of the correct departure hall. If you are parked it is also difficult to leave, because new cars keep coming. Moreover, there is a lot of pressure which makes you hurry up and quickly say goodbye*" (participant 10, translated from Dutch).

The high intensities lead to chaos and stress, which are mentioned by several participants. One participant mentioned the number of signs on the way and the difficulty of reading all in order to make a decision on time.

With regard to the comfort, wayfinding and information about the K&R and P1, a 5-point Likert scale, from strongly disagree to strongly agree, has been used. Analyzing the data through frequency tables it can be concluded that one third of the participants (33,3%) agree on feeling comfortable on the K&R., the mean was 2.94 which is above average. On P1 the majority chooses neutral, which can be compared with an average comfortable feeling.

In terms of wayfinding, the K&R scores most with 4 out of 5, which means the majority agrees it is easy to find, the mean was equal to 3.94. For P1 the ease of finding has a mean of 3 out of 5.
The third and last question about the current K&R and P1 was "I am well informed about the purpose of the K&R and P1". Both locations score average, with a mean value of 2.50 for the K&R and a mean value of 2.83 for P1.

Lastly, the survey is used to find out where passengers obtain information from. For this goal, two questions are asked: 1) where do you find information about the K&R or P1, 2) where do you find information about your flight.
15 out of 18 participants indicated to not search for information about the K&R or P1. In addition, participants use either the website of Schiphol and/or the search functionality of Google. One participant clearly mentioned to never have searched for information.

However, for information about the flight, most participants use the website of the airline (14/24) and of Schiphol (10/24). A smaller group uses the app of the airline and Schiphol. Minority uses Google. One participant mentioned to only use the screens with flight information at Schiphol.

For both dropping off and picking up, the distance to the terminal is the most important factor. Together with the qualitative data explained earlier, it is the expected outcome. In addition to the distance, efficiency is a close second for dropping off. The costs are also indicated to be important for both dropping off and picking up.

Three options for dropping off and picking up
All participants are asked to provide input per option. Subsequently, each option is judged on what is unlikely about it. This resulted in a combination of quantitative and qualitative data for the positive and negative aspects respectively.

Option A: Kiss and Ride
As expected the distance to the departure hall and efficiency of option A score highest for appreciation. Comfort is the third chosen factor. One participant commented that it is free on the K&R.
When asked about the unfavorable things of option A, three main answers can be derived from the comments. The majority of the participants mentioned the short residence time, often associated with no possibility to go inside the terminal. Additionally, seven participants mentioned that the K&R in front of the terminal can be too crowded.

Option B: P1 (short parking)
For option B, the most selected factors are the residence time and the possibility to walk with the passenger inside. 18 participants mentioned the 15-minute walking distance as the main negative factor of option B, because it was too long.

Option C: remote Kiss and Ride
The distant location has scored high on the residence time of 1,5 hours. The possibility to walk with the passenger inside is also recognized as an important factor. However, for this option two participants commented with 'nothing', meaning they did not recognize an attractive option.
For option C, majority indicated the bus transfer to be a disadvantage for option C. Some participants commented they don't want to be dependent on a bus. 6 participants also found the distance to the terminal far.

Preference
Next to the separate options, the three options have been presented with only information about the location, possibilities and regulations in order to make the participant choose the most preferred one. 54,2% has chosen for option A and only 8,3% chose for option C. Two participants chose option 'other', where they indicated that the purpose and goal can have an influence in the chosen option.
"*A for drop off, B for pick up. Dropping off, the traveler will have to hurry, so closer is best, picking up it is best to go as a driver inside the airport and wait for the traveler*" (participant 20).

The motivation for choosing option A is mainly based on the close distance to the terminal and the efficiency that comes with it. Moreover, the participants mention that the residence is enough for saying goodbye. "*It is close and you still have time to say goodbye*" (participant 6, translated from Dutch).

Option B is mainly chosen for the relatively longer residence time of option A. Also, it comes with the possibility to walk with the passenger inside.
The least popular in this case was option C, with only two selections it is motivated as having a long time to park and to extensively say goodbye or pick up.

To examine whether the choices significantly changed, new terms related to money were added per option (figure 10). However, this time the question "Which one of these alternatives would you choose?" has been asked from the perspective of the passenger and driver to understand if there would be a different in preference.

For the question "Now imagine you are the driver. Which of these alternatives would you choose?", the reactions are quite evenly distributed. However, most participants chose for option C (37,5%), which is an impressive difference relative to the first question (8,3%).

7 participants mentioned to choose this option, because it is free. Another incentive is the long residence time: "*You can stay there for a long period of time and you know the passenger will safely be dropped off at the departure hall. When picking up you can easily wait for the passenger to arrive*" (participant 10, translated from Dutch). The choice on option B is mainly based on the costs (partly free) and the relatively close distance.
The smallest group is willing to pay for option A to be close the terminal.

Between driver and passenger, there is a significant difference in option C. Only three participants chose for option C based on the fact that it is free. However, the majority chose for option A and in the motivation, no one mentioned the price. Most participants mention the close distance to the terminal.

Option B is a close second, where the costs are mentioned by a part of the participants. Moreover, the residence time is indicated as an important factor. Figure 11 gives an overview of the responses

Option A - in front of the departure hall (outside)	Option B - P1 (short parking) (mostly indoor)	Option C - remote drop off/pick up location (outside)
Paid for the complete allowed residence time	First 20 minutes for free	Free for the complete allowed residence time (1.5 hours)
After 10 minutes (allowed residence time) the price will significantly increase		Transferbus to the departure hall for free

Figure 10: conditions with pricing

To validate if passengers are willing to pay their opinion is asked. 13 participants indicated to not be willing to pay. Some participants expect the free locations from the service point of view: "*A large company as Schiphol doesn't need to earn money by asking money for picking up and dropping off*"
Other participants don't want to pay for a short residence time such as 10 minutes, because they are only quickly dropping someone off.

An interesting observation was made by a participant about the current payment system: "*Why paying? Now it is also strange that we pay for a place far away (P1). where the close location is free (…) Paying to park is stupid, unless it is to be more sustainable and discourage people to come by car*" (participant 14, translated from Dutch).

There is a group that will be willing to pay, 7 out of 24 participants did indicate to pay for a closer and faster location. One participant mentioned to be willing to pay when there is not enough time and he can get closer by paying.

A few participants didn't explicitly state if they would pay or not, but mentioned it depends on the price.

To get an idea of the amount of money people are willing to pay ,the question has been asked how much they would be willing to pay for the 10 minutes at option A and for one hour for option B.

5 participants indicated to not pay anything for option A, whereby one participant explained this by saying it is a short residence time. Another participant discussed that the main advantage of the current K&R the free location is. Most participants don't mind paying a few euros. One participant is willing to pay €15 for 10 minutes.

The average for option B is relatively higher, where all participants range between 50 cents and €6. One participant indicated a range between €5 and €10.
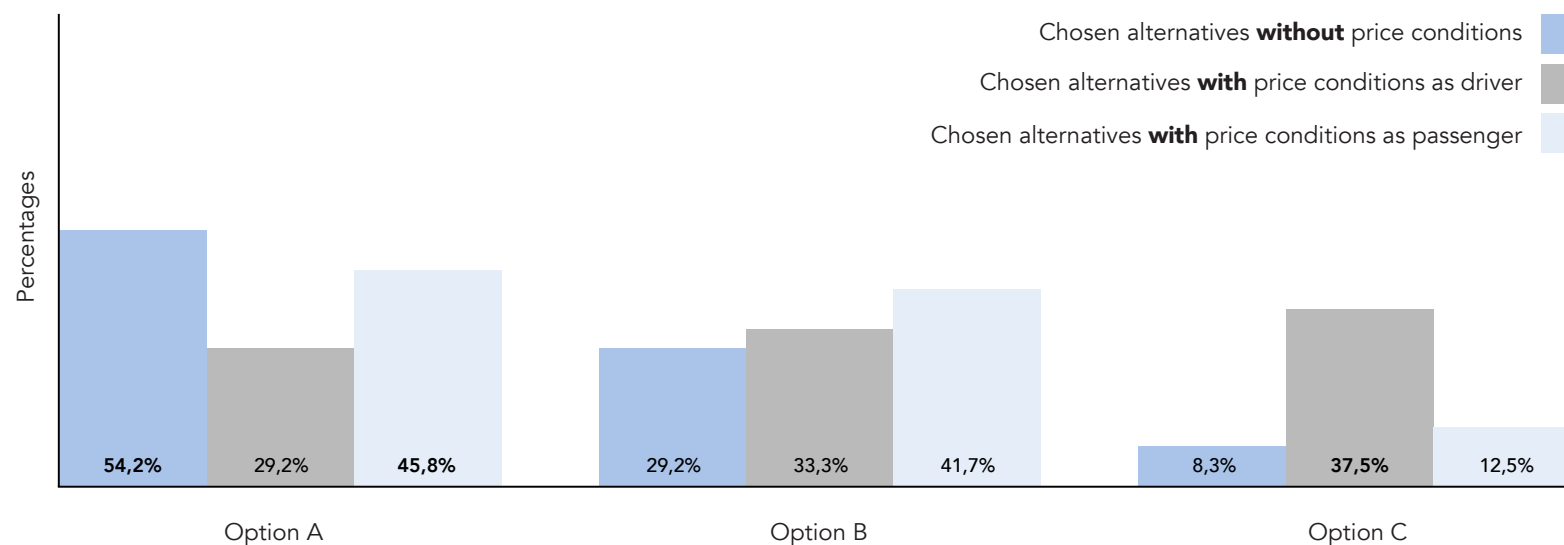
Figure 11: overview preference results

3.2.5 Discussion

The goal of the study was two-fold: 1) to identify the current experience and assessment of the K&R and P1, and 2) to discover which dropping off/picking up location is preferred by the passenger. The study is conducted by means of an online questionnaire. The questionnaire consisted of two parts, where the first part concerns the experience and assessment and the second part introduced the three options to evaluate.

The quantitative data about the usage of the K&R indicate that the area is almost equally used for dropping off and picking up. Hereby the convenience and close distance to the terminal is mentioned by the majority. However, the greater part of participants also indicated the high intensities on the K&R which result in stress and chaos. "Often crowded, a lot chaos. Unfriendly people fighting for a spot" (participant 16, translated from Dutch).

Even though many participants mention this difficulty, feeling comfortable on the K&R has a mean of 2.94, which is above average. The comfort is even higher for P1 (mean score= 3.00).

It is believed that the efficiency of being close to the terminal and being free outweighs the fact that is crowded and chaotic. There is a probability that the fact that the K&R is free is cognitively adding more value to the product (Guilherme, Saraiva, Economia, Doutor, & Brito, 2011). As explained by Guilherme et al. (2011), whenever people can choose between two products, where one is free, people tend to overreact to the free product. Also, the costs are mentioned by 10 of 19 participants to be important when dropping off.

Contrarily, 11 out of 14 chose costs as one of the important factors for picking up. Hence, costs are seen as more important for picking up.

Currently, Schiphol offers the products K&R and P1, where the K&R is only allowed to drop passengers off and P1 is for both dropping off and picking up. It is assumed that participants associated picking up with P1 and dropping off with K&R, which can clarify the factor of costs being important. The same explanation can be considered for the high importance of the close distance to the terminal for dropping off.
"*Costs of parking I guess [option B]*" (participant 20)

The considerations for picking up has less responses than the considerations for dropping off, because that question was added after the pilot with 5 participants. Therefore, the relative percentages are different and should be considered.
Another interesting finding is the relation between searching for information and being well-informed. 9 participants disagree with the fact they are well-informed about the K&R and 6 disagree about being well-informed about P1. Thus, there is quite a big segment of the participants that don't feel well-informed about the respective locations. Nonetheless, when asked where they search for information about the K&R and/or P1, the majority mentions to not search for information. This can mean that they are either unaware about the lack of information or that they expect the airport to be more active in their information provision. It is important to note that 7 of these responses have never visited the K&R and P1 and thus did not have the need to search for this information. Therefore, there responses are left out of the analysis.

The walking distance for option B has been mentioned by 18 out of 24, which makes it the highest factor for disliking option B The walking distance of 15 minutes is the case if the car is parked all the way at the end of P1. Often, the walking distance can shorter (5-10 minutes) depending on where the car is parked. In future studies, it is recommended study the accepted walking distance by passengers.

An interesting observation is the difference in preference when the participants were asked to answer from the driver's perspective and passenger's perspective. As the driver, participants indicate the costs to be important for the decision. However, as the passenger, there are only two participants that choose option C because it is free. The extra travel time for the passengers makes it a less attractive option. It is interesting to do an extensive study on decisions of drivers and passengers separately to understand the dynamics between these two target groups. Who is responsible for paying, who is making the decisions?

In terms of paying the majority mentioned not be willing to pay for a closer option to the terminal, because the closer options are usually allowing less residence times. "*If you quickly want to drop some off, I won't be willing to pay*" (participant 18, translated from Dutch). The K&R has always been free, which makes it an attractive product for passengers. Therefore, participants use the current free close option as a reference for option A.

In total there were 24 participants, with a variety in experience regarding the K&R and P1. As mentioned, there was even a group with no experience at all. The plan for this study was to conduct the study at Schiphol and personally ask the users of the K&R and P1. Unfortunately, it was not allowed to conduct the study since it discusses sensitive topics such as a paid K&R. By asking the passengers in the moment it could evoke expectations and wrong impressions about the plans of Schiphol. Therefore, the study has been conducted with acquaintances and family to prevent wrong impressions. Almost all participants were familiar with the project and this could have influenced the reliability of the results. It is recommended to conduct the study with passengers who are unfamiliar with the project.

3.2.7 Conclusion

Dropping off and picking up at Schiphol can currently be done on the K&R and P1. Drivers that drop off and pick up can be divided in an emotional and practical group (van Heeswijk, 2017). The emotional group wants to say properly goodbye or welcome the passenger in the terminal whereas the practical group quickly wants to pick up/drop off the passenger and leave the airport. The current K&R is a nice facility for the practical group, where the driver can efficiently use the area to drop off/pick up the passenger without paying anything. On the other hand, P1 gives the possibility to park the car relatively close to the terminal and walk to the terminal to properly say goodbye/welcome.

However, from the study it is found participants consider the distance to the terminal, efficiency and the costs as important for dropping off/picking up. The costs for P1 is often mentioned as the barrier for using that location. Simultaneously, the K&R is not favored in times it is crowded, because it feels chaotic and stressful. The results from the diary study conducted in the analysis report also indicate that time and costs are the most influencing factors in the decision-making process.

The majority of the participants indicated not to be willing to pay for closer options, but will choose option B (P1) if the first 20 minutes is free. As mentioned earlier, the costs of P1 is mentioned as the negative aspect of P1, whereas the distance and efficiency is valued.

There is a small segment of the participants that would choose for option C if option A remains free. In case the closest option becomes paid, there is a significant preference for option C from the driver's perspective.

However, the passengers still prefer option A, which can mean the passengers expect the driver to pay. Future work should study the differences between drivers and passengers in case of dropping off/picking up at an airport. However, the insights are valuable for the continuation of this project.

3.3 ALTERNATIVES EVALUATION BY SCHIPHOL EMPLOYEES

The three options studied with possible passengers has discussed some limitations of the study. One of the limitations was the selected participants for the study. In order to gather more input about the three options, an additional questionnaire has been conducted with Schiphol employees. In this study only the options are discussed and not the current K&R and P1 locations.

3.3.1 Participants

The study was voluntary and required at least 20 participants. The aim was to have a variety in age and department at Schiphol, in order to gather insights from different expertise fields.

3.3.2 Stimuli

The three options explained in the previous section were used for the study (figure 9). All options are developed in the same style and were the same size.

3.3.3 Material

Quantitative and qualitative data has been collected by using an online questionnaire (appendix O). The quantitative data was gathered through a combination of multiple choice and 5-point Likert scale questions. The online questionnaire has been send out via mail and Yammer at Schiphol to reach the employees.

3.3.4 Results

In total, 51 people filled out the questionnaire (29 male, 21 female and 1 other). The majority of the participants are between the age of 20-30 and 41-50 years. The goal of the study was to receive input about the three options (figure 9) to understand how the internal stakeholders react to the conditions. The three options have been evaluated separately after which the participants selected a preferred option based on different conditions.

Option A: K&R

The participants could evaluate the positive aspects of each option by selecting one of the six predefined aspects. By selecting 'other' the participants had the option to add new aspects.

Option A scored highest for the close distance to the terminal, the comfort and efficiency. The participants mentioned that the short residence time and the fact that there is no possibility to go inside the terminal and high intensities make it a less preferable option.

Option B: P1 (short parking)

For this option, the mainly chosen positive aspect is the possibility to walk to the terminal (37 out of 51). Secondly, the residence time, efficiency and comfort score high. The walking distance was noted as too short. In addition, the costs are not appreciated. From the Schiphol perspective, participants indicated that sending drivers to P1 still results in traffic at Schiphol Centrum.

Option C: remote K&R

The mostly selected aspect is the efficiency, with the possibility to join the passenger to the terminal. 20 participants selected other. 7 participants mentioned that they didn't find anything positive about option C.

From a operational perspective, other participants (8) stated that this option will be beneficial for reducing the traffic at Schiphol Centrum.

However, the bus transfer together with the long distance is believed to be negative about this option.

Preference

To evaluate the preferred options, the three options were presented twice. The first time without the conditions about money and the second time with conditions about money (figure 10). For both the conditions with and without money involvement, the participants were required to choose an option from the passengers' perspective and from Schiphol's perspective.

