Exploring user experience and efficiency of the closed payment border

Analysis report, March 2016

Expertise Centre for E-ticketing in Public Transport

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Delft University of Technology
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Contents

List of definitions

User/traveller. This research is concerned with the end-user or traveller. In most cases the term ‘user’ refers to a person performing actions around the closed payment border.

He/she. Wherever used in this report, the masculine third person is pronounced indiscriminately and it can be replaced by the opposite sex: ‘he’ can be ‘she’ as well.

Closed payment border. The barrier that separates the paid and the unpaid areas in the station. Travellers will go through the closed payment border (if it is present in the station) when going from the station to the platforms or visa versa.

Gate. Electronic ticketing gates are situated in the closed payment border. It collects fares and the doors of the gate provide the barrier between the paid and unpaid areas. Travellers check-in and out here.

OV-chipkaart system. The usage of the term system is reference to the collection of computer systems and hardware elements that are required to make travelling with the OV-chipkaart possible.

Interaction. Bi-directional information exchange between users and equipment (ISO, 2013). User input and machine response together form an interaction. Information exchange may include physical actions, resulting in sensory feedback.

Usability. The extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use (ISO, 2010).

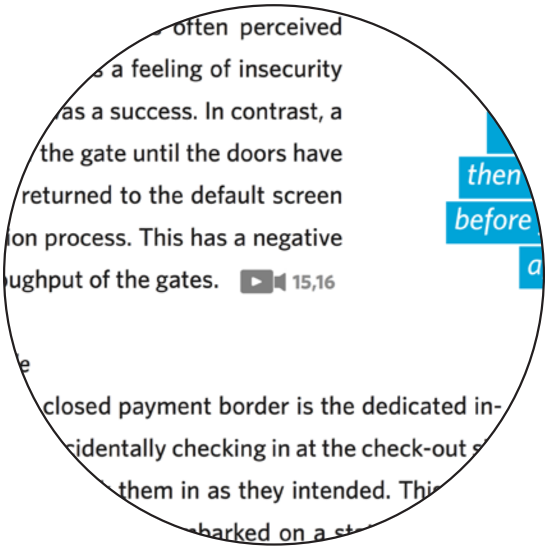
User experience. A person’s perceptions and responses that result from the use and/or anticipated use of a system, product or service (ISO, 2010).

Feed Forward. The information that helps answer questions of execution (doing) is feed forward (Norman, 2013, p.72)

Feedback. The information that aids in understanding what has happened is feedback (Norman, 2013, p.72)

Readers guide

This study gathered a lot of video material that can be used to illustrate the findings, next to the text and images. In this report, video icons are positioned at paragraphs if there is relevant video material available.



In order to access the video material, go on the internet and type **tinyurl.com/GatesVideo** plus the number of the video, e.g. **tinyurl.com/GatesVideo15**, in your browser. This will redirect you to our OV-chip lab Youtube channel, and the video can be seen directly. *Tinyurl* is a service that makes links shorter and custom, so the long Youtube-links can be made easier accessible.

There is a video library available in the back of this report, including all links to all the videos and playlists.

Executive summary

E-ticketing gates for public transportation with suboptimal interaction can cause congestions as well as stress and discomfort for the users, which can lead to discouragement of public transport usage. In this study it was observed that travellers have problems finding and using the correct gate, as well as not being informed and supported when encountering a problem when trying to access a closed payment border. Moreover, it seems possible to improve the efficiency of the gateline as a whole, to combat congestion and utilize the peak capacity of the gateline.

Several types of paying in public transport, collectively called OV-Betalen, enables public transportation users in The Netherlands to travel on all modes of public transportation. In recent years, to let/make people check-in and out and to control access to stations, in the busiest train stations and in most of the metro stations, gates have been introduced. More and more stations are being closed, by fitting closed payment borders, to ensure safety and payment. The gates at train and metro stations are a very determining element for a comfortable check-in/out experience, as well as for a station's peak capacity in terms of traveller numbers.

The study aimed to determine the context of use, the usage patterns and the problems and opportunities of the closed payment border within public transport system of The Netherlands, and the closed payment borders of London, Hong Kong and Tokyo were studied in a comparative nature. A qualitative research approach, with observations, interviews, complaints and self experience, was used to study usage of the closed payment border.

Firstly, usage patterns were identified. Usage patterns refer to the flow of movement that travellers have when approaching and moving through the closed payment border, either when going from the unpaid area to the paid area or visa versa. Users seem to go through four use phases when passing through a gateline: orientation, preparation, validation and information. Within these phases, the users have usage goals and/or cognitive processes and perform micro actions according to the tasks that need to be performed, and the feed forward and feedback the system provides. During the walk flow, the traveller interacts with many aspects of the closed payment border. The previously mentioned flow is without making mistakes, which could and would disrupt the flow even further. These usage issues for travellers in the Dutch system are identified next.

The place of the validator and screen are situated on the front of the gate, which affects the **walking flow** as many actions have to be performed by the user in a short time and thereby slowing the walking speed down. Moreover, having a small space when approaching the gateline gives the travellers less time to orientate and prepare, further slowing their flow. **Assistance** near the gateline seems insufficient to

cater to the travellers' needs, which sometimes makes them feel compelled to jump the gate or tailgate another traveller. Travellers have problems with the differentiation between the **gates of various operators** in the gateline. The gates have too few differentiating aspects to prevent users from accidentally using the incorrect gate, and subsequently lose a lot of money. Lit overhead signage, with the logos and colours of the operators in a spacious setting seem to be a positive aspect. Selecting the right gate in a gateline proves to be a hassle for some travellers. The **green arrows and red crosses** positioned low on the front of the gates are sometimes overlooked and when there are large masses of travellers, they draw a complete blank as to which gate they can take because these signifiers cannot be seen. The **bi-directional** setting diminishes a proper the walk flow by making travellers stop in front of gates and changing gates at the last moment. Moreover, it enforces a mix of walking streams that intertwine with each other, which further obstructs the flow. Travellers sometimes **validate** on the validator on the **wrong side** of the doors (on the left, instead of on the right) because it is insufficiently clear which validator belongs to which gate doors. Moreover, an enlightened validator, such as with QR-scanner equipped gates, seems to better communicate the location of the validator. The current **settings** of the sensors in the gates cannot cope with the behaviour of several use case scenarios. The doors close even though no person went through the gate and travellers get stuck between the doors or get hit by the doors after being confident they had checked in.

Lastly, the closed payment borders of London, Hong Kong and Tokyo were studied to find possible opportunities of overcoming these usability issues.

Having space between the validator and display benefits the walk flow of travellers, due to the fact that the validation phase and the information phase can be done in a sequential manner without losing pace. Moreover, having the validator and screen inside the gate, instead of on the front of the gate, clearly communicates to the users which touchpoints belong to the gate they want to use. Overhead signage is a very helpful part of the closed payment border to guide travellers to the gates they can use, even when it is busy and they cannot see the conventional feed forward aspects. Separate in- and outgoing gates in a gateline to let travellers know from a distance which gates can be used and to prevent walking streams to mix. Allow travellers to solve their problems at the gateline by offering station staff close-by the gateline and by having the gate clearly communicate to the traveller what the problem is and what the problems solving strategy should be. The usage of colours on the gates provides travellers with more feed forward to indicate the operator of the gates that the travellers intent to use. Using a validator with distinctive light and no distracting elements around it helps travellers find it easily. Having a screen swipe and light blink seems to distinct your check-in from the user before you.

Based on the field research, guidelines for user-centred closed gatelines were developed. These will form the basis for a design proposal that will be evaluated with users.

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Rotterdam Centraal - train

1. Introduction

1.1 PROJECT SETUP

The TU Delft Expertise Centre for E-ticketing in Public Transport (X-CEPT) develops integral future solutions for user-centred electronic payment used in public transport in the Netherlands. During nine months, three master of science students from the faculty of Industrial Design Engineering identify which usability problems travellers encounter and develop solutions for these problems. The solutions generated within the graduation lab will look years into the future and take the benefits for the traveller, the positions of different stakeholders and the existing infrastructure into account. The three projects have different topics within the public transport domain: the use of the OV-chipkaart by international travellers, paying possibilities with the bank card in public transport, and user experience and efficiency of the closed payment border. This report covers the latter.

In the first five months, from September to January, an analysis of the existing situation was performed. Field studies were performed to analyse usage of the Dutch system, and a benchmark was performed of gate usage in similar systems in London, Hong Kong and Tokyo. Based on the insights from the field studies, recommendations and design guidelines were formulated.

Stakeholders and project partners

Important stakeholder groups in the context of the closed payment border are public transport operators and station managing parties. A number of these stakeholders participate in this project as project partners, namely the Dutch Railways (NS), the Amsterdam public transport operator (GVB), the Rotterdam public transport operator (RET), the manufacturer of the current closed payment border (Thales) and station-managing parties ProRail, NS Stations and Spoorbouwmeester.

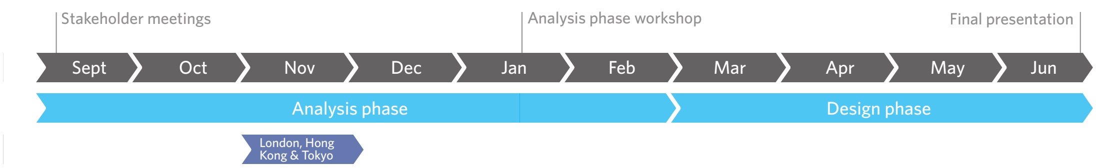

Figure 1. Timeline of the entire project

1.1.1 Closed payment borders

Several types of paying in public transport, collectively called OV-Betalen, enables public transportation users in The Netherlands to travel on all modes of public transportation. In recent years, to let/make people check-in and out and to control access to stations, in the busiest train stations and in most of the metro stations, gates have been introduced. More and more stations are being closed, by fitting closed payment borders, to ensure safety and payment. The gates at train and metro stations are a very determining element for a comfortable check-in/out experience, as well as for a station's peak capacity in terms of traveller numbers. Once all desired railway stations have what NS calls 'controlled access' 90% of all travellers with the train in the Netherlands will encounter a closed gate somewhere along their journey. And with millions of travellers every day, it is therefore important to make the closed payment border in the OV-chipkaart electronic payment system as easy and pleasant to use as possible in order to create a positive societal impact.

1.1.2 Problem statement

Gates with suboptimal interaction can cause congestions as well as stress and discomfort for the users, which can lead to discouragement of public transport usage by some people. It has been observed that travellers have problems finding and using the correct gate, as well as the lack of help and understanding when the traveller encounters a problem when trying to access the closed payment border. It has been named that this makes travellers feel insecure and the system is perceived as unfriendly. Moreover, the efficiency of the gateline as a whole can be improved to combat congestion and utilize the peak capacity. The gates in Amsterdam Central station, for instance, cannot be closed because due to the safety issues because of the limited peak capacity.

1.1.3 Vision & Mission

We envision the closed payment border as a welcoming gateway to start or end the travellers' journey, as opposed to a barrier that restrains them from embarking on their public transport adventure. The closed payment border is a seamless part of the public transport system, which travellers happily go through.

The mission of this project is to improve the usability and efficiency of the closed payment border in the Dutch public transport system to such degree that people won't even notice they used it, yet are confident that they have validated.

1.2 APPROACH

In this project a human-centered design approach is taken. Human-centered design was described by IDEO (2009) as getting to know what is desirable for the users, then investigating what is technically feasible and viable for the organizations involved.

1.2.1 Aim

The aim of this part of the project, the analysis, is to determine the problems and opportunities of the closed payment border within the OV-chipkaart system. The main focus is the perspective of the travellers and the elements on and around the closed payment border that can be improved for them. When the societal aspect is also integrated in IDEO's Human-centered design model, as proposed by Van Kuijk (2015), an innovative new product that is socially responsible can be achieved which also takes the other three aspects into account.

Figure 2 shows the 'sweet spot' of the social innovation model which is where business considerations, user needs and wants, technological developments and requirements, and societal impact are all balanced, in order to generate viable, feasible, desirable and responsible solutions.

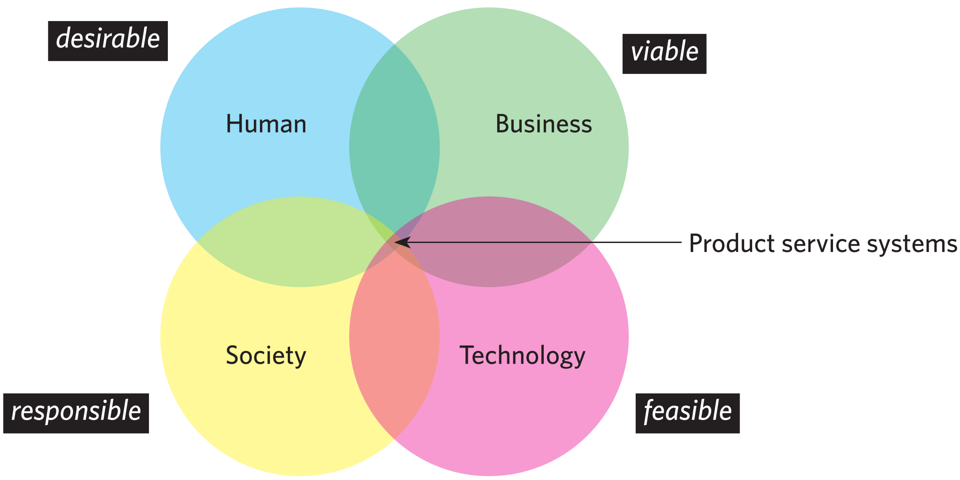

Figure 2. Integrated innovation model by Van Kuijk (2015), adapted from the human-centred design model by IDEO (2009)

1.2.2 Research questions

This study had the following research questions:

- What is the context in which the travellers use the closed payment borders?
- Which actions and cognitive processes do travellers perform while using the gate?
- Which usability problems do travellers encounter while using closed gatelines?
- Who are the stakeholders involved in developing, applying and maintaining closed gatelines and what are their interests?
- How does the closed payment border in the Dutch system compare to other closed payment borders?

1.2.3 Methods

The goal of this project is to come up with a new design for a closed payment border. Qualitative research is needed to gain insights and answers to 'how' and 'why' questions of the usage of the closed payment border. In order to find the answers to the previously proposed research questions, experts and stakeholders were interviewed, literature was studied, field research was performed (observations, interviews with users) and customer complaints were analysed.

The research approach that was taken was qualitative in nature. Qualitative research "is used in the exploration of meaning of social phenomena as experienced by individuals themselves, in their natural context." (Maletrud, 2001). Qualitative insights were obtained by observing travellers in their natural behaviour and by conducting semi-structured interviews (Patton, 2002, p.342 & Schensul et al., 1999, p.149). Following this approach, the researcher gains deeper understanding of the latent knowledge and understands what people know, feel and dream (Sleeswijk Visser, 2005).

Whereas quantitative research aims at obtaining a lot of data to reach summative conclusions, this research aims at gaining rich insights and understanding the thoughts, expectations, attitudes and processes of people. The validity of quantitative data depends on standardized measuring instruments and methods, while qualitative data is based on interpretations in which different interpreters might find different meanings and therefore depends on the researchers. Hence, both approaches have their strengths and weaknesses (Kvale, 1994; Patton, 2002, p.14). Keeping these in mind during the research is key to a successful understanding and analysis of the findings.

The qualitative research methods used are explained and elaborated in the method section of each chapter.

Amsterdam Bijlmer ArenA - metro

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Amsterdam Zuid - metro

2. Literature review

The goal of this report is to provide an analysis of the usage patterns and the usability problems travellers could experience. Users of the closed payment border will be researched and thus it is relevant to analyse existing literature about the mental aspect of users and how they interact with products, systems or services. Moreover, a common understanding about several terms will be used as a basis for this analysis report. Relevant literature on these topics are definitions of usability, interaction and user experience, and an explanation of mental models, human error and a problem solving model, and intuitive interaction.

2.1 DEFINITIONS: USABILITY, INTERACTION, USER EXPERIENCE

To capture the relationship a user has with a product, three terms are usually used: usability, interaction and user experience. The International Organization for Standardization's (ISO) definitions will be used in order to create a common understanding of the terms used in this report and project.

Usability: The extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use (ISO, 2010). This definition makes clear that a product will not have the same level of usability for all users and in all situations. Usability is thus always discussed in relation with the context of usage and the user. Because usability is context-dependent, we need to take stock of the context of use when doing field studies. It has a user performance (interaction) and user experience component, and thus we probably have to both observe and interview, in order to capture both.

Interaction: Bi-directional information exchange between users and equipment (ISO, 2013). User input and machine response together form an interaction. Information exchange may include physical actions, resulting in sensory feedback.

User experience: A person's perceptions and responses that result from the use and/or anticipated use of a system, product or service (ISO, 2010). This anticipated use can be formed through the appearance of the product, making the appearance also matter.

2.2 MENTAL MODELS

People try to understand products and predict interactions by developing "small-scale models" (Craig, 1967) of them. They help people to absorb and process the abundance of information and to quickly take decisions (Kim, 2012). These are referred to as mental models. People form internal, mental models of themselves and the things with which they are interacting, while interacting with the environment, with others, and with the artefacts of technology (Norman, in Gentner & Stevens, 2014, p.7). Mental models are constrained by the user's knowledge background and the prior experiences with similar products or systems. Therefore it is important that, while there might be only one way something is possible, different people will have a different understanding of how that something works.

According to Norman (2013, p.39), when people encounter a product to use, they first try to figure out how to use it. Subsequently they use the product and "try to figure out what state it is in and whether their actions got them their goal". In other words, this states that users have an execution phase, where users figure out how to use it and then use it, and an evaluation phase, where they analyse the feedback of their usage and assess if it accomplished their goal. Rasmussen (1983, p.258) elaborates more on this notion by mentioning that attempts to reach the goal are typically "not performed in reality, but internally as a problem-solving exercise". This means that the successful course of actions is selected from experiments "with an internal representation of the properties and behaviour of the environment".

Skill, rule and knowledge based interactions

Rasmussen (1983) also describes an action model that explains the different ways people extract and understand information from a system (see Figure 3, as used by Kim, 2012, found in Joppien, Niermeijer, Niks & van Kuijk, 2013). People can perform simple interactions by applying the skills they have, without

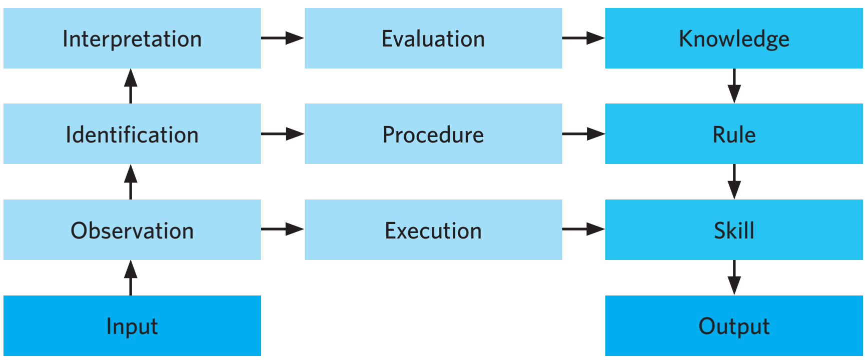

Figure 3. Rasmussen's (1983) action model

the need for instructions or the use of their brain. However, if an interaction requires a higher cognitive level of action, the user has to match the context and the problem that is being faced. This can be done based on, for instance, prior experience or explicit instructions or rules if an automatic skill fails. If this rules-based approach also fails, the person has to reason based on principles, which require more effort. In order to keep the cognitive level of users low, they will try to scale down all actions to an automatic, skill based level. Therefore, as Kim (2012) concludes, "products should be designed in such a way as to reduce high-level cognitive capacity to transfer product usage into automated processes on a low cognitive level considering efficient performance in human product interaction". This means that products need as many skill-based actions as possible, in order to increase usability and to avoid encountering possible usability issues.

2.3 HUMAN ERROR AND PROBLEM SOLVING

When people use products or product service systems, errors are bound to happen and users will try to solve them. Human error is defined as any deviance from 'appropriate' behaviour (Norman, 2013, p.170). 'Appropriate' behaviour in the context of the closed payment border would be using it without having issues regarding usability. Norman classifies two types of errors: slips and mistakes, and they have different implications for design. Norman continues to define two types of slips: action-based slips, where a user applies the correct action to the wrong object, and memory-lapse slips, where the user forgets to do something. Furthermore, Norman defines three types of mistakes: rules-based, where a user appropriately diagnosed the situation but followed the wrong rule, knowledge-based, where a user misdiagnoses the problem because of wrong or incomplete knowledge, and memory-lapse mistakes, where the user forgets something in the stages of goals, plans or evaluation. Some of these mistakes and slips happen at different levels of the mental models that have been discussed in the previous subchapter (2.2). Knowing which types of slips or mistakes users make can help to target these issues by designing specific solutions.

Problem-solving strategies can be found in these mental model levels as well. Reason (1990, p.65) argues a generic error-modelling system with the skill-based, rule-based and knowledge-based levels of Rasmussen's (1983) model. In the skill-based level there are the slips and lapses, in the rule-based level there are the rule-based mistakes and in the knowledge-based level there are the knowledge-based mistakes. The key feature of this model is the claim that, when confronted with a problem, humans "are strongly biased to search for and find a pre-packaged solution at the rule-based level before resorting to the far more effortful knowledge-based level". Rule-based attempts at problem solution will always be tried first. If the problem is easy and the corrective rules are found, the problem solving will return to the skill-based level. If the problem is more severe, the rule-based cycle (of "scanning local signs and symptoms, rule implementation and evaluating the outcome") may be repeated several times. If the repertoire of rule-based solutions is inadequate to cope with the problem, the user will resort to the knowledge-based level in order to solve the problem.

It is relevant to put this problem solving literature into the perspective of a public transport user. In a previous study (Uxad team B6, TU Delft) in the domain of public transport, it was found that when travellers encounter a problem, they go through several phases in order to try to solve their problem (see Figure 4).

