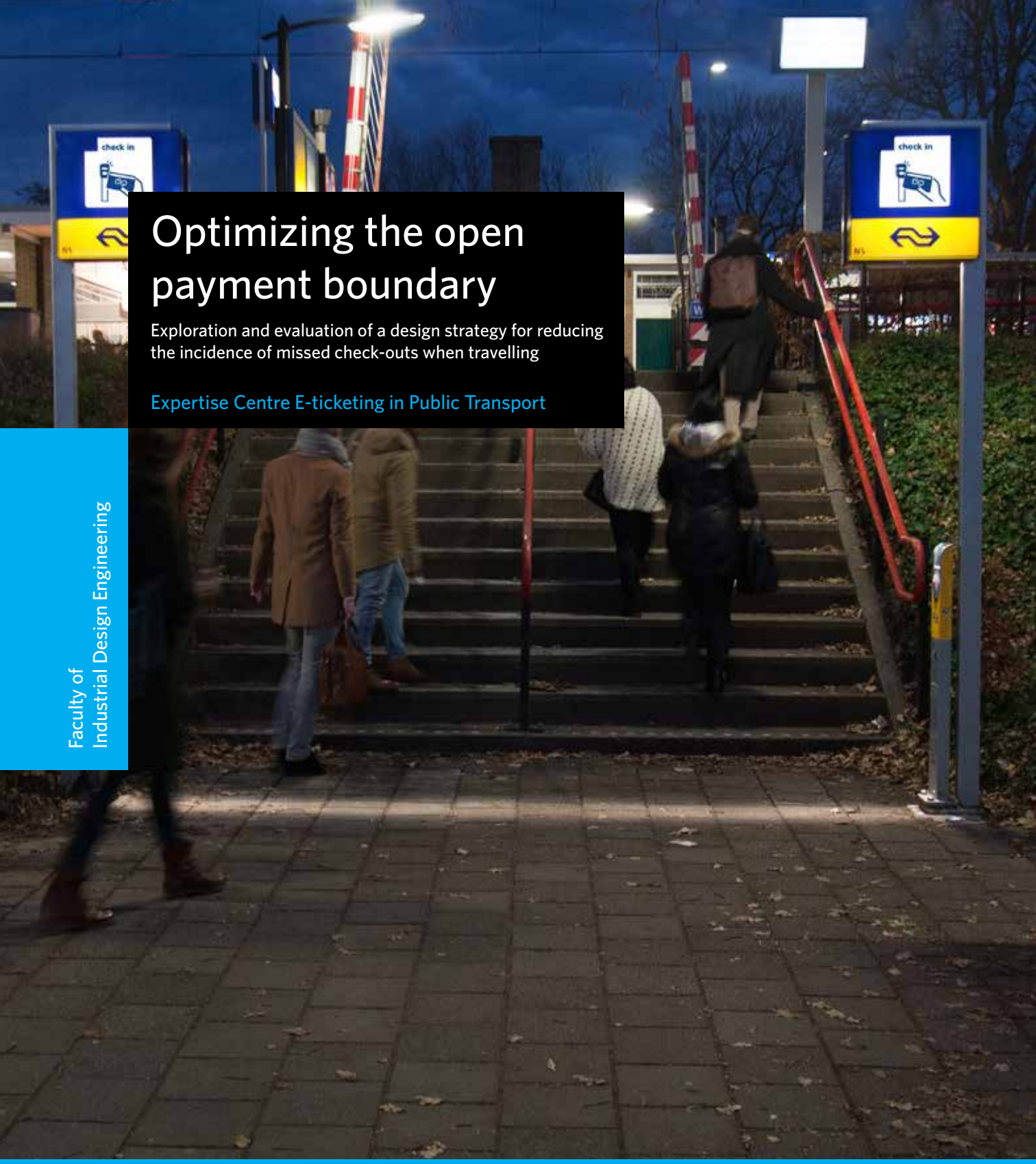

Optimizing the open payment boundary

Exploration and evaluation of a design strategy for reducing the incidence of missed check-outs when travelling

Expertise Centre E-ticketing in Public Transport

Faculty of Industrial Design Engineering

TU Delft

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Exploration and evaluation of a design strategy for reducing the incidence of missed check-outs when travelling

This study was conducted by the Expertise Centre E-ticketing in Public Transport
Delft University of Technology
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Summary

Missed check-outs
Public transport travellers use the public transport payment card (OV-chipkaart), which requires checking in and checking out. Nevertheless, not every journey will have a check-in or check-out. Such 'incomplete transactions' can have a wide range of causes. One important and frequently occurring reason is the 'missed check-out', which occurs when a traveller fails to check out upon arriving at a station. This is evidenced by the number of claims for refunds for overpayment, the number of customer contacts at NS and reactions from travellers. This phenomenon occurs primarily at stations with 'open payment boundaries' (posts rather than gates).

Consequences
Although improvement efforts have been ongoing since the system was introduced, even after 10 years, 1.7% of all trips (with boarding-fare) made by train are still incomplete (Panteia, 2016). Incidental travellers are particularly likely to encounter this problem, as they are more likely to travel on credit and less likely to have built up a routine for checking in and out. They must be particularly careful to check in and out, which creates a greater cognitive burden and makes the travel experience less pleasant. This can have consequences for the appeal of public transport. In addition, requesting refunds for journeys with missed check-outs costs both travellers and public transport operators additional time and money (Panteia, 2014).

Research objective
Reducing the incidence of missed check-outs can offer travellers a better travel experience and help public transport operators to realise cost savings by preventing service contacts and offering more attractive services. NS asked Delft University of Technology (TU Delft) to explore possible solutions and to conduct a trial with modifications at two stations.

The process
In this study, TU Delft has charted the process of checking in and out at stations with open payment boundaries, in addition to exploring ways of guiding people in performing particular tasks. This information was used to design a test installation for a field test. The effects of this trial were examined according to a variety of data (check-out volume, claims and traveller perceptions) at two stations over a three-month period. The effect of the relocation of OV-chipkaart posts that NS carried out at ten stations was also investigated.

The design

For the field test at the Den Bosch and Veenendaal-De Klomp stations, an open payment boundary was developed with supplementary routing, signing and branding, paying considerable attention to visual contrast in these elements. The initial design (see Figure 1) consisted of a portal above the OV-chipkaart posts and a line of coloured LEDs in the floor. These elements connect the posts in manner that creates a visual boundary. Lighting on the floor is also noticeable to travellers who are looking at their telephones. Illuminated, synchronised, flashing card readers call attention to the OV-chipkaart posts as travellers approach the payment boundary.

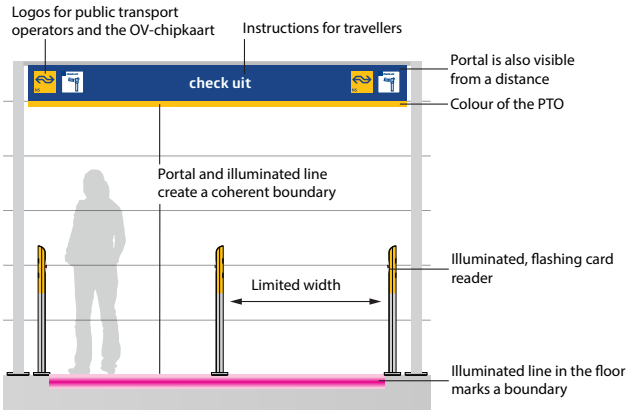

Figure 1: Initial design

After being evaluated with parties involved in the layout of stations, the design was modified according to the applicable national guidelines concerning routing, signing and branding, making it possible and permissible to install the test installation at the Den Bosch and Veenendaal-De Klomp stations. The portal was replaced with separate signs, and the illuminated lines were projected by a lighting fixture in the signs. Due to technical limitations on the part of the current models, the card readers emitted a static (i.e. not flashing) light (see Figure 2).

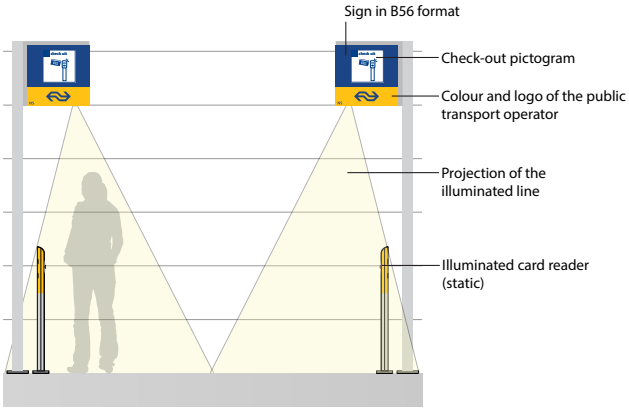

Figure 2: Design as tested at Den Bosch and Veenendaal-De Klomp

Findings

At Veenendaal-De Klomp station, the test installation resulted in a significant reduction in the number of claims. The effect was greater in the weekend than it was on weekdays, possibly suggesting a greater effect amongst incidental travellers. The analysis of check-out volumes did not prove feasible as a measuring instrument. Both of the test installations, as tested at Den Bosch and Veenendaal-De Klomp, were well received by travellers (NS customer survey), although the payment boundary might need to be even more noticeable. The difference in effect between Den Bosch and

Veenendaal-De Klomp might have been due to the difference in context: at the visibly busier Den Bosch station, the payment boundary was located inside, in a lighted area, which reduced the contrast. In addition, the design that was installed in the field was less noticeable than the original design, due to the elimination of a floor marking and a complete portal.

The Front Door Basic principle applied by NS – the location of OV-chipkaart posts at the boundary of the reception and travel domains at seven stations – proved to be an improvement in terms of reductions in queues at posts (to deal with peak-load). At these and three other modified stations, however, no effect was measured in terms of the number of claims or total check-out volume. The modifications at one or more access points might have been too minor to be noticeable at a station level.

In addition, based on previous explorations of the open payment boundary, a literature survey and the outcomes of the field test, design criteria were identified that an open payment boundary should meet in order to reduce the number of journeys with missed check-outs. These criteria can be divided into three main categories: location, visual contrast and surroundings. Open payment boundaries for which consideration is given only to location meet the principles of Front Door Basic. If the layout of the surroundings is considered as well, we call this the Front Door principle. If the visual contrast of the payment boundary is considered as well, we call it Front Door Plus.

Recommendations for the further development of the open payment boundary
Achieving the full concept of the open payment boundary (Front Door Plus) requires several more steps than were taken in the trial conducted in this study (see Figure 3):

1. **Place OV-chipkaart posts directly on the walking route at the boundary of reception and travel domains.** If multiple OV-chipkaart posts are located in a row, place these at a fixed, maximum distance from each other (NS currently uses a distance of 1.8 metres). It may also be necessary to modify walking routes by narrowing broad access points.
2. **Clear the surroundings of the payment boundary as much as possible of other station facilities and objects**. This increases the contrast and ensures that the OV-chipkaart posts are more noticeable.
3. **Provide a visual connection between OV-chipkaart posts** on the ground and at eye level, which will be visible in both daylight and in the dark. This ensures that travellers will be aware that they are passing a payment boundary.
4. **Make the payment boundary more noticeable**. This can be accomplished by increasing the frontal surface (e.g. by increasing the volume of the OV-chipkaart post). Signage at and above eye level can also make them more noticeable with regard to lines of sight at greater distances.

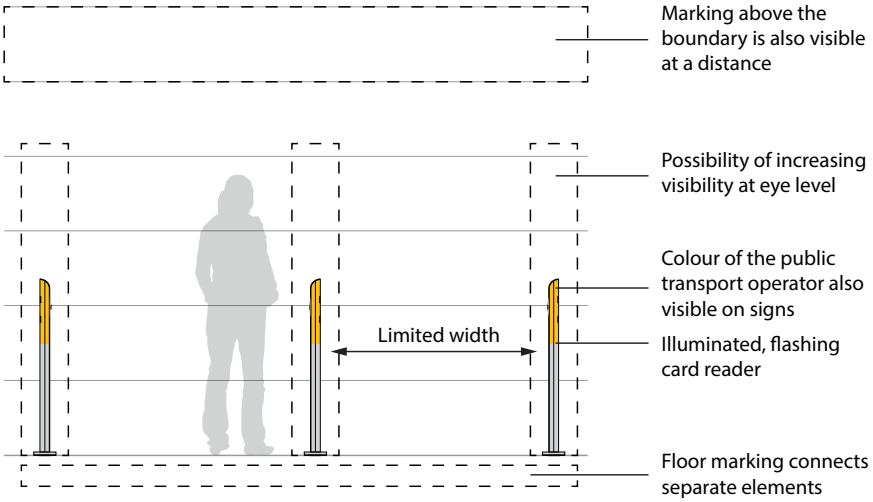

Figure 3: Guidelines for the design of an open payment boundary.

Recommendations for the use of data as a measurement instrument

- **Claims are the best indicator of forgotten check-outs**. The measurement of forgotten check-outs at a specific location is difficult, as it is impossible to identify the stations at which travellers who have not checked out actually disembarked. The proper registration and monitoring of claims could help in the further optimisation of the open payment boundary. Keep in mind that claims are submitted later than the date of travel. At least 90% of all requests are submitted within 56 days after the date of travel.
- **Keep the measurement periods short, and select a stable period in the year**. To ensure effective measurement, this study uses data from one month before and one month after the installation was put in place. In longer periods, disruptions may occur due to holidays. Such disruptions lead to changes in the number and type of travellers. Comparisons between years are not advisable, as fluctuations could be greater than the effects that are being examined.

Parties involved

This study was conducted by TU Delft, commissioned and in close collaboration with NS. NS ordered the construction and placement of the installation and provided TU Delft with data. Other parties who were involved in approving design proposals and issuing permits for the test installation: Bureau Spoorbouwmeester, NS Stations and ProRail.

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1

1 Introduction

1.1 Problem statement and background

With the introduction of the public transport chip card (OV-chipkaart), checking in and out became an integral part of the journey. After the introduction of the card, however, it became known that, after some journeys (about 2%), travellers had forgotten to check out. Only 10% of all travellers requested refunds. This means that each year, around €8.8 million is left with the public transport operators (as measured over the January 2015 - December 2015 period, Rapportage onderzoek incomplete transacties 2016, Panteia). Travellers incur costs for submitting refunds for overpayment (€2.5 million), and public transport operators incur costs for processing these requests (€4.6 million).

Travellers regard forgotten check-outs as a major negative feature of the OV-chipkaart, and this issue has received regular attention in the media. Whereas many metropolitan areas in other countries have closed systems, such that travellers cannot forget to check out, the Netherlands has opted for a semi-open system. Some train and metro stations are closed with gates, while separate validation devices are used at other stations, as well as in buses and trams. The use of an open system imposes a cognitive burden on travellers, who must remember to check out. Without re-designing the payment boundaries, at least part of the problems associated with forgotten tasks will apply to technologies that are currently being explored for future public transport payments: bank cards and smartphones.

Most of the measures that have been taken to date can be found outside the domain of the payment boundary. Examples include the announcements in the train ('... don't forget to check out with NS...'), stickers on the doors of trains and information campaigns. The layout of stations and the location (or relocation) of OV-chipkaart posts have received additional attention at a later stage.

It is assumed that incidental travellers make the most mistakes with checking in and out, as the percentage of incomplete transactions is higher in the weekend than it is on weekdays (Panteia, 2016). In the NOVB, public transport operators indicated a desire to explore improvements that would benefit this group of travellers. NS entered a collaboration with TU Delft in order to conduct further research on this point.

Simultaneous with this project, NS conducted a study on the queues at OV-chipkaart posts. Crowding around OV-chipkaart posts is one reason that travellers do not check out, and is unpleasant for travellers. Given that the relocation of OV-chipkaart posts that NS carried out was part of the 'open payment boundary' concept, the choice was made to devote this study to measuring the effect of these relocations.

1.2 Objective and research questions

Objective

The objective of this project is to investigate the extent to which re-designing open payment boundaries in the railway domain could contribute to minimising the number of journeys with forgotten check-outs by incidental travellers.

Research questions

- How can travellers be encouraged to check in and out?
- What is the effect of locating (or relocating) posts at (or to) the entrance of a station?
- What is the effect of additional facilities?

Additional effects

Travellers would benefit from a reduction in the cognitive load of the OV-chipkaart system. In addition to eliminating the need to request refunds, the design could prevent situations in which travellers almost forget to check out or even have to go back in order to check out. It could also have positive effects for public transport operators: fewer expenses due to a reduced number of customer contacts and enhanced customer appreciation.

Preconditions

This study proceeds from the use of the OV-chipkaart as an identifier for travellers. This project focuses on open payment boundaries ('encouragement'), and it does not address the use of gates ('forcing') or other technologies for reducing forgotten check-outs ('automation') and deliberately 'forgotten' check-outs (fare evasion and fare avoidance).