A summary of the results for the preferences can be seen in figure 12 below. As can be seen, option A is preferred from the passengers' perspective without any conditions about pricing. However, from Schiphol's perspective the preferred option is option C.

In case the K&R becomes paid, P1 is free for 20 minutes and C is free for all time. The favored option for both perspectives switched to option B.
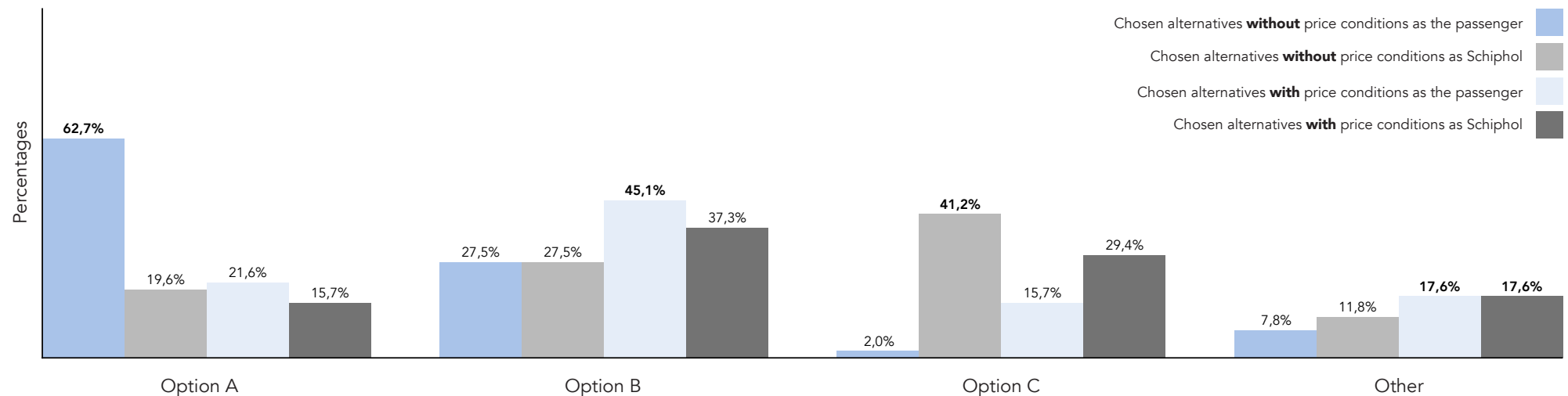
Figure 12: overview preference results Schiphol employees

Choosing option A is mostly based on the efficiency and comfort for the passenger and the distance to the terminal. Participants indicated that it is not always necessary to extensively say goodbye, but that other options should be available to facilitate the user groups that want to say goodbye.

The 10 participants that selected option A from Schiphol's perspective motivated it as being the most customer centric solution for the passenger.
The selection of the paid option A is motivated with receiving extra profit for Schiphol, which is currently not earned.

Option C is preferred from Schiphol's perspective to reduce the intensity and chaos at Schiphol Centrum.

3.3.5 Discussion
Unlike the previous study with the passengers, this study aimed to determine which option is preferred by the Schiphol organization, whereby both the passenger and internal values are considered.

An interesting observation is that Schiphol employees recognize the need to send more people to the remote K&R in order to reduce the intensity at Schiphol Centrum, but from a passengers' perspective, they still selected option A and B as the preferred one. Option C was only selected once for the conditions without pricing. In case option A was presented as a paid location, option C was only chosen by 8 participants (figure 12).
However, it is noticed that some participants gave similar answers for both perspectives, whereby several participants indicated they did not understand the difference between the questions. This could have an influence on the results.

Part of the questionnaire gathered insights about the positive and negative aspects of the individual options. Hereby, the question was 'What do you find attractive about option A/B/C from a Schiphol perspective?'

It is found that the participants evaluated the options based on the passenger experience and not on organizational factors. This is not a bad thing, it shows that the organization does consider the passenger experience, however, it is not evaluated in terms of feasibility.

Just as with the previous study, it is assumed that the current K&R and P1 are used as a reference for the preference selection without price conditions. This influenced the negativity of option B, where some participants commented on the price of P1.
Presenting the price conditions, showed that for both the passenger and Schiphol the preferred option is B, which is motivated with both the benefit for the passenger and Schiphol.

All participants were employees at Schiphol, whereby there is a variety in departments. This provided input from different organizational perspectives. For instance, the customer service department focuses more on the experience, where the operations department is trying to optimize the processes in terms of efficiency and safety. The results are valuable whereby different principles and regulations are considered.

In the questionnaire, no difference in dropping off and picking is indicated. However, from the responses it can be certified that most participants only considered dropping off as the possibility. Some participants did mention that it is important to differentiate the drop off and pick up flow. Nonetheless, participants did point out the benefits for dropping off and picking up respectively.

"*For the passenger the relation between distance, time and money is important. Therefore, for dropping off option A and for picking up option B.*" (Participant 39, translated from Dutch).

Next to the distinction in dropping off and picking up, a number of participants indicated the importance of acknowledging the different target groups and their needs. This is interpreted as the fact that there is not one best option, but each option can be valuable for a different target group. The main target group for dropping off/picking up, is the difference in the emotional and practical group (van Heeswijk, 2017). The results from the individual options are providing insights regarding the (dis)advantages of the respective option for a specific target group. Therefore, it is believed that the gathered findings are valuable for the continuation of this project.

3.3.6 Conclusion
The aim of this study was to gather insights about the positive and negative aspects of each individual option. Moreover, the preferred option from the passenger and Schiphol perspectives have been studied.

Overall, in case option A remains free, it is preferred for the passenger. From Schiphol's perspective option C is preferred, because it reduces the traffic at Schiphol Centrum. However, if option A becomes paid and option B free, the preferred option for both the passenger and Schiphol becomes option B. Currently, the main obstacle for using option B are the costs.

For Schiphol, it is not the best solution to send all traffic to P1, because the traffic will still be at Centrum. Therefore, option C is valued, since it provides an additional option for the passenger and results in less traffic at Schiphol Centrum. The study revealed insights about the valuable aspects of each option. In terms of preference for an option it is difficult to select one option as the best since each option offers different values for different target groups.

3.4 CONCLUSIONS ON K&R ALTERNATIVES
In this chapter two studies have been conducted and described. The aim of the studies was to understand what aspects are considered as (in)valuable when dropping off/picking up at Schiphol.
Two similar surveys are completed by passengers and Schiphol employees. The results from these two studies provided valuable insights about what aspects need to be considered when developing a drop off/pick up location.
An interesting conclusion is that the K&R (option A) is currently experienced as negative due to high intensities and chaos, but it is the preferred option from the passenger's perspective. Passengers even chose this option when it was fully paid. From this can be assumed that passengers expect the driver to pay for parking costs. Accordingly, it is found that drivers prefer option C, because it is fully free.

However, having paid conditions for the K&R was not valued by the participants, because they believed it was weird to pay just for 10 minutes. Therefore, it can be an option to make the first 5/10 minutes free.

Many participants mentioned the costs as the obstacle for using option B (P1). It did become a more valued option with the proposal of making the first 20 minutes free. Responses indicate that option B is beneficial for the passenger, driver and Schiphol, due to the relatively close distance to the terminal for the passenger, no costs for the driver and reducing traffic in front of the terminal. Additionally, the driver also has the option to walk with the passenger inside the terminal.

Nevertheless, sending all traffic to P1 is not solving the intensity problem at Schiphol Centrum. Therefore, it is suggested to use option C as a spare location to redirect traffic to in case of contingencies/congestions at Schiphol Centrum.

In conclusion, dropping off/picking up is not only about the distance to the terminal or comfort. Costs plays an important role in the decision-making process, which can explain why drivers go to the K&R and not P1 even if they experience it as crowded and stressful. Therefore, it is important to consider the parking costs for P1 and remote K&R.

The insights from these studies can be used by Schiphol to identify the relevant aspect for dropping off/picking up. In the next chapter, ideas are generated and selected.

4

IDEA SELECTION

This chapter discusses the next step in the design process, idea generation. Using the selected opportunity area, bottlenecks and ideas are explored and defined.

4.1 CREATIVE SESSIONS

In the analysis report bottlenecks about the K&R have been collected mainly through expert interviews and observations. However, to create more understanding about the cause of congestions two sessions have been organized. During these sessions solutions for the bottlenecks and challenges have been discussed with the participants.

4.1.1 Session with passengers

The first session has been conducted with three participants. The background of the participants was all different, one is a student international business, one studied teaching and the third participant studied graphic design. The aim was to have a variety in their background in order to approach the Kiss and Ride from different perspectives. All participants had knowledge about the Kiss and Ride and could provide input about their experiences as a passenger and as a driver.

Procedure

The method used for gathering insights was the 'how to' technique. By asking the participants how to be on time in general (a), at Schiphol (a) and on the K&R (c) factors were gathered that can influence the journey. Subsequently, the factors were used as a starting point to discuss possible solutions.

Results

The main factor, mentioned by the participants, was that the lack of available space can prevent one from being on time on the K&R. Consequences of the lack of space are the long waiting lines and dangerous situations due to cars switching lanes to cut the line.

Participants also indicated that certain actions can affect the intensity and chaos on the K&R. Examples of such actions are people that leave their baggage cart on the lane or people who drive really slow in order to find a spot. Moreover, the long residence times of waiting drivers are also mentioned as an effecting factor.

Furthermore, it has been mentioned that passengers are not always aware in which departure hall they need to check-in. Hence, it will be valuable to promote the Schiphol app when booking a ticket in order to show passengers the advantages or the available information on the app. To provide information while driving, it is interesting to look into the possibilities to connect route planners with Schiphol platforms.

The earlier stated factors, lack of space, long residence times and unawareness have been used as a starting point to discuss possible solutions. Some ideas can be clustered in infrastructure developments, such as having an extra K&R or expanding the current K&R.

In order to prevent people from searching on the K&R, it is suggested to inform drivers about the number of places per departure hall or use barriers with information about where to go instead of using the current signs with the airlines.

For the long residence times, participants mentioned using a smart parking system with colors to easily spot the cars with a long residence time.

The majority of the time, the participants talked about the fact that people are unaware about where to go on the K&R and where there is any place to park.
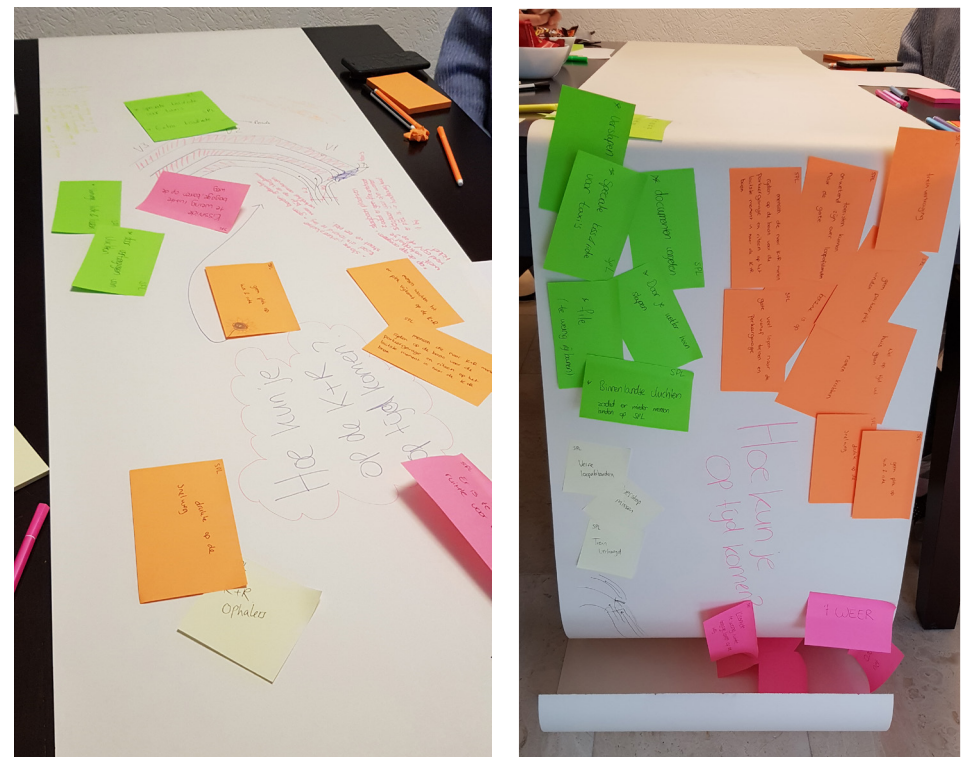
Figure 13: process of the session

4.1.2 Second session

In order to generate insights in the perceived obstacles by Schiphol, a session was conducted with developers and service owners experienced and responsible for landside connectivity. In total seven employees participated (appendix P).
The research questions were defined as follows:
- *What obstacles cause disruptions on and before the K&R?*
- *How can the obstacles be solved?*

Procedure
At the start of the creative session two points were defined, the situation now and the ideal situation. In this context, the ideal situation on the K&R means to have a seamless flow and stress reduction of passengers.
The first task of the participants was to write down any obstacles that they believed prevented the K&R from becoming seamless. This activity has been derived from the exercise 'Jumping Obstacles' from 75 Tools for Creative Thinking (Booreiland, n.d.). The goal of this activity is to think from a quite negative perspective to come up with ideas.
Subsequently, all defined obstacles were grouped in seven main themes. The themes were decided in discussion with the participants by asking which one they thought was relevant and why.

After the creation of seven themes, all participants started with one theme individually. The participants were asked to sketch or write down ideas/actions to solve the obstacle respectively. After three minutes, the participants were asked to pass the paper to someone else in the group. Using this exercise has been inspired by the 'Group Sketching' activity explained by Mansfield (2018). The reason of choosing this particular activity was to make sure all participants could provide input, because it was quite a large group.

Results
The results showed that the overarching problem is the lack of road capacity on the Ceintuurbaan and the K&R. The capacity problems are emphasized due to misuse of the area, long residence times and lack of enforcement. However, the obstacle that passengers can get confused due to the many products Schiphol offers. It is discussed that passengers can be informed in better ways to be aware of the options offered by Schiphol. More detailed explanation of the results can be found in appendix P.

Furthermore, the clustered obstacles have been used to define 7 topics that the participants were asked to ideate about. The topics and the input were as follows:
- Improve the enforcement
- Reduce wrong usage on the K&R
- Inform the offered products more
- Reduce the number of products offered by Schiphol
- Implement the security measures more efficiently
- Offer equal alternatives to the different target groups
- Align the organizational and internal interest

The results of this session show that the capacity can be used more efficiently by having stricter enforcement, repositioning of products, cancelling of products, informing passengers better, understanding the passenger and creating integral visions with equal interests between the stakeholders.

Figure 14: process of the session

4.1.3 General discussion and conclusion

The goal of the creative sessions was to 1) create an in-depth understanding about the bottlenecks and challenges on the K&R that both Schiphol and the passenger can experience, and 2) how the bottlenecks and challenges can be reduced/solved.

The sessions provided validation and evaluation for some of the found bottlenecks in the earlier phases of the project (analysis report). Additionally, new bottlenecks are found. Conducting two sessions with one group from the passenger's perspective and one from Schiphol's perspective provided insights on a broad spectrum.

The passengers experience can be linked to the insecurities on the K&R about where to park or drop off as well as lack of knowledge about the departure halls and alternatives offered.

The second session involved Schiphol developers and service owners, which results into not only taking the passengers into account, but also regulations that need to be considered. The combination of the input is valuable for the feasibility of the project.

Overall, the results of both sessions recognized the lack of information for the passengers both prior and during the journey to the airport. No information about the current situation at Kiss and Ride is available. On the other hand, passengers are not aware about the regulations on the K&R. Suggestions such as using a heatmap on the K&R or promoting the app have been identified. Moreover, input from both sessions recommend more enforcement on the K&R to keep the traffic flow going by using barriers or smart systems to monitor efficiently in order to write out fines.

Nine out of the total ten participants were non-designers and this was of influence on the ideation part of the sessions. The results resulted in more design directions rather than the ideas itself. Therefore, the input is used as inspiration for the project in order to generate ideas. To generate more out-of-the-box solutions, it is recommended to do a creative session with participants that have a design background.

Nevertheless, the input of both sessions has been used for the next phase, ideation.

Figure 15: process of the session

4.2 IDEATION PROCESS

Using the results from the sessions as a starting point, ideation has started. Additionally, findings from earlier research is also taken into consideration as input for the ideas. Eight ideas are developed and briefly explained here below.

