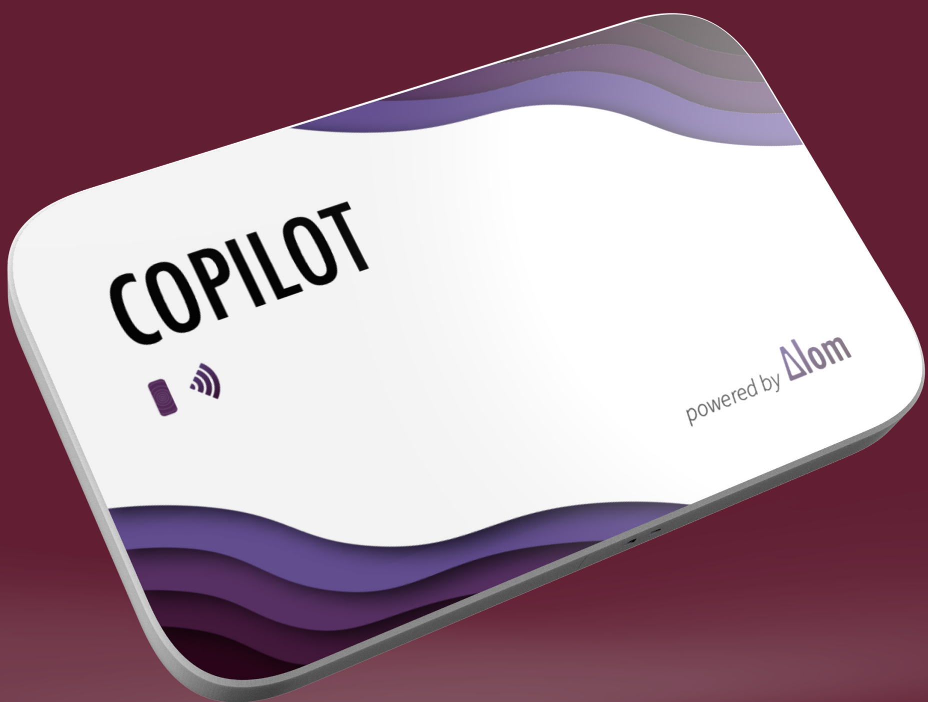
Seamless Mobility

A strategic intervention integrating public & shared mobility facilitating a complementary travel product



Master Thesis

Timothy Puglia

Colophon

Seamless mobility: a strategic intervention integrating public & shared mobility facilitating a complementary travel product

Defended on May 19th, 2022

Double Degree Master Thesis
Strategic Product Design & Integrated Product Design
Faculty of Industrial Design Engineering
Delft University of Technology

In collaboration with Seamless Personal Mobility Lab

Author/Candidate:
M. Timothy Puglia

Chair
Dr. ir. Hiemstra-van Mastrigt, S.

Mentor
Prof. dr. Kortuem, G.

Reference
Puglia, M.T. (2022). Seamless mobility: a strategic intervention integrating public & shared mobility using a complementary travel product. Delft University of Technology.

Preface
In front of you lies my master's thesis for both the masters Strategic Product Design and Integrated Product Design. This project is the culmination of my life of being a student at the Delft University of Technology.

To my chair and mentor, I would like to take a moment to express my gratitude. I am grateful for the degree of freedom you have given me over the past one hundred working days in addition to your continuous input and feedback. Thank you to you both.

To everyone else, thank you for giving your honest input, allowing me to vent my design frustrations, participating in creative sessions, and being part of the almost weekly reflection sessions.

To you, the reader, I hope you will enjoy this thesis and may it be useful in some way or another.

For further inquiries or to get in contact:
http://www.timothypuglia.com

TU Delft

“A harmonious flow of exposition can be expected only when one is writing about things which one already knows.”

—Carl Gustav Jung

Executive summary

Just a couple of years ago the delineation between the public and the private sector was clear. However, with the introduction and proliferation of shared mobility providers, the boundary is becoming fuzzy, especially since these newcomers all use their own specific way of checking in and out. Because they are not incorporated into a single digital ecosystem, the journey from door to door is becoming less seamless the more mobility providers are added to the market. The goal of this thesis is to fully understand what exactly constitutes seamless mobility and how it can be incorporated into the Dutch mobility sector. Consolidating research presented in this thesis in combination with previous research, a full traveller journey map is constructed in which anti-seamless behaviour is identified. Checking in to both a train station gate and a shared modality are the least seamless aspects of the journey. Therefore a new novel seamless interaction idea is presented. The proposed interaction is essentially the inverse of the current situation revolving around the idea of a wireless digital handshake. Wherein the old scenario the traveller must physically present a modality-specific identifier to a permanently closed barrier i.e. gate or moped, a traveller now carries a small modality non-specific token which can be detected by a gate at the train station or by a parked shared modality if it is in close proximity. Check-in gates at the train station are now permanently open and subsequently will only close when a valid token is not detected i.e. the digital handshake cannot be made. The same goes for checking in on a shared modality. Shared modalities are permanently unlocked and turned on and will cut the power, apply the brakes, or sounds an alarm when a valid token is not detected i.e. the digital handshake cannot be made. The combination of the wireless technologies PKES and UWB are selected. The introduction of the aforementioned seamless mobility scenario is dependent on the integration of public transportation and shared mobility services. Based on interviews with a municipality, a shared mobility provider, desk research, and leveraging the future introduction of Account Based Ticketing, nine strategic interventions are proposed. Now made possible by the strategic blueprint, research is done on how future travellers will react to the reimagined seamless mobility scenario. This is done through a series of interaction prototyping tests. Insights are translated in a redesigned travel token, a seamless train station gate, and a seamless scooter. A demonstrator prototype is built for attendees at the thesis defence to experience the reimagined seamless travel scenario.

List of definitions

Account Based Ticketing
A ticketing and payment system in which any travel token, that is linked to your personal account, can be used for transactions

APV
The Algemene Plaatselijke Verordening (APV) contains the municipal rules related to public order and safety.

BIBO (Be-in/Be-out)
A technology that enables travellers to obtain their (virtual) travel tickets just by “being” inside a vehicle.

Card Based Ticketing
A ticketing and payment system in which money is stored on the card itself.

Concession
The right to perform public transport to the exclusion of others in a certain area during a certain period of time.

Concessionaire
Licensed public transport operator to whom a concession has been granted.

MaaS
A new transport concept that integrates existing and new mobility services into one single digital platform, providing customised door to door transport and offering personalised trip planning and payment options. Instead of owning individual modes of transportation, or to complement them, customers would purchase mobility service packages tailored to their individual needs, or simply pay per trip.

Modality
A mode of transportation.

MRDH
Rotterdam-The Hague Metropolitan Area (Metropoolregio Rotterdam Den Haag).

NOVB
In the NOVB (National Public Transport Consultation) the common interest of the traveller, the carriers and the concession grantors is pursued.

OV-authority
Decentralised regional authority tasked with tendering and granting concessions.

OV-chipkaart
The OV-chipkaart is the payment method for public transport in the Netherlands. You charge the card with a balance or you put a travel product on it, such as a one-way ticket, a monthly home-work travel subscription or a travel card.

OV-Pay
OVpay is the national innovation program to introduce new forms of payment step by step with the aim of making traveling and paying in public transport easier.

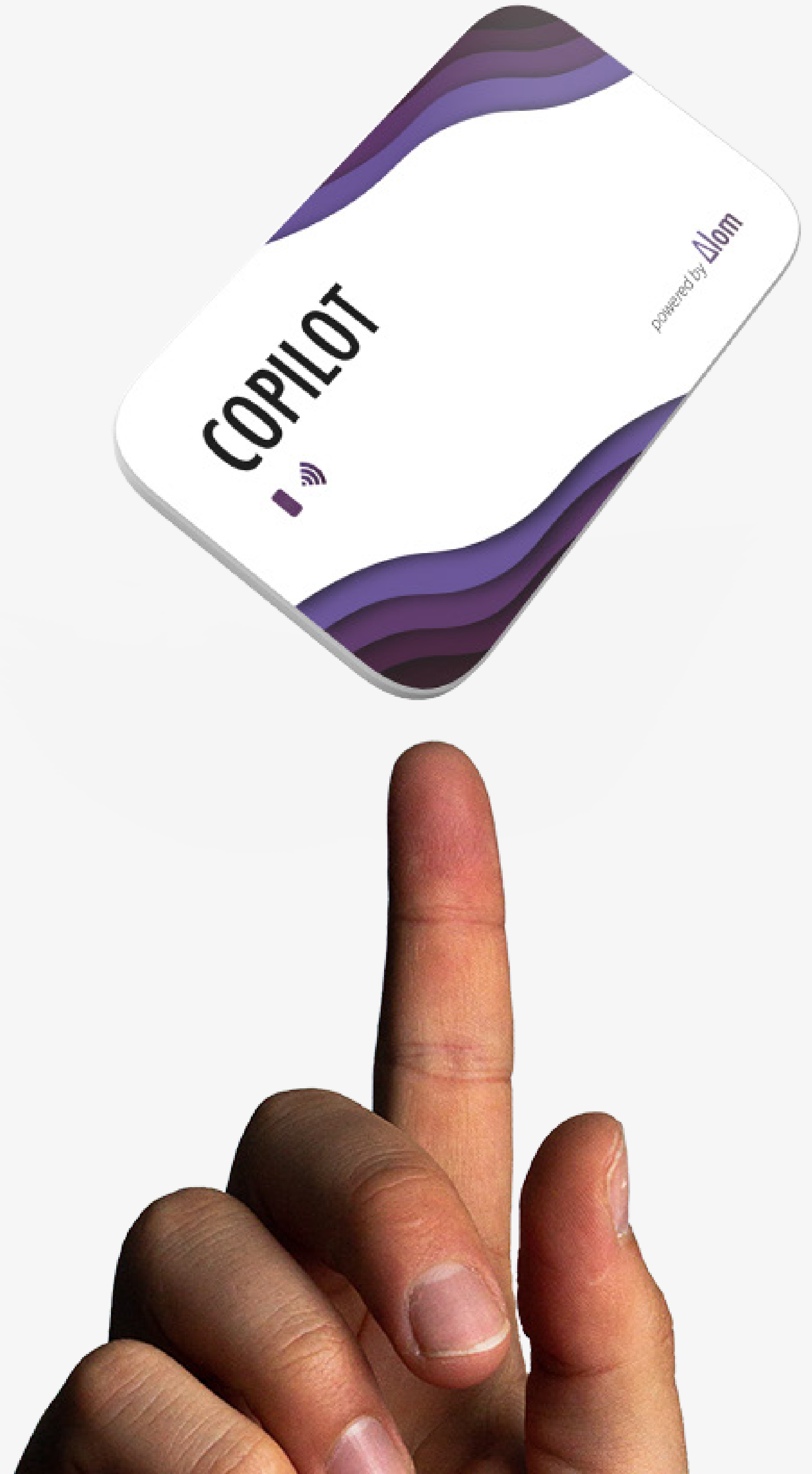
Shared mobility
Demand-driven vehicle-sharing arrangements in which travellers share a vehicle either simultaneously as a group or over time.

Translink
Translink Systems is the company behind the Dutch OV-chipkaart processing of all transactions in public transport.

Table of Contents

COPILOT

powered by Δlom



Chapter 1

Establishing the project

This chapter introduces the project context and the initial design brief. Furthermore, the project approach and the intended deliverables by the two masters are described.

1.1 Project introduction

1.1.1 Project context

Three categories of transportation in The Netherlands exist: public transportation, shared transportation and private transportation [1]. For this thesis, the private layer is out of scope. Public transport is defined as the transportation of all people using a set timetable [2]. Shared transportation is relatively new and is defined as the shared use of a vehicle, bicycle, or other low-speed mode that enables users to have short-term access to transportation modes on an 'as-needed' basis, often serving as a first- or last-mile connection to other modes [3].

The OV-chipkaart incorporates all public transport providers on a national level into a single transaction ecosystem. It is easy to understand for the traveller as there is only one way to pay and check in and check out. Just a couple of years ago the delineation between the public and the private sector was clear. However, with the introduction and proliferation of shared mobility providers, the boundary is becoming fuzzy, especially since these newcomers all use their own specific way of checking in and out. Because they are not incorporated into a single digital ecosystem, the journey from door to door is becoming less seamless the more mobility providers are added to the market. This also means that there are exponentially more ways of getting to a final destination.

The goal is to provide an integrated, care-free, door-to-door travel experience that incorporates various methods of transportation tailored to the wishes and demands of the traveller. Integrating the services offered by all mobility providers into a single MaaS (Mobility as a Service) application or similar type of platform has been posed as a possible solution, although it has not yet led to a successful application in The Netherlands. Currently, there has been a proliferation of these services, likely adding more trouble than they are trying to take away. The Delft University of Technology, the Dutch government (both national and regional), and the private sector are actively working on various MaaS solutions and this graduation project will be joining the efforts.

1.1.2 Initial project assignment

There are two major problems that this graduation project will tackle. The first is that newcomers (usually shared mobility providers) are operating alone and therefore are not integrated into a single travel ecosystem. This implies that for every extra mobility service outside of the OV-chipkaart ecosystem, there is a separate and unique way in both payment and checking in and out. It will be essential to understand the stakeholder needs, and how they can be enticed to be incorporated into a single, reorganised transport ecosystem, ultimately streamlining the travel experience. The second main problem that this project is trying to solve, is that connections and transfers are far from being seamless. The OV-chipkaart system still has too many steps which decrease the feeling of seamlessly travelling: grabbing your card to check in or out, gates at stations, a surplus of smartphone applications, unlocking an OV-fiets, etc. This creates discomfort, creates congestion, and induces stress for travellers. To solve this problem, the entire customer journey and the way in which travellers travel must be re-imagined. All aspects ought to be designed with the user at the centre as they are the ones who must see the benefits.