1.3 Approach

Problems associated with checking in and out have been reported multiple times by consumer organisations, and they have been confirmed by quantitative results in the Panteia report (Panteia, 2016). These results clearly indicate how many travel movements are involved for each concession. Current figures nevertheless cannot be used to indicate why the problem occurs and at which stations.

The basic design for the open payment boundary, which resulted from a project in the OV-chipkaart Graduation Lab (Niermeijer, 2013), was evaluated and used as a starting point for a more detailed design. An installation was elaborated for a field test at two stations: Den Bosch and Veenendaal-De Klomp. The preliminary designs were evaluated with stakeholders, and check-out volumes and claims were analysed.

1.4 Note to readers

This report examines the process of checking in and, in particular, checking out within the OV-chipkaart system at stations without gates. Section 2 addresses how travellers (i.e. users of product-service systems) could be encouraged to perform a task. Sections 3 and 4 describe the concept of the 'open payment boundary', which is the current context of the OV-chipkaart posts at open stations.

The second part of the report concerns the effects of interventions at stations. Sections 5 and 6 address the research method and characteristics of various data sources. Sections 7 and 8 present the results of the research components Front Door Basic and Front Door Plus. Section 9 consists of the conclusions, discussion and recommendations.

Denkt u aan
het uitchecken?
Behalv als u verder
reis met NS.
Houd alvast
uw chipkaart
bij de hand

2

2 Literature

Users and how they can be encouraged to perform a task

The use of the OV-chipkaart can be broken down into various sub-elements that have an influence on interactions between users and the product/system.

Breaking the problem down according to principles from psychology and person-product interaction clearly indicates why it can be troublesome to validate an OV-chipkaart at an open station.

This section describes some of the human capacities that play a role in the use of a payment boundary (2.1), the role of triggers in human behaviour (2.2) and the possibility of designing these triggers (2.3).

2.1 Human capacities

Travellers have several characteristics and limitations that influence the use of the OV-chipkaart. These aspects are difficult to influence. They nevertheless provide insight into why it remains difficult for travellers to check out.

Working memory, cognitive load

A person's working memory (short-term memory) is limited. Psychologists assume 5–9 (7, plus or minus 2) items under ideal circumstances (Miller, 1956). This capacity is strongly influenced by external factors that result in additional cognitive load. Moreover, travellers are not actively trying to remember as much as possible; they are occupied with a wide range of other matters. At some points in the journey, the cognitive burden can be quite high. This is particularly true of the points at which the most is demanded of travellers: departure and arrival.

Observation of payment changes in the context of public transport reveals clear differences between several manners of payment. With single journey tickets (CT tickets), travellers do not need to think about their payment methods except at the beginning of the journey, as they pay directly, with no further financial transactions. Prior to the introduction of the OV-chipkaart, travellers with purchased subscriptions (route-specific or annual public transport passes) were required only to ensure that they had proof of the subscription with them. This group did not have to give any further thought to a ticket throughout the journey. Since the introduction of the

OV-chipkaart all travellers have been required to perform a task twice during each journey and, in many cases, they still feel a sense of uncertainty during verification in the train, wondering whether they have indeed checked in with their OV-chipkaart.

In combination with other distractions arising from the surroundings or their own thoughts, this can lead them to forget to perform an OV-chip task due to an excessive cognitive burden at the time that attention is truly needed.

Prospective memory

In the literature, remembering a task that must be performed in the future is referred to as *prospective memory*. A distinction is made between event-based and time-based prospective memory. Time-based tasks ('in one hour, we must take the cookies out of the oven') are simple to remember with the use of an alarm clock. Action-based tasks must be recalled in another manner. In this context, the trigger (event) that retrieves the delayed task from the memory plays a major role.

Dismukes (2012) uses a model to describe this process (see Figure 4). Humans start by thinking about what needs to be done and where it should be done (ENCODE). This is followed by a period (DELAY) lasting until the events take place (PERFORMANCE INTERVAL). Once the proper event has taken place, the planned task must be carried our (EXECUTION). After it has been performed, reflection on the task (EVALUATION) follows.

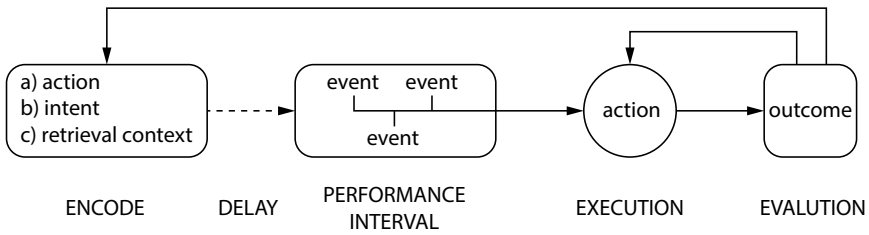

Figure 4: Steps in the prospective memory model according to Dismukes (2012).

Dismukes (2012) presents several measures that help individuals to remember and perform delayed tasks:

- Avoid multi-tasking if a particular task is very important.
- Perform critical tasks immediately instead of delaying them.
- Create obvious hints/reminders and place in places that are hard to miss.
- Draw a link between the task that must be performed and an existing habit.
- Use tools that can support the memory (e.g. reminders in smartphones).

This indicates that individuals who must (or who are expected to) perform a task must be very deliberate about it. If they do not think about it on their own, they need external stimuli (*triggers*) in order to ensure that the delayed task is recalled. The performance of tasks can also be promoted by supporting routines.

Interruptions are an important reason keeping individuals from thinking about delayed tasks. Dismukes and Dodhia (2009) state a number of reasons why it is difficult for people to resume tasks after they have been interrupted:

- The interruption is so abrupt that the individual is unable to determine explicitly how to resume the interrupted task after the interruption.
- Immediately after the interruption, a new task emerges. This keeps the individual from first considering any tasks that have not yet been completed.
- After the interruption, there are no triggers to remind people of the uncompleted tasks.

Checking out with an OV-chipkaart is an excellent example of a delayed task. At the beginning of a journey, travellers must make a mental note that a task must be performed at the station where they disembark. They need a trigger that will remind them to validate the OV-chipkaart.

2.2 The role of triggers in human behaviour

The preceding section describes several human capacities that play a determining role in the use of services like the OV-chipkaart. This is a fact that must be considered, but that does not allow for much guidance. Other concepts, however, offer clear suggestions for guiding behaviour.

Fogg's Behaviour Model

One theory that can be used to determine why users exhibit particular behaviours is Fogg's Behaviour Model (FBM; Fogg, 2009). The model assumes three elements that must occur simultaneously before a particular behaviour will emerge.

1. *Motivation*. A degree of motivation – people usually have a particular reason for doing something.
2. *Ability*. The ability of performing a task.
3. *Trigger*. The signal that urges users to perform a task.

Figure 5 depicts how these three elements are related to each other. The figure also demonstrates that the motivation and the ability to act are clearly related to each other. For example, tasks that demand a great deal of difficulty call for a great deal of motivation to act. In addition, a signal is needed to urge the individual to perform the task.

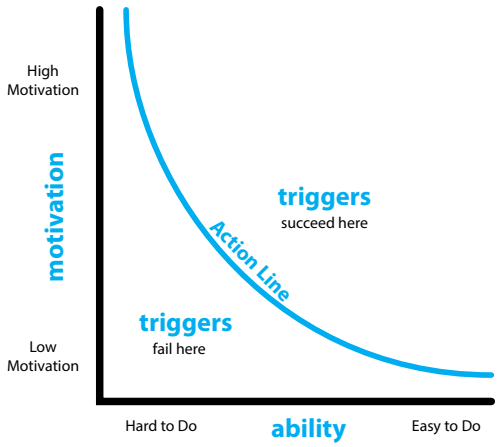

Figure 5: Fogg Behavior Model

Routines: Habits

Checking in and out can be seen as a routine task. Routines become engrained unconsciously when they are built up consistently. It is nevertheless possible to guide and create them. According to Duhigg (2012), habits are constructed of three elements: a task, a cue (trigger) and a reward. These elements can be examined separately.

In order to change a habit, it is important for the cue to be something that is constant in all cases. It could be related to what a user is doing at that particular moment, or it could be related to the particular context or to a particular point in time. The reward (always positive) ensures that the habit will be maintained.

Nudge: an extra incentive

Human behaviour can be easily guided by determining what can be offered to users. Richard Thaler and Cass Sunstein (2008) describe this in the context of making choices. For other situations, however, human behaviour is particularly open to guidance if there is direct, visible feedback on the behaviour. For example, being fined after making a poor choice has less effect than does an immediate reward for doing something good.

People can be guided by using positive means to encourage them to make the 'right' choice instead of punishing them after the fact for making the 'wrong' choice.

2.3 Designing triggers

The previous sections have demonstrated the importance of triggers in human behaviour. These triggers can be incorporated into products, as well as into the entire surrounding area. *Use cues* and *wayfinding* are important concepts in this regard.

Use cues

Products and services have features that play a definitive role in their use – both in preparation and in actual usage. For example, the appearance of a product, as well its sound, can communicate what the product is and how it will operate before the user has done anything. A *use cue* is a feature of a product that indicates its functionalities and how they can be used (Kanis, Rooden, and Green, 2000). The application of use cues can help users to use a product without any explicit explanation of exactly how it works.

Use cues are often related to a product's controls. A particular layout of elements is often used when installing controls. This is also known as mapping. Natural mapping assumes that users will immediately understand what will happen when they use a given control (Norman, 2013).

For the payment boundary, this means that it should be clear to travellers that they will have to do something. It should be possible to infer this from the product or system with which they are interacting (in this case, the entrance to the travel domain of a station).

Wayfinding

Wayfinding literally refers to finding the way, but it also refers to signage. Scientists regard it as the ordering of spaces. Passini (1984) describes it as the issue of the spatial ordering of physical components. He divides the underlying process into the following components:

- The possibility of charting information on the physical surroundings in a cognitive model.
- The possibility of developing a plan containing tasks.
- The possibility of carrying out this plan.

Correa de Jesus (1994) confirms that there is a need for 'clues in the architecture that reassure people that they are going the right way'. This also indicates that the spatial design contributes to a user's spatial orientation.

One important component of wayfinding concerns whether signs are actually noticeable. A sign or other object for which people search is also known as a *target*. Visual distinctiveness is defined as the ease with which a visual object is noticed in its surroundings by an observer who has no knowledge concerning the location, but who does have sufficient information about the object to recognise it as a target. Visual searching thus entails the localisation of an object for which people search within a given environment. This process is supported by the elimination of 'spatial uncertainty' (Monk, 1984).

2.4 Conclusion

With the introduction of the OV-chipkaart, travellers were introduced to a method of payment that was different from that to which they were accustomed. The technical calculation of income changed, as did the mental model encountered by travellers. Travellers had to adjust to having two tasks for each journey, instead of one task or even none at all (as in the case of route-specific or annual pass). This demands additional thinking capacity on the part of travellers. This capacity is nevertheless limited and, when travelling, it is often used for other matters. Moreover, checking out is a delayed task. When checking in, travellers make a note in their memory that they will have to check out. They then need a cue (or trigger) in order to retrieve this thought.

Triggers play an important role in human behaviour. For example, they can retrieve thoughts from memory and initiate a task. Linking tasks to triggers is also important in the creation of routines. A stimulus that prompts people to do something should preferably be positive and immediately present at the moment that something is expected of them. Punishment after the fact for a poor choice (or for no choice) does not have as great an effect.

Triggers can be designed, whether they concern a product, service or an entire environment. Providing the right cue (hint) makes it clear to the users of a product/service that they must do something and what it is that they must do.

3

3 The open payment boundary and the Front Door principle

The use of card readers at stations without gates

At first glance, checking in and out seems quite simple. Travellers hold their OV-chipkaart against a card reader at the beginning and end of a journey, and that's it. In contrast to closed payment boundaries consisting of gates, train stations with OV-chipkaart posts constitute an exception within the OV-chipkaart landscape as a whole. This section describes what makes the 'open payment boundary' different and identifies the most important factors in its usage.

3.1 Conceptual model of the payment boundary

When travellers use public transport, they must check in at an OV-chipkaart post or gate. They cross a boundary, as it were, from an unpaid side to a paid side (see Figure 6). If the proper travel product and a sufficient balance appear on the OV-chipkaart that is presented, its user can check in and out without any problems. In all other cases, travellers must resort to other touchpoints (e.g. ticket vending machines, service shops, websites or apps).

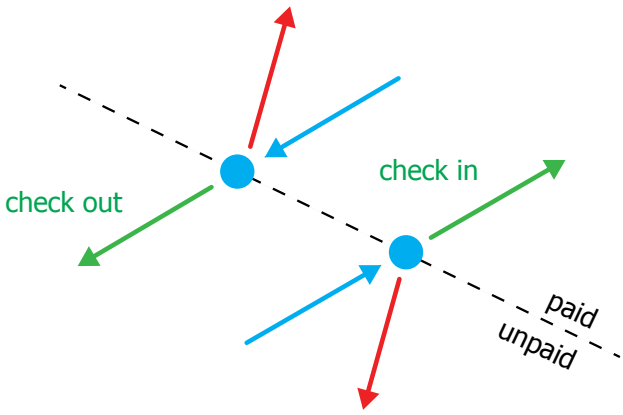

Figure 6: Passing a payment boundary is the transition from an unpaid zone to a paid zone.

In all modalities, the OV-chipkaart devices are arranged in a manner that allows cards to be validated before travelling. Nevertheless, there are fundamental differences between the modalities.

Railway domain

The payment boundary in the railway domain takes several different forms, and it can vary greatly by station:

- 82 of the 410 train stations in the Netherlands are (or will be) closed off with gates. During more than 90% of all journeys with NS, train travellers pass through a closed payment boundary when entering and/or leaving a station. During 50% of all journeys with NS, train travellers pass through an open payment boundary at least once. Train travellers are therefore confronted with different concepts, which make it more difficult for them to adhere to a set pattern of usage.
- The types of train stations vary widely. The layout and available space varies from one station to another, leading to possible variations in the location of the OV-chipkaart facilities. This makes it more difficult to construct a routine.
- Some train stations serve multiple public transport operators. An additional choice must be made upon checking in, checking out or checking over (checking over refers to checking in as well as checking out for a transfer to another public transport operator by rail) at the OV-chipkaart post or gate of the right public transport operator. If this is not done properly, travellers encounter fines or other disadvantageous consequences.

Bus, tram and metro

On the bus or tram, validation nearly always coincides with boarding and disembarking. In this context, the door constitutes the payment boundary. In the metro, people usually pass through a row of closed gates. In both of these contexts, there is a clear point during the journey at which the card must be validated. On the bus and tram, additional crowding occurs at the point at which validation must occur. The bus driver and other travellers must wait for those who are validating an OV-chipkaart. There is also an additional check by the driver or conductor.

Figure 7 presents the differences between the various payment boundaries. The main categories are bus/tram, metro and train. For some trams and metro stations, however, there are exceptions to the manner in which travellers must check in.

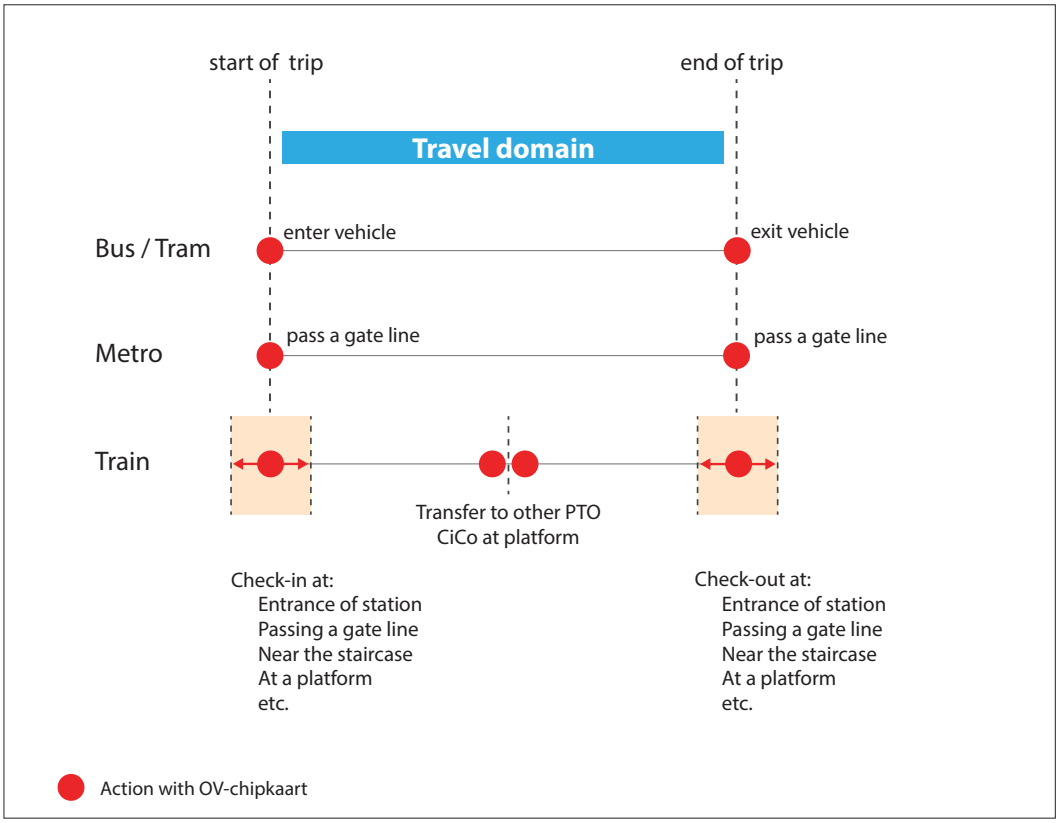

Figure 7: Payment boundary by modality: the railway domain differs from the bus/tram/metro.