Idea 1 – Pre-booking
As mentioned, insecurities in the journey can lead to stress for the passenger (ACI, 2014). On the K&R, the insecurity can signify when the waiting times are become longer. In order to reduce the intensity on the K&R, the idea is to develop a pre-booking service whereby passengers can reserve a place on the K&R. Passengers that don't book will be redirected to another location. By using a booking system, Schiphol can estimate the intensity for the K&R and have more control over the limit of the K&R.
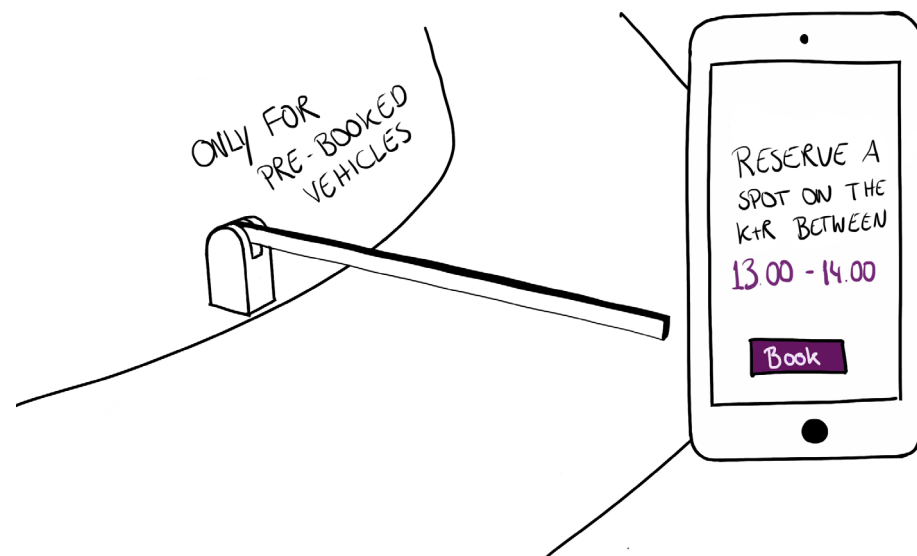
Idea 2 – Information provision
It is found that people are not always aware about where to drop off/pick up. Additionally, the conditions for the available locations are not known or met by the users. When it is crowded on the K&R, passengers can feel more stress due to the waiting times. In these cases, it is not always clear how long the problem will take and what the alternatives are. The idea is to provide more information about the situation at the drop off/pick up locations in order to offer people alternatives to arrive at Schiphol on time. Information provision will be done at home and on the way.
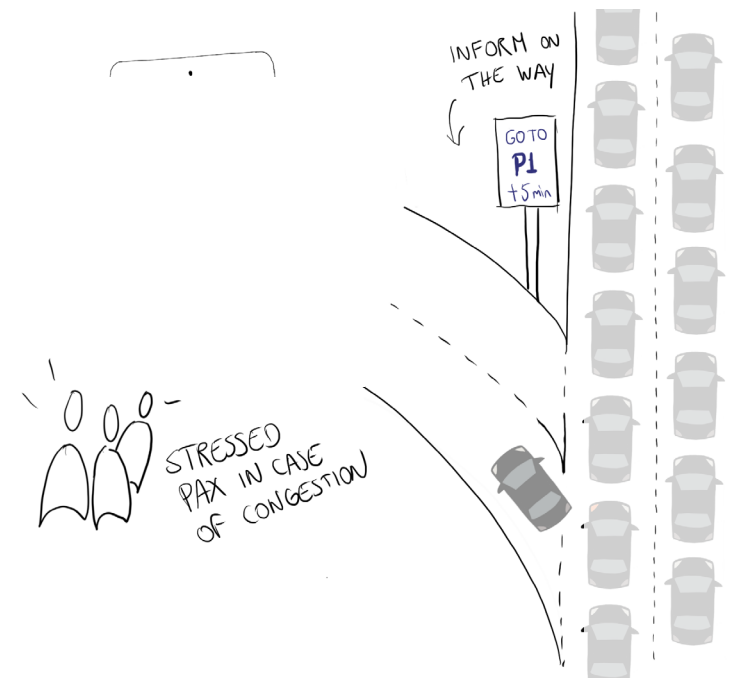
Idea 3 – Carpooling

Introducing a carpool lane on the K&R to motivate passengers to share rides by traveling together. Hereby, the carbon footprint and the intensity on the K&R can be reduced. Moreover, this will contribute to the vision of Schiphol to become more sustainable.

Idea 5 – Smart parking system

The long residence times of collectors and third-party services take up too much of the capacity. Especially in peak hours the traffic flow needs to be as efficient as possible. However, in crowded moments the enforcement is insufficient to keep the traffic flowing. To make the process more efficient a smart parking system can be used to measure the residence time of each car and provide feedback through lights.

From a distance, drivers will also be able to use the lights as an indication of there is a free spot to park.

Idea 4 – Shared car

With the goal of reducing the carbon footprint and the intensity on the K&R, the area can be changed to a car sharing. One car can be used for two flows, the departing and the arriving passenger. Using services such as Car2Go, the area can be used with only electric cars.
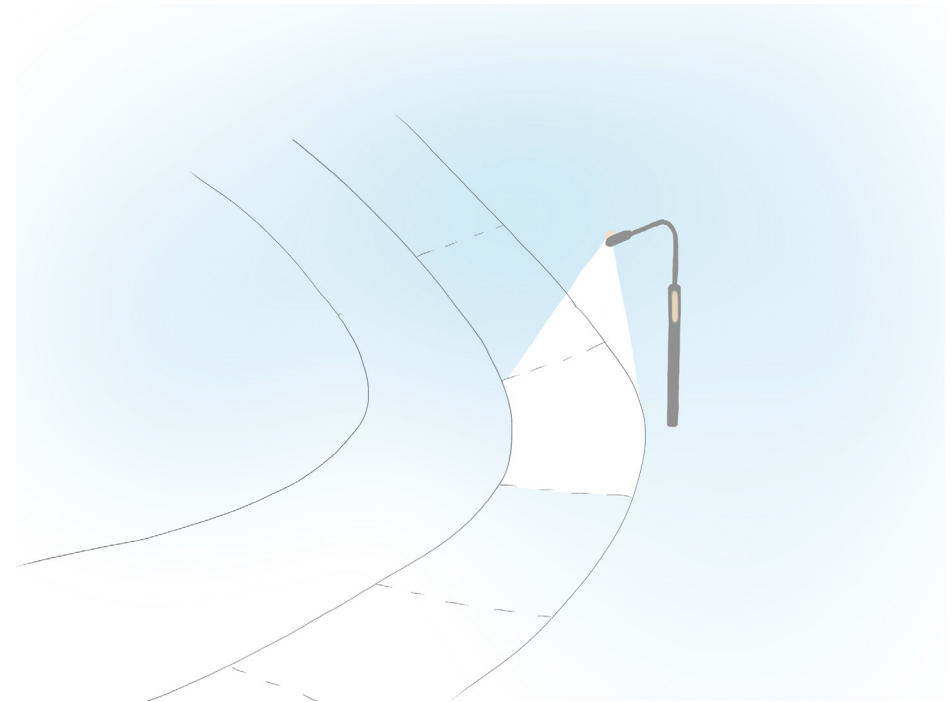
Idea 6 – Green zone
Again with the goal of reducing the carbon footprint, a green zone can be introduced. The greener the car, the closer to the terminal.
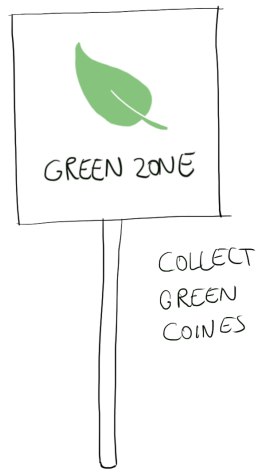
Idea 7 – Heatmap
Using a barrier in front of the Ceintuurbaan that provides information about the intensity on the K&R as well as where there are free spots available. In this way, the passenger will keep the freedom of choice to decide to enter the K&R or P1. (P1 is also accessed from the Ceintuurbaan).
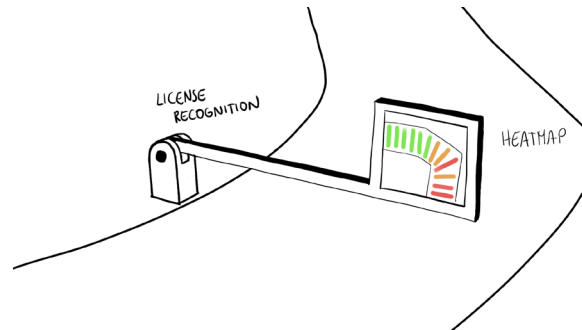
Idea 8 – Rewarding
Providing incentives to motivate the passenger to use other drop off/pick up locations or even other modalities. Discounts or points can be collected when parking in P1 for instance.

GREEN ZONE

COLLECT GREEN COINES

LICENSE RECOGNITION

HEATMAP

RECEIVE A FREE COFFEE COUPON @ P1 - SHORT PARKING

4.3 IDEA SELECTION

In chapter two opportunity area 1 was selected. This area focused on the stressed car travelers in case of congestions, whereby the K&R and Ceintuurbaan are selected as the context. Congestions can be the result of of having too many cars on the K&R or too long residence times.The ideas provide solutions for either on of these problems.

In order to select an idea to continue with, a few criteria have been set:
- The idea should go beyond the K&R domain
- The idea should be valuable for the congestion problem on the K&R
- The idea should add value for the operation at Schiphol
- The idea should add value to the passenger (and driver) experience by reducing the stress while dropping off

Next to the defined criteria, the ideas have been informally discussed with two internal stakeholders at Operations.

4.3.1 Idea selection

The ideas for reducing the carbon footprint combined with the intensity are quite severe solutions whereby many target groups will be forced to find other options than the K&R. Simultaneously the heatmap and smart parking system are specific ideas for the K&R. Other locations that can be accessed by car at Schiphol, often have a smart parking system to show where there are free spots left.

Evaluating the problems found related to the passenger experience, the idea for information provision is an interesting one. In case there is congestion on the K&R passengers tend to panic because they have the responsibility to catch their flight. Consequently, dangerous situations can arise. An example is the April 2018, when the congestion spread till the highway (A4), after which some passengers exited the car to walk to Schiphol in order to catch their flight (RTLnieuws, 2018). For the operational efficiency, the solution in case of congestions is to make sure there are no more cars entering, but only leaving to reduce the pressure.

In addition, the idea for information provision has the opportunity to be expanded with a pre-booking system or rewarding services afterwards.

However, the communication system needs to be developed first to be able to expand. Next to the criteria, the process owner Landside Accessibility and service owner for road infrastructure favored the idea for information provision based on the feasibility, expandability and purpose.

All things considered, idea 2-information provision has been selected to develop further.

4.3.2 Idea description

The goal of the concept is to reduce the insecurities and thus the stress levels while dropping people off on crowded days. Providing a communication system to drive drivers away from the crowded areas can help reduce the high level of intensities.

In case of congestion, there is currently not a lot of information available about the alternatives. This also means that it is difficult to manage the traffic flow and to steer the drivers somewhere else. Figure 5 and 6 demonstrates the current journey of both the passenger and driver where the touchpoints for each phase can be seen. The driver is being informed through navigation apps and the static signs on the road. However, if there are disruptions, not a lot of information is available.

Additionally, information prior the journey can also be provided to prepare the passengers and drivers earlier in the process. The current website of Schiphol provides brief information about the K&R, but is can be expanded with more information about the alternatives and situation. The information can help to make a decision beforehand.

However, it can also be the case that congestion is formed spontaneously. In such a case, Schiphol would want to redirect the drivers to other locations in order to reduce the pressure before the K&R. This can be done through the use of dynamic screens. On the screens information about the intensity and alternatives can be given in order to provide the passengers with options. Additionally, the control room of Schiphol can use the screens to redirect people in case of contingencies.

The advantage for the passenger is the information about where to go in order to arrive on time in the terminal. Drivers want to keep in motion, because when waiting, the driver loses his ability to control his journey.

In addition, McGuire, Kimes, Lynn, Pullman, & Lloyd (2010) argue that the perception of crowding can lead to stress, anxiety and irritation. By using the dynamic screens, the traffic can be distributed efficiently by redirecting cars to the remote location.

In the context of this idea, the remote K&R is used as a back-up location to take the pressure of Schiphol Centrum. This means that the K&R and P1 are the mainly used locations.

4.3.3 Idea development process
In order to elaborate more on details of the idea the idea development has been done in iteratively whereby a topic has been researched and used as input for the next iteration. Each iteration is an extra layer of input to use in the final design (figure 16). For further development the collectors and arriving passengers are left out of scope. Departing passengers experience more stress when being dropped off in case of congestions. Additionally, the study results described in chapter 3 describe the relevance of costs while picking up. Hence, the parking costs for P1 can be an obstacle for using this area. Collectors can be send away from the K&R by providing a free alternative.

4.4 IDEA EVALUATION WITH STAKEHOLDERS
Before the next phase of the idea, a workshop with stakeholders has been organized to gather feedback from different perspectives and expertise. Additionally, it was a good moment to evaluate if the stakeholders had any objections.

4.4.1 Introduction
The goal of this workshop was to gather feedback and validate the idea of information provision with different stakeholders. The idea is divided in two parts, informing at home and informing on the way. Subsequently, the aim was to answer the following research questions.

4.4.2 Participants
Both internal and external stakeholders were invited to provide feedback about the idea (appendix Q). In total there were 12 participants, including stakeholders from Schiphol Operations, Schiphol Parking, KLM, KMar and Rijkswaterstaat.

Overall goal

Improving the experience while dropping off at peak hours at Schiphol

Idea

Informing passengers about the situation at Schiphol to reduce stress and make sure they are aware of alternatives

Acitivity
Research the experience and considerations about three drop off locations (chapter 3)

Results
Use the results from the studies as input for idea description

Acitivity
Workshop with stakeholders to validate if there is interest in the idea and what can be improved/changed (chapter 4)

Results
Use the results as input to iterate/improve the idea

Acitivity
Idea development with exploration in infrastructure, sign placement, information provision and required technology (chapter 5)

Results
Use the findings for the final design.

Activities

Figure 16: overview of idea development process

4.4.3 Procedure

For the workshop visuals have been designed to present the idea (figures 17 and 18). After presenting the idea, the group was divided in two, whereby one group focused on the home part and the other group on informing on the way.

The interactive session was divided in two activities. The first activity called 'Joining forces' was adapted from the toolkit developed by Booreiland (n.d.). The goal of this activity is to evaluate ideas with different expertise, whereby the positive and negative aspects are discussed in two rounds. For the third round the participants were asked to define the two most important aspects that can lead to great consequences.
After defining, each group had to briefly present the results to the other group. The second activity used the defined aspects as a starting to ideate possible solutions in order to prevent the consequence of happening.

4.4.3 Results

As mentioned one group focused on informing at home and one group on informing on the way.

Informing at home
The group evaluating the informing at home part of the idea identified several advantages for both the passenger and Schiphol. The passenger can become more aware about the different alternatives and search for information when things are unclear. By providing information about the intensity on the respective locations, the passengers can predict their journey and use the information to change their decision.
For Schiphol, the distribution on the road infrastructure can be improved by having more control over the provided information. An opportunity to take into account was the use of push messages with actual information. In addition, the app can be used to provide information in case of contingencies/emergencies.

If the information is real-time, the status of the K&R is not interesting when leaving the house, because it is a dynamic environment. Hence, there is no guarantee that the situation will stay that way.

The main aspect to prevent problems is the reliability and the promotion of the app. Using incentives to promote the app, such as the first 15 minutes parking for free after downloading the app.
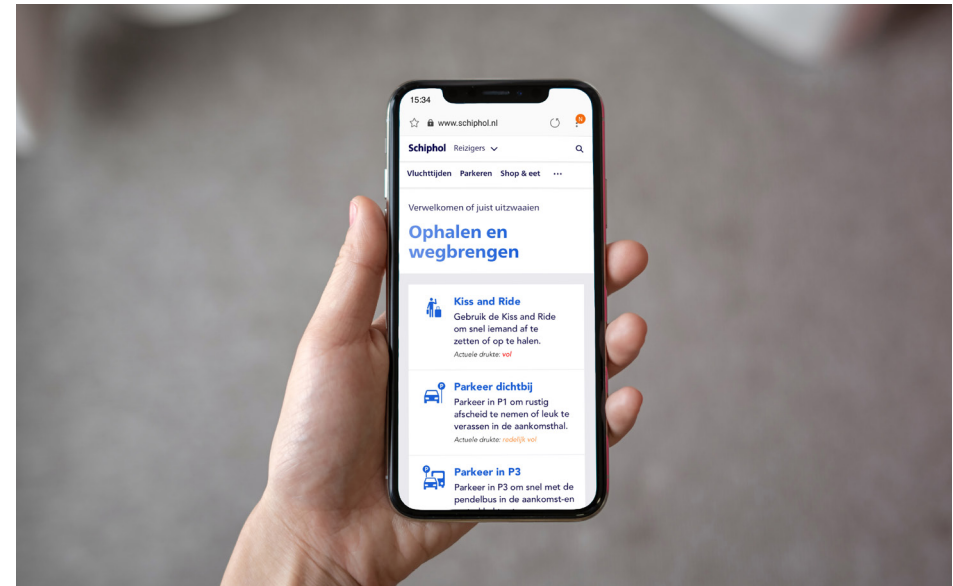
Figure 18: informing on the way

The user groups with long residence times on the K&R (collectors, third-party services) have quite an impact on the intensity of the K&R and thus the status on the app. The app is mainly valuable for providing the different alternatives. This advantage can be enhanced by connecting the information with other modalities such as train and bus, to provide travel information on an integrated level.

Informing on the way
The second part of the idea, informing on the way, consisted of the use of dynamic screens in order to provide information about the situation and redirections in order to drop the passengers off. The group indicated that the screens provide actual information, whereby the driver is not required to use his/her own phone. The information on the signs have a high trust level, which is beneficial in the steering of cars.
For Schiphol, a connection can be made with the control room to in order to manage the information and act upon contingencies/emergencies accordingly.