Identification - The first phase is understanding the problem that has been encountered.
Attribution - Whose fault is it; the system or mine?
Prioritization - Should I fix the underlying problem or catch the next train?
Trying out - Trying out problem-solving strategies.
Resolving - Either postpone the problem or follow the instructions from the service personnel or info-pole.

In conclusion, there are several types of human error that travellers using the closed payment border can encounter. Finding out which type of error is being made might help in designing effective solutions on the closed payment border in order to prevent these errors from happening again. Moreover, problem-solving solutions by users follow several steps in the metal models of skill-based, rule-based and knowledge-based. In the domain of public transport this has been researched and problem-solving steps have been found.

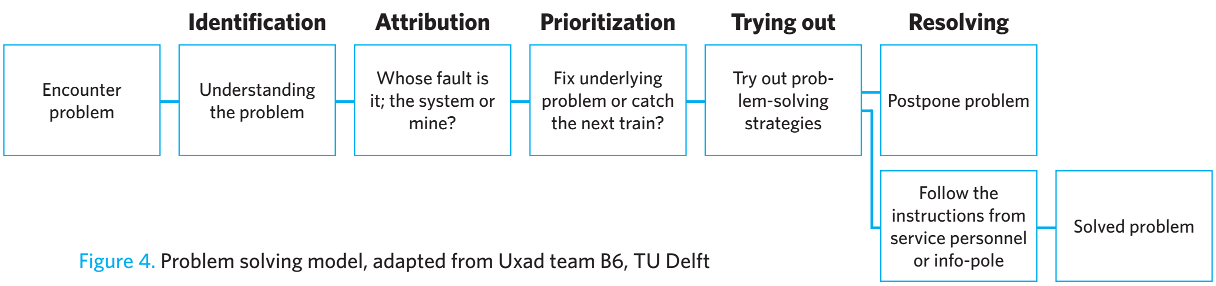

Figure 4. Problem solving model, adapted from Uxad team B6, TU Delft

2.4 INTUITIVE INTERACTION

Infrequent users of counter-intuitive products may encounter problems (Kellogg, 1987), and tend to see the counter-intuitive products as undependable and unfriendly (Blackler et al., 2003). Since the public transport system is accessible for all individuals in society, intermittent and casual users will use a public transport service, and thus the closed payment border, as well. To facilitate use by intermittent and casual users, designers need to make products easier to learn and use (Blackler et al. 2003). Their research suggests that to increase the intuitive usability of a product, familiar features and controls should be included in a way that "is easy to follow and is consistent with the user's expectations according the her/

his past experience". Wensveen *et al.* (2004) suggest that interaction can be made intuitive by unifying action and reaction as much as possible. However, they argue, full unification may be difficult as more functionality is added to electronic products. Information is needed when it is not possible for designers to establish direct couplings between action and function. This information, called feedback and feed forward, should guide the user's actions towards the intended function. The information that helps answer questions of execution (doing) is feed forward, and the information that aids in understanding what has happened is feedback (Norman, 2013, p.72). Wensveen *et al.* (2004) distinguish three types of feedback and feed forward: functional, augmented and inherent.

- *Functional feedback:* "The information generated by the system when performing its function, e.g. sound, light or motion".
- *Augmented feedback:* The information from an additional source rather than the information coming from the action itself. Therefore it "appeals more to the cognitive skills of the user instead of appealing to the perceptual motor skills". This kind of feedback usually informs the user about the internal state of the system.
- *Inherent feedback:* "The information provided as a natural consequence of making an action. It is feedback arising from the movement itself." (Laurillard, 1993, as quoted in Wensveen et al., 2004)
- *Functional feed forward:* The information that informs the user about the more general purpose of a product and its functional features.
- *Augmented feed forward:* The information that the user receives from an additional source about the action possibilities or the purpose of action possibilities. This appeals to the user's cognitive skills.
- *Inherent feed forward:* The information that communicates what kind of action is possible and how this can be carried out.

In conclusion, we assume that the closed payment border will need a design that is intuitive to use due to the intermittent travellers that will use it. This can be achieved through unifying action and reaction as much as possible. There are several types of feedback and feed forward, and design can be adjusted on these different levels in order to make the design more intuitive for use.

2.5 CONCLUSION

The theories presented in this chapter help to understand various aspects of the user and of the user-product interaction. This would benefit the research to better understand the closed payment border and the areas of attention that need to be considered for a new user-centred design.

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Amsterdam Bijlmer ArenA - train

3. The Dutch closed payment border

3.1 INTRODUCTION

Closed payment borders are implemented in most of the metro stations and about 55 (mostly the biggest and Randstad region) railway stations (as per February 2016). Closed payment borders are used to collect fares from travellers and to keep unwanted people out. The appearance and behaviour of the gatelines is determined by different types of payment in public transport, the interests of stakeholders and travellers, and types of gates available on the market. This chapter will give an overview of the Dutch closed payment border system: what it is and how it works, where it can be found and what it looks like, and who the stakeholders and their interests are.

3.1.1 Aim

The aim within this chapter is to give an overview of the aspects of the Dutch closed payment border, such as payment options and physical set-up, and to investigate the interests of the stakeholders.

3.1.2 Research questions

- How does the OV-chipkaart system work, and what role does the closed payment border play in this?
- What are the technological developments?
- How does the closed payment border work?
- Who are the stakeholders and what are their interests?

3.1.3 Methods

In order to gain insights and to create an understanding of the context, stakeholder interviews were performed, literature was studied, and the closed payment border was observed and used.

Interviews with stakeholders were done to gain a better understanding of the stakeholders involved and their interests concerning the closed payment borders in the public transport system in The Netherlands. For all interviews a semi-structured approach was used (Patton, 2002, p.342 & Schensul et al., 1999, p.149). The interviews were prepared in advance; important questions were formulated in order to guarantee that all topics of interest were covered during the interview. During the interview, the researcher and the interviewee were free to ask questions and to bring up more topics to get more in depth information.

3.2 OV-BETALEN: E-TICKETING IN DUTCH PUBLIC TRANSPORT

All possibilities to pay for travelling in the public transport system in The Netherlands is called OV-Betalen. This part will explain the history of payment methods in the Dutch public transport system, future envisioned payment methods, how paying in public transport works and where it can be done, and which stakeholders are involved in this.

3.2.1 Current payment methods in public transport

Currently there are several ways for travellers to pay for using the public transport system. These payment methods include the OV-Chipkaart, paper tickets and e-tickets.

OV-Chipkaart

In 2001, the NS (national rail), GVB (Amsterdam), RET (Rotterdam), HTM (The Hague), and Connexxion (regional bus) formed the Trans Link Systems (TLS) joint venture in order to set-up a national electronic ticketing system. These stakeholders together provided 80 percent of all public transport at that time. After the first implementation in 2004, the name of this new, national electronic ticketing system is 'OV-chipkaart' (Joppien *et al.*, 2013).

The OV-chipkaart, a smart card the size of a credit card, enables public transportation users in The Netherlands to travel on all modes of public transportation. It costs 7.50 euro to buy and can be personal (linked to a specific person, with photo for identification, see Figure 5) or anonymous. Personal cards can hold season tickets (e.g. free travel during the week) or discount tickets (e.g. 40% discount off peak). These 'travel products' on the personal OV-chipkaart can be of many different operators. For instance, a traveller can have both a discount for the NS (national rail) and free travel on another operator. Travellers have to put credit on the OV-chipkaart in order to use it for payment in the public transport system. This can, for instance, be done at ticket vending machines in stations.

Paper tickets

Ticket vending machines can also provide travellers with single-use paper tickets. Similar to the OV-chipkaart, paper tickets make use of NFC (Near Field Communication) technology to validate and are therefore referred to as a 'single-use OV-chipkaart'. Other disposable cards, as some of the HTM, GVB, RET, can be used for multiple days, such as the 72-hours travel card from the GVB.

Figure 5. Validating with a personal OV-chipkaart at a NS gate


Inchecken
geannuleerd
Saldo € 42,91
L.T. GROOT OBBINK
13-06-1991 M

E-tickets

E-tickets are printed tickets that travellers acquire some time before they make their journey. These are, for instance, used for travels in multiple countries (e.g. The Netherlands to Belgium) or for travelling to and from an event (e.g. concert or football match, the ticket is then used for entering public transport as well as the event). These e-tickets use barcodes or QR-codes for validation.

3.2.2 How paying in public transport works

In order to travel with the public transport in The Netherlands, travellers need to, firstly, acquire a valid transport ticket (see 3.2.1). This can be done by buying a ticket with QR-code at home, by buying a single-use ticket at the ticket vending machine or by charging the OV-chipkaart with credit. Secondly, travellers have to validate their transport ticket before entering the transport modality or system, which is called check-in. This can be done at validators, such as the poles (see Figure 6, right side) at open payment borders and gates (see Figure 6, left side) at closed payment borders. Lastly, when exiting the transport system, travellers have to checkout at the validators in order for the backoffice to calculate the fare price and to show this in combination with the balance left on the OV-chipkaart. Notice that single-use tickets and QR-code tickets will not show the fare and balance, since they do not have this.

Figure 6. Gates and poles used for validation in the Dutch public transport system (RSB, 2012)

3.2.3 Future payment solutions in public transport

The Nationaal Openbaar Vervoer Beraad (NOVB), a public transport deliberation group for the Dutch public transport, produced a vision on future payment methods in the public transport domain (NOVB, 2014). Since these will have impact on the use of the closed payment border in the Dutch public transport system, below a number of possible future payment options will be discussed, namely: EMV, Be in Be out, Mobile payment and Single check-in check out.

EMV

Using a bank card for direct payment in public transport is considered one of the payment methods of the future. EMV is an abbreviation of the standard for contactless payment: Eurocard Mastercard Visa. It uses a chip in the bank card to communicate with the system. Contactless payment means the travellers only have to hold their cards against the reader to ensure a payment. To determine the correct fare for the traveller, it is necessary to validate at the start and end of the journey. By using EMV in public transport, travellers would not have to buy an OV-chipkaart or paper ticket, as they can use their bank card directly to pay for their travels. Contrary to the current smart card system of the OV-chipkaart, with bank cards there would be a 'smart backoffice' and the card would not hold much more than an identifier number. This means that all validators should be connected to the back-office via high-speed data connections. Because of this there are also limits in terms of the feedback that users can be provided with at the validator.

Be in Be out

This method of payment relies on location-based technology, most likely (a combination of) beacons, GPS and (NFC) validation at gates. It is envisioned that the public transport system will notice when a traveller enters and exits (e.g through smartphone) a system or vehicle and can calculate the fare with that information. Travellers would not have to actively validate (check-in or check out) anymore and would subsequently not be able to forget to do it. A concern with this method is the privacy of the traveller.

Mobile payment

For mobile payment there are two feasible technologies: Smart-OV and EMV. Smart-OV uses NFC technology, a chip in the smartphone, and an app. EMV goes through an app and the NFC of the phone, so it does not need a sim card chip. Mobile payment would be able to be used the same way as an OV-chipkaart to validate when entering or exiting the public transport domain. Payment will be transferred through banks towards the public transport operators and the traveller can see the balance and fare price on his smartphone (app). Travellers would not have to buy a ticket or OV-chipkaart to access the public transport domain.

Single check-in check out

Currently, on train stations with multiple operators, gates and poles are available for the different operators. The principle of 'single check-in check out' would, if implemented, ensure that the traveller does not have to choose between different operators during check-in or checkout. All validation possibilities can be used, regardless of the operator used. This would prevent travellers from making mistakes with validating at the wrong operator and it would eliminate the need to use the transfer poles on platforms between trains of different operators. The Meijdam commission already recommended a number of years ago (Meijdam commission, 2011) that single check-in/out should be implemented. Operators are still busy trying to find a way to implement it. The subject is still on the agenda of the NOVB.

3.3 CLOSED PAYMENT BORDER WITHIN THE PUBLIC TRANSPORT SYSTEM

A closed payment border within the public transport system is a barrier where travellers have to validate their ticket, which means that they let the system know that they have either entered or exited (moved from paid to unpaid area, or vice versa). In the Dutch system, these borders are placed in many metro and a large portion of train stations to combat fare evaders, and to ensure safety. In general, closed payment borders consist of a row of gates, also known as a gateline, which creates a barrier between the paid and unpaid areas in stations (see Figure 7). This section will explain how it was implemented, the types of gates and how they work.

3.3.1 Implementation of the closed payment border

Since the start of the implementation of the OV-chipkaart system, transport operators started implementing gates in their stations. Metro stations in Rotterdam had gates installed in 2005 but, due to the delays in the OV-chipkaart implementation, these were not closed yet (Berg & Heide, 2005). But with the development in implementation came the installation of gates in all metro stations and in some train stations. Around the start of 2016, many years after a fully implemented OV-chipkaart system, all metro stations have functional gates installed and around 55 train stations have a closed payment border. The aim of the NS (national train operator) is to install closed payment borders at about 80 stations in the Netherlands, on a total of 400 train stations. Appendix A shows the current train stations with closed payment borders and the ones that will be closed in the (near) future. Once all designated railway stations have, what NS calls, 'controlled access', 90% of all travellers with the train in the Netherlands will encounter a closed gate somewhere along their journey.

Figure 7. The closed payment border at Rotterdam Centraal

3.3.2 Types of gates

There are several types of gates in use in the train modality system in The Netherlands (RSB, 2012). There are four types: TARL-Gate (placed in Amsterdam Centraal station), T14-Gate (placed on the Hoekse Lijn), and the T4-Gate, both in high and low version, is placed in the rest of the Netherlands (see Figure 8). Since the TARL-Gate will be phased out soon and the T14-Gate is nearly identical to the most commonly used T4-Gates, this report will address the T4-Gate as the 'normal' gate in the closed payment borders in the Dutch public transport system. Moreover, all metro stations use this type as well. The T4-Gates with high doors are implemented in all metro stations and many (mostly the unmanned) train stations, whereas the T4-Gates with low doors are installed in a few train stations (e.g. Rotterdam Centraal).

In this report, 'gate' in the Dutch context will refer to the T4-Gate which has either high or low doors depending on the context. The metal box attached to the ground containing all mechanical parts will be referred to as 'cabinet', and the part on the cabinet containing the validator and display will be referred to as the 'head'. A 'gateline' will be referred to as a row of T4-Gates, forming the closed payment border. When 'the gates in the Dutch system' are mentioned, these are referring to both metro and train gates. A 'wide gate' will be referred to as a gate with wider space between the cabinets.

Figure 8. The high doors version of the T4-Gate (RSB, 2012)

The gates in the Dutch public transport system are designed and manufactured by Thales. The cabinets are approximately 2 meters long, 1 meter high and 20 centimetres wide. The doors are about 25 centimetres wide and 1,50m high (30cm from the ground) each, with some space in between to ensure travellers wont get their fingers stuck in between. Wide gates have wider doors (about 40 cm) to accommodate the extra wide space between the cabinets. In a gateline, 'normal' gates have 60 cm walking space between the cabinets and 'wide' gates have 90 cm. The gates are build in such a way that both sides of the gate are mirrored and thus identical.

Gates have a place on the front (and back) of the cabinet, which can indicate a green arrow or a red cross from LEDs, to show travellers the direction the gate is set in and thus which gate can be used and which ones cannot. The 'head' is located on a slightly tilted front (and back) part of the cabinet, and is a plastic inlay into the metal shape of the cabinet. The head consists of a plastic shape in a colour (e.g. yellow for NS) with a display and a validator. This validator is round and has a contrasting colour with a graphical hand and OV-chipkaart on it. The gates in some train stations can also contain another type of validator: one with light that can scan, next to the OV-chipkaart and single-use tickets, QR-code tickets.

3.3.3 How a gate works

Travellers will present their card at the validator of an accessible gate to validate their travel ticket and to open the doors in order to go through. The gate will give sound feedback depending on the validation (success or not) and the display will show a screen depending on this. The train gates communicate three main messages: The validation is successful, the validation is unsuccessful, or the traveller needs to perform another step (see Figure 9). An overview of all possible screens that the display on the gate can give, for both checking-in and checking-out, are shown in Appendix B.
After the validation has been successful, the doors will open and the information will be displayed on the screen. The gate has sensors on the sides of the cabinets to detect what passes the gate and to notice misuse. Travellers can check out after a check-in within 35 minutes without having to pay a fare fee, in

Figure 9. Examples of messages the display on the gate can communicate: validation successful (white), validation unsuccesful (red) and another step is needed (yellow)


metro
trein
SOS

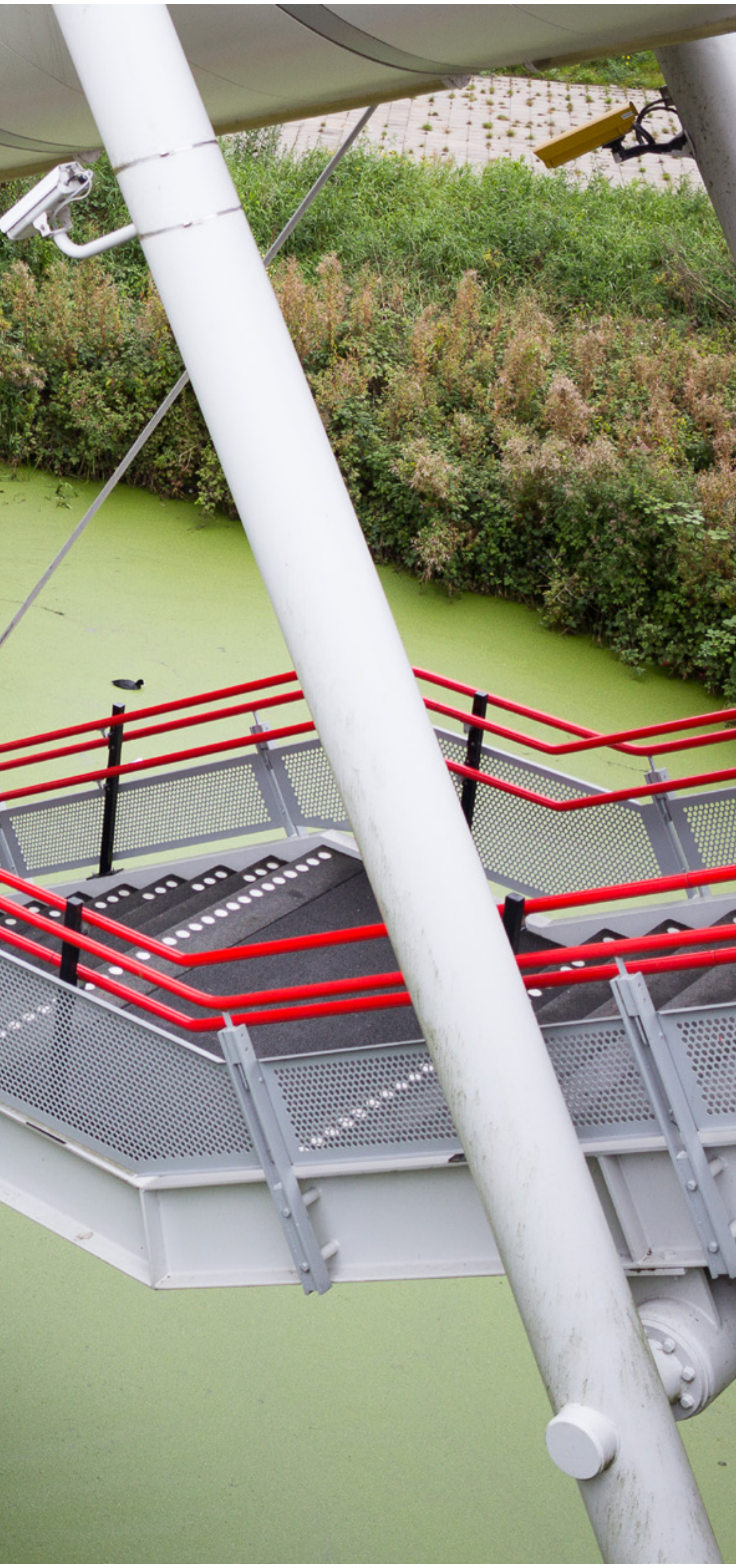


Figure 10. A gateline at station Duivendrecht with gates from two operators: the GVB (metro) and NS (train)

order for travellers to move around stations freely to, for instance, buy something from a shop or pass through the station hall.

3.3.4 Types of stations

As mentioned before, closed payment borders can be found in many metro and train stations. Gatelines have to be placed with enough space around them in the station building due to safety regulations, and subsequently there are stations where the gateline consists of gates from multiple operators. This is not just due to safety regulation, but also due the fact that the Netherlands has a system with multiple operators operating under their own brand and each having its own validators and back-office (that subsequently send the data to TransLink Systems).

Stations with multiple modalities are stations (e.g. Amsterdam Amstel) where metro platforms and train platforms are at the same level, sometimes even with the same staircase leading to it. Since the gate types are the same (T4-Gates), the only difference is the colour of the head and the display type, and the overhead signage indicating the modality of the gates below it (see Figure 10). There are also stations, like Amsterdam Bijlmer Arena, that have multiple modalities but separated gatelines per modality. Some train stations have multiple train operators (e.g. Arnhem) which then do have overhead signage above the gateline to indicate the different gates of the two different train operators. And, of course, there are metro stations with only metro gatelines and there are train stations with only train gatelines. Characteristically, this last category of stations do not have signage overhead to indicate the modality.

3.4 STAKEHOLDERS

There are several stakeholders involved around the closed payment border. It is important to find out how concessions and purchasing of closed payment borders is done, who the project partners are for this study, and what their interests are.

3.4.1 Stakeholders, concessions & purchasing

The closed payment border system is operated, applied and influenced by different stakeholders. These can be divided into six main groups (see Figure 11): travellers, public transport operators, governments, station managing parties, technology & service suppliers, and TLS. Additionally, there is the NOVB that handles cross-concession affairs, and there are regulators.