Therefore first the research question to answer is: 'What exactly constitutes seamless travel?'. Only by having a fundamental understanding of the first research question can the sub-research question be answered: 'How to incorporate seamless travel in the Dutch mobility sector?'

1.1.3 Seamless Personal Mobility Lab

This graduation project will be done together with the Seamless Personal Mobility Lab. The Seamless Personal Mobility Lab is one of the Delft Design Labs of the faculty of Industrial Design Engineering. In the design lab, students and researchers of Industrial Design Engineering at the Delft University of Technology work together with transport operators, mobility companies, government and technology developers to gain a better understanding of the wants, needs and behaviour of travellers. Within the lab, multiple graduations and research projects are executed. The lab focuses on the main themes of MaaS and seamless travelling, both of which are fundamental pillars in the project.

More information about the lab, partners and other projects can be found via: https://delftdesignlabs.org/seamless-personal-mobility/

Seamless
Personal
Mobility

1.2 Project approach & deliverables

This project is part of a double degree graduation assignment. The masters Strategic Product Design and Integrated Product Design must both be covered and time must somewhat be equally allocated. The two masters during the project will be executed in parallel by continuously jumping from the strategic level to the product level and vice versa. By execution of a project in this particular fashion, the proposed design will be a fully integrated solution with a strong foundation on both the strategic level and the product level. In the end, the two masters will have a separate final deliverable: a strategic intervention blueprint and a complementary personal travel product for the masters Strategic Product Design and Integrated Product Design respectively.

This thesis uses the diamond method for the design approach (figure 1). Normally speaking, this guiding framework uses two diamonds in which each diamond consists of a diverging and converging phase. However, with the addition of a second master, a third diamond is added. The project approach consists of six phases in total: discover, define, explore, strategise, develop, and deliver. Some of the phases are master specific, while others are shared by both masters. The objective of each phase is briefly discussed below.

In the discover phase, the main emphasis lies on knowledge building split up into three categories: understanding what constitutes something being seamless, the current context of public transportation and shared mobility including their interactions, and the needs and desires of the main stakeholders. This research was conducted through a combination of desk research, expert interviews, sensitising booklets, various types of observations, and literature research. Chapter 02 tries to develop a fundamental understanding of the term seamlessness supporting the vision. Chapter 03 explores the current context and interaction of both the public transportation sector and shared mobility. Chapter 04 is focused on understanding the needs of the municipality, the shared mobility provider, and the traveller.

In the define phase, chapter 05 consolidates the insights and literature from previous chapters in a complete traveller's journey from the perspective of the traveller. Regarding the perspective of the municipality and the shared mobility provider, chapter 06 synthesises their needs from which a meaningful opportunity gap is identified. This chapter also defines the scope of the traveller's journey constructed in the previous chapter. To clearly define how the opportunity gap can best be leveraged, a new design brief including a more specific problem statement is formulated. Finally, a new interaction scenario is proposed.

The explore phase consists of a technology deep dive. Current technologies of both public transportation and shared mobility are investigated including their innovation space. Technical requirements required by the proposed interaction scenario in the previous chapter are formulated after which technology scouting is initiated. A combination of wireless technologies is selected laying the foundation of the travel product embodiment design.

In the strategise phase, four strategic design goals are formulated after which a reorganisation is proposed based on all previous insights. Nine strategic interventions are discussed which allow for the complete integration of both public transportation and shared mobility. This integration is necessary for the new interaction idea bringing a truly seamless and care-free travel experience to the traveller. The strategic reorganisation is necessary for the complementary travel product to properly operate.

In the develop phase, the proposed interaction scenario, now made possible by the strategic interventions, is explored through a series of design sprints. These include interaction prototyping, creative facilitation, concept embodiment and branding. In addition, the new seamless travel experience is evaluated using participants to fully understand how future travellers might react. In the end, a design is created for a new train station gate, a sharable scooter, and a wireless token.

Finally, in the deliver phase, the final concepts of the train station gate, the scooter, and the wireless token are presented in a showcase including the traveller's interactions and the accompanying branding. Furthermore, a final functional working prototype is built which can be tested by attendees during the defence of this thesis.

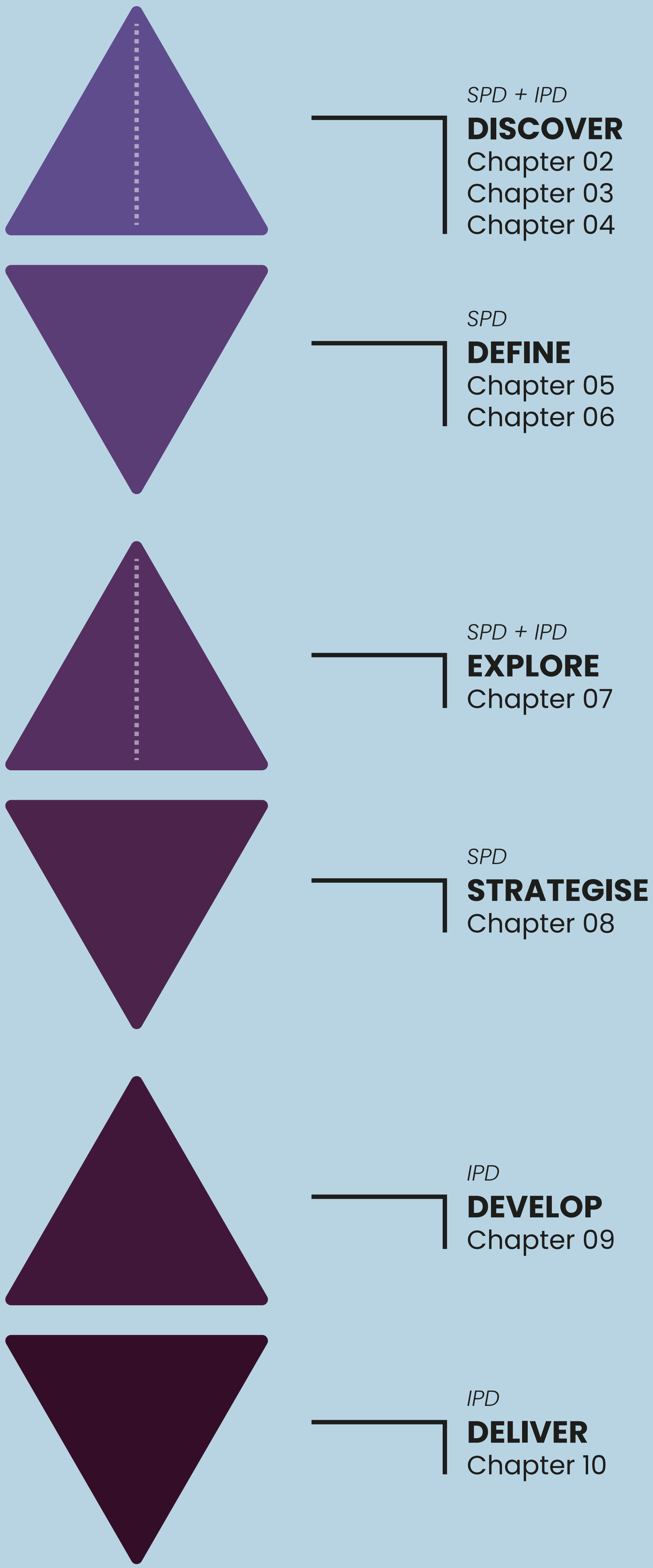


Figure 1 - Diamond method approach

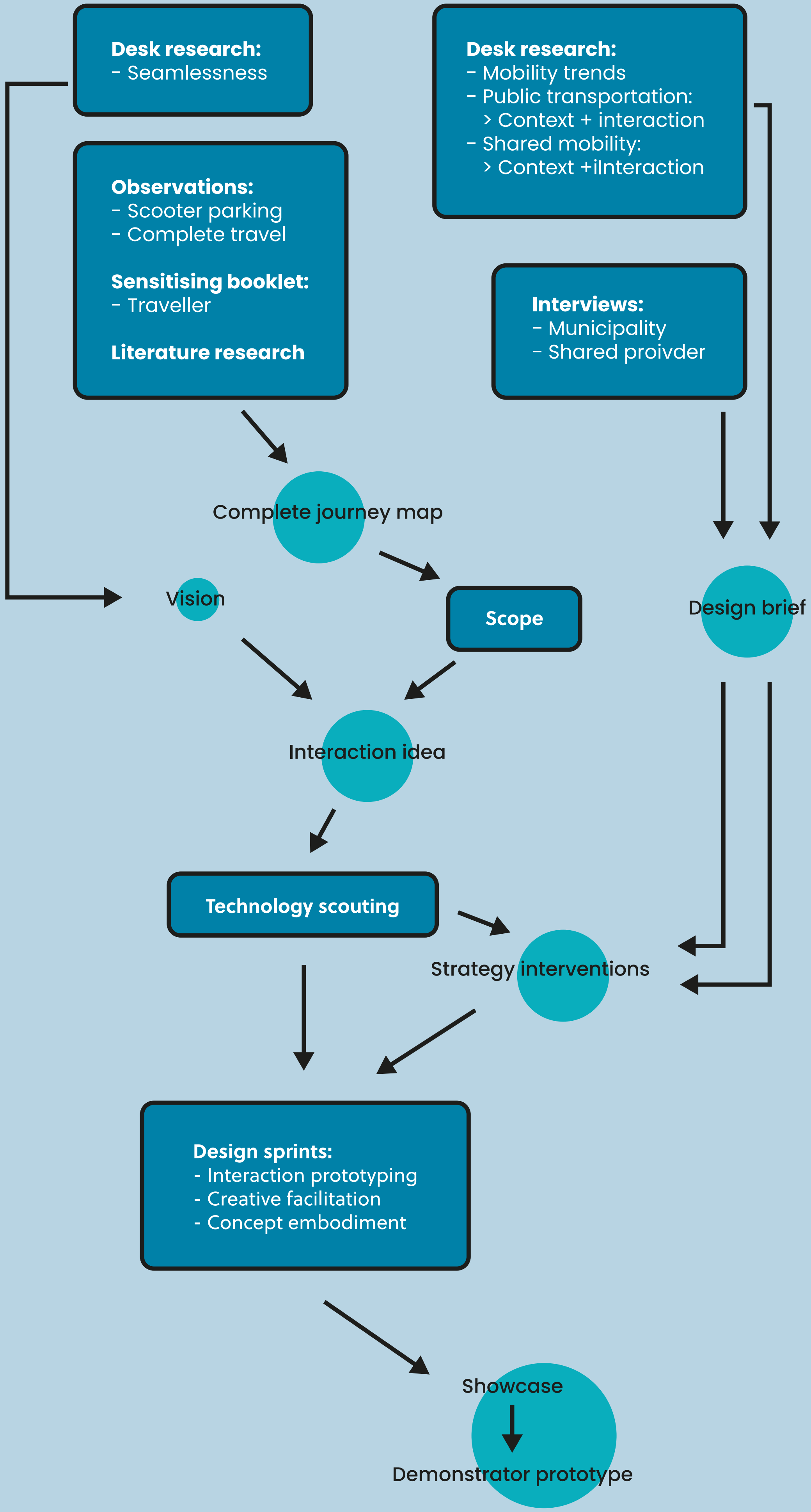


Figure 2 - Report structure

Chapter 2

Theme exploration

This chapter investigates what exactly constitutes something being seamless in the mobility context. This is done by exploring various fields of interest and by benchmarking an analogous application. Furthermore, mobility trends are discussed.

2.1 Understanding seamlessness

To design for seamlessness, it is imperative to fully understand what exactly constitutes something being seamless—and by extension, when it is not. There is a great knowledge gap in the definition of seamlessness whether that concerns the mobility sector or elsewhere. Therefore, first, an etymological research regarding the origin and current context of the term seamless is performed. Progressing from these definitions, various fields such as psychology, philosophy, and computer science, are explored. These seemingly unrelated fields are explored to get an outsider's perspective of what seamlessness could implicate in the mobility sector. Lessons learned per explored field are as ineffective as simply investigating seamlessness in the mobility sector, however, the combination of lessons from manifold fields provides at the very least a fundamental base for reasoning, and at the very best a complete explanation.

2.1.1 Etymological dichotomy of seamlessness

The diachronic definition, that is the definition in its historical context, given by the Oxford English Dictionary defines seamless as: 'Smooth and continuous, with no apparent gaps or spaces between one part and the next.' [4]. Seamless was introduced by storytellers and writers throughout history, especially during the 17th century, using the term to describe the white seamless garment of Christ. The seamless garment is used to elicit the imagery of purity and subsequently was not torn apart by those dividing up his possessions after his death [5]. In historical context, seamless is used in the literal sense; the definition quite literally says what the word already is saying.

Words however evolve and subsume different meanings over time. During the 20th century, the term seamless gained substantially more attraction and use in text, though in a different context. Analysing seamless from a synchronic perspective, that is using the active and current contextual definition, in part by ignoring historical events, the Merriam-Webster Dictionary adds the explanation: 'Having no awkward transitions, interruptions, or indications of disparity.' [6]. By analysing the various forms in which seamlessness can be defined, using its references and synonyms, it became clear that there is an unexplained etymological dichotomy when the term seamless is used in a modern context. Terms such as flawless, continuous, harmonious, and integrated are used to help define what seamlessness is, however more often than not, terms such as transitions, interruption, gaps, and division indicate what seamlessness is not. This dichotomy raises the question if the term seamless can be purely explained by what it is, or whether it must include an elimination of aspects of what is it not. A handful of selected terms from the tree in their relative fields (see figure 3) are explored.