The main discussion for this idea was about the level of choice freedom Schiphol wants to give to the drivers. You want them to give the choice, but not too many choices so they don't get stressed while choosing. The idea was given to give two choices per decision moment, whereby one moment is on the freeway (decision between remote and centrum) and the other moment is at Schiphol Centrum (decision between K&R and P1). In this way, the driver will have freedom of choice, but the distribution over the road infrastructure can be done earlier. The importance of providing drivers with two choices per decision point is also mentioned by Glastra-van Loon (2017), where he described the 'highway model'. In the highway model there is a main flow, from which each option is split from the main flow.

It is also mentioned to frequently inform the driver, in case someone missed the sign. About the information on the screens, there should be a balance between providing information about the current situation and dynamics of the information. Since the status can change, it should be considered to use a range.
Instead of using the number of places, it can help to use minutes about the waiting times. The names of the different locations are also an effect on the decision, remote sounds less attractive than Schiphol Centrum.

By the end of the workshop, everyone provided input about the required stakeholders to realize the idea. Stakeholders that play a role are Schiphol Digital/IT, passengers, Marketing, Airlines, Transport Operators, Contentproviders (Google, TomTom), Wayfinding experts, Schiphol Parking, Schiphol Real Estate, Rijkswaterstaat and Provincie.

4.4.4 Conclusion
The goal of the workshop was to gather feedback from the stakeholders in order to validate their level of interest and concerns about the idea. It was a nice workshop where positive reactions were received.
The key points of improvement are briefly summarized here below.

- For the dynamic screens, the number of presented choices can be reduced to two instead of three in order to make it less stressful for the driver to make a decision.
- Start informing on the freeway and not after entering the Schiphol terrain. Also, place multiple screens on the road to keep repeating the information so there is enough time to make a fitting decision.
- The content of the dynamic screens needs to be updated in a certain timeframe and not every second.
- Use waiting time instead of number of free places.

- In order to prepare the passengers before leaving the house, the app needs to be promoted so people become aware of the alternatives to drop off.
- Real-time status in the app is less relevant than predicted information.
- The reliability of the data needs to be extensively tested.

The feedback on how to improve of the app and dynamic screens is valuable input for the iteration of the idea. The positive feedback validates that there is an interest in this idea, however some participants indicated to have more enthusiasm for the dynamic screens, because it opens up more control at Schiphol Centrum to act upon unplanned contingencies/emergencies.
One of the participants was an enforcer on the K&R, who was more concerned about the collectors on the K&R. However, the scope is deliberately focused on dropping off in peak hours, because that is the target group to experience more stress in times of congestion. Moreover, the problem with the collectors is the long residence time. By informing passengers about the three options explained in chapter 3, and providing free alternatives it can be expected that more collectors will choose for an option other than the K&R.

Nevertheless, it is important to be aware of this bottleneck and take it into account. The idea will be further developed in terms of placement of the signs, content of the signs and the technology that will be required for realization.

5

IDEA DEVELOPMENT

In this chapter, the idea with the dynamic signs will be developed further. The idea exists of three elements, the infrastructure placement of the signs with regard to the infrastructure, the technology for measuring and controlling as well as the content of the signs itself. These three elements are discussed and explored individually in order to gather insights and draw conclusions for the final design.

5.1 INFRASTRUCTURE
The goal of the dynamic signs is the redirect drivers to alternate drop off locations in case the K&R in front of the terminal has a high intensity level. Therefore, it is important to explore what principles play a role in the traffic flow and wayfinding in traffic. This section describes the requirements for the placement of signs and the considerations for the infrastructure.

5.1.1 Traffic signs
Traffic signs can be found in different sizes and shapes. There are traffic signs to indicate the regulations and speed limits for a specific area. However, there are also signs for wayfinding purposes to guide the decision-process by informing the driver of where to find what.

For the signs with wayfinding purpose, there are three categories of signs that can be differentiated.
1) the advance direction sign, this is placed prior the decision point in order to inform the driver about the options (Wegenwiki, 2014).
2) interchange directional signs, these are used at the decision point to inform for the last time which exit has to be taken respectively (Wegenwiki, 2011)
3) confirmation signs that are used after a decision point to provide information where one is driving (Wegenwiki, 2016b).

The design of the signs can vary according to the lane as well. Advance direction signs are usually overhead signs (figure 19 and 20).
For interchange directional signs, a difference can be made between roadside signs and decision signpost (figures 21 and 22).

At Schiphol a combination of overhead, roadside and decision signposts can be found. Often information is provided through overhead signs. In case there is one lane it is most beneficial to use the roadside signs. However, in case there are more than two lanes it is valuable to use the overhead sign.
In the Netherlands, the main characteristic of such the traffic signs for wayfinding purposes, is the blue background color.

For dynamic information, matrix signs and variable message signs are used. The matrix sign can present a limited number of symbols, for instance a green arrow or red cross (Wegenwiki, 2016a) (figure 23). However, the variable message sign (figure 24) is more dynamic whereby text, images or a combination of text and images can be shown (Wegenwiki, 2017). According to the scenario that is being followed, the information on the dynamic part will change.
There are traditional variable message signs on which text and several icons in one or color can be projected. In addition, bermDRIPS can show text, images or a combination of text and images. The regular bermDRIPS use white and red in order to for instance show the level of congestion on the freeway (bermdrip classic (figure 24, left). However, if needed it is possible to use more colors in order to help the information provision (CROW, 2017) (figure 24, right). These matrix and variable message signs use LED technology and animated light to indicate changes in traffic.

For the positioning of a sign requirements can found as well. The positioing needs to be in line with the visual field of the driver. The vertical field of vision of people is approximately 15 degrees (Schultz, Schulz, & Fricke, 2007) (Mijksenaar, 2014).
Experts from Mijksenaar (2014) state that the best horizontal visual field is 10 degrees left and right. Consequently, the signs will need to be placed within this field of vision. Lack of visibility of the sign results in wayfinding errors (Burns, 1998).

15 degrees

front view
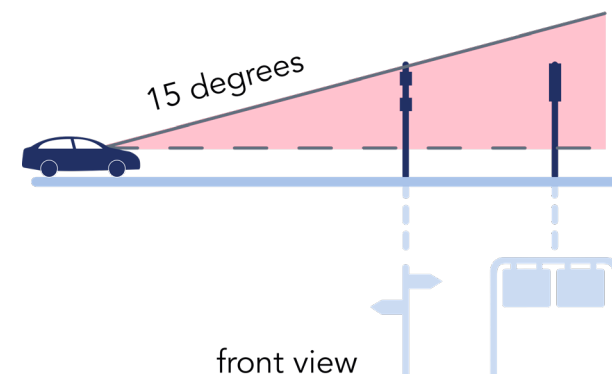
Figure 25: visual field of driver (Schultz, Schulz, & Fricke, 2007) (Mijksenaar, 2014)

Figure 19: overhead sign (Verkeerinbeeld, 2015)

Figure 20: overhead sign type 2 (Naamplaat bewegwijzering, n.d.-b)

Figure 21: roadside sign (Naamplaat bewegwijzering, n.d.-a)

Figure 22: decision signpost (Plaatsengids, n.d.)

Figure 23: matrix signs showing the speed limit and a red cross (Plaatsengids, n.d.)

Figure 24: a regular bermDRIP on the left, colored bermDRIPS on the right (van Weel, n.d.)

5.1.2 Placement of signs
In terms of traffic, the main bottleneck at Schiphol is the Ceintuurbaan Zuid. In peak hours, the capacity is not sufficient for the intensity. High intensities result in congestions and dangerous situations. The dynamic signs will be used to redirect drivers, but having changing information can influence the wayfinding experience. Hence, the positioning and visibility of traffic signs is an important factor for steering drivers.

Burns (1998) stated that the most frequent problem in wayfinding was that drivers missed a sign or saw it too late. Making a mistake in wayfinding can be the result of the lack of information or being presented with too much information to process while driving (Burns, 1998).

As discussed earlier, it is important to minimize the number of options per decision point. The highway model has been discussed in the previous chapter, whereby it is explained that there is one main flow from which drivers can exit to other locations (Glastra-van Loon, 2017). Sometimes the infrastructure doesn't allow the highway model to be realized, but uses a junction to choose a direction (left or right).

Scharine & McBeath (2002) found that in case of a T-junction, drivers tend to go to the right. Figure 26 illustrates the highway model and junction principle. The red dots represent a decision point.

Next to the division of the infrastructure, Glastra-van Loon (2017) also mentions the importance of circulation for intuitive wayfinding. In case a driver takes the wrong turn, a return loop is beneficial to give a second chance. Currently, Schiphol offers this option with the "Return to Schiphol" sign at the end of the K&R (figure 27).

Figure 26: highway model (left) and junction principle (right)

Figure 27: 'Return to Schiphol' sign (Google Maps, 2018)

In the Netherlands the road infrastructure can be divided in three categories: 1) through-road, 2) distributor and 3) access road (SWOV, 2017) (figure 28).

The through-road can only be found outside residential areas, where the allowed speed limit can be 80 km/h, 100 km/h, 120 km/h and 130 km/h (SWOV, 2017). An access road provides access to residential areas and can be found both in and outside of residential areas. In residential areas the speed limit can be 15 km/h or 30 km/h, whereas outside residential areas the limit can be 60 km/h (SWOV, 2017).

The distributor connects the through-road with the access road, here the speed limit can be 50 km/h, 70 km/h or 80 km/h (SWOV, 2017).

Mijksenaar studied and provided advice about the placement of signs for decision points on the road. Hereby, the speed limits with regard to three categories have been taken into account. Part of the advice is based on guidelines of CROW (Centrum voor Regelgeving en Onderzoek in de Grond-, Water- en Wegenbouw en de Verkeerstechniek).

Most roads within the Schiphol terrain are distributor roads. Areas such as the K&R are access roads, whereby the Ceintuurbaan Zuid is the distributor.

The use of advance direction signs is only applicable for distributor roads and are placed 200 meters before a decision point (Mijksenaar, 2014).
In addition, decision signs are placed directly at the decision point in order to inform the driver for the last time before deciding the direction (Wegenwiki, 2011).

Moreover, Mijksenaar (2014) advices to have at least 300 meters in between decision points in order to provide enough time to read and process the information.

Information has to be repeated in order to have enough time to consider and make a decision (Burns, 1998) (Mijksenaar, personal communication 2019).
Figure 29 shows a visual of the placement of signs with regard to distance from the decision point(s). The red dots represent the decision points.

	Outside residential area	In residential area
Through-road	80 km/h, 100 km/h, 120 km/h, 130 km/h	NA
Distributor	80 km/h	50 km/h, 70 km/h
Access road	60 km/h	15 km/h, 30 km/h

Figure 28: Overview of the road types in the Netherlands
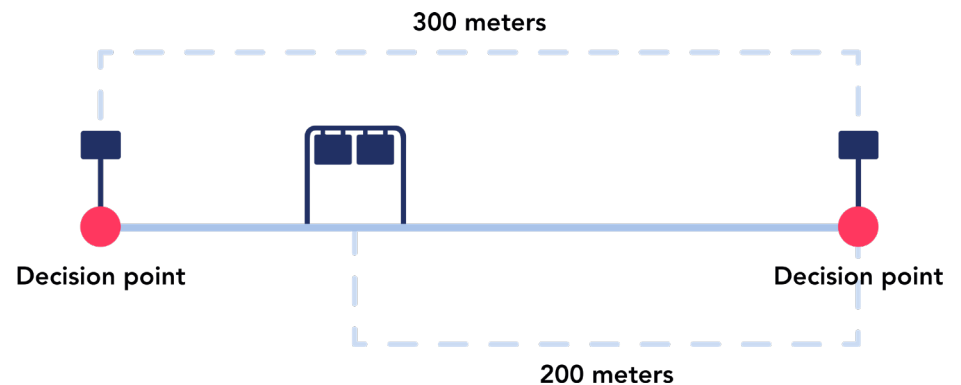
Figure 29: placement of signs with regard to decision point

Applying these principles at Schiphol, it means that advance direction signs need to be placed at most areas. To illustrate this, an example situation at Schiphol is described below. All flows can be seen in figure 30.

In the example, the earlier explained drop off locations are used (chapter 3). These are the K&R, P1 (short parking) and a remote K&R, which in this case is P3 (long parking). Analyzing the decision points and mapping the distance between those decision points it is found that the infrastructure does not always allow the principles to be met (figure 30).
The distance between decision point 2 and 3 is 145 meters. Having only 145 meters is not only too little time for reading and interpreting a sign, it is also inefficient for the visual field of the driver, since the vertical field is approximately 15 degrees.

For situations such as these it is recommended to try to either enlarge the distance between these points or reduce the speed limit to provide more time to read and interpret the information.

Decision point 2 and 3 are both located at the so called 'new exit' (figure 31). Due to the infrastructure, it is not possible to expand this new exit. Haarlemmermeer (2017) advices to reduce the speed limit to 30 km/h. Since it remains to be a distributor typed road, an advance direction sign can be used. However, there is no possibility to place this sign 200 meters before the junction. Therefore, reducing the speed to 30 km/h will provide enough time to read the overhead sign.

Return to Schiphol flow
P1 flow
K&R flow
Remote K&R (P3) flow

Figure 30: mapping of the decision points (black dots) for the different flows (enlarged on the next spread)
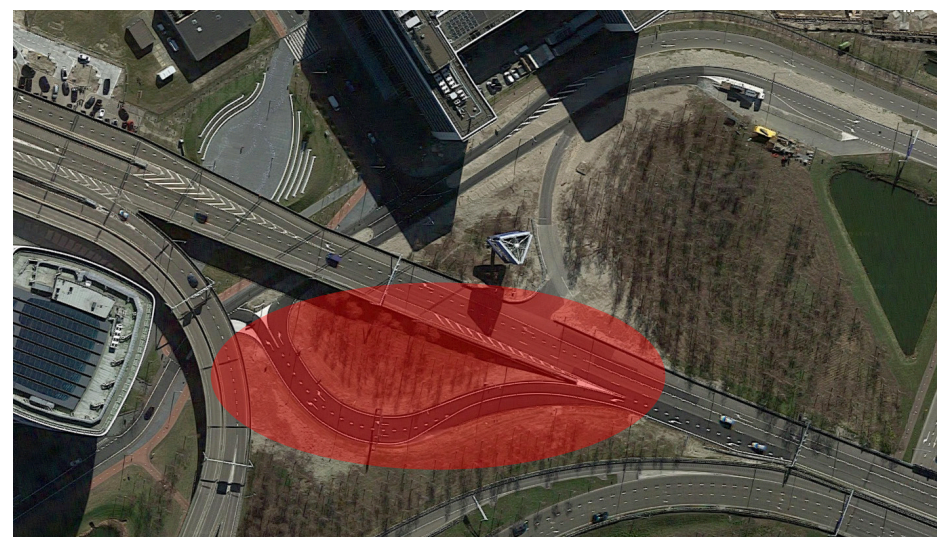
Figure 31: the new exit at Schiphol (highlighted in red)

5.2 INFORMATION PROVISION

Driving requires a lot of attention, where distractions can have (extreme) consequences, such as a reduction in sign reading or road awareness (Chan, Gonzalez, & Perez, 2016). In the dynamic environment drivers need to understand the situation and location in order to make decisions and arrive at the right destination. The decision-making process is influenced by several factors (Burns, 1998). First, the driver needs to become aware that there is more than one direction to choose from, whereby the environment or the cognitive map has to help becoming aware (Burns, 1998). In this process, the road signs are one of the environmental factors.

Therefore, the content of the signs is also an important factor for informing and steering people in traffic. In this section, visuals are created and studied with experts and passengers.

5.2.1 Visual hierarchy and patterns

In order to study and propose a design for the content of the dynamic signs, visuals have been created.

For the design of the visuals, theory about visual hierarchy has been studied. Jones (2011) identified several factors to consider in order to achieve hierarchy based on the rank of the content in the visual. The factors used for the design of the visuals are briefly described here below (Jones, 2011):

- Size: the size can be correlated with the rank. The bigger, the more attention it will attract.
- Color: contrast in color will attract more attention. Hence, contrasting colors can be used for important elements in the visuals.
- Alignment: literary ordering the elements by aligning the elements in relation to the complete visual.
- Repetition: using the same style for related elements, such as making all titles bold and larger. In this way people will be able to quickly scan for the title.
- Whitespace: ensure there is enough space between the elements, where it is still possible to understand which elements belong to each other.

The factors can be considered to ensure hierarchy in the information shown on the screens. Using contrast in color can attract more attention in case something needs to be informed first. According to Gao, Podladchikova, Shaposhnikov, Hong, & Shevtsova (2006) the color and shape of a traffic sign is valuable for recognizing the particular sign.

For webpages there are two reading patterns identified for processing information (Soegaard, 2018). Pages with little content, are scanned by means of a Z-pattern. Then, the user scans from the top left to top right and then goes from bottom left to right again (Soegaard, 2018). A similar pattern has been found by Chan, Gonzalez, & Perez (2016), where they used eye-tracking to study the reading patterns of traffic signs. The results show that drivers scan the sign in a top to down, left to right approach, and have a primarily focus on the center part of signs (Chan, Gonzalez, & Perez, 2016).

Moreover, features from existing traffic signs are used as a source of inspiration to reduce the difficulty of interpreting the signs. In context of the idea, the dynamic sign is used for wayfinding purposes to show drivers which location is inaccessible, and which direction should be followed instead.