Travellers are the most important group, because there would be no need for public transport without them. They use the closed payment borders of public transport operators, which set requirements for the gates to be executed by technology & service suppliers through concessions. Station managing parties have influence on the placement/positioning of gatelines and space management in stations, in order to maintain safety and station throughput. TLS handles the system to process all transactions. Regulators oversee whether TLS and the public transport operators stay within the law. Regional and national government set requirements and rules for the closed payment border. The NOVB is an organization tasked with solving inter-concession problems for the future.

If public transport operators decide to place a closed payment border in stations they operate in, they formulate requirements and put out a tender for technology & service suppliers. The technology & service providers present their proposal for a closed payment border with the service supplied around it, and the public transport operators decide which supplier can provide the closed payment border for a certain timespan. After several years, the contract expires and a new concession is put up.

3.4.2 Project partners and their interests

There are several transport operators, station managing parties and one technology & service supplier attached to this project as partners. The transport operators involved are the Amsterdam public transport operator GVB, the Rotterdam transport operator RET and the national train operator NS. The station managing parties involved are infrastructure manager ProRail, architecture body Spoorbouwmeester and station retail NS Stations. The technology & service supplier is the supplier of the closed payment border in the current Dutch system, Thales. Interviews with representatives from these organizations were held one-

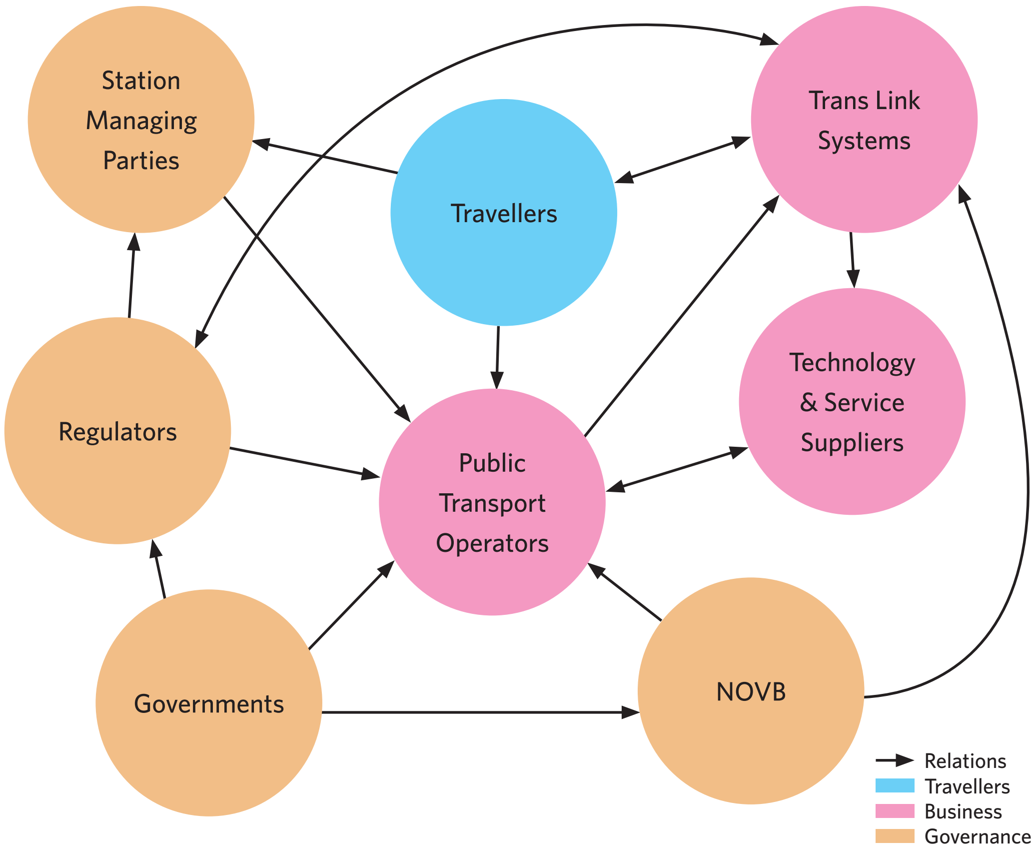


Figure 11. The stakeholders and their relations to each other

on-one with the researcher to gain insights into how they are involved around the closed payment border and what their interest are.

The public transport operators (GVB, RET and NS) have similar interests regarding the closed payment border. The main focus points are safety, security, capacity (user throughput) and robustness, next to the fare collecting aspect. It was stressed that the gates in The Netherlands need to be very vandalism resistant. Furthermore, it is mentioned that the flow speed of the gates is a constant worry. The efficiency of the gateline, that the row of gates is optimally used, is also a point of interest for them. The transport operators want to use the guidelines from this study to incorporate in the specifications for the next concession.

"Actually that is what we want; that the row is optimally used."

GVB

"There was little thought about usability; the machines were built from a technical point of view and not from a user point of view."

RET

"What is the gate capacity when people are unfamiliar with the system?"

NS Stations

The station managing parties (ProRail, Spoorbouwmeester and NS Stations) also have some overlap in their interests. Mostly they are concerned with the flow (throughput) capacity of the gates, with the focus on the safety of travellers. They are also concerned about the passenger flows in the station and what the effect of the (placing of the) closed payment border has on this. ProRail, for instance, wants the station be as empty as possible to accommodate all the passenger streams. Spoorbouwmeester has the aim to make (train) stations a neutral place, not specific for one operator. The stations should be recognizable and homogeneous in their interior and routing, signing and branding across all stations in the Dutch system. The closed payment border is a part of the station, so in their view those visions would also apply to it.

3.5 CONCLUSIONS

In this chapter, a picture of the context surrounding public transport, and specifically the closed payment border, has been painted. We have looked at the different payment methods currently available in public transport and the payment methods of the future. Furthermore, a description has been given about how paying in public transport works. The closed payment border has been introduced as one way for users to pay in public transport. The gates in these payment borders have been explained, including how they work and in which stations they can be found. Knowing the build-up and workings of the gate will help to set the right focus during field research and directly understand what is happening and what users are talking about. Lastly, the stakeholders and their interests for the closed payment border were discussed. Knowing interests of stakeholders is important for the synthesis phase, where we will develop feasible solutions.

In the next chapter, the usage of the aforementioned closed payment border by Dutch travellers will be studied. Several qualitative research methods will be used to find out which usage patterns become apparent and which usability problems occur.

Amsterdam Zuid - metro

4

Rotterdam Centraal - train

4. Studying the usage of the Dutch closed payment border

In chapter 3 the OV-chipkaart system, the closed payment border system and the stakeholders involved have been described to understand the context of the closed payment border in the Dutch public transport system. This chapter focuses on the usage of the closed payment border within this system and explores how people interact with the gates and its context, and the usability problems that some of the users encountered.

To be able to design a successful user-centred redesign of the closed payment border, an understanding of how people use and experience the closed payment border is required. Studying the behaviour of the users of the system can do this. Qualitative research methods, such as observations, interviews and submitted complaints, were applied in this chapter to find the identified problems that some of the users of the Dutch closed payment border experienced. Firstly, these aspects are described by the usage patterns and secondly, which usability issues occur. Found problems are clustered into problem areas of the closed payment border.

4.1 METHOD

4.1.1 Aim

The aim of the research in the Netherlands is to discover and understand how travellers in the Netherlands interact with and experience the closed payment border. It is important to find out what happens (and why) around the closed payment border and what the consequences are for travellers.

4.1.2 Research questions

- What types of users can be distinguished?
- How do travellers interact with and experience Dutch closed payment borders?
- What are the elements of the closed payment borders that users interact with?
- How do gates perform in different states (e.g. peak, low, emergency, two way)?

4.1.3 Data collection

To investigate how travellers interact with the closed payment border, observations were performed at train and metro stations. Some interviews in context with Dutch public transport users were conducted in order to gain insights on what people think about the closed payment border. Also, complaints from travellers submitted at the OV Loket were processed to gain more insights into the problems that travellers have at hand. Below the sampling strategy, and methods for the observations and interviews are discussed.

Sampling strategy

The visited stations (see Table 1) were selected based on properties of the stations, such as high or low gates, the availability of operators and/or modalities, the size of the station, whether it is a manned or unmanned station, and how the crowd at the station is. The usage of the closed payment border might be affected by a different consistency of the crowd at the station, for instance when it is peak time there will be a lot of people at the same time and some stations have touristic visitors. The sampling strategy aimed to cover all these aspects with at least several stations, in order to gain a comprehensive and representative view on the effect they have on the travellers' usage patterns.

Table 1. Sampling strategy graph: visited stations vs. considered aspects

		GATES		OPERATORS/ MODALITIES				STATION SIZE			ASSIS-TANCE		CROWD			
		high gate	low gate	single operator - train	single operator - metro	multiple train operators	multiple modalities m&t	large station	medium station	small station	manned	unmanned	peak	off-peak	event	tourists
THE NETHERLANDS	*Amsterdam Amstel*	●					●		●		●		●	●		
	Amsterdam Bijlmer	●					●		●		●		●	●	●	●
	Amsterdam Centraal	●	●	●	●			●			●		●	●		●
	Amsterdam Duivendrecht	●					●		●		●			●		
	Amsterdam Holendrecht	●					●			●		●		●		
	Amsterdam Lelylaan	●					●		●		●			●		●
	Amsterdam Zuid	●					●	●			●		●	●		●
	Arnhem		●			●		●			●		●	●		●
	Delft		●	●					●		●		●	●		●
	Heiloo	●		●						●		●		●		
	Leiden	●		●				●			●		●	●		
	Rotterdam Centraal		●	●	●			●			●		●	●		●
	Zwolle	●				●			●		●		●	●		

Observations

The primary source for data collection was on-site observations. Observations were performed at train stations and metro stations, in order to investigate what travellers are doing around the use of the closed payment border (see Figure 12). Some stations had a mix of metro and train, or multiple train operators. Observing the natural behaviour of people using the closed payment border can reveal important insights. How people behave can be different from what they say and think they do (Sanders & Stappers, 2012, p.52-53).

Both the 'onlooker' and 'participant' observational approached were used (Patton, 2002). As an onlooker, distance was kept between the users of the gates and myself. Arguably, many of the users did not notice the presence or the intent of the researcher. As a participant, the researcher was fully engaged in experiencing the setting while at the same time observing other participants (Patton 2002, p265) during the trajectory from outside the station, all the way to the platform.

All observational research was done in a covert matter (Patton 2002, p269). None of the people observed were informed nor hinted towards a research approach and will thus not be aware or think about being observed. It can thereby be concluded that the observational research will not be negatively influenced, as all observed people act in their natural behaviour. Since the people that were observed were not judged on their personal performance of any kind, ethics and morality would not pose an issue. All observational qualitative information gathered from this research will be treated in an anonymous and holistic matter, not focused down to describe mistakes made while using the system to a specific person.

Observations were mostly written down, with a separate interpretation of each observation by the researcher. Wherever possible, observational findings were supported by video captured material.
A more elaborate observation approach can be found in Appendix C.

Interviewing

Formal and informal interviews were conducted in order to find out how travellers experience the Dutch closed payment border. These interviews were done with people present in the context of the closed payment border, for instance when waiting for the train. In this study, this research method was more of a secondary strategy for data collection, due to the fact that observations gave the researcher more insights. For all interviews a semi-structured approach was used (Patton, 2002, p.342 & Schensul et al., 1999, p.149). A set of basic questions is asked in every interview, while other questions are asked based on answers


Haag Centraal
SOS

and flow of the interview. The interview guide can be found in Appendix D. The interviews were done in a one-on-one setting. Whenever possible, interviews were recorded on video in order to prevent loss of information. However, some interviewees either did not want to be recorded or the start of the interview did not leave a time to interrupt the interviewee to ask for permission for filming. In those cases, gathering information had higher priority than catching it on tape, and the researcher wrote the findings down after the interview.

OV Loket

The OV Loket (ovloket.nl) is an organization with the goal to help travellers who have a complaint about public transport. The organization provided a list with 72 complaints specifically about the closed payment border. The complaints were collected from April 2015 to October 2015 (see Appendix E). These complaints gave insights into the issues travellers encountered while interacting with the closed payment border. Because of the high threshold of submitting a complaint (at the OV Loket or any place where complaints can be acknowledged), the complaints are often about complex issues, travellers are severely bothered by them and they have issues solving them. Quotes from these complaints are used to illustrate the findings.

4.1.4 Data analysis

The most important findings of the raw data were compiled in statement cards (Sanders & Stappers, 2012), which make the individual usability issues more tangible and give a clear overview of the problems at hand. The cards contain an illustrative image of the problem, a colour for the country (e.g. magenta represents the Dutch system), an icon showing the source of the data (e.g. observation), the name of the source file which enables backtracking, a finding (e.g. something that has been observed or something a traveller said), and the interpretation of this finding by the researcher (see Figure 13). For an overview of all statement cards of the problems that users encounter in the Netherlands, see Appendix F.

Figure 13. An example of a statement card used for data analysis

Figure 12. Observations of travellers using the closed payment border

4.2 USAGE PATTERNS

Through the research, several patterns of use by the travellers in the Dutch system can be identified.

4.2.1 Usage phases

Travellers have a certain flow of movement when they approach and go through a closed payment border, either when going from the unpaid area to the paid area or visa versa. It became evident that users of the closed payment border tend to follow a certain repertoire of use phases and actions when going through. As Figure 14 illustrates, four phases of use can be identified: orientation, preparation, validation and information. Within these phases, the users have usage goals and/or cognitive processes and performs micro actions according to the tasks that need to be performed (in purple) and the feed forward (in orange) and feedback the system gives to the traveller (in pink). The information that helps answer questions of

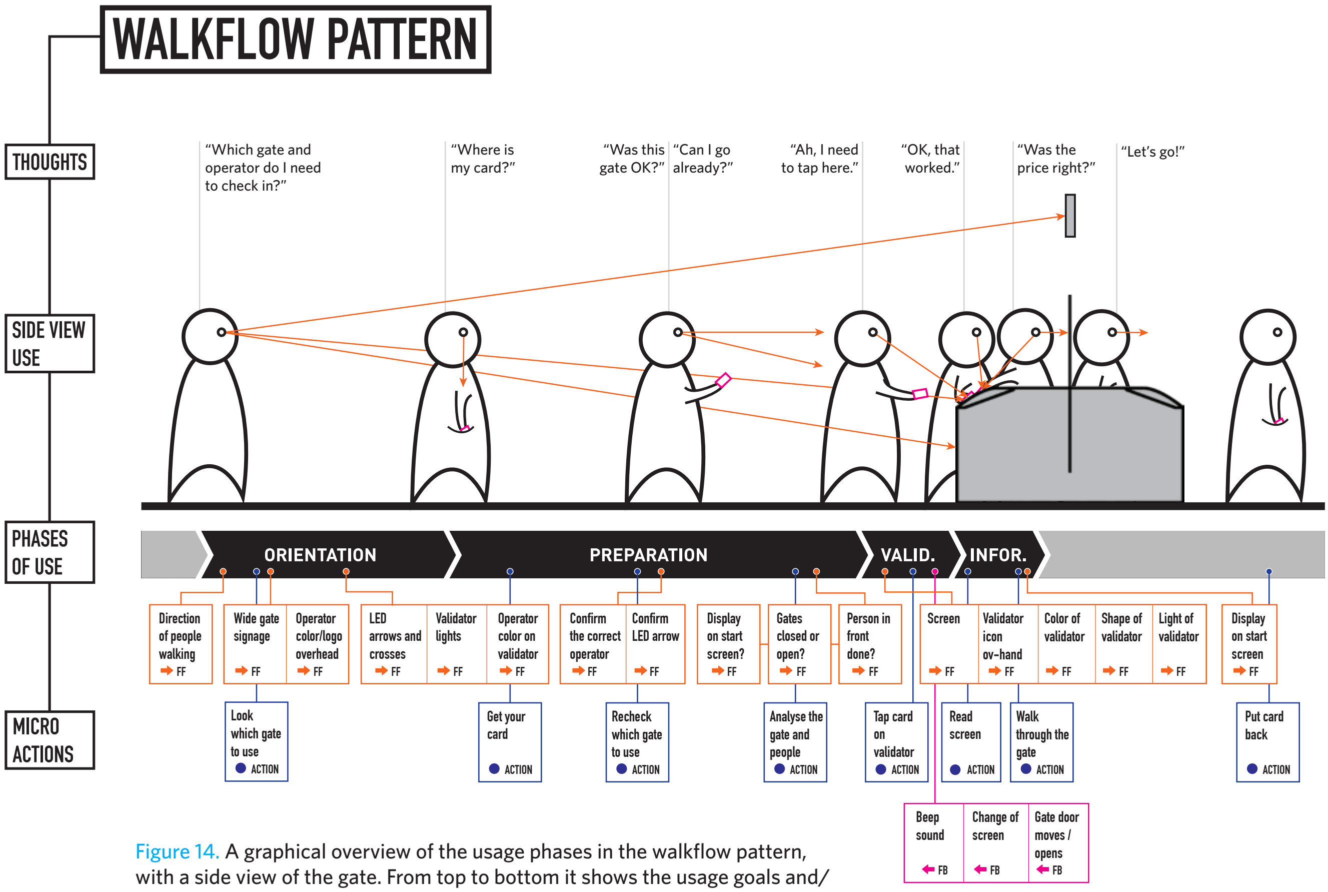


Figure 14. A graphical overview of the usage phases in the walkflow pattern, with a side view of the gate. From top to bottom it shows the usage goals and/or cognitive processes, the user with the direction of attention, the four phases of use, and the micro actions that users perform along the phases of use

execution (doing) is feed forward, and the information that aids in understanding what has happened is feedback (Norman, 2013, p.72).

Orientation phase

In the orientation phase (Figure 15), the traveller looks which operator and gate is needed to check-in/out. The direction in which other travellers are walking can give an indication of where a gate could be which the user should or should not use. Furthermore, the signage overhead for the wide gate and operator colour/logo give more indications which gateline should be chosen. The user also gets feed forward from the individual gates, through the LED green arrows and red crosses, lights on the validator, and the colour of the 'head' of the gate.

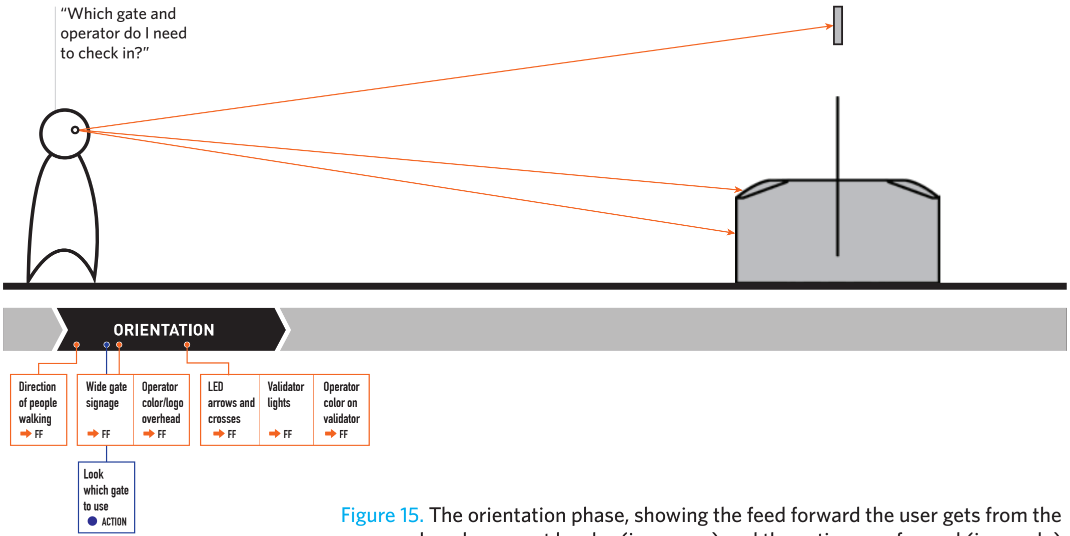


Figure 15. The orientation phase, showing the feed forward the user gets from the closed payment border (in orange) and the actions performed (in purple)

Preparation phase

After the orientation phase, the preparation phase (Figure 16) starts when the user has decided which gate will be used and the ticket gets taken out of the pocket. While getting closer to the gate, users often do a re-check of the previously mentioned feed forward aspects to reassure themselves of whether they have chosen the correct gate. Users are also affected by the actions of people in front of them; the display can still show the previous validation and the gate doors can still be open or moving.

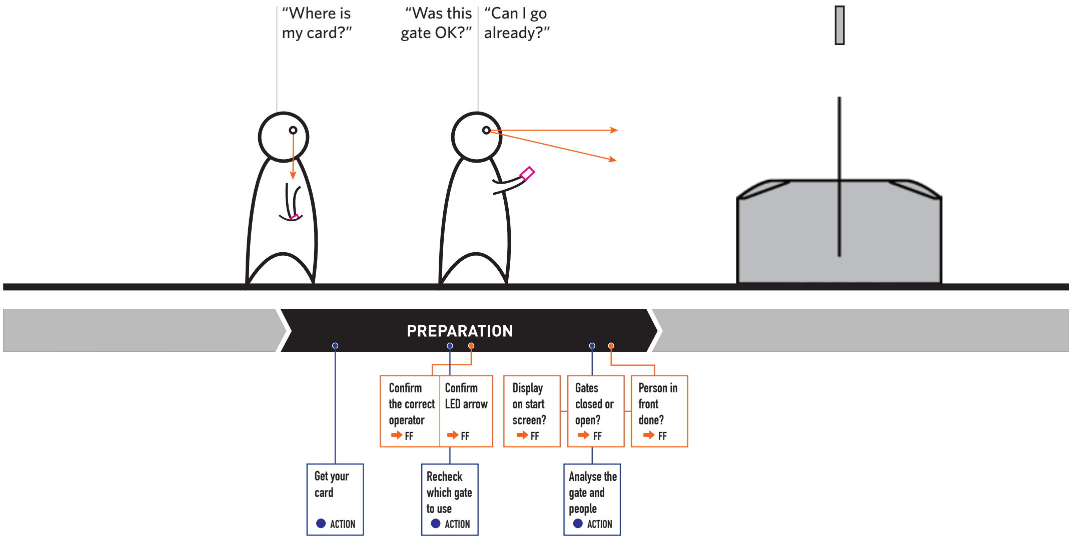


Figure 16. The preparation phase, with several actions (in purple) and feed forward (in orange)

Validation phase

When the user has his ticket ready for validation and the user is confident that everything is in order to validate, the display, OV-hand icon on the validator, the colour of the 'head', the shape of the 'head' and the light of the validator give the user signals where to validate (Figure 17). The user will then press the ticket on the validator, and the gate gives feedback on the validation: a beep sound will be heard, the display will show a different screen, and the door opens. The user now knows the validation worked.