3.1.1 Distinction between forgetting to check in and forgetting to check out

A distinction can be made between forgetting to check in and forgetting to check out. People are less likely to forget to check in than they are to forget to check out. The most likely explanation is that a task preceding the journey corresponds to purchasing a paper ticket or validating a stamp card before the journey: pay first, and then travel. It is also a part of a set routine which also includes looking at departure times. In contrast, checking out was never a part of the former routine of travellers. The consequences of forgetting to check in are often greater than those associated with forgetting to check out. Travellers who have forgotten to check in are subject to being fined (for not being in possession of a valid ticket). They also run the risk of wanting to check out even if they have not checked in, such that they pay only the boarding fare, thus possibly paying too much for the journey. Travellers who forget to check out pay only the boarding fare, which exceeds the actual destination fare for many journeys. For metropolitan transport, the boarding fare nearly always exceeds the destination fare.

3.1.2 The use of the payment boundary

Payment boundaries are used in several different ways. For example, frequent travellers very quickly learn where the OV-chipkaart posts are located, and they might even know exactly which ones they should use in order to avoid waiting. The use of OV-chipkaart posts is less routine for infrequent travellers, as well as for frequent travellers who are not familiar with a station. Payment boundaries should ideally facilitate three phases of usage (Niermeijer, 2013).

1. **Wayfinding and recognition**
   In this phase, the exact location of the payment boundary should be clear, and it should be recognised by travellers. The payment boundary should be visually obvious, not only from close by, but from some distance as well. This allows travellers to prepare (e.g. by reaching for their OV-chipkaart).

2. **Validation**
   Validation should proceed smoothly, and travellers should receive assistance in the case of error messages. This phase is primarily concerned with the OV-chipkaart post.

3. **Information and support**
   Adequate information about the use of the OV-chipkaart and the resolution of problems should be located in the area surrounding the payment boundary. Examples include information about the OV-chipkaart and the rules associated with it, ticket vending machines and staff.

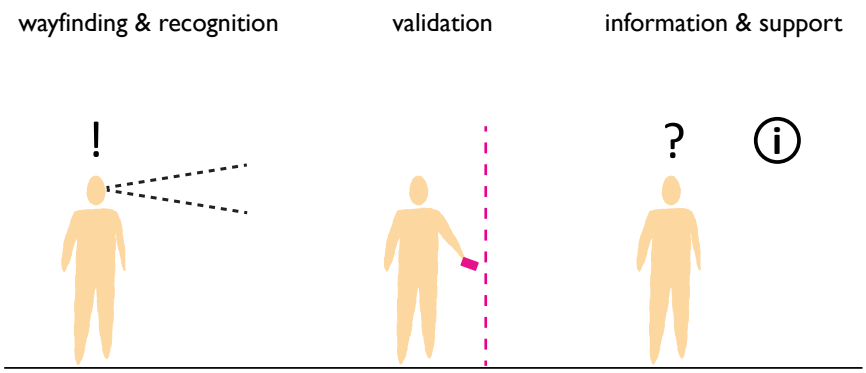

Figure 8: Three phases of usage for a payment boundary.

This three-way categorisation (see Figure 8) also applies to closed payment boundaries. However, it is impossible to overlook gates, as they restrict the access point, which cannot be passed without performing a task. The contradiction here is that, while a row of gates is more obvious and more likely to be recognised, these features are less necessary here, as the closed doors force travellers to validate their tickets anyway.

3.2 Previous research: uniformity between touchpoints

A previous study conducted at TU Delft (Niermeijer, 2013) focused on the uniformity of OV-chipkaart touchpoints at stations without gates. That study constituted the background to the present study. The result emerged according to field research in the Netherlands, Hong Kong and London. Three factors were important in this regard:

1. **Product**: the OV-chipkaart as a platform, the equipment and the card. The various touchpoints together constitute a product/service with which to pay for public transport.
2. **The intended end-user**, in this context, only the traveller is considered. As users of the product/service, travellers must engage in a certain interaction with the system. They must perform a task and, most importantly, they must understand what they are expected to do.
3. **The surroundings**; everything that occurs outside the direct interaction between the user and the product can have an influence on the interaction.

The location and coordination of the various facilities generates coherence, which makes it easier for travellers to use and understand the OV-chipkaart. The basic principle in this regard was that single check-ins and check-outs would be implemented within the railway system and that stations would have only one type of OV-chipkaart post. In the design concept, therefore, magenta was selected as the main colour, as it was not necessary to distinguish between various public transport operators (see Figure 9).

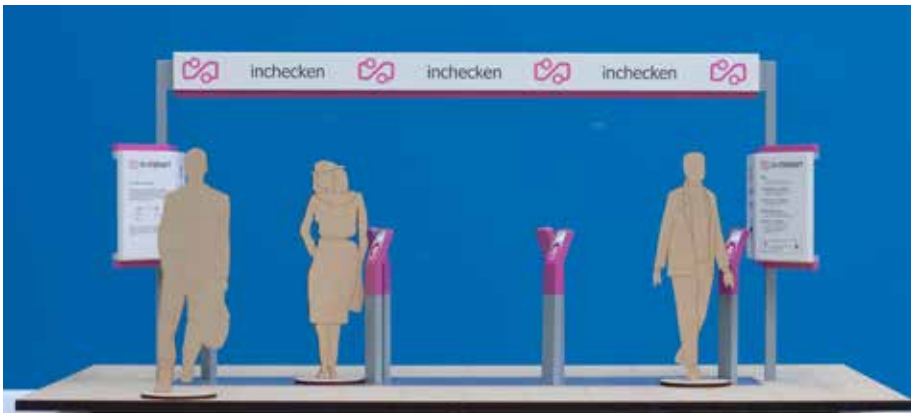

Figure 9: Design concept for an open payment boundary; coherence between touchpoints.

Important elements in this design concept include placing the OV-chipkaart posts at the access point to the travel domain and the elimination of as many other objects as possible that are not important to the use of an OV-chipkaart. This creates a 'boundary' that can be clearly recognised by travellers, with the OV-chipkaart posts always located on the walking route. Other elements of this payment boundary include clear marking above the OV-chipkaart posts and on the floor. All of these interventions help to accentuate the location of the OV-chipkaart posts.

3.3 Mistakes when checking in and out and their consequences

3.3.1 Possible mistakes

Travellers play an important role within the OV-chipkaart system as a whole. They are the ones who must ultimately check in and out. This demands the attention of travellers, who can make mistakes in this regard. There are several reasons why travellers may not check in or out properly.

Forgetting to check in and/or out

Travellers sometimes intend to check in but fail to perform the task. The equipment is apparently not obvious enough, or travellers do not pay attention to it because they are occupied with other matters or become distracted at exactly the wrong time.

Almost forgetting to check out

Travellers who realise that they have forgotten to check out have the option of returning and checking out anyway. Although this group is not reflected in data on claims, the situation does involve inconvenience.

Making mistakes when checking in and out

In addition to deliberate and unconscious failure to check in/check out, people may miss some check-ins and check-outs because they think that they have validated their cards when actually they have not. This could be due to technical defects, as well as to an improper interpretation of the feedback from an OV-chipkaart post. For example, it could occur as travellers are rapidly validating their cards one after the other. If the second person does this too soon, this person might see the previous person's feedback and think that it applies to him. In other cases, travellers may pay primary attention to the sound without realising that it was coming from another OV-chipkaart post.

Deliberate failure to check in and/or out: fare evasion and fare avoidance

In some cases, travellers do not forget to validate their cards. They sometimes do this deliberately. People who deliberately do not check in are classed as fare evaders. Completely closed stations could offer at least a partial solution to this problem.

Travellers who do check in but who deliberately do not check out are classed as fare avoiders. This actually occurs only if the destination fare exceeds the boarding fare, i.e. in the case of long lines. Fare evasion and fare avoidance fall outside the scope of this study.

3.3.2 Reasons for forgetting to check out, according to travellers

Travellers have noted several reasons why they occasionally forget to check out (Niermeijer, 2013).

- They are occupied with other matters and are not paying attention to the OV-chipkaart.
  - They are engaged in routine travel, such that they are not actively thinking about travelling, and thus also not thinking about the OV-chipkaart.
  - Travellers are distracted by the surroundings: static features (e.g. advertising or food outlets) or dynamic features (e.g. activities or other travellers).
  - They are occupied with subsequent steps in the trip (e.g. seeking other forms of transport).
  - They are talking to someone.
  - They are occupied with their phones.
- The OV-chipkaart posts are not obvious enough, due to:
  - Location (e.g. the OV-chipkaart posts are not located along the walking route). Travellers have to walk some distance back in order to reach the exit, or they have to deviate from the shortest route.
  - The OV-chipkaart posts are not obvious enough, and people tend to pass them by.

3.3.3 Consequences of forgetting to check out

Many travellers often do not realise that they have made a mistake until they have left the travel domain and cannot immediately correct the error. In addition to having financial consequences, such situations contribute to negative perceptions concerning the use of the OV-chipkaart and public transport in general.

3.4 From the needs of travellers to requirements at the payment boundary

Travellers need triggers for at least six aspects of checking out.

1. Travellers should clearly see the payment boundary along their route.
2. The payment boundary should be clearly distinct from other station facilities and objects.

3. Travellers should encounter an OV-chipkaart post on the route between the entrance that they have used and the place where they would like to stand on the platform without having to deviate too far from their walking route.
4. For travellers, validation (checking in or out) should occur at the right time: at the boundary between the reception and travel domains. This is the moment immediately before departure, such that travellers are no longer occupied with other matters (e.g. running errands or searching for/verifying the departure platform).
5. Travellers should encounter only one OV-chipkaart post (or payment boundary). Otherwise, there is a risk that they will validate their cards at both payment boundaries by reflex.
6. Travellers should be able to see the payment boundary approaching. This increases the likelihood that they will notice the payment boundary. It also allows travellers sufficient time to prepare for checking in or out.

The following table presents the needs of travellers alongside the features of a payment boundary. These features constitute criteria on which payment boundaries could be assessed.

Table 1: Needs of travellers alongside the features of a payment boundary. The Front Door principle is indicated in green, with Front Door Basic in yellow and Front Door Plus in blue.

	Front Door					Front Door Plus			
Needs of travellers / *Features of the payment boundary*	Location	Free standing	Passage width	Visible from a distance	1 payment boundary	Frontal surface	Colour	Light	Coherence
Visible									
Standing out									
Always come a cross a validator (while taking the shortest route)	Front Door Basic								
The right moment (boundary entrance/travel domain)	Front Door Basic								
Enough time to prepare (does not come as a surpise)									
Only one boundary each entrance									

3.5 Conclusion

Checking in and out with the OV-chipkaart can take place in several different ways and at several different times during a trip, depending upon the modality and structure of the train (or other) station. In the bus, tram and metro, OV-chipkaart equipment is usually installed in an unambiguous manner. Train stations, however, occupy a special place within the OV-chipkaart landscape as a whole, and payment boundaries are implemented in several different ways. Travellers may encounter both gates and posts at various locations at the station. As a result, travellers must be particularly alert, and they are likely to make mistakes.

If travellers unconsciously forget to check out, it could be because they are not actively thinking about checking out (prospective memory). Alternatively, it might be because the point at which the card must be validated is not obvious enough (i.e. the trigger is missing).

4

4 The current situation at open stations

The OV-chipkaart system has been modified since its introduction. At stations, this can be seen in the variety of ways in which OV-chipkaart equipment is positioned. This section provides insight into the various arrangements and what has been done throughout the years in order to reduce the incidence of travel with missed check-outs.

4.1 Current types of installations

Several open payment boundaries can be seen in the current situation. They have emerged in a variety of ways. The most important ones are as follows:

Next to a stamp-card machine

This is visible at many small stations. When the first OV-chipkaart posts were installed, it was assumed that an OV-chipkaart post would fulfil the same function as a stamp-card machine. The decision to take over this location thus seemed logical at the time of the introduction of the OV-chipkaart. However, OV-chipkaart posts are used much more frequently. In the period leading up to full use of the OV-chipkaart, additional OV-chipkaart posts were installed.

Distributed across the platform

OV-chipkaart posts should be located as close to the train as possible, but spread across the platform in a safe place, in order to prevent back-ups at the access points. In practice, the posts that are located closest to the access point are used most often, and localised capacity limitations lead to the first hick-ups in peak periods.

Distributed throughout the station

This is the case particularly at access points on the boundary between the reception and travel domains. At smaller stations, this could be on the platform. At larger stations, it could be at the main entrance. This is the most common situation for stations with OV-chipkaart posts. For each station, an assessment was made of where the most OV-chipkaart posts would be needed. This differs by station, depending upon the number of travellers and the number of access points.

Installed in a row on a ribbed steel plate

These situations are 'temporary' until gates are installed. They are characterised by the 'threshold' of the ribbed steel plate. All of the cables needed to operate the posts are located under this plate, which also serves as a clear point of recognition, alerting them to the fact that they are walking past OV-chipkaart posts (Niermeijer, 2013).

A gate line with doors open

In Bangkok, most of the planned BTS stations have had gates with the doors open for some time, as delays have occurred in the process of closing off stations or because of the considerable time elapsing between installation and use. This is a special category of open payment boundary, as it is intended to be a closed boundary. In contrast to OV-chipkaart posts, gates have separate sides for checking in and for checking out. This leads to different types of usage problems, including checking in on the check-out side, and vice versa.

4.2 Observations in the field

Observation of situations at various stations reveals several remarkable, recurring features. The following examples are grouped by topic.

There are no direct lines of sight towards OV-chipkaart posts

OV-chipkaart posts are not always located in direct sight as people enter or exit the travel domain. They are located in a corner, or they are clearly visible from one side only. One specific example has to do with lifts where the OV-chipkaart posts are clearly visible upon entering the lift, but are not in the passenger's field of vision upon exiting the lift.

Figure 10: Example of an OV-chipkaart post beside a lift: clearly visible when approaching the lift, but not visible upon exiting (checking out).

Figure 11: Another lift with OV-chipkaart posts on both sides of the door. In the photo on the right, the OV-chipkaart posts are located just around the corner. The stamp-card machine and the ticket vending machine are clearly visible.

OV-chipkaart posts located amidst other facilities

Many objects are located at stations and on platforms, including information panels, waste bins, information and emergency call boxes, stamp-card readers and billboards. It is no coincidence that they are often very close to the access points. Because OV-chipkaart posts are smaller than other objects, they are less noticeable. In some cases, they might not be visible at all (see Figure 12).

Figure 12: Examples of situations in which OV-chipkaart posts are located amidst other facilities and are thus not clearly visible.

Uncoloured OV-chipkaart posts

The yellow colour on OV-chipkaart posts comes from a sticker. It is common to see OV-chipkaart posts without such stickers or with stickers that have been partially peeled away (see Figure 13). The grey version is less noticeable, and travellers are accustomed to scanning their cards on posts with a yellow top (for NS). Confusion can thus arise concerning the right public transport operator at stations where multiple operators are active.

Figure 13: Examples of the OV-chipkaart post no longer having a yellow sticker. As a result, the post becomes a nondescript object at the station.

Wide walking routes and access points

The platforms of smaller stations often have multiple access points or flow seamlessly into the reception domain. Bicycle parking facilities and car parks are located directly adjacent to a platform, or platforms have multiple secondary access points. There is little space between these various areas, or the access points are very wide. As a result, travellers are not guided directly along an OV-chipkaart post (see Figure 14).

Figure 14: Situations in which no clear walking route is dictated or in which the OV-chipkaart post is not located along the walking route.

4.3 Current solutions for preventing forgetting to check out when travelling

Since the introduction of the OV-chipkaart multiple measures have been taken in order to reduce the percentage of journeys with missed check-outs at open stations. Examples include measures at the payment boundary and at other places in the travel domain in addition to information and encouragement for travellers.

Measures at the payment boundary

In the field, measures that have been taken have to do with the location, number and appearance of the OV-chipkaart posts (see Figure 15).