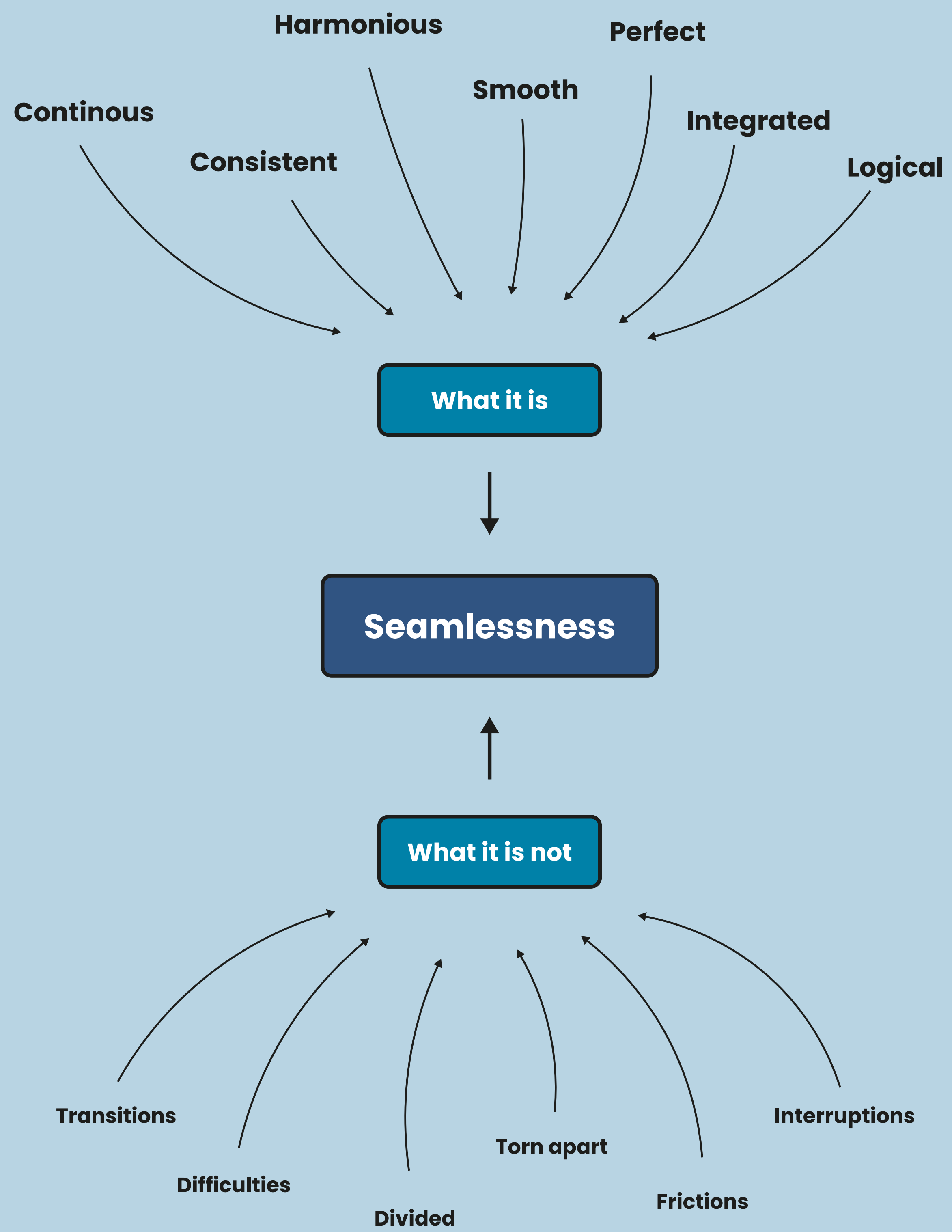


Figure 3 - Etymological dichotomy of seamlessness

2.1.2 Seamlessness: what it is

One of the most prevalent words which keep popping up is the term continuous. Continuity, in the relation between cognition and behaviour, is called ‘flow’. Csikszentmihaly, a psychologist credited for the invention of the concept, states that flow occurs when an individual is totally absorbed in a task and is mainly motivated by the enjoyment and satisfaction the task provides [7]. Flow is the holistic sensation of being in total involvement and focusing on the activity at hand. Colloquially speaking, it is more widely recognised as ‘in the zone’, ‘in the groove’, or ‘tuned in’ and can only be achieved by finding the optimal balance between challenge and skill [8]. For example, a sportsman running a marathon, a surgeon during a 10-hour surgical intervention, or the patience of a creative artist, achieve ‘flow’ when executing their work whilst deriving great enjoyment from the act of doing the work. Csikszentmihaly provides another definition for being in flow as per an interview by Wired magazine [9]:

“…being completely involved in an activity for its own sake. The ego falls away. Time flies. Every action, movement, and thought follows inevitably from the previous one, like playing jazz. Your whole being is involved, and you’re using your skills to the utmost.”

That is of course only until one is interrupted. When flow is achieved, it is exciting, fulfilling, and enjoyable [10]. These are characteristics highly desirable in travelling. Most importantly, flow is derived not from external rewards, but from the continuous act itself. Seamless travel requires a mental state of continuous flow being completely absorbed in the task itself.

“My mind isn’t wandering. I am not thinking of something else. I am totally involved in what I am doing. My body feels good. I don’t seem to hear anything. The world seems to be cut off from me. I am less aware of myself and my problems.”

—Csikszentmihalyi

A direct synonym for seamlessness is integration. With the rapid advancements in wireless technologies over the last few decades, and the abundance of interconnected devices (known under the umbrella term of Internet of Things), there has been a great increase in the standardisation and integration for seamless connectivity. Weiser has coined the phrase ubiquitous computing which implies, from a computer science concept, that computing happens everywhere, at any time, on any device, and in any format. Invisibility is according to Weiser a central theme in ubiquitous computing, stating that components, electronics, and technologies are hidden inside commonplace objects. Weiser’s famous quote regarding the foundation of ubiquitous computing is the following [11]:

“A good tool is an invisible tool. By invisible, I mean that the tool does not intrude on your consciousness; you focus on the task, not the tool.”

Weiser continues on the topic of invisibility [12]:

“Therefore we are trying to conceive a new way of thinking about computers in the world, one that takes into account the natural human environment and allows the computers themselves to vanish into the background. Such a disappearance is a fundamental consequence not of technology, but of human psychology. Whenever people learn something sufficiently well, they cease to be aware of it. When you look at a street sign, for example, you absorb its information without consciously performing the act of reading... All say, in essence, that only when things disappear in this way are we freed to use them without thinking and so to focus beyond them on new goals.”

Technology in Weiser’s opinion should not interfere with human activity but should seek to help and stimulate in such a way that those technologies fall into the background. These seemingly invisible technologies provide implicit interaction enabling seamless transitions between the real and digital world which in turn initiates spontaneous behaviour. A well-designed and integrated mobility ecosystem should fall invisibly into the background. Neither the technologies nor the system itself should show itself. This implies that modalities should not be consciously absorbed. One must forget being in, or sitting on, a modality as it frees the traveller to experience something else which in turn stimulates spontaneous behaviour [13], [14].

Harmony is another central topic when it comes to defining seamlessness. Being in complete harmony with one’s environment is a significant aspect of Taoism: a religion based on the “Tao” doctrine. Tao paves the way to achieve harmony with its main objective to bring good health, social balance, and harmony to the individual [15]. Tao’s main rule is to follow fate without resistance which can only be attained by becoming one with the unplanned rhythms of the all called ‘The Way’ [16], [17]. To do so, in general, Taoist ethics accentuate the principle ‘Wu Wei’ which dictates action without intention [18]. Going against the flow from a Taoistic perspective induces cognitive dissonance whereby high stress and anxiety levels are invoked having a negative influence on one’s mental state. A dynamic, adaptable, user-centred offering of mobility is required to attain the concept of ‘action without intention’. Only then are travellers able to ‘drift to their destination’. Harmony implies accepting the unplanned imperfections without resistance and by doing so, an internal balance with low levels of stress and anxiety can be achieved.

2.1.3 Seamlessness: what it is not

Seamlessness implies the absence of interruptions. Interruptions come, generally speaking, in two varieties. The first is an external (exogenous) event. This could be a fire-alarm siren or a ringtone of a mobile phone. Usually, these types of events are specifically designed to interrupt as they require immediate attention. The second type of interruption is an internal (endogenous) event. Endogenous interruptions are triggered by a sudden subtask which has to be performed such as looking up a reference when writing a paper. Both exogenous and endogenous interruptions can only be defined as an interruption if the intention remains to return to the original task [19]. Interruptions on the surface do not seem to have major implications for daily life as they are quite commonplace, though the very opposite is the case. A growing body of evidence has shown that interruptions are negatively influencing productivity and are increasing the chances of accidents. Half of the incident reports at NASA are attributable to interruptions and a comparison study found a 53% increase in errors by interrupted pilots flying in a simulator compared to those who were not interrupted [20], [21]. When someone is interrupted while performing a task, the individual halts the original task and at some point in the future must recall where it must be resumed. This is done by what is called prospective memory, and when it is invoked, the brain is now burdened with an additional cognitive load. This is especially the case when an individual must switch between virtual information spaces and physical spaces or two distinct user interfaces [22]. Interruptions, both exogenous and endogenous variants, must at all times be avoided. A traveller might say sentences such as 'What was I saying, oh, right…' after having checked in and must be counteracted.

Diving deeper into the field of cognitive load brings us to the concept of choice. The existence of choice in a seamless system might seem paradoxical, however, there are good arguments in favour of having the ability of choice from a consumer perspective. Schwartz argues that choice is a necessary part of freedom, although having an abundance of options to choose from is not positively influencing the sense of freedom [23]. The proliferation of options renders people paralysed and disappointed rather than liberated. In his words, they become passive 'pickers', rather than active 'choosers'. In both field and laboratory settings, people are more inclined to purchase consumables when offered a limited array of 6 choices rather than a more extensive array of 24 choices. Satisfaction levels increased in participants who were presented with the limited set of options [24]. Choice can foster freedom, empowerment, and independence, but it is not an unalloyed good. Too much choice can produce a paralysing uncertainty, depression, and selfishness [25].

Seamlessness is undivided i.e. the constituent elements of the whole should not fight for their position without proper regard for other elements. At the moment when a system is broken up into quantifiable elements, it is easy to simply optimise for those associated variables. Assuming variables have been optimised, does not imply that the whole system is optimised. In fact, it could even be negatively affected. Heying and Weinstein argued this point in the modern approach to consuming food, among other aspects of life [26]. A reductionist approach to nutrition fails as the the body is not a static, simple system, nor does every individual have the exact same needs. An individual does not just need the precise, dictated amount of proteins from a protein shake, the correct amount of vitamin C from tablets, however, humans must, through the evolutionary lens, consume food as our ancestors did. A reductionist, nutrient-centric approach fails to allow the advantages of food as a whole to manifest themselves. Not only is it healthier for the individual, but it also provides a moment of coming together, for celebration, for grief, for cultural reasons, for connection. The sum of the constituents is not greater than the whole. The traveller is not a static being but is a dynamic entity with unique needs. Optimising the broken-down quantifiable elements of their travel is of little importance when the entire trip is not accounted for. In fact, it could make a system worse. To combat this, elements of the mobility chain should at least share characteristics and should not fight for their own position without proper regard to the others.

Seamless design directly entails a design that is without friction or difficulties. According to Morewedge and Kahneman, the brain operates on two metaphorical systems called system 1 and system 2 [27]. System 1 is concerned with fast thinking; it is unconscious, automatic and effortless. In addition, it is without self-awareness or control and makes up for roughly 98% of our thinking. System 2 on the other hand is only concerned with slow thinking; it is conscious, effortful, controlled, and rational. Contrary to system 1, system 2 is including self-awareness and makes up for about 2% of our thinking. Throughout an individual's day, myriad decisions ranging in difficulty have to be made. Consciously processing every decision would induce a cognitive overload and will make the brain crash. To save mental energy, system 1 makes use of necessary shortcuts called heuristics as it derives conclusions from automatic operations of associative memory. Simply put, the brain loves effortless thinking and operates the vast majority of the time under 'the law of least effort'. As Kahneman puts it [28]:

'The law asserts that if there are several ways of achieving the same goal, people will eventually gravitate to the least demanding course of action. In the economy of action, effort is a cost, and the acquisition of skill is driven by the balance of benefits and costs. Laziness is built deep into our nature.'

A seamless journey is a journey where only system 1 of the brain is used. A trip must be able to be completed using only associative memory and rely on simple heuristics. The traveller will invariably gravitate to the journey with the least amount of action.

2.2 Benchmarking

2.2.1 Approaching seamless grocery shopping

In 2018, Amazon opened its first seamless convenience store in Seattle called Amazon Go. The store is built around 'walk-out technologies' and offers the consumer a radical new way of shopping. Intending to improve customer convenience, the store integrates 'machine learning, computer vision, and Artificial Intelligence into the very fabric of the store, so customers never have to wait in line. No lines, no checkouts, no registers.' [29]. Located at the store entrance, there are several check-in gates that the customer can open by scanning their QR code in the Amazon Go application. Once access to the store is gained, the customer puts their phone away and begins shopping. Every item put in the shopping crate is recorded by force sensors in the shelves and myriad cameras and tracking sensors in the ceiling. There are no cashiers at the exit of the store and the customer is free to exit—to just 'walk out'. Payment is done automatically in the background through the Amazon account and the receipt is sent to the app which informs the customer of their purchases. According to a report by Accenture, Amazon Go has changed the convenience experience forever [30].

The implementation of technologies yielded good advantages and the customer response has been positive. There are no cashiers which takes away the risk of human error being mainly monetary theft and till miscalculations. There are also no wait times for customers which allows them to save time on their shopping trips and go on with their day-to-day activities with an increase of 33% [31]. Furthermore, general customer satisfaction has also increased [32]. A study found that 57% of customers would like to see an Amazon Go or similar tech-enabled store near them [33]. The age cohort with the highest interest is the generation Z and X with 77% stating that they are 'especially interested' in the frictionless service [34].

