Opening the closed

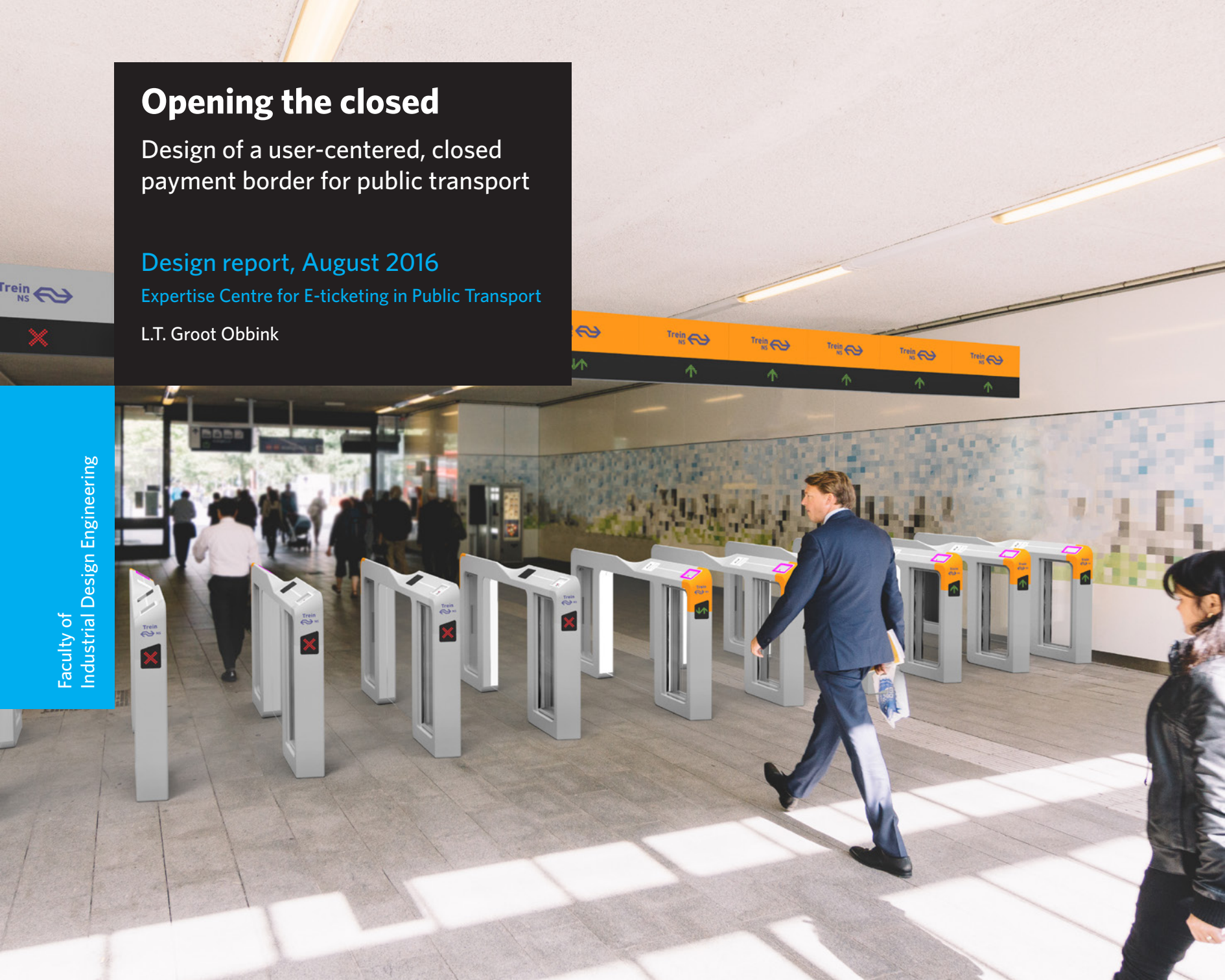
Design of a user-centered, closed payment border for public transport

Design report, August 2016

Expertise Centre for E-ticketing in Public Transport

L.T. Groot Obbink

Faculty of
Industrial Design Engineering



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This report is part of the Expertise Centre for E-ticketing in Public Transport (X-CEPT)

Master Design for Interaction
Faculty of Industrial Design Engineering
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 hall 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.

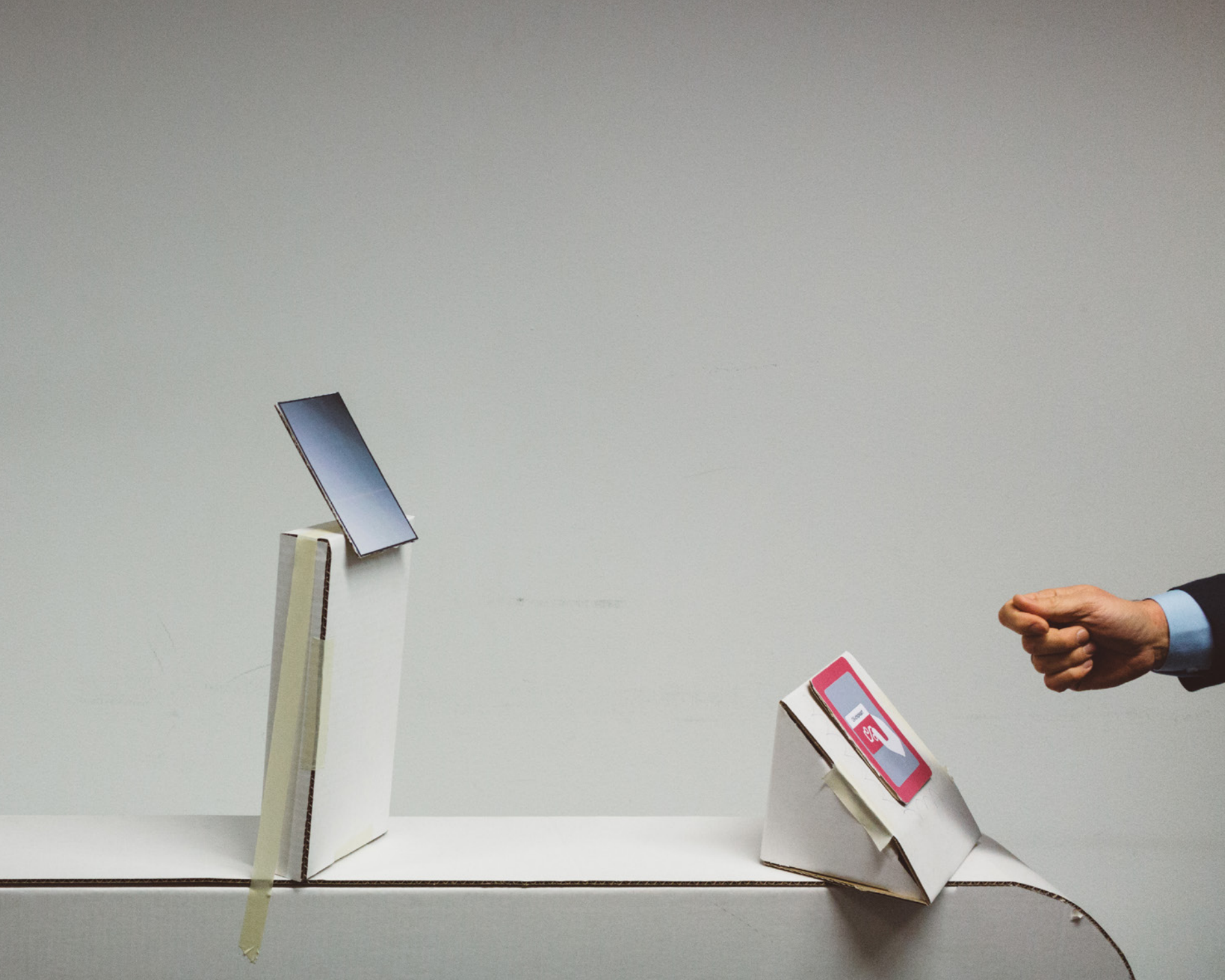
Usability. The extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use (ISO, 2010).

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).

OV-Betalen. Collective name for all payment in public transport in The Netherlands.



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.

Some aspects that were found that could be improved in the Dutch system. For instance, 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. 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. 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.

Some aspects that were positively experienced in the systems abroad, could serve as opportunities for the design of a new closed payment border for the Dutch system. For example, 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. 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. A screen swipe and validator light blink seems to distinct the user's check-in from the user before him.

These findings were the starting point of the design phase. Firstly, ideation brought up many partial design solutions. These were clustered together into four different concepts (Chapter 3). The

concepts differentiated on many small design aspects, such as the shape of the gate and the user interface, and one significant aspect: the place of the doors on the gate. One concept has the doors at the end of the gate, allowing for a faster throughput but the gates would only be single way. Two concepts has the doors in the middle, similar to the current design gates. The last concept has doors on the front and back of the gate, which are open on default. This is in contrast to the other concepts, which have doors that are closed on default.

These concepts were evaluated with stakeholders, using 3D-printed scale models and digital renderings of the concepts as stimulus material (Chapter 4). The criteria from the stakeholders were combined with the user-centered criteria found in the analysis phase of the project. The four concepts were evaluated on these criteria, it was chosen to continue the development of the open design concept, due to the inviting character and improved throughput.

The chosen concept had to be developed into a design (Chapter 5). Several positively evaluated aspects from other concepts were added to the chosen concept and many design aspects were improved and detailed. Ultimately, a new design closed payment border was proposed, and evaluated with participants in a usertest (chapter 6). The usertest was performed with 9 participants, of which 4 were frequent users of the (current design) gates and 5 were infrequent users. Various stimulus material was used to evaluate the usability and user experience of the new design closed payment border, such as a full-scale functional prototype, a virtual reality environment with the design and various digital renderings. The results of the usertest showed that the participants evaluated the design as clear and friendly. Especially the overhead signage (feed forward operator and which gate can be used), the user interface and the open character were appreciated. Some small negative aspects had to be redesigned.

After the proposed design was evaluated in the usertest, changes in the design were made and the final design was proposed (Chapter 7). The new user-centered closed payment border proposed in this project explores the advantages of having an open gateline, in combination with many new design aspects such as the UI and feed forward aspects. This design reduces the usage issues that travellers will have at the closed payment border and improves the throughput with the placement of the doors, UI and feed forward aspects.

The gates have a lightbox on the front, which can be turned on or off depending on whether the gate is on. The lightbox has the colour of the operator, also represented by their logo and name, which gives feed forward to the users about the operator of the gate and the direction of the gate. The green arrows and red crosses also give recognition to users about which gate can be used and which one cannot. Furthermore, overhead signage gives the same feed forward, with lightboxes and arrows/crosses, to users when they approach to the gateline. The overhead signage is especially useful when it is busy and the gates can hardly be seen. The user interface, consisting of a validator, lightstrip and display, is turned off when the (side of the) gate cannot be used. When on, the validator has a contrasting light that gives feed forward that it can be used. It gives feedback through light and sound upon validation, depending whether validation was successful or not. If successful, a light will move towards the display and a message is shown. If unsuccessful, the validator, lightstrip and display, in combination with the lights underneath the gate, will light up yellow or red, depending on the error. At this point, the doors will close.

This design needs to be tested and developed further before it can be implemented in to stations. Several design aspects could also be transferred to concepts with the doors in the middle, or a high doors version of the proposed design (Chapter 8).

Overhead signage
Static sign, gives some extra feed forward to users about the operator and modality.

Closed doors in the middle
The doors are closed on default. The need to open at every validation, causing users to slow down while walking through the gate. The opening of the doors does give feedback that validation was successful.

User interface
Close together on the front of the gate, which diminishes the walking speed and throughput. Not clear enough as to which side it belongs to. Validator does not give enough recognition whether it can accept validation or not.

Feedback
The gate does not give enough feedback upon validation, with only the display and sound.

Arrows and crosses
Situated on the front of the gate. This does not give enough feed forward as to which gate can be used, especially when it is busy.

Current design, in the field

Lightbox overhead
Can be turned on/off. Shows the colour of the operator, and at the same time which gate can be used and which one cannot.

Operator colour, logo and text
Gives travellers feed forward about the operator of the gates. Every operator has its own recognizable colour and logo. Text explains the modality.

User interface
The user interface is positioned further away from each other. The validator has light to give feed forward that it is on, the guiding light directs users to the display and the display can be read while walking through the gate.

Doors on both sides of the gate
The gates are open on default, and close when something is wrong. The doors are placed at the end, in order to have a longer walk-in distance. This allows the doors to close before the user has reached the end.

Lightbox gate
Can be turned on and off. Indicates the colour of the operator, and at the same time which gate can be used. Also has text and a logo.

Chamfered top and front
The chamfered top and front guides users to the correct validator, so they will use the one that belongs to the gate they are standing in front of.

New proposed design

1

Rotterdam Centraal - train

1. Introduction

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 with the train. 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.

1.1.1 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.

1.1.2 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 should be 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 entered or exited the system correctly.

1.2 DESIGN BRIEF

In order to improve the user experience and efficiency of the closed payment border, the goal of this study is to develop a new design for a closed payment border in the Netherlands. This new design, including concepts during the design process, will be evaluated and tested with stakeholders and users, in order to create a design proposition that takes into account the wishes and concerns of the business, technology and (mainly focused on the) human aspects surrounding the closed payment border.

1.2.1 Aim

The aim of this study is to develop ideas, concepts and a design proposal for a closed payment border in public transport, based on

"So.. what'd be a better, human-centered door?"

"An ideal door is one that as I walk up to it, and walk through it, I am not even aware that I had opened the door."

Norman, 2016

the usage patterns, usage problems, and opportunities found in the analysis phase.

1.2.2 Research questions

This study aims to find the answers to the following research questions:

- How can usage and interaction of the closed payment border be improved?
- How can the findings from the analysis be translated into design aspects of the closed payment border?
- What human, business, technological and societal aspects are relevant for the design of a new closed payment border?
- What are the considerations of the stakeholders regarding the new design of the closed payment border?
- What do users think of the new design of the closed payment border, and how do they interact with it?

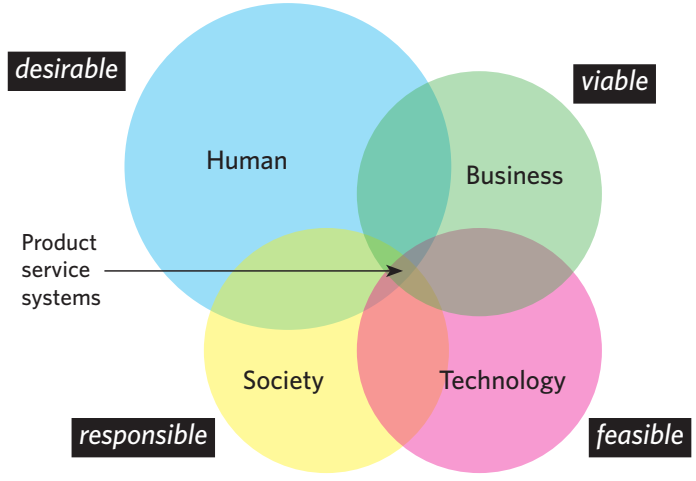


Figure 1. Integrated innovation model by Van Kuijk (2015), adapted from the human-centred design model by IDEO (2009). This project focuses mostly on the human aspect, thus the larger scale.

1.3 APPROACH

A user-centered design approach was used to develop integrated design solutions. Firstly, qualitative research methods were performed, in the analysis phase (Groot Obbink, 2016), in order to to gain insights and answers to 'how' and 'why' questions of the usage of the closed payment border. These insights gave the opportunity to generate ideas and concepts that led to a new design proposition of the closed payment border in public transport. Moreover, the business and technology sides are addressed by taking stakeholder considerations on the proposed concepts into account and by integrating new technology in the field, such as mobile payment, be-in be-out and 3D-sensors.

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. 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 1 shows the 'sweet spot' of this integrated 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.

1.4 PROJECT SETUP

The TU Delft Expertise Centre for E-ticketing in Public Transport (X-CEPT) develops integral future solutions for user-centered electronic payment used in public transport in the Netherlands. 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 Expertise Centre will look years into the future and take the benefits for the traveller, the positions of different stakeholders and the existing infrastructure into account.

In the first part of the project, 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.

This report takes the insights from the analysis phase and, through ideation and concept development, turns them into a new design for the closed payment border.

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 party ProRail.

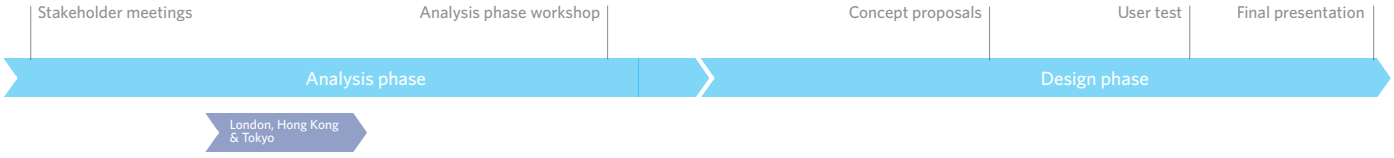
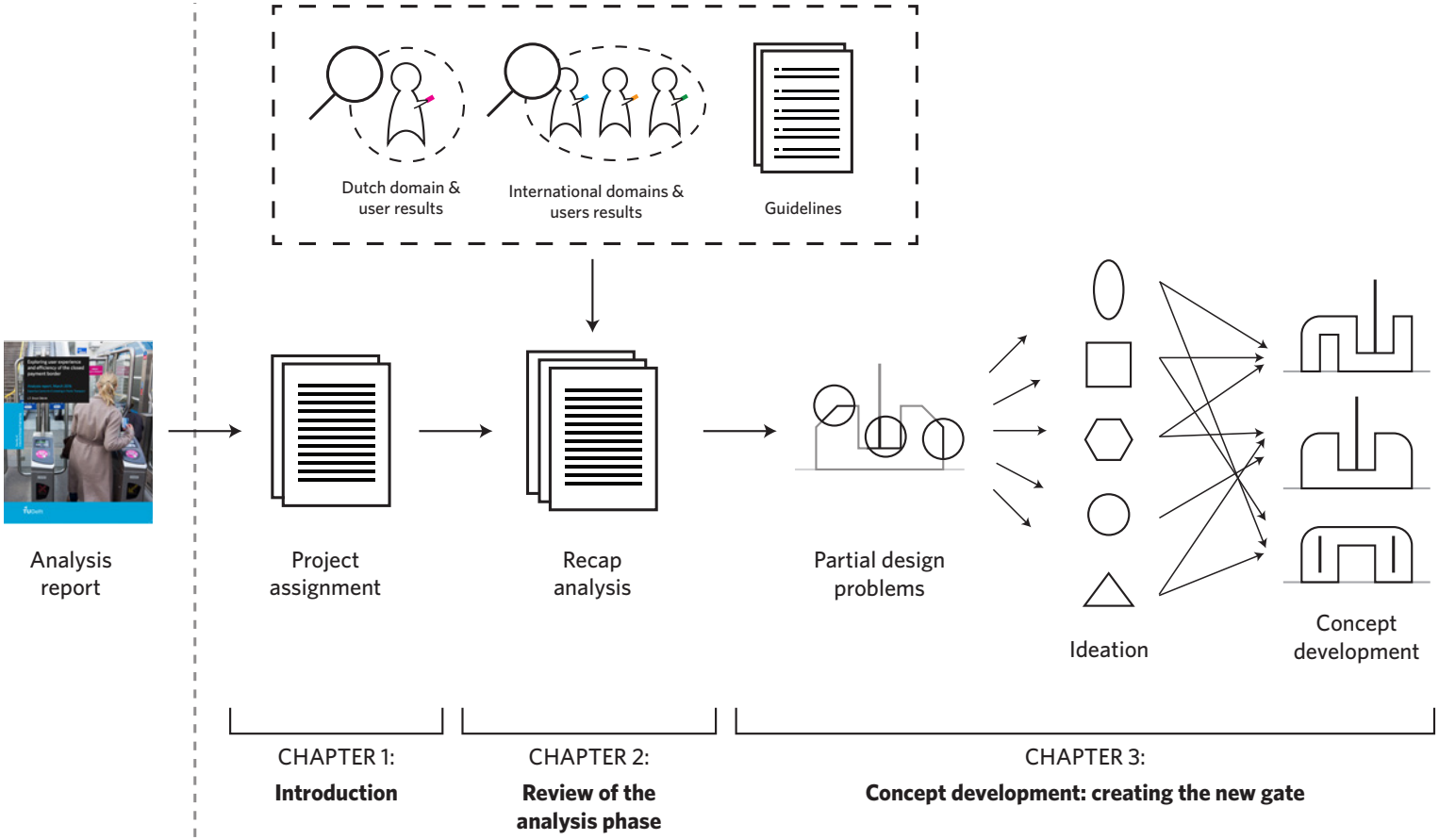


Figure 2. Timeline of the entire project.

Amsterdam Zuid - metro

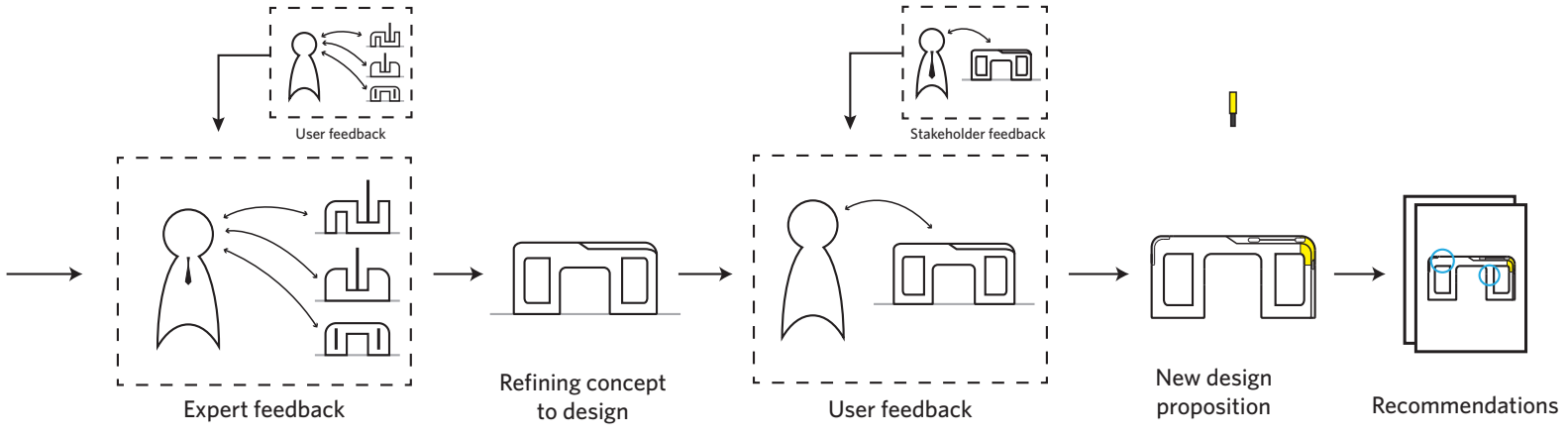
1.5 PROCESS

The analysis report (Groot Obbink, 2016) of this project forms the starting point for the design phase. The report of the design phase starts with a short recapitulation of the analysis phase. Next, the issues found in the analysis of the closed payment border are addressed in the ideation, and design solutions are generated. These partial solutions are bundled and developed into four concepts. In order to get an understanding of the considerations of the stakeholders regarding the closed payment border and the proposed concepts, interviews were done with each stakeholder using stimuli. Ultimately, one of the concepts is chosen based on the user-centered criteria, set by the researcher during the analysis phase, and the



considerations of the stakeholders, taking into account the business and technology aspects. Next, the chosen concept is developed further, detailing it into a design. This proposed design is made into a functional prototype and digital visualizations, and these stimuli are evaluated with users. Insights from the user evaluation are used to develop the proposed design into a final design.

Chapter 7 demonstrates the user-centered closed payment border design. The last chapter of this report proposes recommendations for other design options and further research.



CHAPTER 4:
Concept selection

CHAPTER 5:
Design refinement

CHAPTER 6:
User evaluation

CHAPTER 7:
A user centred design of a new closed payment border

CHAPTER 8:
Conclusion

2

Amsterdam Duivendrecht - train & metro

2. Review of the analysis phase

2.1 INTRODUCTION

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.

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

2.2 RESULTS

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).

2.2.1 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 traveller 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.

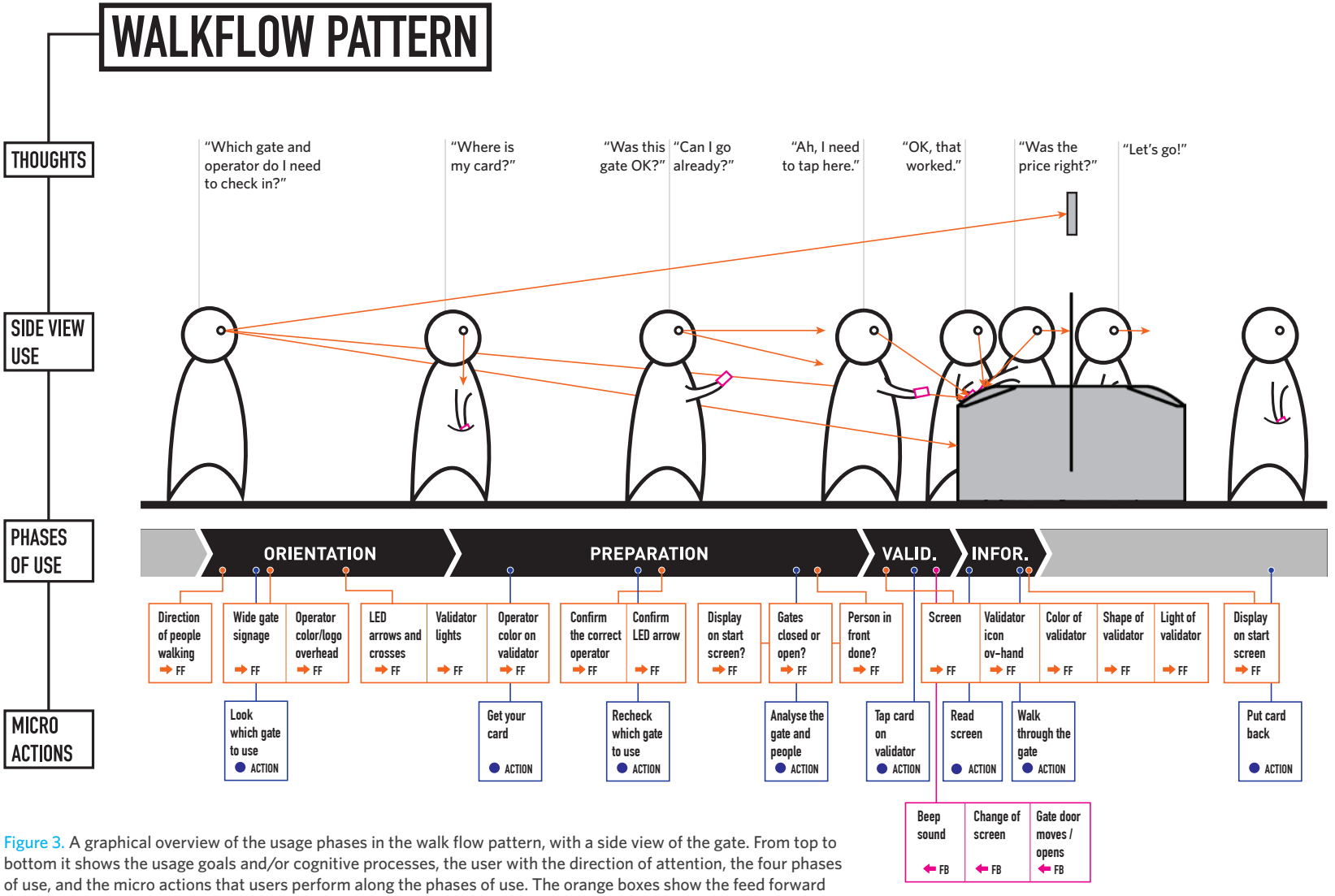


Figure 3. A graphical overview of the usage phases in the walk flow pattern, with a side view of the gate. From top to bottom it shows the usage goals and/or cognitive processes, the user with the direction of attention, the four phases of use, and the micro actions that users perform along the phases of use. The orange boxes show the feed forward elements, the blue the actions of the user and the pink are feedback.

2.2.2 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, 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.

The current **settings** of the sensors in the gates cannot cope with the behaviour of all 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.

2.2.3 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 with 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.

2.3 GUIDELINES FOR A USER-CENTERED 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-centered 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

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


ENVIRONMENT
GATELINE
GATE
UI
MM
Lift
ov-chipkaart
M50 Gein
M51 Centraal Station
metro

Monzen-Nakacho metro station, Japan

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.

2.4 CONCLUSION

This analysis phase of this study found usage patterns, usage problems, and opportunities regarding travellers using the closed payment border. These were translated into guidelines for a user-centred closed payment border for public transport. These findings and guidelines will be used in the rest of the study, where design solutions are generated based on this research.


3

3. Concept development: creating the new gate

3.1 INTRODUCTION

The results of the analysis phase and, subsequently, the guidelines for a user-centered closed payment border were proposed in the last chapter. These findings and guidelines will be used to generate ideas in order to come up with a new design that solves the issues in the current system and gives an overall better experience to the user. This chapter demonstrates how the guidelines are used for ideation, which is ultimately translated into four closed payment border concepts.

3.2 IDEATION

The findings from the analysis phase, where issues in the Dutch system were found and opportunities from systems abroad were seen, give a solid basis to which design elements need to be considered and what could work well. Drawings, cardboard 1:1 scale models, and miniature foam and clay models were used during the ideation phase.

Positioning user interface

During the analysis it was found that the positioning of the user interface (validator, screen) on the gate was suboptimal for users to maintain a fast walking pace and sometimes confused users as to which validator belonged to the gate they are standing in front of. In the systems abroad it was noticed that the validator and display were positioned more apart from each other and inside the gate instead of on the front. This seemed to improve the usability and throughput of the gate, and is therefore a proposition that will be incorporated in the new ideas for the gate design.