As explained previously, traffic signs for wayfinding and steering purposes can exist of a static and dynamic part. On the blue part of the sign static information is given, such as the location name. However, dynamic information is given on matrix and variable message signs (figure 23 and 24)

Using the insights about visual hierarchy, reading patterns and current traffic signs a first version of signs have been designed. The developed visuals are explained in the following section.

Return to Schiphol flow
P1 flow
K&R flow
Remote K&R (P3) flow

Benthem Crouwel NACO
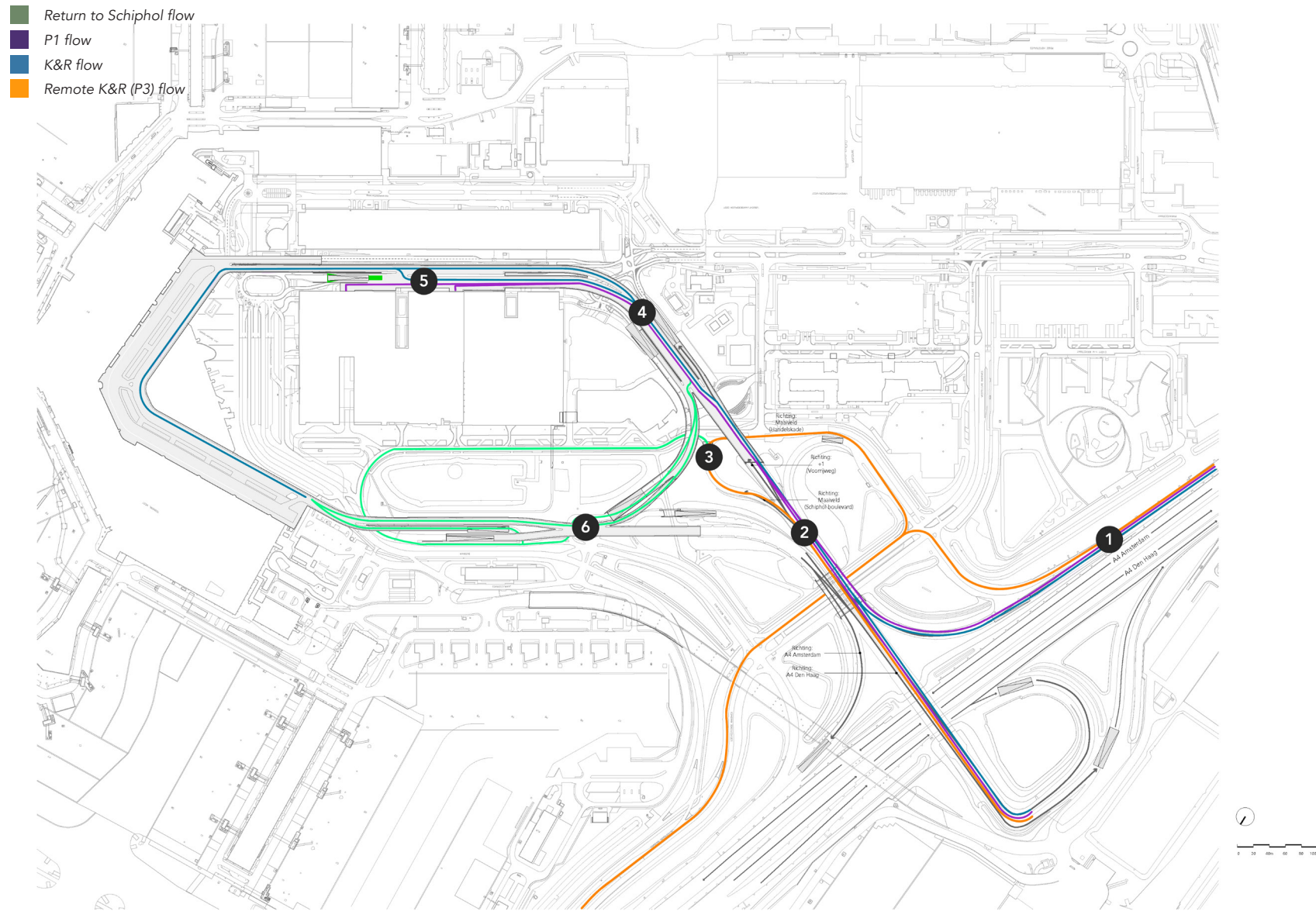
Figure 32: enlarged map with decision points

5.2.2 Development of visuals

In order to design the content of the signs, it is important know the number of the decision points. Using the same three locations K&R, P1 and remote K&R as explained in the previous section, the decision points can be mapped (figure 32). In total, there are six decision points. The decision points are used as a guide to design the visuals.

The purpose of the developed visuals was to get a review from three different wayfinding experts (experts from the airport and Mijksenaar).
The visuals differed in terms of content and not regarding the shape. All signs were rectangular, where the static part was made blue and the dynamic part black (figure 33). All designed signs can be found in appendix R.

Most feedback was focused on the labeling of locations and the text for informing passengers about the situation. The wayfinding experts indicated that in terms of congestion or contingencies, it is best to eliminated the freedom of choice. It is not required to provide a lot of information, since that can lead to information overload. Information such as "crowded" and/or "full" can be relative and not have an impact on all drivers. Therefore, it is advised to use more strict signage such as a red cross. In case everything is well, no information is required (Mijksenaar experts, personal communication 2019).
Decision point 1 is located on the freeway. Hereby, it is important to be aware of the target groups that will use the sign. For instance, the visual seen in figure 34), is a sign for on the freeway where information is given about Schiphol Centrum and Long parking. The dynamic text "crowded" on the freeway is not applicable for all target groups or locations. Because it is only crowded at departures, and not for parking or cargo users. Therefore, it is better to inform for each location individually (Mijksenaar experts, personal communication 2019). From this can be concluded that the dynamic references have to be valuable and relevant for the target groups driving by. In summary, the labels and the information on the screens has been discussed rather than the shape and color of the signs.
Consequently, the feedback from the wayfinding experts was used to iterate and thus create another set of visuals. The signs have again been created for the three locations represented in figure 32. Hence, the K&R, P1 and an additional remote K&R. For each decision point a visual is created and presented in figure 36. Different from the first iteration is the additional dynamic black screen on top of the blue sign.
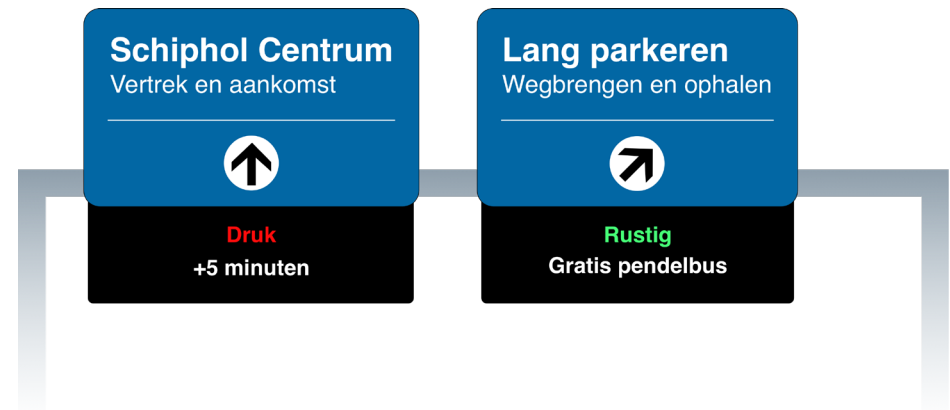
Figure 34: example of sign for decision point 4

Figure 33: shape of the first iteration of signs

Figure 35: shape of the second iteration of signs

Additionally, a smaller screen has been placed next to the locations to be able to provide information per individual location on the sign (figure 35). The black screen at the bottom is a matrix sign, whereas the top and small screen are variable message signs. The variable message sign provides more flexibility for presenting information. The second version of the visuals is used as a starting point for validation and will be explained in the next section.

Figure 36: visuals for every decision point mapped in figure 31

Decision point 1
Remote K&R or Departures/P1

⚠ Omleiding
Vertrek Snel afzetten — Volg A
P1 Parkeren 0-48 uur
↓

Vertrek Snel afzetten — A
P3 Lang parkeren 3 dagen of langer
🛏 Hotels
↘

Decision point 2
Remote K&R or Departures/P1

Vertrek Snel afzetten — A
P3 Lang parkeren 3 dagen of langer
Hotels
↙

⚠ Omleiding
Vertrek Snel afzetten — Volg A
P1 Parkeren 0-48 uur
↓

300m
🚕 Car Rental
↘

Decision point 3
Remote K&R or back to Departures/P1

P6 Valet
Hotels
✈ Terug naar Schiphol
↙

Vertrek Snel afzetten — A
P3 Lang parkeren 3 dagen of langer
↘

Decision point 4
Departure or P1

Vertrek Wegbrengen — A
P1 Parkeren 0-48 uur
↓

⚠ Omleiding
Vertrek Wegbrengen — Volg A
↙

🚗 Car Rental
↘

Decision point 5
Departures or P1

Vertrek Snel afzetten — A
P1 Parkeren 0-48 uur
↓

⚠ Omleiding
Vertrek Snel afzetten — Volg A
✗

The content of the dynamic parts is for a scenario in which the K&R is crowded. Therefore, the aim is to redirect drivers to either P1 or the remote K&R.

5.2.3 Validation of visuals

As mentioned, the designed visuals of figure 36 are used as a starting point for the user study. The purpose of the dynamic signs is to act in case of congestion and/or contingencies in order to steer drivers to other locations. In order to analyze the impact of the signs, a study was conducted by means of video fragments. The goal was two-fold: 1) to understand if the messages on the signs influenced the choices of the users and 2) to understand if the messages on the separate signs were conveyed clearly.

In the current situation, there are two drop off locations, the K&R and P1 short parking. Chapter three explored and described the use of an additional location in case of congestion/contingency at Schiphol Centrum.

However, this has just been a conceptual study and is not yet implemented. For the user study the current infrastructure is used, whereby videos are recorded at Schiphol. Therefore, the remote K&R is left out of scope, because there is currently no remote location in existence. Instead, the area in front of the Sheraton Hotel is used as a fictional remote K&R. See figure 37 for an overview of the used locations.

Confidential
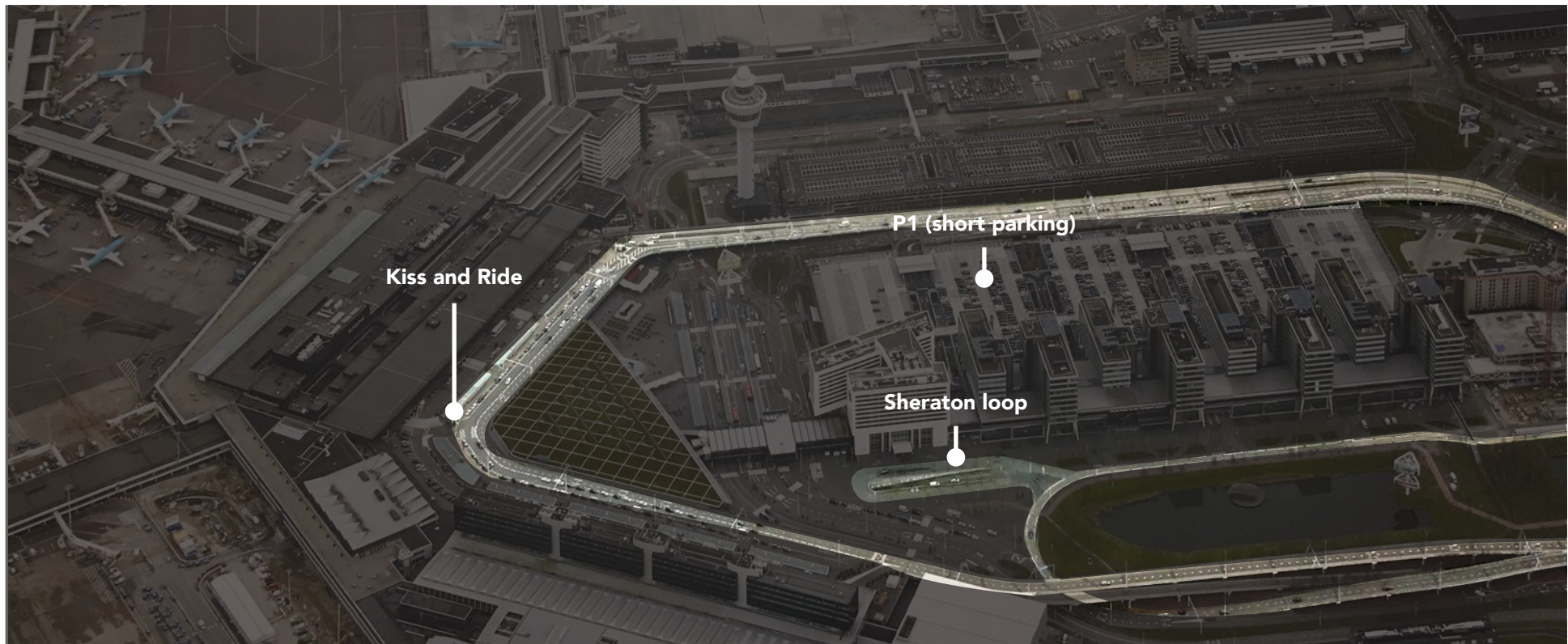
Figure 37: overview of the three locations. Kiss and Ride, P1 and Sheraton Loop

Participants

For this study, a variety in age was required. Moreover, the participants were chosen based on their familiarity with the Kiss and Ride and/or surrounding areas at Schiphol. Prior the study, participants were asked to sign an informed consent form.

Stimuli

In total seven video fragments were edited in Adobe After Effects. The videos were recorded at Schiphol with a smartphone attached to the windshield of a car and had a resolution of 1920x1080 pixels. The aim of the video fragments was to display the journeys of the three locations shown in figure 37. Hence, the recorded videos contained the required routes accordingly.

Using the second version of the visuals as a template, five visuals are created for this study in particular (see appendix S). The visuals were exported with a resolution of 72 PPI, because it was used on a screen. Eventually, the visuals have been placed as still images in these seven video fragments (figure 38). The goal of this was to demonstrate the usage and impact of the designed visuals in context.

Materials

For the study, a 10.5-inch tablet (iPad Pro) has been used to play the videos and discuss the visuals. The edited video fragments were arranged accordingly and added to the program Keynote on the iPad Pro (version 4.3). The Keynote was made interactive whereby arrows were placed to use as links for the decisions of participants (figure 39).

In addition to the Keynote, the visuals were added separately to the drawing program Procreate (version 4.2.5) on the iPad Pro in order to discuss the visuals in more detail. Hereby, the Apple Pencil has been used for drawing purposes. Semi-constructed interviews were conducted to gather qualitative data about the impact and changes of the signs.

Procedure

Prior to the start of the video fragments, the participants were given the task to drop a passenger off at departures on a busy day. Therefore, they were asked to go to departures.

The participants were asked to sit at a table and watch the first video fragment.

In this fragment, the car drives at the beginning of the Ceintuurbaan Zuid towards the first two signs (figure 38). After the fragment ended, the participant was asked to choose a direction by means of the arrows (figure 39).
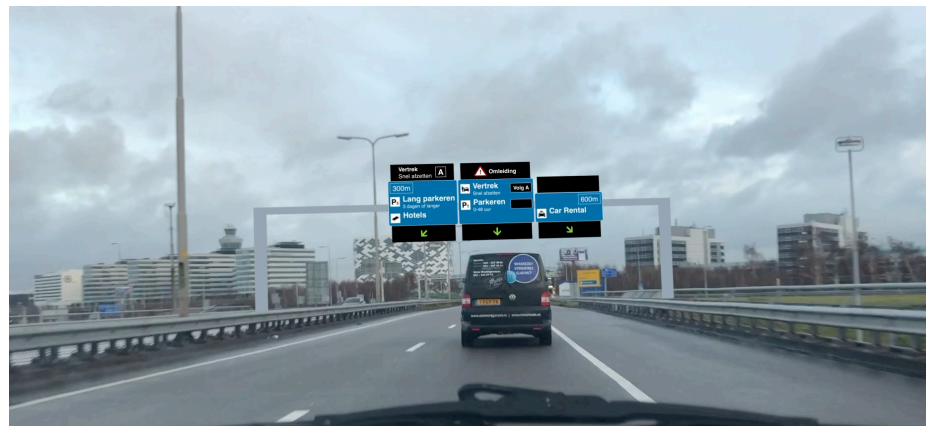
Figure 38: placement of visuals in the videos

Figure 39: arrows that participants could click to continue the 'journey'

This process was repeated until the participant reached one of the three possible end destinations (figure 37). The decision-making process was observed and noted by the researcher. Hereby, the chosen directions were observed.
After a destination was reached, the study continued with a semi-constructed interview. During this interview questions about the journey and signs wereasked. Subsequently, the signs were discussed in detail separately.

Results
For the study, ten participants (three male, seven female) between the ages 20 and 72 participated in the study. The driving experience varied greatly. Half of the participants (5/10) had a driving experience within the range of 0.5 years and 6 years, where the other half is ranged within 24 and 50 years. All participants were Dutch, which means all quotes are translated from Dutch. 80% of the participants were frequent flyer at Schiphol, with an average of two or three times flying a year.

The first part of the study aimed to understand if the signs influenced the decision of the participants. Since the task was given to drop someone off at departures, the goal of the signs was to redirect the participants to either Sheraton or P1.