- The posts have been made more specific to particular public transport operators by applying the operator's colour to the top of the post. This was particularly important at stations with multiple public transport operators. When they were introduced, NS posts had only a small blue band displaying a logo.
- Continuous process: evaluating the placement of OV-chipkaart and relocating them according to transaction data and random observations by staff. The two most important criteria are capacity and availability. Since 2015, posts have been relocated according to the Front Door principle: at the boundary between the reception and travel domains.
- Transfer facilities at stations with multiple public transport operators. The location of multiple posts is marked by an attention cube, and a sign provides brief instructions concerning the task that must be performed.

Figure 15: From left to right: No colour; with a 'cigar band' and floor markings; yellow top and in a row; transfer cube with three OV-chipkaart posts of different public transport operators.

Measures in the travel domain

These measures concern facilities that have nothing to do with the payment boundary:

- Information in the form of posters and dynamic information in trains.
- Announcements upon arrival at a station. 'If you are travelling on credit with your OV-chipkaart and this station is your final destination, do not forget to check out from NS' (text dependent upon the type of station; for example, if multiple public transport operators are active).
- Reminder in the Travel Planner once a journey has been selected.
- Stickers on the doors of Sprinters: 'Do not forget to check out'.

General information

- Education, training and deployment of staff (e.g. to instruct travellers and assist them when checking in and out.
- Information in the form of national advertising on television or in other media.

Figure 16: From left to right: Sticker on the door of a Sprinter; marking on an OV-chipkaart post; notification in an app; service staff at stations.

4.4 Conclusion

Measures taken to reduce the problems have thus far been limited to incremental modifications to OV-chipkaart posts or their arrangement (e.g. relocating OV-chipkaart posts to access points). Other measures appear to be directed primarily towards repeatedly instructing travellers at places other than the payment boundary to be alert to checking in and out. Measures would nevertheless be more effective at locations where travellers actually have to use their OV-chipkaart.

Two important solutions from a previous project conducted at TU Delft (Niermeijer, 2013) have now been applied in the relocation of posts: consistent placement (reception domain) and arrangement in rows. It is nevertheless unclear whether any further reduction could be achieved in the number of forgotten check-outs. The 'signage and recognition' phase at the boundary between the reception and travel domains has the greatest need for modification. Higher attention values should be used in order to alert travellers to the payment boundary.

Because NS were already working to relocate OV-chipkaart posts, the decision was made to divide the study into two parts:

1. Effect study on the relocation of OV-chipkaart posts (Front Door Basic), as carried out by NS in 2016;
2. Development and evaluation of Front Door Plus, which involves facilities in addition to the Front Door principle according to a design by TU Delft.

5

5 Research methods

The study is composed of two parts: an effect study on the relocation of OV-chipkaart posts and an effect study concerning a newly developed test installation. Prior to the measurements, ten stations were selected as suitable to participate in the effect studies. Various datasets were reviewed and analysed for the purpose of the measurements.

5.1 Study design

5.1.1 Evaluation of Front Door Basic

Ten stations were selected at which the OV-chipkaart posts had been relocated as close as possible to the access points were selected for the evaluation of the Front Door principle. Transactions with the OV-chipkaart and data on claims from before and after the modification were compared.

5.1.2 Exploration of Front Door Plus

For the exploration of the Front Door Plus concept, a design was created in response to findings from field studies and a previous literature survey. Following evaluations with stakeholders, test installations were placed at two stations. After the test period, several datasets were analysed.

5.2 Selection of stations

Ten stations were selected for the effect study on the Front Door principle, and two stations were selected for Front Door Plus. The effect study on the check-in and check-out behaviour of travellers was based on a comparison of the number of claims and the check-out volume before and after the intervention.

Beginning in 2015, NS began making modifications to open stations. In 2016, 67 open stations (stations without gates, also referred to as ET-stations) had been modified (over the entire period). Not all of these modifications involved relocating OV-chipkaart posts. The modifications also included such measures as updating the guide lines for the blind and visually impaired.

Of the stations at which payment boundaries had been modified, ten stations were selected for the effect study (see Table 2), based on five criteria:

- Modified in 2016 or the last quarter of 2015;
- Open stations (ET stations);
- Only NS stops at these stations (no other public transport operators);
- In 2016, no other alterations were performed by NS and/or ProRail;
- The number of travellers was large enough to allow the measurement of effects: at least 1,000 travellers boarding/disembarking/transferring per day.

Table 2: Size of stations, by number of travellers.

Station	Indication of travellers boarding/ disembarking/transferring on an average working day (2013)
Bloemendaal	1.400
Bodegraven	3.000
Den Bosch	53.600
Deurne	5.200
Nunspeet	2.800
Schagen	5.500
Tilburg Universiteit	7.600
Utrecht Terwijde	2.500
Veenendaal-De Klomp	3.750
Zaandam	24.550

5.3 Measuring methods: sources

The modifications at the stations may have resulted in an observable effect in the check-in/check-out behaviour of travellers. Various sources were compared to determine whether an effect had occurred.

5.3.1 OV-chipkaart transactions

These are all of the check-in and check-out tasks that were performed with the OV-chipkaart. If fewer travellers had forgotten to check out, this should have been reflected in an increase in the number of check-outs. All transactions occurring throughout the 16-month period were included in the analysis: 14 months before the alteration and 2 months thereafter.

5.3.2 Refund claims

A small share of the travellers who have forgotten to check out file claims with NS to receive a refund of the fare that they paid but did not travel. All 'claims' occurring throughout the 16-month period were included in the analysis – 14 months before the alteration and 2 months thereafter.

5.3.3 Quantitative assessment of station access points: how extensive was the intervention?

All of the selected stations had been modified according to the Front Door principle, as adopted by NS. All of the stations differ, however, in terms of layout, size and available space. For this reason, no two 'front doors' are the same, and the modifications are customised. A major intervention could be expected to generate a greater effect. In order to obtain insight into the scale of the changes, a comparison was made between the arrangement of the various payment boundaries before and after they were modified. The access points were assessed according to five criteria (see Section 3.4).

As shown in the table below, with the exception of Tilburg Universiteit, all of the stations improved when the aforementioned criteria were used. There were two outliers: Bloemendaal and Nunspeet. This might have been due to the small number of access points. Modifications to one of the access points were immediately observable at the level of the station.

Table 3: Quantitative assessment of the ten modified stations. On a scale of 0 to 7.

Station	Number of access points	Number of access points modified	Score Before	Score After	Difference
Bloemendaal	1	1	4,2	6,6	+2,4
Bodegraven	8	4	4,0	4,9	+0,9
Den Bosch	4	2	4,2	5,6	+1,4
Deurne	4	1	4,6	5,0	+0,4
Nunspeet	2	2	2,4	6,8	+4,4
Schagen	8	1	4,8	5,7	+0,9
Tilburg Universiteit	4	2	6,5	6,5	0,0
Utrecht Terwijde	4	2	4,7	5,9	+1,2
Veenendaal-De Klomp	3	3	5,4	6,6	+1,2
Zaandam	4	2	4,3	5,2	+0,9

Bloemendaal

Bloemendaal station is the smallest one addressed in this study. The two OV-chipkaart posts that had been located on the platform were relocated to the station's access point, immediately in front of the pedestrian tunnel. This is the only access point to the platform.

Bodegraven
Bodegraven has a relatively large number of access points (nine in all). At two access points, double OV-chipkaart posts were removed and relocated to two somewhat smaller access points where there had been no OV-chipkaart. This resulted in there being at least one OV-chipkaart post at each access point.

Den Bosch
Only the front side of Den Bosch station was modified. The intervention consisted of placing a large number of OV-chipkaart posts in a row. The station as a whole did not score 100% as a front door, as a few OV-chipkaart posts are still located in sequence, and the passageways are still relatively broad.

Deurne
At the Deurne station, the OV-chipkaart posts on one platform were placed closer together and in a row (the modification took place in several steps). Other access points were left unmodified.

Nunspeet
The Nunspeet station now has a clear front door, as the OV-chipkaart posts are now positioned in a row and a secondary access point now has an OV-chipkaart post (where there had previously not been one). The large difference in assessments is partly due to these changes.

Schagen
On one of the two platforms, the OV-chipkaart posts at one of the access points have been placed in a row. They had previously been spread over a length of 20 metres. An additional OV-chipkaart post was also installed next to the lift. The change at station level was quite small, due to the large number of access points.

Tilburg Universiteit
The relocations at the Tilburg Universiteit station could be regarded as a minor optimisation. According to the qualitative assessment, the Front Door level remained the same.

Utrecht Terwijde
On both platforms, one OV-chipkaart post was installed across from another, constituting a minor optimisation.

Veenendaal-De Klomp
Each of the platforms had previously had one OV-chipkaart post. Another post was located outside of the platforms, next to the ticket vending machines. The OV-chipkaart posts were relocated to the station's access points. One OV-chipkaart post was added to each of the two most frequently used access points.

Zaandam
The OV-chipkaart posts at the Zaandam station were spread across the platforms. In the modifications, 5 of the 18 OV-chipkaart posts were relocated closer to the stairways and escalators.

5.4 Data analysis

5.4.1 OV-chipkaart transactions

The analysis of OV-chipkaart transactions consisted of comparing the volume of check-out transactions occurring four weeks before and after modification. The check-out data were divided into weekdays (large share of commuters, who are assumed to travel routinely) and weekend days (large share of incidental travellers, who are assumed to have little or no routine). An increase could indicate fewer incomplete transactions.

As a control for seasonal fluctuations, the figures from the measurement period were compared to the figures from the year before or the year thereafter.

5.4.2 Refund claims

A similar type of analysis was performed on the claims. The interventions were expected to have led to a reduction in the number of claims.

Because a relatively long period could elapse between the date of a missed check-out and the date of a claim, each measurement assumed a period of eight weeks after the date of travel as the date on which the claims had been submitted. In other words, the difference between the travel date and the claim date was restricted to eight weeks. Analysis of the data reveals that 92% of the claims in 2016 were submitted within eight weeks.

5.5 Secondary sources

In addition to the analysis of OV-chipkaart transactions and claims NS examined other data that could be expected to reflect effects: NS Extra and queue analyses. NS also commissioned a customer survey.

5.5.1 NS Extra: predicting the location of a missing check-out

The NS Extra service was launched in 2016 for NS travellers to automatically indicate whether they have missed a check-out. Algorithms for analysing travel relationships were used to predict where travellers have forgotten to check out. This does not mean that all notifications resulted in claims. Travellers are notified by e-mail and must take further action themselves in order to request a refund.

The algorithms that were used for NS Extra were applied to the data from the selected stations in order to determine whether any difference could be observed before and after the modifications.

The data from NS Extra revealed no observable difference between the situation before the modifications and the situation thereafter. One explanation could be that there was no difference or that the difference was too small to show up in the current models. A second explanation could be that the intervention was too small. By way of comparison, the closure of gates is clearly reflected in the NS Extra data.

5.5.2 NS: queue analysis

NS analysed the effects of the interventions on queues for all of the renovated stations. Queues (or localised capacity shortages) might have a negative influence on the number of check-out transactions. The activity analysis is based on the number of transactions per minute. Periods of at least 40 seconds in which more than 36 transaction per minute were registered were defined as 'high-activity blocks'. The context of the OV-chipkaart posts at the stations was then examined, as well as whether the high-activity block had also been disruptive to travellers. A simulation was used to determine the extent to which the high-activity blocks had an influence on delays (for travellers), as well as the number of travellers in line for the OV-chipkaart post. The results yield the following categorisation of the consequences of each high-activity block:

> 45	Bottleneck leading to delay
40 – 45	Delay
36 – 40	Possible delay (depending upon location)
< 36	No problem

5.5.3 NS: Front Door Plus customer survey

NS commissioned a market-research firm to conduct a survey in order to chart the perceptions of travellers as well. Travellers were interviewed after passing through the test installations at the Den Bosch and Veenendaal-De Klomp stations. They were asked how they would rate the location of the OV-chipkaart posts at the station, the test installation as a whole and the facilities separately.

6

6 Patterns in OV-chipkaart transactions and claim data

This study draws primarily on two different data sources: OV-chipkaart transactions and claims. Each of these sources reveals a part of what exactly occurs around a payment boundary. Interpreting the measurement results requires knowledge of patterns.

6.1 OV-chipkaart transactions: number of check-outs

OV-chipkaart transactions can be divided into several categories: check-ins and check-outs, top-offs and product loading. This study focuses exclusively on the check-out transactions. Any difference observed in the number of journeys in which the traveller forgot to check out should be reflected in the check-out volume. Various characteristics of the check-outs are explained in the following sections.

6.1.1 Weekly patterns

A clear pattern can be observed for all stations during an average week (in September). On weekdays, there are two or three times as many travellers as there are in the weekend. This can be observed in both Den Bosch (the largest station in this study) and Bloemendaal (the smallest station) (see Figures 17 and 18). Deviations from this pattern might be related to such causes as disruptions, or events that attract large numbers of people. Sunday is usually the quietest day.

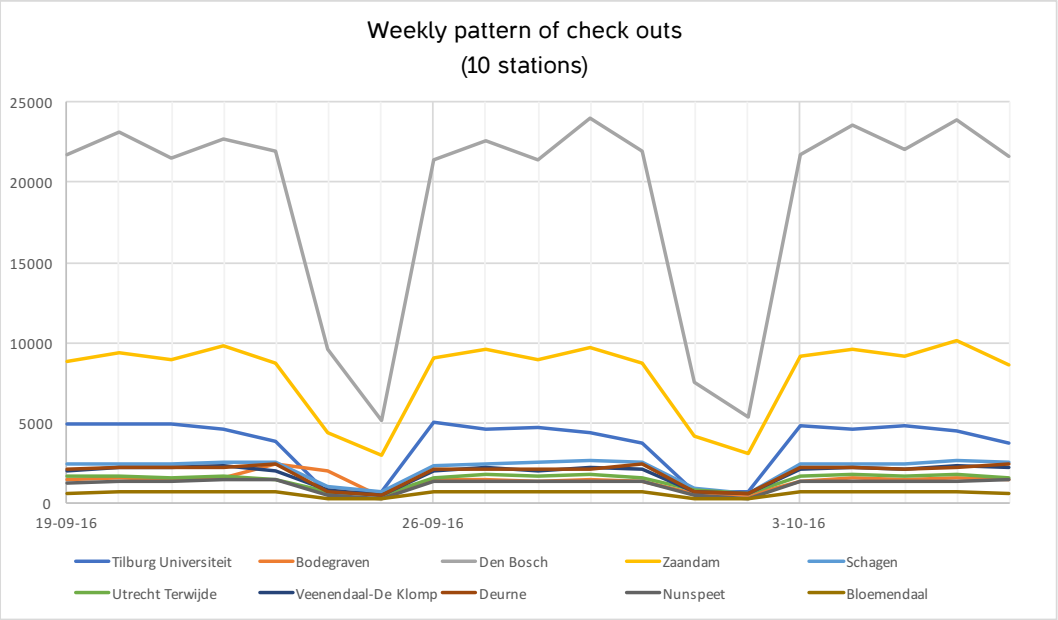

Figure 17: Number of check-outs per day: a recurring weekly pattern can be observed.

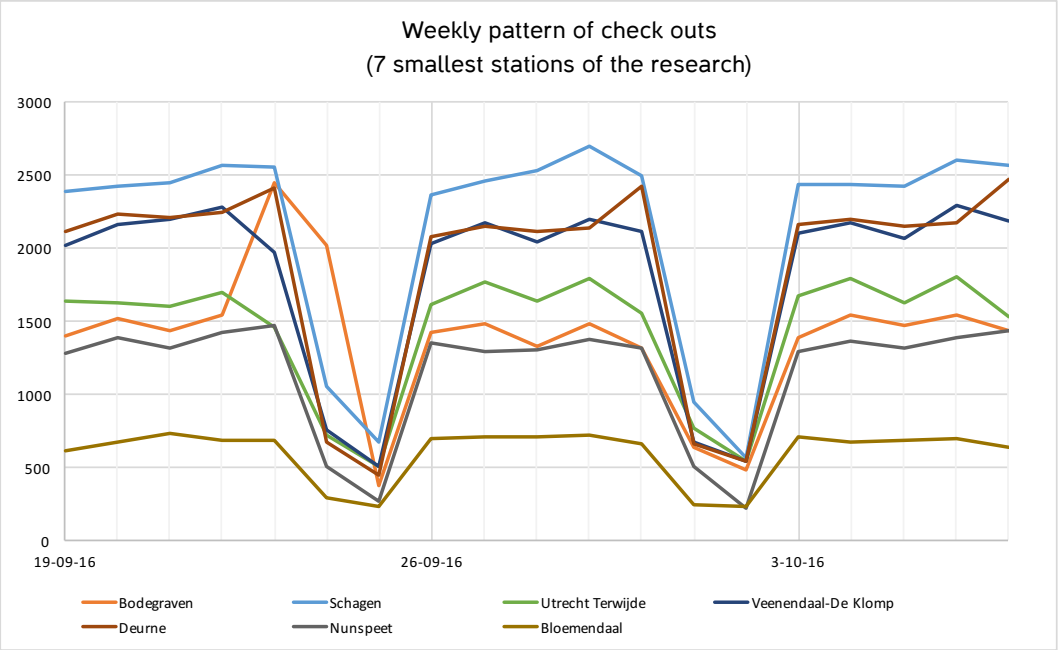

Figure 18: Number of check-outs per day for the seven smallest stations in this study.