Preventing left side validation

The position of the validator and the shape of the gate should also aim to prevent the users from validating on the wrong validator. The 'wall' between gates that was found in Japan seemed very effective at this. A angled top shape of the gate might also prevent users from using the left side validator.

Validator

Users in the Dutch system sometimes had trouble finding the validator. It was seen in the Dutch and Japanese systems that light on the validator attracts users. Furthermore, an recognizable color and shape of the validator also positively affects the ability of users to find the place to validate their travel ticket. The validator on the new design gate could be rectangular, in the length of the gate, or round, to synchronize with the validation poles in the system. It could be completely of light or have a ring or edge that gives light. The validator should be able to accept all payment options, in order for users to not have to choose a gate according to the payment option they prefer.

Guiding

Users need to be guided to the correct gate, in order to prevent users from stalling and keep the throughput high. Overhead signage proved very effective in the system of Hong Kong. Giving information about the direction of the gates above the gateline is very useful for travellers when it is busy and the gates can hardly be seen. The gates and overhead signage should indicate which gates can be used, for instance by both having arrows and crosses, and using green and red colours.

Difference in operators

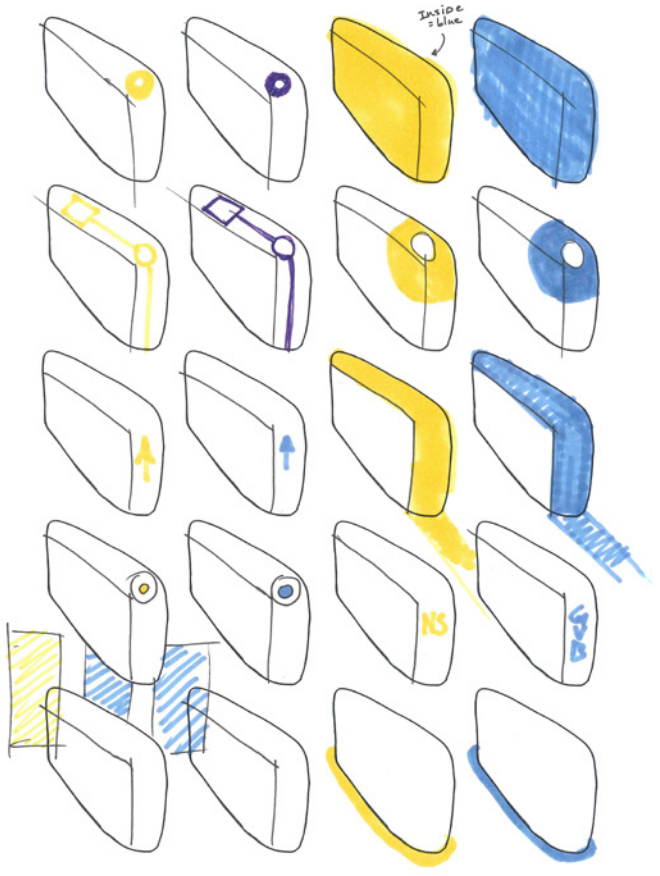
Users should get clear feed forward as to which gate belongs to which operator. In the current Dutch system, some users check in or out at the gates of the wrong operator, thereby losing a lot of money that needs to be recovered. This happens at gatelines with multiple operators. In the public transport system of Japan it was seen that the gates and signage were recognizable by their colour: the colour of the operator of the gates. This proved very effective for recognition both on a far distance and close-by on the gate itself. The new gate and gateline should also incorporate more distinctive features of the operators in order for users to be able to choose the correct gate. For instance, lighting with the colour of the operator on the front of the gate could be used, or the whole gate could be made in the colour of the operator.

Assistance

As found in the analysis phase, users prefer to have assistance in the form of a person close-by the gateline. The new design gateline could incorporate a assistance booth in the middle of the gateline, separating the inward and outward gates, or on the side of the gateline. The wide gate could be close to this assistance booth, because that gate might require the most help.

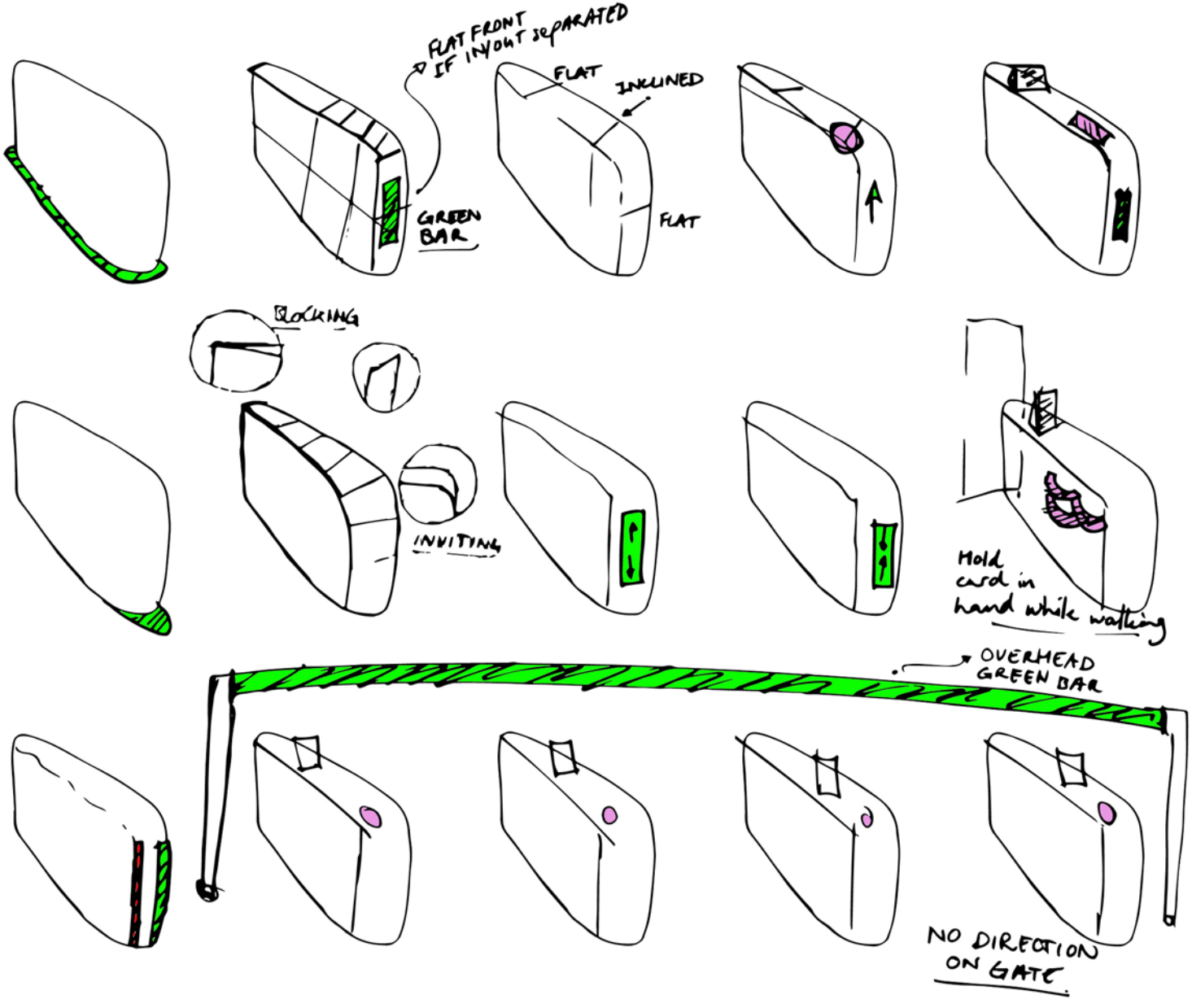
Position of the doors

In order to keep the throughput high, the position of the doors could be varied to accommodate a longer walk-in space in combination of the sequential user interface. For instance, the doors could be at the back of the gate, allowing for no delay when walking through because users do not have to wait for the doors to open. However, this makes the gate only one directional and can therefore not be switched according to peak capacity. In turn, this positioning and shape of the gate does allow a faster walk-flow and better recognition to which gates are inward and which are outward.



▲ Figure 5. Some ideation sketches about communicating the difference between the gates of operators.

▶ Figure 6. Some ideation sketches about various aspects of the gate and gateline design.


FLAT FRONT IF IN/OUT SEPARATED
FLAT
INCLINED
GREEN BAR
FLAT
BLOCKING
INVITING
Hold card in hand while waiting
OVERHEAD GREEN BAR
NO DIRECTION ON GATE

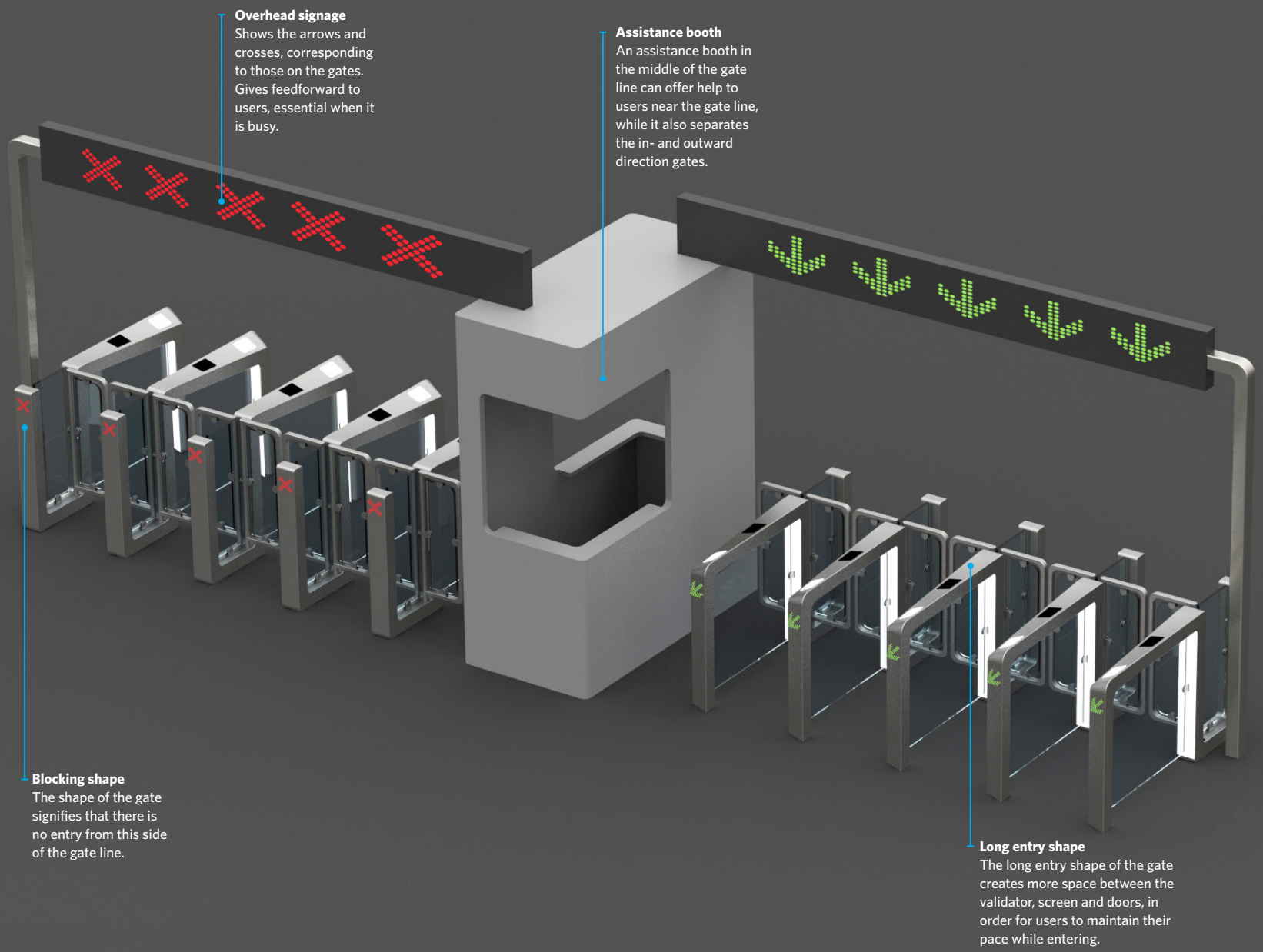
3.3 CONCEPTS

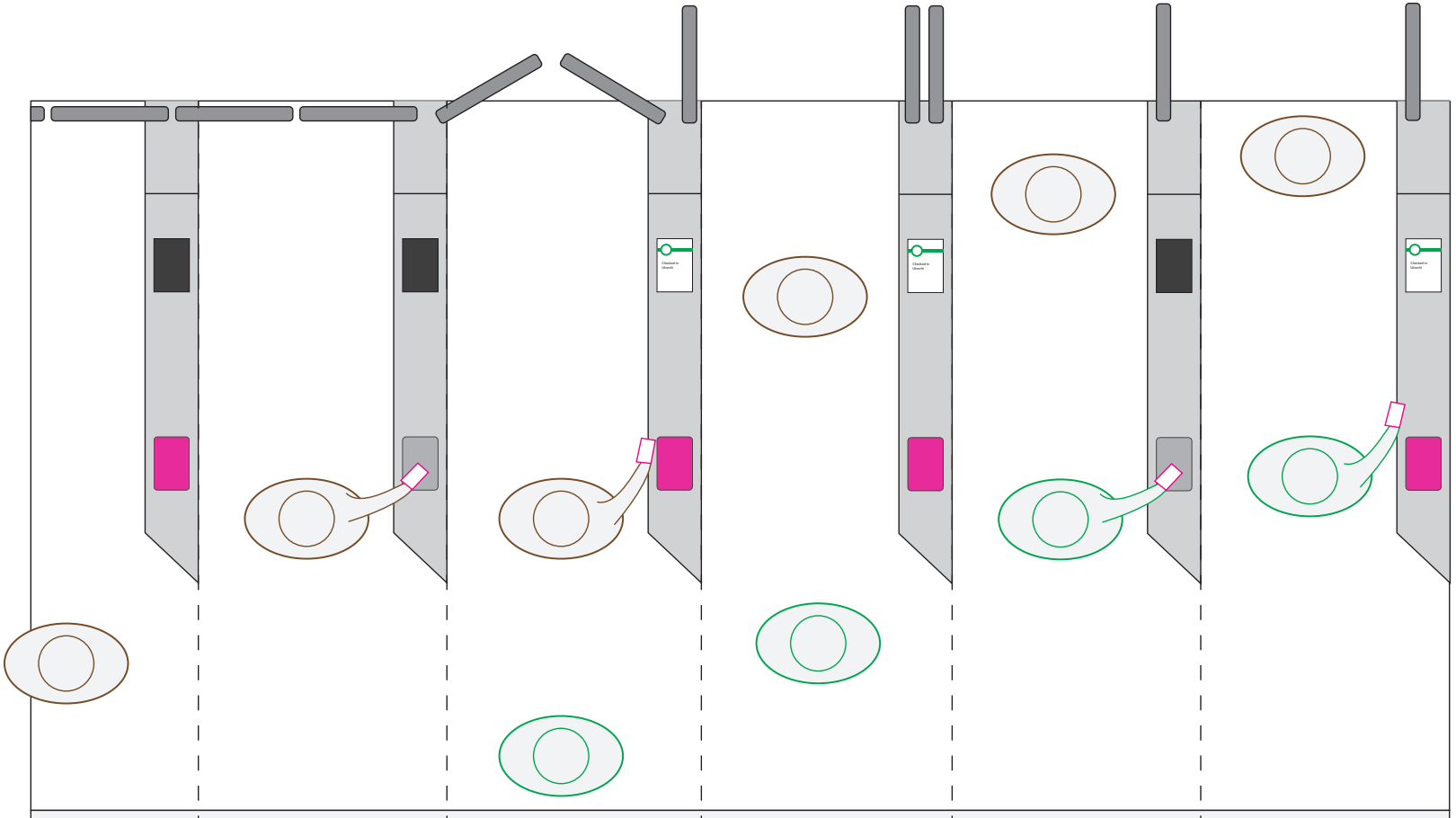
Several partial design solutions have been created, and have to manifest into multiple design concepts that contain many of these partial solutions. Four concepts have emerged, differentiating in many small aspects but also in one main aspect: the placing of the doors along the gate.

3.3.1 Concept 1: Single direction gates

The first concept that has been proposed was the single direction gate. As the name suggests, the main feature that set this concept apart is the fact that it can only be used in one direction. The shape of the cabinet embodies a inviting, round front and a blocking, straight back side, to emphasize the single directional feature. In combination with the assistance booth in the middle of the gate line and the overhead signage, the right side of the gate line would have the entry side and the left side would have the exit side, separated by the assistance booth. As found from the research, separating the inward and outward gates in the gate line guides users to the correct gate they can use and facilitates the use of an assistance booth close-by in the gate line. The validator and display are located on top of the gate, along the length of the cabinet. Since the doors are on the end of the gate, users will have a longer distance between the validator, screen and doors, which would improve the walk flow. Furthermore, the shape of the cabinet is angled in the front of the gate, turning straight towards the end. The angled front and top gives feed forward to the users about which validator belongs to the doors they are standing in front of. Moreover, it discourages users to validate on their left side, because that validator is not easy to reach and visible. The validator has a light that gives feed forward to the users that validation can be done. When a user validates, this light very briefly turns off and then on again, a sound can be heard and the information will be shown on the display. The validator blink suggests that the validation has been done, and the turning back on of the light gives feed forward to the next user that validation can be done. When the next user comes, and the previous user's information is still on the display, there is a very brief black screen between the information screens in order to clearly distinguish the information between the users.

Figure 7. Digital rendering of the gate of Concept 1: single direction gates.


Overhead signage
Shows the arrows and crosses, corresponding to those on the gates. Gives feedforward to users, essential when it is busy.
Assistance booth
An assistance booth in the middle of the gate line can offer help to users near the gate line, while it also separates the in- and outward direction gates.
Blocking shape
The shape of the gate signifies that there is no entry from this side of the gate line.
Long entry shape
The long entry shape of the gate creates more space between the validator, screen and doors, in order for users to maintain their pace while entering.



STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6
Default mode. A traveller approaches the gate.	The traveller touches his card on the validator. The light on the validator goes off briefly and back on again.	The screen displays the travellers' information. The doors open.	The first traveller continues walking through the gate. Another traveller approaches the gate.	The display still shows the first traveller's information. The second traveller taps his card on the validator. The validator briefly turns off and on and the display briefly shows a black screen.	After the brief black screen, the second traveller sees his information on the display. He continues through the gate.

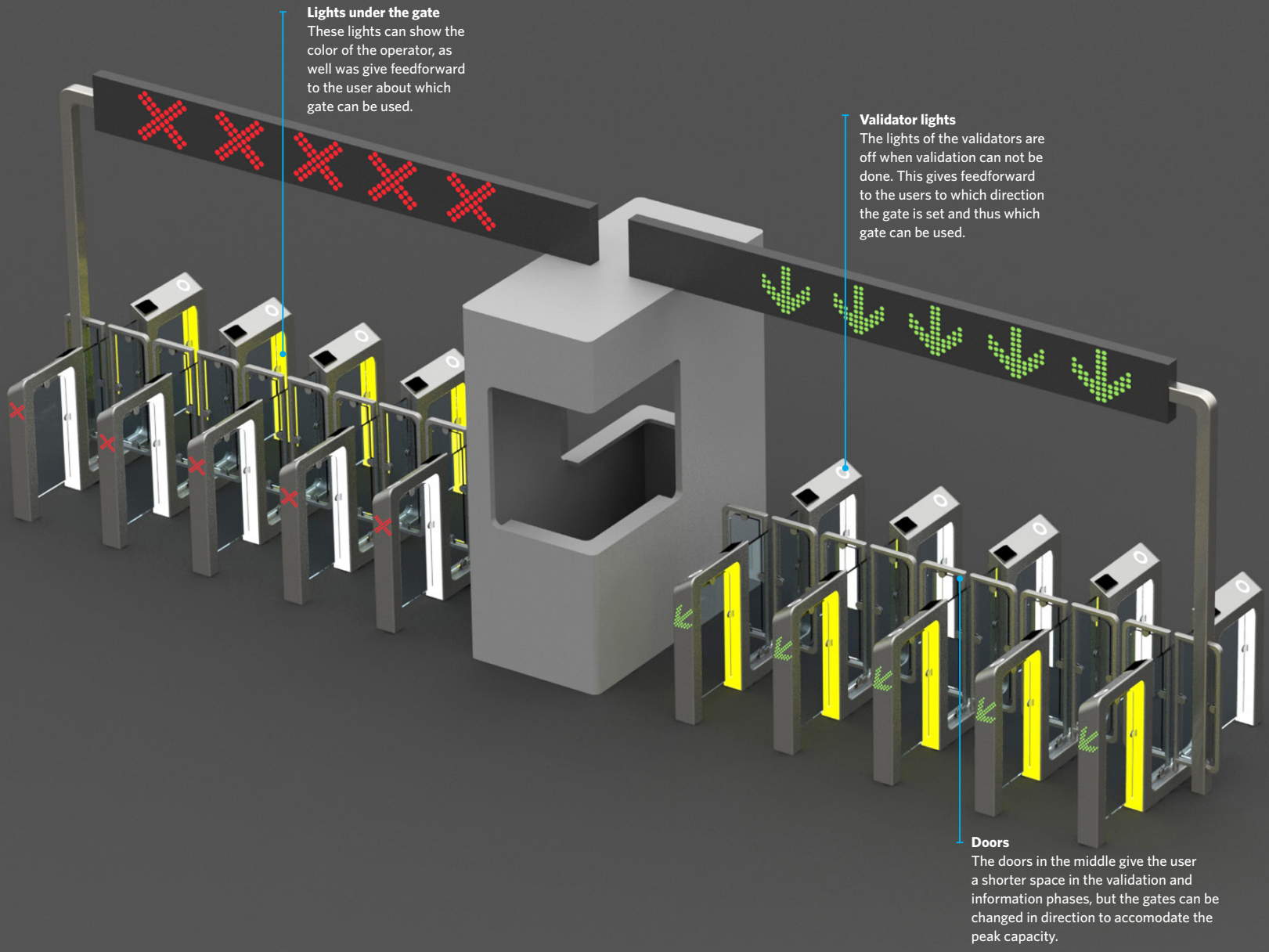
▲ Figure 8. Top view of the interaction between the user and the gate.

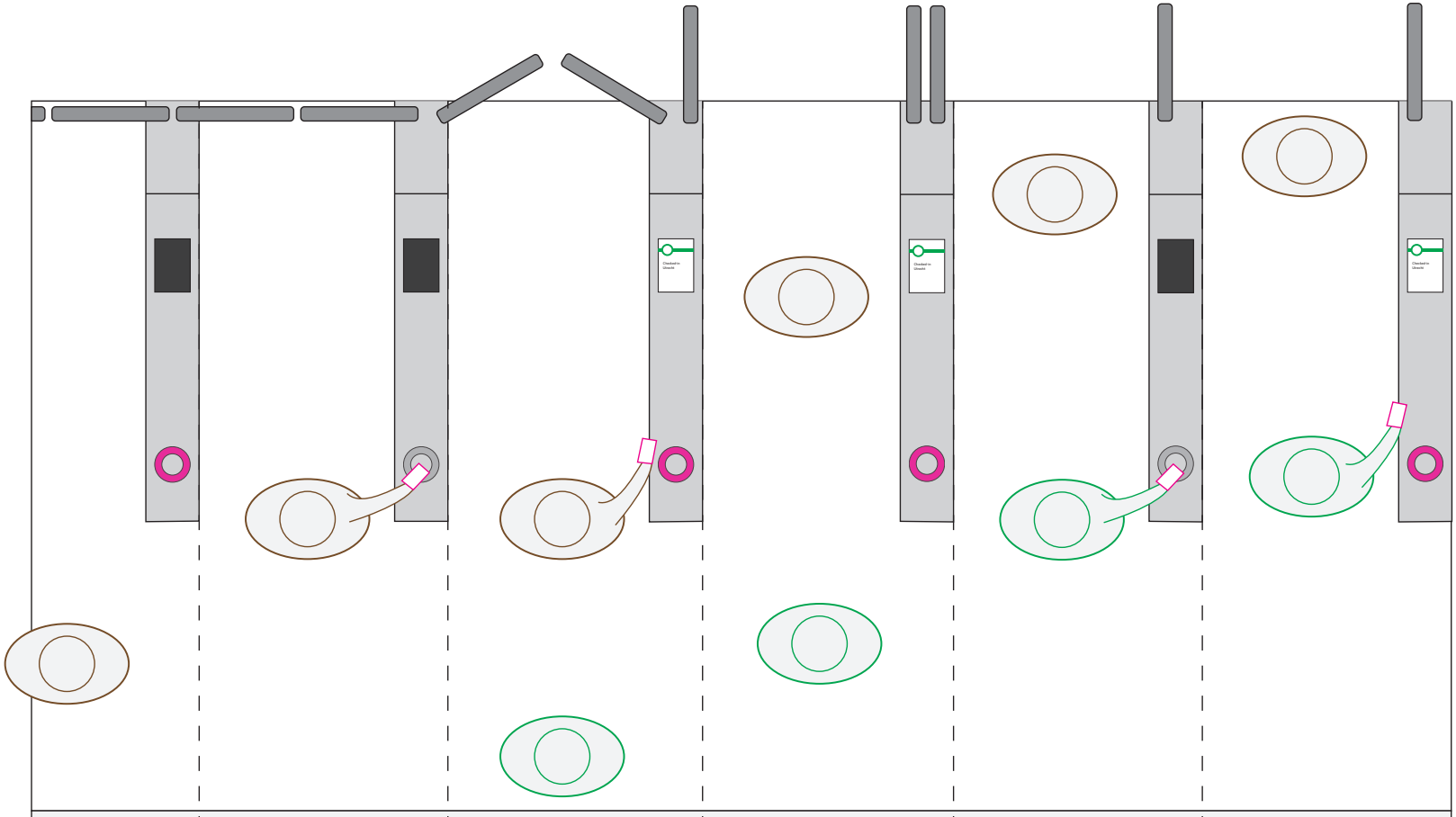
◀ Figure 9. Digital rendering of a gateline setup of Concept 1: single direction gates.

3.3.2 Concept 2: Two direction gates, angle

The second concept that has been proposed is a gate that can be accessed from both sides, as is the case in the current system. The doors are in the middle of the gate and there is a validator-display combination at both ends. The validator and display are located on top of the gate along the length of the cabinet. The top of the gate is on an angle, in order to give users more feed forward about which validator and display belong to which doors. The validator is flat on top of the gate and the display is angled towards the user. The green arrow (or red cross) on the front of the cabinet is situated on the edge of the side where the user will walk past, instead of in the middle, in order to give more feed forward to which elements of the gate belong to the doors that the users are standing in front of. The interaction with the validator and display is similar to that of Concept 1, but in this concept the lights of the validators on the side that is closed (not usable / red cross) will be off to give more signals to the users to which validator (and thus gate) can be used. Another aspect of importance with this concept is the ability to switch directions of the gates in the gate line and the optional placement of an assistance booth, either on the side or in the middle.

Figure 10. Digital rendering of the gate of Concept 2: two direction gates, angle.


Lights under the gate
These lights can show the color of the operator, as well was give feedforward to the user about which gate can be used.
Validator lights
The lights of the validators are off when validation can not be done. This gives feedforward to the users to which direction the gate is set and thus which gate can be used.
Doors
The doors in the middle give the user a shorter space in the validation and information phases, but the gates can be changed in direction to accomodate the peak capacity.



STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6
Default mode. A traveller approaches the gate.	The traveller touches his card on the validator. The light on the validator goes off briefly and back on again.	The screen displays the travellers' information. The doors open.	The first traveller continues walking through the gate. Another traveller approaches the gate.	The display still shows the first traveller's information. The second traveller taps his card on the validator. The validator briefly turns off and on and the display briefly shows a black screen.	After the brief black screen, the second traveller sees his information on the display. He continues through the gate.

▲ Figure 11. Top view of the interaction between the user and the gate.

◀ Figure 12. Digital rendering of a gateline setup of Concept 2: two direction gates, angle.

3.3.3 Concept 3: Two direction gates, wall

The third concept is a gate that can, just like Concept 2, be accessed from both side of the closed payment border. It has doors in the middle of the gate, and a validator and display on both sides of the gate. Instead of an angled top of the cabinet, where the validator and display are located, it is flat with a small wall on the edge. This way, the display and validator are straight instead of on an angle, which can give a different usability while validating and receiving information, resulting in a slightly different walk flow. Moreover, the wall serves as a divider between the gates, preventing users from validating at the validator that is not connected to the doors they try to open. The interaction during validating and receiving information is fairly similar to the other concepts. However, this concept has a small LED strip between the validator and display, which will guide the user from the validator to the display by means of a moving light. When a user validates, the light of the validator briefly turns off (and back on again), which sets a light in motion that travels to the display which will show the user's information. The guiding light aims to pull users to the next touchpoint along the gate, in order to prevent users from standing still and thus obstructing the walk flow.