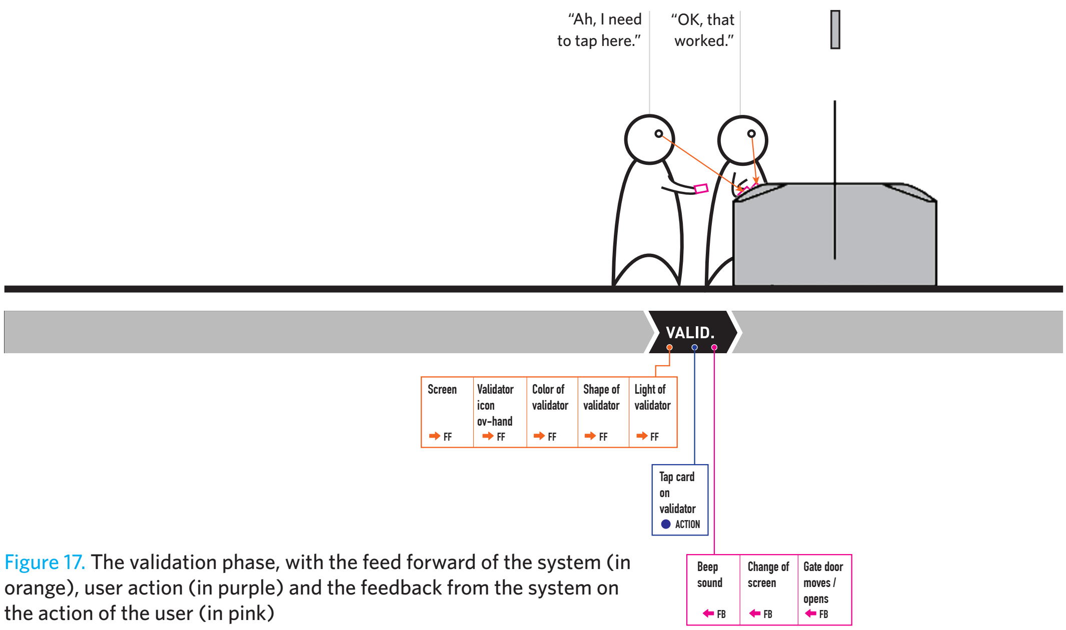


Figure 17. The validation phase, with the feed forward of the system (in orange), user action (in purple) and the feedback from the system on the action of the user (in pink)

Information phase

After the validation is a success, the user can read the information on the screen and continue walking through the gate (Figure 18). After the user has passed, the display returns to the default screen and the doors close again. The user puts the ticket back into his pocket and continues his journey.

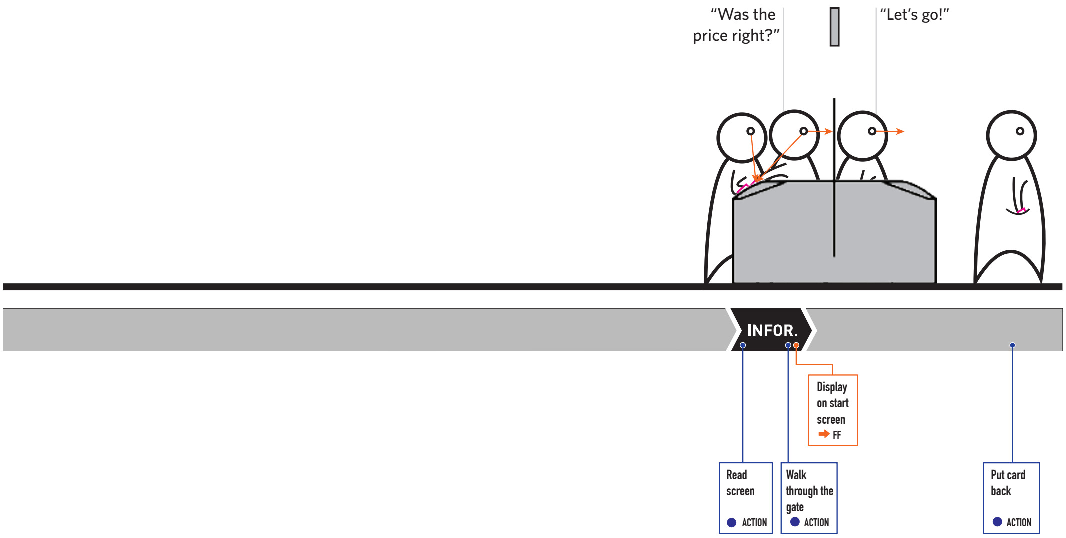


Figure 18. The information phase, with several actions (in purple) and feed forward (in orange)

During the walk flow, the traveller interacts with many aspects of the closed payment border. The previously illustrated flows show a use without making mistakes, which could and would disrupt the flow even further. Chapter 4.3 will describe these aspects in more detail.

4.2.2 Decision making

Users of the public transport system have many choices during their journey starting from outside the station all the way until they reach the platform and thus their travel mode. Figure 19 shows a decision diagram, which illustrates the many questions travellers need to ask themselves (shown on the left side) before they will proceed to the next touchpoint. The shown diagram illustrates all the choices travellers have when they approach a train or metro station, with possibly multiple modalities and/or operators. The blue part in the diagram shows the decisions travellers have around the closed payment border.

Travellers are faced with (too) many choices and, consequently, can make many mistakes while interacting with the system. For instance, travellers that want to take the train should use the gates from the train operator (NS), but can (depending on the payment method they use) also use the gates from another modality or operator that is present in the station. Another example is that travellers with QR-codes can only use the gates with a QR-code reader, which not all validators have.

4.2.3 User groups

A good understanding of who the users are is required in order to study them. Generally, every person who interacts with the closed payment border, such as a traveller, a service employee, a maintenance employee or other can be considered as a user. Studying the usage of each of those user groups requires a different approach. Since the focus of this analysis is to improve the usability and flow of the closed payment border, the user is defined as those who use the closed payment border for travelling. The focus is on the front-end user, who uses the closed payment border to check-in or check-out (see Figure 20).

The user group is very broad and usage varies between sub-groups. In order to analyse the usage of the user groups better and to be able to focus on specific sub-groups, the broad group of 'travellers' needs to be further divided. User groups are often based on socio-demographic aspects, such as age, income or education. However, this discrimination is not relevant for studying the users of the closed payment border. More relevant discriminators seem to be how often travellers use public transport (travel frequency), how familiar they are with a station they are visiting, the level of understanding of the difference between public transport operators in the Netherlands, and the physical and mental abilities.

Travel behaviour

- Frequency of use. This can vary from once a year to multiple times a week.
- Familiarity with stations. Is the user travelling from or to the same station every time?

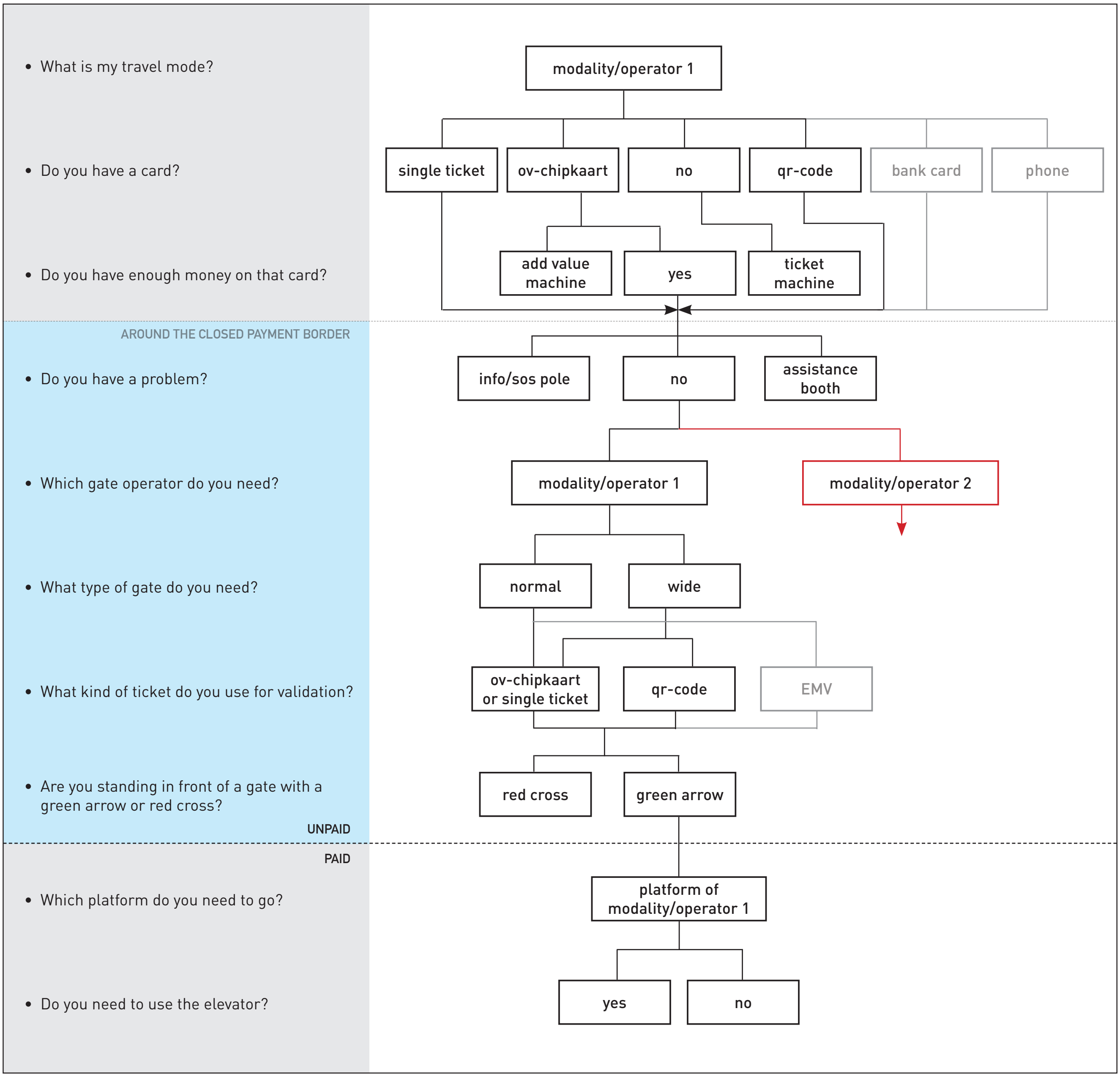


Figure 19. A decision diagram for travellers in a station, showing the questions travellers have (left side) and the choices that are given to them (right side) around the use of the closed payment border

User properties

- Physical and/or mental handicap, most prominently language barriers and the use of wheelchairs, strollers, bags and bikes.
- Knowledge of the different operators and its tickets.

Combining these factors led to multiple user groups, which can roughly be put under two main user groups in terms usage of the closed payment border: infrequent & frequent travellers. Since there is a bit of a gray area between these groups, it can best be illustrated in a matrix (Figure 21).

Infrequent travellers

These users are travelling very infrequently and are often not familiar with stations. These travellers are the incidental travellers and tourists, whom often arrive at a station they are not familiar with. Moreover, tourists might have little knowledge of the system and the language and the difference in public transport companies often forms a barrier.

Frequent travellers

These travellers are, for instance, the daily commuters. They travel several times a week from home to work and back in a fixed pattern while using the same station, modality and platform. These users are experienced on their common route and know how to use the closed payment border because they pass it many times. This also benefits their usage of closed payment borders in stations they are not familiar with.

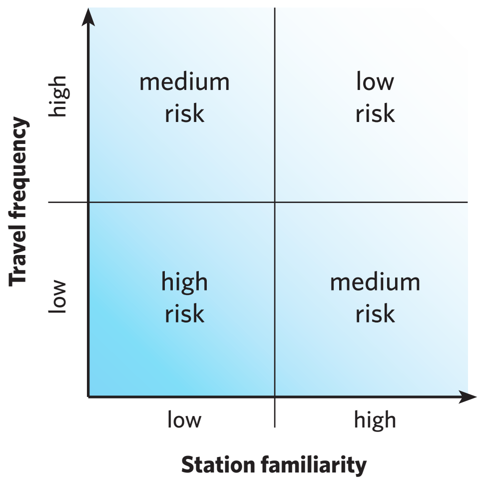


Figure 21. Traveller aspects (travel frequency and station familiarity) and the probable risk they have to encounter issues

Figure 20. Travellers using the closed payment border

4.2.4 Interaction levels

Based on the statement cards (see 4.1.4), similar problems were clustered into problem areas. These areas differ on which level the user interacts with the closed payment border. Four levels of interaction with the closed payment border can be identified (as illustrated in Figure 22):

- UI (level 1)
- Gate (level 2)
- Gateline (level 3)
- Environment (level 4)

Users of the closed payment border encountered different problems on each level they interact with. Some of the problem areas overlap multiple interaction levels; some are specific for one interaction level. We specify 'UI' as the aspects of the closed payment border where the user closely interacts with, namely during validation and information gathering: the head (validator and screen) on the cabinet.

In order to clearly communicate on which interaction level the user encounters a problem with the closed payment border, a small list of the problem areas with their corresponding interaction levels is given below. Next, all problem areas will be elaborated in detail.

Table 2. The problem areas of the closed payment border and their corresponding interaction levels

Problem area	*Interaction level(s)*			
Walk flow	UI	Gate	Gateline	Environm.
Assistance	UI			Environm.
Difference in operators		Gate	Gateline	
Finding the correct gate			Gateline	
Validation	UI	Gate		
Gate settings		Gate		

Figure 22. Interaction with closed payment borders takes place on four levels: 1) user interface, 2) gate, 3) gateline and 4) environment


GATE
UI
MM
Lift
ov-chipkaart
GVB
Tickets &
metro

4.3 USAGE ISSUES

Several usage issues were found through the data collection. Whereas the vast majority of the users studied in the observations did not encounter severe usability problems, the analysis focuses on the users that did encounter problems.

4.3.1 Walk flow

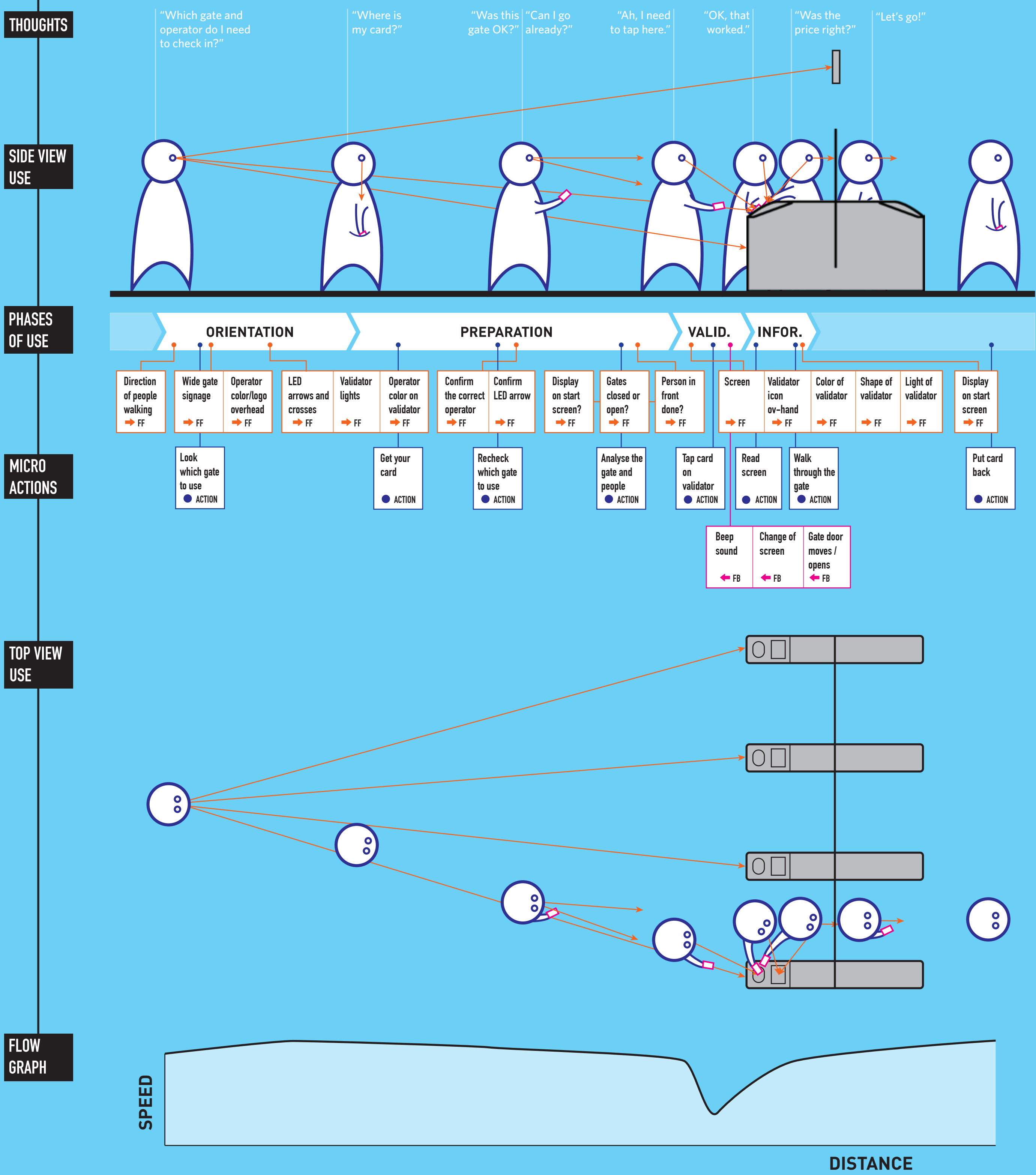
For an ideal flow through the closed payment border, it is beneficial to maintain a constant walking speed and thus not to stall or stand still. As can be seen in the flow graph (Figure 24), there is a significant drop in speed of the travellers when they flow through the closed payment border; this drop is around the validation and information phases. The gate has both validation and information at nearly the same place, namely the front of the gate. This means that many micro actions need to happen in a short time/distance span, which makes the user slow down. Furthermore, many frequent travellers hold the ticket on the validator while moving forward, often quickly or not at all checking the screen. This movement makes the body to be further than the hand with the ticket, which is still on the validator, because the validation takes longer than the speed with which the traveller wants to go through the gate (see Figure 23).

Figure 23. Observing travellers moving through the closed payment border. Notice how travellers hold their card on the validator while moving and where their body is positioned while looking at the display

▶ Figure 24.
The graphical representation of a frequent traveller's walk flow when moving through a gateline. From top to bottom it shows the usage goals and/or cognitive processes, the user with the direction of attention, the four phases of use, the micro actions that users perform along the phases of use (feed forward in orange, user actions in purple and feedback in pink), a top view of the walk flow and a graph showing the user's walking speed over distance

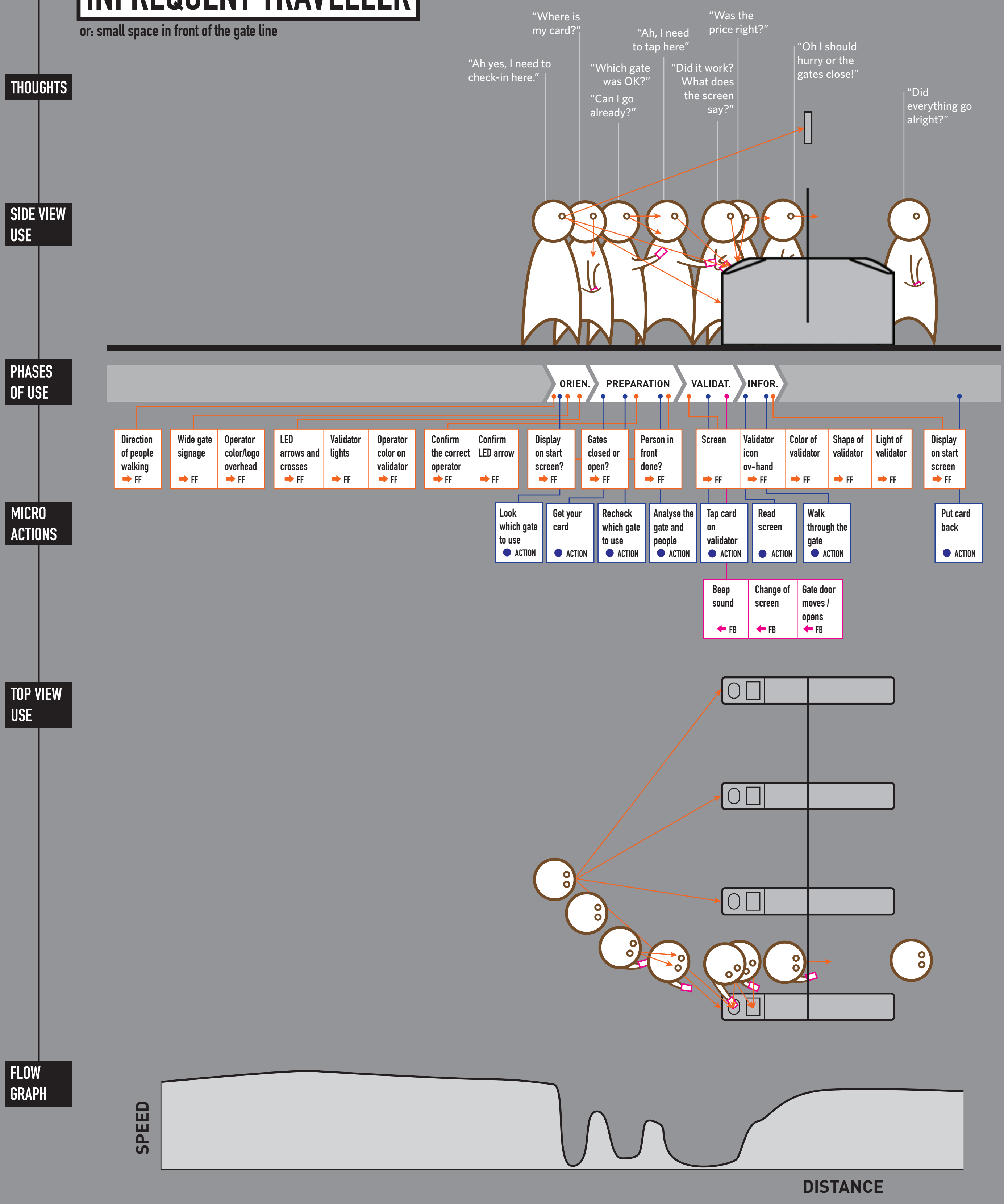
FREQUENT TRAVELLER

or: large space in front of the gate line



INFREQUENT TRAVELLER

or: small space in front of the gate line



The walk flow when approaching the gateline is also often disrupted by people moving in the opposite direction. When gate directions are set with gatelines having mixed directions (e.g. 3 gates inwards, 2 gates outwards, 2 gates inwards, 3 gates outwards, in the gateline), streams of people will cross each other and this significantly disrupts the flow. Moreover, the feed forward in the orientation and preparation phases are less clearly visible for the user; this means that travellers cannot, for instance, see the difference in the gates of the operators or find a gate with a green arrow directly. This also applies when people moving through the station walk parallel to the gateline.