The majority of the participants (5/10) followed the signs to the departures. A small segment (3/10) chose for the third option, Sheraton. However, two indicated it was not a deliberate choice.
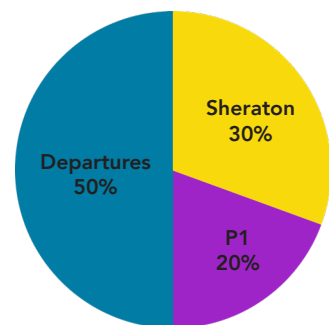
Figure 40: overview of percentages of arrived destinations

"*No, I didn't know where I was going to end*" (Participant 2).

Two participants followed the signs to P1-short parking, whereby one mentioned she always drops someone off at P1. The other participants stated it was not a deliberate decision. Figure 40 shows the chosen directions of the participants. "*I wanted to go to the K&R, but the white arrow showed me to go left*" (Participant 6).

After reaching a destination, the participants were asked about what got their attention about the signs. Most indicated that the different locations such a departures and parking were easy to spot and distinguish.
"*There is a clear distinction between departures, parking and car rental. Easy to spot where I want to go*"(participant 5).

Participants explained that the white text also grabbed attention while driving by the signs. One participant spotted the white arrow and two recognized the black screens as the matrix signs on current traffic signs.

The five participants that ended at departures where the only ones that could have seen the red crosses. However, all indicated that while watching the video, the red crosses were not seen.
While watching the video the red triangle was seen by four participants due to the red color, whereby two of these four participants also noticed the text 'detour'.

For the second part of the study, the four signs have been discussed individually, whereby the participants were asked to specify what information is interpreted from the signs now they can analyze each sign for a longer period of time.

In general, the majority of the participants indicated that in case of a detour/redirection in traffic, yellow signs are expected. Together with this expectation, participants explained they expected letter 'A' to come after the first sign and not all at once. For this the suggestions are made to have an extra sign, or that the usage of yellow text can help attract more attention since it will be in line with the expectations of yellow signs. No relation is found between the need for yellow signs and the driving experience of the participants.
After analyzing the signs in more detail, a great part of the participants (7/10)

understand the meaning of the white arrow and state they will follow the arrow in real life. All participants recognize the red cross and are familiar with the meaning of the red cross.

However, half of the participants mentioned that the arrows and crosses would attract more attention if the signs would have been lit.

"*If it is meant to be matrix signs as the current ones, it will probably attract my attention, because it is lit.*" (Participant 6, translated from Dutch).

For the question '*Do you have any changes you would like to add to the signs to make it clearer?*', three common categories were identified. These categories being, the use of colors, labeling of locations and the placement of several elements on the signs.

The use of color has been mentioned several times. 'Detour' has been noticed due to the red triangle next to it. Three participants proposed the use of one color to group all information about the detour (figure 41). One participant believed that the black and white combination was not eye-catching.

In order to attract more attention about the information at the top of the signs, participants mentioned to place the information lower on the screen or using LEDs. Other suggestions were given about the placement of the letter A (figure 42).

Another change that is mentioned by participants was to make the blue sign dynamic as well, in order to remove departures from the sign when it is not allowed to go in. However, in order to make sure that the information does not change frequently it is decided to provide partly static and partly dynamic information.

One participant suggested to use the same icon for the dynamic signs as well in order to spot differences easier.

Comments were given about the definition of locations, where most replied that it feels contradictory to have long parking on the same sign as departures. In addition, participants mentioned the lack of information about the redirection. A few participants commented that they are forced to go to a paid garage, whereas the K&R is free.

"*I am forced to go to the paid parking garage, where is my free coffee? I am obliged to pay.*" (Participant 2).

Two participants indicated they expect information about the situation earlier in their journey, such as at home.
"*I do expect more information about the detours on the Schiphol website.*" (Participant 4)

Figure 41: using one color to cluster the information
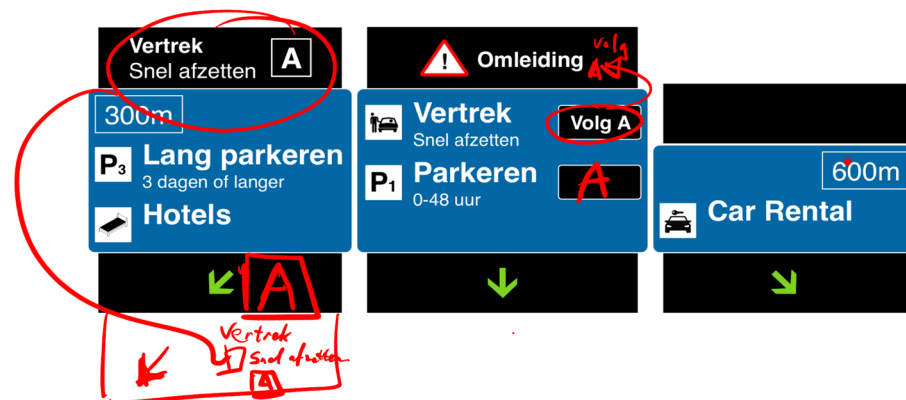
Figure 42: repositioning the information below

Discussion

In order to study the impact of the designed signs in case of redirections at Schiphol, seven video fragments and four signs were developed. Additionally, the four signs have been discussed separately to understand how the messages of the signs were interpreted and what improvements could be done.

The results show that the information about the detour and redirection was not obvious for the participants. Therefore, many participants followed the route and ended up at departures. There are a few factors to take into considerations. The signs were designed in two-dimensional (2D) and placed in a three-dimensional (3D) environment, whereby the signs were still images. Matrix signs in the Netherlands work with LED technology, which makes them more attractive. Since the dynamic elements of the signs were not lit, the attention did not immediately go to the information on the black part, because all the elements on the signs were equally visible. It is assumed that the use of animated and brighter matrix signs in the video would have had an impact on the decisions of the participants. This was also mentioned by several participants.

The dynamic elements were placed below and on top of the blue sign (figure 35). It is mentioned that the top black part was not attracting the attention. Considering the earlier discussed visual field of the driver (figure 25), the high placement of the dynamic sign at the top can be more difficult to see. The vertical visual field is approximately 15 degrees (Schultz, Schulz, & Fricke, 2007) (Mijksenaar, 2014). The higher the sign, the less time the driver has left to read the sign, especially when there is a lot of text.

The first element that participants noticed was the white text on the blue sign. The reading pattern while driving is found to be from top to down, left to right, with a focus on the center part of the sign (Chan, Gonzalez, & Perez, 2016). If the starting point is the white text on the blue part, it is a probability that the users continued their reading pattern towards the bottom. Therefore, some participants recommended to place the information about the detour under the blue sign (figure 42). However, it is believed that by using limited information at the top, it can still be interpreted on time.

Next to the visual improvements, participants also discussed textual improvements. It is assumed that not everyone is equally aware of the products at Schiphol. Therefore, not all participants know where the different products are located and what they mean. One participant associated long parking with departures, which caused her to go to Sheraton. After, she indicated she was aiming for the departure hall.

"*No, I wanted to go the K&R. I associated long parking with departures.*" (Participant 8).

The participants that were frequent visitors of Schiphol and the K&R in particular did not require the signs to search for the K&R. They mentioned that the sign was mainly used for confirmation purposes, thus to validate they were on the right track in order to get to departures. Therefore, the information about the detour was unnoticed. One participant mentioned that whenever there is a lot of traffic, she is looking out more for alternatives to be faster at the end destination. In the video, the roads were noticeably empty. It is believed that the situation in the video influenced the impact of the signs. Therefore, it is suggested to conduct a study where congestion is in effect.

In addition, participants did mention that having departures and long parking on the same sign is confusing, because it is contradictory. The alternative to drop someone off in front of the Sheraton hotel is, as explained, a theoretical scenario and not used in practice. In order to steer drivers to Sheraton in case of congestions, the drivers have to be informed about the option beforehand. Otherwise, passengers can feel more stressed when they are redirected away from the departure halls.

"*Being sent in the same direction as long parking is contradictory, so I will follow 'departures'. Especially when I am not familiar about the location.*" (Participant 2)

In order to redirect, the most frequent given suggestion was the use of yellow signs or yellow text. Redirections in traffic are often communicated with an additional yellow sign (figure 43). However, not in all cases an additional sign can be placed. For providing information per lane, it can be suggested to use yellow text on matrix signs.

This suggestion has been mentioned by several participants as well. Using

yellow characteristics can help drivers in understanding it is a redirection and now it is a temporary situation. An example of such a solution can be seen in figure 44.

In total ten participants have participated in the study. The age and driving experience varied, which is a good representation of the diversity of passengers. it is recommended to conduct the study with a larger group in order to gather more insights about the impact of the signs and support the found results in more detail.

Considering the impact of the dynamic signs, it is found that visuals used in the videos had almost no impact on the participants. This means that the majority of the participants did not change their route by means of the information provided on the signs. Therefore, the suggestions and insights from this study can be used for improving the designs and conduct another study.

Conclusions
In case of congestions on the Ceintuurbaan Zuid and the K&R, the goal is to use dynamic signage to steer and redirect drivers to other locations. As a result, the intensity in front of the terminal can be reduced and controlled. Prior the study a set of visuals have been designed to present how such dynamic signs can look.
The aim of this study is to understand the impact of the designed signs as well as the conveyed message of the signs. Additionally, insights are gathered about how improvements can be made to the signs.

The dynamic signs had little to no influence on the decision of the participants. The main reason found is that the information about the detour is not seen. Suggestions are made for improving the signs in such a way to attract more attention and be clearer for redirecting the drivers. The most mentioned suggestion is the repositioning of the dynamic elements, whereby the use of yellow can help understand that it is a temporary redirection.
Also, it was commented that the first sign doesn't need to show 'A', because it is expected that it comes later. This is also the case in traffic.
The suggestions can be used to enhance the visuals. Subsequently, future work should study the impact of the improved designs.

Figure 43: yellow detour signs in the Netherlands (Hagelstein, 2015)

Figure 44: Example of yellow characteristics on a variable message sign (Farmartin, 2013)

5.3 TECHNOLOGY
This section describes the technology where the aim is to understand what technology is required for the realization of the dynamic signs at Schiphol.

5.3.1 Components
Schiphol has a lot of technology available, however most of the technology is inside the terminal.

In order to know when congestion occurs, sensors are required to measure and interpret the level of intensity. Sensors will quantify the number and travel speed of cars in that specific area. The relation of the number of cars and travel speed can provide enough insights in the level of congestion. Hence, a low travel speed together with a high number of cars can indicate a congestion.

The same principle is used at the security filters inside the terminal, where sensors measure the number of people in a specific area to indicate the waiting time. This type of data is measured with BlipTrack. BlipTrack is a platform where a combination of different sensors collect and analyze data (Veovo, n.d.). The data owner of BlipTrack at Schiphol explained there for measuring the intensity in a specific area, a combination of two modules is used (BLIP Business Owner at the airport, personal communication 2019).

1) Bluetooth and Wi-Fi sensor to measure the residence time of individuals.
2) People counter, measuring the number of individuals that are present in the area.

The combination of these two sensors provides a higher reliability in the outcome. It is a proven concept, which can be seen from the fact that almost the complete terminal is covered with BlipTrack sensors.

For traffic purposes, it is also recommended to use the combination of two modules. However, instead of using the same indoor sensors, the outdoor sensors have to be used. Hence, the BlipTrack Traffic Sensor and Radar (figure 45 and 46). For every entrance and exit a combination of the two sensors is required. Figure 47 is a simplified illustration of the principle of BlipTrack. At every entrance the number of cars is counted, and at every exit the number of leaving cars is counted.

The sum of these two quantities provides information about the number of cars within the two points where the sensors are located.The Bluetooth and Wi-Fi module can follow devices (smartphones, smartwatches) and use that data to measure the residence time of individuals.

The data is collected and interpreted by the provided software of BlipTrack and can be viewed in its own dashboard. However, it is also possible to link the data with Wilbur. As indicated, Wilbur is used for managing day-to-day operations where information about for instance intensities at security is given (appendix M and X.A). In this dashboard, the control room can easily monitor the situation of the respective areas.

BlipTrack Traffic Sensor

BlipTrack Radar

Figure 45: BlipTrack Traffic Sensor (Veovo, n.d.)

Figure 46: BlipTrack Radar (Veovo, n.d.)

Sensor set 3

+ 5

+ 20

17 cars in the area

- 8

Sensor

Sensor
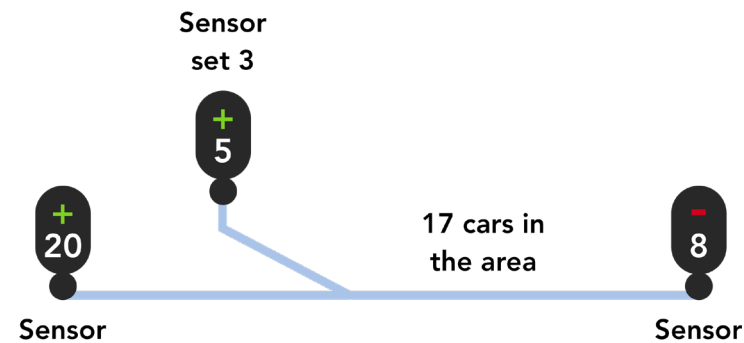
Figure 47: simplified illustration of BlipTrack principle

When a new functionality needs to be tested, the labs environment is used. This indicates that the data is new and not thoroughly tested.

Currently, the functionality of Wilbur is to receive data in order to monitor and take action when something escalates. The manager in the control room is the person to contact the operation to take measures. This functionality can be defined as the Collector role of smart things (Cila, Smit, Giaccardi, & Kröse, 2017). However, some things are done automatically, such as the waiting times in the security area. These actions are identified as things in the Actor role, whereby the data is used as input for the system to act upon (Cila, Smit, Giaccardi, & Kröse, 2017).

At Schiphol a pilot has been done where the traffic was measured in order to understand the level of congestion at the Ceintuurbaan Zuid. Hereby, the conclusion was drawn that the data is received slightly later than the real situation. This means that if there is a congestion at the moment, the information is shown a few minutes later. In a few minutes a lot can happen in traffic, therefore it was decided to use the average measurements of the former 5 minutes (UX designer at the airport, personal communication 2019). The interpretation of the measurements presented the level of congestion in Wilbur for the control room could easily monitor and act if needed.

For the dynamic signs, it is recommended to provide an additional functionality; the function to act through the dashboard. For instance, providing the option to change the content of the dynamic signs in case of emergencies or fault in the data. The team manager of Airport Control mentioned that this functionality is not yet active in the dashboard, but that the back-end is ready to add such functionalities if needed (Team Manager Airport Control at the airport, personal communication 2019).

Next to the dashboard and sensors, the signs are needed. The signs are not fully dynamic, but have a number of matrix and variable message signs integrated. These matrix and variable message signs and data from BlipTrack will connect with Wilbur in order to control and act. The same principle has been tested with indoor dynamic signage, whereby a virtual button and sign was created (figure 48). The button 'Force AF1' or 'Force AF2' activate a different scenario, whereby the sign changes accordingly.
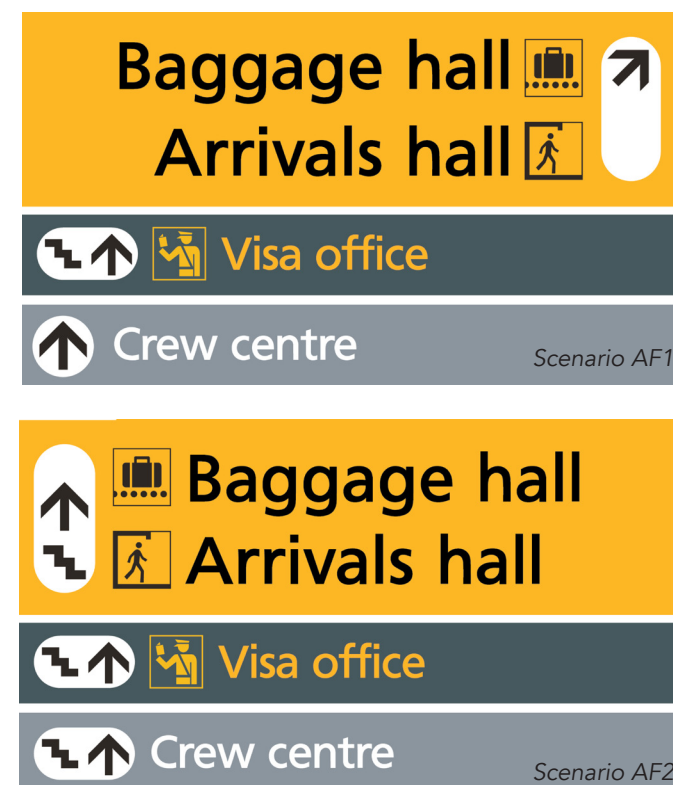
Figure 48: Example Wilbur, dynamic signage

5.4 CONCLUSIONS

This chapter studied and described the different elements of the idea. Each element is another layer of the integrated system that works together.

The overall goal of the idea is to improve the traffic flow in case of congestions and contingencies. Subsequently, having a tool to steer drivers can reduce the stress levels of the passengers.

Theory is explored for understanding what plays a role for wayfinding in traffic, such as having the option for circulation in the journey. Also, the requirements for placement of signs is discussed and presented, whereby it is found what placement is best for the driver to have enough time to read and interpret the signs.