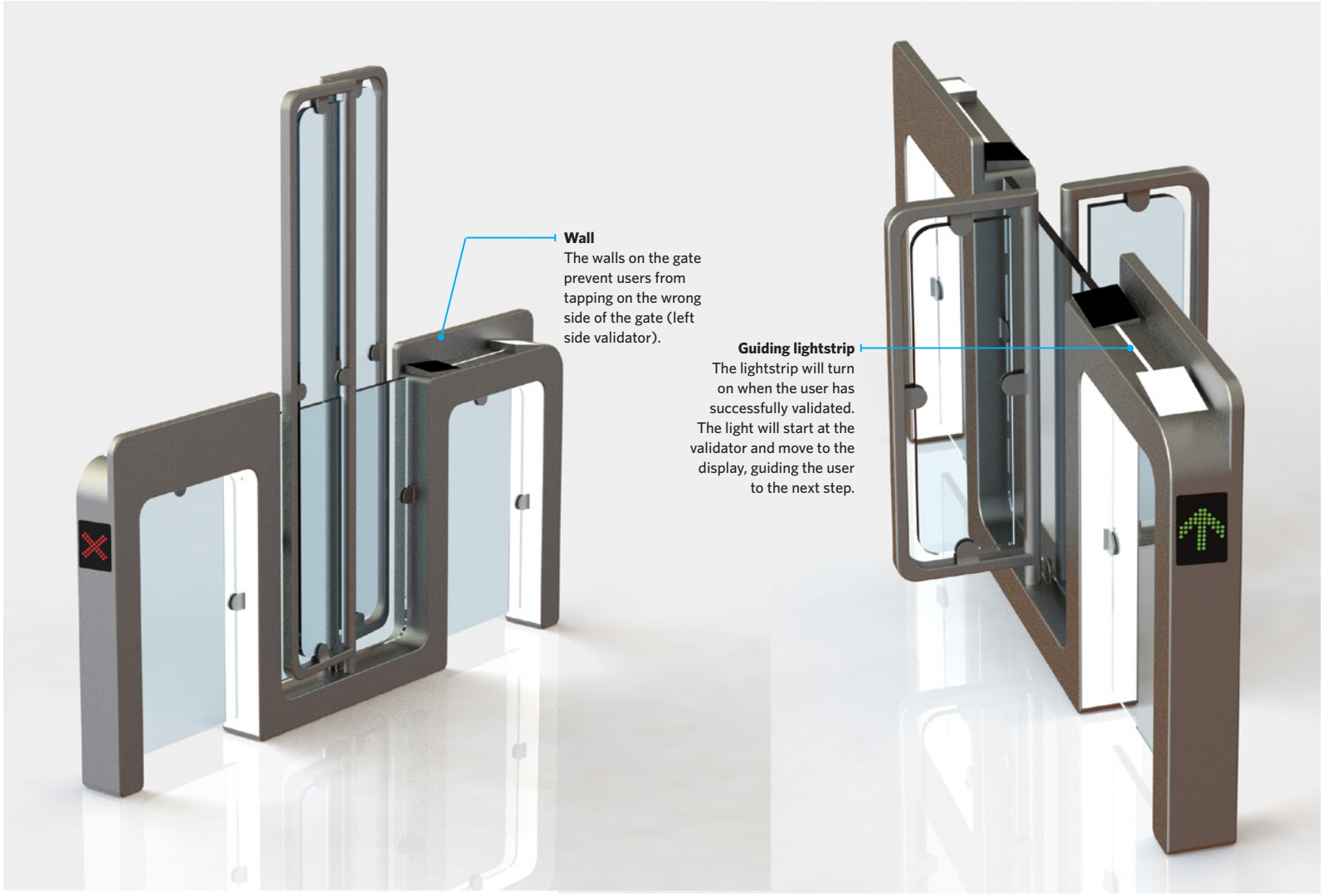
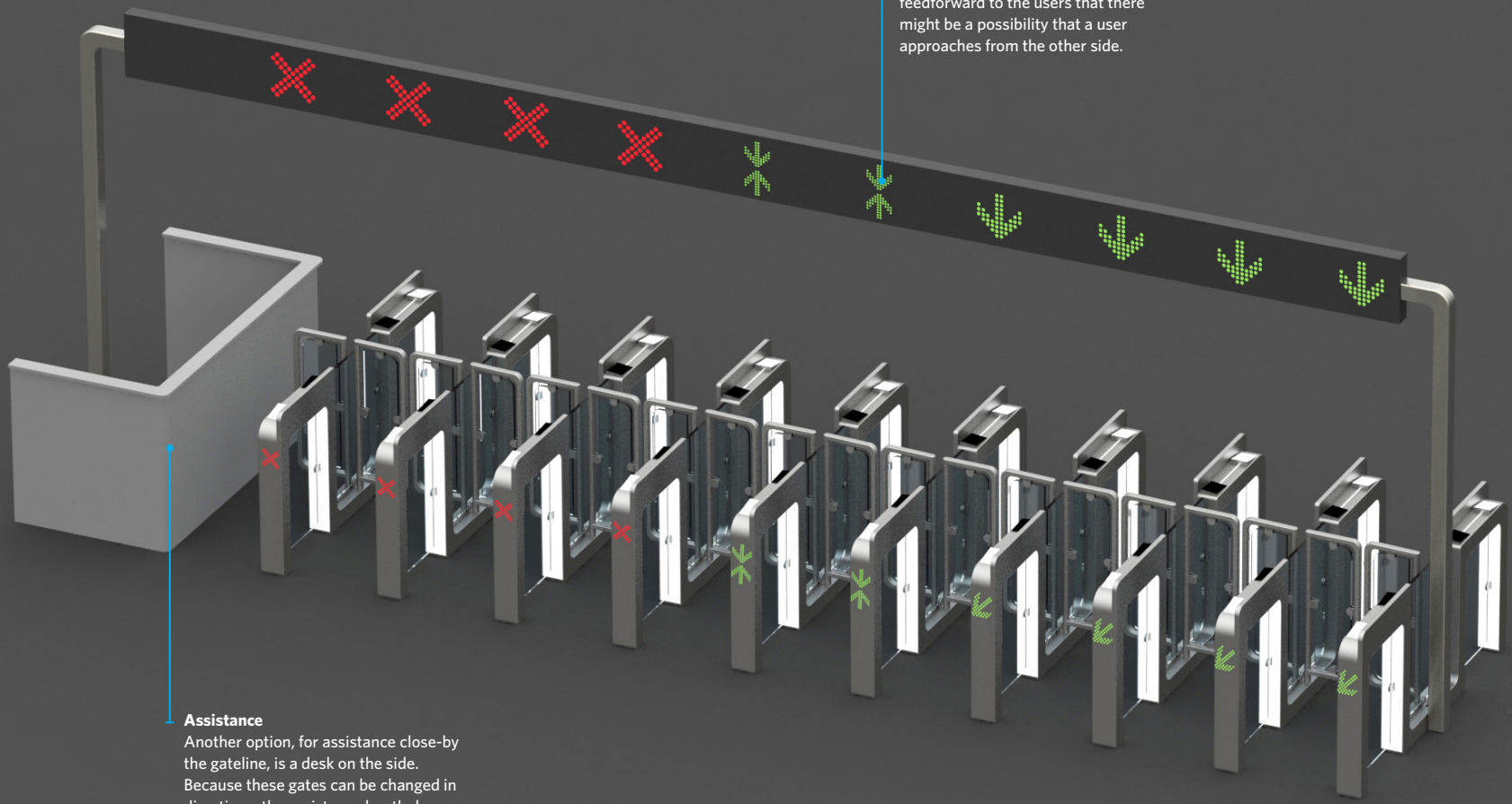
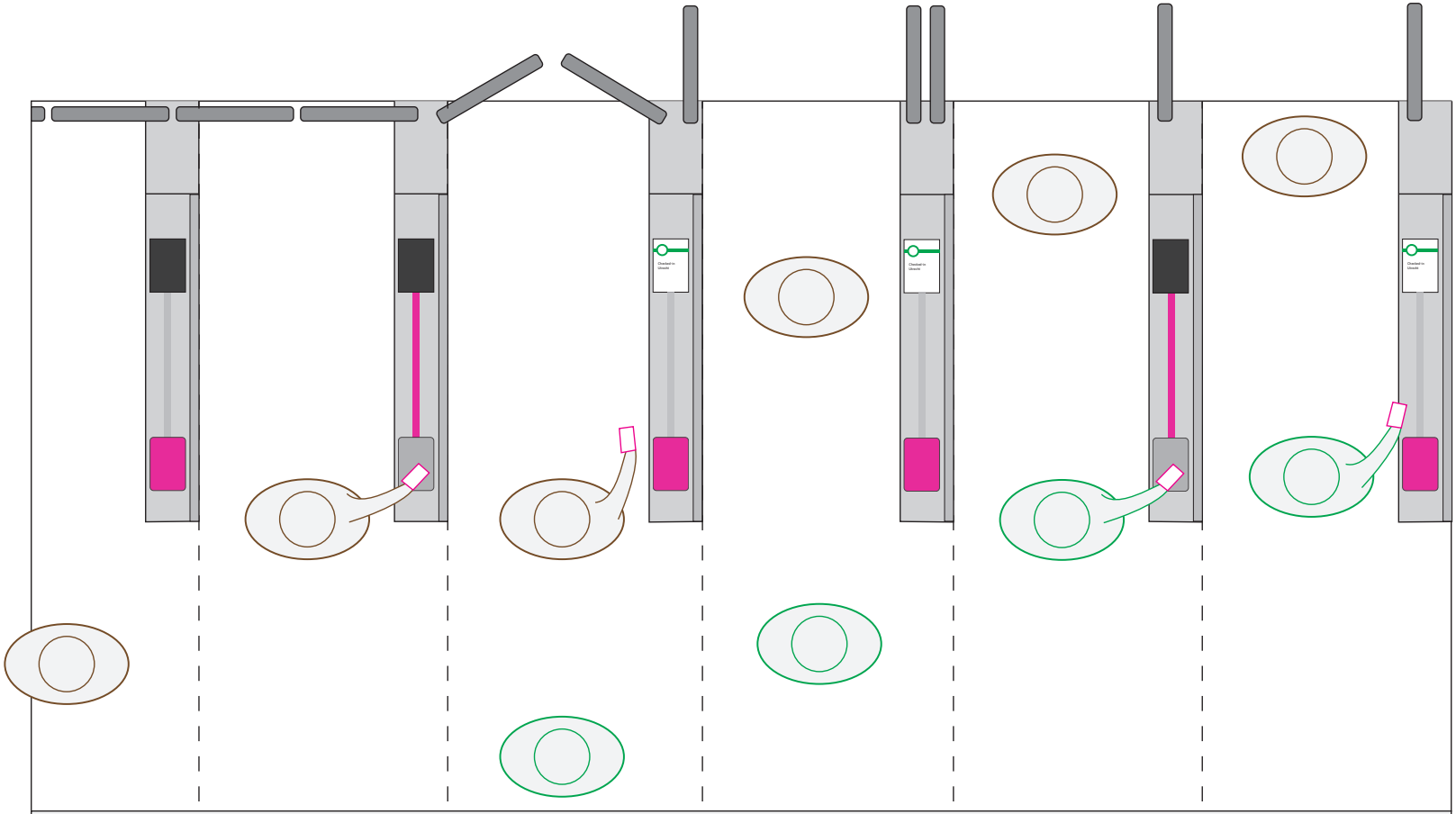


Figure 13. Digital rendering of the gate of Concept 3: two direction gates, wall.



Bi-directional
The green arrows on the overhead signage and the gates have a different shape when the gate is in the bi-directional setting. This gives feedforward to the users that there might be a possibility that a user approaches from the other side.

Assistance
Another option, for assistance close-by the gateline, is a desk on the side. Because these gates can be changed in directions, the assistance booth does not have to be in the middle to separate the in- and outward directions.



STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6
Default mode. A traveller approaches the gate.	The traveller touches his card on the validator. The light on the validator goes off briefly, and a light starts to move to the screen, and the validator light is back on again.	The screen displays the travellers' information. The doors open.	The first traveller continues walking through the gate. Another traveller approaches the gate.	The display still shows the first traveller's information. The second traveller taps his card on the validator. The light on the validator goes off briefly, and a light starts to move to the screen, and the validator light is back on again.	After the brief black screen, the second traveller sees his information on the display. He continues through the gate.

▲ Figure 14. Top view of the interaction between the user and the gate.

◀ Figure 15. Digital rendering of a gateline setup of Concept 3: two direction gates, wall.

3.3.4 Concept 4: Two direction gates, open on default

The last concept is radically different from the other three concepts: it has doors on either side of the gate that are open on default. Users will have to check in and out as usual, but the doors will not have to make a movement since they are already open. They only close when a user walks into the gate without validating. Since the doors are on the end of the gates instead of the middle, users will have a longer walking distance until the door, which gives it enough time to close before the user has attempted to walk through. Most of the users will check-in and check out in a regular fashion and maintenance costs can be saved if the doors will not have to open and closed all the time. Moreover, the walk flow is increased due to the fact that users would not have to wait for the doors to open. Also, the distance between the validator and display is larger compared to the second and third concept because there are no doors in the middle. In the current design of this concept there is only place for small doors, as opposed to the possibility of having high doors that the other concepts have. The fact that all gates are open on default will give it an open, inviting and friendly character that only closes for those users that try to misuse it. Furthermore, with the introduction of the new technology of be-in be-out, this concept would be the most fitting because the gate has more time to recognize and validate the user when he walks in.

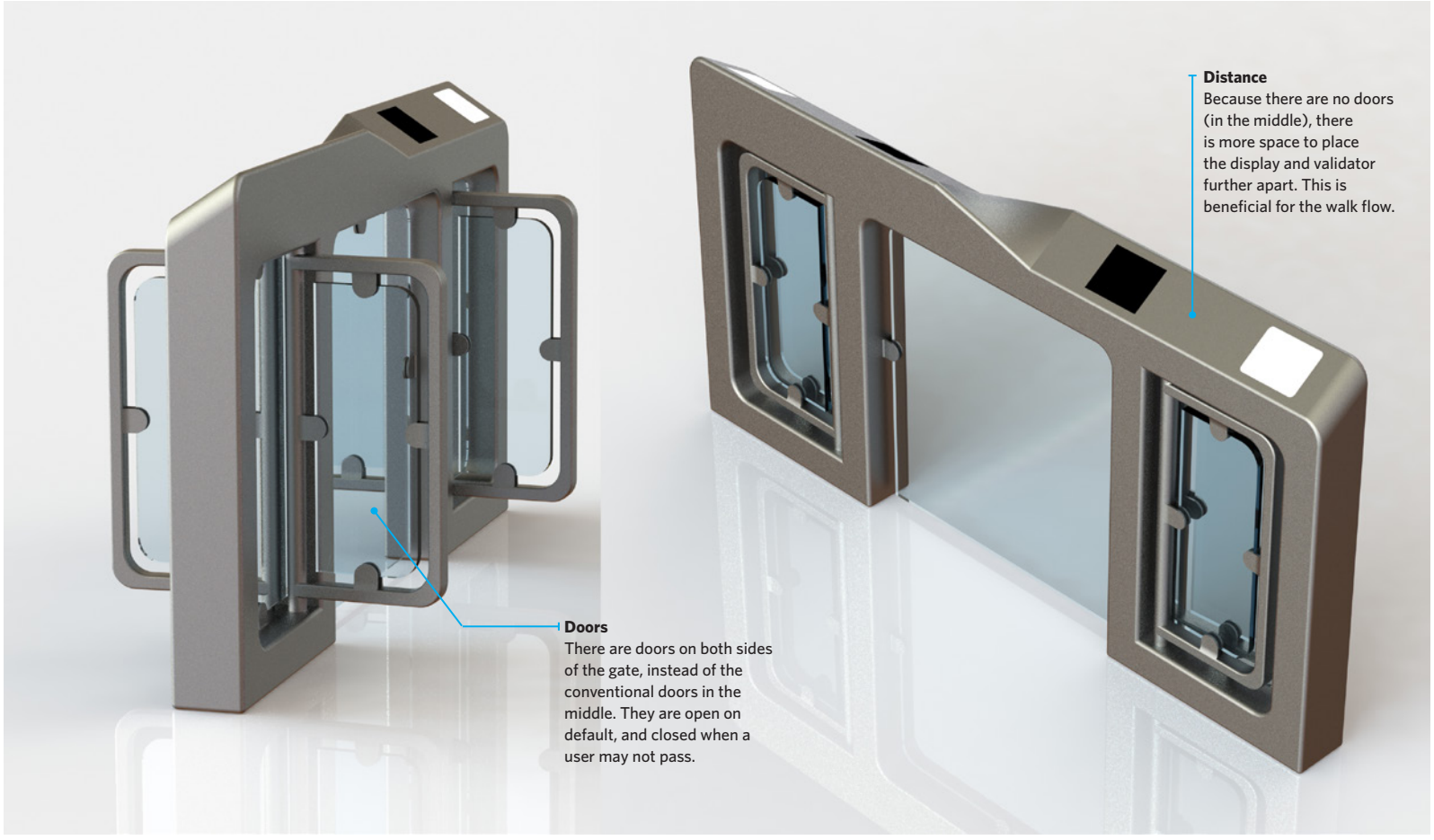
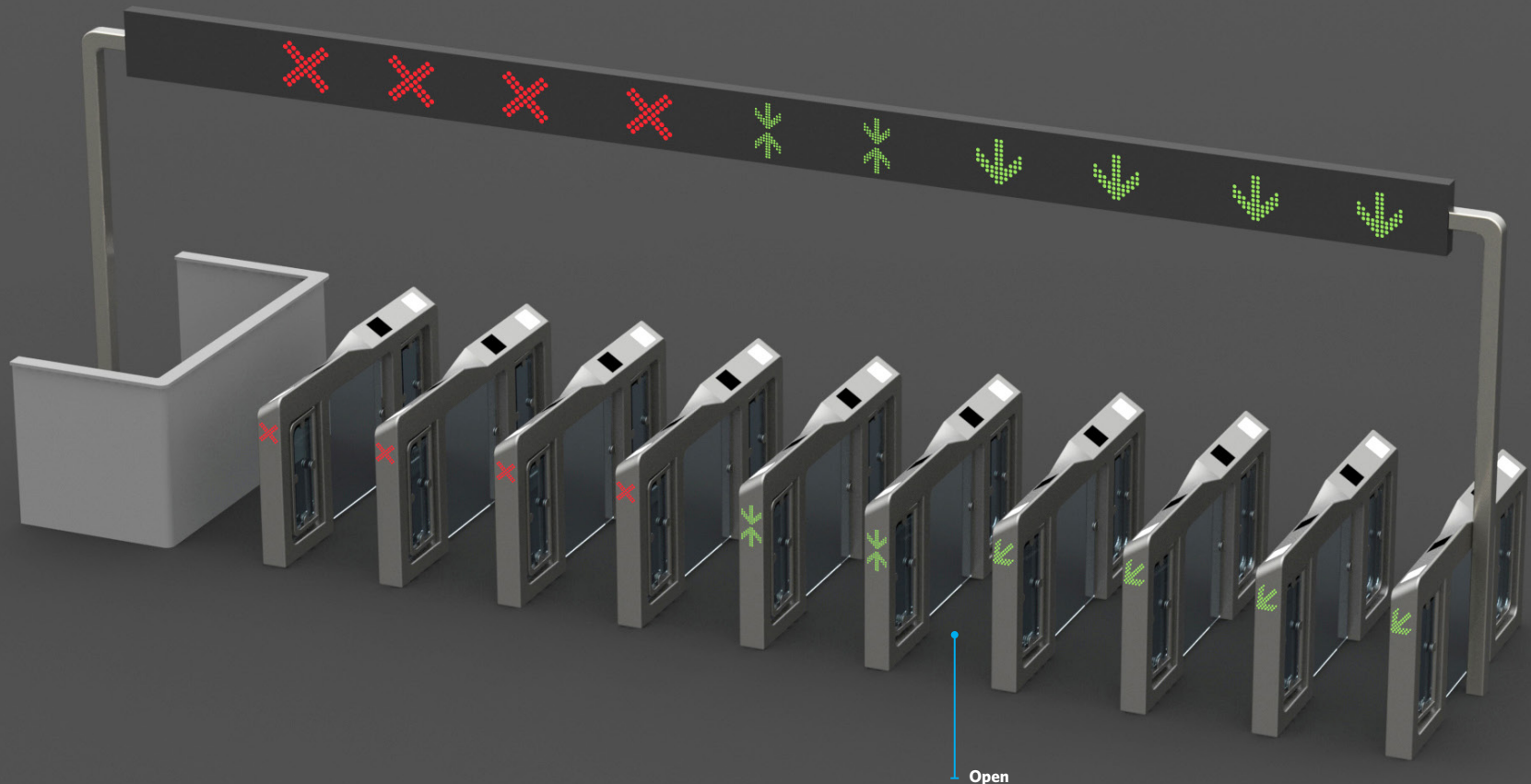
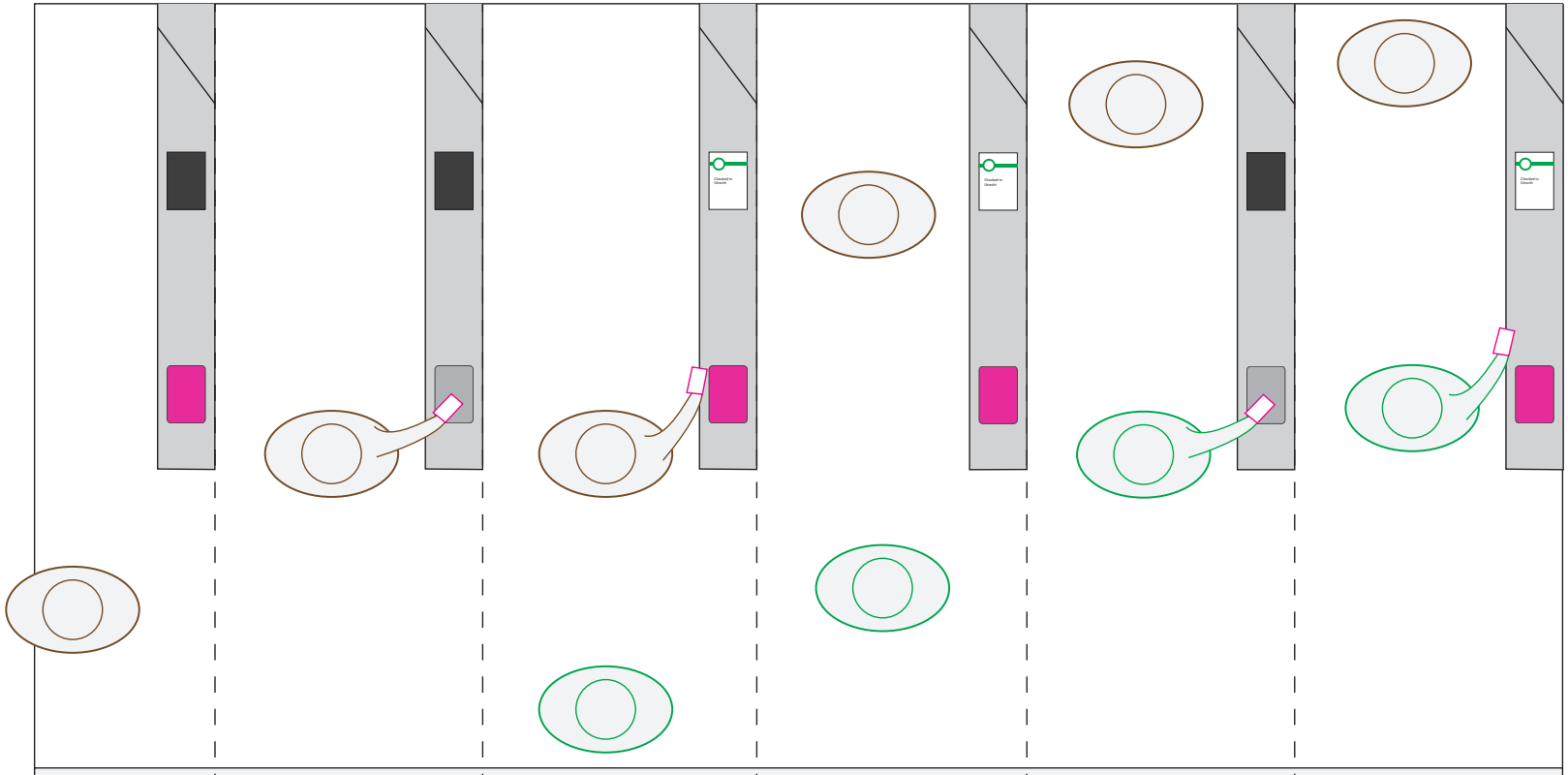


Figure 16. Digital rendering of the gate of Concept 4: two direction gates, open on default.



Open
The gateline with the doors open on default gives a much more friendly user experience and increases the walk flow, since users do not have to wait for the doors to open.



STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6
Default mode. A traveller approaches the gate.	The traveller touches his card on the validator. The light on the validator goes off briefly and back on again.	The screen displays the travellers' information. The doors open.	The first traveller continues walking through the gate. Another traveller approaches the gate.	The display still shows the first traveller's information. The second traveller taps his card on the validator. The validator briefly turns off and on and the display briefly shows a black screen.	After the brief black screen, the second traveller sees his information on the display. He continues through the gate.

▲ Figure 17. Top view of the interaction between the user and the gate.

◀ Figure 18. Digital rendering of a gateline setup of Concept 4: two direction gates, open on default.

3.3.5 Error messages

All concepts will give feedback when a user encounters a problem (with the validation of the card), see Figure 19. The displays will turn red, the colour of error, and the lights of the validators do the same. The display will tell the user what the problem is and how it can be solved.

3.4 CONCLUSION

This chapter has brought four concepts to light which combat the usability problems of users. The concepts share several design aspects, but also differentiate on a fundamental basis. In the next chapter, these four concepts will be evaluated with the stakeholders, to find out their considerations regarding the concepts and closed payment borders in general. Ultimately, one of these concepts will be chosen as the basis for the final design proposition of a user-centered closed payment border.

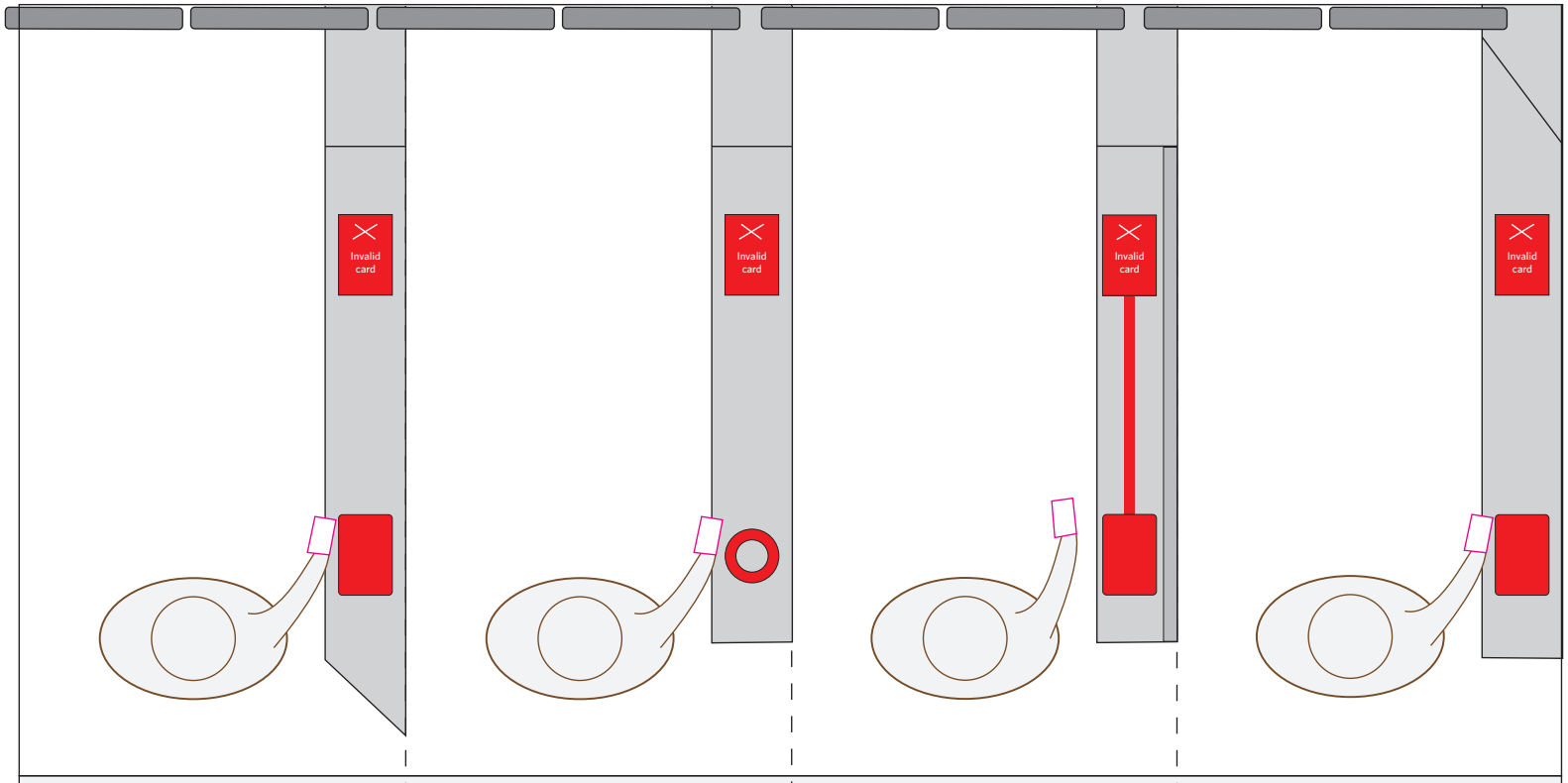


Figure 19. Top view of the error messages the concepts will give to the users as feedback.


4

4. Concept selection

4.1 INTRODUCTION

In the last chapter, four closed payment border concepts emerged from ideation. These concepts need to be evaluated and discussed in order to select one concept for further development. In this chapter, the four proposed concepts are evaluated with stakeholders in order to find out their concerns and wishes. Ultimately, these considerations will be taken into account, along with the criteria found from the field research during the analysis phase, to assess the concepts in order to select the most fitting proposal for further development.

Research questions

- What are the considerations for the stakeholders regarding the design of the gates and gatelines?
- How do the concepts compare to each other, regarding the criteria found from the user research and the considerations of the stakeholders?
- Which features are considered optimal in the concepts?

4.2 METHOD

Interviews with stakeholders were done to gain a better understanding of their considerations and concerns regarding the proposed concepts for a user-centered redesign of 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. The concepts were discussed one-by-one, whereby each concept was explained by its design aspects, gate line setting and interaction. Furthermore, the positive and negative aspects of the design were proposed. 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.