The flow of movement as described before seems to take place generally when there is a large space in front of the gateline. In some stations, however, there is less space in front of the gateline and thus the approach will be shorter. In this case, the phases of use and the according micro actions need to be performed in a shorter distance, which negatively impacts the flow. In this case we see a walk flow pattern comparable to that of travellers who are inexperienced payment border users, as can be seen in Figure 25.

From observations it became clear that, when approaching the gateline, some users started the orientation phase much later (and thus closer to the closed payment border). Whereas the frequent travellers sometimes skip some micro actions, such as gate confirmation, reading of the screen and behaviour depending on the person in front, infrequent travellers perform them more thorough and obviously. Another difference is the validation and information phase, where infrequent travellers often come to a complete halt when validating and, subsequently, take their time reading the information on the screen before moving through the (almost closing) gates. 1,2

4.3.2 Problem solving

When a traveller has trouble going through a gate, assistance can be acquired by using the info-pole next to the gateline or by asking station staff often situated in a booth somewhere in the unpaid area (e.g. station Delft) and/or sometimes in the paid area (e.g. station Leiden Centraal). In some unmanned stations (e.g. station Amsterdam Holendrecht) however, no personal assistance is offered and only the info-poles are installed on both sides of every gateline.

The pattern put forward in the model in chapter 2.3, on how people deal with problems with a gateline, has been observed in this research as well. The model states that the encountered problem is either solved or postponed. In the domain of the closed payment border, this generally means either a service employee has helped or the info-pole has been used, or the problem has been postponed by not using the gates at all, jumping the gates or tailgating another traveller.

Figure 25. The graphical representation of an infrequent traveller's walk flow when moving through a gateline

Figure 26 shows the interaction with the closed payment border and the feedback the gate can give, depending on the info the screen will display. The yellow lines represent the user's actions after the yellow screens (e.g. try again, or not enough money) and the red lines represent the user's actions after the red screens (e.g. check-in not possible) on the display that can be shown after validation. Because the personal assistance and the info-pole are sometimes not sufficient for the travellers (not available or they do not notice it being there), users see tailgating or jumping over the gates as the unwanted but necessary and quickest option to solve their issue.

The types of problems that travellers run into which they need to solve vary. Often travellers have special (e.g. international) tickets that the gate cannot read and they can thus not continue through. Travellers sometimes get presented with a display screen that tells them their OV-chipkaart does not work on the gate they try to use. From the analysis of the OV Loket complaints, travellers also struggled with the fact that gates did not open after validation and that there was nobody to help these travellers open the (rightfully paid for) gate.

The info-pole should help all travellers with their problems they have, but the travellers with problems regularly overlook that possibility. They conclude that they can either not find station staff or it is somewhere they cannot reach. From observations and analysing the complaints, it showed that this results in travellers having to jump over the gates or tailgate someone. A feeling of fear of being locked in has sometimes been named in some of the complaints.

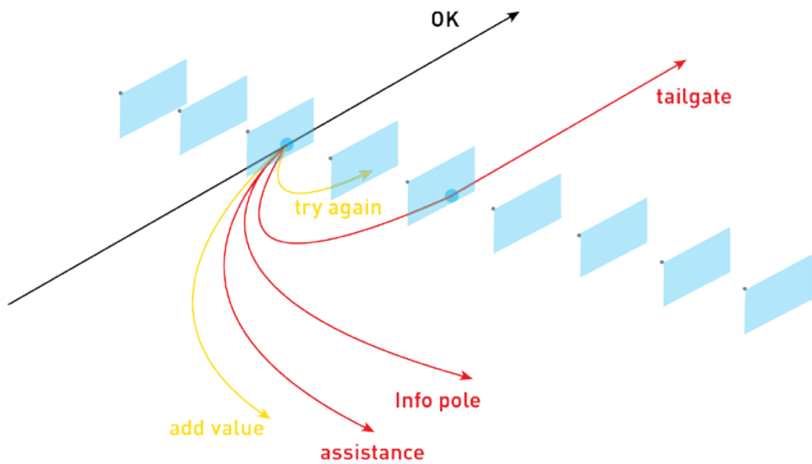


Figure 26. The interactions a traveller can have with the closed payment border. The yellow arrows show the user's actions after the gate shows a yellow screen, and the red arrows represent the user's actions after a red screen. The gates are illustrated in blue

Some problems are not directly related to the closed payment border, but can become reasons for travellers to have to look for problem solving solutions. For instance, some travellers use the transfer poles on the platform to check-out, and then realise there are gates downstairs where they had to validate. Travellers want to go through the gates without paying the flat fee of only check-out and having to either go through and claim it back later or ask the info-pole to open the gate for them. Moreover, people with small children ventilate their desire to go through the gate with everyone at the same time while all tickets are being validated, instead of having the children going through one-by-one and having them unsupervised on the other side of the gateline. Furthermore, some travellers are by times observed having issues with their validation at the gate and seemingly confused about what to do next. Also, the feeling of safety is currently often not endorsed when no personnel has authority over the gateline, which lowers the threshold for travellers to do something illegal (tailgating or jumping the gates). Travellers experience unsafety regarding fare evaders because of the lack of personnel to enforce the rules around the gateline.

"Obvious fare evaders, who (...) cause a new problem, at the absence of supervision: intimidating travellers."

OV Loket complaint 16

4.3.3 Difference in operators

Stations in the Netherlands can have multiple public transport operators, like the GVB (metro) and NS (train) at station Amsterdam Amstel or BrengArriva (train) and NS (train) at station Arnhem. These different operators will have their own validators and the travellers need to validate at the correct gate to indicate the public transport operator they will use. In some stations, the gatelines of the different operators are separate within the station (e.g. station Amsterdam Bijlmer ArenA). However, in some stations (like Amsterdam Amstel and Arnhem) a single gateline will consist of gates of multiple operators. These gates will differ in the colour of the 'head', the stickers on the doors and the overhead signage with colours and logos of the operators. Travellers are required to use the gate of the operator they will use (check-in) or have used (check-out), but this regularly causes confusion and mistakes. The closed payment border system does not combat travellers to check-out at the gates of the operator of which they did not check-in with. This would bring the traveller a lot of unnecessary costs.

"It is clumsy that there are two types of gates, which are nearly identical, and it is poorly indicated."

OV Loket complaint 4

"The situation at the check-in and out on station Amsterdam Amstel is confusing. It is not clearly marked on the gates to which operator is belongs."

OV Loket complaint 9


trein
trein
trein
Stationsplein
ArenA

Figure 27. A gateline at station Duivendrecht with gates from two operators: the GVB (metro) and NS (train)

The complaints and interviewees indicate that users often do not see the difference between the gates of the operators and mistakenly use the wrong gate. Complaints are also made that the different operators are poorly indicated on the gates. The overhead signage, with the various operators on it, gave a more positive response with travellers when there is a large space before the gateline and travellers can clearly notice the colours and logos on the illuminated signage (station Arnhem). In Amsterdam Amstel station signage is used which is not illuminated and the space in front is less large, which results in the many wrong check-outs that are being recorded every day.

"This feels very unjust because I visibly did had checked-in, but apparently at the wrong transport operator.

OV Loket complaint 60

It has repeatedly been observed that tourists try to use one operator's ticket on a different operator's gate, which leaves them confused why the gates do not open. For them, the current state of operator denotations is insufficient for a pleasant use of the closed payment border. Moreover, stalling tourists near the gateline does not benefit the flow of other travellers. 3

4.3.4 Finding the correct gate

When a traveller approaches the gateline, the correct gate needs to be found to go through. Dutch closed payment borders have ingoing, outgoing and bi-directional gates. As described in the walk flow (chapter 4.2.1), travellers scan the gateline for the red crosses and green arrows on the front of the gates to see which one they can use.

Using a gate with a red cross

Whereas many travellers flow to a gate with a green arrow directly, some users try to validate at a gate that shows the red LED cross on the front (see Figure 28). It is only after trying to validate that they find out the gate cannot be used from the side they are on. Subsequently, a particular behaviour occurs: the traveller moves to the gate to the right, tries to validate, and gets rejected again. This procedure might repeat several times before the user takes a step back, notices a gate that is valid for validation and proceeds there. Travellers notice this either on the movement of other travellers or after seeing the green arrows. The behaviour of trying to validate at an incorrect gate tends to occur more often when travellers approach from the side of the gateline (walking parallel), when there is only a small space in front of the gateline, or when they are standing close to the gate. Since the signifier for the correct gate is fairly low on the front of the gate and the display does not signal enough, travellers tend to miss this and proceed to a trial-and-error validation method. 4,5,6,7

Figure 28. A traveller uses a gate with a red cross

Bi-directional gates

Gates in a bi-directional setting can accept travellers validating from either side of the gateline. When a traveller validates, the other side is briefly unable to accept validation. The green arrow changing to a red cross and the display showing a different screen than the default screen indicates this. These gates are often placed on the outer sides of the gateline, resulting in a mix of opposite traveller walking streams. Moreover, the bi-directional setting is a smasher for a good flow through the closed payment border; it forces users to wait for the traveller on the opposite side to validate and go through the gate. A race of 'who can reach the validator first' ensues between the two travellers on both sides. When it is busy, the wait can be annoyingly long due to the stream of continuous people validating after each other. This forces travellers to divert, last minute, to the gate(s) next to the bi-directional gate, which in turn disrupts the flow of the person behind the traveller who had aimed to use that gate (see Figure 29). 8,9

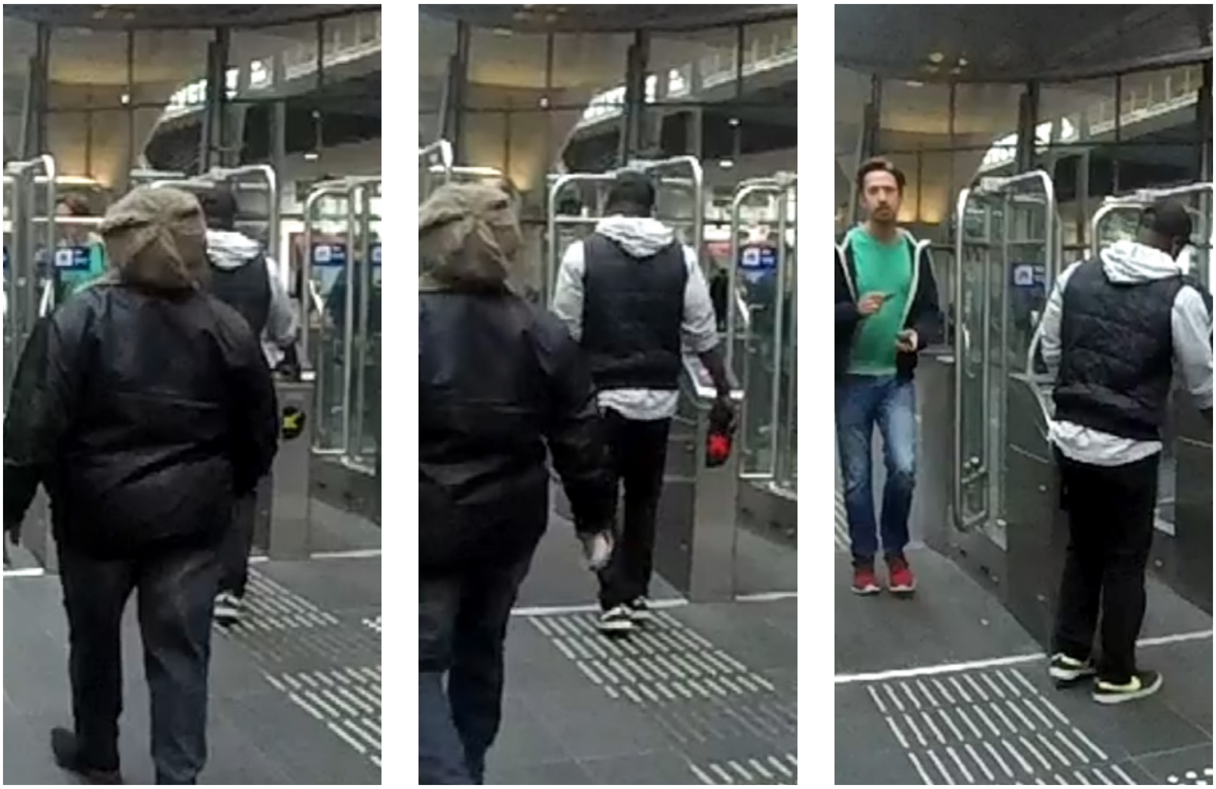


Figure 29. A traveller experiences the problem with the bi-directional setting: he approaches a gate with a green arrow, the gate turns to a red cross just before validation because of a user on the other side, and the traveller diverts to another gate

Gateline visibility

Travellers can find themselves engulfed in a stream of people exiting a metro or train onto the gateline. In such cases travellers often follow other users to find the correct gate to go through, whilst manoeuvring through oncoming travellers from the opposite direction. Furthermore, feed forward used for choosing the correct gate is obstructed by the people in front of the traveller and often forces them to make changes to their walking trajectory in a last minute fashion. The flow of a proper throughput of travellers through the closed payment border is severely affected by the mixed walking directions and the lack of visibility for choosing the correct gate. 10,11

4.3.5 Validation

The validation process starts when the traveller has reached the validator and has readied the ticket. As described in the walk flow (chapter 4.3.1), there is a lot of feed forward for the traveller on what and where the validator is on the gate and the feedback the traveller gets after tapping the ticket on the validator.

Finding the validator

Some travellers have trouble finding the place on the gate where they should validate their ticket to open the gate doors. As an assistance person, standing next to a metro gateline all day to help travellers, points out: a few travellers, mostly infrequent ones, tend to tap their ticket everywhere but the validator, like at the green LED arrow on the front of the gate. Moreover, some travellers tap their ticket on the display before they try the validator. In one particular

Figure 30. The visibility of the gateline when it is busy is very limited


Uitgang
Trein

“But it also happens that the card is placed here. The card goes everywhere except here.”

GVB employee, station Amsterdam Bijlmer

case it has been observed that a traveller tried to check-out by tapping the ticket on the screen, getting no response from the gate and moving to another gate at the right side several times. Ultimately, the traveller reached the wide gate on the far right side, which has a QR-code validator with lights. At this gate, the user directly tapped the card on the validator, in contrast to the previous gates with a different (non-light) validator. This traveller uses the feed forward of the lights of the validator to identify where the validator is. 12

Validating on the left side of the gate

The validator on the right side of the gate doors should be used to open them. However, travellers regularly attempt to move through the doors in front of them after validating at the validator on their left side. This prompts the doors on the left side gate to open and the users must rush to go through there after they realise what happened and noticed the gate doors in front of them did not open. Most travellers still make it through before the doors close, but some do not and are left puzzled what happened (see Figure 31). These events are evident for the fact that the place of the validator does not communicate the corresponding gate doors correctly to the user. The design of the current gate has too few aspects that show the user which gate they are using, mostly by having the ‘head’ in the middle between two sets of gate doors. 13,14

Figure 31. Two guys validating at the left side validator (left image), opening the wrong gate doors (middle image) and are confused what happened, with one of the guys still at the other side (right image)

Gate refresh

In order to maintain a high throughput of the closed payment border, travellers can validate while the state of the gate is still affected by the user in front. More specifically: validation can start even though the doors are still open and the display still shows the screen with the information of the previous validation. Many frequent travellers know this fact and validate in rapid succession, sometimes only knowing the validation is correct by hearing the 'beep' feedback since the screen has no change by showing the same as the person in front and the doors remain open. This minimal feedback is often perceived as insufficient, giving the travellers a feeling of insecurity whether or not the validation was a success. In contrast, a few travellers wait in front of the gate until the doors have closed and the display has returned to the default screen before starting the validation process. This has a negative effect on the flow and throughput of the gates. 15,16

"Everything around me beeps, I walk through the gate. BAM! The gate closes while I'm standing inside. I take a serious blow, feel like a criminal and am thereby not checked out."

OV Loket complaint 35

"Because it is busy, it is completely unclear if you have checked out. Meanwhile I already get nervous when I see those aggressive gates.

OV Loket complaint 35

"They keep looking, the doors open, then they look back at their thing, and before you know it the doors are closed again. You see that a lot as well."

GVB employee, station Amsterdam Bijlmer

Check-in at the check-out side

Another aspect of the Dutch closed payment border is the dedicated in- and out-check side. There have been complaints of travellers accidentally checking in at the check-out side, which costs them a significant flat fee and does not actually check them in as they intended. This occurs mostly when the gateline still has open doors or when travellers have embarked on a station with an open payment border, forgot to check-in, want to check-in at the nearest stop at a station, only to find gates where they can only validate at the check-out side. Users sometimes think both sides of the gate can be used to check-in, which might be evident to the claim that there is not enough differentiation between the two sides to help travellers recognize this.

4.3.6 Gate settings and sensors

In the current settings of the gate, the doors will close after a certain amount of time even if the traveller has not passed yet. The sensors in the sides of the gates will detect users to prevent misuse like tailgating by closing the doors and sounding a beeping alarm sound. However, the gates seem to fail to be able to notice that the traveller, who has validated and is legitimized for a passage through the gates, has not passed yet and thus should have no reason to close yet. As the assistance person standing next to a metro gateline points out: some travellers wait too long in front of the validator/screen after validating and the doors close, which forces the traveller to be helped by opening the doors for them again. Moreover, several travellers complain and have been observed that they have gotten stuck between the doors with their bike or luggage. More often, doors hit travellers even though they were confident they had checked in. It can be concluded that the sensors in the gates can react better on the traveller using the gate, and the doors should move accordingly. 17

"I don't know if this is because of a broken sensor or that the gate reacts slowly, but it gives a particularly inhospitable feeling."

OV Loket complaint 31

"Several family members just got stuck with their bike. Also when they had luggage, the gates closed again. It really becomes too crazy."

OV Loket complaint 28

4.4 USABILITY SEVERITY ASSESSMENT

Even though this project aims to solve all usability problems found in this study, it is beneficial to see which problems have higher priority to be solved than others. To determine the severity of a usability problem, one has to assess (Nielsen, 1995):

Impact: is the problem easy or difficult to overcome for the user?
Frequency: is the problem a common or rare occurrence among users?
Persistency: is the problem a one-time or repeated problem for a user?

Table 3: Usability area severity assessment: impact (y-axis) vs. frequency (x-axis). Colour-coded persistency level: low (light blue), medium (blue), and high (dark blue).

High impact	Check-in at check-out side	Validating left side validator	Difference in operators
	Problem solving	Gate settings & sensors	
Medium impact			
Low impact	Using a gate with a red cross	Gateline visibility	Walk flow
		Gate refresh	
	Finding the validator	Bi-directional gates	
	Low frequency	*Medium frequency*	*High frequency*

For instance, the problem that travellers check-in or out at the gates of the wrong operator happens quite frequently among all users, it sometimes overcomes the same user multiple times, and it is very difficult for the user to overcome due to, for example, the monetary hassle afterwards.

4.5 CONCLUSIONS

In this chapter, the usage of the closed payment border in the Dutch public transport system has been analysed through the means of observations, interviews and analysing complaints, and the users, usage patterns, and usability problems encountered have been addressed.

Several aspects of the closed payment border contribute to suboptimal interaction and flow.