The interaction with the 'just walk-out technologies' was a bit of a shock to most customers, however, they tend to familiarise themselves with the new user experience in just a couple of shopping trips. A store official notes about early customers:

"What we didn't necessarily expect was how many people would stop at the end on their first trip or two and ask, "is it really okay if I just leave?" Or, "are you sure it's alright?" And our associates would say "sure," we even actually wrote it above the door "you're good to go. Thanks for shopping." So that's been fun to see, it tends to wear off after the first or second trip, it becomes more natural..."

—Amazon official

It is important to state that not everything went according to plan or was positively perceived by the public. A study by Accenture found the vast majority of people are more inclined to resolve the issue with a person rather than a digital channel if for whatever reason the system failed or showed an error [35]. Even though the Amazon Go shopping experience appears fully automated, there is still personnel at the site to resolve conflicts or customer inquiries. Furthermore, those who wish to shop, wanting to linger in the aisles, are now implicitly encouraged to treat their shopping experience like a race. Finally, the desire for the most convenient shopping experience has come at the expense of general privacy and digital security. One Amazon Go shopper points out:

"The only sacrifice you make: near-constant surveillance. … But if you can get past the surveillance, and you don't mind Amazon gaining even more information about what you buy and eat, Amazon Go is convenient. … It's creepy and it's awesome. I'm totally going back."

Huberman points out a privacy cost-effect between on the one hand the advantages of superb convenience, and on the other hand, surrendering an individual's right to privacy with their behaviour and purchases to be used in different applications or even being sold. In effect, the customer is paying for their own subjugation. In addition, Huberman goes against the doctrine of the smartphone being the one ticket to freedom, pleasure, and empowerment [36].

In the mobility context, efficiency could lead to increased satisfaction. In addition, younger audiences are likely to be early adopters. An important takeaway is that radical technological innovations don't resonate well with customers, though they will adapt relatively quickly. There is an intricate relation between technological innovations requiring data, and surrendering an individual's privacy. Smartphones must not be the only solution, nor should superfluous data collection be a prerequisite. A proper balance between the amount of data to operate a service concerning a user's privacy is essential.

Figure 4 - Amazon Go store

2.3 Mobility related trends

2.3.1 MaaS

Mobility as a Services is a recent mobility concept which embodies the vision of integrated and seamless mobility [37], [38], [39], [40]. Rather than locating, booking, and paying for each mode of transportation separately, MaaS envisions the integration of public transport modalities (such as trains, trams, and busses) and shared transport modalities (such as sharable mopeds, scooters, and bicycles) into a single digital platform. MaaS ultimately provides highly personalised door-to-door transport [41]. Different definitions in literature for MaaS exist, the one used in this report is as follows by Durand [42]:

MaaS is defined as a new transport concept that integrates existing and new mobility services into one single digital platform, providing customised door-to-door transport and offering personalised trip planning and payment options. Instead of owning individual modes of transportation, or to complement them, customers would purchase mobility service packages tailored to their individual needs, or simply pay per trip.

Promises

The role of a subscription in MaaS is of high importance as it gives the user the possibility to plan, book, and pay for their trip all in a single service. For the traveller, this means that offering a single service makes booking and paying easier as the service now provides a convenient overview of all transportation modes and mobility aggregators that gather and sell all mobility services [43]. Another advantage is that through the single digital platform, the traveller is able to choose various payment options based on their individual needs such as 'pay-as-you-go', 'pre/post pay', or a monthly subscription [44]. The result is that MaaS is highly personalised to the needs and preferences of the traveller.

Challenges

There are several key challenges for MaaS to be successful. Choice freedom in the range of different modes is valued highly among travellers [45], especially for the groups in which private cars will be less important in future [46]. In addition, on the advent of the introduction of MaaS, it could disrupt the current role and organisation of the public transportation sector [47]: it should function as the back-bone of MaaS [48], [49]. Another key area is which poses a challenge is the necessary behavioural change in travellers. Travellers are, in general, behaviourally inert and prefer the status quo [50]; habits dominate behavioural outcomes in stable contexts [51], [52], [53], [54], [55]. When travellers are accustomed to their habitual travelling behaviour, they are not inclined to change their behaviour if no external triggers exist. To an extent, this means that MaaS may have more potential for incidental trips, although travellers must actually start to use the service in the first place—which is difficult to achieve [56].

Furthermore, there are indications that different socio-demographic and cultural groups have a higher degree of proclivity to adopt MaaS services. For example, young to middle-aged cohorts residing in urban areas are more inclined as the first group to switch from the current mobility system to MaaS—this conclusion is also in line with the seamless grocery shopping experience discussed in the previous chapter. Highly educated people show more willingness to use MaaS and households with at least two young children showed less willingness to adopt MaaS [57], [58]. Cultural acceptance proves to be an indication for the adoption of MaaS as well. The degree to which a culture is already service-oriented, such as accepting home-delivered groceries, using the internet to search for travel information, booking and paying for trips, and using ride-sharing, determines the adoption of MaaS.

Finally, MaaS should be economically feasible for everyone. Prices must represent the added value and preferably should not be higher than current, traditional modes of transportation [59].

Adoption

Within a MaaS system, there are two distinct roles in the value chain which the public and shared mobility providers can adopt: MaaS integrators and MaaS operators. MaaS integrators assemble and organise the offerings of the mobility service provider, whereas the MaaS operators deliver a final digital interface including the assembled mobility service providers to the travellers [60]. The adoption of those two roles will exist in three possible pathways: market-driven, public-controlled, and public-private. Market-driven development could either increase the efficiency of and access to public transport or create an unjust transport system. On the other hand, the risk of a public-controlled development is that a system is created which is not attractive to end-users. A public-private scenario seems to be a preferable option it allows for maximum integration and innovation. Regulating bodies must orchestrate and harmonise integral parts of the MaaS system, though they should leave enough room for innovative solutions or new mobility providers to enter the market [61]. Privacy and data protection remain important aspects to ward over by the regulating bodies.

A study by Deloite identifies four main topics from a municipality perspective which must be fully embraced in order to introduce MaaS. First, governments need to see the benefits that MaaS has to offer and should actively buy-in. Second, as the innovative capabilities of the private sector are essential, public-private partnerships should be established, preferably open. Third, the technology architecture must be agreed upon for new players to quickly enter the market. Finally, public transportation is vital and should not be excluded. In addition, the currently existing payment infrastructure should be leveraged [62].

Current offerings of MaaS

In The Netherlands, the Ministry of Infrastructure and Water Management and seven regions have jointly developed seven nationally scalable MaaS pilots. They are located in De Zuidas (Amsterdam), Vleuten en De Meern (Utrecht-Leidsche Rijn), Twente, Groningen-Drenthe, Rotterdam-Den Haag, Eindhoven, and Limburg. Several market-driven efforts such as Moves, Gaiyo and Glimble are now in service. The result is a proliferation of initiatives which has not yet led to a successful application.

2.3.2 Payement & ticketing

In 2023, the current OV-chipkaart and the IT system it relies on will be phased out. Its replacement is a completely new digital architecture which allows travellers to check in and out with their preferred device whether that is a credit card, debit card, smartphone etc. To facilitate this change, the underlying technology will migrate from a card-based ticketing system to an account-based ticketing system.

Card Based vs Account Based Ticketing

In a Card Based ticketing system, money and travel products are stored on the smart card itself (e.g. the OV-chipkaart). When a traveller scans the smart card at the terminal, the transaction is executed locally. Because the transaction is executed locally, the data necessary to check in must be stored on the card itself. Only when a sufficient amount of money is stored on the card, or if the card is carrying a particular subscription or travel product (e.g. time-based passes, discount products, student travel subscriptions etc.) is the check in approved. The data of the transaction is at a later stage forwarded to Translink.

Contrary to the Card Based Ticketing system, in an Account Based Ticketing system, the card is only used to identify the traveller. The transaction is not executed locally but instead is done on a central server in a virtual account where all the relevant information and travel products are stored. Using an Account Based Ticketing system opens the possibility to use various forms of identification such as a credit card, debit card, or smartphone as they can likewise be used as a means to identify the traveller.

Vision NOVB payment methods

The NOVB released their vision for future payment schemes in the public transportation sector in 2014 [63]. Even though they recognise the success and ease of use that the OV-chipkaart has brought over the years, they still see shortcomings in the current system. With the advent of novel technologies, new ways of paying in the public transportation system could result in an easier and more customer-friendly interaction for the Dutch traveller. These new payment methods may offer the opportunity to remove many barriers such as a missed check-out, loading a balance on the OV-chipkaart and the initial purchase costs. Different groups of travellers can also be served simultaneously in a way that matches their desired travel experience. With the future introduction of the Account Based Ticketing system, the vision of the NOVB states that there must be multiple payment methods which can be used throughout the entire journey based on individual needs and preferences.

OV-Pay

To realise the vision set out by the NOVB, all public transport companies joined hands and became members of the Cooperatie Openbaar Vervoersbedrijven on 1 January 2016. These public transportation companies are therefore also joint owners of Translink Systems, the company behind the OV-chipkaart [64]. The Cooperatie Openbaar Vervoersbedrijven will execute between 2021 and 2023 under the denominator OV-Pay several pilots. Currently, there are three pilots. In these pilots, travellers can now check in and out in the city busses of Arriva and Transdev in Lelystad and Gooi en Vechtstreek respectively using a credit or debit card or a smartphone loaded with a credit or debit card [65]. After 2023, the current OV-chipkaart will be phased out completely and will be replaced by a new version. Paper tickets will remain in place as well.

Be-in/be-out

The NOVB vision has also identified a future scenario where the traveller is checked in and out by simple ‘being’ inside a modality such as a train. By carrying an unobtrusive tag, and without any interaction required from the user apart from entering the geofence of a modality, the transportation service provider is able to wirelessly identify a traveller and subsequently check the traveller in and out when a journey is finished.

As an advantage, BIBO will increase satisfaction among travellers in the long run [66]. The development of proposed technologies such as GPS or Bluetooth and if they are integrated on for example smartphones lies outside the sphere of influence of those willing to implement the technologies in their mobility services and therefore create an independent relationship. That is on top of the fact that not everyone is in the possession of a smartphone, and the fact that people, as pointed out by a Rover investigation, are unwilling to enable, for example, Bluetooth as it drains the smartphone battery. Privacy and digital security issues are important considerations when using continuous location tracking and data gathering for BIBO.

General trends are discussed in appendix 2.

Chapter 3

Current context & interaction

This chapter explores the current context and organisational structure of both public transportation and shared mobility. In addition, the way in which travellers currently interact with these modalities is investigated.

3.1 Public transportation context

3.1.1 Brief history

Public transportation in The Netherlands arose during the late 19th century as commercial initiatives. At the time, there was little to no influence by the central or local government. Only when it became apparent that there was a great need for an ordered public transportation sector, the fact that the commercial initiatives were not profitable, and when the government concluded that it was a vital tool to achieve policy objectives, did the central government got actively involved. Until the introduction of the Wet Personenvervoer 2000 in 2001, the government had full responsibility of implementation and execution. The Wet Personenvervoer 2000 introduced the concession model which transferred the responsibility, implementation, and execution of public transport to commercial parties, however within the legislative boundaries provided by the concession set up by the government.

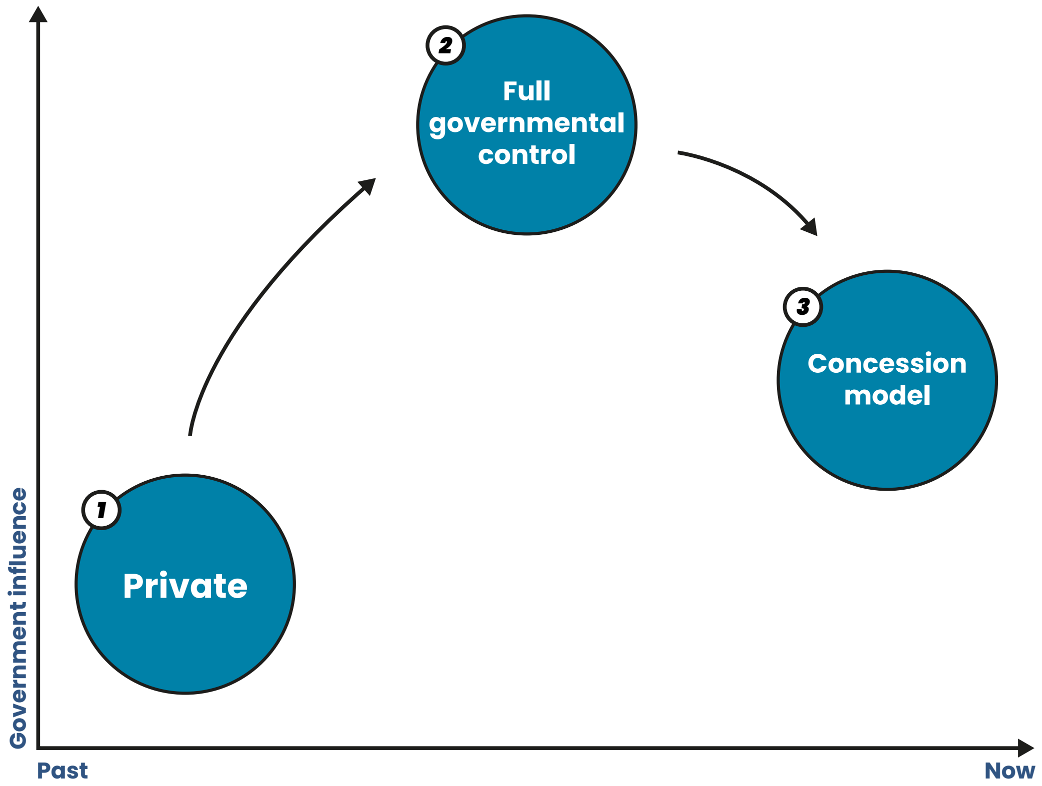


Figure 5 - History government influence public transportation sector

3.1.2 Stakeholders

Figure 6 provides an overview of all the relevant stakeholders in the public sector alongside the interconnected relations. In general, three segments are identified in which the public transport can be categorised, each with its demarcation and management (see table 1) [67].