Since some stakeholders brought in a few extra people to get familiar with this project and to give their viewpoints on the concepts as well, a presentation (or a short recap) about the analysis phase results was given in order to have all people who give feedback on the concepts on the same level of understanding.

Stimulus material

During these interviews with the stakeholders, synthesizing material was used to give a better understanding and feel for the four concepts. The synthesizing material consisted of 3D-printed 1:10 scale physical models of the concepts (see Figure 20) and printed digital renderings of the gate and gate line per concept, including a graphical representation of a top view sequence of the interaction with the gate (see Figure 21).

4.3 PROJECT PARTNER FEEDBACK ON CONCEPTS

An explanation of each concept proposal with its design aspects and the reasoning behind it will be given, following with the feedback that has been given on it by the stakeholders.

Common features among all concepts

All concepts have an assistance booth, either on the side or in the middle of the gate line, and overhead signage above the gates. From

the research it was found that users prefer personal, close-by help for their problems at the gate line. The usage of the assistance booth inside the gate line was embraced by only one stakeholder, whom mentioned that they will test this themselves in one of their stations. Other stakeholders did not emphasize this importance and one of them even suggested that they will aim to eventually take the personnel out of the stations.

The overhead signage proved very guiding for the users in the research, and thus was incorporated into the concepts. The stakeholders all agreed on its positive effect on the usage and thus marked this aspect as something they would like to incorporate. The use of a different indication of the bi-directional setting of a gate, indicated by two opposing green arrows on the overhead signage and front of the gate, will give users recognition that there might be other users coming from the other side of the gate line using the same gate. This indication was considered a positive improvement by the stakeholders.

Since all concepts will use 3D scanning technology (as used in the new Noord-Zuidlijn gates in Amsterdam), it opens space in the sides of the gates concepts since the sensors do not have to be in the side of the cabinet anymore. If the components can fit in the proposed bodies of the concepts, glass and light can be incorporated in the sides of the gates to give a open character and gives a possibility of using coloured light. This can be used, for instance, to signal the colours of the operator of the gate or show error colours when a user encounters an error.

The concepts do not have any operator indications on them, because for the travellers it is ideal if they do not have to choose between the gates of operators: the idea of single check-in check out. All travellers can use any of the gates in the gate line instead of looking for the gate of the operator they have used, in case the gate line has gates of multiple operators. In case 'single check-in check out' is not implemented yet, operator indications will have to be added to the final design. For instance, colours of the operator under the overhead signage and around the validator, in order to communicate it from a distance and up close.

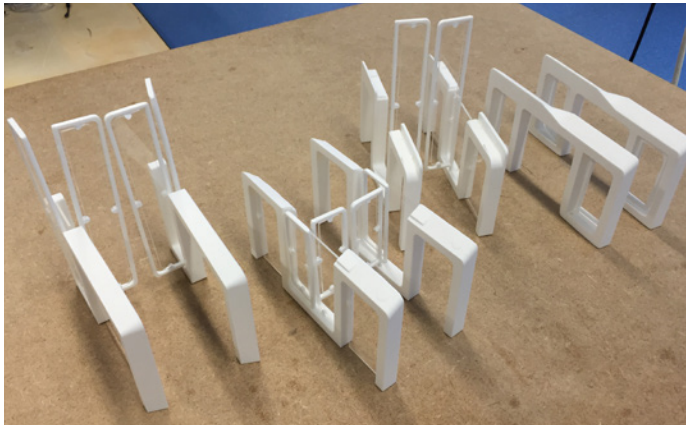


Figure 20. 3D-printed 1:10 scale models of the four concepts used as stimulus material for the stakeholder feedback sessions.

Figure 21. Printed digital renderings of the gate and gate line per concept, including a graphical representation of a top view sequence of the interaction with the gate.

Concept 1: Single direction gates

The main drawback of this concept for the stakeholders is the inability to switch directions of the gate, depending on the peak time capacity. For instance, when many users will come out of the train or metro in the morning at a specific gate line, they want to be able to switch the inward and outward directions in order to accommodate the capacity needed to let all users through the gate line safely. This concept, however, boasts better guidance, offers less choices to the users, and has a longer distance between validator, display and doors, which would empower a better walk flow (and thus throughput) of the gate line and therefore would perhaps not need a switchable setting. The interaction with the validator and display was considered by the stakeholders as a very positive aspect and a improvement of the current system.

Concept 2: Two direction gates, angle

This concept comes the most close to the current system and was one of the reasons that this concept was most preferable. The stakeholders recognized the improved design aspects iterated from the research and mostly liked having the ability of switching directions and the possibility to easily fit this concept in the existing (small, medium and large) stations. Moreover, blind users should be able to have access to a bi-directional gate due to the guidance for these users on the floor.

Concept 3: Two direction gates, wall

The stakeholders did not mind the difference between Concept 2 and 3, since the biggest advantage (for them) is the bi-directional possibility. The guiding light between the validator and display was well received by the stakeholders, and they notice the positive impact it can have. This aspect can be incorporated in all concepts. When choosing between the angled and 'walled' top of the cabinet, one argument of a stakeholder was that an angled top would have less/none stuff or trash on it that users leave behind.

Concept 4: Two direction gates, open on default

Some stakeholders were not positive about this concept due to their requirement of having high doors on all their gates. However, it was acknowledged that having doors at the end of the gate and open on default would be the best for the walk flow, as well as a reduction in the maintenance costs. Furthermore, some stakeholders recognized the benefit of this gate in terms of the be-in be-out adaptability. Therefore they considered this concept as a long term possibility instead of a short term possibility.

4.4 CRITERIA FOR CONCEPT ASSESSMENT

Several criteria on which the concepts will be assessed come from the research done in the analysis phase of this project (Groot Obbink, 2016). These criteria are based on the usage patterns and issues that travellers encountered, which are important to be improved for a better user experience and efficiency of the closed payment border.

- *Flow/speed*. This criteria is aimed at the speed and throughput of travellers going through the gates in the closed payment border. This is mostly concerned with the placement of the validator, display and doors on the gate, as those were the critical points in the analysis.
- *UI refresh / interaction*. During the analysis phase it was found that the interface does not give enough differentiation between the check-in/out of the different users, which gave them a feeling of insecureness. Moreover, some users did not know where to validate and some users waited before the gate until it went back into its starting position while they could have used the gate already.
- *Throughput capacity*. This is concerned with how well the closed payment border can handle the peak capacity of travellers. The concepts are judged on their ability to facilitate this on both the gate line and gate level.
- *Guiding towards gate*. Some travellers were observed to have trouble finding the correct gate they can use, which resulted in a disruption

in the flow and throughput of the closed payment border. Aspects considered here are the layout of the gate line, the overhead signage and the feed forward on the gates themselves.

- *Welcoming/inviting.* In terms of user experience, the closed payment border should be welcoming to users. This is interpreted as which impression the gate line gives in terms of openness to the users and how the gate line makes it comfortable for them to find their way through the closed payment border.

More criteria to consider were found through the stakeholder interviews, which will also be used to access the concepts. Even though the user-centered criteria were the main focus of the designs, the criteria posed by the stakeholders, the context and technology should be considered as well.

- *Bi-directional possibility.* The gate lines of the concepts should have a gate with a bi-directional possibility in order to be able to accommodate the visually impaired users, who follow a line on the floor towards a bi-directional gate. There should only be one line to follow that goes through the closed payment border, in order to allow these users to access it from both sides of the border.
- *Be-in Be-out proof.* One of the newest technologies, regarding paying in public transport, that is aimed to be implemented in the future is Be-in Be-out. This method of payment relies on location-based technology, whereby travellers would not have to actively validate (check-in or check out) anymore. This implies that the closed payment border should be able to recognize an approaching user and open the doors of a gate this user.
- *Barrier for entry.* Some stakeholders stressed the fact that the gates they operate need to have high doors, in order to prevent misuse. This criteria also concerns how well the closed payment border tries to prevent users from going into the gates which they should (and can)not use.
- *Maintenance.* As this is an aspect of the closed payment border that costs the public transport operators a lot of resources, they are hope to keep this as low as possible. Furthermore, performing maintenance on gates means temporary downtime and less capacity in the gate line.
- *Fit with current system.* Not only is it comfortable for the stakeholders to be able to use the concepts in the current infrastructure as possible, the travellers will also have to adapt and learn the new closed payment border if one of the concepts will be introduced.

4.5 CONCEPT COMPARISON BASED ON CRITERIA

The concepts were assessed on the previously proposed criteria by rating every aspect between +3 to -3, depending on how well the concepts scores on that criterion. As Table 1 shows, the concepts are situate on the horizontal axis and the criteria for assessment on the vertical axis. The green and red blocks represent how well the concepts score on the criteria, and the concept that fits each criteria the best is shown on the lowest row in the table. Concepts 2 and 3 are combined in the table, since they were considered nearly identical and were scored that way as well.

Flow/speed

The distance between the validator, display and doors along the cabinet of the gate is evident to the walk flow that users will have. Concept 2/3 embodies this well, but Concept 1 has a longer walk-in due to its single direction build and will thus provide a better flow for the users. Concept 4 also has a longer walk-in and there are (on default) no doors that need to open for the users, thus also scoring well on this criterion.

Table 1. An overview of the criteria that have been considered for the concept assessment and how well the concepts score on these criteria.

		Criteria for concept assessment										
	rating	Flow/speed	UI refresh / interaction	Throughput capacity	Guiding towards gate	Welcoming / inviting	Bi-direction-al possibility	Be-in Be-out proof	Barrier for entry	Mainte-nance	Fit with current situation	*grade*
Concept 1 *Single direction gates*	+3											+11
	+2											
	+1											
	-1											
	-2											
	-3											
Concept 2/3 *Two direction gates, angle & wall*	+3											+17
	+2											
	+1											
	-1											
	-2											
	-3											
Concept 4 *Two direction gates, open on default*	+3											+14
	+2											
	+1											
	-1											
	-2											
	-3											
best concept per criteria		1/4	2/3	4	1	4	2/3	4	1	4	2/3	

UI refresh / interaction

The UI works similarly among all concepts and it makes a clear improvement compared to the current system. The guiding light between the validator and screen will give the third concept an even better interaction between the users and UI and therefore scores higher. However, this aspect can be added to all concepts.

Throughput capacity

The first concept has the drawback that the transport operators cannot change the direction settings due to the single directional build of the gate, in order to accommodate the influx of the peak amount of travellers. However, the clear separation of in- and outward gates in the gate line and the longer distance between validator, display and doors of this concept are aimed to accommodate a higher throughput. Compared to the first concept, Concept 2/3 can be set in different directions by the transport operators but the distance to the doors is shorter. The last concept can be set in any direction and has doors that are open on default, which is the most ideal for a high throughput capacity.

Guiding towards gate

The overhead signage in the gate lines of all concepts helps guiding travellers to the correct gate. The first concept has the best guidance for travellers of all concepts, due to the separation of in- and outward gates (right side is always the way to go) and the shape of the gate: it has one side that communicates a blockade and one side that is open and inviting.

Welcoming/inviting

The fourth concept scores the highest due to its open setting in its default mode. This gives users a transparent view of the closed payment border which invites users to go through instead of putting up a wall. The first concepts scores better on this criterion than the second/third concept, because the open side of the gate line is more clearly communicated with the users. The shape of the single directional gates is more inviting than of those with the doors in the middle.

Bi-directional possibility

The concept of the single direction gates does not allow for a bi-directional setting. The only way to guide visually impaired users through this gate line is by having two lines on the floor, one for inward and one for outward, which might confuse them and is thus far from ideal. Concept 2/3 scores best on this criterion because the fourth concept might have trouble with the movement of the doors when users walk in from both sides at the same time, something the concepts with doors in the middle would have less problems with.

Be-in Be-out proof

When this technology would be widely implemented, users will be able to walk through the closed payment border without having to actively perform any action. This means the system should recognize the user and open the doors for this user. The fourth concept would best fit this technology, due to its long walk-in and open doors. The first concept also has a long walk-in, which gives the system more time to validate the user before he walks into the doors. With Concept 2/3 this length is shorter, because the doors are in the middle, and users might need to wait in front of the doors before the system has noticed which user needs to be validated for which gate.

Barrier for entry

The first concept poses as the best barrier for entry due to its single

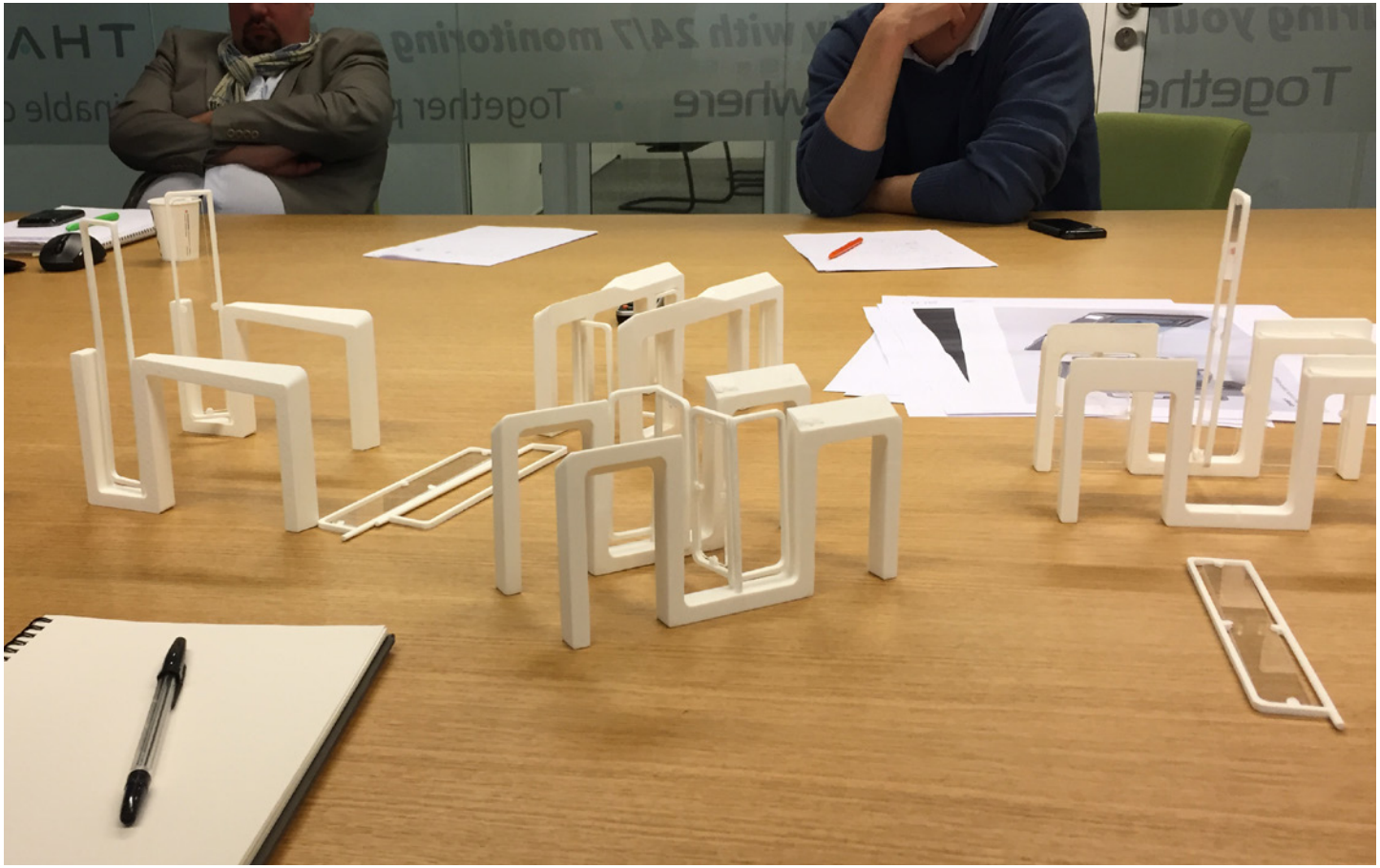


Figure 22. Stimulus material used during one of the stakeholder meetings.

direction gate shape, which gives feed forward to the users that the left side of the gate line cannot be used and the right side is used for entry. Concept 2/3 also scores well because it supports the high doors in order to keep fare evaders out. However, users could still walk into the gate on the wrong side (without any result). The fourth concept scores the worst on this criterion due to the fact that the current design of this concept does not have high doors. This might allow some fare evaders to jump over the gate doors, especially when there is no supervision on the gate line by station staff.

Maintenance

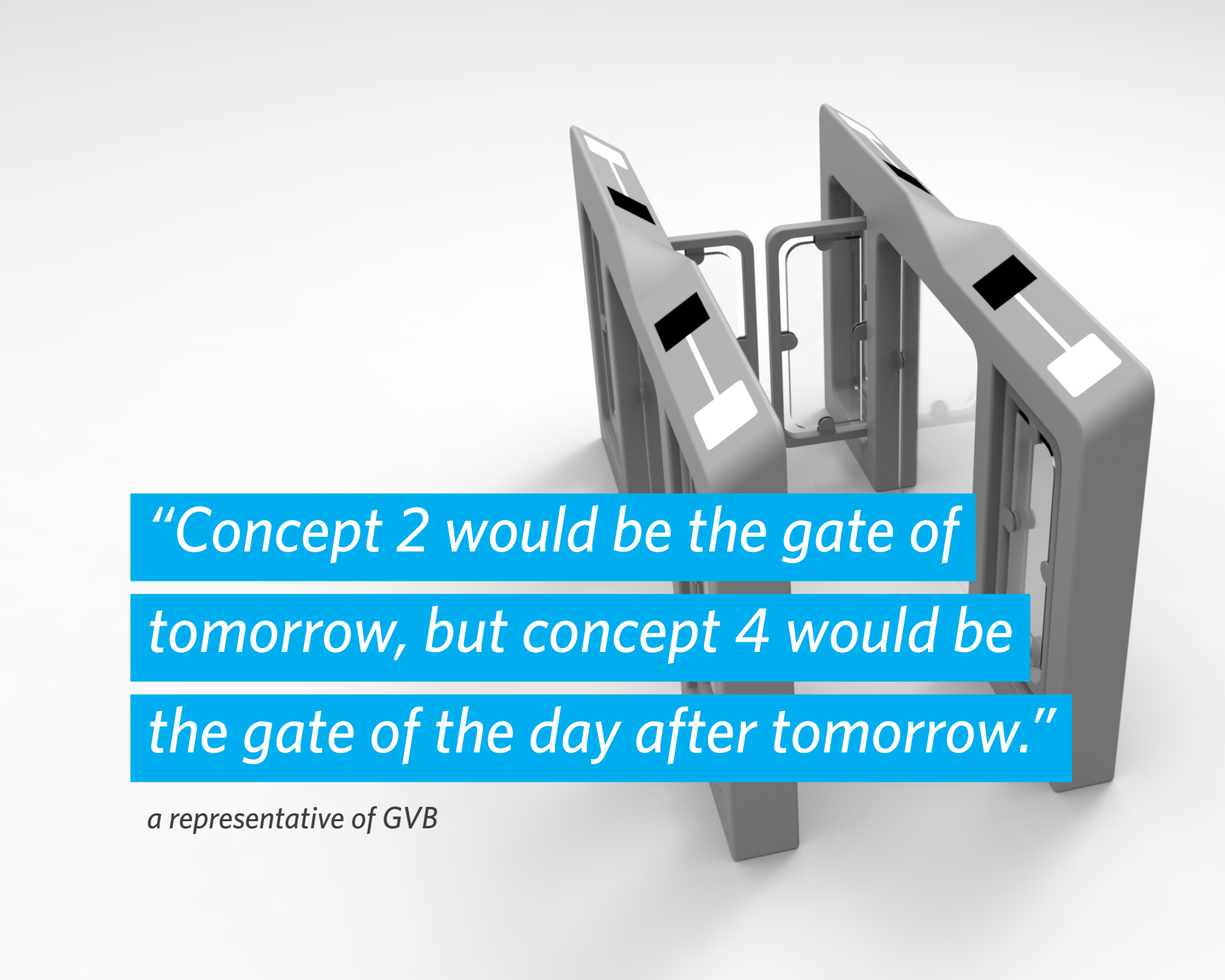
Concept 1 and 2/3 do not differ from the current system in terms of door movements, and thus in maintenance costs. Concept 4, however, only closes its doors when a person tries to enter without validating. Since nearly all users validate when going through the closed payment border, the doors would not have to make many movements and the motors will thus have less wear and tear. This would result in a massive reduction in maintenance costs.

Fit with current situation

Concept 2/3 would fit best with the current situation of the closed payment border. The layout of the gate it nearly identical for the infrastructure and users will know how to use these gates because they have gotten used to it. Concept 1 would need some adjustments to the infrastructure and users need to get used to the new design of the gate and gate line. The last concept would be the least fitting with the current system, especially due to the doors that are open on default and the users will have to get used to that.

4.6 CONCLUSION

The four concepts proposed in the previous chapter have been assessed on criteria from the analysis phase and the stakeholder meetings. From this assessment, the concept with the doors in the middle (Concept 2/3) seems to have the best aspects, mostly affected by the criteria set by the stakeholders. The concept that is open on default (Concept 4) scores best on the criteria set by the user-centered perspective from the analysis phase of this project. For this project, the concept with doors open on default (Concept 4) will be looked into further. This concept has many aspects that improve the usability and user experience and overcomes the usage issues found in the field research in the analysis phase. During the stakeholder meetings it was mentioned several times that Concept 2/3 fits best in a short term perspective, and the fourth concept fits best in a long term perspective due to its adaptability for 'be-in be-out' and all-round performance on the user-centered criteria. Since this project aims to find integral solutions that look years into the future, an exploration will be done with Concept 4. When the design of Concept 4 can show it can overcome the aspects that scored negatively in the comparison, this can be a integral, user-centered closed payment border for the future.



"Concept 2 would be the gate of tomorrow, but concept 4 would be the gate of the day after tomorrow."

a representative of GVB


5
Trein
NS
Metro
RET
RET
Metro
GVB

5. Design refinement

5.1 INTRODUCTION

The concept chosen in the previous chapter has to be developed into a design. Several aspects from other concepts were positively evaluated and can be incorporated into this design as well. It is known which design aspects are important for users and which aspects for stakeholders. This chapter will show the considerations and development of the concept to a design, which will be evaluated with users in the next chapter.

5.2 ASPECTS FOR REFINEMENT

Several design aspects have to be developed further, in order to bring the concept to a design level. These aspects, such as positive elements from other concepts, detailing features and how the design works, will be elaborated and the considerations will be explained. It should be noted, however, that the creative process is iterative and the explanations here mostly give the general story of the development of each aspect, not all of the details and ideas.

High doors

One of the design aspects that the stakeholders thought was important is the ability to have high doors in the gate. The concept has low doors underneath the body of the gate and adding high doors would make the placing of the user interface above the doors practically impossible. After some trying out with high door ideas on the concept (see Appendix A), it was chosen to continue this development with the low doors version of the gate. The focus of this project was to improve the user experience and efficiency of the closed payment border, so the low doors version was further developed to explore other design features that help reach this focus, rather than make a gate that aims to keep people out. A high doors version of the final design will be proposed in the end of this project, in order to show how it might be possible to implement high doors into the design.

Chamfered front on the gate

During the concept comparison, the chamfered front shape on the gate from Concept 1 was recognized as having a positive effect on the guiding ability of the gate. Having a chamfered front on the gate would guide users better to the entrance of the gate they should take. This aspect has therefore been implemented into the design.

Validator

The design of the validator has been detailed further. In the concept phase it was know that the validator should have light to attract users, that it should give feedback on validation and that it should be able to accept all payment options. This needs to be possible physically, so the barcode reader works with different technology than the card readers. Therefore, the validator should have glass in the middle with a reader in the bottom of the validator. This reader has a static white

Figure 23. Some ideation on the development and detailing of the validator.

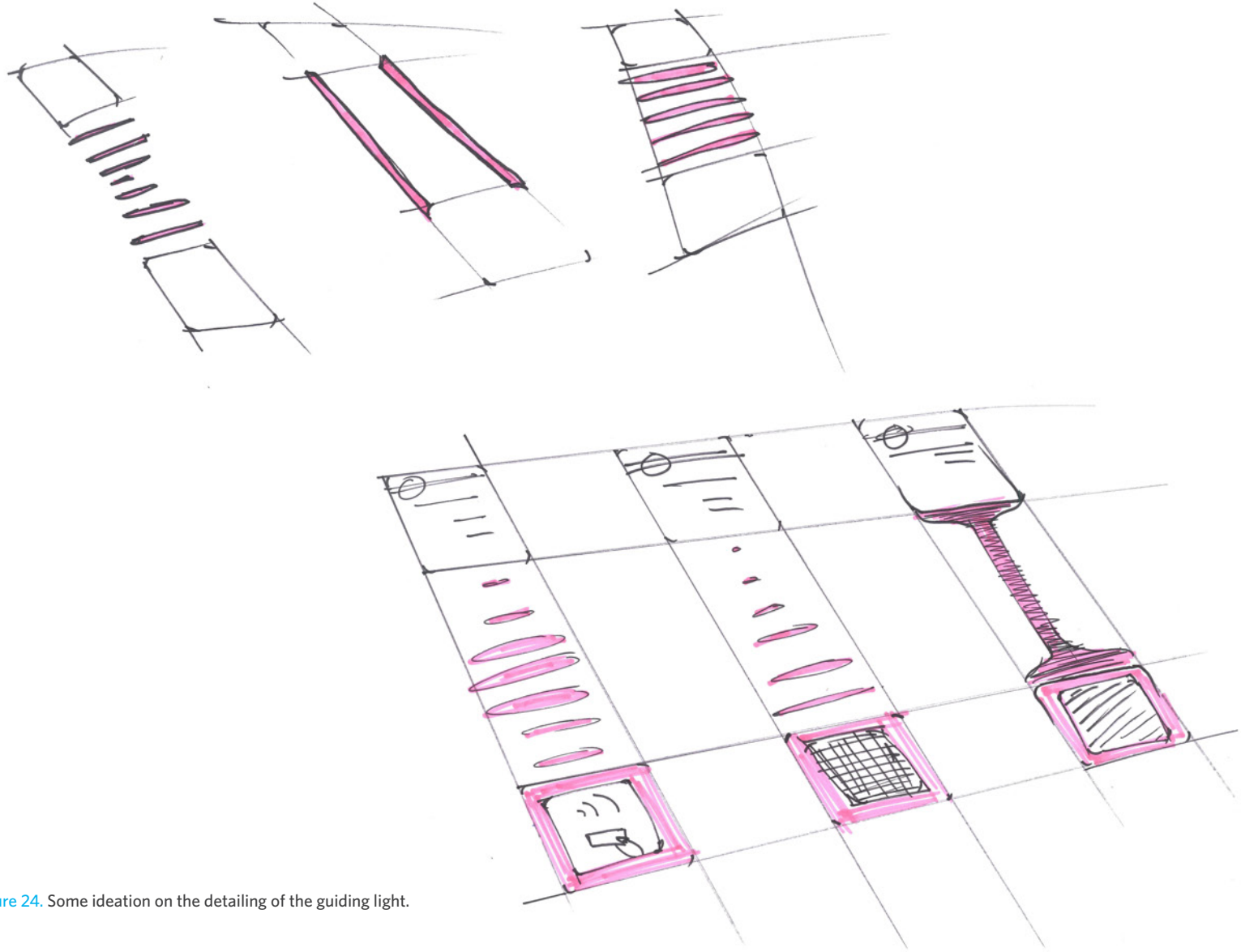


Figure 24. Some ideation on the detailing of the guiding light.

light coming from the bottom of the validator. The validator should still give feedback to users on validation, so a light ring around the glass would fulfil this purpose. A pink colour was chosen to indicate OV-Betalen (collective name for all payment in public transport) and because it is a striking, contrasting colour with the rest of the gate. Lastly, the payment options should be made clear with icons to let users know what they can use to validate. The shape of the validator was made rectangular with round edges, in unity with the shape of the gate. It is about 10x15 cm, in order to have a large enough space for people to hold their card while they are still on the move.

Guiding light

The lightstrip between the validator and display of Concept 3 was evaluated by the stakeholders as an interesting aspect and it could have an positive impact on the throughput of the gate, because it aims to guide users after the validation to the next step in using the gate: getting their information. This aspect was incorporated into the chosen concept and detailed further. Several guiding light design ideas were created, varying in the size and shape of the light (see Figure 24). Ultimately, the guiding light was chosen to be a thin and straight line between the validator and display, with small curvature near the attached sides. This design element should have a supportive function, and not become a gimmick. Therefore, it should not have any bells and whistles. This design aims to convey a direct/ straight message, with the small curves at the beginning to simulate that light/information is absorbed from the validator and expanded at the displays (similar to the idea on the bottom right of Figure 24).

Display messages

After validation has been done, the display will show a message to communicate with the user what has happened. Several things can happen at the validation: the validation is successful, the card has not enough money and the card does not work. Because the chosen concept is open on default, it would be possible for users to walk in without validation. The gate should then close and communicate a message at the display as to what has happened. Lastly, the gate should have a default message, so users get feed forward that a gate can be used.

Figure 25. Iterations on the layout of the default screen.

How the gate works

Many design aspects on the concept, like the validator light, the display and the guiding light, can give feedback on the actions of the user at the gate. The lights underneath the gate can be used for this as well; this was an design aspect from other concepts (e.g. Concept 3) that can be incorporated in the chosen concept. As shown in chapter 3.3.5, the whole user interface gives feedback when, for instance, and error occurs. How the gate gives feedback in the different states (e.g. successful validation or an error), is explained with illustrations of the usage scenarios in Appendix B.

Materialization

The chosen concept was made of metal, similarly to the gates in the current system in The Netherlands. However, in order to improve the

user experience and to make the material fit the open and friendly character of the new gate design, it is chosen to use hardened plastic as a material. During the analysis phase of this project (Groot Obbink, 2016) this material was found on the newest type of gate found in Hong Kong. This material could give a much less industrial, machine-like feeling to users, when they interact with the gates. It should be kept in mind that the material should be durable and strong enough to survive people who vandalize the gates.