- The place of the validator and screen are situated on the front of the gate, which affects the walking flow by forcing many actions performed by the user in a short time and thereby slowing the walking speed down. Moreover, having a small space when approaching the gateline gives the travellers less time to orientate and prepare, further slowing their flow.
- Assistance near the gateline seems insufficient to cater to the travellers' needs, which sometimes makes them feel compelled to jump the gate or tailgate another traveller.
- Travellers have problems with the differentiation between the gates of various operators in the gateline. The gates have too few differentiating aspects to prevent users from accidentally using the incorrect gate, and subsequently lose a lot of money. Enlightened overhead signage with the logos and colours of the operators in a spacious setting seem to be a positive aspect.
- Finding the right gate to use proves to be a hassle for some travellers. The bi-directional setting diminishes a proper the walk flow by making travellers stop in front of gates and changing gates at the last moment. Moreover, it enforces a mix of walking streams that intertwine with each other, which further obstructs the flow. The green arrows and red crosses lowly on the front of the gates are sometimes overlooked and when there are large masses of travellers, they draw a complete blank as to which gate they can take because these signifiers cannot be seen.
- Travellers sometimes validate on the wrong validator because it is insufficiently clear which validator belongs to which gate doors. Moreover, an enlightened validator seems to better communicate the location of the validator.
- The current settings of the sensors in the gates cannot cope with the behaviour of several travellers. The doors close even though no person went through the gate and travellers get stuck between the doors or get hit by the doors after being confident they had checked in.

In the next chapter, international examples of closed payment borders will be analysed to gain knowledge into the behaviour of the local travellers and how they use their system. This provides insights into how other closed payment border systems cope with similar problems that had been found in the Dutch system. Afterwards, a comparison is made and it is explored how the Dutch system can be improved even more.

5

Hatchobori Station, Tokyo, Japan - train

5. Studying international examples of closed payment borders

In the previous chapter, the usage of the Dutch closed payment border was analysed. In this chapter, international examples of closed payment borders are researched in order to gain insights into their workings and what kind of patterns of use the local travellers have. Moreover, this generates insights into how other closed payment border systems cope with the problems identified in the Dutch system.

Three places were visited to do research: London (United Kingdom), Hong Kong, and Tokyo (Japan). These places were selected based on preliminary research on the internet, keeping in mind several criteria: the system needs to have an electronic ticketing option, the system needs to be gated, the amount of different kinds of gates, the amount of differentiation to the gates in the Dutch system, maturity of the gated and electronic payment system, language barriers and possibility to speak with people of the companies behind the systems.

In November 2015, London (4 days), Hong Kong (5 days) and Tokyo (7 days) were visited.

5.1 METHOD

5.1.1 Aim

The aim of the research in London, Hong Kong and Tokyo is to gain an understanding of the contexts of the closed payment borders. Furthermore, it is aimed to discover and understand how local travellers interact with and experience their respective closed payment borders. It is important to find out what happens around the closed payment border, what the underlying causes are, and what the consequences are for travellers. Ultimately this research aims to create a comparison of closed payment border systems.

5.1.2 Research questions

Research questions for the research in the international examples are similar to the ones used in the Dutch context, due to the comparative nature of this research.

- What is the context of use of the closed payment borders in London, Hong Kong and Tokyo?
- How do travellers interact with and experience these closed payment borders?
- What are the elements of the closed payment borders that users interact with?
- How do gates perform in different states (e.g. peak, low, emergency, two way)?

5.1.3 Data collection

Data collection was done in a similar fashion as when studying the Dutch system. Observations at train and metro stations were done to investigate what travellers are doing when using a closed payment border. Interviews in context were conducted in order to gain insights on what people think about using a closed payment border. Moreover, the researcher's personal travel experiences and meetings with relevant experts helped to give an understanding of the public transport closed payment border system.

Figure 32. An interviewee in Tokyo

Personal experience

Due to the researcher's unfamiliarity with the closed payment borders and the public transport systems of the previously mentioned international examples, the personal experience of the researcher has also been a method of qualitative data collection. The researcher has direct contact with and gets close to the people, situation and phenomenon under study; the researcher's personal experiences and insights are an important part of the inquiry and critical to understanding the closed payment border and public transport system (Patton 2002, p40).

Figure 33. Personal experiences are recorded on camera

Expert interviews

Interviews with relevant people in the industry of the aforementioned locations were conducted to gain more insights into the context and considerations around the closed payment borders. In London, an interview was conducted with a 'Service Delivery Manager' from Transport for London who provided a general overview of the transport system and the context of the closed payment border. In Hong Kong an interview was conducted with an 'Engineering Planning Manager' from MTR Corporation who provided a general overview of the transport system and how they manage and decide the layout of new stations. Furthermore, an interview was conducted with people from Octopus (General Manager, Sales and Marketing department) about how Octopus works and what it can do outside of the public transport domain.

5.1.4 Data analysis

Data analysis was performed similarly to the data analysis of the Dutch system. The results of the observations, interviews, and personal experiences are clustered into problem areas of the closed payment border. In order to be able to make a comparison later on (chapter 6), findings from the international examples, clustered into the same problem areas as found in the Dutch system, comprise from both negative and positive aspects of the closed payment borders in the respective systems. This was done using statement cards (see chapter 4.1.3), with a different colour for each country (e.g. blue for London, green for Tokyo). For an overview of the statement cards of the international examples, see Appendix G, H, and I.

Figure 34. Data analysis with statement cards

5.2 LONDON

5.2.1 Context of use

London has an almost fully gated system within its public transport system. This involves both the Underground and trains. Even though there are many different train operators, gatelines are always situated in such a way that travellers can only get in or out with that operator, and thus do not have the opportunity to use a gate of an operator they did not get in with. According to TfL, half of the travellers have some sort of smart card for e-ticketing, while the other half of the travellers uses pay-as-you-go. Payment possibilities in the London public transport system include the Oyster card, contactless payment (bank card) and mobile payment. Oyster is a smart card which can hold pay as you go credit, and can be used in most of London's public transportation system. For this research, the researcher used the Oyster card to access the gates in the public transport system of London.

The visited stations (see Appendix J) are comprised of both Underground and train stations. Train stations are often large and open buildings (see Figure 35), in contrast to the cramped Underground stations. Subsequently, gatelines in the Underground are sub optimally placed and do not have much space around them. This in contrast to gatelines in train stations, which have a lot of space around them and can be placed more strategically.

Gates in the public transportation system of London come in various models. Older models have large

Figure 35. A gateline for the train in Paddington station


14:3341
5
WARNING
Have you paid?
NetworkRail
Improving the

metal structures and newer models have a more slender shape. In general, closed payment borders in the public transport system of London consist of gates with low paddle-shaped doors that move away from the user when opening, have vertical standing displays on top of the gates (in the middle next to the doors) including the green arrows and red crosses, and have a yellow-coloured validator on top of the gate (see Figure 37). 18

5.2.2 Usage of the closed payment border

Walk flow

Through the observations in the Dutch system the pattern was established that travellers have a certain flow of movement when they approach and go through the closed payment border, either when going from the unpaid area to the paid area or visa versa. From extensively analysing the behaviour of travellers, it became evident that frequent users of the closed payment border tend to follow a certain repertoire of use phases and actions when going through. As Figure 36 illustrates, travellers in London get feed forward in the validation and information phases from elements of the gates, which are apart from each other. Because the travellers interact with the elements of the gate in a successive matter, it can be observed that the walk flow/speed is rarely interrupted. Generally, users validate their card on top of the gate and then move their view to the display in front of them, which is located even higher than the validator. This seems to make the flow of actions, namely validation and information gathering, a smooth process and can be done in a fairly continuous movement. The continuity of flow is also supported by a fast response of doors and validators.

The London Underground has separate in- and outward gatelines, or sometimes attached in one gateline. This in contrast with the gatelines for trains, which have in- and outward gates mixed within the gateline. Generally it can be observed that when gate directions are mixed, travellers not only seem to stand in front of or try to use a 'wrong' direction gate but also interrupt each other's walking pattern due to the walking directions that cross each other. This is greatly improved when the gateline directions are separated, like in the Underground closed payment border. 21,22

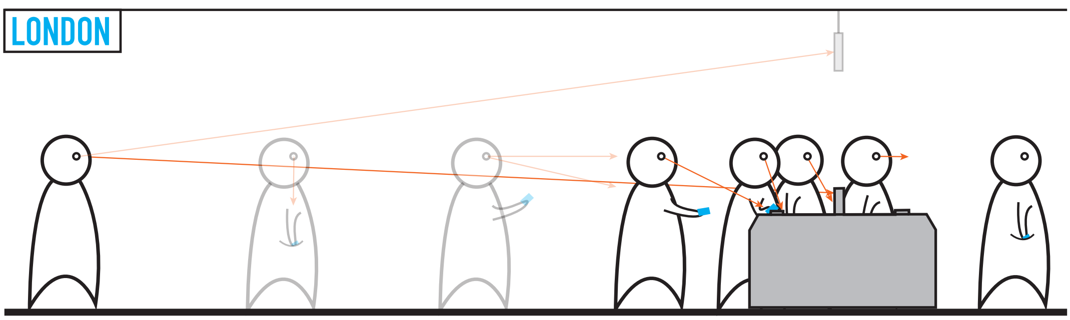


Figure 36. The walk flow of travellers using the closed payment border in London. The orange lines show the attention of the user and the figures show the movement of the user

▸ Figure 37. A person using a gate in London Bridge station

Platforms 1 to 3
WARNING
Have you paid?
1540 West Croydon
via Selhurst
1541 Barnehurst 1 On time
Page 1 of 2 15:21:45
1603 Horsham
via Gatwick Airport
Page 2 of 2 15:21:45
WARNING
Have you paid?
37
38

Problem solving

The London Underground features assistance personnel at every closed payment border in the system (see Figure 38). These people often have an assistance booth in the middle of, or next to, the gateline. Their aim is only to help travellers get through the gates, and thus offer different service than personnel at, for instance, the ticket machines. Whenever a traveller arrives at the gateline and has a problem with his card, the display on the gate will direct this traveller to assistance personnel by saying 'seek assistance'. The assistance personnel will subsequently make sure the traveller gets through the gate. It is impossible to have insufficient funds when exiting the Underground system due to the possibility of a negative balance on the Oyster card, thus assistance personnel main purpose is to help to prevent travellers clogging the gateline. This is observed and experienced as a comfortable, convenient and close-by solution for errors at the gateline. However, as one interviewee mentioned, travellers might not know what the problem was and consequently don't know how they could prevent it the next time.

Several gatelines for train operators have wide gates, which are operated by assistance personnel (see Figure 39). Apart from kindly opening the door and helping travellers (like mothers with children, people with luggage or wheelchair users) going through, they also help other travellers who have questions.

28,29

Figure 38. Assistance personnel in the gateline of the Underground

Figure 39. An assistance person operating the customer assistance gate


Special Notices
Please Check Timetable for Services
Special Notices
Please Check Timetable for Services
Assistance gate
Platforms 3 and 4
Platforms 5 to 7
WARNING
Have you paid?
Customer assistance
Hello Tomorrow
Hello Tomorrow


Platform
Southern
Monarflex
1/3 OFF
Rail Fares
PLATFORMS
1, 2 & 3

Figure 40. Green arrows and red crosses on the overhead signage

Finding the correct gate: bi-directional gates

As mentioned before, Underground gatelines have separated entry and exit gates. This also involves wide gates, which are always one directional and on the edge of the gateline. Train gatelines, however, do have bi-directional gates, such as the previously mentioned 'assistance personnel'-gate. The dedicated directions of the wide gate in the Underground have been observed as effectively preventing travellers from crossing each other and therefore keeping the throughput from being intermittent.

Finding the correct gate: gateline visibility

Travellers in the Underground can often find their way when it is busy due to the overhead signage indicating the metro line they will enter. Since the entry and exit gates are separated in the gateline, this signage is a clear indication to where the traveller should go. Overhead green arrows and red crosses have been installed in one visited train station (see Figure 40). Each gate has a corresponding arrow or cross above it. This gives travellers such feed forward that they seem to choose the gate they will use from a large distance, even when it would be busy. 34

Validation: finding the validator

The validators used in the public transport system in London have a cylindrical shape with a slight angle towards the gate entrance, and have a recognizable yellow colour with a black edge (see Figure 41). This is very contrasting with the metal/grey colours of the rest of the gate, and no travellers have been observed being unable to directly find the validator when trying to check-in or out.

Validation: gate refresh

The previously mentioned validators have a small LED light above it, indicating orange (default / ready to validate), green (validation success) and red (validation fail or the use of a paper ticket). With this LED light, travellers get feed forward that the validator is ready to facilitate a validation even though the display might still show the previous traveller's information and the doors could still be open. From the observations it can be concluded that travellers look at the LED light before starting the validation process and travellers proceed to validate rapidly after each other. None of the travellers have been observed stalling in front of a gate and waiting for the doors to close and the display to be black again. 40

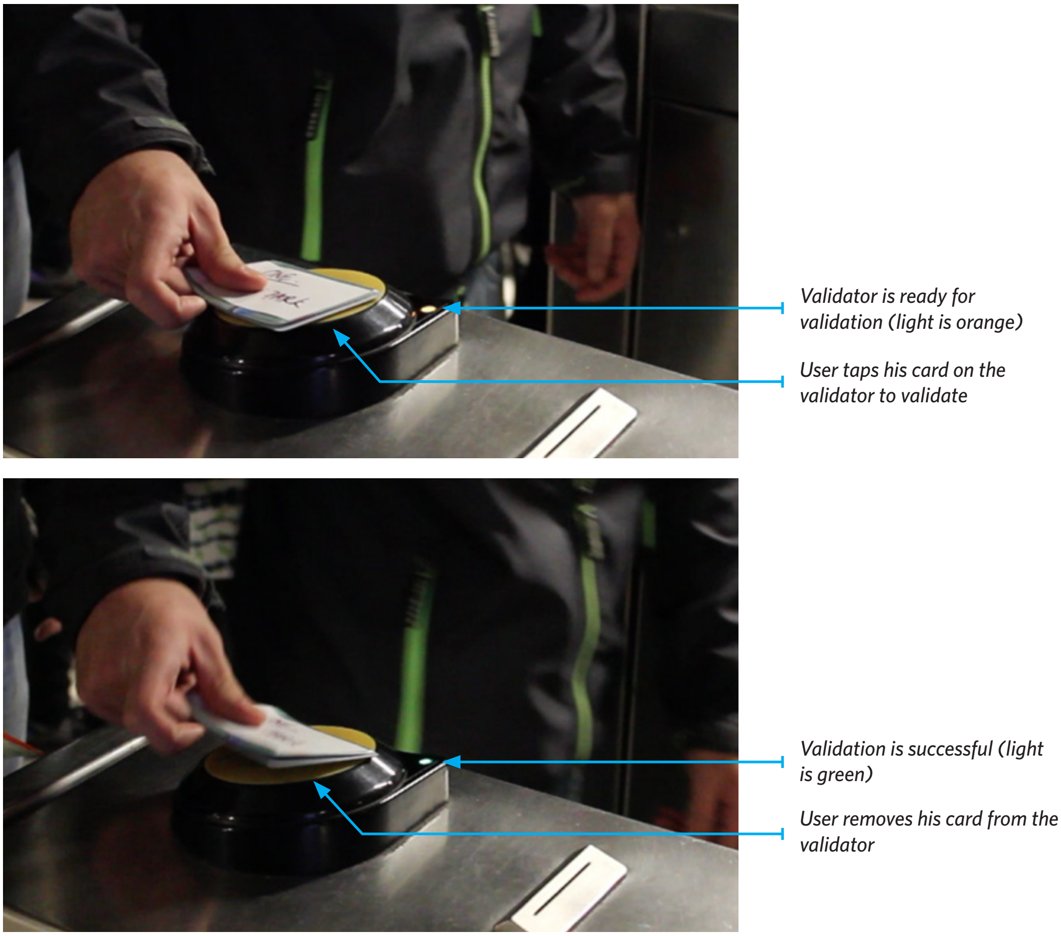


Figure 41. The LED on the validator shows orange when validation can be done, and green when it was successful

Victoria station - Underground

5.3 HONG KONG

5.3.1 Context of use

In Hong Kong, the fully gated metro system (MTR) has been visited. Only one operator operates this metro system (the MTR Corporation Limited) and it is therefore not possible to have check-in or out issues with gates from multiple operators. The Octopus card, a smart card that can hold credit, is the main method of payment for travellers of the MTR and was also used by the researcher when using the gates in the MTR. Other validation options are smart watches, phones and QR-codes.

The metro stations (see Appendix J for visited stations) are often very large and the buildings comprise of the train tracks on the lowest level, walkways and concourse with the closed payment border on the level above (ground or underground level) and sometimes retail and offices on the level(s) above that. There is plentiful space around the closed payment borders.

There are several different models of gates in the metro system in Hong Kong. The majority of the gate types have turnstiles. Some gates, such as wide gates and the gates in new stations, have doors that come out of the gate to block the passage (see Figure 42, right side). The turnstile gates are large metal boxes with the turnstiles in the middle of the gate, have an arrow/cross on the front, and have the display and validator on top of the gate. The validator is a square-sized yellow block located more towards the front of the gate, whereas the display is located around the middle of the gate. This display is angled upwards. Turnstile gates with the same features are also present in a much shorter/compact form.

Figure 42. A gateline for the MTR


升降機
Lift
優先使用 Priority

Newer stations (e.g. on the Island Line) utilize a new model gate, which has a blue top and white sides, with red doors (see Figure 44 & 45). This gate has a validator that is flat on the top of the gate towards the front side, shown by the shape/logo of the Octopus card. The display is in the middle on top of the gate, angled upwards. These gates solve one problem that MTR had with the turnstile gates: the 'customer service' of allowing travellers with, for instance, baggage easy access to the system. 19

5.3.2 Usage of the closed payment border

Walk flow

For analysing the usage pattern of the walk flow, the newest model gate has been used for illustration. However, due to the positioning of the validator and screen on the turnstile gates, a near identical walk flow can be found with the old turnstile gates. As Figure 43 illustrates, travellers in Hong Kong get feed forward in the validation and information phases from the validator and screen on the gates, which have some distance between each other. Because of this distance between the validator and display, travellers interact with the elements of the gate in a successive matter and the walk flow/speed seems to be rarely interrupted. Generally, users validate their card on top of the gate, at the Octopus card symbol, and then move their view to the display in front of them. Moreover, travellers get extra feedback from the gate by light on the insides of the gate (as a confirmation of validation). This seems to make the flow of actions, namely validation and information gathering, a smooth process and can be done in a fairly continuous movement. The continuity of flow is also supported by a fast response of doors and validators.

Furthermore, because inward and outward gatelines are separated and thus travellers only need to take a look once in their orientation phase to see which gate(s) they can use, travellers in Hong Kong don't have their walk flow interrupted by a passenger stream in the opposite direction or the possibility of standing in front of a gate for the other direction. Interviewed travellers notice that because of this, they can follow the other travellers to the correct gates, can look at the overhead signage, or find the correct gateline merely by memory. 23,24

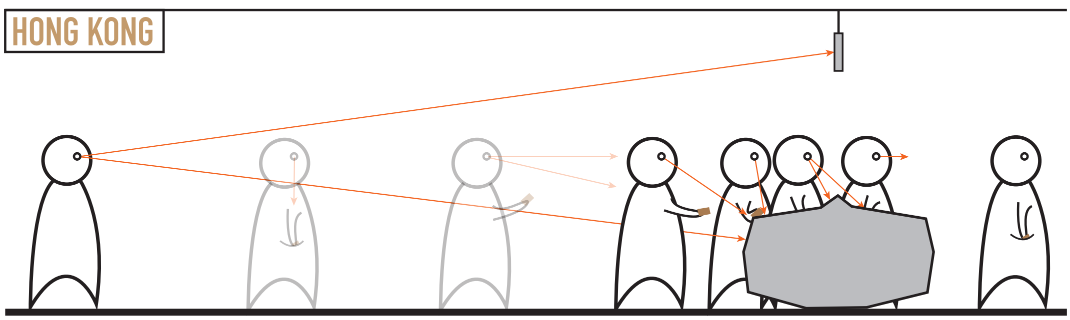


Figure 43. The walk flow of travellers using the closed payment border in Hong Kong. The orange lines show the attention of the user and the figures show the movement of the user

▶ Figure 44. Travellers using the newer model gates


往月台
to Platform
升降機
Lift
升降機
Lift
43
42


協助
Assistance
查詢
Information
車票
Tickets
八達通
Octopus
增值
Add-Value
推廣項目
Promotions
協助
Assistance
入口
Entry
出口
Exit
請在此等候
Please wait here

Figure 45. The assistance booth can be accessed from both the paid and the unpaid area

Problem solving

The MTR has large assistance booths in stations, for information, tickets, adding-value and more. In the newly built stations, a booth can be found on the border of the paid and unpaid area. This allows travellers to access the assistance from both sides (see Figure 45). Since these booths are not directly attached to the closed payment borders, they don't function primarily as problem solvers to get travellers through the gateline. What can be observed, though, is that when travellers encounter a problem when validating, they often directly move to that booth and wait in line there for help. After that, they will proceed to access the closed payment border in a regular fashion again.

Finding the correct gate: Using a gate with a red cross

Gatelines in Hong Kong often communicate the fact that gates cannot be used from the side travellers approach by many red crosses; an LED red cross on the front of the gate, one on the display, and one on the overhead signage. Some gatelines, however, do not have red crosses on the front of the gate or at the display at all. Due to the dedicated entry/exit gatelines, some gatelines only have a display, validator, and LED indication on one side of the gate and the other side is merely metal. The overhead signage still boasts a large red cross in this case. This setup seems to effectively communicate with travellers that they should not approach that gateline, since no travellers have been observed coming even near those gates.

Finding the correct gate: gateline visibility

Overhead signage is used in Hong Kong to increase the visibility and feed forward for travellers to find which gate(s) they can use (see Figure 46). It has been observed that this works exceptionally well when the MTR station gets busy, and travellers are unable to see the red crosses and green arrows on the gates due to the amount of travellers in front of them. In combination with the separated in- and outward sides of the gateline, the overhead signage only shows a few crosses and train symbols (or exit-signs) above the many gates to effectively guide travellers to the correct gate(s). Interviewees also mentioned that the overhead signage is used to find their way to a gate they can use. Because of the overhead signage, travellers orientate themselves from a large distance when approaching the closed payment border.