In order to develop designs for the signs, wayfinding experts are consulted to gather feedback. Using the feedback a user study has been conducted to study if the designed signs had an impact as expected. The findings of this study indicate suggestions to improve the signs for better interpretation. These suggestions are used for a final iteration of the signs, presented in chapter 6.

Lastly, the technology required for the concept is explored and discussed.
All insights of this chapter are used for integrating it into general design principles and a final design.

6

FINAL DESIGN
In the previous chapter the idea has been developed in detail by describing the required elements for creating an integrated system of dynamic signs. By using the insights, the final design is described in this chapter. Moreover, a summary of design principles is described.

6.1 FINAL DESIGN DETAILS

This section discusses the individual elements in detail by applying the insights into a use-case for dropping off at the current infrastructure at Schiphol.

6.1.1 Dropping off use-case

It is found that during peak hours the Ceintuurbaan Zuid and K&R cannot operate safely due to the high intensities. Next to the dangerous situations and difficulty of operating, the passengers can become more stressed due to the unawareness of the situation. The study described in chapter three concluded that people are not well-informed about the rules and alternatives to drop off. When there is congestion happening, not everyone is aware of the alternatives. The goal of the dynamic signs is to redirect drivers and passengers in case of congestions by steering them to the alternatives. In this section, the current infrastructure is used to present how the concept works and operates.

Presently, Schiphol offers two options to drop off, the K&R and P1. The number of cars keep increasing on the K&R which results in more peak hours and thus more congestions. For the presentation of the concept the earlier mentioned remote K&R in front of the Sheraton Hotel is taken into account (page 59). Figure 50 shows the flows for the three locations K&R, P1 and Sheraton. In the same figure, the 'return to Schiphol' flow is illustrated. It is important to have a second chance in case the driver makes a wrong decision (Glastra-van Loon, 2017)(Mijksenaar, 2014).

Using the flow map, the decision points can be defined. All decision points are plotted in figure 51. In total there are six decision points for the dropping off flow. The rule of thumb is to have at least 300 meters in between decision points. Almost all decision points in figure 50 comply to this rule. Only the distance between decision point 4 and 5 is less than 300 meters. It is 280 meters, whereby at both decision points the same decision needs to made. Hence, it is enough time to interpret the signs.

As explained earlier, signs need to be placed 200 meters in advance as well as at the location of the decision point. Figure 51 illustrates the placement of advance direction, interchange direction and confirmation signs.
Additionally, the type of sign used per location is visualized with the icons. In total 14 signs are required.

It is important to note that the flow for Sheraton is only available when there is congestion on the Ceintuurbaan Zuid.
The diagram in figure 51 is an overview of when each of the areas is (in) accessible. In case one area is crowded and thus closed, at least two areas are available instead. This is due to the additional area in front of Sheraton to provide enough alternatives for the dropping off process.

	Kiss and Ride	P1 - short parking	Sheraton loop
Scenario 1: all is well, no congestions	🟢	🟢	🔴
Scenario 2: congestion at Ceintuurbaan Zuid and K&R	🔴	🟢	🟢
Scenario 3: congestion at Ceintuurbaan Zuid and P1	🟢	🔴	🟢
Scenario 4: both the K&R and P1 are crowded	🔴	🔴	🔴

Figure 49: overview of scenarios and the accessibilities

The relevance of a decision points is depending on the activated scenario. For scenario 1, decision point 2 and 3 are not applicable, because there is no access to the Sheraton loop. When either the K&R or P1 are closed, the decision points 4 and 5 are out of use as well. In these cases, the signs are used for informing about the detour and redirection routes.

Previously a user study has been conducted to study the impact and improvements of the signs to help the wayfinding process in case of congestions. The insights from this study are applied in the new design of the signs. For each scenario, the content of the dynamic signs changes accordingly. These are explained below.
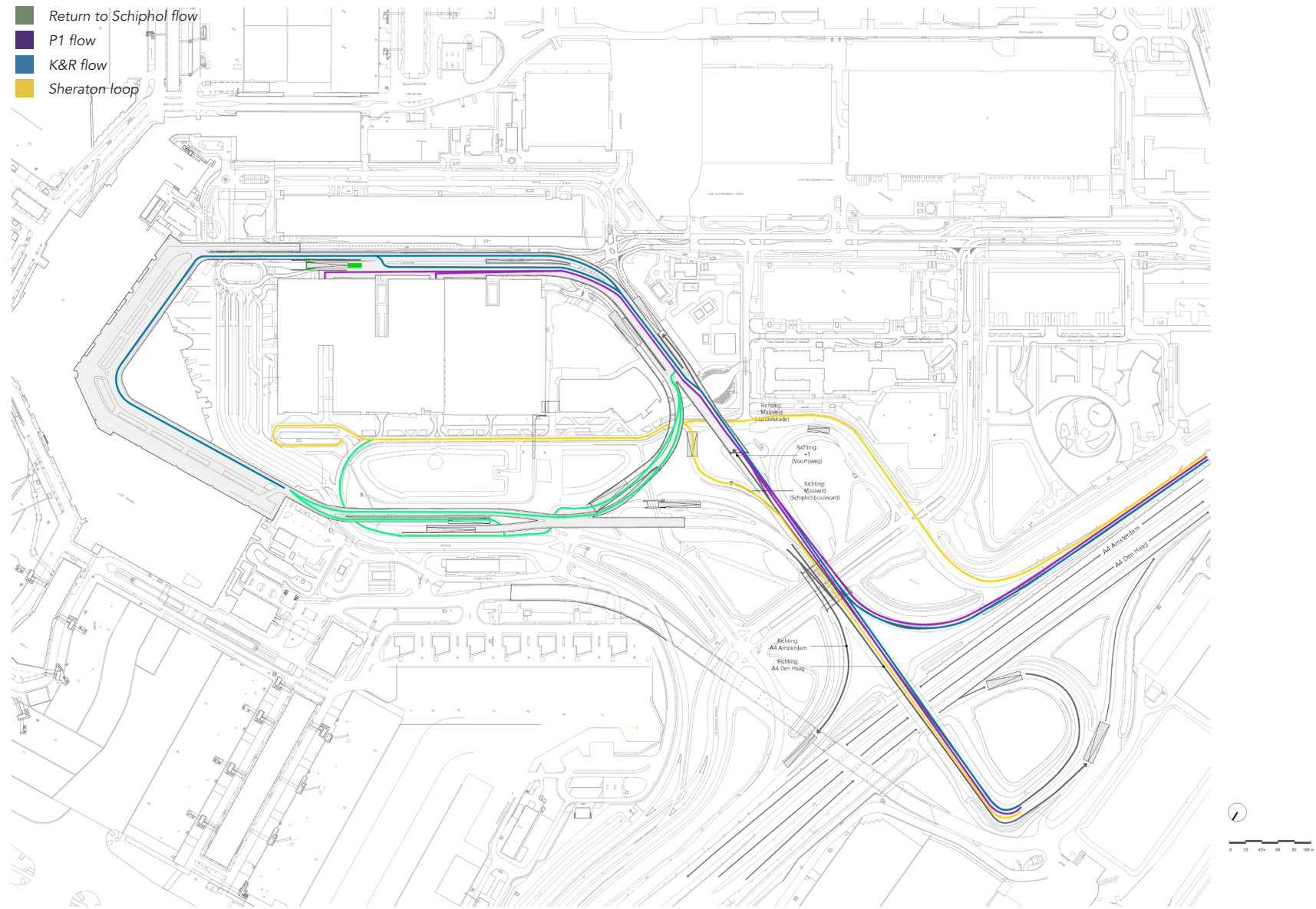
Figure 50: dropping off flows for the current infrastructure

Legend:
- Return to Schiphol flow
- P1 flow
- K&R flow
- Sheraton loop

Decision points
1) From A4/Den Haag: Ceintuurbaan Zuid or Sheraton loop
2) From A4/Amsterdam: Ceintuurbaan Zuid or Sheraton loop
3) Schiphol Boulevard: Sheraton loop or return to Schiphol
4) P1 or departures
5) P1 or departures
6) Return or exit
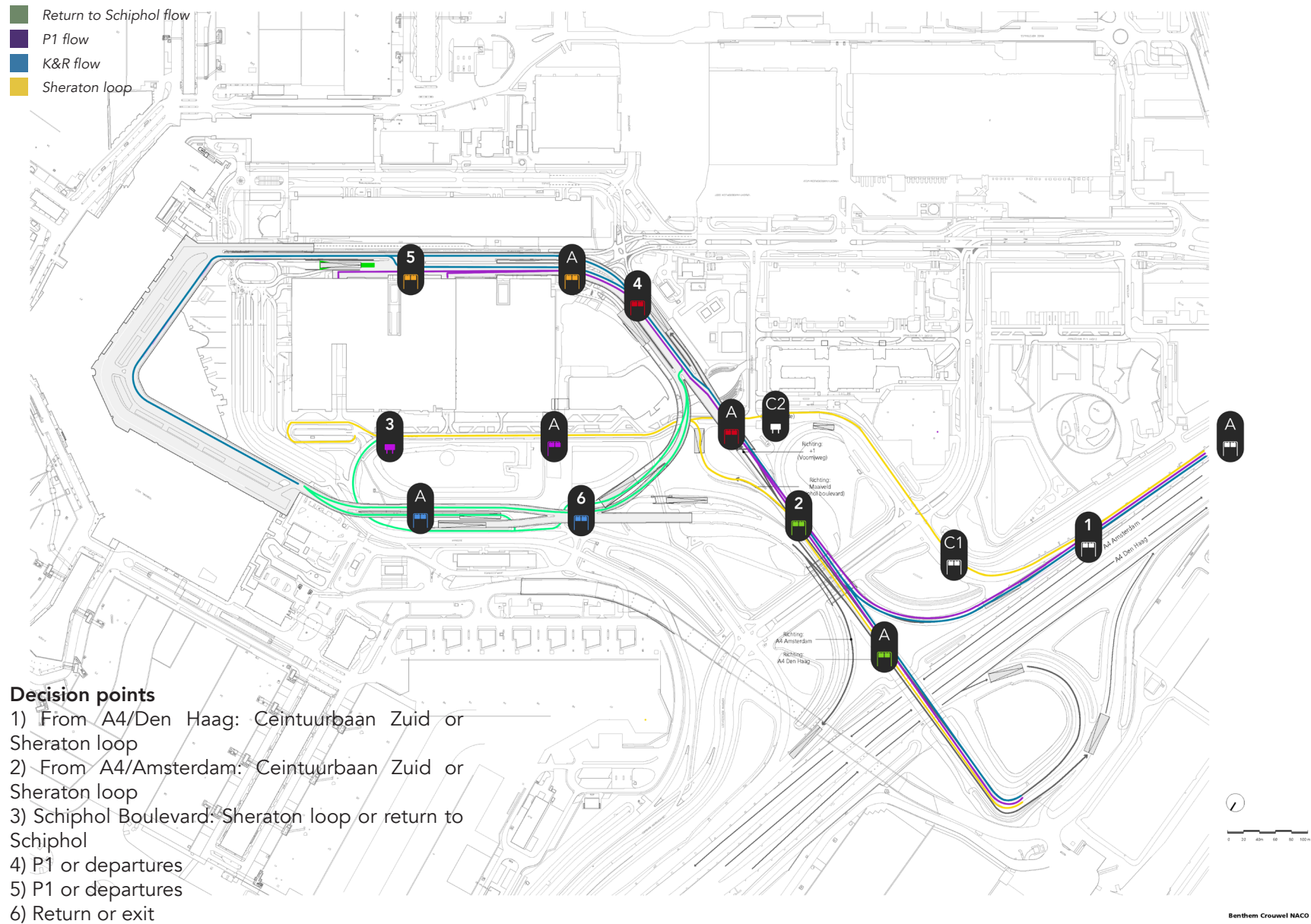
Figure 51: decision points and sign placements for the current infrastructure

Scenario 1
All is well, the K&R and P1 are accessible. The loop in front of Sheraton is closed. Therefore, no information about redirections is required. Other than the arrows, no additional information is shown on the matrix signs.

Scenario 2
The Ceintuurbaan Zuid towards the K&R is starting to have congestion. Until traffic is reduced at the K&R and Ceintuurbaan Zuid, drivers need to be redirected to the Sheraton loop and/or P1.

Scenario 3
Instead of congestion towards and at the K&R, a lot of traffic is detected in front of P1. Also, is seems that P1 is almost full. Therefore, traffic needs to be redirected towards the K&R and Sheraton.

Scenario 4
Both the K&R and P1 are full. Additionally, congestion is formed on the Ceintuurbaan Zuid until the exit of the freeway. To prevent dangerous situations, it is important to stop traffic from coming towards the K&R and P1. In this case, Sheraton is also not accessible since there only 15/20 can enter at once (Senior Developer at the airport, personal communication 2019).

For each scenario, the content on the signs change accordingly in order to steer the drivers in the right direction. For all the separate decision points, the content with respect to the scenarios is presented in the figures 52, 53, 54, 55, 56 and 57.

The decision points and required signage are presented on the next pages. The signs provide dynamic information through the matrix signs at the bottom and the variable message signs on the blue part and at the top of the sign.

Results from the visual study described in chapter 5, indicate the for the first sign, the advance direction sign, it is not required to provide information about 'A'. The text 'follow A' is sufficient. This is also applied in third set of visuals.

Therefore, interchange directional sign, placed at the decision point, provides information about 'A'. This principle is adapted from the usual way of providing information about redirections (figure 43)

It is decided to not place extra signs for 'A', but to integrate it all in one sign. Therefore, the signage for 'A' is place at the top of the blue part. It is believed that due to the brightness of the LED and the color, drivers will be able to see it.

The matrix signs at the bottom haven't been adjusted. They still provide information with the arrows and crosses.

Figure 52: sign content for decision point 1
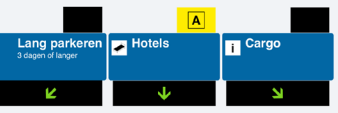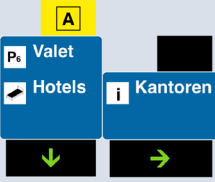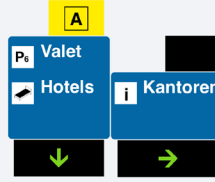
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Advance direction sign A				
Interchange directional sign 1				
Confirmation sign 1 C1	NA			NA
Confirmation sign 2 C2	NA			NA

Figure 53: sign content for decision point 2

Figure 54: sign content for decision point 3

Figure 55: sign content for decision point 4
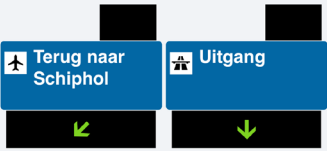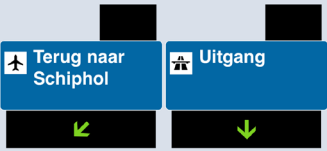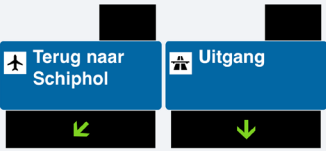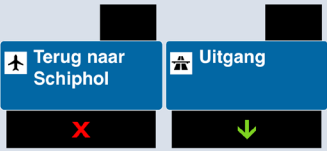
Figure 56: sign content for decision point 5

Figure 57: sign content for decision point 6

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Advance direction sign A	Terug naar Schiphol / Uitgang	Terug naar Schiphol / Uitgang	Terug naar Schiphol / Uitgang	Terug naar Schiphol / Uitgang
Interchange directional sign 6	Terug naar Schiphol / Uitgang	Terug naar Schiphol / Uitgang	Terug naar Schiphol / Uitgang	Terug naar Schiphol / Uitgang

The decision points and required signage has been explained. However, a crucial part of the system are the sensors that need to measure and interpret data in order to provide input about the level of intensity of an area.

For the technology, it is decided to use BlipTrack in order to measure the number of cars and the flows at Schiphol Centrum. For each entrance and exit a combination of two modules needs to be placed. In figure 58, the placement of the sensors can be found. To measure the number of cars in the respective areas, 16 set of sensors are required (figure 58). In addition, the sensors provide insights about the travel speed of the cars, which is valuable data to measure if there is congestion.