Height of the gate

The height of the validator and display are determining factors for the shape of the gate. This height must be between 0.9 and 1.2 meters from the ground (ITS, 2011). It is also assumed that it is most comfortable for users when the validator is below elbow height, since (presumably) the wrist and arm can be mostly stay in a relaxed position. The elbow height of the smallest user group (60+ years old female) and the tallest user group (20-30 years old male) were found (DINED, 2004). The elbow of the smallest 5% of the smallest user group (60+ female, P5) was found being 91 cm from the ground, and the elbow of the largest 5% of the largest user group (20-30 male, P95) is 125 cm from the ground. Having the validator at an average of 100 cm height from the ground, this would accommodate most of the users to be able to validate while still holding the arm in a comfortable position. Since the validator is on an angle, because of the chamfered top of the gate, it would even be possible to validate at a height of about 97 cm to 103 cm.

Collages

Three collages were created to serve as inspiration on how several design aspects can look and be detailed (see all three in Appendix C). The topics of the three collages are persuading & directed light, contrasting colour, and flow. The collages contain examples of products, architecture and art that are believed to represent or contain some aspects of the three topics. An example as to how the collages are used on the design: the body shape of the gate was detailed in same way as the architecture and products on the collage on the topic of 'flow' (see Figure 26).

Figure 26. One of the collages used as inspiration for the design.

Operator recognition

Any recognition of the operator of the gate was not present on the concepts, because it was believed that the concept of 'single check-in check out' would be used. That would mean every gate can be used to get in or out of a station, regardless of operator or modality. At stations with multiple operators (e.g. Amsterdam Amstel) this would mean that users do not have to choose between the gates of metro and train, but can take any gate they want. However, this concept will not be implemented in the near future, and therefore it is necessary to use recognition of the operator on the gates.

In the analysis phase it was found that users have too little recognition on the gates as to which operator it belongs, and thus at which gate the users need to check-in or out. At the gates in Japan it could be seen that the colour used by operators was clearly present at the gates and overhead, with them both being fully in the same colour. For instance, the monorail gates were purple, the gates of a certain train operator were green. This use of colour gives users better recognition as to which gate belongs to each operator, and will therefore be implemented in the design. Users have to know the operator of the gate before they start validation, otherwise it would be too late and they might have validated at the gate of the wrong operator. Therefore, recognition of the operator of the gate will be present at the overhead signage (recognition far away from the gateline) and on the gate, before the validator. This way, users will get feed forward at the orientation phase when they approach the gateline, and when they start their validation phase.

By using the colour of the operator as one of the feed forward aspects to indicate the operator of the gates, it is important to use distinctive colours per operator. This way, users will not get confused between operators and it will be better recognizable. Furthermore, the logo and name of the operator will be present on the colour. Lastly, since

Figure 27. An idea on how to use the colours of the operators on the gates, in combination with text and logos.

not every traveller knows the modality of the operator (e.g. GVB is metro), this should also be available on the gate in text.

During the iteration of this design aspect it became clear that the fixed colouring of the gate can make it less clear to users as to which gate can be used (inward direction) and which gates cannot (outward direction). It would be more effective if the gates only have colouring on the front of the gate near the validator that can be used to check-in or out. However, transport operators which directions of gates during rush hours to accommodate peak capacity, and therefore the static colouring on the gates would not work anymore. Ultimately it was chosen to use lightboxes that have light in the colour of the operator, that can be turned of or on depending on the direction of the gate. Furthermore, this element also gives feed forward to the traveller as to which gate can be used.


INFO
Informatie
trein
trein

Assistance options

During the concept phase, assistance booths were placed in the middle of the gateline or at the side of the gateline. When placed in the middle of the gateline, it can be used as a separation between inward and outward gates. Both these options can help travellers on both sides of the closed payment border, and have oversight on what travellers do around the gateline.

The info/SOS-pole, located at both sides of every gateline in the current system, was disregarded during the concept phase. During the analysis phase of this project it became evident that users prefer to talk to a person in order to get help, which explains the use of assistance booths in the gateline rather than a pole. However, the info/SOS-pole can be redesigned to make it more approachable, since nearly all users either do not use the current pole or do not even know it exists. An idea is to create a more personal pole (see Figure 28). The shape of the pole has some shape features of a person and it has a display at eye-height. This display will have a static image of a service employee and turn into a live feed of the service person in the control room when the button is pressed. The user can interact with the assistance person by talking to and seeing each other. This way, no assistance personnel have to be in the station, yet personal assistance can be provided from the control room somewhere else.

The assistance booths in the middle and on the side of the gateline should be the same height as the gates in the gateline, and as wide as one gate passage. This way, it fits as an integrated element in the gateline and the space of only one gate width is sacrificed. This size of the assistance booth could be big enough for an assistance person to stay in. Recognition for this booth is provided by a recognizable (info-)colour, and by signage in the same colour above the gateline.

◀ Figure 28. An idea for how a new design information pole could look.

These proposed assistance options will not be developed further than the idea level. See Appendix D for more images.

Figure 29. An idea for how a assistance booth in the middle of the gateline could look.

5.3 CONCLUSION

Up until now, the concept chosen in chapter 4 has been redesigned on several design aspects, leading to a design proposition for a new closed payment border. This chapter will conclude with an explanation of the proposed design and its elements, which will be used evaluated with participants in the usage evaluation in the next chapter.

Gate

The gates have doors on the front and back of the gate. These are open on default, and will only close when something is wrong. The doors are placed at the ends of the gate to accommodate the time it takes for them to close versus the time it takes for a user to reach the end. The front and top of the gate are chamfered, to clearly communicate with the users to which elements on the gate belong to the doorway they attempt to go through. Because the gates can be set to be used from either side, this chamfered shape is mirrored on both sides. The user interface on top of the gate consists of a validator, a guiding light and a display. The validator Has a light ring that shows a pink colour when the gate is on, and the validator (light) is off when the gate is off. It can accept all kinds of payment options available in public transport. Once the user has validated correctly, a light will move from the validator towards the display. This is done through the guiding light, which aims to pull the users' attention to the display after they have validated, in order to improve the throughput. The display will show a message as feedback on the validation. It also shows a default screen when a gate is on, and the display is black when it is off. Lastly, the gate gives feed forward to users about which gate can be used through the green arrows and the red crosses on the front of the gate, and through the lightboxes. These lightboxes can be turn on and off, depending on which gate is on or off, and also communicate the operator of the gate through the colour of the light and the logo with text.

Messages & error states

The gates are open on default. When a user validates correctly, he can walk through and a green 'In' screen is shown. When a user has insufficient money, the doors will close, the validator light, the guiding light and the light underneath the gate will become yellow, and the display will show the yellow message with the issue. The same will happen when a user has a problem with his card or walks in without validating, but then the lights will be red and the display will show one of the red messages. This way, the user gets clear feedback that something went wrong, that he cannot continue, and the screen shows the problem and what can be done about it.

Gateline

The gateline consists of many gates. Overhead signage is added above the gateline to communicate the operator of the gates and the direction of the gates to the user when he approaches from a distance. The overhead signage has the same arrow/cross and lightbox combination as the gates have on the front, and the gate and overhead are set in the same way. When the gate is off, the overhead signage above that gate is also turned off. This makes it clear for users which gates can be used and which operator they are from. The bi-directional (wide) gate has a green arrow that goes both ways, giving feed forward to users that the gate is bi-directional and that they thus can expect travellers from the opposite direction.

Chamfered shape
Guides users to use the validator of the gate they are standing in front of.

Guiding light
A moving light draws users from the validator to the display after validation.

Display
Shows messages to give feedback to users about their validation.

Logos validator
Logos of the different payment options are visible in the validator.

Validator
The light shows that it can accept a card when it is on. When the light is off, it communicates that this gate cannot be used.

Light underneath gate
The light underneath the gate is always on (white), and shows other colors as feedback on user's validation.


Default screen
Successful check-in
Insufficient money
Card problem
Illegal pass
Inchecken
bij de trein van NS
Houd uw vervoersbewijs boven de kaartlezer.
In
2e klasse
40% korting
Saldo te laag
Ga naar een oplaadpunt
Geen toegang
Ga naar het servicepunt
Geen toegang
Houd uw geldige vervoersbewijs boven het licht
Symbol
Main message
Suggested user action
White background, shows the gate is on.
Green colour communicates 'good'.
Red background is an error colour.
Display is off on the side the gate is off.

Lightbox overhead
The lightboxes on the overhead signage can be turned on and off, depending on the direction of the gate. It also communicates the operator of the gate through colour, logo and text.

Arrows & crosses
Present on both gate and overhead signage. Gives feed forward to users about the direction of the gate.

Bi-directional arrow
Shows the gate is bi-directional and a wide gate. Users can expect users coming from the other side.

Lightbox gate
Works together with the lightboxes on the overhead signage. Can be turned on and off. Indicates usable gate and operator.


6

6. User evaluation

6.1 INTRODUCTION

In the previous chapter, the concept chosen in chapter 4 was further developed into a design. This proposed design will be tested by evaluating it with users. This chapter first describes the methods that have been used to set up the user test, in terms of user test participants, user test location, and stimuli used, and finally the outcomes of the test.

6.1.1 Goal

The goal of the evaluation with users is to explore how the newly proposed design is experienced by users and if the design overcomes the usability problems found with the current closed payment border system, established in the analysis phase of this project. This usage evaluation expects to gain insights into the interaction with all interaction-levels of the closed payment border (see page 25) and the usage phases in the walk-flow pattern (see page 22), in order to create a comparative reflection on the usage pattern and usage problems found in the analysis of the current system.

6.1.2 Research questions

- How do users use / interact with the closed payment border?
- How do users experience the new design?
- What usage issues do users encounter and what causes them?
- What feed forward and feedback do the users identify while evaluating the new design?

6.2 METHOD

The evaluation is done in a qualitative manner: qualitative research is used to gain insights and answers to 'how' and 'why' questions in regards to the usage of the newly designed closed payment border. It aims at gaining rich insights and understanding the thoughts, expectations, attitudes and processes of the participants. Qualitative research methods used in this user evaluation are observations and semi-structured interviews according to a predefined set of tasks and topics.

Contextual fidelity

Because the newly designed closed payment border is not been built and implemented yet, stimuli are prepared to simulate the envisioned experience and usage that the design should convey. The users become participants, and the product-service combination becomes a prototype. The UI and gate interaction levels, and the validation and information usage phases, are tested with a full-scale, functional prototype of the gate. The gateline and environment interaction levels, and the orientation usage phase, are tested with the digital renderings and a virtual reality environment of a closed payment border in context.

6.2.1 Participants

Two user groups emerged from the analysis phase to have different usage patterns while using the closed payment border, namely frequent (see Table 2, P1-4) and infrequent users (see Table 2, P5-9). Since the new closed payment border is designed with an integral view, the usage patterns of both user groups should be improved and the usage problems reduced or eliminated. Therefore, the user test is done with four frequent travellers and five infrequent travellers. Every usage evaluation involved one participant, in order to gain rich insights into their experience and opinions on the design.

Frequent travellers are considered to come across a closed payment border 3 or more times per week. Infrequent users are considered to use the closed payment border about once per month or less. In order to be representative of the actual overall user population, the participant group has right- and left-handed participants, an equal ratio of women and men, and a homogeneous distribution of age.

Table 2. An overview of the participants and their age, sex, travel frequency and whether they are right or left handed.

Participant	Age	m/f	Travel frequency	Hand usage
P1	26	male	3 times per week	Right hand
P2	38	female	7 times per week	Right hand
P3	29	male	5 times per week	Right hand
P4	56	male	3 times per week	Right hand
P5	60	female	2 times per month	Right hand
P6	24	male	1 time per month	Right hand
P7	43	female	2 times per year	Left hand
P8	42	female	1 time per month	Right hand
P9	56	female	5 times per year	Right hand

6.2.2 Location

The usage evaluation is held in a test lab in the faculty of Industrial Design Engineering of the TU Delft. The room has two cameras and two microphones hanging from the ceiling, to be able to capture all that is being done and said in the usage evaluation. Furthermore, the room has a one-way mirror to the room next to it, where the camera displays and recording equipment is located. This way, observers could look into the usage evaluation from that room, either on the monitors or directly though the window.

6.2.3 Stimuli

Several stimuli are used during the usage evaluation for the participants to gain a rich feeling of the proposed design, in order to evoke a stronger and more reliable experience.

Gate prototype

A full-scale functioning prototype of the gate has been built for participants to use during the evaluation (see also Appendix E). By using a functional prototype, it is expected that the participants can experience the usage of the gate and how they would interact with it. Usage patterns during the validation and information phases can be analysed and usage problems can be encountered and evaluated. Furthermore, the physical aspects of the gate can be experienced.

Virtual reality environment

The design of the closed payment border is placed into a virtual model of the context, for the participants to get an immersive feeling of the design in context. Participants can experience the virtual environment by using VR-goggles and a keypad. A smartphone with the virtual environment loaded on it is placed into the VR-goggles. Participants wear the goggles on their head, in front of their eyes, and can move their head around to look around and use the keypad to walk around in the digital environment (see Figure 32).

The environment is a rendering of (a part of) station Den Haag Centraal, around the closed payment border, with the proposed design placed inside. The closed payment border in the virtual environment has no interactive elements, but can be walked through to look at it from both sides (see Figure 33).

Prints of digital renderings

Several gatelines of the closed payment border are digitally rendered. Proposing prints of these renderings allows participants to look at multiple setups and discuss these, with the ability to point at details.

Figure 30. Set-up of the usertest: prototype of the gate (left side), VR-goggles (table, middle) and renderings of the new design (table, right).

6.3 DATA COLLECTION

It is important to understand why people make certain actions when using the model during the usertest. This knowledge can be gained when the participants **think out loud**. **Observations (video recording)** and **questions** are posed after the participants have performed a task. The participants are presented with a **virtual reality environment** of the design in context to get immersed into the proposed context. Participants are asked which elements of the design aspects gives them feed forward to understand how the design works. Participants are **observed** (video recording) which usability problems they encounter and **interviewed** why this problem occurred.

Episodic user experience

We want to know how the participants reflect on their experience with using the proposed closed payment border. An **AttrakDiff questionnaire** can be used to rate the user experience of the design on 22 semantic differentials. Both the old and new design are evaluated to be able to compare them (see Appendix F).

6.4 PROCEDURE

The usertests are spread over two days: four participants on the first day and five on the next. Every user evaluation, from welcoming the participant to wrapping up the user test, consumed about one hour.

5 min: Welcoming & bring to room & introduction research
5 min: Recap current system & introduce new design
15 min: Using the gate model
5 min: Using the VR-goggles
10 min: Using the renderings on paper
10 min: Filling in the AttrakDiff
5 min: Open discussion & leading out

Welcoming & bring to room & introduction research: 5 minutes

The stimuli are in the same room and can be seen from the moment the participant walks in (see Figure 30). The moderator explains the context of the project and what will be tested during the usage evaluation. The moderator made sure that the participants do not know that the design that is being evaluated has been made by the moderator himself, in order to prevent biased opinions and fear of saying their honest opinion.

Recap current system & introduce new design: 5 minutes

Firstly, a short overview of the closed payment border in the current system was given by the moderator. Photographs of closed payment borders at station Rotterdam Centraal (both metro and train) and station Amsterdam Duivendrecht (train & metro in one gateline) were used to illustrate the design of the current system (see Appendix G). This gave the participants a certain basis of understanding of the current system.

Next, three renderings, displaying the new design, were presented to the participants (see Appendix H). An explanation was given about the fundamental difference in design between the current system and the newly designed system; the gates in the current system have doors in the middle and are closed on default, the new design has doors on both ends and are open on default. No more details are explained, and participants are given time to take a look at the renderings. This attempted to simulate how a new user would encounter the new closed payment border in a station without having used it yet. The moderator now prepares the prototype.

Using the gate model: 15 minutes

Now that the participants have seen how the closed payment border would visually look in the context of a station, it is time to be able to interact with the (prototype of the) gate itself. See Appendix E for images of the prototype, and how it works.

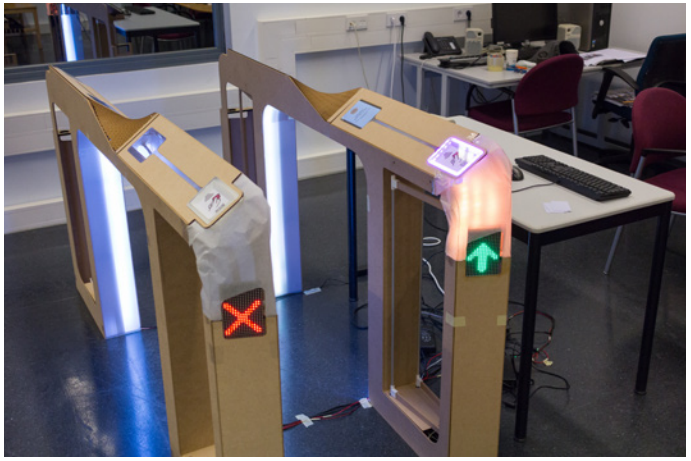


Figure 31. The prototype was used during the usertest.

Participants are given a white card (valid card, representing an OV-chipkaart) and given the task of going through the gates in order to get to the other side. The moderator, on first hand, gives no further instructions. Depending on the actions of the participant, several questions can be asked by the moderator about what the choices of actions were, why they did that (feed forward), what feedback the participants got from the gate, and what possibly went wrong. Participants can try using the valid card to go through the gate multiple times to experience it. Every aspect of the gate design is discussed and reflected on by the participant.
Next, the participant is given another card (insufficient money) and is asked to use the gate again. The participant will encounter an error state, and is asked if it is understood what is happening / what has happened, and how it could be solved. The same procedure is repeated with a card that is 'broken' (red error state). It is also shown how the gate would perform when the user would walk in without paying (also red error state).

Using VR-goggles: 5 minutes

After the gate and the UI have been discussed by using the prototype, the gateline and environment of the closed payment border will be addressed. A virtual environment will be used first.
Since this type of stimulus is fairly new, some participants might not have experienced using VR-goggles before, and some time can be spend on getting used to it.
The participants are asked to experience the closed payment border in the virtual environment (see Figure 33). This will give the

Figure 32. Participant using the VR-goggles to look around and walk in the virtual environment, in order to experience the new design.

Figure 33. Screenshot of the virtual reality environment, showing Den Haag Centraal with the new gateline design. Users can walk through and around the gateline.

participants a visual glimpse of the totality of the closed payment border design, and understand the context that the design would be placed in. After the participants have gotten used to the virtual environment and the design, questions are posed about which elements catches their eyes, which aspects they look at and if they can describe the elements of the design that gives them feed forward about, for instance, which gates they can use to get to the trains and which ones they cannot.

Using the renderings on paper: 10 minutes

Next, the moderator and participant take a look at the paper renderings (see Appendix I). The participant was asked several questions about the feed forward of the closed payment border, in terms of decision making (on/off, operators). The participant is asked to decide which gate he/she will use in order to get to the metro (in the context of metro-train gateline) they need to take. It is important to find out why the participant chooses certain actions

and what made him/her do so.
Another point that has been addressed are the assistance options near the gateline (see Appendix D). Participants were asked how they would react to an error in a real situation and how do they would respond to the options offered in the new design.

Filling in the AttrakDiff: 10 minutes
Lastly, participants are asked to fill in an AttrakDiff form (Hassenzahl *et al.*, 2008) to judge the design on 22 semantic differentials (see Appendix F). The current system will be rated first, and the new design second. One image of the current design and one image of the new design are used for reference. These images (see Figure 34) are made as similar as possible, in order to overcome judgement based on the quality of the image instead of the actual design. Both answers are filled in on the same form. Participants were encouraged to elaborate their answers when they are filling in the form.

Figure 34. Participant fills in the AttrakDiff, using an image of the current design and an image of the new design.

Open discussion & leading out: 5 minutes
After filling in the AttrakDiff form, there was some time for an open discussion: what did they like, what not, what was hard, etc. This aimed to find some more opinions that had not been ventilated before.

6.5 RESULTS

Feedback consisted largely of the things participants said when using the stimuli or when asked about certain aspects of the design. Transcripts of (most of what) the participants and the moderator said during the usertests can be found in Appendix J.
Because many different stimuli were used to cover multiple aspects of the proposed design during the usertest, the results are categorized in multiple groups:

- Recognition gate line
- Gate usage
- Understanding the icons
- Experiencing error states
- Information on the display
- AttrakDiff questionnaire

An overview table of the results can be found in Appendix K.
The results of the usertest are explained per group in the next sub-chapters. The findings are illustrated with images of the usertest and quotes from the participants, to give a representative view of the results.

The feedback on the assistance options has been somewhat neglected, since many participants had never used the information pole and were unable to give feedback on it. All participants mentioned that they would prefer to talk to a person if they would encounter a problem. The assistance booth in the middle of the gate line was considered ideal by some participants.

6.5.1 Recognition gate line

In general, all feed forward elements from the gate and gateline were identified and understood by all participants. The arrows and crosses were recognized immediately by the participants, presumably because they remember them from the current closed payment border system. Participants looked on both the gates and the overhead signage for the arrows and crosses to find out which gate they can use. After the participants had experienced the new gateline design a few times, by looking at the virtual reality environment and many renderings, it was important to notice that they now looked at the operator colours first to identify which gate they would use. The on/off of these colours was understood and experienced as clear by all participants. Some participants also used the text and logos, indicating the operators, to orientate themselves. The overhead signage was often mentioned as very clear, especially if it would be busy and other users would be standing in front of the gates. Many participants would look at the overhead signage first to orientate themselves. The light of the validator gave the participants feed forward to which gates can be used and which cannot. The pink colour of the lights on the validator were not understood by some participants, but they did recognize it as a distinctive colour which draws their attention.

Figure 35. Participant explains he looks at the colours on the overhead signage.

Figure 36. Participant explains he looks at the colours on the gates.

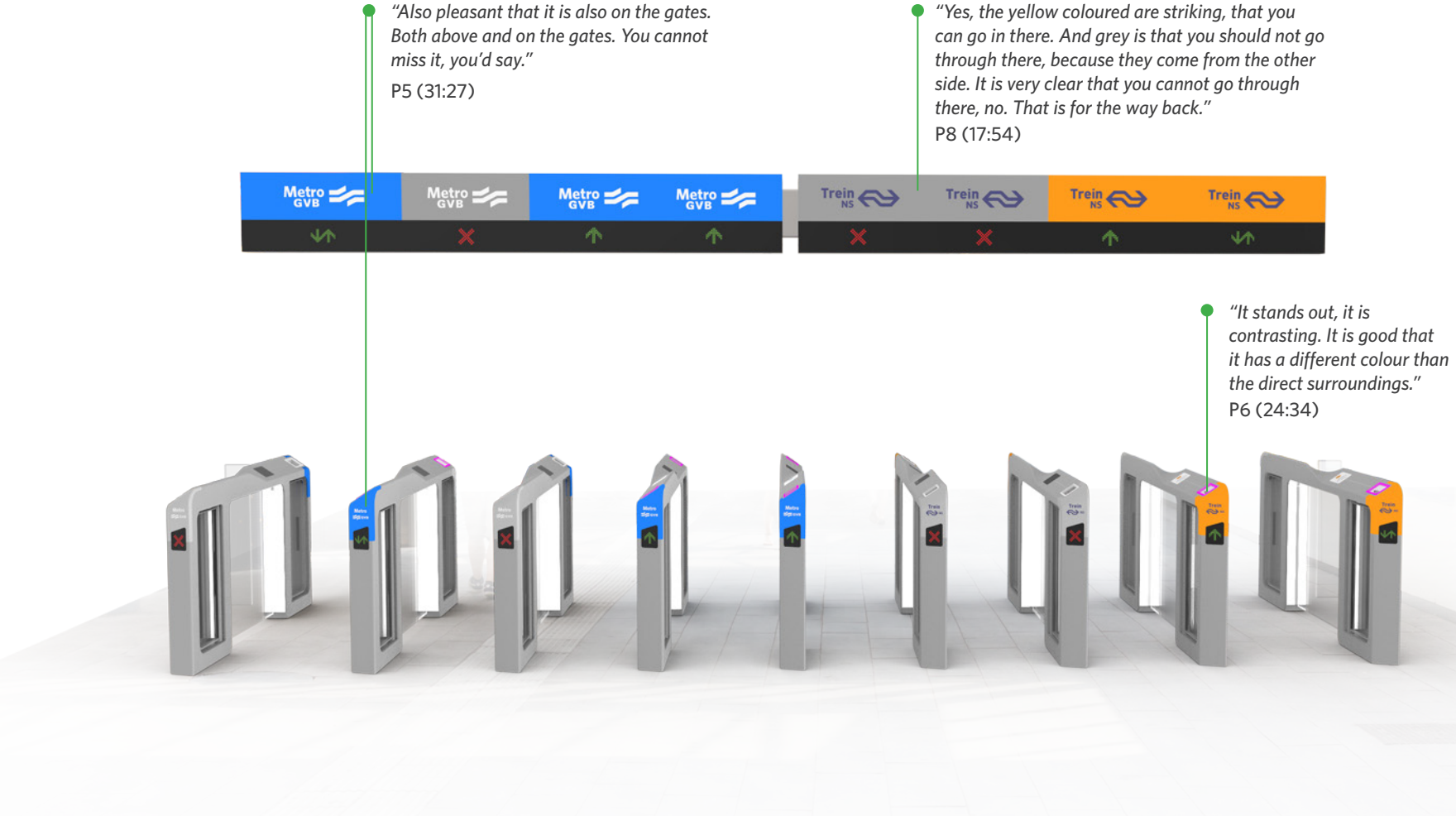


Figure 37. Multiple-operator gateline with some quotes from participants about several aspects.

6.5.2 Gate usage

Participants have experienced the use of the gate and some functionality by trying out the prototype. The participants found the new design visually and ergonomically more pleasant. It was mentioned that the position of the validator and display inside the gate gives better oversight. One participant noticed that he doesn't need to hurry so much when using the gate, because validation is first and receiving information a bit further. Many participants experienced the position of the display inside the gate as easy and visually comfortable. One participant mentioned this was comfortable because of the height of the display (on the gate). One participant said he was not sure if the angle of the display was good. The guiding light, which is the LED strip between the validator and the display, was noticed by all participants and mostly positively experienced. Many participants found it grabs their attention towards the display, giving them the feeling to continue moving. One participant mentioned this light could be made green, because the display also has a green message.

The angled top of the gate seemed to prevent the participants to tap on the left side validator. On the prototype, the left side validator was off and the right side validator (the correct one for the gate they were using) was on. Two participants mentioned the angled top restrained them from tapping on the left side validator. The only participant who was left handed was asked this specifically and she experienced the angled shape as restraining her from using that validator as well.

6.5.3 Understanding the icons

There were three icons on the validator of the prototype, which indicate the payment methods that can be used on the gate. Participants were asked what they thought these icons meant. The contactless (bankcard) icon was not known by nearly any participants, with many of them thinking it meant wifi or that the validator is detecting radiowaves. The icon with the hand holding a pink card, representing the use of the OV-chipkaart, was understood by many participants. Many of them indicated that the OV-chipkaart should be held against the validators, and some participants mentioned that you should have a valid ticket or that you should hold your card in your hand. The last icon, a QR-code representing the possibility of validating those, was not understood well by the participants. Some participants thought they can scan that icon on the validator to get information. Many participants did know the QR-code, but not what the intended purpose was on the validator.

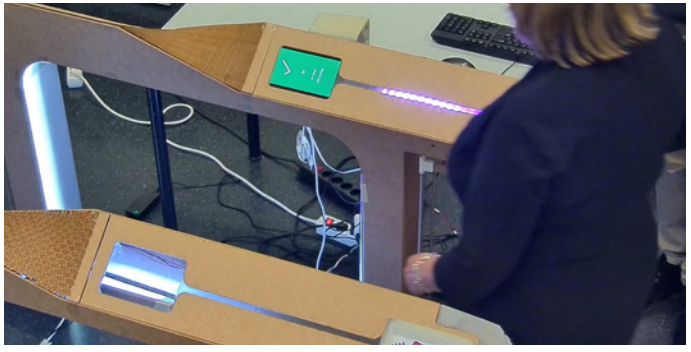


Figure 38. Participant uses the gate prototype.