Table 1 - Categories of the public transportation sector

MARKET	DEMARCATION	MANAGEMENT
Regional public transport	Regional transportation (busses, trams etc.), including public transport over water and regional trains	Provinces and metropolitan regions
National public transport	Intercities and sprinters on the main railway network	Central government
International public transport	Railway and buss tranportation cross-border	Released by the EU

There are six stakeholders in the Dutch public transportation sector: (1) concession provider, (2) concessionaire, (3) TransLink Systems, (4) data processors, (5) advisory and consultative bodies, and (6) the traveller. The role and responsibility of each category are briefly explained below. International (public) transportation is out of scope for this project.

Concession provider

A concession is a temporary monopoly granted by a local or national authority. The national authority, i.e. the central government, grants the concession to a national railway carrier which at the time of writing this report is NS. The rest of the public transportation throughout The Netherlands is organised in a decentralised manner. Currently, 14 regional OV-authorities provide concessions to regional public transportation services such as bus and tram mobility providers. The central government provides legislative boundaries and develops national traffic and transportation policies. In addition, the central government grants subsidies for management, maintenance, and expansion of the railway network, and subsidies for infrastructure and operation of regional public transport.

Concessionaire

A concessionaire is a licensed public transport operator to whom a concession has been granted. They are for the most part privatised companies, however, they operate within the boundaries set by the OV-authorities and central government. Regional concession holders operate for a fixed amount of time after which a new tendering procedure is initiated. Roughly speaking, regional concessionaires operate for around 8 to 15 years, while the concession for the national railroad is granted for around 30 years.

Translink Systems

The company was founded in 2001 as a joint venture by the five largest public transport companies: Connexxion, GVB, HTM, NS and RET. These companies have set up Translink Systems together to realise one electronic payment system in Dutch public transport: the OV-chipkaart. Translink Systems collects all money streams and pays the concessionaires the amount to which they are entitled. In addition, Translink Systems sends travel data to the data processors. Nowadays, all public transportation providers are part of Translink.

Data processors

CROW-NDOV is the organisation that collects and passes on current travel information about public transport on behalf of all public transport authorities. Via two NDOV offices (9292 and the independent OpenGeo) the standardised data flows from all carriers to all kinds of apps, DRIS-screens (digital and dynamic information screen at a station), travel planners and websites.

Advisory and consultative bodies

In the Regional Openbaar Vervoer Beraad (ROVB), public transport authorities and regional carriers discuss national issues in regional public transportation (i.e. bus, tram, metro, regional train and ferry). The National Openbaar Vervoer Beraad (NOVB) also includes the two national key players on railways: the Ministry of Infrastructure and Water Management as the national public transport authority, and NS as the operator of the main rail network. The Spoortafels make sure that regional and national public transport are aligned. Finally, ROCOVs are consultative bodies representing the interests of the travellers.

Traveller

Almost the entire system is invisible to the traveller apart from the modalities used in the traveller's commute, and the OV-chipkaart which is used as a validator and payment card to gain access to the mobility services.

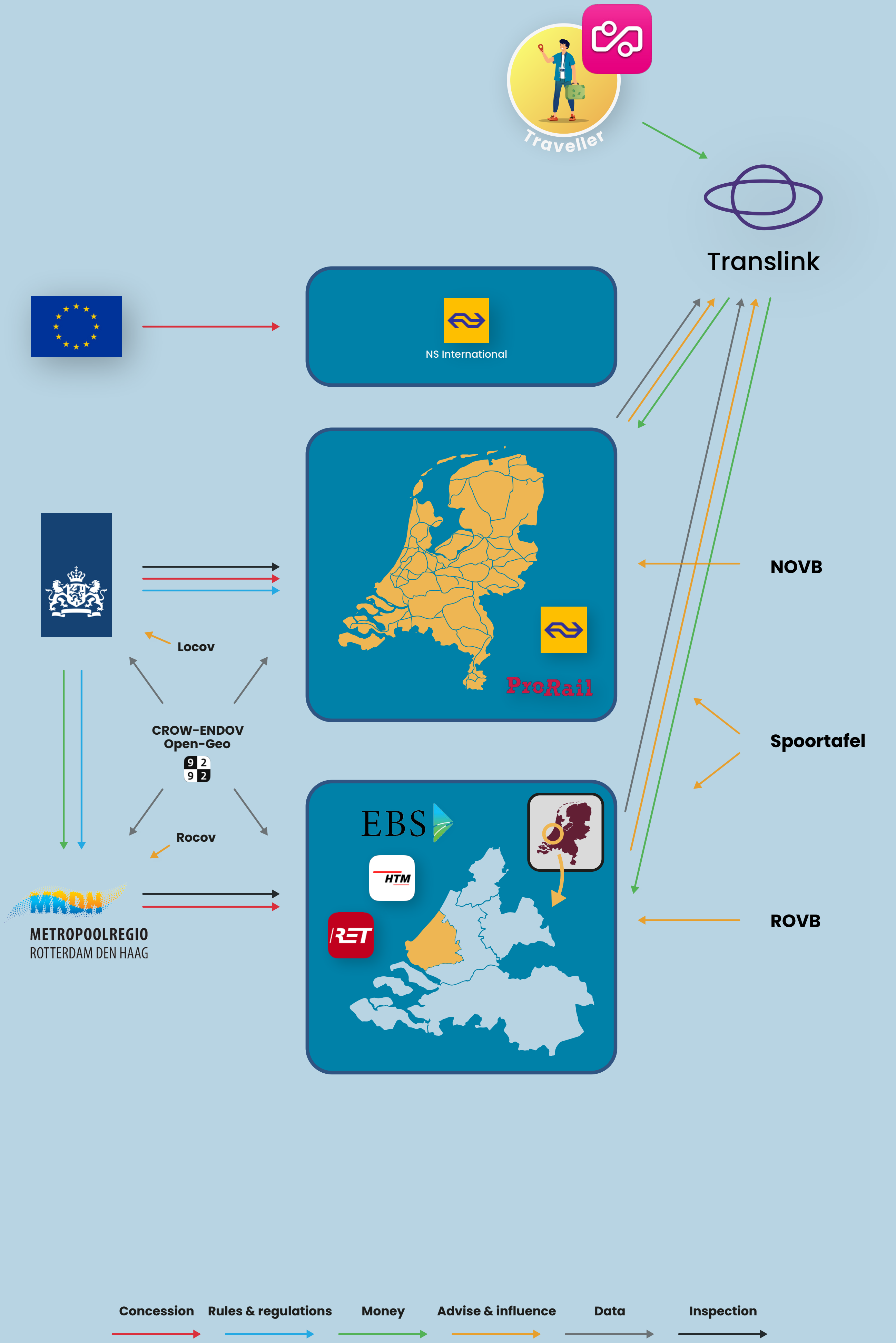


Figure 6 - Overview stakeholders public transportation sector

3.1.3 Current vision

Toekomstbeeld Openbaar Vervoer is the main vision for future public transportation in The Netherlands. This vision for 2040 has been drawn up by the central government, the public transport authorities, carriers and ProRail. The common thread is that the distinction between public transport (bus, tram, metro, train) and individual transport (bicycle, car, taxi) will increase in the coming decades towards a combination of large-scale collective transport in urban areas and small-scale demand-oriented transport in sparsely populated areas. This form of mobility is all about speed, convenience, reliability and affordability. The Toekomstbeeld OV sees eight starting points [68].

1. From public transport to mobility chains
2. Flexible, demand-oriented transport at lower demand
3. Faster connections between economic centres and across borders
4. Stronger public transport in urban regions for better accessibility and quality of life
5. Public transport continues to connect regional centres and medium-sized cities
6. More sustainable collective transport to achieve targets for climate and air quality
7. Innovations for accessible large cities, flexible mobility and cheaper public transport
8. Better collaboration and smarter financing for affordable door-to-door travel

3.2 Public transportation interaction

3.2.1 Brief history

The OV-chipkaart, a smart card to access all public transportation services throughout The Netherlands, is preceded by various ticketing systems. The first of which was the 'Strippenkaart', introduced in the 1980s. This particular ticketing system was based on a national zoning scheme with the goal to be more convenient for the traveller since they would not have to purchase separate tickets per operator [69]. To pay for a trip, the passenger counted the number of zones plus one (the base rate) and got their card stamped in a stamping machine. Revenue from the sales of the Strippenkaart was subsequently divided among the operators based on survey data. This generated discontent from the operators as every one of them had the idea that they were underpaid. To mitigate the problem, in the late 1980s a magnetic card was briefly introduced, though did not last for long as it turned out to be too expensive. In addition, Arriva ran a pilot called the 'Tripperpas' which was based on an RFID identification. The Tripperpas could be seen as the precursor to the OV-chipkaart which was developed in 2001 by a joint venture of the five largest transport operators. To this day, the current form of ticketing is the OV-chipkaart and can be used throughout the entire Dutch public transport sector.

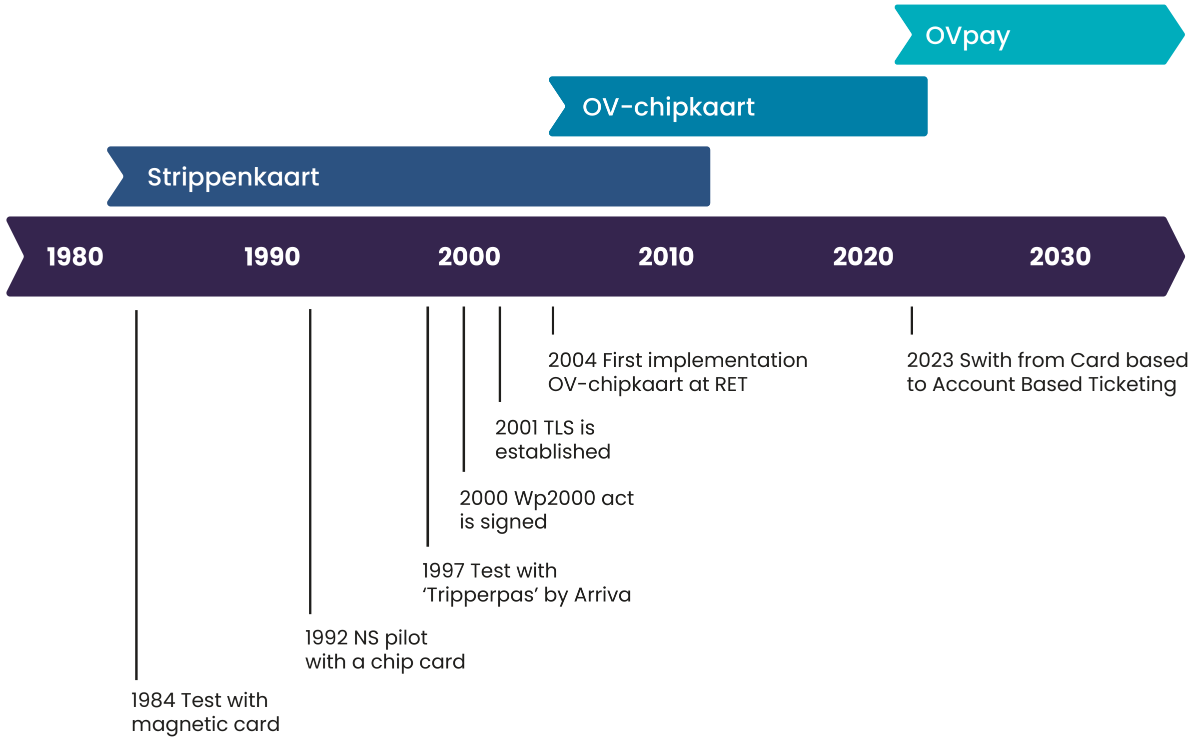


Figure 7 - History check-in methods public transportation

3.2.2 One card to rule them all

Essentially, the traveller has to carry a single smart card for the entire public transportation sector, no matter where they are in the Netherlands. This greatly improves convenience as the traveller does not have to buy a specific ticket for every carrier. There are two variants in existence: the first is an anonymous card on which only money can be deposited. The second is a personal card on which, in addition to money, travel products can be loaded. Apart from having the correct travel products and some deposited money on the card, the only action to be performed by the traveller is checking in and checking out. This is simply done by briefly holding the OV-chipkaart in front of a card reader, either at the entrance of a station or at the door of for example a bus or tram.

3.3 Shared mobility context

3.3.1 Brief history

After a slow start, shared mobility has undergone a stormy development in recent years. The Wittefietsenplan was the first plan in the world to introduce the shared bicycle in the streets of Amsterdam. The Netherlands is therefore not only known as a cycling country but also as the inventor of shared mobility. Because the Wittefietsenplan was way ahead of his time, it took a long time before shared mobility could grow significantly. The OV-fiets was introduced in the Netherlands at the turn of the century. Shortly afterwards, around 2007, the advance of docked shared bicycles began in Paris and other major European cities. The number of shared bicycles and cities increased slowly, partly due to the high investment costs in docking stations and the problems with spatial integration. The shared bicycle took off as Chinese scale-ups made huge investments in the free-floating shared bicycles around 2016. Cities were not ready for these types of free-floating services flooding the streets. In the end, municipalities were overwhelmed by the proliferation of bicycles and had to intervene [70]. Many of these Chinese providers have since disappeared from the Netherlands, though some are still active. Overall, shared mobility is increasingly becoming popular in cities [71].