Comparison of check-ins and check-outs reveals clear differences, particularly in the weekend (see Figure 19). On Saturday, there are more check-outs than there are check-ins. The pattern is reversed on Sunday. This pattern could reflect people visiting the city for a weekend, although it might also be due to the student population in a city.

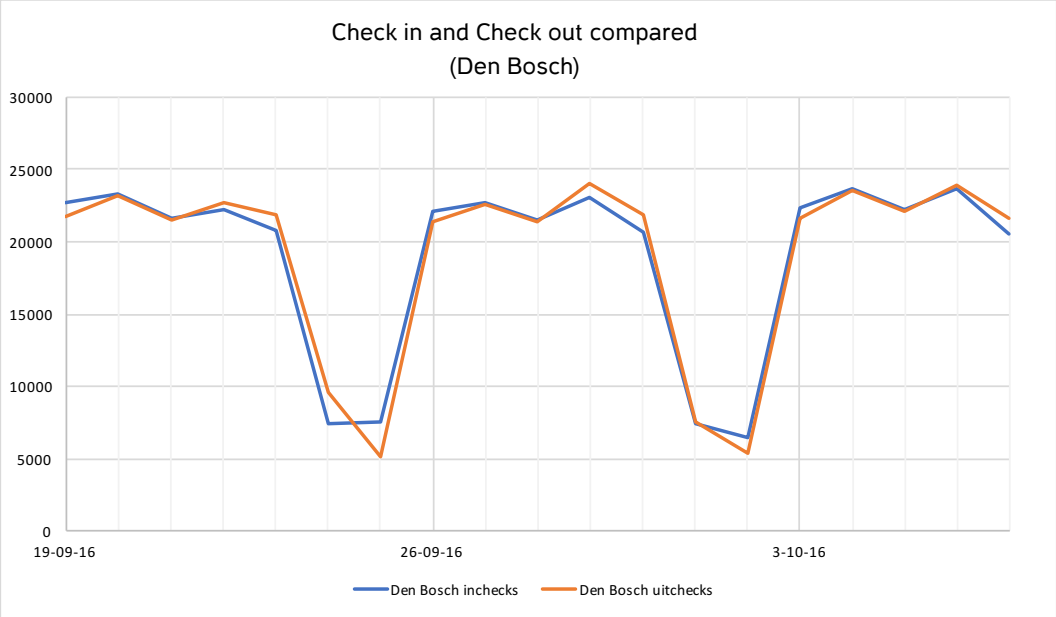

Figure 19: The weekly pattern of check-ins and check-outs at the station in Den Bosch.

6.1.2 Yearly pattern

Clear fluctuations can be observed throughout the year (see Figure 20). These fluctuations are due primarily to holiday periods, including the Christmas holidays (set period) and the autumn holiday (specific to the region). The summer holidays are the largest and longest period. These fluctuations are important when comparing transaction volumes before and after an alteration.

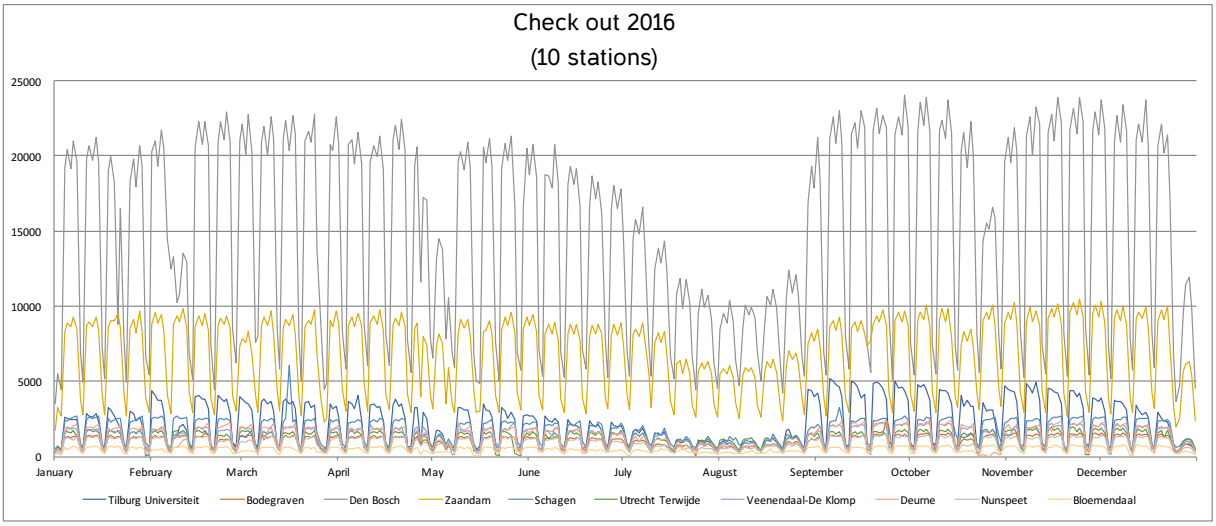

Figure 20: Yearly check-out pattern in 2016. Holiday periods are clearly visible.

6.2 Claim data: travellers requesting refunds

6.2.1 Weekly pattern

With regard to claims, there are no clear differences between weekdays and weekend days within a given week. Den Bosch station is presented as an example, given its large absolute number of claims. No clear pattern can be observed when focusing only on the number of claims per day (see Figure 21). A different picture emerges, however, if this number is divided by the number of claims per 10,000 check-outs (see Figure 22). There are relatively more claims in the weekend.

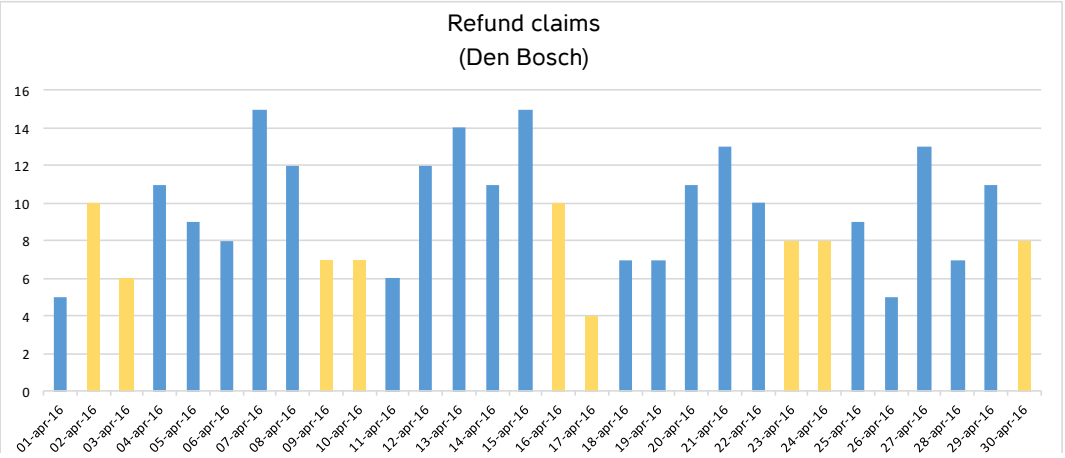

Figure 21: Number of claims per day for Den Bosch station in April 2016.

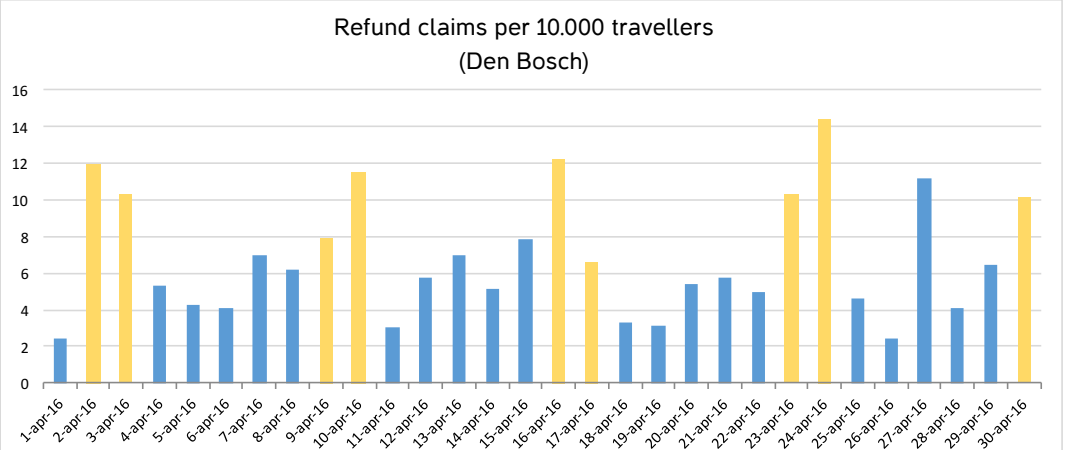

Figure 22: Number of claims per 10,000 travellers per day for Den Bosch station in April 2016.

6.2.2 Yearly pattern and trend

In contrast to the check-out transactions, no clear pattern can be observed when examining claims over a two-year period (see Figure 23). The years 2015 and 2016 cannot be simply compared to each other. In the past two years, a major increase can be seen, although the number of travellers has not undergone a commensurate increase. Other factors could be important in this regard:

- The situation at the stations (e.g. the closure of the gates at stations). This could have a positive effect: when leaving a closed station, it is nearly impossible to forget to check out. It could also have a negative effect: for example, when 'forced' to check out, travellers might discover that they had not checked in, such that they might have paid too much.
- In general, it has become easier to submit a claim. For example, there is a central point where travellers can view their missed check-outs and submit claims: www.uitcheckgemist.nl. Public transport operators have gradually joined this initiative. For the period through 2016, however, this does not apply to journeys made with NS.
- Broad implementation of NS Extra: travellers are notified by email whenever a missing transaction is detected. This might have lowered the threshold for requesting refunds.

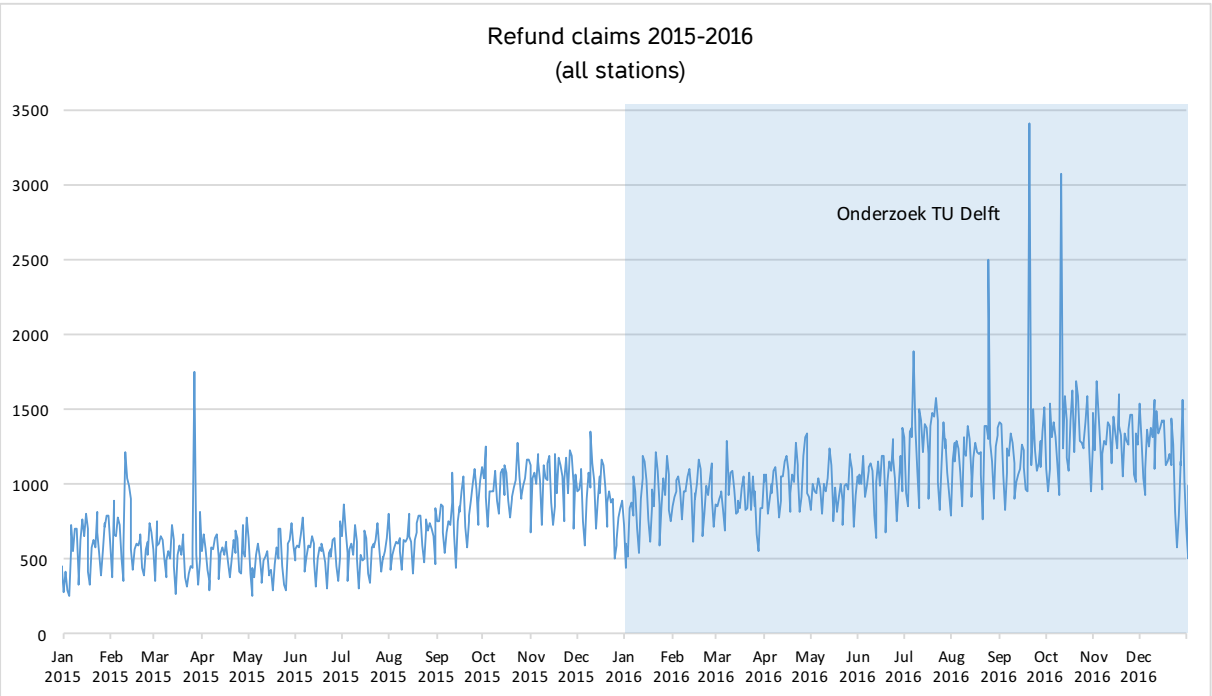

Figure 23: Number of claims having the ten stations in the study as the starting point or final destination. The number increases, and no clear pattern can be identified throughout one year.

6.2.3 Claim term: difference between travel and claim date

Claims are received at a delay. Figure 24 presents an overview of all claims from the ten stations in this study having travel dates in 2016 and having been received through February 2017. After 28 days, 80% of all claims had been submitted, with 92% having been submitted within 56 days. This is important when using claims to measure an effect due to changes in the field. In this context, it is assumed that the speed and distribution with which travellers submit claims remains constant.

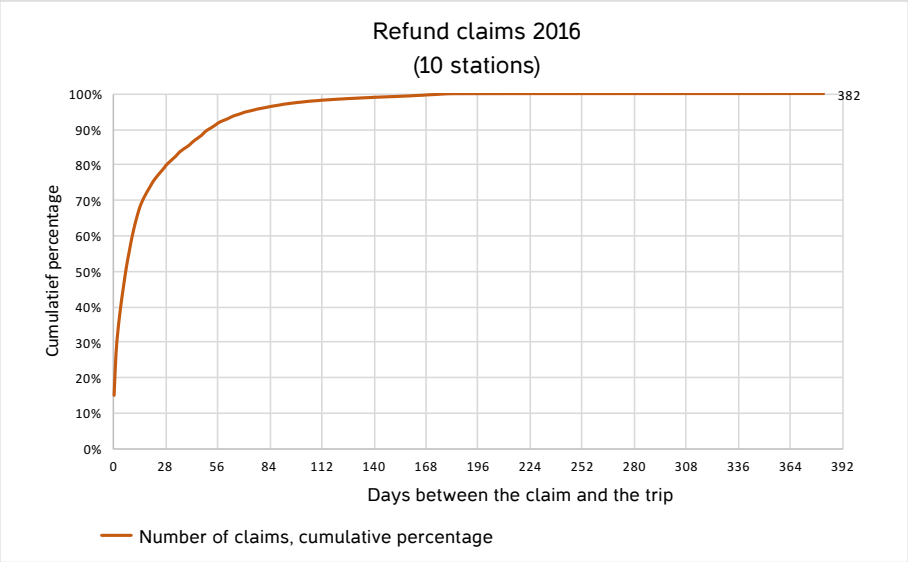

Figure 24: Claims from the ten stations in this study in 2016: after eight weeks, 92% of all claims from a given travel date had been received in the processing system.

6.3 Conclusion

The OV-chipkaart transactions and claims reveal different images when examining weekly or yearly overviews. The OV-chipkaart transactions are highly predictable, as travel patterns often remain constant for years. Recurring fluctuations are caused by holidays (decrease in commuters). Incidental fluctuations are caused by major disruptions or events. It is important to consider differences in check-outs, as the modifications at the stations were not carried out at the same time.

Claims reveal a less predictable pattern. Weekly patterns are less clear, and the years 2015 and 2016 cannot simply be compared to each other. The claims submitted in the year before the alteration do not appear to be suitable for use as a reference.

7

7 Front Door Basic: Results of the effect study

In recent years (2015-2016), OV-chipkaart posts have been relocated according to the Front Door Basic principle: a payment boundary at the boundary between the reception and travel domains (NS definition). This was done in part in order to resolve problems of capacity (queues during moments of high activity), thereby reducing dangerous situations on platforms and increasing customer satisfaction. It also reduces the distance that train travellers must walk. Relocating OV-chipkaart posts to the access points of stations is also an important component of the concept of 'the open payment boundary'. The relocation of OV-chipkaart posts could possibly have an effect even on the number of forgotten check-outs. This assumption and a larger number of stations to be examined provided reason to consider these alterations in this study.

The objective is to determine whether an effect can be observed in the number of journeys with forgotten check-outs when OV-chipkaart posts are relocated at open stations according to the 'basic' Front Door principle. The research question is thus as follows: What is the effect of installing or relocating posts to a station's 'access point' on the number of journeys with forgotten check-outs?