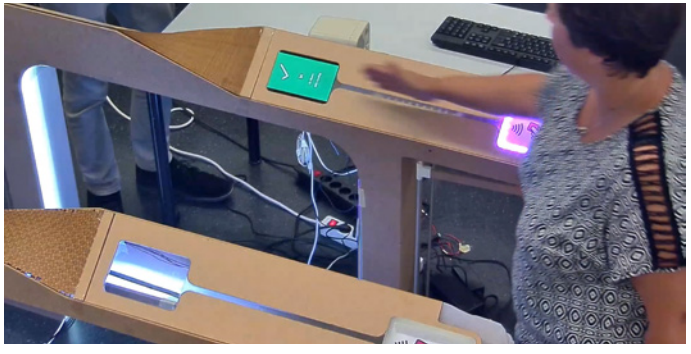
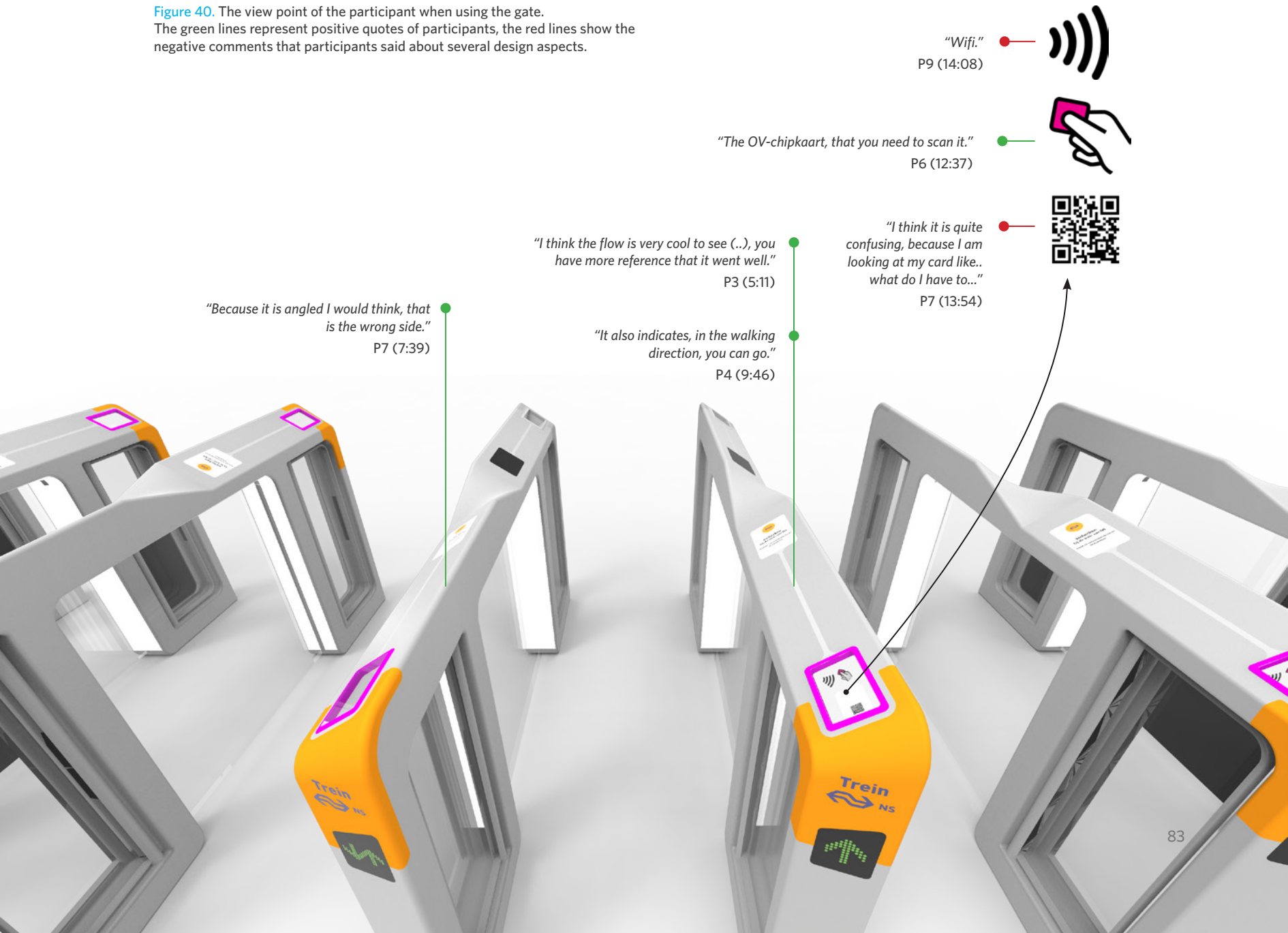


Figure 39. Participant explains that the guiding light draws her to the display.

Figure 40. The view point of the participant when using the gate.
The green lines represent positive quotes of participants, the red lines show the negative comments that participants said about several design aspects.



6.5.4 Experiencing error states

The participants experienced the error states as clear. The combination of the colours, the doors closing, the sound and the message on the display gave all participants recognition that something went wrong. One participant experienced this as unfriendly and another participant said it made him feel being wrong. The other participants did not get any bad feelings while encountering an error state, and were positive on the direct and clear message that the error state gives with the colour.

It was also mentioned that when it would be busy, and the participant would encounter an error state (e.g. insufficient money on card), the participant would have to back out of the gate and thereby block other travellers. That could be experienced as unpleasant.

One participant stated that the sound of error is neutral, and that it could give a more negative sound.

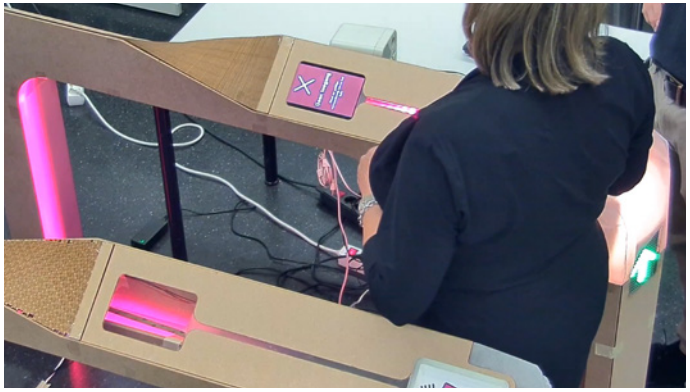


Figure 41. Participant experiencing the red error state.

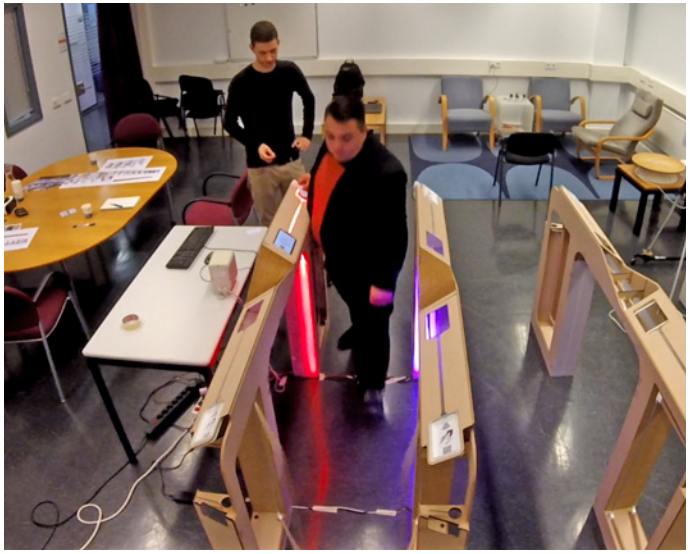


Figure 42. Participant was confident he could get in without paying.

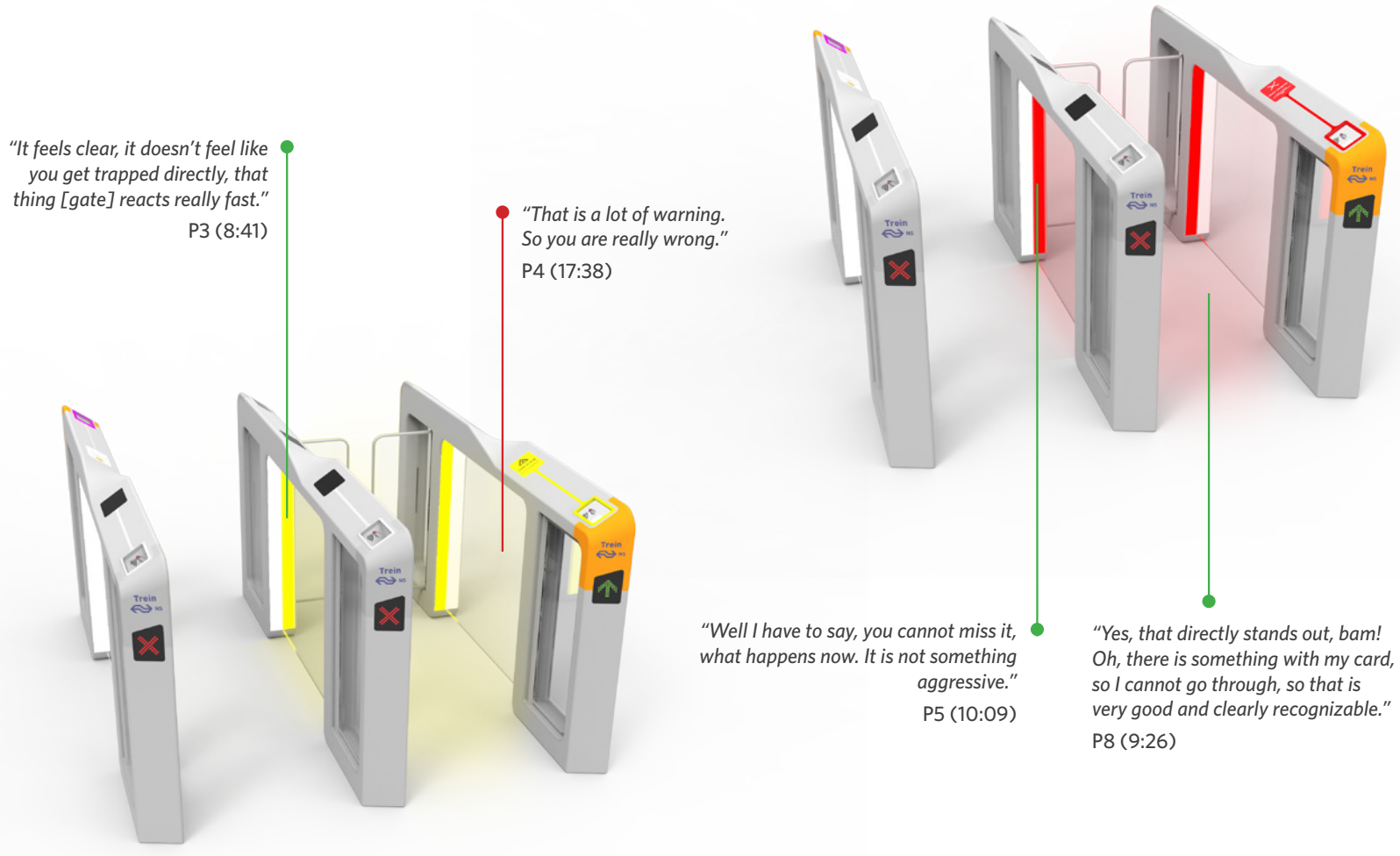


Figure 43. The error states that were tested with participants: (left side) insufficient money and (right side) no entry because of a broken card or by walking in without paying.

6.5.5 Information on the display

Participants encountered five different displays when using the prototype. The default display (see Figure 44, left screen) was not commented on by participants often, but one of them mentioned that the operator logo and icon were not seen and deemed not useful. Another participant thought it was confusing to have a red circle and icon (RET, Rotterdam metro operator), which could look like a stop sign.

After participants used a card to check in, the green screen is shown. All participants experienced this as a very clear message, whit some of them mentioning that only the colour and icon would be enough feedback to know the check-in was a success.

The participants encountered the yellow screen when trying the card with insufficient money, which gives the yellow error state. This screen was also evaluated as a clear message, and all participants knew what was wrong and what to do next.

When the participants used the broken card or tried to pass the gates without paying, the red screens would appear. All participants thought the red colour and cross icon is clear, showing that they could not enter. However, it was not understood what the reason of the red screen was. This left some confusion if the problems is from the user or the system.

Furthermore, it was mentioned by two participants that tourists would not understand the messages because it is in Dutch.

Figure 44. The five screen messages that were used in the usertest, and some comments from participants.

6.5.6 AttrakDiff questionnaire

At the end of the usertest, participants filled in an AttrakDiff form to rate the current design gates and the new design on many semantic qualities. The data sheets with all results can be found in Appendix L, and a box-plot with the results in Appendix M.

The results of the AttrakDiff seem to indicate a higher rating for the semantics on attractiveness. Participants often mentioned that they really likes the way it looks, that it is "pretty" and "friendly". Another comment that has been mentioned many times by the participants is that they appreciate that the design is inviting, because it is open.

One point where the new design seems to be rated lower than the current design is how predictable it seems. Some participants thought the possibility that the gate would close when they (unknowingly) have insufficient money on their card, makes the gate feel unpredictable.

"I think it is definitely cleaner than now. I think the whole idea with the open doors much more accessible, much more inviting."
P3 (16:03)

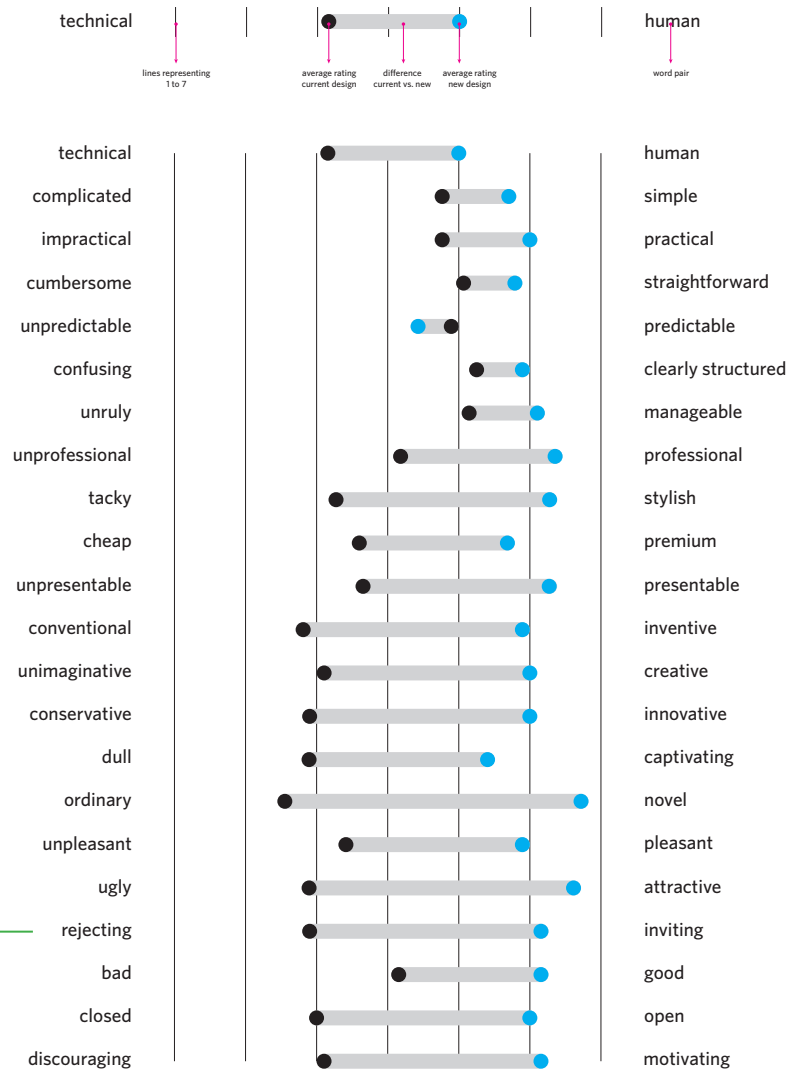


Figure 45. The average scores (1 to 7) for the current design (in black) and blue (new design). The grey bar shows the difference between the two values.

6.6 DISCUSSION

The results of the usertest give some indication to what actual users think about the new design of the closed payment border and how they experience it. However, there are some limitations to the usertest that have to be taken into mind that might have influenced the validity of the results.

Amount of participants

The amount of participants for this usage evaluation study was small, with 9 participants. The AttrakDiff questionnaire can therefore only give an indication to how the participants evaluate the experience of the new design; the data is too limited to be used for statistics. The small amount of participants could be argued to be enough to find usability problems with the new design. Some studies show that qualitative usage evaluation with 5 participants can find about 80% of the usability problems that users would encounter (Nielsen & Landauer, 1993). However, other studies show that this varies between 55% and 99% (Faulkner, 2003). This usertest had 9 participants, which could be evident that most of the usability problems users can encounter have been found.

Furthermore, the user evaluations are one-on-one with the moderator, thus the possible effect of multiple users influencing each other is not taken into account.

Usage evaluation environment

The usage evaluation was done in a university lab room, not in the actual context of use. This could have influenced the experience that the prototype gave to the participants, and their ability to empathise with the design in context. The physical space around the (prototype of the) design was limited in the usertest, but would be much more free in the context of a station. Influence of other travellers, sound and time pressure to catch a train would all exist in the real usage situation, but were not included in the evaluation.

Prototype

The prototype used in the evaluation is not the actual final design; it is a representation of how it would work and the size/spacing. Furthermore, there were only three gates, of which one was working, and not a whole gate line.

The prototype did not work flawlessly during all evaluations. For instance, the movement of the doors slightly moved the gates, which affected the alignment of the sensors that trigger the red error state. At some point during the usertests, the moderator was very uncertain about how the prototype would behave, which affected his willingness to let participants try out the prototype by themselves. It has happened on two occasions that the doors closed on a participants when they should not have, since the participant checked-in with the valid card. This might have affected their evaluation of the new design and perhaps given a wrong impression on how the new design works.

First time use

Since this is a new design, the participants evaluated the design mostly as a first time user. Many participants indicated that they would understand it better after using it a few times.

It was interesting to see that, during the beginning of an evaluation, participants first look at the arrows and crosses for recognition. Presumably, this is because they are familiar with it from the current system. At the end of the usertest, after having seen and discussed multiple gateline renderings and the virtual environment, participants first looked at the colours (on/off) for recognition, before the arrows and crosses. This could indicate that users who are new to the system, first get recognition from the familiar arrows and crosses, but frequent users look at the colours for recognition after they have learned that it means the same as the arrows and crosses.

6.7 CONCLUSION

In this chapter, the design proposition of the new closed payment border was evaluated with 9 participants by the use of a 1:1 scale prototype, digital renderings and a virtual reality environment. Many design aspects were well understood and clear to the participants, especially the overhead signage and the recognition with the arrows, crosses, lightboxes (on/off) on the overhead and gates, and operator logo and text. Some aspects were less well understood and need to be redesigned.

6.7.1 Elements for redesign

In order to improve the design, the design aspects that were negatively evaluated in the usertest will be redesigned.

Icons for payment options

The icons for contactless payment (bankcard) and QR-code were not well understood by the participants. The icon for the OV-chipcard, which was a pink card with a hand, was understood by the participants. Therefore, the redesign of the icons will incorporate a hand holding a card, and a textual name of the payment option to clearly communicate what is meant.

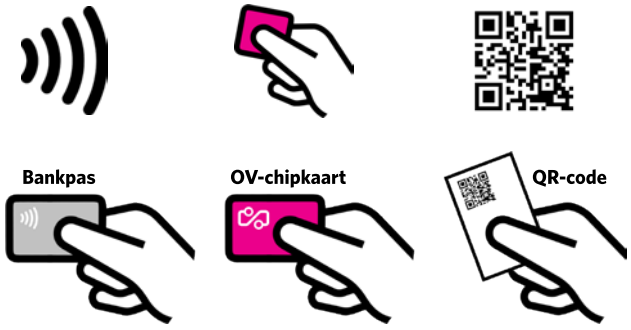


Figure 46. The icons used during the usertest (above) and the new set of icons for payment options.

Information on screens

Some screens were evaluated as clear (successful validation, insufficient money) but some were not (red error messages). This was due to the lack of information, on the screen, on what had happened. The main communication was 'No entrance', which did not give the participants any clue to what actually was the reason why they were not allowed in. Therefore, the way information is communicated in this scenario is redesigned.

Figure 47. The screen (left) used during the usertest, that showed when a broken card was used. The new screen (right) now communicates what is actually wrong, instead of only saying 'no entrance'.

Lights under the gate

The gate design used during the usertest had lights (white colour on default) under the gate that were completely on. These lights were used to communicate the error states, but can also be used to indicate which gate is usable and which is not. By turning off the lights visible from the 'closed' side of the gate, more feed forward is given to the user that the gate cannot be used. Contrasting, on the other side the lights will be on, indicating the gate can be used.

7

7. A user-centered design of a new closed payment border

7.1 INTRODUCTION

In the previous chapter, the redesigned concept was evaluated by participants. The design proposed in the usertest showed improvement to the current gate design, and some aspects for revision were found and redesigned. This chapter proposes the final design: a user-centered design of a new closed payment border for public transport.

7.2 DESIGN

The new, user-centered design of the closed payment border aims to improve the user experience and efficiency, while reducing the usage problems that users encounter. This design is based on front-end user research and evaluated with stakeholders and users, and offers an integral design for the future.

The new closed payment border has a redesigned gate, user interface (UI) and gateline. The new closed payment border design has a fundamentally different design/usage aspect compared to the current gates in the field: the doors are open on default.

To fully explain all details of the design of the new closed payment border, the interaction levels (UI, gate & gateline, see page 25) that the travellers will interact with will be touched upon separately. Firstly, the design of the gate will be elaborated. Next, the user interface on the gate is explained, including the messages on the display. After that, different use cases (normal usage, busy normal usage, error states) are depicted to illustrate how this gate and the UI will work. Lastly, the design of the whole gateline is elaborated, including multiple designs of different operators, as well as in-context illustrations.

Overhead signage
Gives recognition to users from a distance. Gives same feed forward to the users as the front of the gate does.

Gate
Houses the user interface, doors and recognition elements on front. Can be used from both sides.

User interface
The validator, guiding light and display where users interact with. It gives feedback on the user's validation.

Gateline
A row of gates, including the overhead signage.

Amsterdam Centraal, train

7.2.1 Gate

Each closed payment border consists of several gates. The gates of the new design have doors on both the front and the back side, and are open on default. When a user validates correctly, he can continue through the payment border, without having the doors to open. The doors will close only if a traveller has a problem with the validation (e.g. insufficient money on card) or when no validation has been done (entry without paying). They are placed at the end of the gate, in order to have enough time to close when a user is not allowed entry. The design that is explained here has low doors; see chapter 8.3.2 for a high door possibility. By having gates that only close when something is wrong, the amount of mechanical movements of the doors is significantly reduced, resulting in a decrease in maintenance costs. The doors are triggered to close through a validation error or when the 3D sensor, situated above the gateline, notices an illegal entry or tailgating.

Each gate has a **lightbox** on the front and back of the gate. This can be switched on and off, depending on which direction the gate is set in. When the lightbox is on, it gives feed forward to the users that this gate is active and thus can be used. Subsequently, when it is turned off, it indicates that the gate cannot be used from that side. This also allows operators to accommodate peak capacity during rush hours by turning off the UI and lightbox on one side of the gates and turning them on at the other side. The lightbox has the colour of the operator, including the modality, logo and name in text, to guide travellers to the correct gate they need to use.

Green arrows and red crosses tell users, just like the lightbox, which gate is on (usable) and which gate is off (not usable). The UI (**validator and display**) also indicate this. Having multiple design aspects indicating which gate can be used offers redundancy to help communicate it with all types of users. Infrequent users might looks at the arrows and crosses for recognition because they are familiar with that, whereas frequent users might look at the lightboxes because they have found out it represents the same as the arrow and crosses. The lightbox has made the rule-based action (recognition gate on/off with arrows/crosses) into a skill-based action, which takes much less cognitive capacity (Rasmussen, 1983, via Kim, 2012).

The front and the top of the gate have a **chamfered shape**, in order to guide users to the correct entrance (space between two cabinets) that corresponds to the right validator. The angled top of the gate restrains users from validating on the left side validator with their left hand, and makes the (correct) validator on the right side the accessible option.

The **lights underneath** the gate are on towards the side of the gate that is on, giving feed forward to users about which gate is usable and which is for the other direction. These lights also give feedback when a user encounters a problem at the gate.

The gates are 15 cm wide, 200 cm long and 105 cm high on its highest side. The distance between the gates can be 65 cm, when using the existing infrastructure on the floor in stations. See Appendix N for all dimensions.

The gates have a hard plastic shell, which gives them a more friendly appearance in contrast to the mechanical feeling of metal gates. Moreover, the rounded edges also advocate this. Furthermore, the gates are grey to remain fairly neutral in the station environment, with very contrasting colours of the elements that give feed forward and feedback to the users (e.g pink validator lights, lightbox, arrows and crosses).

▶ Figure 48. Two inward and two outward gates. Some of the main features and design aspects are explained.

Lightbox
The lightbox on the front of the gate can be switched on and off. When on, it indicates which gate can be used and the colour indicates which operator it is for.

Display inside the gate
The display is positioned further forward inside the gate. This allows users to continue walking through the gate while they get their information.

Validator
The pink light ring indicates which validator is on. Icons communicate which payment methods can be used.

Arrows and crosses
The green arrows and red crosses give feed forward to users as to which gate can be used.

Chamfered top and front
The chamfered top and front guides users to the correct validator, so they will use the one that belongs to the gate they are standing in front of.

Doors on both sides of the gate
The gates are open on default, and close when something is wrong. The doors are placed at the end, in order to have a longer walk-in distance. This allows the doors to close before the user has reached the end.

7.2.2 User interface (UI)

The user interface of the gate gives feed forward to the user about the actions that need to be done and gives feedback on those actions.

Validator

The gate has a validator that can read travel tickets in order to accept or deny travellers entry. It should accommodate all types of travel products travellers can use in the public transport system, in order to prevent travellers from having to choose the correct gate according to their ticket. Three logos (see also Figure 49) are situated inside the validator, to communicate with the users which payment options they have: contactless payment with the bankcard, using the OV-chipkaart, or using a (type of) barcode on a ticket. In a few years from now, contactless payment with the bankcard will be introduced into the public transport system (Trouw, 2016). The OV-chipkaart has been in the Dutch public transport system for many years, and the pink colour and logo are recognizable features. International (train) travel tickets, or tickets to events, generally have barcodes that can be validated at the poles and gates.

The validator has a light ring around it. The colour of this light is recognizable and contrasting with its surroundings, in order to help users find the validator when they want to check-in or out. This light also changes when an error occurs at the gate, to give feedback to the user.

Figure 49. The icons used in the validator to communicate the different payment options at the gate: Bankcard, OV-chipkaart and barcode.

The validator is embossed from the chamfered top shape of the gate (see Figure 50). This gives users not only recognition from the contrasting light, but also a guiding tactile aspect.

When a user checks-in but does not continue through the gate, the system should recognize this and delete the check-in after a certain time.

Guiding light

There is a light strip between the validator and the screen, which will let a light move from the validator to the display when validation is successful (see chapter 7.2.3 for illustrations). This aims to take the attention of the user from the validator towards the display, after the validation has been done, with the purpose of keeping the throughput going. Users are guided to the next step in the usage of the gate, which hopes to prevent them from standing still at the validator. When the validation is successful, a green light will move to the display. Furthermore, this light strip also changes colour when an error occurs (e.g. insufficient money on card) at validation, to give feedback to the user. When there is an error at the validation, the whole strip will light up in a colour depending on the error.

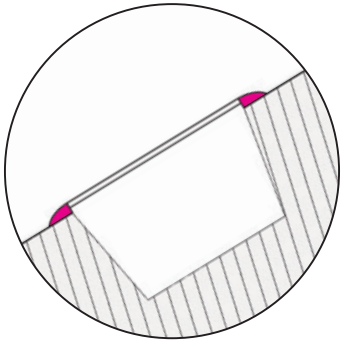


Figure 50. Cut-though section of the validator. The top is embossed, which gives it also a tactile recognition aspect to the user.

Display, validator and lightbox off
The display, validator light and the lightbox on front of the gate are switched off when the gate cannot be used (from that side).

Display
The display can communicate multiple messages with the user (see page 101).

Guiding light
The guiding light sends a light from the validator to the display. This pulls the user's attention towards the display after validating, in order to guide users to the next step. It attempts to improve the throughput of travellers.

Validator
Pink light ring indicates which validator is on. Icons communicate which payment methods can be used.

Sound

The gate will give sound feedback on the validation in three ways:

- One beep at check-in.
- Two beeps at check-out.
- Two longer, lower beeps at an error.

Based on the findings in the analysis phase, the sound feedback on a successful check-in or out should be direct, short, sharp and clear to the user. It should be direct in a way that the user can understand that the sound is feedback on his/her action, not the sound of the user on another gate in the gateline. Similarly to the fact that the validator should directly catch the signal of one of the payment methods when held above the validator, the sound feedback should be instantaneous and direct, in order to give the user clear feedback that his card has been validated and that he can continue. When a high throughput is desired, the validation and subsequent sound feedback should be fast and direct so users stay in the fast walking mindset. The sound could be like a short '*pi*'.

Even though gates make it clear to users whether they go into a station or to the outside, and thus users do not necessarily have to get sound feedback whether they check in or out, the different sound feedback will still have to be implemented. In order to keep consistency for the users throughout the public transport system, the check-in has one beep and check out has two beeps because of the fact that the validation poles (situated in stations that do not have gates) give sound feedback in this way.

When an error with validation occurs, or when a traveller walks through without validating, the doors will close, the display will show an error screen, the guiding light will turn to a colour, the validator light and the lights underneath the gate will turn this same colour, and the error sound will play. This error sound should be direct, clear and friendly. In line with the open character of this gate design, the error sound should remind the user that something went wrong in a clear but friendly manner. The redundancy of error feedback through the user interface allows the sound to be a friendly, mild medium instead of a hostile answer of the gate. The sound should, however, be significantly distinct from the 'successful' sounds. The sound should therefore be longer and lower, for instance like '*tu-duuu*'.