Figure 8 - Check in using an OV-chipkaart

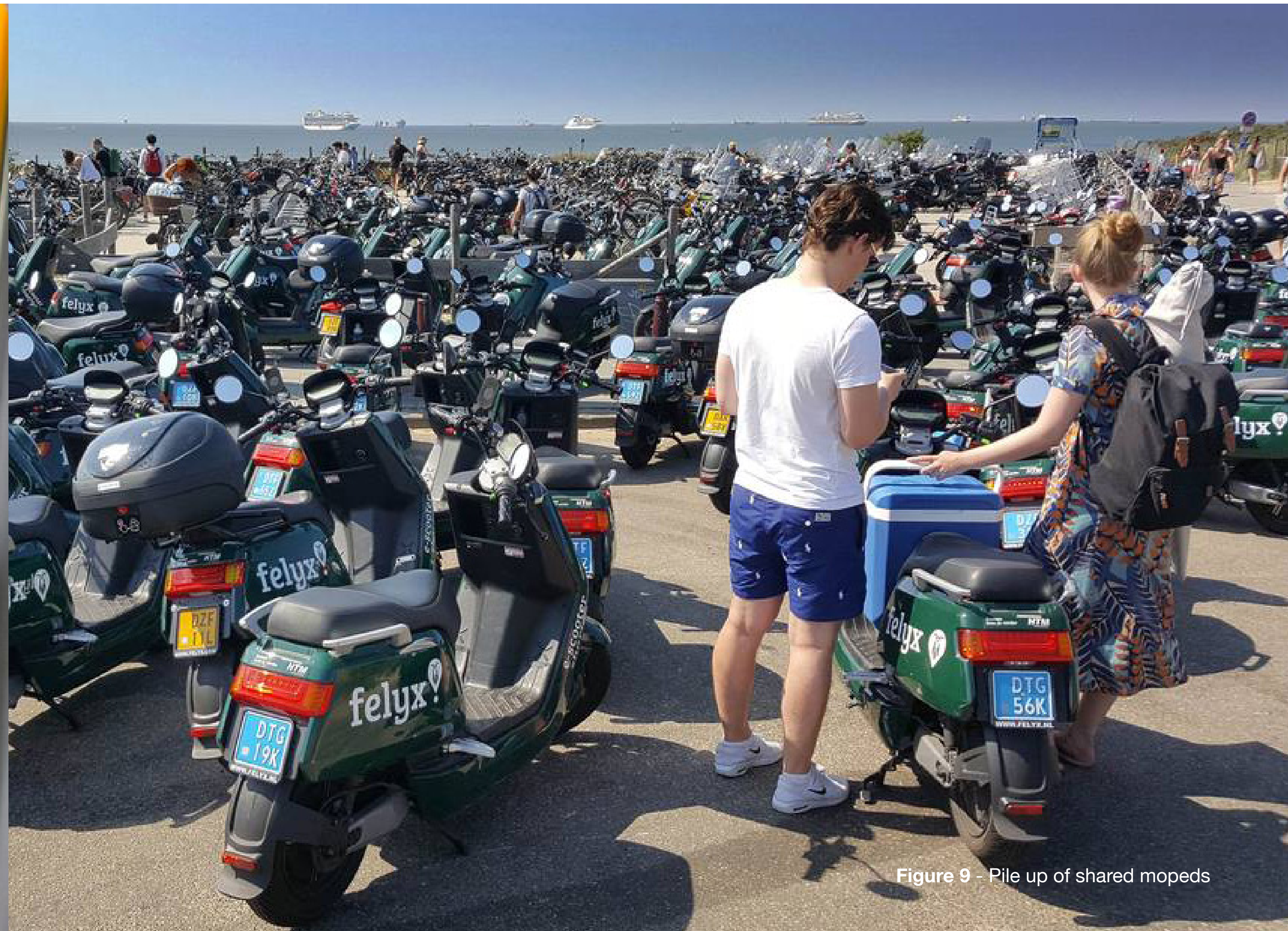


Figure 9 - Pile up of shared mopeds

3.3.2 Stakeholders

Contrary to the public transportation sector where ample information was available regarding the decentralised manner of organisation, only a few documents were found on how shared mobility providers are regulated and organised. As these documents indicated that the shared mobility providers are governed on a city level basis, an interview was conducted with two mobility experts from The Hague to fully understand the roles of each stakeholder. The interview was split up into two different parts. The first part involved mapping out relevant parties and stakeholders on a whiteboard together with the two mobility experts whereas the second part of the interview was a round of questioning to fully understand the needs of all involved parties, why certain decisions were made, the relationship with public transportation, and a more general discussion regarding seamless travel. An overview of how precisely the shared mobility providers are regulated can be seen in figure 10. The results of the second part of the interview are discussed in chapter 4.1.

Shared mobility providers are regulated and organised wildly different compared to the public transportation sector. Rather than decentralising the authority to different levels of regulatory bodies, in the shared mobility domain there only exists a direct relationship between the city and the shared mobility providers themselves. In total, six stakeholders in the shared mobility sector are identified: (1) the municipality, (2) the shared mobility provider, (3) the data processor, (4) the central government, (5) assorted bodies of government, and (6) the traveller. The explanation per stakeholder is from the perspective of the municipality of The Hague, and therefore may differ, from other municipalities.

The municipality

The municipality is the only authority when it comes to the regulation of shared mobility providers. In general, a permit system, not a concession model, regulates how the providers of shared vehicles use the public space in the city. These permits give the municipality an instrument to intervene if the agreements are not met. The permits are distributed based on the Algemene Plaatselijke Verordening. A highly interesting aspect is that the regulation takes place on a per city basis. This means that neighbouring cities must draw up their own policies and legislation and must set up their own permit system. Even more peculiar is the fact that a shared mobility provider can operate, as given by numerous examples throughout the Netherlands, in multiple municipalities at the same time. While the service is the same for the traveller, it falls per municipality under a different set of rules and requirements. The municipality does not provide monetary aid, e.g. subsidies, but does need to inspect the shared mobility operator to ensure they comply with the agreements set up by the APV.

The shared mobility provider

Shared mobility providers are fully privatised businesses and do not receive any form of subsidies unlike bus and tram services. While some are fully economically viable, some operate on a private investment basis. Shared mobility providers are, generally speaking, free in the way they design their modalities as long as they comply with the APV requirements set up by a municipality, and fall within general guidelines, such as safety requirements set up by the central government. Shared mobility providers must share their data with the data processor and knowledge platform CROW. This is done so that the municipality can determine whether or not the shared mobility provider complies with the agreed-upon requirements.

Data processor

Data from the shared mobility providers are sent to CROW. This data can be reviewed by the municipality to determine whether or not the shared mobility provider complies with the agreed-upon requirements.

Central government

The objective of the government, specifically the Ministry of Infrastructure and Water Management, is to bring parties together, to promote knowledge sharing, knowledge development and standardisation. The ministry does this from an instigating role by stimulating and subsidising several MaaS projects.

Assorted bodies

There is a small assortment of stakeholders whose role is not yet specified. These include the G5 (the five biggest municipalities in The Netherlands), the OV-authority (in this case the MRDH which is one of the 14 regional OV-authorities), and the province. These stakeholders are heavily involved in the public transportation sector, however, they rarely get involved in the shared transportation sector. Currently, there are investigating where they can provide their expertise or may even take up a leadership role.

Traveller

Likewise compared to the situation in the public transportation overview, almost the entire system is invisible to the traveller apart from the modalities used in the traveller's commute, and the smartphone which is usually used as a validator and payment method to gain access to the mobility services.

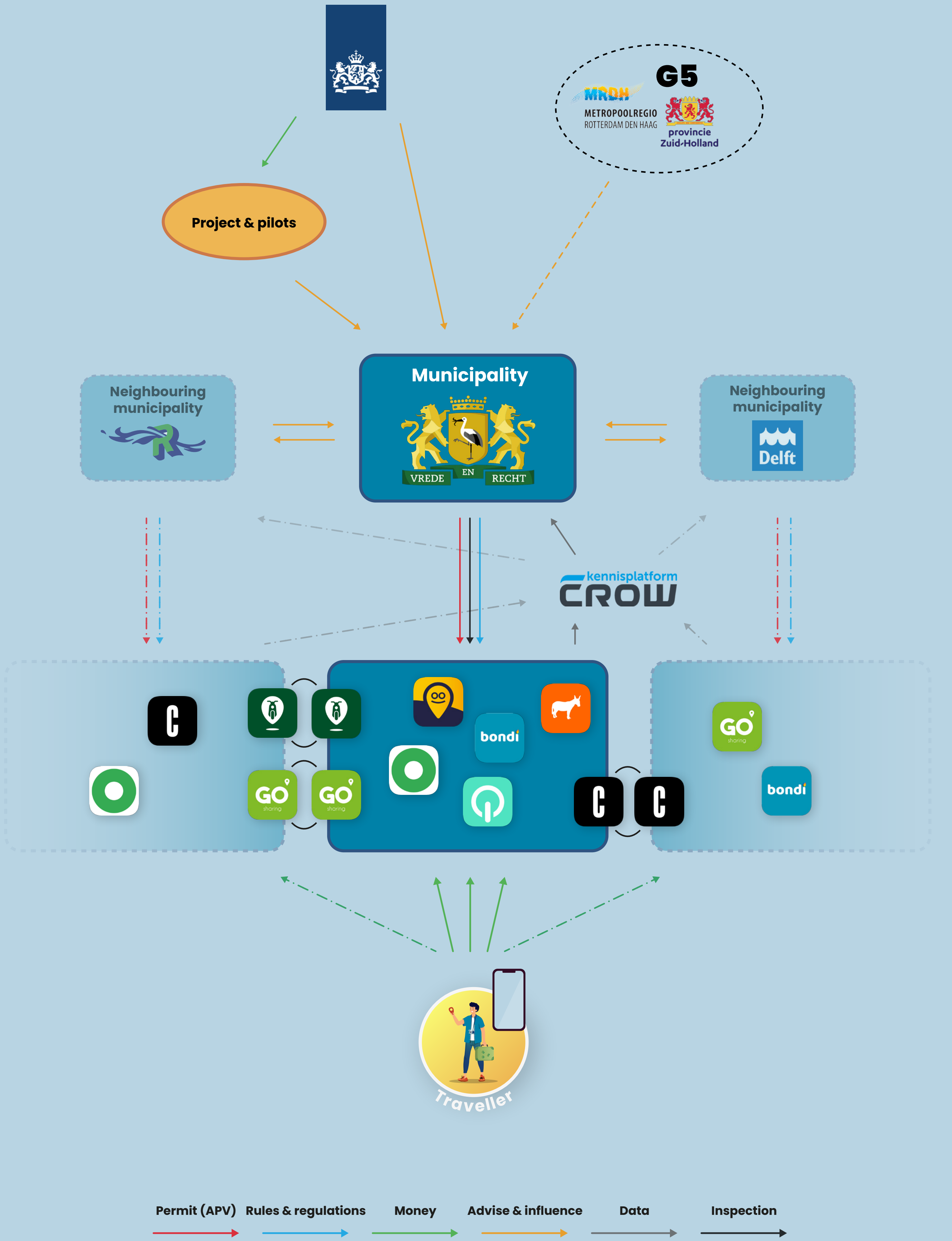


Figure 10 - Overview stakeholders shared mobility sector

3.3.3 Current vision

A general vision when it comes to shared modalities from a municipalities perspective is difficult to formulate as each municipality has its own local vision. As an example, while Leiden does not want any form of shared modalities in the historical city as space is scarce [72], The Hague has a completely different approach where they have provided specific zones where shared modalities can be parked. In a 2019 document from the municipality of The Hague, and based on the desirability of subsystems developing in The Hague, roughly three tracks are conceivable that describe possible roles for the municipality. They are (1) let free, (2) regulate, and (3) stimulate [73].