7.1 Results

The results consist of the following: analyses of data from OV-chipkaart transactions and claims; results from analyses conducted by NS.

7.1.1 OV-chipkaart transactions

The number of OV-chipkaart transactions from before the intervention were compared to the number thereafter. If the difference between check-ins and check-outs has decreased, it is possible that fewer people forgot to check out. When comparing all ten stations, however, no clear pattern can be observed.

7.1.2 Claim data

The claim data also reveal no clear image. For example, more claims were in fact submitted at several stations. There does not appear to be any clear association between the interventions at the stations and the number of claims. Comparison with the control year also does not confirm any differences. All claims from the measurement period are presented in Appendix C.

7.1.3 Analysis by NS: decrease in queues

The modifications at these ten stations (and others) were intended to reduce the number of queues, to increase uniformity and/or to improve the position of OV-chipkaart posts in relation to the access points. Weeks 2, 3 and 4 of 2016 were compared to the same period in 2017. Analyses of queues reveal a positive effect. 'Negative queues' decreased by 50%. The category of 'possible delay' decreased by 54% (see Appendix A).

7.2 Discussion and limitations

The methods used are an approximation with which to investigate whether any differences can be observed as a result of modifications at stations, as no data are available for incomplete transactions at a specific location. For example, a small number of additional check-outs at a station could be obscured by existing fluctuations in OV-chipkaart transactions.

The percentage of claims provides an indication of how many people forget to check out. However, only some of these travellers actually request refunds. According to the report from a study of incomplete transactions in 2016 (Panteia, 2016), refunds are requested for 1 of every 10 transactions.

The ten selected stations were modified during the year. As a result, the number and types of travellers at each station could vary sharply throughout the various periods of measurement. This could have made it more difficult to observe differences due to the intervention.

As stated in Section 3, the interventions at the stations did all generate the same changes when considering the station as a whole. For example, it is quite conceivable that the relocation of two of a total of ten OV-chipkaart posts would have a smaller effect than would the relocation of both of a total of two OV-chipkaart posts. This does not take into account the frequency with which a given OV-chipkaart post is used. This could make the differences even greater and the interpretation of differences even more complex.

7.3 Conclusion

The relocation and addition of OV-chipkaart posts had little or no effect on the number of journeys with forgotten check-outs. If there is any effect, it is so small that it cannot be observed within the fluctuations of the OV-chipkaart transactions. There was also no clear decrease in the number of claims during the measurement period. The available measurement methods constitute an approximate description of the number of forgotten check-outs, and they require a large difference between the before and after situations in order to observe any effect.

As measured by NS, however, the modifications to the stations did have a positive effect with regard to queues and detours. This was one of the initial objectives of the relocations.

8

8 Front Door Plus: Development and evaluation

The location of OV-chipkaart posts is not the only aspect influencing whether travellers will check in and out. A major effect could possibly be observed if the validation site were to be highlighted more strongly, in addition to the relocations. To investigate this, two stations were selected, and the access points were provided with additional facilities. Based on observations in the field, an installation was developed and, following evaluations with stakeholders, modified to become a test installation.

The objective is to determine whether any effect can be observed in the number of forgotten check-outs if facilities are installed in addition to the Front Door Basic principle. The research question is thus as follows: What effect does the installation of additional facilities at OV-chipkaart posts have on the number of forgotten check-outs?

8.1 The design

The design for the test installation was developed in three stages: the design was modified in steps following evaluations with stakeholders.

8.1.1 Underlying principles of the design

The validation of an OV-chipkaart is clearly different from other tasks at a station. In nearly all cases, the interaction begins with the traveller (e.g. 'From which platform will my train depart?'). It is then facilitated by the facilities that are present (e.g. signs). In the case of validating an OV-chipkaart, the interaction begins with the public transport operator, who determines that every traveller with an OV-chipkaart is obligated to check in and out. Travellers have no choice, and they cannot skip this step. At many stations with OV-chipkaart posts, this compulsory character can be difficult or hardly to see.

One important starting point involves highlighting the site at which travellers should check in and out. In this regard, stakeholders expressed a desire for the test installations to fall within the guidelines formulated in the Toolkit for RSB (Routing Signing Branding) as much as possible.

8.1.2 Initial proposal: portal and illuminated line

The initial proposal (based on the design developed by Niermeijer, 2013) was based on enhancing visibility through the addition of frontal surface. One requirement from the stakeholders was that it should be installed higher than 2.5 metres. The first design assumes a portal across the entire width of an access point, above all OV-chipkaart posts. The appearance is heavily derived from existing portals above a row of gates at a station where multiple public transport operators stop. An illuminated line incorporated into the floor combines with the portal to connect the OV-chipkaart posts, thereby visually reinforcing the boundary (see Figure 25). Another choice was made to have the card reader for the OV-chipkaart emit light in order to make it more noticeable and obvious where the OV-chipkaart should be held. Figure 26 and Figure 27 are photo montages of the existing situation with the proposal for the payment boundary.

The initial proposal was submitted to the most important stakeholders: NS Reizigers, NS Stations, ProRail, and Bureau Spoorbouwmeester. The proposal was regarded as 'fairly imposing'. The portal was described as too prominent and excessively obstructing the view of other signs. The illuminated line in the floor was also rejected because, in general, 'communication does not take place through the floor' – this is reserved for guiding lines. In addition, an illuminated line was perceived as an excessively complex intervention for a trial, in addition to being perceived as vulnerable to disruptions. It would also be maintenance-intensive in future implementation.

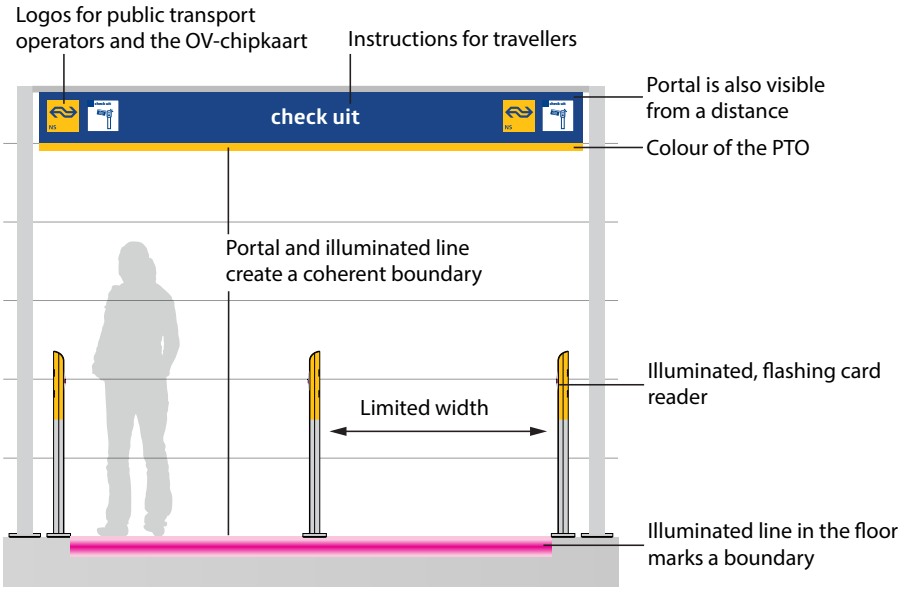

Figure 25: Schematic representation of the initial proposal for the test installation.

Figure 26: Photo montage of the Den Bosch station hall with the initial proposal. Modification of the location of the OV-chipkaart posts is not included here.

Figure 27: Photo montage of an access point on the rear side of the station in Den Bosch with the initial proposal; another OV-chipkaart post has been added in order to restrict the width of the passageway.

Floor markings

Floor markings can be found at various sites within and outside the railway domain. It is a commonly used method for indicating where and when someone should or is allowed to be. It can also provide redundancy: the marking is visible from various heights and surfaces.

Halt line on the pedestrian crossing: intended to draw attention to the signal of the traffic light while using a telephone.

LED-line along all access points from the hall to the platform (Utrecht CS).

Three markings on the platform: end of the platform (solid line), safe zone ('dotted line'), guide line.

Marking for gates in a station hall: intended to indicate the distinction between public transport operators.

8.1.3 Revised proposal: signs and floor marking

The revised design assumes separate signs above all OV-chipkaart posts or groups of OV-chipkaart posts (see Figure 28). The illuminated line is replaced by lighting fixtures in the signs that project a line on the floor. The light is quite visible, due to a light-reflecting line on the floor (see Figure 29 and Figure 30). The format of the sign is not as well suited to displaying two icons (public transport operator and OV-chipkaart) next to each other. The choice was made to have the sign have two colours, so that it will still correspond to the portal visually. It also bears a strong resemblance to the top of the AVM at gate lines (see Figure 31 on p. 58). The logo of the public transport operator now appears in the border. The addition of the public transport operator's colour increases the contrast with the surroundings and provides clear coherence between the sign and the OV-chipkaart post.

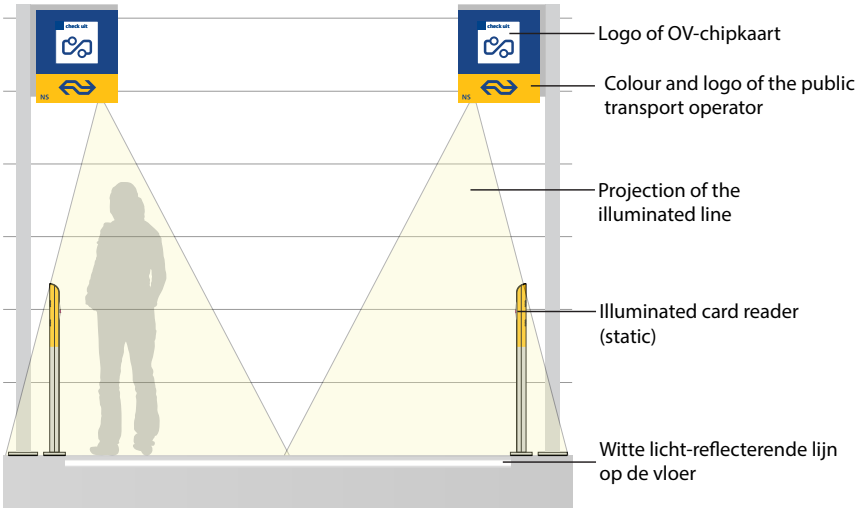

Figure 28: Schematic presentation of the revised proposal: separate signs and a projected illuminated line.

Figure 29: Photo montage of the Den Bosch station hall with the revised proposal.

Figure 30: Photo montage of Veenendaal-De Klomp station with the final design.

Figure 31: 'NS machine inside the gates' (AVM) with a green/blue cube.

8.1.4 Tested design: B56 signs and projected illuminated line

The final design uses a sign of standard format (B56) and the transfer pictogram as it is used at the transfer point for international travel. No permission was obtained for the use of the light-reflecting stripe, and it was therefore not included in the test. Figure 33 is a photo montage of the Den Bosch station hall with the tested design.

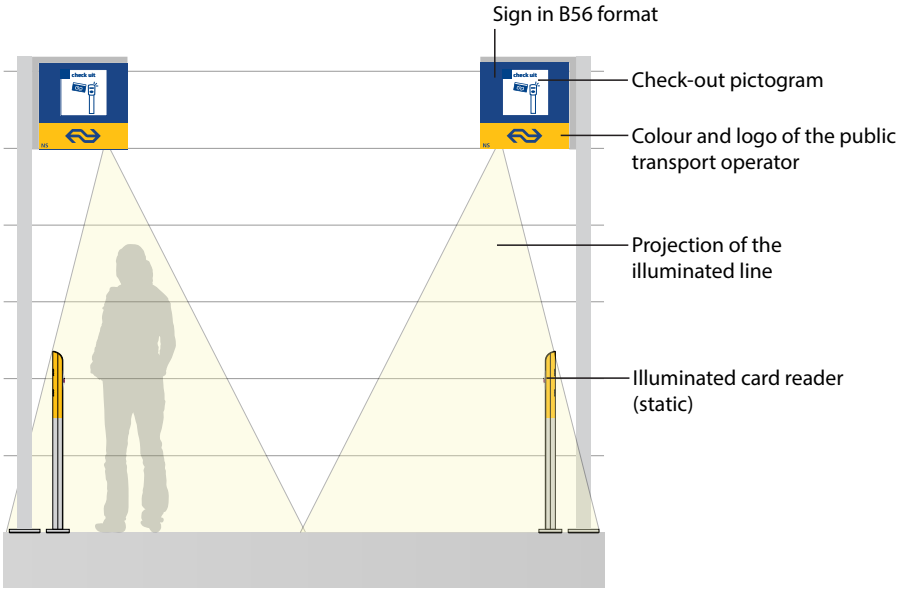

Figure 32: Tested design: B56 signs above the OV-chipkaart posts and a projected illuminated line.

Figure 33: Photo montage of the Den Bosch station hall with the tested design.

8.2 Implementation of the test installation

The facilities were installed in a slightly different way at each of the two trial stations. Both installations were located in the stations from the first week of November 2016 through the first week of February 2017.

8.2.1 Den Bosch

At Den Bosch station, eight illuminated signs (B56 format) were installed, one of which was one-sided to accommodate an information screen. The signs were equipped with one or two lighting fixtures that projected a line onto the ground. At the main entrance, the masts were positioned between the OV-chipkaart posts. At the secondary entrance, the signs were hung from the roof construction. All OV-chipkaart posts located at the payment boundary (14 in all) were equipped with illuminated card readers.

Figure 34: Den Bosch station hall with the installation in the evening and in daylight.

Figure 35: Den Bosch station hall with the installation. There is a relatively large amount of distraction: illuminated elements and other signs.

Figure 36: Rear side of Den Bosch station. On one side, the sign could not be hung above the OV-chipkaart post, due to limited height. Moreover, this sign is one-sided.

8.2.2 Veenendaal-De Klomp

At Veenendaal-De Klomp station, five signs were positioned at the three access points, each with one lighting fixture. All of the OV-chipkaart posts (five in all) were equipped with an illuminated card reader. At this station, there is more contrast with the surroundings than is the case at Den Bosch station (see Figure 37 and Figure 38). The illuminated elements are also more visible in the dark (see Figure 40).

Figure 37: The access point from and to the car park.

Figure 38: At this exit, the signs are highly visible when descending the stairs.

Figure 39: The installation on the side of the bus stops.

Figure 40: When it is dark, the signs and the illuminated line form a sharp contrast with the surroundings, thus drawing attention.

8.3 Results

A two-month measurement period was observed for both of the stations: one month before the modification and one month after. A longer period generated wide fluctuations in the number of travellers and types of travellers (e.g. due to holidays), which made a comparison of the two periods highly problematic. Because differences between months could possibly be explained by differences over time that recur each year, the differences in claims in the month before and the month after the modification were also compared to the differences in the same period one year earlier.

8.3.1 Den Bosch

At Den Bosch station, there was no significant difference between the situations before and after the facilities were installed. This is true of both the OV-chipkaart transactions and the claims. Figure 41 clearly demonstrates that there is little or no difference. The tables belonging to Figure 41 and Figure 42 are included in Appendix D.

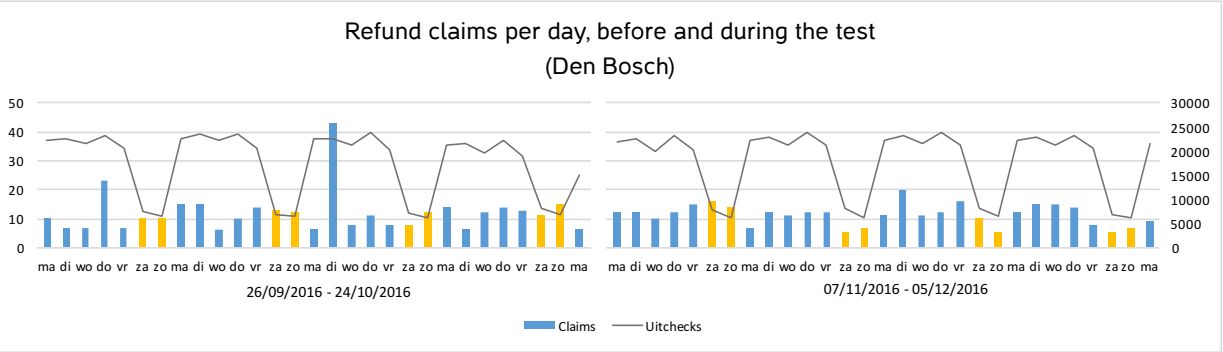

Figure 41: Number of claims per day at Den Bosch station, before and after the intervention. With the exception of one outlier, there was no observable difference.