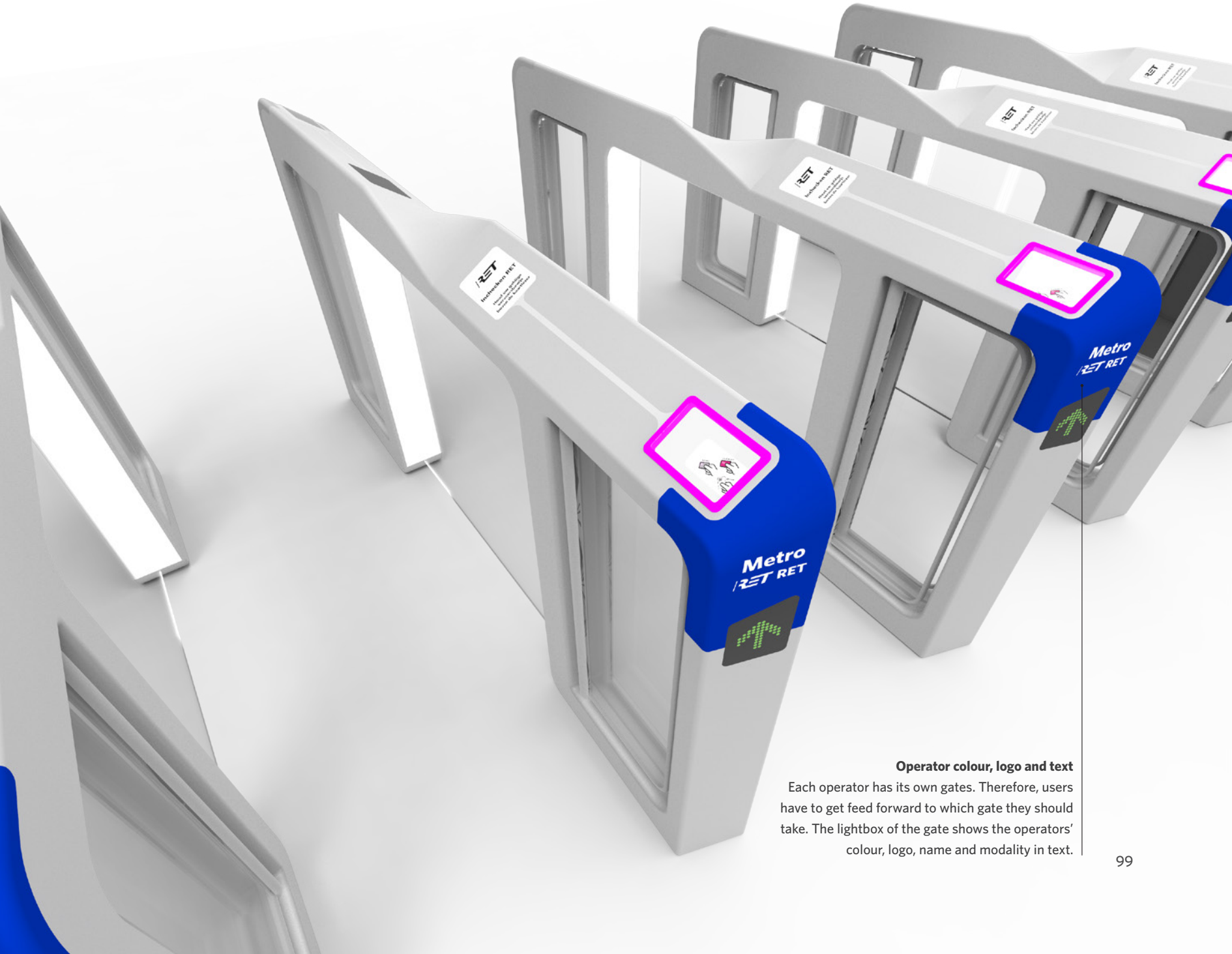
Messages on the display

Travellers need clear feedback when they present their card to the validator. The UI gives feedback through the validator light ring, the guiding light between the validator and the display, sound, and the messages on the display. These messages can be multiple things, depending on the validation.

- Validation successful
    - The user has now checked-in.
    - The user has now checked out.
- Validation is not successful
    - The user has insufficient money on the card.
    - The card is not valid.
    - The user attempts to walk into the gate without validating.

The messages are built from layers of colour, symbol, main topic and extra information or suggested user action (see Figure 51). These layers offer redundancy to help communicate with a large group of users, including the low-literate and colour blind.

Figure 52 shows all screens that the display can give as feedback. There are six screens possible: the default screen, the successful check-in or out screen, the insufficient money screen, the problem-with-card screen and the screen that is shown when a user attempts to walk into the gate without validating.



Operator colour, logo and text

Each operator has its own gates. Therefore, users have to get feed forward to which gate they should take. The lightbox of the gate shows the operators' colour, logo, name and modality in text.

Default screen

The screen that is shown when the gate is on has a white background with black letters. When a gate cannot be used (from one side), the display is off, and thus black. Having a white background on the screen communicates that it is on. It shows the logo and name of the operator of the gate.

Check-in / check out

On a successful check-in or out, the screen will turn green, which is perceived as 'good'. This allows users to quickly notice whether their validation was successful. A very short and direct message 'In' or 'Out', in combination with the symbol in white, also strengthens this.

Insufficient money on card

The yellow colour and black symbol communicates clearly that something went wrong that needs to be solved before being able to continue. The main issue is direct and understandable, and a suggestion is given to the users so they know what they have to do in order to solve the issue.

The card is not valid

When there is a problem with the card, the display will communicate this with a red screen and a white cross. This indicates a bigger problem with the card and that the user cannot continue.

Not validating

When a user attempts to pass the gate without validating, the gate will not allow passage and the display communicates this with a clear red display. The user is told that no validation has been done and suggests that the user should validate.

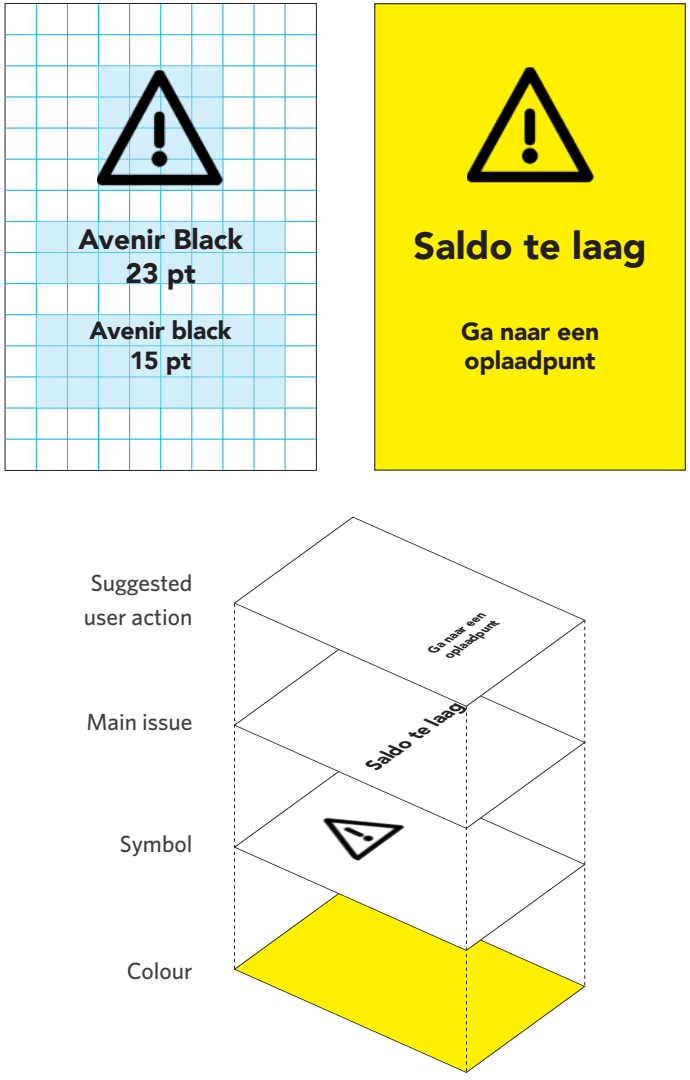


Figure 51. An example of how a message (insufficient money on card) is built with layers of information. The screens are 10 by 15 cm.

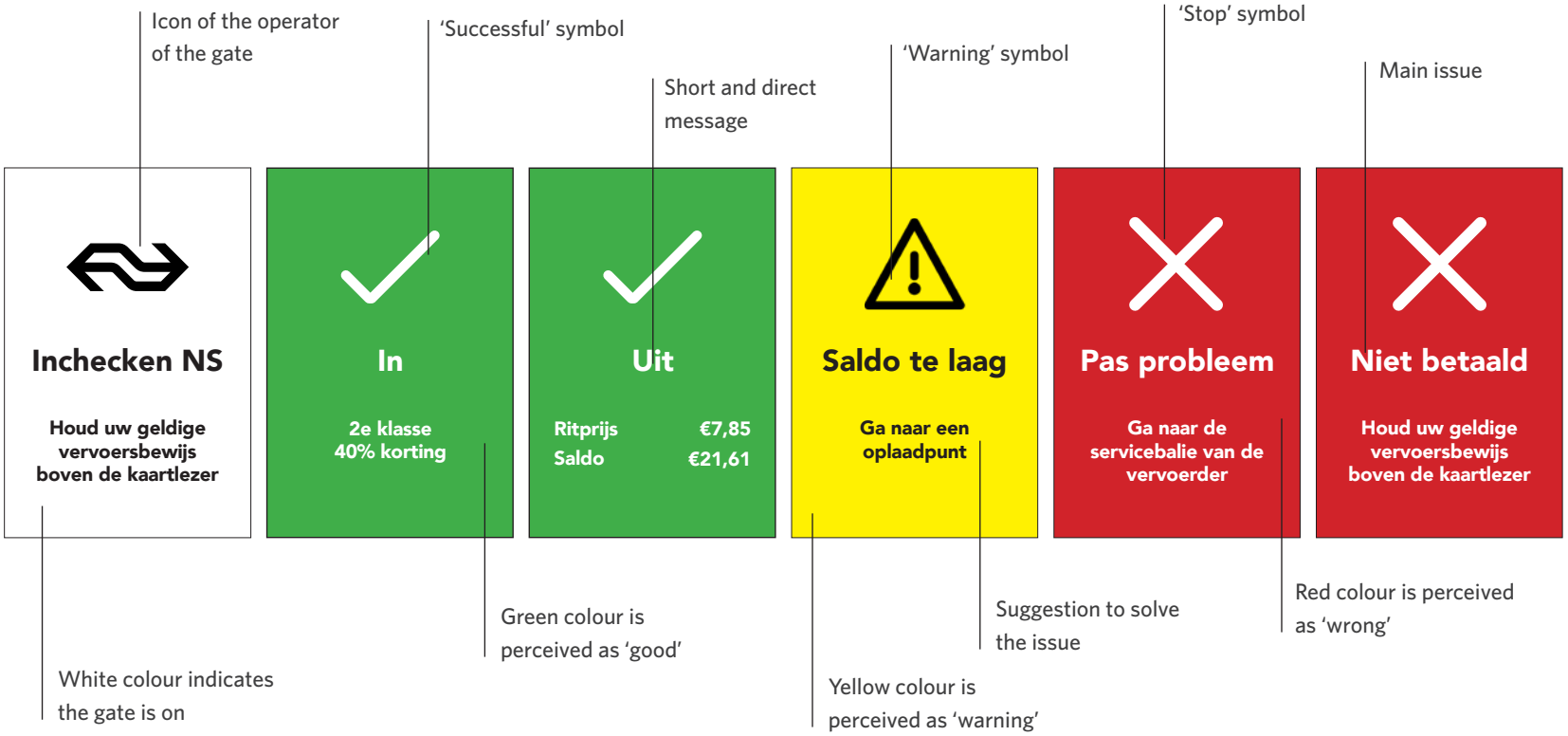


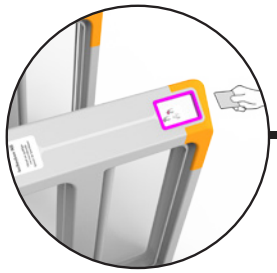
Figure 52. The six messages that can be displayed by the gate (from left to right): default screen, successful check-in, check-out, insufficient money, problem with card, and attempting to enter without paying.

7.2.3 Using the gate

How the gate, and specifically the user interface, works, is a very determining factor for the user experience and the throughput of travellers.

Normal usage

How the gate works when a traveller uses it, when there are no other travellers around, is explained on this spread.

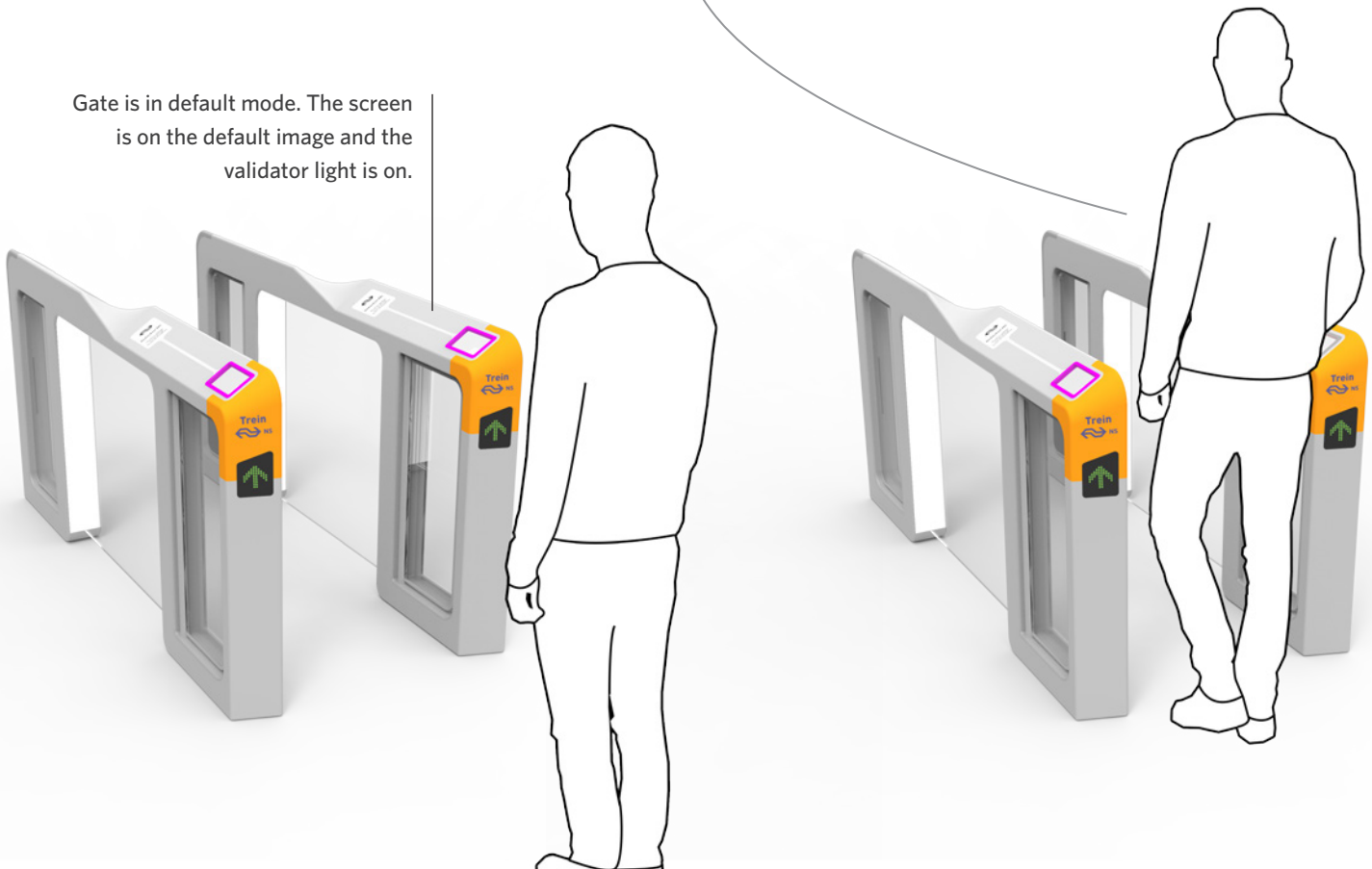


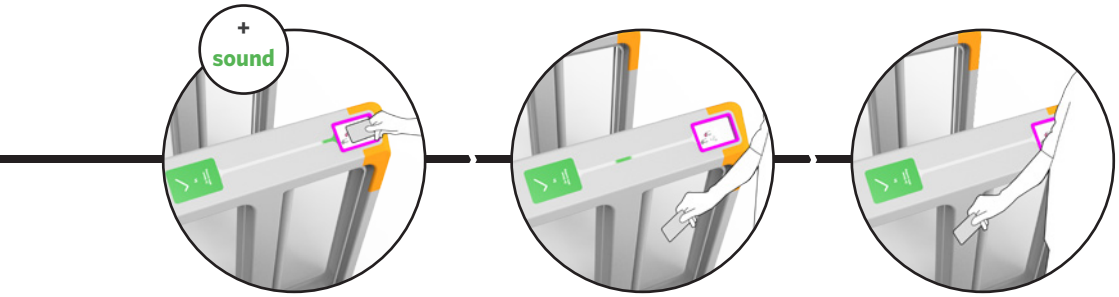
The validator light shows that it can accept a card.

User holds a card above the validator.

The light of the validator very briefly blinks, to give feedback that it is reading the card.

Gate is in default mode. The screen is on the default image and the validator light is on.





The card has been accepted. The light of the validator turns back on, the display shows the green screen, a sound plays and the guiding light starts moving.

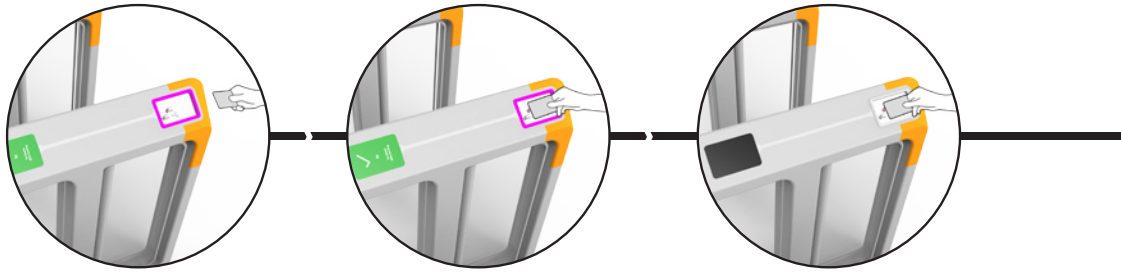
The guiding light moves from the validator to the display.

The user's information can be read while the user walks through the gate.

When the user has passed the gate, it returns back into default mode.

Busy, normal usage

How the gate works when a traveller uses it, when there are many other travellers around, is explained on this spread. This could happen, for instance, when it is busy in the rush hour.

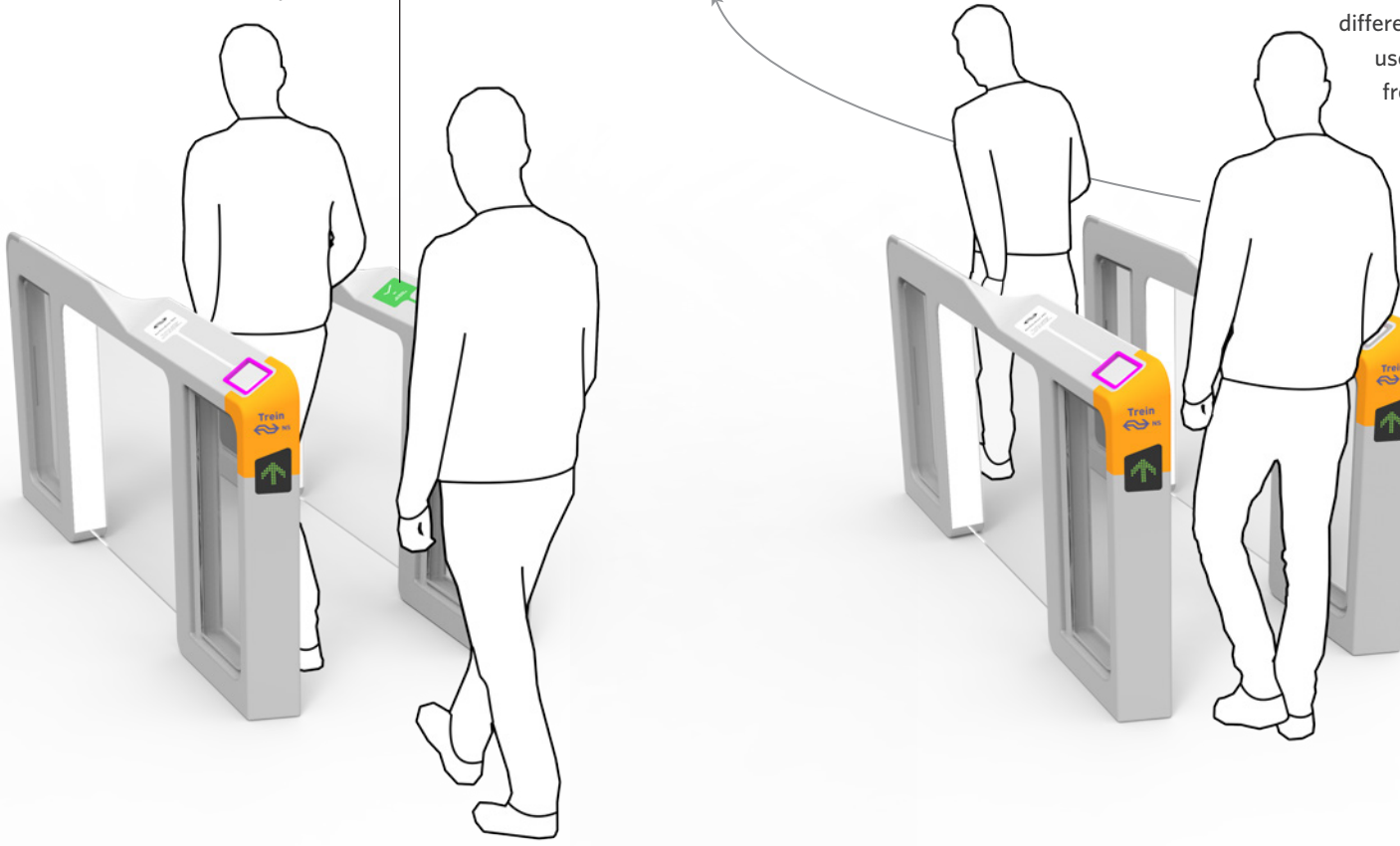


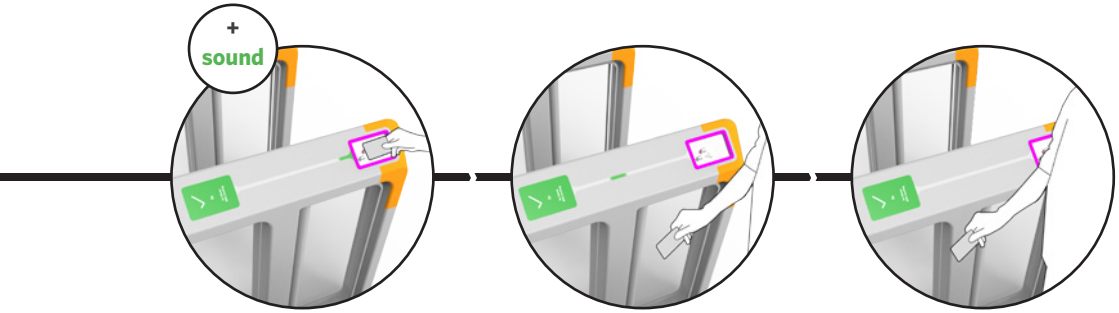
The light of the validator very briefly blinks, to give feedback that it is reading the card. The display will also briefly blink with a black screen, to clearly differentiate the new user's information from the previous user.

The user holds a card above the validator.

The validator light shows that it can accept a card, even though the information of the previous user is still visible.

The information of the first passenger is still visible , because he has not passed the end of the gate yet. The next user can already validate.





The card has been accepted. The light of the validator turns back on, the display shows the green screen, a sound plays and the guiding light starts moving.

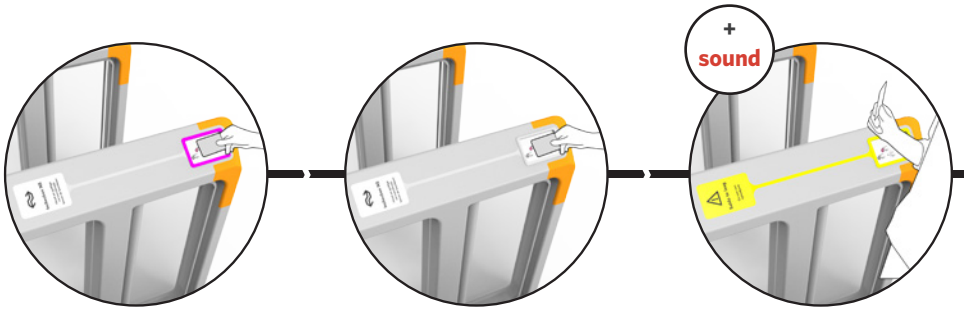
The guiding light moves from the validator to the display.

The user's information can be read while the user walks through the gate.

When the user has passed the gate, it returns back into default mode.

Error state: insufficient money

A traveller can have insufficient money on his/her card when a check-in is attempted. The gate will then close and give feedback through sound, light and the display that the traveller cannot pass because of insufficient funds. This spread explains how this works.

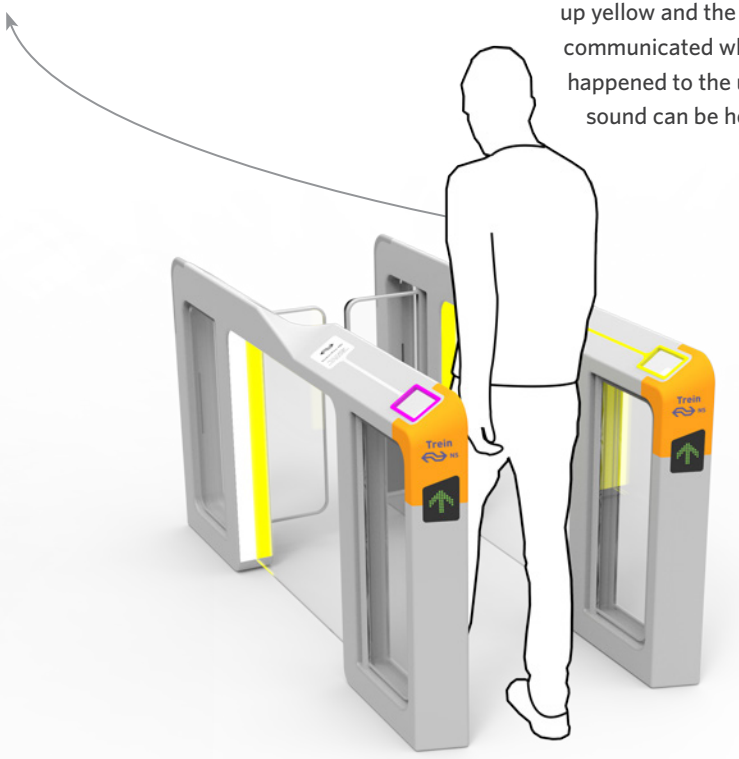


The user holds a card above the validator.

The light of the validator very briefly blinks, to give feedback that it is reading the card.

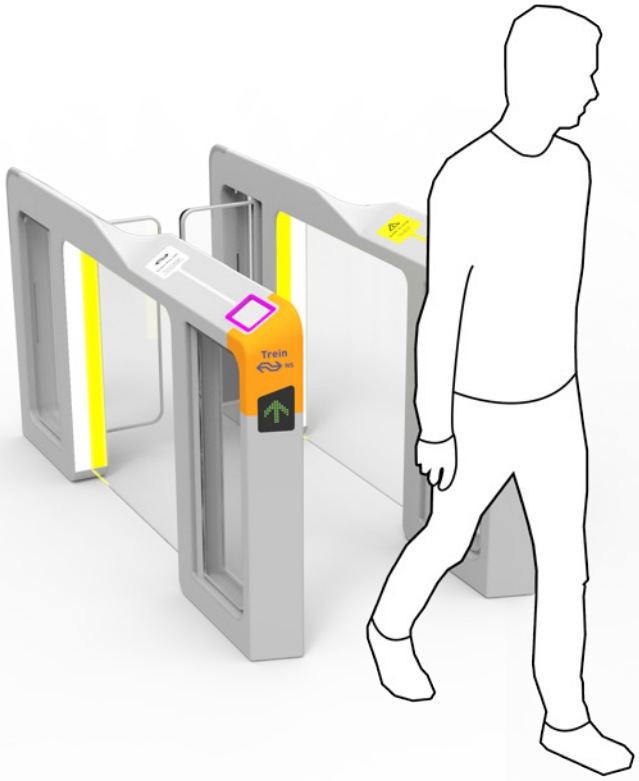
The card that the traveller uses has insufficient money. The doors of the gate close, everything lights up yellow and the display communicated what has happened to the user. A sound can be heard.

The user tries to check-in or out.



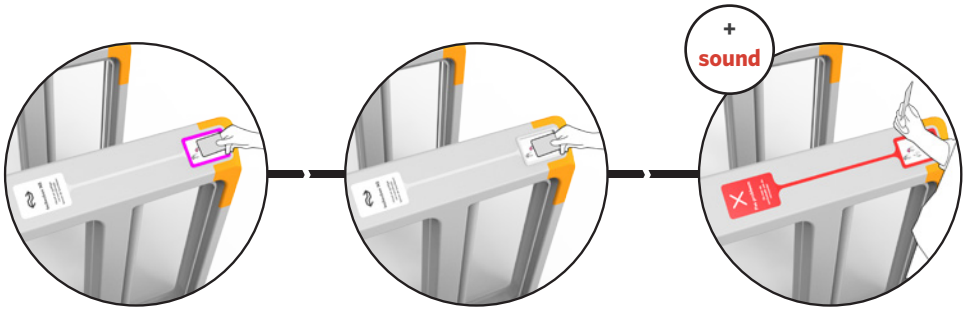
The yellow error state will remain until the user has left the gate.

The gate will return to the default state after the user has left.



Error state: problem with card

A traveller can have a problem with his/her card, which makes it unusable to check-in or out. The gate will close, the lights will turn red, a sound is heard and the display will communicate the error and what can be done about it. After the user has left the gate back the way he came, the gate will turn back to the default state.