35

Validation: finding the validator

The validator is made recognizable on the turnstile gates by having a yellow square shape on top of the gray/metal gate, with the Octopus card graphics on top of the validator. This makes the validator recognizable and distinctive from the rest of the gate. Some of the wide-gates with flappy doors, however, have a more flat validator with only the Octopus graphic on a blue background. This in combination with many stickers and other information on the gate around the validator makes it less obvious for travellers where to validate.

Figure 46. The overhead signage allows travellers to orientate themselves even when it is busy

同日
第二程九折
一拍即賞
30/11/2015

5.4 TOKYO

5.4.1 Context of use

The public transport in Tokyo is a fully gated system. There are two metro operators and several train operators, all with their own gates and gatelines. These gatelines are always specific for one operator and it is therefore not possible for travellers to get confused or make mistakes about using the correct gate of the operator that has been used. At some metro stations, however, both metro operators reside and travellers can make use of a gate that transfers them from one operator to the other without having to pay extra for having two separate travels. This means that travellers use one validator that checks you out with one operator and in with the next, and travellers thus don't have to use two validators (perform two actions). Travellers can use paper single journey tickets or make use of one of the several smart cards in the public transport system. The researcher acquired and used the Suica (from train operator JR) smart card and the Pasmo (from the metro operator Tokyo Metro) smart card. Both smart cards work the same; they can hold credit and can be used in all public transport modalities. Travellers can get the cards from the ticket machines of the corresponding operators.

The stations visited (see Appendix J) are sometimes comparable to a maze and easy to get lost in if it wasn't for the clear wayfinding. Metro stations are underground and connected by many stairs and hallways. Sometimes stations are very large and intertwined with gigantic shopping malls. Tokyo Station, for instance, has metro operators, train operators and long distance high-speed train operators, giving them ample closed payment borders and travellers to analyse.

Figure 47. A gateline in the metro system of Tokyo


東西線
Tozai Line
T 12
2 東西線 大手町 中野 三鷹方面
Tozai Line for Otemachi, Nakano, Mitaka
1 東西線 西船橋
AED

The gates in the public transport system of Tokyo are in essence very similar to each other with a few cosmetic differences (see Figure 47 & 48). The gates have small flap doors on both ends of the gate, rather than one in the middle. Wide gates have a bit longer flaps and therefore protrude from the front of the gate (see Figure 48). Gate doors stay open for some time after a traveller has used it, but will close if the next traveller enters and does not validate. Red stop symbols and green upward arrows of LEDs are situated on the front (and back) side of the gates. The paper ticket entry slot is located on the front corner edge and the exit slot is nearly at the other end of the gate, with a display nearby to show the information. The LED smart card validator is situated on top of the gate on a slight angle with the display for that information a bit further along the gate. Gates have colours indicating whether it is smart card (IC) only or for both paper ticket and smart card, and to indicate for which operator the gates are (see also Figure 55). 20

5.4.2 Usage of the closed payment border

Walk flow

As Figure 49 illustrates, travellers in Tokyo get feed forward in the validation and information phases from the validator and display on the gates, which have some distance between each other. It can be observed that the walk flow/speed is nearly not interrupted, because the validator, display and doors are distributed in such a way over the gate that they allow users to keep their pace while interacting which each of these elements (validating, seeing feedback, passing doors). Generally, users validate their card on top of the gate, at the enlightened validator, and then move their view to the display in front of them. Moreover, travellers get extra feedback from the gate by the LED lights on the inside of the 'walls' on top alongside the gate. This seems to make the flow of actions, namely validation and information gathering, a smooth process that can be done in a continuous movement. The continuity of flow is also supported by a fast response of doors and validators. Furthermore, due to the placement of the doors at the end of the gate, travellers are not slowed down by having to wait for the doors to respond and open upon validation because of the distance between validator and doors on the gate.

It has been observed that many travellers do not slow down their movement at all when passing through the closed payment border. These travellers appear to move their view from validator to display to facing forwards. It has rarely been observed, however, that a traveller walks with such pace that he is forced to twist his head backwards to get information from the screen.

Gate directions are often mixed in gatelines. Moreover, stations frequently have walking paths perpendicular to each other and not much space around the gateline, which is not beneficial for a straight approach to the gateline. It is often observed that travellers bump into each other when walking around the station or when they approach or use the gatelines. 25,26,27

Figure 48. A gate of train operator JR in Tokyo. Notice the usage of colour, the doors on both sides of the gates, and the several elements on top of the gate

TOKYO

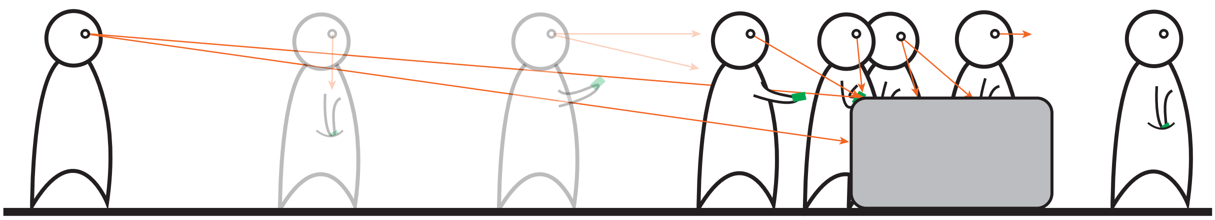


Figure 49. The walk flow of travellers using the closed payment border in Tokyo. The orange lines show the attention of the user and the figures show the movement of the user


うらが白色の
きっぷ
JR東日本 秋葉原駅
昭和通り口
(東口)
切符を紛失された際は
ご事情をお伺いします

Figure 50. Personnel in the assistance booth helps a traveller by solving his problem and letting him through the gate

Problem solving

When a traveller encounters an error upon validation, the gate will give several signals. The gate will give a beep sound, the validator light will turn red, the display will show a stop sign and text, the LEDs in the 'walls' on the side of the gate will be red, the doors will close (if they were open) and a voice will say what is wrong (e.g. ticket not valid) or what the traveller should do next (e.g. go to station staff). After analysing the behaviour of travellers encountering these errors at the gates, a clear pattern can be identified. Directly after an error has been given, travellers proceed to the assistance booth next to the gateline or the (add value) ticket machines. Some travellers try validating again and get access on the second try. This is often caused by having their card in their wallet and after taking it out it works without issues.

The assistance booths come in different shapes and sizes, but are always located close by the gateline. Moreover, these booths often have their own (gate-)doors to let travellers pass after their issue has been resolved. Having these problem-solving solutions close by the gateline makes the threshold for travellers to seek help (and thus not stall in front of the gateline) low and accessible. Travellers that were interviewed also substantiated this; they know station staff is close by and it is their first course of action to go there. 30,31,32

Difference in operators

As mentioned before, the public transport in Tokyo features several operators and their gates are differentiated by colour. Not only for differentiating smart-card-only gates and paper-ticket-and-smart-card gates (e.g. green vs. black gates for train operator JR, see Figure 55), but also the operator of the gates. Metro gates are blue-ish green or pink, JR train gates are green or black, and the monorail operator uses dark blue gates (see Figure 51). These colours often connect with the operator (logo) colours, like the green from JR (see Figure 52) and dark blue from the monorail. By colouring the gates themselves, a clear differentiation between gates from operators is created and the gates become increasingly recognizable to indicate the operator.

The gates between the two metro operators (Tokyo Metro and Toei) in some metro stations have a specific colour as well. This, in combination with overhead signage and floor stickers in the same colour, gives travellers feed forward for the purpose of the gate. For instance, one transfer gate in a gateline was coloured orange (as well as a sticker on the floor and a part of the overhead signage) to distinct itself from the other gates, which were pink or blue-ish green.

Figure 51. The monorail operator uses dark blue colours on its gates.


東京モノレール
TOKYO MONORAIL
羽田空港方面
for Haneda Airport
单轨电车乘车处
모노레일 타는 곳
先発
First
次発
Second
15:08 普通 羽田空港 国際線 第1第2
15:12 空港快速 羽田空港 国際線 第1第2
今度
ご注意　空港快速は天王洲アイル駅には止まりません
銀座本社・本店
モノレール浜松町駅
Monorail Hamamatsuchō Sta.
中央口
Central Gate
インフォメーション
出口
JR線
Information

Finding the correct gate: using a gate with a red cross

Gates in the public transport system in Tokyo have LED stop signs on the front of the gate or stickered stop signs on the flappy doors to indicate which gate can be used and which cannot. It has been repeatedly observed, however, that travellers approach these gates regardless and notice last-minute that they cannot use that gate by seeing the stop signs. Travellers notice this as well due to the fact that dedicated one-way gates do not have any validator on the other side, and they can thus not even attempt to validate there.

Finding the correct gate: bi-directional gates

Some gates in gatelines are set in a bi-directional setting. A few travellers have been observed to stall and stand still in front of a bi-directional gate after they had to wait for a traveller from the other side. This severely obstructed the walk flow for travellers coming from the other side, but also travellers from behind who tried to use the gate next to the bi-directional gate. 33

Finding the correct gate: gateline visibility

Gate directions are often mixed in gatelines in the public transport system of Tokyo, which makes the traveller walking streams cross and obstruct each other. Furthermore, since all feed forward for gate direction indication is below waist level on the gate, travellers cannot orientate and approach the correct gate in a confident matter when it is busy (see Figure 52). 36

Figure 52. Walking directions are opposite and the gateline is difficult to see

Validation: finding the validator

Validators on gates in Tokyo are clearly identifiable because of their iconic blue LED lit oval shape (see Figure 53). This is contrasting with the rest of the gate and therefore recognizable from a distance. The LED lighting also indicates which validators/gates can be used, and which cannot (LEDs will be off). 37

Figure 53. The blue light validator is easily found on the gate

Validation: tapping on the wrong side of the gate

The gates have 'walls' standing alongside the length of the gate from front to end. These ensure a clear separation between gates in the gateline. In combination with having the validator and display positioned a bit away from the front of the gate, these walls give the traveller feed forward to which elements of the gate belong to the doors that are attempted to open. Furthermore, the walls make sure that travellers refrain from attempting to use the validator of the gate on their left.

It has not been observed that any traveller attempted to validate on another validator than the one of the gate they wanted to use. 38,39


15
チャージ
14
IC
専用
IC
IC
専用
IC
7 8
8 9
9

Validation: gate refresh

Travellers can use the gates in rapid succession. The validator indicates the ability to receive a validation by showing the blue LED light. At validation this light will briefly go off and back on, to give travellers feedback that the validation was being done. Because the light is back on after a validation, the next traveller gets feed forward that validation can be done. Moreover, after validating, the display will give a brief black screen between the information of the previous traveller and the current. This makes it clear which information is for which traveller. It was observed and experienced that travellers have enough time to read their information before it is cleared by the next traveller, even when they validated in rapid succession. No traveller has been observed waiting for the gate to return to its default state before starting validation.

41,42

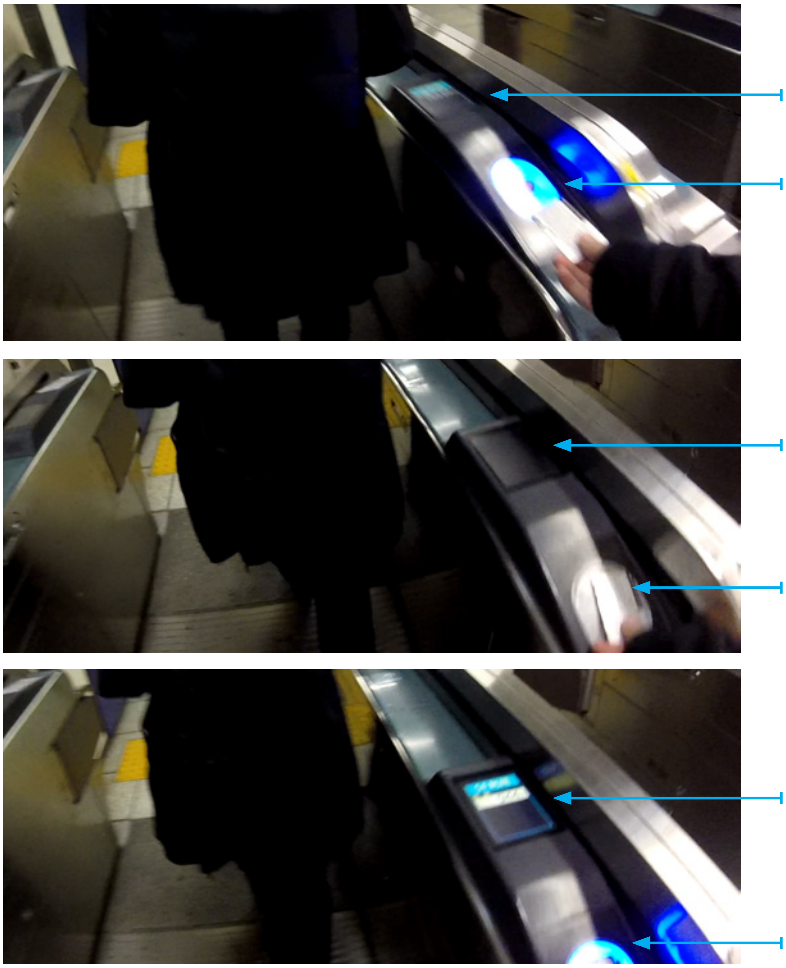


Figure 54. A sequence showing the state of the gate before, during, and after validation

◀ Figure 55. The walls on the gates divide the gates in the gateline

5.5 CROSS CASE COMPARISON

In order to see which aspects of the closed payment borders work well from a travellers point of view, an overview of how the different closed payment border systems compare, with its good and bad aspects, is made in this cross case comparison (see also Table 4). The international examples of closed payment borders will be compared to the Dutch closed payment border on the usage issues identified in the Dutch system in chapter 4.3.

Walk flow

In Hong Kong, London, and Tokyo users interacted with the validator and the display on the gate in a sequential matter (first the validator, then the display a little further along the gate), whereas users of the Dutch system did this at one point on the gate (see Figure 56). The positioning of the validator and the display in the international examples ensured that users maintained a better walk flow through their validation and information phases. It is therefore evident that, in order to increase the walk flow for users in the Dutch system, there should be more distance between the position of the validator and the display on the gate. Moreover, as seen in the system of Hong Kong, separation of inward and outward direction gates in a gateline (or even completely separated gatelines) benefits the walk flow for travellers.

Problem solving

There is much less personal assistance personal around the closed payment borders in the Dutch system compared to the ones of London, Hong Kong and Tokyo. The provided assistance in the shape of info-poles proved insufficient to prevent travellers of misuse in the Dutch system. When there is close-by assistance provided however, like the assistance personnel next to the gatelines in London and the assistance booths in Hong Kong and Tokyo, travellers have more incentives to directly solve their encountered problem and to prevent misuse. Furthermore, clear communication with travellers what the problem is at the gate and how they could solve it proved beneficial for the problem solving approach of travellers. They directly remove themselves from the gateline and know how and where to solve their problem.

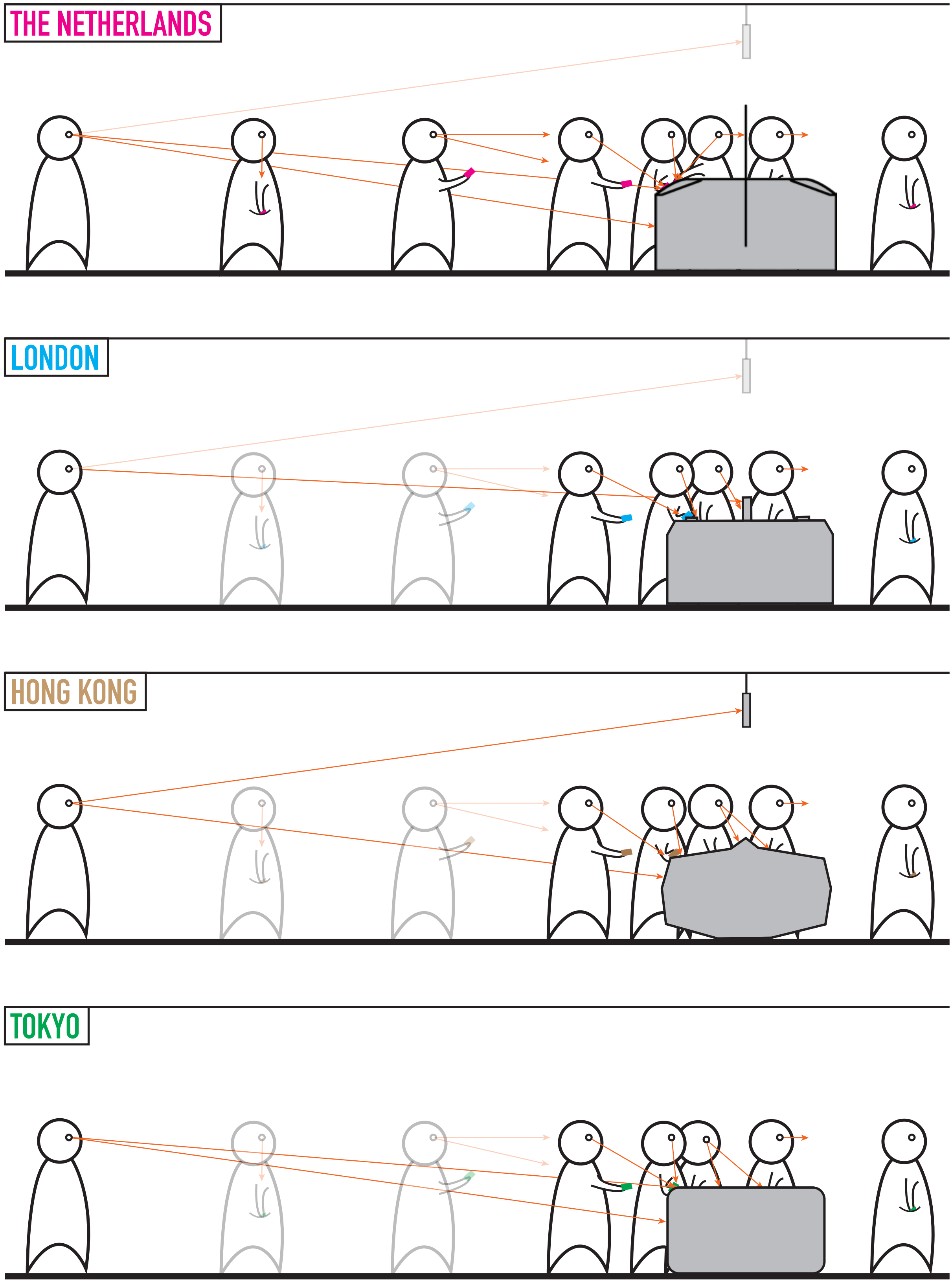
Difference in operators

The colours on the gates in the closed payment borders in Tokyo seem the most effective solution to communicate the gate's purpose and to which operator it belongs. The gates in the Dutch system use colour to indicate the operator on the overhead signage and head of the gate, but for the users this proved too little signification to indicate the operators.

Finding the correct gate: using a gate with a red cross

There was little difference on the point of signifiers to show which gate cannot be used between the compared closed payment border systems. The Hong Kong system has some aspects that might improve

▶ Figure 56. Cross case comparison of the walk flows


THE NETHERLANDS
LONDON
HONG KONG
TOKYO

the prevention of travellers using the gates with a red cross, namely overhead signage (extra red cross feed forward) and gates that have only one direction (no validator, screen, and cross on the other side).

Finding the correct gate: bi-directional gates

Bi-directional gates can be found in all researched closed payment border systems. It was observed everywhere that travellers had to wait and got blocked by travellers from the other side of the gate when trying to use a bi-directional gate. In the London Underground, however, no bi-directional gates are installed, but the gatelines sometimes do have single-way wide gates, which seemed to give no usage issues.

Finding the correct gate: Gateline visibility

The gateline visibility for travellers is greatly improved in the Hong Kong system and in some stations in London through the use of overhead signage. When it is busy, travellers in these systems could still find the gates they can use.

Validation: finding the validator

Similar to the validators on the Dutch gates, the validators in Hong Kong and London give feed forward to the travellers through its physical shape and colour. Having a contrasting colour makes it easier for travellers to identify the validator. The validator used in Tokyo however, recognizable by the oval-shaped light, was the most findable by users. The combination of light on a contrasting background without any other distracting elements around it is effective feed forward for travellers to find the place of the validator.

Validation: tapping on the wrong side of the gate

The gates in Tokyo have the most effective measure to tackle this usability issue: walls on top of gates to make clear distinctions between the gates in the gatelines. Because of these, there is no mistaking to which gate the doors, display and validator belong and no traveller has the incentive to attempt to validate on the validator of the wrong gate; an issue frequently seen happening to users in the Dutch system.

Validation: gate refresh

The gates in the Dutch system give insufficient feed forward to users to let them know that validation can be done, even though the previous user's information is still on the screen and the doors are still open. This makes users wait unnecessarily and can make them unsure in validation has been a success. The newer model gates in Hong Kong had a similar interaction. The validators in London have LEDs that indicate successful and unsuccessful validation as well as if the validator is ready to receive validation. A similar interaction was observed among travellers using the gates in Tokyo; switching on a built-in light in the validator is used to indicate whether validation is possible and if something is wrong. Moreover, a black screen swipe helps travellers distinguish their information from that of the user before them.