8.3.2 Veenendaal-De Klomp

For Veenendaal-De Klomp station, 64 claims were submitted during the 29 days before the intervention (an average of 2.2 claims per day), and 40 claims were submitted during the 29 days after the intervention (an average of 1.4 claims per day). A t-test indicated that this decrease of 0.8 claims was statistically significant, $t(56)=2.23$, $p = 0.03$. The difference was significantly more positive than it had been in the control months the year before – $t(56)=2.91$, $p = 0.005$ – when the claims increased by 0.5 during the same period. Figure 42 demonstrates a clear difference in the number of claims before and after the intervention.

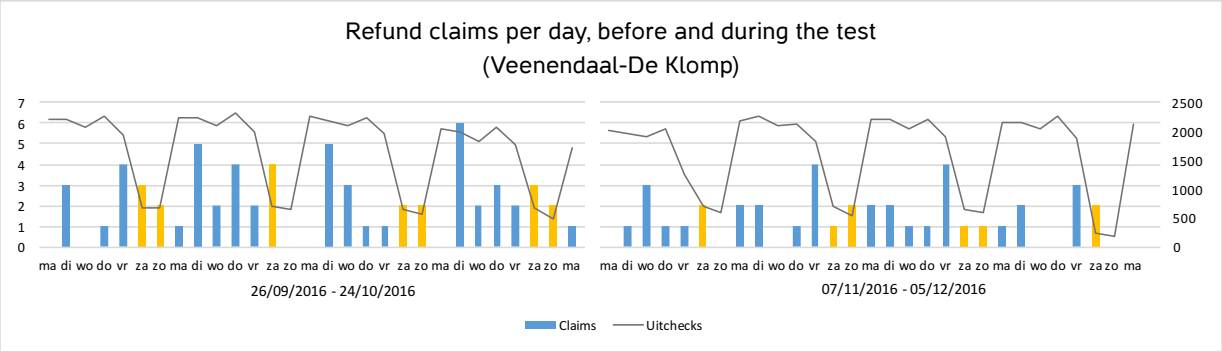

Figure 42: Number of claims per day at Veenendaal-De Klomp station, before and after the intervention. A clear decrease in the number of claims can be seen during the intervention.

8.3.3 Study by NS: travellers' perceptions

NS commissioned a study of the perceptions of travellers at each of the stations investigated. In all, 241 travellers were asked if they 'had noticed anything about the check-out posts'. Of the travellers who came to these stations at least once per year, (n=224), 47% regarded the relocation of the OV-chipkaart posts as an improvement, while 38% of the 224 respondents had not noticed the relocation. With regard to the other facilities, travellers indicated that the sign attracted the most attention, followed by the illuminated card reader. It should be noted that it was difficult or impossible to see either the illuminated card reader or the illuminated stripe during the day. According to the travellers at Veenendaal-De Klomp station, the additional facilities drew more attention more frequently than was the case at Den Bosch station, particularly with regard to the lighting.

When asked if they had any additional recommendations for NS with regard to how they could help travellers to avoid forgetting to check out, their answers referred to greater consistency of location, even more accentuation (signs at eye level) and forced check-out (use of gates or automatic check-out by smartphone).

> *"Lower the sign on the post by one metre. Use the NS app to determine location. This would make it unnecessary to check in or out."*
> *('s-Hertogenbosch)*

> *"Gates, but that is not friendly."*
> *('s-Hertogenbosch)*

> *"It's confusing that they are not located in the same place everywhere. The illuminated stripe is hardly visible. Please make it brighter and turn it off during the day. Prefer posts both on the platform and at the exit."*
> *(Veenendaal-De Klomp)*

8.4 Discussion

8.4.1 Limitations of the test installation

Illuminated card reader
With the current OV-chipkaart post, it is not possible to have multiple card readers flash in a synchronised (and subtle) manner. For this reason, the decision was made to keep them static during the trial. Flashing lights attract more attention (consider the turn signals on cars or the rotating and flashing lights on emergency service vehicles). The intensity of the light was also relatively low. According to the customer survey, few travellers had noticed it.

Standard lighting fixture
A choice was made to use a standard lighting fixture to project the illuminated line. The contrast with the surrounding was ultimately relatively low, and only a few travellers had noticed the line. The intensity of the light could be optimised through customisation. Light interacts with the surface on which it is projected. The effect is greater with a light-coloured floor.

Marking on the floor
The original design included a light-reflecting line on the floor. The absence of this marking made the appearance of boundary during the day different from its appearance in the evening hours. In addition, the illuminated line was less visible due to the low reflective capacity of the existing surface.

8.4.2 Differences in context between Den Bosch and Veenendaal-De Klomp

The difference in effect with regard to claims and the observations of travellers can be traced to differences in context. The contrast is greater at Veenendaal-De Klomp station, as few other station facilities are positioned there. In the station hall and walkway in Den Bosch, there are many signs (some illuminated) and hospitality facilities that compete with the payment boundary.

8.5 Conclusion

Identical test installations were tested at two stations. Their design was realised by evaluating design proposals with various stakeholders. A measurable and significant positive effect was observed at Veenendaal-De Klomp station: the number of claims decreased.

> *The highlighting of the payment boundary could lead to a reduction in the number of journeys with a missed check-out.*

No effect was measured at Den Bosch station. The difference between the stations could be explained by the different contexts in which the payment boundaries are installed. We cannot rule out the possibility that the effect would have been greater if the original design had been applied.

A majority of the train travellers who participated in the NS customer survey and who had noticed the relocation of the OV-chipkaart posts regarded this change as an improvement.

9

9 Conclusion

9.1 Answers to the research questions

The central question in this study was whether travellers can be encouraged to check out. This was investigated using installations at stations. The results indicate that it is possible and measureable, depending upon the situation and the type of modification.

9.1.1 It is possible to reduce the number of check-outs by applying the Front Door Plus arrangement.

Elements of the Front Door Plus principle were applied at the Den Bosch and Veenendaal-De Klomp stations: signs above the OV-chipkaart posts, with integrated fixtures that project an illuminated line in the evening hours (Figure 43). The OV-chipkaart posts were also equipped with light-emitting card readers. After the end of the trial, the OV-chipkaart transactions and the claims were analysed for changes. The only significant positive effect to be observed was at Veenendaal-De Klomp station, where the number of claims declined. The decrease was greater in the weekend than it was on weekdays. This effect might be greater for incidental travellers.

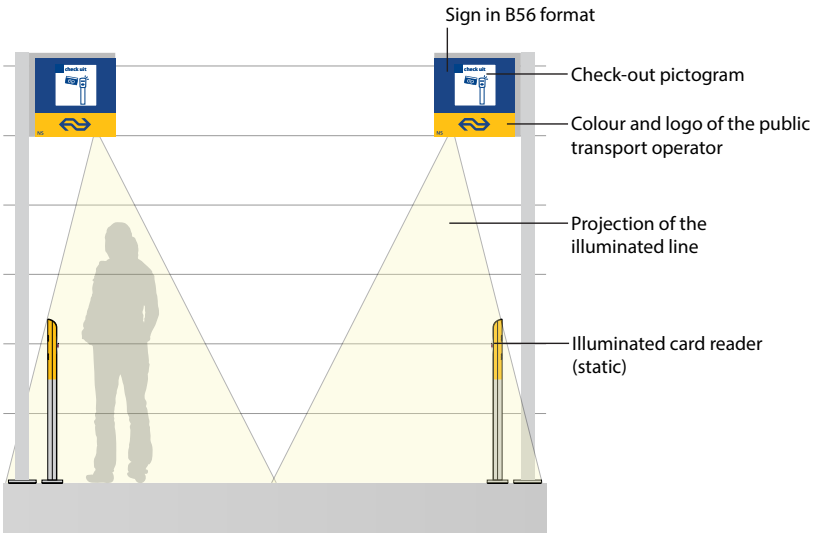

Figure 43: The design tested at the Den Bosch and Veenendaal-De Klomp stations.

9.1.2 The relocation of OV-chipkaart posts according to the Front Door Basic principle (i.e. in a row at the entrance to the station) alone yielded no measureable effect.

NS has made modifications to OV-chipkaart posts at a large number of stations. The objectives included the reduction of bothersome queues by making optimal use of and/or expanding the capacity. One possible solution would be to position OV-chipkaart posts at the access points of stations or platforms. It was assumed that the Front Door Basic concept might also have a positive effect on the number of journeys with a forgotten check-out.

This study investigated ten stations at which NS had only relocated or added OV-chipkaart posts at one or more access points (see Figure 44). This study revealed no measureable reduction in the number of claims and OV-chipkaart transactions after the intervention.

Figure 44: An example (Utrecht Terwijde) from before and after the modification: on both platforms, one OV-chipkaart post was positioned closer to the access point.

9.1.3 Triggers can be used to encourage people to check out.

For many travellers, checking in and out is a task that they perform unconsciously, without thinking about it. Checking out is a delayed task. As they are checking in, travellers know that they will soon have to check out as well, but this task can be pushed to the background. Triggers can help to return this task to the forefront. This works best when travellers can perform the task immediately in response to the trigger. To encourage this, the check-out moment should:

1. be marked as obviously as possible, so that it can trigger the necessary routine on the part of travellers;
2. occur at a set moment, so that the fixed check-in/check-out routines of travellers can be applied in all stations.

9.1.4 Design criteria for encouraging check-outs at an open payment boundary

During the development and evaluation of the payment boundary according to the Front Door Plus arrangement, various design criteria emerged that could be to create an open payment boundary that encourages travellers to check out.

These criteria can be divided into the needs of travellers and features that the payment boundary should have in order to respond to them (see Table 4, p. 72).

Needs of travellers::

1. Travellers should clearly see the payment boundary on their route.
2. The payment boundary should be clearly distinct from other station facilities and objects.
3. Travellers should encounter an OV-chipkaart post on the route between the entrance that they have used and the place where they would like to stand on the platform without having to deviate too far from their walking route.
4. For travellers, validation (checking in or out) should occur at the right time: at the boundary between the reception and travel domains. This is the moment immediately before departure, such that travellers are no longer occupied with other matters (e.g. buying sandwiches or checking departure times).
5. Travellers should encounter only one OV-chipkaart post (or row of OV-chipkaart posts). Otherwise, there is a risk that they will validate their cards at both payment boundaries by reflex.
6. Travellers should be able to see the payment boundary approaching. This increases the likelihood that they will notice the payment boundary. It also allows travellers sufficient time to prepare for checking in or out.

Design criteria for Front Door Basic

- Consistent placement, so that the check-in/check-out routines of travellers are valid at all stations by always positioning the payment boundary at the division between the reception and travel domains.

Design criteria for Front Door

- Free-standing, so that the OV-chipkaart post is always visible and so that no travellers who are not there to check in or out will be walking there. The payment boundary should therefore be free of other station facilities.
- Limited passageway width of no more than 180 cm (three times 60 cm). This will ensure that travellers will always pass by an OV-chipkaart post.
- Good visibility by positioning the payment boundary in such a way that it is clearly visible from both sides (i.e. the check-in and check-out side) from a distance, as well as during periods of heavy activity.

- Only one payment boundary per access point, so that travellers will always encounter only one OV-chipkaart post or row of posts.

Design criteria for Front Door Plus

- **Frontal surface**: Equipping the payment boundary with as much frontal surface area as possible will ensure visibility (e.g. through signs or by enlarging the validation devices).
- **Colour**: All components of the payment boundary should have a clearly noticeable colour. This provides coherence, ensures contrast with the surroundings and can create a clear distinction between public transport operators.
- **Lighting**: Equipping the payment boundary with illuminated elements ensures visibility and distinctiveness, particularly in the dark. This can be done with illuminated signs and through the lighting of the entire zone.
- **Coherence**: The various facilities can be visually connected to each other so that the boundary as a whole becomes more of a coherent unit (a boundary) and is therefore more obvious to travellers. Two distinct strategies to this end were identified:
  - Regularity: placement of elements at equal distances creates a pattern, such that the separate elements are seen as a coherent unit;
  - Connecting elements: a continuous portal and visual marking on the floor.

Table 4: Needs of travellers alongside the features of a payment boundary. The Front Door principle is indicated in green, with Front Door Basic in yellow and Front Door Plus in blue.

	Front Door					Front Door Plus			
Needs of travellers / *Features of the payment boundary*	Location	Free standing	Passage width	Visible from a distance	1 payment boundary	Frontal surface	Colour	Light	Coherence
Visible									
Standing out									
Always come a cross a validator (while taking the shortest route)	Front Door Basic								
The right moment (boundary entrance/travel domain)	Front Door Basic								
Enough time to prepare (does not come as a surpise)									
Only one boundary each entrance									

9.2 Discussion

9.2.1 Difference in results possibly due to usage context

Analysis of the claims reveals that, in the case of Veenendaal-De Klomp, there was a significant positive difference between before and after the modification of the access points. For Den Bosch station, outliers in the data prevented the confirmation of this difference. One possible explanation for the difference in the results could be related to differences between the stations in terms of the context of usage. Den Bosch is a 'busier' station with regard to architecture, signage and other objects. Because the payment boundary was inside, the illuminated objects did not provide as much contrast as they did at Veenendaal-De Klomp (see Figure 45).

Figure 45: Veenendaal-De Klomp and Den Bosch stations with the test installation.

9.2.2 Suboptimaal stimulusmateriaal

The installation used in the field study was less obvious than the stimulus equipment that had originally been planned, due to technical limitations and requirements imposed on the installation by the parties responsible for the station environment (see Figure 46). A statistically significant effect was nevertheless identified at Veenendaal-De Klomp station. It is conceivable that a positive effect could have been achieved at Den Bosch station as well, if a more obvious payment boundary had been tested.

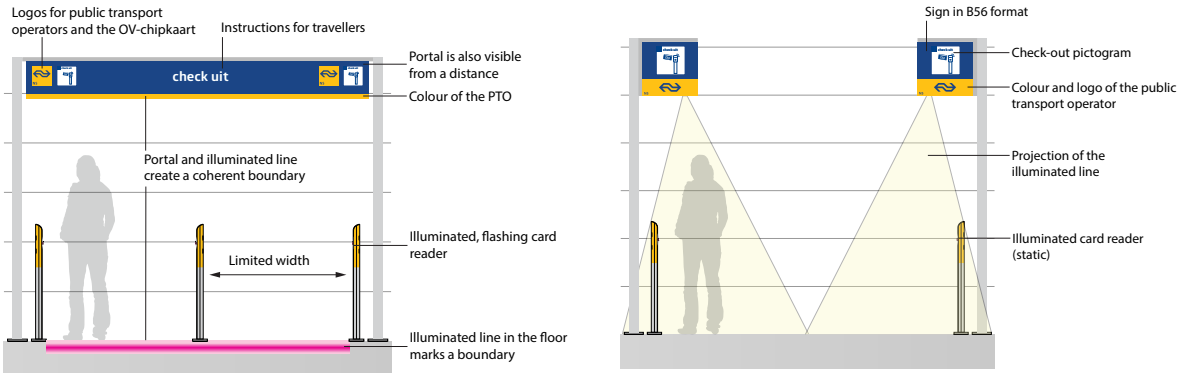

Figure 46: Proposed and installed stimulus equipment.

9.2.3 Priorities: obvious elements in a neutral station layout

The current policy with regard to the layout of stations is to make and maintain them as neutral and transparent as possible. According to the literature and the results of this study, however, highlighting the zone in which travellers must check in and out could reduce the number of journeys with forgotten check-outs. In addition, OV-chipkaart posts are the only facilities at stations that all travellers are always required to use. If the objective is to reduce the number of journeys with missed check-outs, the visibility of the payment facilities should take higher priority in the guidelines for station layout.

9.2.4 Visual contrast is determined in part by the surroundings

The presence of other signs or facilities in the vicinity of the payment boundary can reduce the visual contrast of the check-out-zone (see Figure 47). Conversely, the absence of other facilities can increase the contrast with the payment boundary. The modification of the surroundings was not part of this study. The design of an access point with a payment boundary calls for an integral approach that also considers all other facilities in the immediate surroundings of the OV-chipkaart posts.

Figure 47: Visual distraction in the hall of Den Bosch station.

9.3 Recommendations

9.3.1 Follow-up design for a payment boundary

In this study, the design of a payment boundary was limited to the installation of signs and illuminated elements. The following topics should be addressed in follow-up designs in order to achieve the full Front Door Plus concept:

1. Locate OV-chipkaart posts directly on the walking route. For rows of multiple OV-chipkaart posts, they should be positioned at a fixed maximum distance from each other (NS now uses a distance of 1.8 metres). It might also be necessary to modify walking routes by narrowing broad access points.
2. Make the surroundings of the payment boundary as free as possible of other station facilities and objects. This increases the contrast and ensures that the OV-chipkaart posts are more noticeable.
3. Provide a visual connection between OV-chipkaart posts on the floor and at eye level, which will be visible in both daylight and in the dark.
4. Make the payment boundary more noticeable. This could be accomplished by increasing the frontal surface (e.g. by increasing the volume of the OV-chipkaart post). Signage at and above eye level can also make them more noticeable with regard to lines of sight at greater distances.
5. Use flashing card readers (synchronised and slow).
6. Other forms of light and movement could be used in order to attract attention. Experiment with them in order to arrive at an acceptable compromise between subtlety and visual contrast.