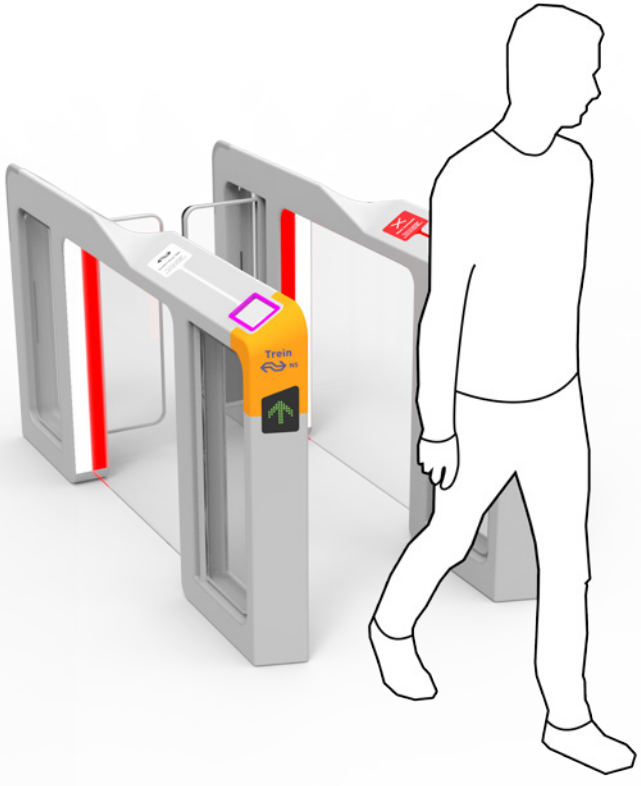


The user holds a card above the validator.

The light of the validator very briefly blinks, to give feedback that it is reading the card.

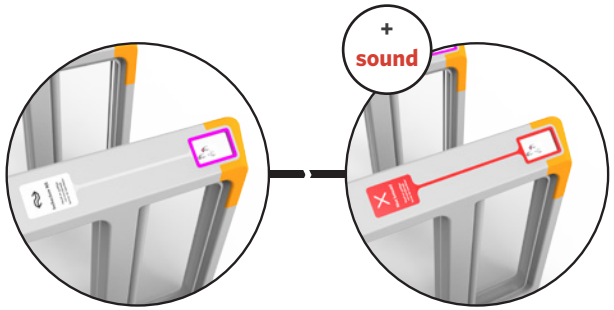
The card that the traveller uses has a problem. The doors of the gate close, everything lights up red and the display communicated what has happened to the user. A sound can be heard.

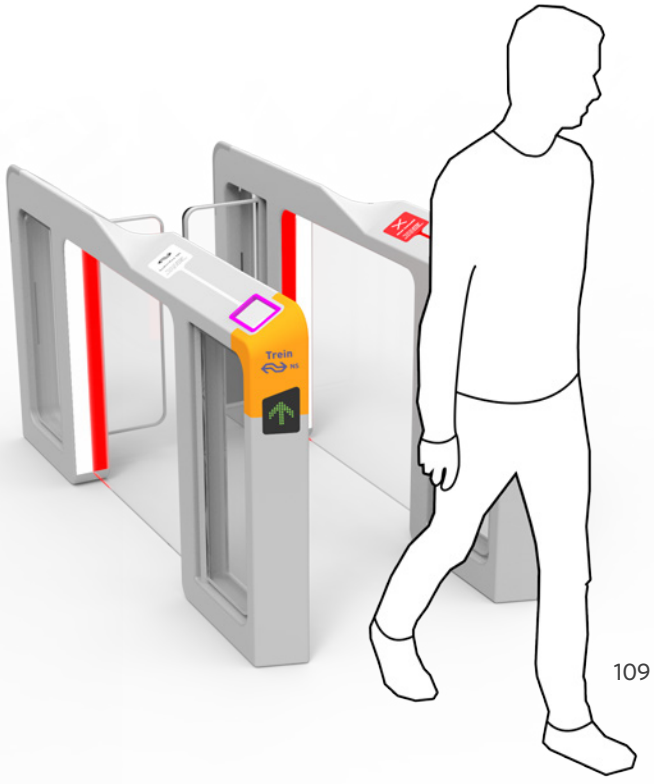
The user tries to check-in or out.



Error state: illegal pass

The open default state of the gate might tempt travellers to attempt to walk through the gate without paying. To prevent this, the sensors of the gate will notice the traveller walking into the gate, and the doors will close, the lights will turn red, a sound is played and the display will give an error message. This is similar to the use case 'problem with card', but the message on the display is different. When the traveller walks back out of the gate, it will return to the default state. If the traveller presents a valid card to the card reader while in this error state, the validation process will start like a normal check-in/ out.





7.2.4 Gateline

A closed payment border consists of many gates in a row, making a gateline. In the new design closed payment border, overhead signage has been added to the gateline. This gives the same feed forward to users as the gates do, with the added value that users can get this information from a larger distance and when there are other travellers walking in front of them. This is particularly useful when it is busy in the station, for instance during rush hours. Just like the lightboxes on the gates, the overhead signage has lightboxes, that are the width of a gate, that can be turned on or off depending on the direction of the gate. The lightboxes and the arrows/crosses of the overhead signage work together with the ones on the gates underneath. This way, both are on or off at the same time. To increase capacity, for instance during rush hour, the lightboxes, arrows and crosses, validators, screens and lights underneath the gates can be turned on or off to open up more gates in a certain direction.

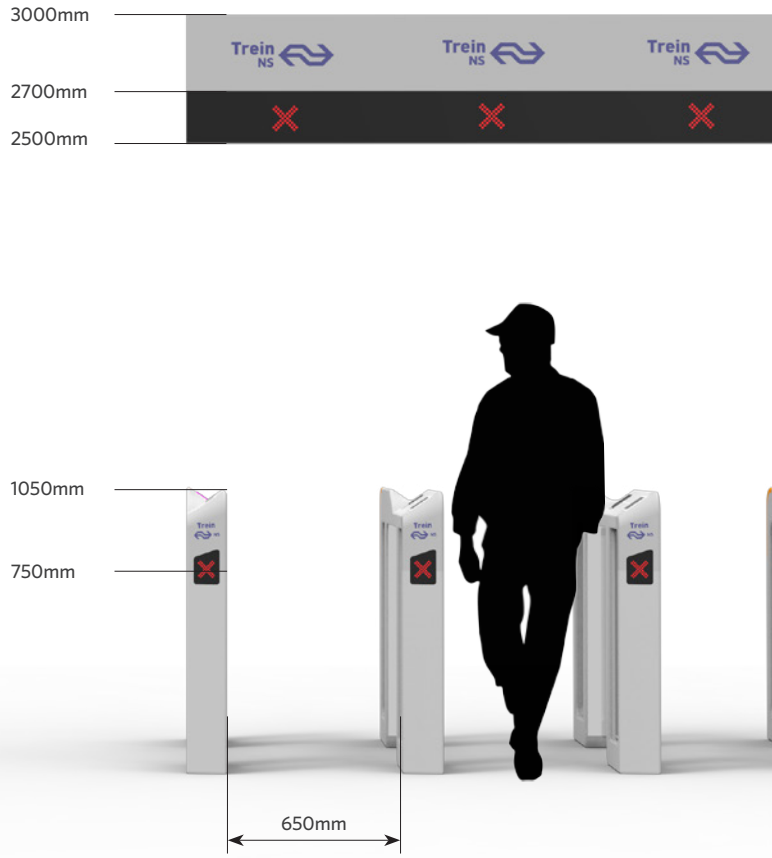
When a gateline has gates of only one operator, it is beneficial to separate the inward and outward gates. Preferabably, the gates on the right side are inward and the ones on the left side are outward, since people walk on the right side. By separating the inward and outward gates, users will always know which side they should walk to get in or out. Furthermore, they also don't have to cross each other, which prevents delay and congestion. With very long gatelines (e.g. Rotterdam Centraal, train) this does not fully apply; groups of inward and groups of outward gates should be placed alternately.

Gatelines with multiple operators (see next pages) can have all gates in one line, with clear recognition from the colors of the lightboxes and the logos and text on the overhead and gate. However, if there is enough space available, it is recommended to leave some space between the gatelines of different operators by using, for instance, glass panels. Since single check-in check out is not implemented yet, it must be clearly stated/shown to users which gates belong to each operator. By clearly separating the gatelines, this is more strongly communicated.

Pages 114 and 115 show how the gateline could possible be placed and look in the contexts of station Amsterdam Zuid and station Breda.

▶ Figure 53. A gateline of the metro of Rotterdam (RET). The lightboxes have the colour of the operator to clearly communicate this to the users.

▼ Figure 54. The height of the overhead signage and the gates in a gateline.



Lightbox overhead
Can be turned on/off. Shows the colour of the operator, and at the same time which gate can be used and which one cannot.

Operator colour, logo and text
Gives travellers feed forward about the operator of the gates. Every operator (here: RET) has its own recognizable colour and logo. Text explains the modality.

Arrows and crosses
Gives recognition to the users about which gates are inward, and which gates are outward. These work together with the arrows and crosses on the gates below.

Lightbox edge
Gives recognition to travellers approaching from the side, without confusing them to which gate the lightbox belongs.

Lightbox gate
Can be turned on and off. Indicates the colour of the operator, and at the same time which gate can be used. Also has text and a logo.

Lightbox overhead
Can be turned on/off. Shows the colour of the operator, and at the same time which gate can be used and which one cannot.

Text & logo
Gives recognition about the operator and modality.

Arrows and crosses
Gives recognition to which gates are inward and which are outward.

Validator
Validator light gives feed forward to users as to which gate can be used and which one cannot.

Lightbox gate
Can be turned on and off. Indicates the colour of the operator, and at the same time which gate can be used. Also has text and a logo.

Bi-directional arrow
Indicates that the gate is a wide, bi-directional gate and that users can expect other users coming from the other side.

Amsterdam Zuid - metro & train

Amsterdam Zuid - train

Breda - train

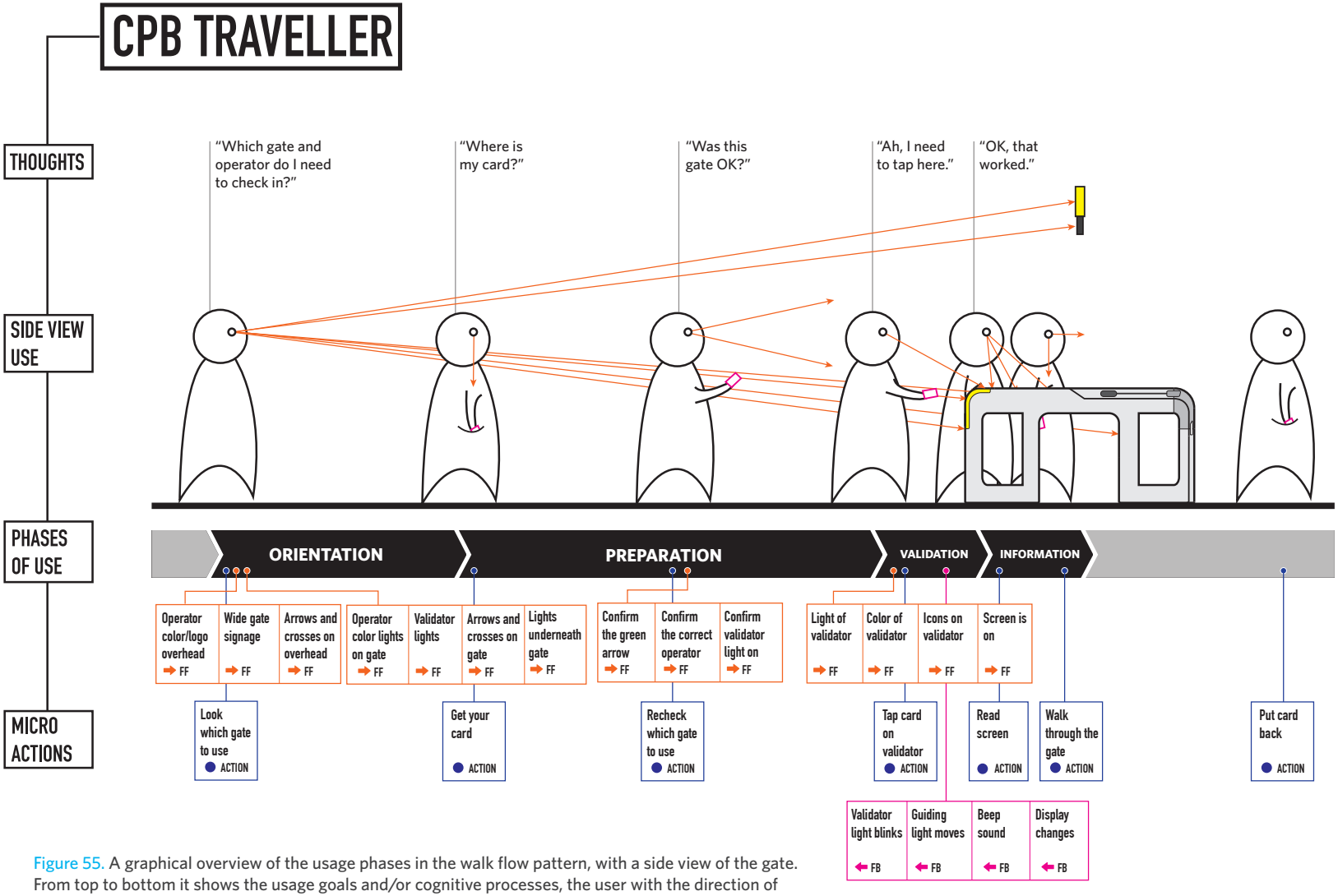
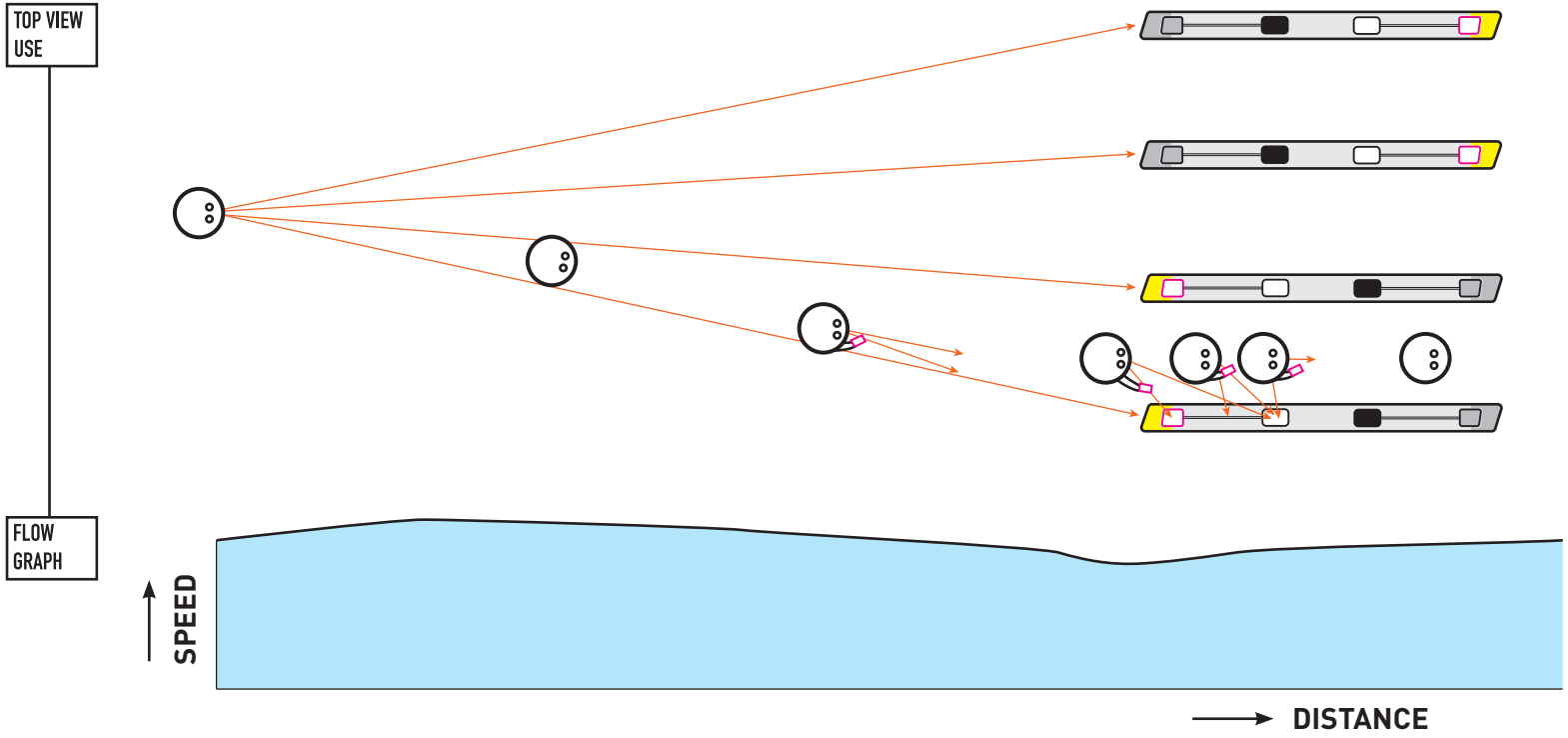


Figure 55. A graphical overview of the usage phases in the walk flow pattern, with a side view of the gate. From top to bottom it shows the usage goals and/or cognitive processes, the user with the direction of attention, the four phases of use, and the micro actions that users perform along the phases of use. The orange boxes show the feed forward elements, the blue the actions of the user and the pink are feedback.

7.2.5 Phases of use

Four phases of use that travellers go through when using the closed payment border were determined during the analysis phase of this project. The new design has been put in a similar graphical representation, with a user going through the four stages: orientation, preparation, validation and information. The users now get much more feed forward during the orientation and preparation phases. The validation and information phases now have a longer distance in which the users can validate and get information from the gate, due to the positioning of the validator and display in the design of the gate. This allows the users to keep a higher pace while going through the gate, while comfortably getting the information they need.

▼ Figure 56. The top view of the usage, with the orange arrows representing the feed forward aspects that the system gives to the user. The speed is now nearly consistent during the whole length of walking through the gateline.




8

8. Conclusion

In the previous chapter, the final design of the new, user-centered closed payment border for public transport has been explained. This chapter will conclude this (research and) design project, and give recommendations on point of uncertainty about the design, about other possible design options, and about possible next steps for the further development of this project.

8.1 CONCLUSION

This project set out to explore the user experience and efficiency of the closed payment border in the Dutch public transportation system, in order to develop user-centered solutions for a new design closed payment border. After field research in the public transportation systems of The Netherlands, London, Hong Kong and Tokyo, usage patterns and issues were found in the Dutch system. Furthermore, opportunities for these issues were identified in the systems abroad. These findings paved the way for the design phase, where a new design closed payment border was developed. Firstly, ideas were generated on the design aspects that could be improved. These were translated into four concepts, which were evaluated with the stakeholders. Based on the user-centered design criteria from the research phase and the criteria set by the stakeholders, it was chosen to further develop the open gates concept, which only closes when something is wrong. This concept increases the throughput, gives a friendly appearance and reduces maintenance. The concept was further developed into a design, which gives more feed forward and feedback to the users through light on the gate and overhead, and through a redesigned user interface. This design was evaluated with users, who thought the design was clear and friendly. Especially the overhead signage (feed forward operator and which gate can be used), the user interface and the open character were appreciated.
The new user-centered closed payment border proposed in this project explores the advantages of having an open gateline, in combination with many new design aspects such as the UI and feed forward aspects. This design reduces the usage issues that travellers will have at the closed payment border and improves the throughput with the placement of the doors, UI and feed forward aspects.
This design needs to be tested and developed further before it can be implemented in the field. Several design aspects could also be transferred to concepts with the doors in the middle, or a high doors version of the proposed design.

8.2 RECOMMENDATIONS

There are several recommendations to be made for this project. Firstly, some points of the design that still have some uncertainty are addressed. Next, other design options are suggested, and how this can be taken further. Lastly, some other aspects for an effective closed payment border are mentioned.

8.3.1 Points of uncertainty in the proposed design

Some parts of the proposed design in this report need to be investigated further, because they have not been developed further than the idea level or the researcher was not sure about some aspects of the design, for instance when the usertest gave mixed responses.

Design aspects

The changes made to the design after the usertest have not been evaluated with users. For instance, the icons in the validator indicating the several payment/ticket options that the gate accepts,

had been redesigned after the findings of the usertest suggested the hand-with-card was well understood but the contactless logo alone was not.

The angle of the display on the gate could be changed slightly, turning it a bit more towards the user at the position when he validates. During the usertest, only one participant said he was unsure about the angle, while others were content with getting their information while walking through the gate. Further development of the gate design should evaluate this aspect again.

The sounds that the gate makes, namely 'successful' and 'unsuccessful' validation sounds, were not developed far in this design. In this project it was established what the sounds should convey to the users, but the actual development of the sound should be looked into further.

Assistance

The new propositions for users to get assistance around the closed payment border, such as the redesigned information pole and the assistance booth in the middle of the gateline, have not been developed further than the idea phase. These propositions were evaluated with a few of the participants of the usertest, and none of them could evaluate the new design information pole properly, because they have never used the one in the current system either. The assistance booth in the middle of the gateline was desired by some participants. These propositions are based on multiple findings from the user research in this project, as well as other projects (e.g. Lehr, 2016 and Mak & van Lieshout, 2016). These propositions need to be further developed from idea level to design.

Operator logo and text

The lightboxes on the overhead signage and the lightboxes on the gates have the colour of the operator of the gates, with the logo, name and modality also visible. These logos and text can be redesigned to fit with the RSB (routing, signing, branding) in order to create an equal layout everywhere. The design proposed in this project merely highlights the importance of these elements (operator logo, text) on the correct place (lightbox overhead, gate), in order for users to choose the correct gate and thus prevent issues.

8.3.2 Other design options

It is possible to take some aspects from this project and develop it into another new gate. During this project, some stakeholders spoke their desire for a high doors gate. Therefore, an open gate design with high doors and a closed gate design with doors in the middle will be proposed to show what the possibilities could be.

Gate with high doors

A high doors version of the design proposed in this project is possible (see Figure 57). The gate will have single high doors on the front and back. These are foldable doors, in order to save space compared to one large door. Two doors (like in the current design) is not possible because that would get in the way of the validator-display unit, and that would make checking in or out impossible. Because the door is at the end of the gate, a 'slower' closing speed would still be acceptable to keep misbehaving users out. This needs to be further developed and tested of course. The door mechanism, which has two frames of 30 cm wide (making 60 cm total width of the passageway) and 180 cm high, should be strong enough, but also quick enough to close on time. This needs to be further developed by some engineers in order to see if this design is feasible or not. The body of the gate is 20 cm wide, in order to accomodate the door.

▸ Figure 57. Gate design with foldable high doors. This design is open on default (left) and the doors will close when an error occurs (right).


Train
Train
Train


Trein
NS
Trein
NS


Metro
GVB
Metro
GVB

Closed gate with doors in the middle

Design elements from the proposed design in this project can be translated into a closed gate with the doors in middle (see Figure 58). In essence, this would be similar to the gate in the current system, but with a new UI (screen, validator) position, on an angled top, and the recognition elements such as the operator light on the front. It would not be recommended to use this design with open doors, because then there would be too little time for them to close if someone walks in without paying. On the other hand, throughput would be diminished because the user has to wait for the doors have to open, and with the validator deeper into the gate, this waiting time could be longer than in the current system. The doors should open very quickly. Furthermore, it is recommended to look further into the most comfortable angle of the display, so users can read their information without any issue. In the proposed design here, this is still a point of uncertainty.

Continuation of the project

The proposed design in this project, or the other design options suggested, need to be further tested and developed before it can be implemented into stations. The sensors of the system, for instance, should be extensively tested since that heavily affects how the gate will behave and thus what experience it gives to the users. Full scale tests should be held with a whole gateline, including overhead signage, in order to see the effects on the throughput of travellers.

8.3.3 Other aspects for an effective closed payment border

There are some other aspects, like the surroundings of the closed payment border or new technologies that are used, that have to be considered in order to make an effective closed payment border.

◀ Figure 58. Gate design with closed doors in the middle. This design can have both high and low doors, which are closed on default.

Station architecture

The efficiency and user experience of the closed payment borders in stations is also affected by the layout of the station. In an ideal situation, travellers will approach the closed payment border head-on, with a large free space in front. This way, travellers have enough time to go through the first two phases of the defined usage phases (orientation, preparation) in order to choose the correct gate and prepare for the validation. This will keep the throughput high and travellers will make less mistakes while choosing a gate. Transport operators and station architects should strive to place the closed payment borders in this way as best as possible.

Recognition wide gate

The signs for the wide gate in the gateline should not only indicate a wheelchair icon. It is used for more than that, and it might be stigmatizing. The recognition for the wide gate should indicate 'wide gate', implying a wider distance between cabinets, or indicate more types of users, by using icons like a stroller and baggage.

Be-in / Be-out

A technology that is aimed to be implemented in the close-by future is the concept of be-in / be-out. With beacon technology the system will be able to detect users and 'scan' their valid card without them having to actively check-in or out. In terms of throughput, the new design gate can work well with this. However, this technology should work really well and accurate before people will trust it and want to use it. Because the doors are open on default, the possibility (and thus the uncertainty!) exists that the doors will close when a traveller walks in, when the technology fails to detect his card. This would be a far suboptimal interaction and really diminishes the open character of this design.

Single check-in check out

The concept of single check-in check out has been considered by transport operators for some years now (Meijdam commision, 2011). This concept implies that users can check-in or out at all gates, and that the operators will figure out the distribution of money in the back-office. By implementing this concept, users would not have to choose between the gates of different operators, and would subsequently not be able to make a mistake. During the usertest of this project, some participants mentioned that they do not understand why it is not possible yet, as it would take away another choice they would have to make while choosing a gate in the gateline. For the design this would have certain consequences: The logos and text of the operators on overhead and gate can be removed, and the colour of the lightboxes can be white instead of yellow, blue, etc.

3D-sensor technology

The gate is dependant of the 3D-sensor technology, situated above the gateline, to determine where the travellers around the closed payment border are. Whether a gate has to close to prevent someone from illegally entering depends on how well this technology can recognize people. Therefore, this technology needs to work very accurately; this needs to be researched, tested with the design and optimized. For instance, when a user checks-in from the correct side and another traveller enters from the opposite side illegally, the sensors should notice the movements and allow the gate to act accordingly (see Figure 59). The effectiveness of the new design closed payment border is much higher when this sensor technology works well.

Design-driven approach

Transport operators must push manufacturers to make what the operators want, with the focus on the needs and wishes of the end users. For instance, by having a design agency make a preliminary design and giving that to the manufacturers in the concession. This way, a better, well-thought design driven (instead of technology driven) design will be made that is more optimal for the end users, of which there are millions each day.

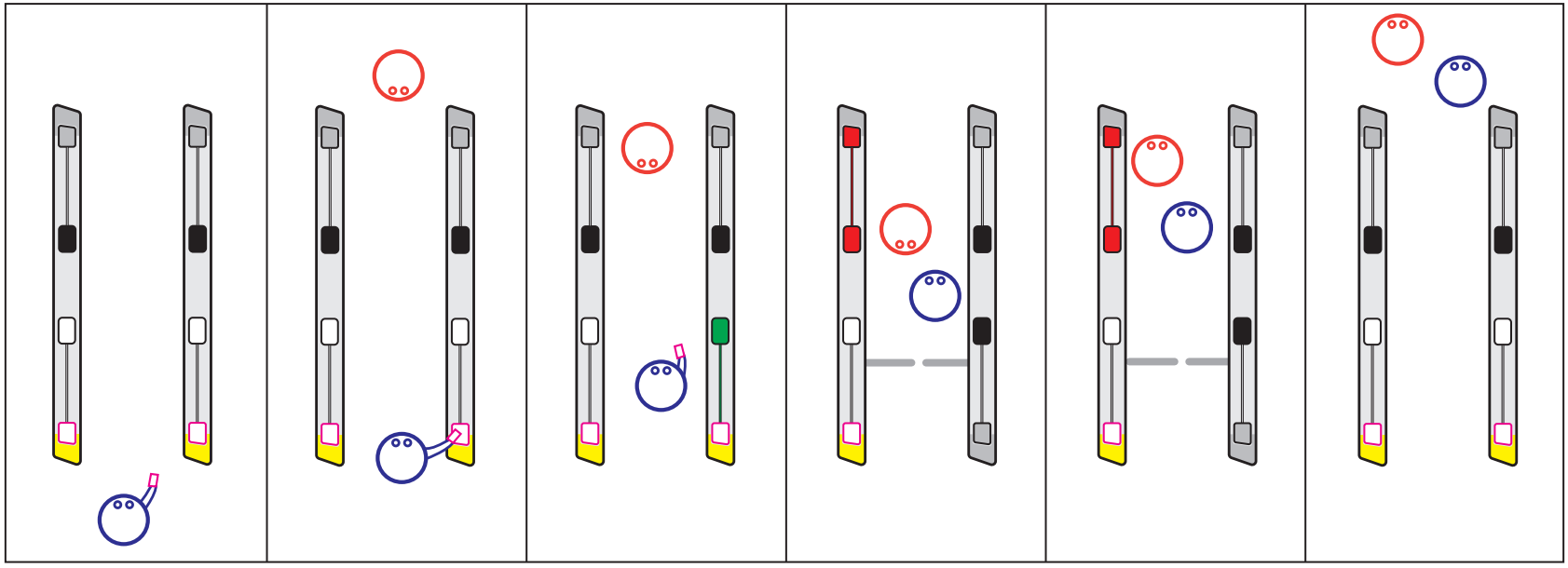
▶ Figure 59. Top view of the gateline, this is what the 3D sensor would see. Use case: It should notice a person attempting to enter illegally, and close the doors without obstructing a user that validated.

User Red approaches the gates that are off (set in other direction). Wants to get through without paying.

Red sees that Blue has successfully validated. Thinks passage is possible while Red is in the gate.

The gate notices that Red enters without paying. **The gate waits until Blue has passed the doors before closing. Red cannot continue.** Gets feedback on UI and lights underneath gate.

Red turns around and walks out of the gate.



User Blue walks up to the gate, prepares card.

Blue validates card at the validator.

Blue has validated successfully. The guiding light shines and the display shows a green message. Blue continues walking.

Blue notices Red, but got feedback that validation was successful. **The doors shut behind Blue and passage is unobstructed.** Sees no feedback directed at Blue.

Blue continues walking out of the gate.

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Colophon

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Project
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