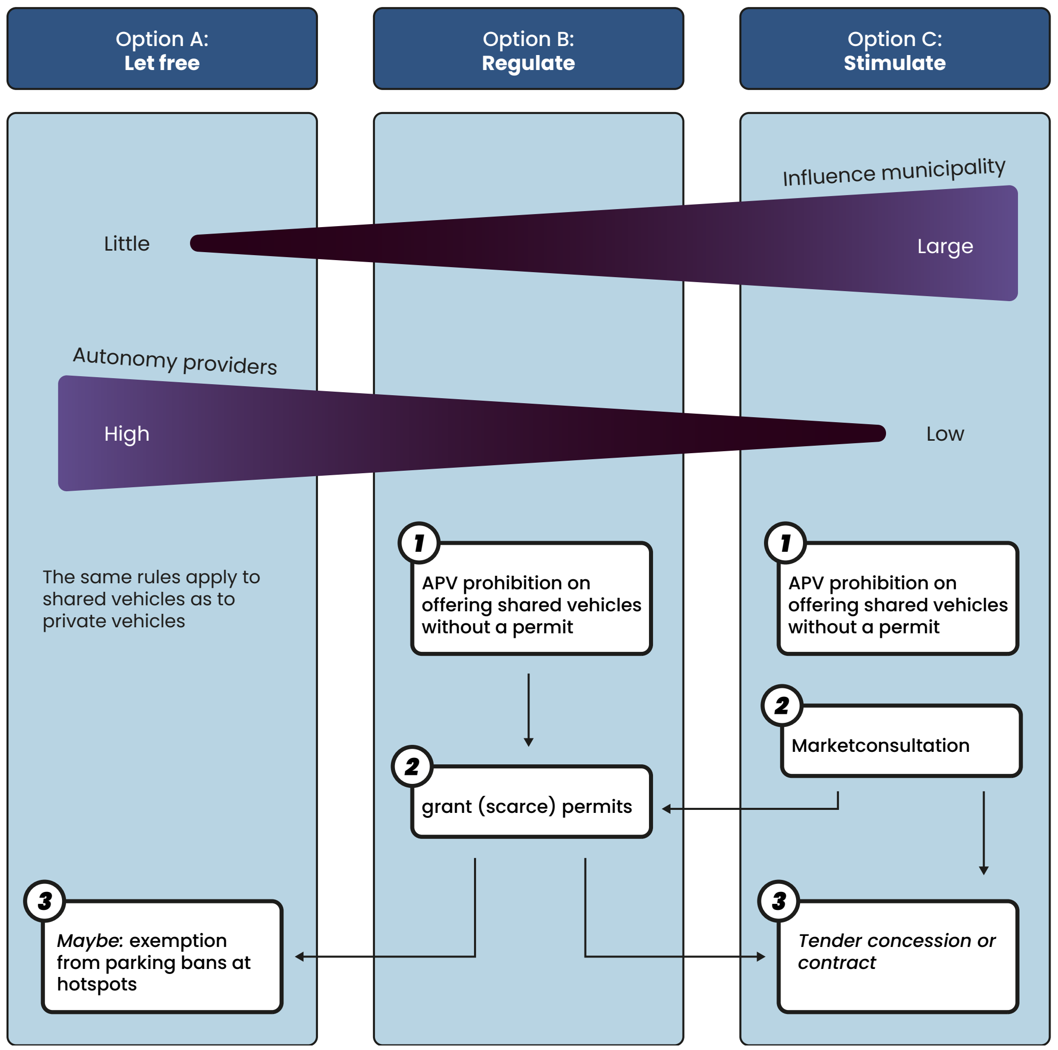


Figure 11 - Possible regulation options for shared mobility services

3.4 Shared mobility interaction

3.4.1 Brief history

Taking shared bicycles as an example, generally speaking, there are four generations of shared modalities: (1) white bikes, (2) coin-deposit stations, (3) dock-based stations, and (4) free-floating bikes. The first generation was the free sharing generation of which the Wittefietsenplan is a prime example [74]. Everyone could take the unlocked by to anywhere within the city. The second generation is coin-deposit based. Bycyklen in Copenhagen with a fleet of 800 bicycles is a good example. Upon depositing two EUROS, a bicycle can be used. As the deposit costs are only a fraction of the purchasing costs of the bicycle, and a user does not have to register, it does not come as a surprise that the system was prone to theft and vandalism. The third generation is rentable bicycles where a user pays per trip or for the duration of a trip and has to identify using for example a membership card, smart card, or cell phone. They do have to be returned to a designated dock. Examples include Vélo'v in Lyon which launched in 2005, Vélib' in Paris which launched in 2007, and more close to home the OV-fiets launched in 2004 which currently can be unlocked using the OV-chipkaart either on the bicycle itself or by an employee of NS (the operator). The final and fourth generation is the dock-less free-floating bicycle. Almost every fourth generation sharable bicycle must be unlocked and locked using an app on a phone (see figure 12). Other modalities, such as shared mopeds or cars, use some similar form of parking (mostly dock-based or free-floating).

3.4.2 Many apps to rule many shared modalities

Contrary to the OV-chipkaart method of checking in and out, one that uses a single smart card for all public transportation modalities throughout the Netherlands, every shared modality service provider requires a user to download an application on a smartphone where they must first register an account, fill in bank details for payments, on some occasion deposit money, and where applicable, upload a drivers license. All these actions must be performed before a user is allowed to use the service itself. On average, if a user would like to use every shared mobility service in the Netherlands—including those where a driver's license is required—they would need to install more applications than the total number of applications they currently have installed on their phone [75]. As previously mentioned, MaaS platforms are trying to implement the abundance of shared modality applications in a single package, providing a streamlined environment to locate, book, and pay for a trip. One of these examples is Gaiyo, a smartphone application claiming 'No matter your route, type of journey or means of transport, you can plan, book, and pay for everything in Gaiyo.' [76]. Indeed, you can indeed see multiple forms of modalities from different service providers on the map, however upon trying to book, the user sometimes is redirected to the app of the shared mobility service provider in question, still requiring to have the application installed, including having gone through the cumbersome steps of uploading banking details and a drivers license etc [77], [78]. It is up to the modality service provider to determine if they want to be included in a particular MaaS application. Not only for the traveller is there an abundance of applications, but there is also an abundance of choices to choose from in MaaS applications for the service modality providers, requiring careful selection if the desire exists to integrate. Currently, there is a proliferation of initiatives, which has not yet led to a successful application.

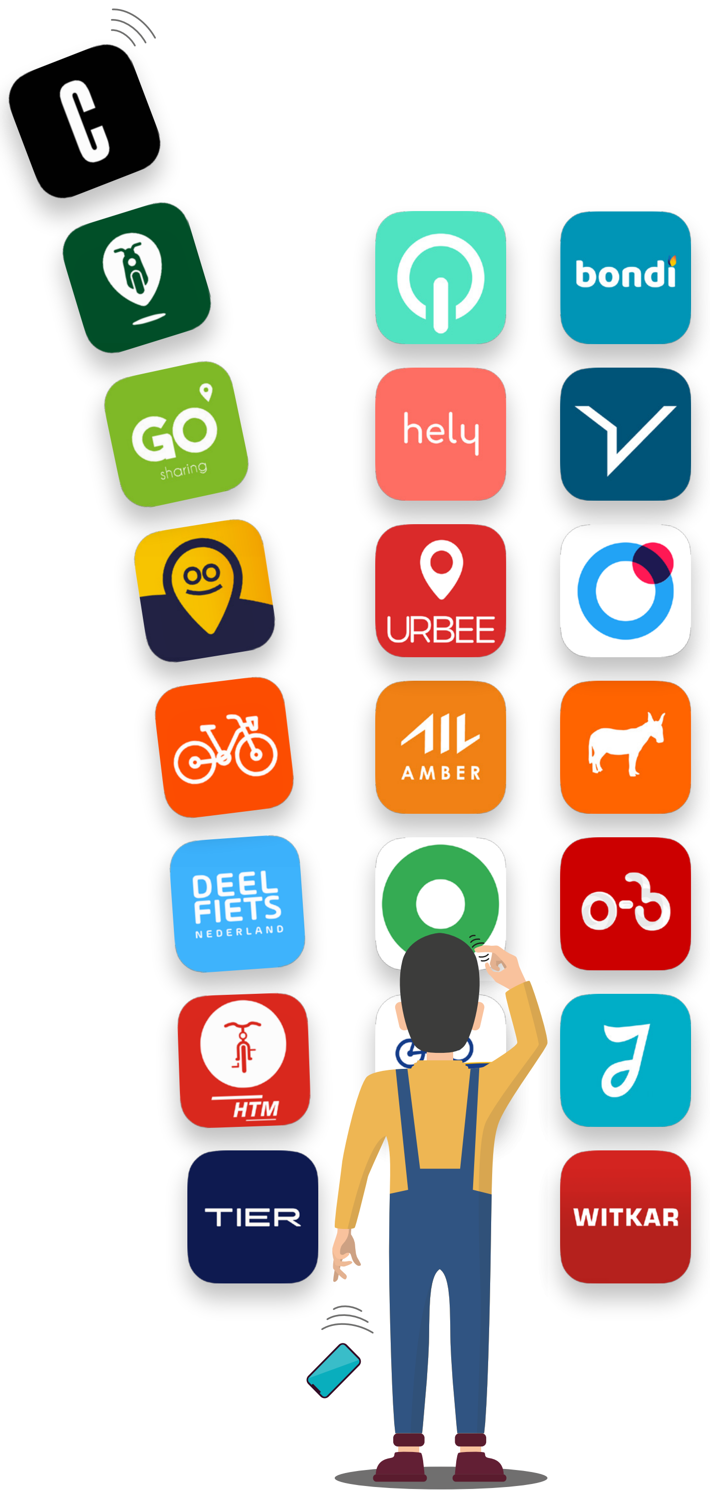


Figure 12 - Too many shared mobility provider applications

Chapter 4

Interviews & observations

The purpose of this chapter is to understand the needs and desires of the three main stakeholders: (1) the municipality, (2) the shared mobility service provider, and (3) the traveller. This is done by multiple forms of interviews and observations.

4.1 Municipality perspective

As mentioned before, an interview with mobility experts was conducted. In addition to creating an overview of which stakeholder does exactly what, the interview also covered questions such as why certain decisions were made, what the current state of innovation is, what the needs are from a municipalities perspective and possible organisational structures in the future. An interesting conversation ensued. Keeping in mind the fact that the interview was conducted with a single municipality, policies, opinions, and strategic decisions might vary compared to different municipalities, though they can still be used to draw general conclusions. The semi-structured interview guide used during the interview can be found in appendix 3.

Innovation pathway

At the beginning of the shared mobility revolution, mobility providers approached, logically, the municipalities, voicing their desire to exploit their services on the streets of a particular city. The municipality held a facilitating role as they were keen on introducing shared vehicles on their streets. Over the years, more and more shared mobility providers approached the municipality and they got in a sense flooded with new market entries.

'More and more market parties applied, oh, we must do something with them as well.'

According to the mobility experts, innovation takes place on the level of the municipality. Consecutively, the path of innovation is bottom-up: at first, the mobility providers are constantly making improvements, and the municipality then developes customised policies, which then move upstream towards the MRDH and the central government. The mobility experts accentuate the fact that there is no top-down innovation i.e. no central form of government develops legislation and policies which then are executed by municipalities and the mobility providers.

Desire for standardisation

Shared mobility should not end at the borders of a particular municipality. As expressed by the mobility expert, a shared car should be able to be parked in a different city without the limitation of a permit that is bound by a geographical demarcation. As of right now, communication between municipalities is done on an informal basis; someone concerned with mobility from one city makes a call to another asking 'Hey, we are struggling with a particular APV. How did you do it?'. The policy agenda is developed per city meaning that each city has its own legislative version of a particular APV. These are to some extent comparable to, for example, a neighbouring city, though they are not exactly the same. It would be, from the perspective of a municipality, desirable to streamline the policies, especially when it comes to cross-municipality, i.e. regional, usage of shared modalities.

'Why do we [different municipalities] all make separate policy documents?'

Concession model

Shared mobility providers, generally speaking, do not suffer from teething issues anymore. In the early stages, the choice was made to give permits to multiple operators to promote competition and foster quick developments—although this can be different per city. As pointed out, shared mobility providers are leaving the early stages of innovation and have become mature companies. In other words, from a technological perspective, the concept has proven successful. Thereby, the possibility of transitioning from a permit system based on APVs toward a concession based model arises.

'Shared mobilities are starting to exit the innovation curve.'

The transition towards a concession based model is a possibility. The MRDH could for example start giving out concessions for shared mobility providers parallel to public transport providers. An investigation is however necessary to find out the attitude of the shared mobility providers whether or not they would welcome and comply with such interventions. Thinking outwards a bit more, there exists the possibility to adapt the OV-chipkaart to include shared mobility services which are by then managed in a concession form by some form of government.

'You could say that the central government is going to issue a concession for a MaaS system.'

To the future

There exists an assortment of governmental bodies to whom it is not yet clear what role they could take on and how they will enact their possible future regulatory powers. These bodies include the G5 (the five biggest municipalities in The Netherlands), the MRDH (an OV-authority), and the province which are for the moment bodies mainly used for knowledge sharing. They currently do not hold a significant position when it comes to shared mobility and they are not sure if they want to take on a role similar to their current role in managing the public transportation sector. The desire exists, as expressed by the mobility expert, that it would be more convenient to organise the shared mobility sector from a more central regulatory body compared to the municipalities themselves. Specifically speaking of the MRDH, an example role of being a matchmaker between provider and municipality is given. The shared mobility sector would as a consequence be more streamlined and uniform, hinting at the central theme of mobility being seamless.

'Well, couldn't the MRDH be some kind of matchmaker between provider and municipality?'

At the moment when no one is taking on the role of the so-called vision champion. Due to the absence of a vision champion, market parties will move forward themselves. This is already the case considering the developments at Q-park. They are using their parking garages to facilitate shared car providers. Even though this seems like a logical evolvement, the downside is that it falls completely out of the purview of the managerial supervision and inspection of the municipality. These types of uncontrolled innovations start to fight for their own position, distancing from competitors instead of improving using competition.

Not only the role of the G5, the MRDH, and the province is questioned, the ministry is questioned as well. What is going to happen when the 7 MaaS pilots are finished? Who will take the leading role? Will that be a privatised company? Some form of government? And how will the knowledge acquired by these pilots be used? Looking toward the future, it is important to realise that major changes in such a complex system do not happen overnight, but will require extensive communication and time. On a final note, the MaaS question is not technological, but organisational.

'Maas is not a technical problem, but an organisational problem.'

4.2 Shared mobility provider perspective

An interview was conducted with a shared mobility provider that offers their services in various cities throughout The Netherlands, including The Hague. The interview held a similar structure compared to the mobility expert interviewed in chapter 4.1, now gaining insight from the service provider's perspective. Understanding the needs of the providers is imperative as they are the ones who must adapt to future policies and strategic changes. Keeping in mind the fact that the interview was conducted with a single mobility provider, opinions might vary with other providers, though they can still be used to draw a general conclusions. The semi-structured interview guide used during the interview can be found in appendix 4.

From idea to the street

The process from an idea to ultimately having shared vehicles on the streets is an interesting one. Way before launching, direct competitors were asked for advice about what their pain points were, what worked out, and what did not. This suggests that competitors are willing to help each other, delivering the best possible travel solution for the end-user. The competitors are not trying to withhold information, and they are not trying to out-innovate with the aim of removing the competition. To get the shared modality on the streets, a permit is required for which only the municipality is approached. Contact with the MRDH or the province never took place. As pointed out, and combining general conclusions from the shared modality stakeholder overview and mobility expert interview, every municipality is different in its own way. The interviewee provides examples of how their service must be altered, sometimes quite significantly such as changing the model from free-floating to back-to-many (dock-based model), to comply with the wishes of the municipality. This greatly inhibits the rate of expansion of a shared mobility provider, because every city has different wishes and demands.

'Every municipality is different in its own way.'

MaaS as a solution

The concept, implications, and integration of MaaS have also been discussed. First and foremost, there is a proliferation of MaaS providers as the interviewed company is being approached every other week by a new Maas provider. They note that at this point there is a MaaS app per city resulting in a confusing network of MaaS services. This is a rather strange development as MaaS's primary reason for existence is to streamline and integrate services. If there are too many MaaS providers, they add more trouble to the problem they are trying to solve.