Figure 58: placement of sensors
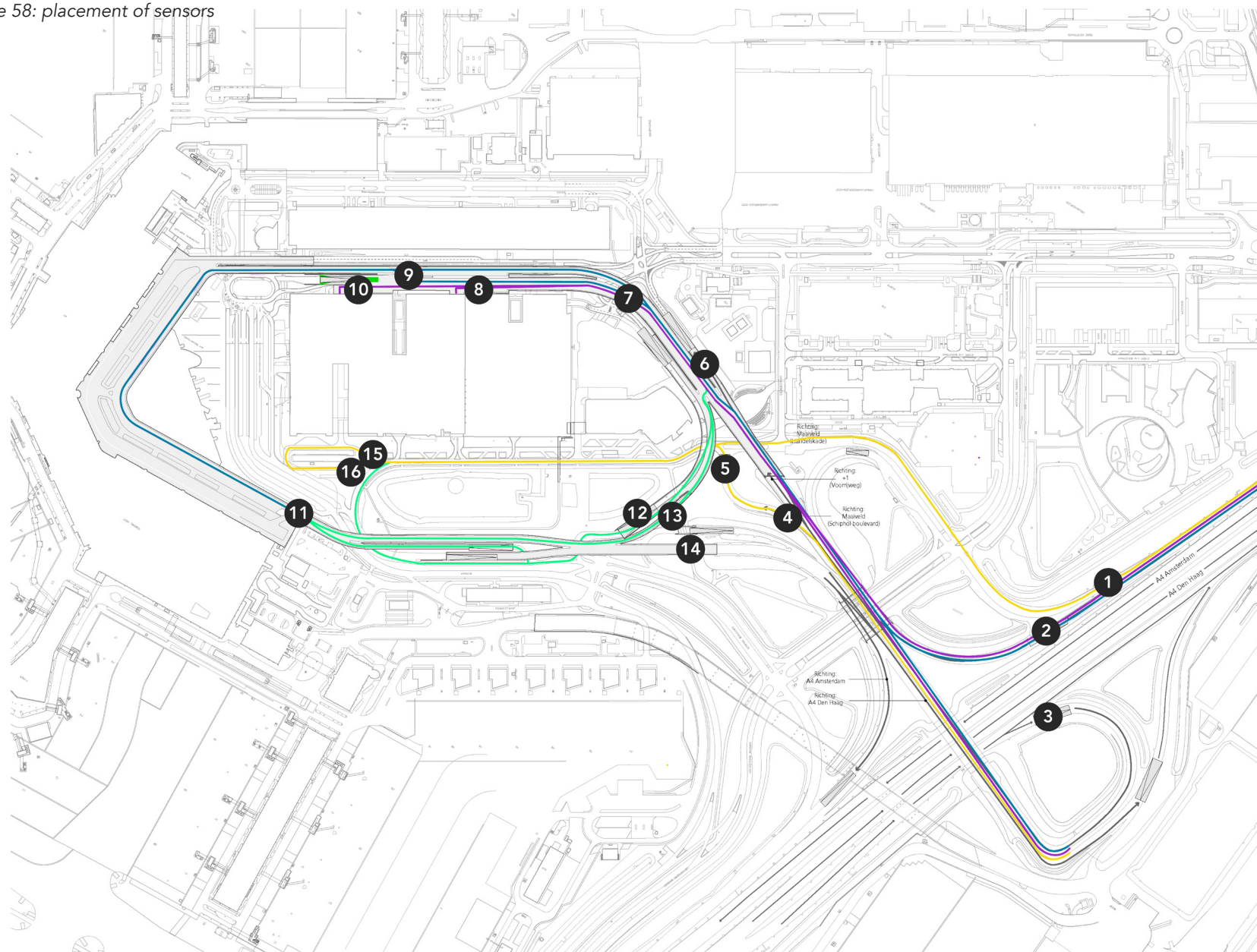
6.1.2 Product-system service overview

The individual elements are interlinked with each other. For realization, hardware and software is required. An overview of the required hardware and software is given in figure 59.

BlipTrack sensors provided by Veovo are delivered with their own software. The software is able to act on the data that is being collected. The outcome of the collected data has to be presented in the dashboard Wilbur.

From the dashboard information can be monitored and act upon. It is possible to automate the process such as with the security waiting times. For this, different scenarios need to be defined and activated accordingly. This means that for each scenario the boundary conditions need to be determined and assigned. Subsequently, the content of the dynamic sign will change according to the active scenario.

Matrix and variable message signs are provided with their own software. This software is used to manage which content is presented on the signs. To make sure that the signs can be controlled from the control room, it is required that the data from Wilbur can be linked with the software of the signs.
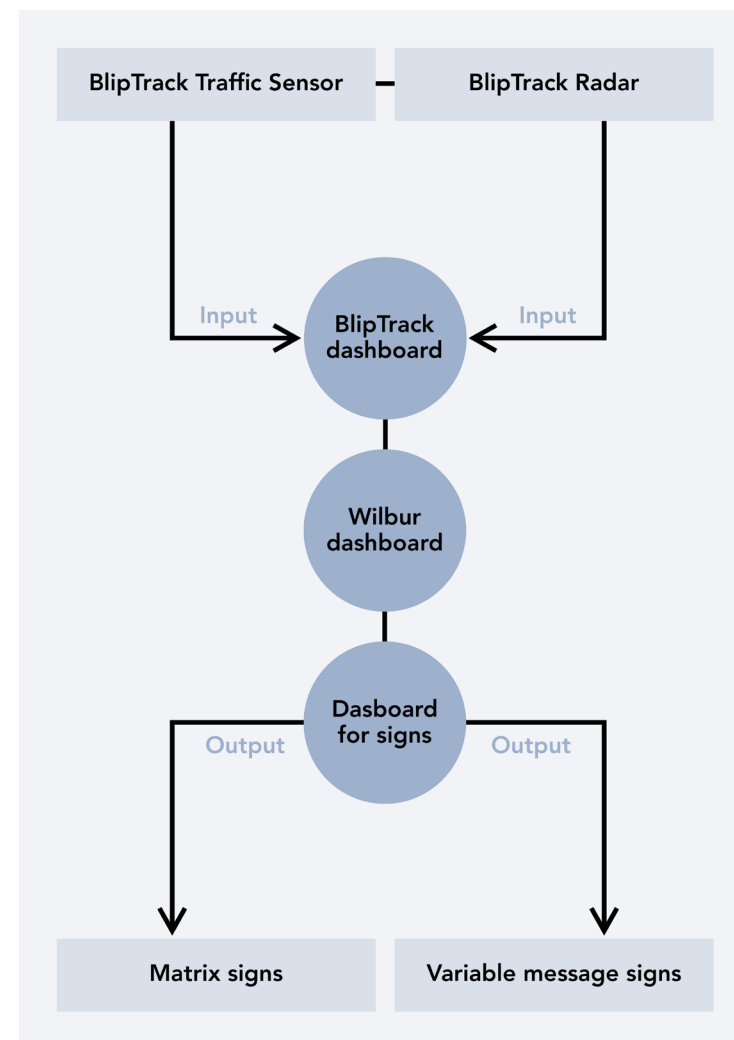

Figure 59: overview of the required hardware and software

6.2 DESIGN PRINCIPLES
In the previous section the concept is described by implementing the findings in the current situation at Schiphol. In this section, general design principles are described and discussed.

6.2.1 Design principles
The design principles are derived from the findings from the idea development and the final design phase.

BlipTrack measurement
- In case the intensity levels have to be measured, every entrance and exit on the road needs to be equipped with the two sensors (counter and Bluetooth/Wi-Fi modules)(Veovo, n.d.).

- The sensors need to be connected with Wilbur, the dashboard for the control room at Schiphol.

Wilbur
- Wilbur automatically updates the content on the screens based on the relation of the number of cars and travel speed of cars. The combination of this data can provide insights in the level of congestion (Bremer, 2018).

- Every minute BlipTrack data is collected about the previous five minutes. This means there can be a delay in the presented results. The control room is equipped with cameras to real-time observe the traffic situation. If the delay in the data causes the signs to be updated too late, the controller has to have an option to manually adjust the content of the signs (UX Designer at the airport, personal communication 2019).

- Two functionalities for the signs are required; 1) automatic function to update the signs according to the scenario that is active and 2) manual function to manually update the content in case of delay in the data or emergencies.

Wayfinding
- For the wayfinding experience, a second chance is important (Mijksenaar, 2014) (Glastra-van Loon, 2017). This can be achieved with the return loop.

- Firstly, the flow for each individual target group needs to be defined to explore the number of decision points and decision moments. For each decision point, it is advised to use offer two options and no more. Schiphol Centrum is quite complex and crowded, where drivers and passengers want to be at the end destination as soon as possible.

- Dynamic signs have to eliminate the options that are too crowded. No option provision, but steering is required (Wayfinding expert at the airport, personal communication 2019).

Signs
- To provide clear information and instructions, each lane needs to have its own sign.

- If there is a single lane, a road sign or single overhead sign can be used.

- If there are two lanes, two road signs or an overhead sign can be used.

- If there are more than two lanes, it is advised to use overhead signs only. In this way, dynamic information per lane can be presented.

Placement of signs
- Every decision point needs at least two signs. However, if there is room for more it can never hurt to repeat information (Mijksenaar experts, personal communication 2019).

- 200 meters before the decision point an advance direction sign is used to inform about the options the driver can choose from. If one of the options is closed, this has to be communicated on the advance direction sign by using the text 'follow A' (Mijksenaar, 2014).

- At the decision point interchange decision signs are used. This is also the moment to provide information about the redirection route and confirm the earlier shown information (Wegenwiki, 2011).

- It is advised to have 300 meters in between decision points. This will provide enough time to read and interpret the signs and go through the decision-

making process (Mijksenaar, 2014).
- Signs need to be placed in the vertical vision of field of 15 degrees (Schultz, Schulz, & Fricke, 2007) (Mijksenaar, 2014).
- Signs need to be placed in the horizontal vision of field of 10 degrees (Mijksenaar, 2014).

Information provision
- Start using dynamic information at Schiphol terrain. On the freeway, it is difficult because the flows of different target groups pass by the sign (Mijksenaar experts, personal communication 2019).

- Each sign is equipped with three dynamic parts. One matrix sign underneath to show arrows and crosses. In the sign and at the top a small variable message sign can be found to provide additional information.

- One variable message sign is placed behind the location to provide specific information (Mijksenaar experts, personal communication 2019).

- An additional variable message sign is placed at the top, which will be only used to indicate the redirection route. It is at the top and therefore difficult to see. However, using yellow bright LEDs with information about the detour, the driver will have enough time to read.

6.3 REALIZATION
The design details and principles are explained. The final step is to explore how this dynamic wayfinding system can be realized at Schiphol.

6.3.1 Stakeholders
In the first quarter of 2019, an initiative, called Smart Roads, at Schiphol has (re)started its project. The vision of the project is in line with the proposed dynamic wayfinding system. Therefore, it is strongly advised to use the findings of this project as input for the initiative. However, in addition to Schiphol, it is required to involve more stakeholders in the process of developing the dynamic wayfinding system.

In the analysis report, the involvement stakeholders for landside connectivity were discussed. Here it was found that changes with regard to the road

infrastructure needs to be discussed in consultation with Ministery IenW and Province. Considering that the dynamic wayfinding system requires connecting stand-alone systems with each other, it is important to involve the Digital/IT department at Schiphol.
Next to the backend and traffic regulations, the content for the signs and wayfinding experience is elaborated for dropping off. An iteration of the designs is evaluated with wayfinding experts from Mijksenaar and Schiphol. For implementation in different areas it is advised to consult with the wayfinding experts for validation and evaluation of the wayfinding experience.

6.3.2 Roadmap
The first step for realization is the installation of the BlipTrack sensors. Subsequently, the data from BlipTrack can be linked with Wilbur. The same principle is used in the terminal and proves to have a high reliability level of around 99% (BLIP Business Owner at the airport, personal communication 2019). Additionally, a pilot is done at the Ceintuurbaan Zuid with promising results. However, prior implementation of the dynamic wayfinding system, it is advised to thoroughly measure with multiple sensors in order to get a better overview of the intensity levels at more areas, such as the K&R and P1.

Before installing and connecting the signs, it is proposed to individually measure with the sensors in order to discover and detect the conditions for the different scenarios. Hence, which congestion levels can be distinguished and which scenarios are linked to these respective levels. Using the insights from the measurements the scenarios can be tested with dynamic signage.

The design principles advice the use of overhead and roadside signs. However, replacing all signs at Schiphol is a high investment. Therefore, it is highly recommended to conduct the initial testing with mobile variable message signs. Hereby, it is good to note that mobile variable message signs can be compared with the principles of roadside signs. This means that testing with mobile variable message signs can only be done at locations with one or two lanes. Nevertheless, testing with the mobile signs will provide insights in the impact of the dynamic signage and the reliability of the data from the sensors.

If the test proves to provide enough insights to validate the effect and impact that is required for realization, the overhead and roadside signs can be placed. Finally, the three elements, signs, sensors and software can be connected and integrated.

1	2	3	4	5	6	7
Install	**Measure**	**Evaluate**	**Test**	**Evaluate**	**Conclude**	**Implement**
Install the BlipTrack sensors at every entrance and exit on the road. After installation, the data of BlipTrack needs to be connected with Wilbur.	Use the installed sensors and data for measuring on the respective areas to discover and define the congestion levels.	Use the results of the measurements to validate the reliability and value of the BlipTrack sensors. Does the data provide the expected insights for assessing the level of congestion?	If the data proves to provide the require insights for the product-service system, the data can be used for testing the impact of the dynamic signage. Hereby, the question should be asked whether the dynamic provision of information helps steer drivers in case of congestions.	In this phase it is important to evaluate the dynamic signage system. What problems occured while testing? Which aspects proved to be valuable and impactful? Step 4 and 5 can be repeated for each seperate area that is being tested.	If the testing and evaluating phases validate that the use of dynamic signage in case of congestions has an impact on the traffic flow and is effective the decision can be made to continue the implementation.	After deciding to continue with the implementation of the product-service system, the overhead and roadside signs need to be installed. In addition, the software of the signs need to be connected with Wilbur to provide a dashboard and interface for observing and managing the signs in the control room.

7

CONCLUSIONS AND RECOMMENDATIONS
This chapter covers the conclusions and recommendations of the project. The research and findings from the project are discussed and described.

7.1 CONCLUSION

Schiphol is the third largest airport of Europe, with 326 direct destinations. The number of passengers keeps increasing, which requires Schiphol to expand in order to keep facilitating the passengers as good as possible. A new terminal and pier is developed and realized in 2023, which will result in even more passengers.

The journey of the passengers does not start when entering the terminal, it starts at home when booking a ticket. Subsequently, people assess their overall experience by the first and last impression of the journey. The journey towards the airport, and therefore the landside connectivity, plays an important role.

The purpose of this project was to explore how the landside connectivity can be improved through the Internet of Things.

The Internet of Things (IoT) is the collection of 'things' that are connected to each other and to the Internet (Morgan, n.d.). The principle of IoT can be applied in many contexts, such as cities, homes and airports. For airports, IoT is a valuable tool for improving the passenger experience and to achieve operational efficiency (IoT Innovation, 2017).

Studying the passenger journey, it was found that insecurities have to be reduced in order to prevent stress (ACI, 2014). Time plays an important role in the mind of the departing passenger, since the passenger has to catch a flight and has the responsibility to be on time. Whenever there is a disruption and the duration is unknown it can lead to an increase of stress levels.

Landside connectivity exists of four areas where different modalities can make use of. Main bottlenecks around these areas is are capacity and wayfinding problems. These problems keep increasing with the growing number of passengers.

Dropping off at Schiphol is an interesting flow with a lot of media attention and bottlenecks at the Kiss and Ride. The congestions on the Ceintuurbaan Zuid and Kiss and Ride result in dangerous situations, whereby a solution is developed for the enhancement of the traffic flow in such situations.

The connected system is developed and applied to the current situation for dropping off at Schiphol.
Sensors measure the congestion level in order to steer drivers to the alternative locations when one area becomes too crowded. Steering is done via the dynamic signs that are placed on the road.

The main benefit of this system is that Schiphol and the KMar can take control in case of congestions/contingencies. As a result, unsafe situations can be prevented.
In addition, the optimized traffic flow and information provision in stressful times will be beneficial for the passengers and drivers. By providing alternatives when one location is inaccessible, the insecurity level of the passenger can be reduced.

In conclusion, the thesis provided the design of a connected system to improve the traffic flow at the chaotic and crowded areas at Schiphol. By elaborating on Ceintuurbaan Zuid and K&R the project contributed to the future development of these areas.

7.2 RECOMMENDATIONS

The design described in the report elaborated on the dynamic signage at Schiphol to provide a way of steering drivers in alternate directions in case of congestions and emergencies. The content of the signs has been studied with users, whereby a scenario of dropping off in a peak hour has been simulated. The videos used for simulating this scenario showed no congestion, because at the time the video was recorded it was not crowded. This could have had an influence on the results. Before implementation it is recommended to test the proposed sign content in real traffic and evaluate the proposals with wayfinding experts.

The scope was focused on the departing passengers since they have the most stress to catch their flight. However, congestions on the K&R are not only the result of departing passengers. Findings from the thesis show that collectors and other third-party services cause the long residence times and thus increase in capacity problems. The main reason that different target groups value the K&R is the fact that it is free. After closing the free arrival area and the short stop an increase of 30% can be seen on the K&R.

In order to reduce the intensity levels on the K&R, it is highly recommended to reduce the parking costs of P1 by for instance making the first 20 minutes free. Perhaps a pilot can be conducted to validate the impact of the cost reduction.

Moreover, the design focused on the use of dynamic signs for information provision. However, signs are often as confirmation tools by the drivers (Mijksenaar experts, personal communication 2019). Hence it is important to inform the drivers and passengers prior their journey about the alternatives and perhaps the situation at Schiphol. One option can be the official Schiphol platforms such as the website and app. In chapter 4, the expansion of the Schiphol app and website has been discussed briefly. The insights highly recommend promoting the app and website of Schiphol to have an additional medium to communicate information to the passengers.

The connected system described in this report applied the design principles for the use case of dropping off at Schiphol. However, the same system can be applied for other areas at landside connectivity as well. In the analysis report four areas are explored, after which opportunity areas are generated. The in chapter 2 described opportunity areas are also interesting for the dynamic wayfinding system. It is valuable to explore the possibilities of dynamic signage both for traffic and indoor navigation purposes.

In the analysis report mobility trends are explored, where it is interesting to take future developments into account. The trends show a reduction of car ownership and the possible introduction of autonomous cars. It is interesting to study the effects of these developments on the K&R and Ceintuurbaan Zuid.

Lastly, several ideas are generated but not selected for the scope of this project. However, there are ideas that can be valuable for future projects.

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