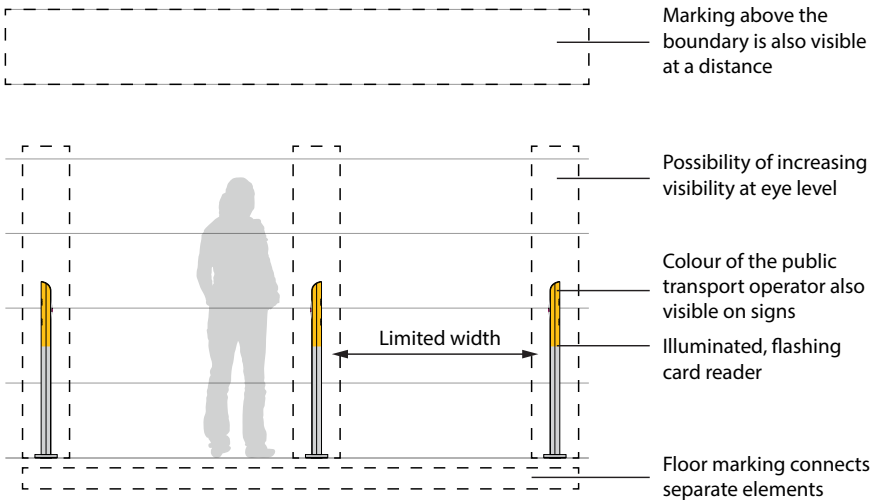

Figure 48: Schematic representation of options for the further accentuation of an open payment boundary.

9.3.2 Evaluate the requirements for the design of station facilities

The design of the current station environment (neutral materials and colours: stainless steel, glass and grey) is heavily focused on harmony and clarity. This makes information systems (beginning at a height of 2.5 metres, with a blue/white colour scheme) more noticeable. All of these systems are passive: travellers use them as if they feel that they need them. In contrast, the validation of the OV-chipkaart is a mandatory part of the journey. The associated facilities should thus be actively prominent. Travellers should not be able to overlook the fact that there is a payment boundary. Evaluate the priorities of these active and passive facilities.

9.4 Follow-up research

9.4.1 Most effective measuring instrument: claims

This study draws upon multiple data sources. Claims ultimately proved the most suitable for measuring an effect.

The number of claims is obviously also dependent upon the number of travellers using a station. It would be advisable to select a measurement period with the greatest possible stability in the number of travellers. Differences in the number of travellers (e.g. weekends and holidays) are often indicative of another type of traveller who uses a variety of types of tickets (with or without a boarding fare) and travel patterns (routine or incidental).

The use of claims as a source is also subject to limitations. The number of claims is an indication of the number of forgotten check-outs. But not everyone will request a refund. The extent to which people request refunds can also be influenced by information campaigns (nudging travellers) and creating better facilities for requesting refunds (lowering the threshold). Given that the effects of these options occur primarily in the long term, the measurement period should not be too long.

9.4.2 Missed check-outs in other usage contexts

This study concerns open payment boundaries at train stations where only NS stops. There are also stations with multiple public transport operators. Incomplete transactions occur relatively more frequently at these stations than they do at other stations (e.g. due to errors made when transferring or to travellers validating cards with a public transport operator other than the ones with which they are travelling). Figure 49 displays how the installation that was developed could also be used to distinguish between various public transport operators. In addition to the railway domain, incomplete transactions also continue to occur in other modes of transport (e.g. buses and trams). An approach similar to the one used in this study could be followed in both contexts: analysing a problem in context, generating a solution, measuring the effect of the solution.

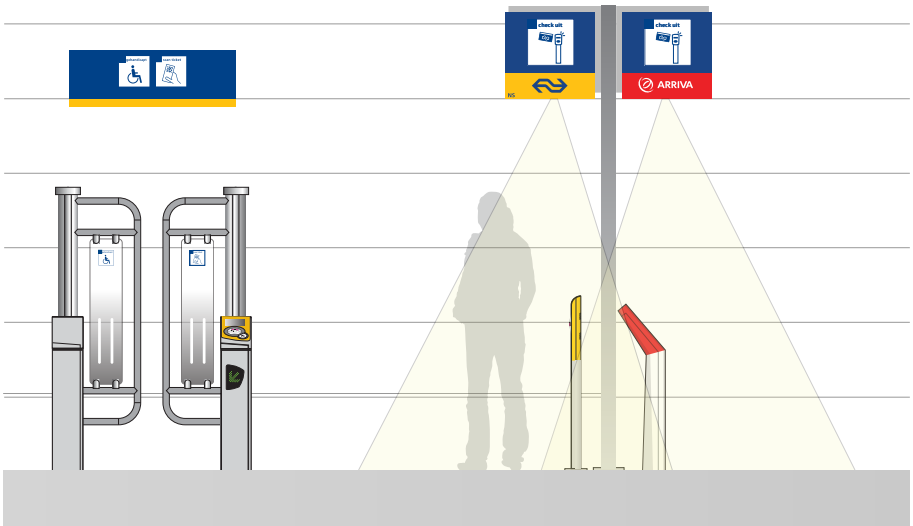

Figure 49: The sign used in the trial corresponds to the portal that is used above the row of gates. In addition, the coloured border makes it possible to make clear distinctions between various public transport operators.

9.4.3 Further steps: knowledge question or product development?

This study concerns the effect of a modification of the payment boundary. The field test with Front Door Plus (at the Den Bosch and Veenendaal-De Klomp stations) nevertheless offered the opportunity to determine the extent to which the number of journeys with missed check-outs at an open payment boundary could be reduced through the use of visual stimulation. The installations that were tested at the two stations had nevertheless been heavily modified from the initial proposal. Wherever possible, they were assessed according to the current guidelines and handbooks. As a result, the approach taken by the parties involved strongly resembled a development project for a permanent installation instead of an experiment focusing on a knowledge question. Follow-up studies will require making a clear choice of one of these two strategies.

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Appendix A: Queue scores

2,3 en 4 week januari 2016				2,3 en 4 week januari 2017		
Deurne	0	27	30	0	0	0
Den Bosch	0	103	0	0	90	36
Schagen	11	0	0	0	0	0
Tilburg Universiteit	0	50	0	0	0	0
Utrecht Terwijde	0	23	0	0	26	0
Veenendaal-De Klomp	4	0	48	0	0	0
Zaandam	0	95	0	0	39	0
Totaal	**15**	**298**	**78**	**0**	**155**	**36**
Totaal oranje en rood	313			155		

Afname per categorie	100%	48%	54%
Afname negatieve wachtrijen (oranje en rood)	50%		

	TRANSACTIE/ MINUUT (binnen het drukteblok)	KNELPUNT	VERTRAGING/ SECONDEN
	> 45	Vertragingsknelpunt	> 30
	40 - 45	Vertraging	41 - 55% > 11
	36 - 40	Mogelijk vertraging (afhankelijk van positie)	33 - 40% > 11
	< 36	Geen probleem	0% > 10

Appendix B: Front Door Basic station modifications

Bloemendaal

Soort ingreep	Cico's van perron naar maaiveld verplaatst.
Periode van verbouwing	12 mei 2016
Aantal toegangen	1
Aantal toegangen aangepast	1
Totaal aantal cico's voor aanpassing	2
Totaal aantal cico's na aanpassing	2
Aantal aangepaste cico's	2 verplaatst

Bodegraven

Soort ingreep	Twee toegangen voorzien van een cico.
Periode van verbouwing	30 mei 2016
Aantal toegangen	9
Aantal toegangen aangepast	4
Totaal aantal cico's voor aanpassing	9
Totaal aantal cico's na aanpassing	9
Aantal aangepaste cico's	2 verplaatst

Den Bosch

Soort ingreep	Cico's op een rij geplaatst.
Periode van verbouwing	9 juli 2016
Aantal toegangen	4
Aantal toegangen aangepast	2
Totaal aantal cico's voor aanpassing	17
Totaal aantal cico's na aanpassing	17
Aantal aangepaste cico's	12 verplaatst

Deurne

Soort ingreep	Cico's op een rij geplaatst op 1 perron.
Periode van verbouwing	26 mei 2016
Aantal toegangen	5
Aantal toegangen aangepast	1
Totaal aantal cico's voor aanpassing	6
Totaal aantal cico's na aanpassing	7
Aantal aangepaste cico's	2 verplaatst, 1 bijgeplaatst

Nunspeet

Soort ingreep	Cico's op een rij bij toegang. Extra cico bij secundaire toegang.
Periode van verbouwing	27 november 2015
Aantal toegangen	2
Aantal toegangen aangepast	2
Totaal aantal cico's voor aanpassing	3
Totaal aantal cico's na aanpassing	4
Aantal aangepaste cico's	3 verplaatst, 1 bijgeplaatst

Schagen

Soort ingreep	Cico's op een rij geplaatst op 1 perron. Extra cico bij lift.
Periode van verbouwing	19 september 2016
Aantal toegangen	7
Aantal toegangen aangepast	1
Totaal aantal cico's voor aanpassing	10
Totaal aantal cico's na aanpassing	11
Aantal aangepaste cico's	3 verplaatst, 1 bijgeplaatst

Tilburg Universiteit

Soort ingreep	Cico's naar toegang verplaatst en geoptimaliseerd voor loopstromen.
Periode van verbouwing	19 september 2016
Aantal toegangen	4
Aantal toegangen aangepast	2
Totaal aantal cico's voor aanpassing	7
Totaal aantal cico's na aanpassing	7
Aantal aangepaste cico's	3 verplaatst

Utrecht Terwijde

Soort ingreep	Cico's dichter bij toegang gezet.
Periode van verbouwing	8 juli 2016
Aantal toegangen	4
Aantal toegangen aangepast	2
Totaal aantal cico's voor aanpassing	6
Totaal aantal cico's na aanpassing	6
Aantal aangepaste cico's	2 verplaatst

Veenendaal-De Klomp

Soort ingreep	Cico's van het perron naar toegangen verplaatst en cico's bijgeplaatst.
Periode van verbouwing	27 mei 2016
Aantal toegangen	3
Aantal toegangen aangepast	3
Totaal aantal cico's voor aanpassing	3
Totaal aantal cico's na aanpassing	5
Aantal aangepaste cico's	3 verplaatst, 2 bijgeplaatst

Zaandam

Soort ingreep	Cico's dichter bij de (rol)trappen geplaatst op het perron
Periode van verbouwing	26 februari 2016
Aantal toegangen	4
Aantal toegangen aangepast	3
Totaal aantal cico's voor aanpassing	18
Totaal aantal cico's na aanpassing	18
Aantal aangepaste cico's	5 verplaatst

Appendix C: Claims pertaining to ten Front Door Basic stations

	ma	di	wo	do	vr	za	zo	ma	di	wo	do	vr	za	zo	ma	di	wo	do	vr	za	zo	ma	di	wo	do	vr	za	zo
Bloemendaal_voor				1	1				2	1		1				1	1	1								1	1	1
Bloemendaal_na			1	2					1		2						1		3				1		1			
Bloemendaal_controle_voor				1		1								2	1	2		1		3	1							1
Bloemendaal_controle_na		1				1								1			1		1						2		1	
Bodegraven_voor		1	1		2		3		2	2					1	1	1		1	1	2	2		1	2	2		
Bodegraven_na	1	3	1	1	1			2			1		1	1	2			1	1	1		1	2	1	2			
Bodegraven_controle_voor		2		1	3										1		1	1		1				1	2	2		1
Bodegraven_controle_na					1			1	1	2						1					1	2		2				1
Deurne_voor	1	2		1				1	1		1	1		3		1		1		1				1				
Deurne_na	1			3			1	2	1				1	1	3				1	1	1	1	1	4	2	1	1	1
Deurne_controle_voor			1	1	1						2		1				1			1	1	1	1		1	1	1	
Deurne_controle_na		1								1	1						1		1		1	2	2	1	1			
Den Bosch_voor	7	11	15	9	11	11	5	9	9	7	6	11	6	9	10	5	12	7	7	8	9	6	9	3	13	9	8	5
Den Bosch_na	12	8	5	7	13	15	5	13	11	10	8	18	11	3	16	18	8	14	8	6	4	7	6	8	8	10	6	3
Den Bosch_controle_voor	2	7	9	11	8	8	4	4	8	3	3	8	6	6	5	5	5	4	13	9	1	7	9	6	12	5	15	4
Den Bosch_controle_na	2	7	9	6	16	5	3	12	8	6	9	9	6	3	9	4	6	9	9	5	5	8	7	6	6	7	12	7
Nunspeet_voor	1			1	1					1	1							1	1	1		1			2			
Nunspeet_na		1	1	1	1				2		1	1	1									1						
Nunspeet_controle_voor			2						1		4	2	1	1											1		2	
Nunspeet_controle_na		1	1	1			1	1	1							1	1			2	1	1		2		1		
Schagen_voor	3	2			1			4	2		1	1	3	1		1	2	3				3	1	1	2	1		
Schagen_na	5	3	4	2	3	1			5	1	2	1	1	2	4	7	1	3	1	7		2	1				1	2
Schagen_controle_voor	4		2			1	1		1	2	2	1			1	2	1	1	1		1			3	1		1	
Schagen_controle_na		1	5	2	3	1	1	2			2	1	1		1		1	1	2		1		2		2	1	1	
Tilburg Universiteit_voor	1	2	2	1	2	2				2		1	2	1				3		1		3		1	1	2		1
Tilburg Universiteit_na				2					2	1	1	2				3			1				1	1			2	
Tilburg Universiteit_controle_voor					3			1	4	2	2	1	1		3			1					1	1	1	2	2	
Tilburg Universiteit_controle_na		1	2	1				1	1		1	2						1	2				1	2				
Utrecht Terwijde_voor		1					1	2				1	2				3		3		1	1	2		2		2	1
Utrecht Terwijde_na	1			1		3			1	2		6			1	1	1	2	1	1	1		2	2	1	1	3	
Utrecht Terwijde_controle_voor			1					2				3	1	1	1		2	1				1						
Utrecht Terwijde_controle_na			1	1	1					1	1	1		1		1		1	1								1	3
Veenendaal-De Klomp_voor		4	4	4		2	1	1	1	1		1	1	1	3						1		1	2	1		2	
Veenendaal-De Klomp_na	3		1	1		2	1	4		3	2	2	1				2	3		1			2	3	4	2		1
Veenendaal-De Klomp_controle_voor	2	1			1			1		2	1	2				2		1	1	1			2	1	2	2	1	
Veenendaal-De Klomp_controle_na	1		3	1						1	2			1		1	1	1		1			4			1	1	
Zaandam_voor	2	6	5	6	4	5	5	3	3	6	1	5	4	5	9	4	3	3	9	9	3	7	6	3	3	4	8	5
Zaandam_na	4	6	4	2	4	5	3	7	6	6	5	4	6	3	5	4	3	4	4	4	5	3	4	2	4	7	3	1
Zaandam_controle_voor	5	3	3	5	4	2	2	1	3	3	7	5	2	1	1	3	6	6	3	4	5	4	4	3	1	6	2	2
Zaandam_controle_na	4	2	2	3	3	2		3	3	5	4	2	1	2	1	2	6	1	2	2	1	3	1	1	4	7	2	5

Appendix D: Claims pertaining to Den Bosch en Veenendaal-De Klomp station

Den Bosch

	ma	di	wo	do	vr	za	zo	ma	di	wo	do	vr	za	zo	ma	di	wo	do	vr	za	zo	ma	di	wo	do	vr	za	zo	ma
voor (2016)	10	7	7	23	7	10	10	15	15	6	10	14	13	12	6	43	8	11	8	8	12	14	6	12	14	13	11	15	6
na (2016)	12	12	10	12	15	16	14	7	12	11	12	12	5	7	11	20	11	12	16	10	5	12	15	15	14	8	5	7	9
voor (2015)	6	9	11	7	11	9	5	6	10	8	6	16	9	2	8	3	5	8	8	11	10	5	6	10	12	18	6	10	10
na (2015)	3	7	6	13	9	9	10	7	4	7	11	9	16	8	17	13	10	20	16	11	6	5	3	8	8	12	10	4	3

Veenendaal-De Klomp

	ma	di	wo	do	vr	za	zo	ma	di	wo	do	vr	za	zo	ma	di	wo	do	vr	za	zo	ma	di	wo	do	vr	za	zo	ma
voor (2016)		3		1	4	3	2	1	5	2	4	2	4			5	3	1	1	2	2		6	2	3	2	3	2	1
na (2016)		1	3	1	1	2		2	2		1	4	1	2	2	2	1	1	4	1	1	1	2			3	2		
voor (2015)		1	1			1			1	1		3	1						2		1					1	2		1
na (2015)	1		1		3	2		3		2		1	2	1		3	3		1	1		3						2	2