	THE NETHERLANDS	LONDON	HONG KONG	TOKYO
1. Walk flow	• Validator and display on the front, close to each other. • Mixed directions gates in gateline.	• Validator and display on top of the gate, apart from each other. • Some gatelines with mixed directional gates.	• Validator and display on top of the gate, apart from each other. • Gatelines separated and never mixed.	• Validator and display on top of the gate, apart from each other. • Gatelines with mixed directional gates.
2. Problem solving	• Info-poles at every gateline. • Sometimes assistance personnel in the station.	• Assistance personnel at every gateline. • Some wide gates are operated by a person.	• Assistance booth somewhere in each station, reachable from both paid and unpaid area.	• Assistance personnel at gatelines. • Station staff in booths near gatelines.
3. Difference in operators	• Multiple train and metro operators, all with their own gates. • Difference shown by validator/display & overhead signage.	• Multiple operators with their own gates. • Not possible for travellers to use a wrong gate.	• One operators with its own gates.	• Multiple train and metro operators, all with their own gates. • Difference shown by colours of the gates.
4. Finding the correct gate: Using a gate with a red cross	• Red cross on the front of the gate.	• Red cross on the front of the gate.	• Red cross on overhead signage, front of the gate and on the display. • Sometimes no red crosses at all.	• Red stop sign on the front of the gate or doors.
4. Finding the correct gate: Bi-directional gates	• Bi-directional gates at train and metro gatelines.	• Bi-directional gates at train gatelines. • No bi-directional gates in the Underground.	• Turnstile gates not bi-directional. • (Wide)gates with flaps are bi-directional.	• Bi-directional gate at train and metro gatelines.
4. Finding the correct gate: Gateline visibility	• Mixed directional gates in a gateline.	• Underground exit and entry gates not mixed, train gatelines do. • Overhead name of line. • Overhead green arrows and crosses (once).	• Separated gatelines for entry and exit. • Overhead signage in and out side. • One cross per multiple gates.	• Mixed directional gates in a gateline.
5. Validation: Finding the validator	• Flat validator with little colour and material contrast. • Some validators have lights (QR-readers).	• Validator with an outstanding round shape, with contrasting colours and material.	• Validator with an outstanding round shape, with contrasting colours and material. • Few with too much information around it.	• Validator with coloured light. • Contrasting with the rest of the gate. • No distractions around it on the gate.
5. Validation: Tapping on the wrong side of the gate	• Validator in the middle of two pairs of doors.	• Validator in the middle two pairs of doors, with the validator slightly angled to the correct side.	• Validator slightly positioned on the side of the corresponding doors.	• Gates clearly separated from each other. • Walls over the length of the gate.
5. Validation: Gate refresh	• Lack of feed forward from the gate to show validation/ use can be done.	• Small LED light next to the validator, showing if validation can be done.	• Lack of feed forward from the gate to show validation/ use can be done.	• Light of the validator on means validation can be done. • Display has black screen between travellers.

5.6 CONCLUSIONS

In this chapter, several international examples of closed payment borders have been researched and analysed on the usability issue areas found from the Dutch system. Furthermore, a comparison is made between the Dutch and international closed payment borders in order to define the elements that best tackle these usability issues.

The closed payment borders and their users found in the public transport systems of London, Hong Kong and Tokyo are all different and have their own interesting and insightful aspects. They differ in size, operators, and shape, among other aspects, that all have an effect on the usage when travellers interact with the respective closed payment borders.

From analysing the usage of the closed payment borders in London, Hong Kong and Tokyo, several conclusions can be drawn regarding aspects of the closed payment border.

- Having space between the validator, display and doors benefits the walk flow of travellers, due to the fact that the validation phase and the information phase can be done without losing pace.
- Having the validator and screen inside the gate, instead of on the front of the gate, clearly communicates to the users which touchpoints belong to the gate they want to use.
- Separate in- and outgoing gates in a gateline to let travellers know from a distance which gates can be used and to prevent walking streams to mix, which results in a better flow.
- Have as much space in front of the gateline as possible to give travellers ample time to find a gate they can use. Also, prevent other walking streams (e.g. people crossing in front of the gateline) from interfering with a traveller’s straight approach to the gateline.
- Allow travellers to solve their problems at the gateline by offering station staff close-by the gateline and by having the gate clearly communicate to the traveller what the problem is and what the problems solving strategy should be.
- The usage of colours on the gates provides travellers with more feed forward to indicate the operator of the gates that the travellers intent to use.
- Using gates with only one possible direction might give travellers less stimuli to use the gates from the wrong side.
- Overhead signage is a very helpful part of the closed payment border to guide travellers to the gates they can use, even when it is busy and they cannot see the conventional feed forward aspects.
- A validator with distinctive light and no distracting elements around it seems to attract users.
- The use of elements on top of the gate to clearly divide the gates in the gateline allows travellers to link the correct touchpoints on the gate to the doors they want to open.
- Having a screen swipe and light blink distincts your check-in from the user before you.

6

Arnhem station - train

6. General conclusions

The goal of this study was to improve the user experience and efficiency of the closed payment border in the Dutch public transport system by studying users in context. Qualitative research in the Dutch public transport system was carried out by performing observations, interviews with users in context and analysing submitted complaints. Furthermore, the closed payment border systems and users of London, Hong Kong and Tokyo were studied in 16 days abroad. In total, 46 (train & metro) stations were visited in the four contexts, countless travellers were observed and 199 insight cards were generated.

In this chapter we will review the overall conclusions of this study, with the found usage patterns, usage issues and opportunities. Next, the study is evaluated and discussed. Lastly, guidelines for a user-centred closed payment border design are proposed.

6.1 CONCLUSIONS

This study studied the users of closed payment borders in order to analyse how users actually use it (usage patterns), which issues they came across while using it (usage issues) and which aspects of the closed payment borders in the four contexts had a positive effect on the usability and experience of travellers (opportunities).

6.1.1 Usage patterns

Travellers have a certain flow of movement when they approach and go through the closed payment border, either when going from the unpaid area to the paid area or visa versa. From extensively observing the behaviour of travellers, it became evident that users of the closed payment border tend to follow a certain repertoire of use phases and actions when going through. **Four phases of use can be identified: orientation, preparation, validation and information.** Within these phases, users have several usage goals and/or cognitive processes, and performs micro actions according to the tasks that need to be performed and the feed forward and feedback the system gives to the traveller.

- In the *orientation phase*, travellers check which gates they can use by looking, for instance, at the transport operator colours or signage, the green arrows and red crosses and the movement of other travellers.
- In the *preparation phase*, travellers prepare their card while moving towards the gateline. They can do a re-check to see if they are going to the correct by looking at the colours and signage again, and identifying the state of the traveller in front and the gate.

- In the *validation phase*, the traveller has arrived at the desired gate and starts validating with the card. The traveller sees the display and validation to decide where to aim and then taps the validator, and gets feedback in sound, screen and the doors opening.
- In the *information phase*, the user gets his information from the display and continues through the gate.

During the walk flow, the traveller interacts with many aspects of the closed payment border. The previously illustrated flows show a use without making mistakes, which could and would disrupt the flow even further.

6.1.2 Usage issues

The place of the validator and screen are situated on the front of the gate, which affects the **walking flow** by forcing many actions performed by the user in a short time and thereby slowing the walking speed down. Moreover, having a small space when approaching the gateline gives the travellers less time to orientate and prepare, further slowing their flow.

Travellers have problems with the differentiation between the **gates of various operators** in the gateline. The gates have too few differentiating aspects to prevent users from accidentally using the incorrect gate, and as a consequence can lose a lot of money.

Assistance near the gateline seems insufficient to cater to the travellers' needs, which sometimes makes them feel compelled to jump the gate or tailgate another traveller.

Finding the right gate to use proves to be a hassle for some travellers. The **bi-directional setting** negatively affects the walk flow by making travellers stop in front of gates and changing gates at the last moment. Moreover, in enforces a mix of walking streams that intertwine with each other, which further obstructs the flow. The **green arrows and red crosses** in the lower part on the front of the gates are sometimes overlooked and when there are large masses of travellers, travellers draw a complete blank as to which gate they can take because these signifiers cannot be seen.

Travellers sometimes **validate on the wrong validator** because it is insufficiently clear which validator belongs to which gate doors.

The current **settings** of the sensors in the gates cannot cope with the behaviour of several travellers. The doors close even though no person went through the gate and travellers get stuck between the doors or get hit by the doors after being confident they had checked in.

6.1.3 Opportunities

The walk flow of travellers is positively affected when there is a space between the validator and display along the cabinet, due to the fact that the validation phase and the information phase can be done in a sequential manner without losing pace. Moreover, when the validator and screen are placed inside the gate, it seems to clearly communicate to the user which touchpoints belong to the gate they want to use. Elements on top of the gate clearly divide the gates in the gateline and this allows travellers to link the correct touchpoints on the gate to the doors they want to open.

Overhead signage is a very helpful part of the closed payment border, which guides travellers to the gates they can use, even when it is busy and they cannot see the conventional feed forward aspects. Separating in- and outgoing gates in a gateline lets travellers know from a distance which gates can be used and it prevents walking streams to mix. Travellers get enough time to find a gate they can use when there is as much space in front of the gateline as possible. Also, the walk flow is positively affected when other walking streams are prevented from interfering with a traveller's straight approach to the gateline. Travellers might get less stimuli to use the gates from the wrong side when gates with only one direction are present.

The throughput and user experience gets improved when travellers can solve their problems at the gateline when there is station staff close-by and when the gate clearly communicate to the traveller what the problem is and what the problems solving strategy should be.

The usage of colours on the gates provides travellers with more feed forward to indicate the operator of the gates that the travellers intent to use. A validator with distinctive light and no distracting elements around it helps travellers find it easily. A screen swipe and light blink on the validator seems to communicate a clear distinction between the users' check-in and the user before them.

6.2 DISCUSSION

The results from this study were mostly through observational research methods. Within the time constraints and manpower, this approach proved to give insights in the patterns of use and the usability issues that travellers face in the context of the closed payment border in the Dutch public transport system to draw grounded conclusions for improvements. The majority of the patterns and issues reported were observed repeatedly, which seems to lend confidence to the findings. And if incidental observations were reported, this was indicated in the report. Interviews with users in the Dutch system were mostly focussed to one problem they had, and this found issue was backed up by the insights found through the observational research. The complaints from the OV Loket gave more backup and depth into usability issues that the research hinted towards, but helped in making this more concrete. The trustworthiness of the complaints cannot be guaranteed because the researcher did not get these complaints in person or observed these happening. However, the complaints did originate from the OV Loket, which is an organization with the focus on travellers.

This study was done using qualitative research methods. Possible problems with qualitative research may include that it is not trustworthy due to interview bias, not reliable because it rests upon leading questions, and that different interpreters find different meanings (Kvale, 1994).

In order to make this study richer in research and findings, one might argue that more observations and interviews could be done on more places in the Dutch public transport system. However, this study approach already found insights that were consolidated through multiple research methods, on multiple places and with multiple users. Moreover, the visited contexts were distributed over the set criteria to cover all aspects of the closed payment border context.

6.3 GUIDELINES FOR A USER-CENTRED CLOSED PAYMENT BORDER

This sub-chapter proposes guidelines for the design of a user-centred closed payment border based on the research performed in the study. Following these guidelines for future concessions and implementations of the closed payment border in the Dutch public transport system will help overcome the usability issues currently experienced by travellers in the Dutch system. These guidelines and all results and insights from this analysis study will be used in the design phase, were a new closed payment border for the Dutch public transport system will be proposed. The guidelines might change during this design phase, as new insights might be gained. Look up the synthesis report to see the final version of the guidelines for a user-centred closed payment border.

Interaction levels

Design for the four interaction levels: environment, gateline, gate and user interface. The closed payment border should be an integral solution keeping these interaction levels in mind, in order to give travellers a coherent usage and experience. The closed payment border consists of many different elements that cannot be considered individually when designing a new proposition.

Guiding

Users need to be guided to the right gate. Allow users to find the gates they can use consistently and intuitively. Especially when it is busy, travellers need more signifiers that guide them to a gate they can use. Ideally, closed payment borders have a lot of free space around them in order to give travellers enough time and vision to get the feed forward from the closed payment border as possible. Moreover, the environment around the closed payment border should allow a straight, perpendicular approach to the gateline. This will also give the travellers the opportunity to orientate themselves to which gate can or should be used. A separation of the inward and outward gates in a gateline proved most efficient for travellers. This way, travellers can know which gate to use during the orientation phase and will not be obstructed by travellers walking in the opposite direction. Overhead signage should be used to give travellers feed forward of the directions of the gates in the gateline; this is essential for orientation when it is busy around the closed payment border. The overhead signage must clearly show where the wide gate is and must show icons with a wheelchair, baggage, stroller and bike, to guide these users there.

The validator should consist of a distinctive light on a contrasting underground and there should be no distracting elements around it for users to easily find the validator. This light of the validator can also indicate problem messages in parallel with the display (e.g. red error on display, red light on validator). This validator light should blink when validation is done so users get extra feedback on their validation and, because the light is back on, the next users know they can start validating. The briefly on-off validator light will form a combination with a screen wipe on the display: a black screen will be displayed briefly before the user's information is shown to clearly differentiate the information of the current user and the user before him.

Recognition

The closed payment border should clearly indicate the elements on the gate and users should be given the understanding when and for what it can be used. For instance, it should be communicated with the users which gates are wide gates, which gates are inwards and which are outwards, and where the validator is. Moreover, users should be given the understanding what the elements on the gate are used for. Wide gates are necessary in all gatelines, so these should be implemented on the far most side of the gateline in a single-directional setting in order for travellers to maintain consistency in finding the place of the wide gate. The (wide) bi-directional gate, if needed, can be placed in between the inward and outward direction gates to keep the walking directions homogeneous. This bi-directional feature of the gate should be communicated with the travellers before they arrive at the gateline. The closed payment border should communicate the different operators more clearly to the users. The overhead signage can also accommodate feed forward of the difference in operators. The gates should show more colour representing the operator, so travellers get more feed forward on the gate to which operator it belongs. These colours should match with the overhead signage and be recognizable by travellers to understand the operator it represents.

Problem solving

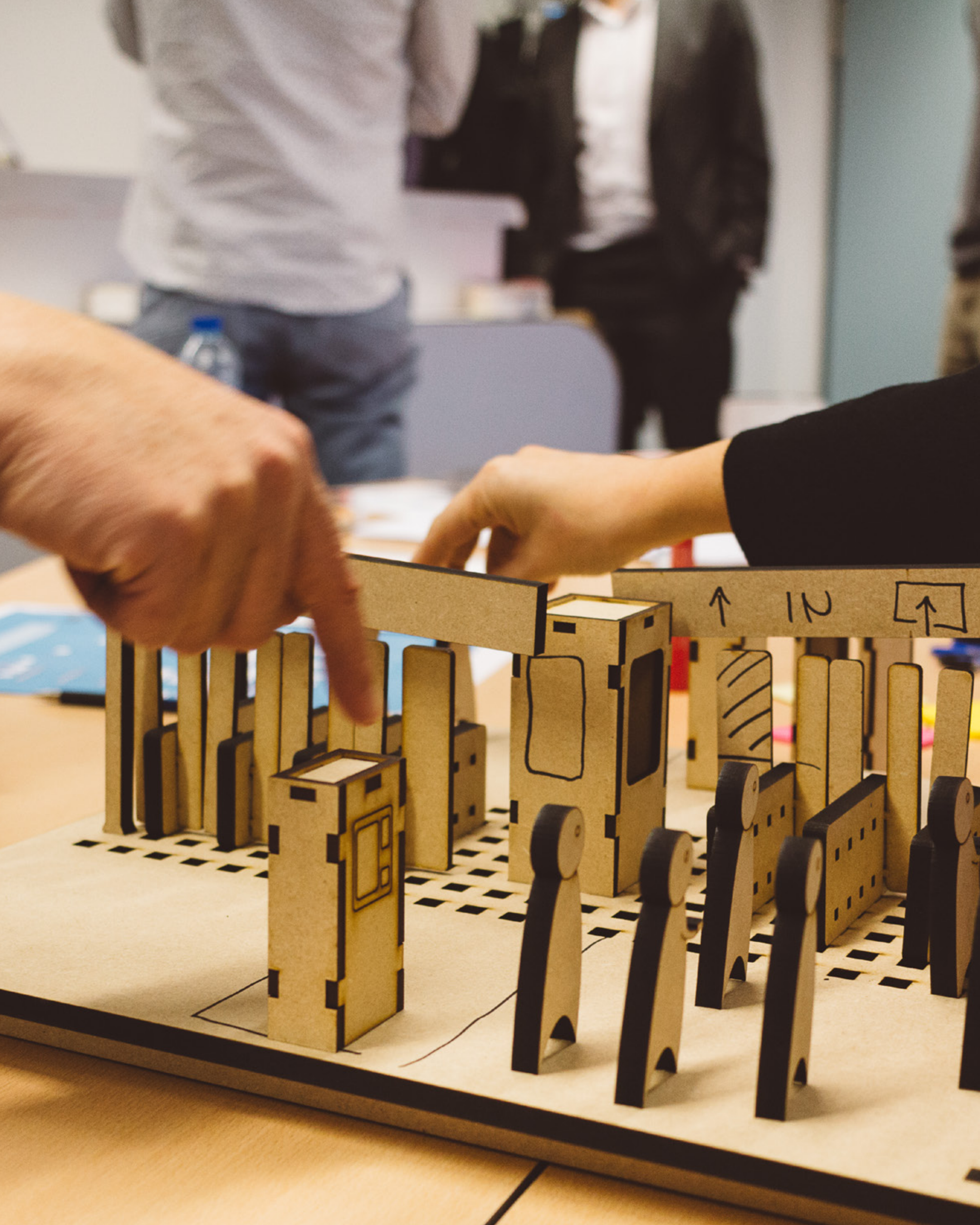
Offer more problem solving solutions for users and communicate this effectively with them. Assistance personnel should be close-by the closed payment border to help travellers who have problems getting through the gates. These personnel should be accessible from both sides of the gateline. By giving them a booth and controllable doors, they can be an integrated part of the closed payment border, either in the middle between the gates in either directions or at the side of the gateline. Furthermore, it would help travellers in their problem solving solutions when the display can communicate the error and how this could be solved.

Sequential validation and information gaining

Allow users to validate and get information from the gates in a comfortable, sequential manner where they keep their walking pace. Having enough space between the validator, display and doors is important to maintain a fast throughput while travellers can comfortably validate, receive information and continue through the doors. The validator and display should be situated inside on top, alongside the length of the gate. The gates should have elements on top of the gate to divide the gates within a gateline. Because of these elements, it will make clear to the traveller which validator, display and doors belong to the gate they are standing in front of. The settings and sensors of the gate should anticipate the movement of the users and the doors should behave accordingly.

Choices

User should be offered less choices around the closed payment border. This way, there is a lower cognitive load on the users. The concept of single check-in check out also strongly advocates this, by removing the choices of which gates of which operator they need to use. Space can be saved when the gates would be designed for a single direction, thus only having one validator and display and doors at the end on the gate. This would also help travellers by taking away the possibility of trying to validate at a gate for the opposite direction, because that possibility (read: the usage of a validator) is not there. Lastly, the validator must technology-wise be able to facilitate all future technologies of payment methods, like bank cards and mobile phones, in order to remove the burden for the travellers of having to choose a gate according to the type of validator present on the gate.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Video library

THE DUTCH SYSTEM

Full playlist tinyurl.com/DutchPlaylist

Problem area	Video number	Link
Walk flow	1	tinyurl.com/GatesVideo1
	2	tinyurl.com/GatesVideo2
Difference in operators	3	tinyurl.com/GatesVideo3
Using a gate with a red cross	4	tinyurl.com/GatesVideo4
	5	tinyurl.com/GatesVideo5
	6	tinyurl.com/GatesVideo6
	7	tinyurl.com/GatesVideo7
Bi-directional gates	8	tinyurl.com/GatesVideo8
	9	tinyurl.com/GatesVideo9
Gateline visibility	10	tinyurl.com/GatesVideo10
	11	tinyurl.com/GatesVideo11
Finding the validator	12	tinyurl.com/GatesVideo12
Tapping left side validator	13	tinyurl.com/GatesVideo13
	14	tinyurl.com/GatesVideo14
Gate refresh	15	tinyurl.com/GatesVideo15
	16	tinyurl.com/GatesVideo16
Settings	17	tinyurl.com/GatesVideo17

THE LONDON, HONG KONG AND TOKYO SYSTEMS

Full playlist tinyurl.com/LondonHongkongTokyoPlaylist

Using a gate	London	18	tinyurl.com/GatesVideo18
	Hong Kong	19	tinyurl.com/GatesVideo19
	Tokyo	20	tinyurl.com/GatesVideo20

Problem area	**System**	**Video number**	**Link**
Walk flow	London	21	tinyurl.com/GatesVideo21
	London	22	tinyurl.com/GatesVideo22
	Hong Kong	23	tinyurl.com/GatesVideo23
	Hong Kong	24	tinyurl.com/GatesVideo24
	Tokyo	25	tinyurl.com/GatesVideo25
	Tokyo	26	tinyurl.com/GatesVideo26
	Tokyo	27	tinyurl.com/GatesVideo27
Problem solving	London	28	tinyurl.com/GatesVideo28
	London	29	tinyurl.com/GatesVideo29
	Tokyo	30	tinyurl.com/GatesVideo30
	Tokyo	31	tinyurl.com/GatesVideo31
	Tokyo	32	tinyurl.com/GatesVideo32
Bi-directional gates	Tokyo	33	tinyurl.com/GatesVideo33
Gateline visibility	London	34	tinyurl.com/GatesVideo34
	Hong Kong	35	tinyurl.com/GatesVideo35
	Tokyo	36	tinyurl.com/GatesVideo36
Finding the validator	Tokyo	37	tinyurl.com/GatesVideo37
Tapping left side validator	Tokyo	38	tinyurl.com/GatesVideo38
	Tokyo	39	tinyurl.com/GatesVideo39
Gate refresh	London	40	tinyurl.com/GatesVideo40
	Tokyo	41	tinyurl.com/GatesVideo41
	Tokyo	42	tinyurl.com/GatesVideo42

Colophon

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Project

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