'There is a MaaS app per city at this point, and it is a bit confusing.'

The current MaaS pilots performed by the ministry seem not to deliver promising results and did not provide the correct pathway to reach what is intended by MaaS. A clearly articulated desire is the fact that the guidelines must be setup up properly, including technological aspects, by some form of government. A toolkit was briefly mentioned as some type of solution. The challenge for implementing MaaS in The Netherlands is properly defining the role of regulating bodies and their level of involvement. As of right now, that is still an open-ended question. They even go as far as saying that they would wish to be integrated into a (common) public transportation system to provide a better experience for the traveller—the stakeholder for whom it is all about. The aforementioned arguments are reasons to not focus on MaaS in the short term, though, in the end, the service will integrate.

Shared versus public

In a way, shared modality service providers are public transport, though the difference lies in the fact that shared modality service providers do not receive the 'rights' like public transportation companies do e.g. subsidies and special permissions. The main delineation is where the money comes from: for public transportation, it is tax money, and for shared modality service providers it is private money. Even though there is an overlap in provided services, getting the traveller from A to B, the perception from the cities is different. It feels, from the perspective of the provider, that they are given extra obstacles, and sometimes, such as in Leiden, denied access at all, resulting in the impression that shared modality service providers are a threat.

'Sometimes in the cities, we are met as a threat, like they don't want us.'

A paradoxical relationship exists where on the one hand, there is a desire to act and be treated like public transportation, and on the other hand, the wish to remain in a city with competitors, fostering innovation. Competition keeps you on your toes, providing a better service every day. Being treated like public transportation removes some level of competition as they are regulated using a concession but provides advantages such as the possibility of receiving subsidies, being better integrated with other forms of public transportation, and using the same checking in and out method. The question of whether or not shared mobility service providers would accept a mandatory form of checking in and out, such as the OV-chipkaart, was answered with an unequivocal 'yes'. Since everybody already has the card, shared mobility service providers will reach a broader audience once granted access to that system.

'We are trying to look more like public transport and to be treated like public transport.'

To the future

Looking ahead, it remains unclear who should take the lead. It will not be the shared mobility providers themselves as they are only inwards focused. It would not be hard to believe that at the moment one of the providers has taken the lead, they will not have a preference for similar

providers in their MaaS service. Shared mobility service providers are waiting to see which MaaS service will become the one. Furthermore, a big challenge is gaining the trust of the users with their data. Especially once systems are integrated, the question arises of what level of control can be exercised by the shared mobility service providers and how user feedback is incorporated.

The main challenge is forming a mission for everyone, not performing too many pilots. The shared mobility service providers eventually will adapt. Generally speaking, the problem is an awareness question. According to the shared mobility provider, up to 90% still don't use or even know about the services that are being offered. In the end, the shared mobility provider understands that travellers simply want to get to their destination. They sum it up quite nicely:

'In the end, it is the people driving from place to place. The travellers do not really care about what application they have on their phone, what colour their modality is, or what brand name is on it.'

4.3 Traveller perspective

4.3.1 Setup and tools

It is imperative to fully understand the experiences of the travellers during their entire journey. For this interview, participants are asked to go on a trip of their choosing, however, they must include both a shared and a public means of transportation. A sensitising booklet was made to make sure all of the experiences are recollected to their fullest extent. The participants were instructed to fill in the booklets during or at the end of the trip. A sensitising booklet, or a make toolkit, involve participants by having them perform a creative act concerning the subject under study. To support the participants in recalling memories, explaining feelings, and imagining future scenarios [79]. The sensitising booklet can be found in appendix 5.

Once the booklet was filled in by the participant, semi-guided interviews [80] were performed. This guide can be found in appendix 6. Interviews are a fundamental research method for direct contact with participants, to collect firsthand personal accounts of experience, opinions, attitudes, and perceptions [81]. The interviews were conducted to collect these experiences regarding the use of shared mobility and public transportation. In total seven interviews using sensitising booklets are performed. Insights below are general takeaways shared by multiple participants. Keeping in mind the fact that the interviews were conducted with only a handful of travellers, recollected opinions, experiences and perceptions might not give an exact representative picture, though they can still be used to draw a general conclusion.

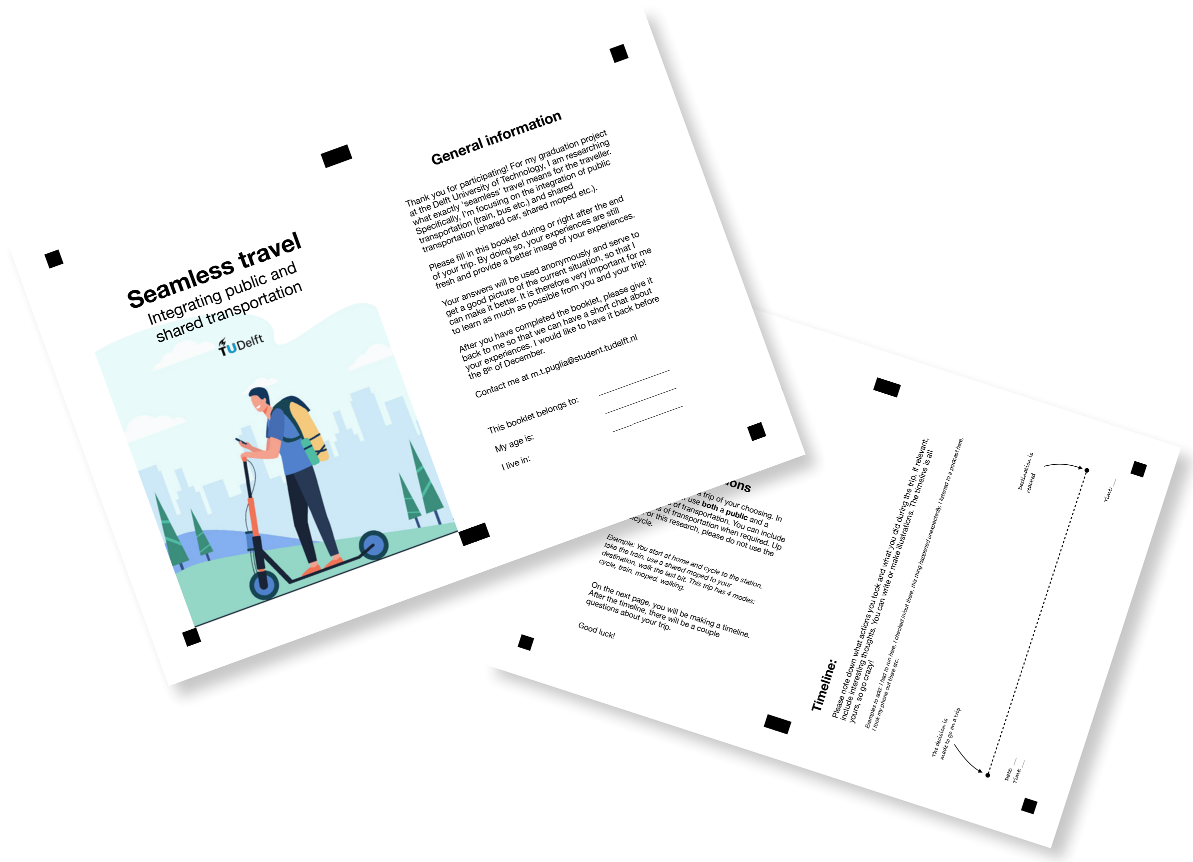


Figure 13 - Sensitising booklet

4.3.2 Insights

In case of emergency

Five out of seven participants mentioned that they use shared mobility only in case of an emergency. Only when the participants were short on time or in a hurry, when there is no alternative available, when the trains are delayed or not working that particular day, or when a transfer does not work out, did participants use shared modalities. Most of the time, the preferred way of travelling remains with only public transportation services.

"The trip was a necessity, otherwise I wouldn't have done it."

Apps, apps, apps…

Five out of seven participants had strong negative associations with the applications on their phones. These applications are required to unlock a shared modality. The negative associations were sometimes directed toward a specific aspect of the applications, and sometimes as discontent with the method in general.

"I have a general hatred towards those apps…"

The participants mentioned that some aspect of the application was not working in addition to the fact that they did not enjoy having too many applications on their phone. For instance, a participant was forced to log in again but the application failed repeatedly, a participant found out that they did not have enough credit to unlock a shared modality, and a participant could not check out because as the moped was not in the correct 'service area' while standing right next to multiple moped of the same brand resulting in just leaving the moped unlocked and having to call the service company to ask if they could check-out remotely. This results in both a lack of control and increased stress levels.

'Then it says 'outside the service area', and then I'm like 'I'm between two of your other mopeds…'. How is this outside the service area?'

The experience of not being in control or having increased stress is amplified by the surplus of actions a traveller has to go through just to check in or out, not to mention the perceived stress from the reservation timer. Multiple participants pointed this out and started asking the question of why there is not just a simple NFC tag or just a button one can push to end the trip.

'Why can't I just push a button that says 'I'm done''.

Unfair, unforeseen and high costs

Unfair or unforeseen costs are another interesting negative association perceived by six out of seven participants. As opposed to the public transportation services where travellers are billed per zone travelled, shared transportation generally bills per minute travelled. The participants explain that they did not enjoy paying per minute as they felt that it was unfair to get billed for the reservation time, the time spent just taking the helmets out from the case, and when they unexpectedly had to change route because of roadblocks. In general, participants knew that the use of shared modalities was more expensive, being an extra incentive to take public transportation, with one participant already having made peace with the approximated costs for a particular trip. Being on the clock combined with being in traffic induces stress.

'Then you're already paying for the moped, even though I haven't moved an inch.'

It's fun!

Withal the aforementioned negativity, one would expect that using shared modalities does not have upsides, however, the opposite is the case. Just after having gone through the surplus of action and finally hitting the gas, do they enjoy the ride. Five out of seven participants mention that once they get going, their troubles fade away. According to the participants, the ride experience is fun and the travellers are enjoying themselves. They know that they are on the clock, and they know that they will still pay more in the end, but still, the participants are able to look around and are experiencing a certain sense of flow.

'The app that doesn't work half the time, but once I'm driving, I'm really enjoying myself.'

Apart from the ride being fun, shared modalities provide a better sense of freedom and flexibility compared to public transportation. They mention that once they are on their way, they feel more in control of where they are going and that they feel more flexible to choose how to get there.

'On a moped, I feel much more in control of where I am going, and therefore my journey.'

Flowing over

All travellers used the train on their trip and all of them pointed out that travelling by train is a relaxing experience. They are able to close their eyes for a moment or listen to a podcast for example. Interestingly, the relaxing train experience gets interrupted by the need to reserve a shared modality in advance. First, there is a moment of decreased sense of control as there might not be a shared modality available, and then they feel stressed as the reservation timer starts running. One participant mentions that the podcast got rewound for a couple of minutes as the attention was directed towards reserving the shared modality. Apparently, the interaction is not geographically confined to where the modality is at that particular moment but flows over into different sections of the journey.

'You then stop listening to the podcast and you have to rewind. It feels forced.'

This is also an indication that spontaneous use is non-existent. Five out of seven participants mentioned that they would rather be focused on the 'here and now' as opposed to thinking ahead of what they might be doing in 15 minutes. Spontaneous use is also inhibited by the fact that there are too many steps to be taken just to spontaneously be tempted to use a shared modality.

'If I now walk past a shared scooter and I think 'oh that's handy to grab right now', you don't do that because you need 5 more steps. You have to grab your phone, open the app, find the thing, you have to select it, you have to reserve it, you have to start it, and only then can you sit on it. Spontaneity is hard to find.'

Reputation

Four out of seven participants pointed out several opinions concerning the reputation of shared modalities. Firstly, in a general sense, shared modalities have a bad reputation when it comes to inadequately parked vehicles—especially scooters though they are not common in the Netherlands. Secondly, some participants feel like they are a tourist in their own city when they ride on a brightly coloured, off-looking shared modality as they stand out too much from the crowd. Changing the perception of people regarding shared modalities is key. And finally, once they are riding, the experience feels like a luxury as there is an entire electrified vehicle reserved just for one person. This is in combination with the higher associated costs and the fact that they have complete freedom of choice and flexibility as you can park it anywhere you want.

'I think they are really ugly and I don't want to look like a moron.'

Two different worlds

In the end, all participants denote that the public transportation sector and the shared mobility sector feel as though they are two completely different worlds. They identify differences in experiences such as responsibility, flexibility, level of control, level of certainty, amount of freedom, the way of checking in and out, the way that they are paying for the service etc. Participants started asking themselves the question of why the checking-in and out method is so different for example? Why not just an NFC tag to check-in, or a simple 'I'm done' button to check-out, or why the OV-chipkaart is not included in shared modalities. As one participant puts it bluntly:

'There is such a big difference in vibe between a train and a scooter; the train is possible without a telephone, scooter without an OV-chipkaart. They are completely different worlds. It's annoying having to grab two different things'

On the topic of seamless travel did one participant express their needs by saying the following:

'Seamless mobility is that, like a totally spoiled monkey, I no longer have to think about how to get somewhere. Now I have to be prepared and have all those apps.'

4.4 Shared scooter interaction observation

4.4.1 Setup and tools used

Travellers were observed outside Rotterdam Central station at the designated shared mobility parking spot. The recorded observations were fully anonymised where necessary. Two different parking areas were filmed for a total of two hours over two days. 31 departures and 13 arrivals were captured and analysed. Meaningful variables such as the estimated age, gender, type of modality, brand of modality, and interaction duration were recorded. Afterwards, the recorded observations were viewed multiple times from start to finish, trying to observe emerging patterns of behaviour shared by travellers. For the departure, three extra variables of importance were identified. These are whether or not a traveller stopped in their tracks upon taking out their phone, the number of times they repeated suddenly stopping, and the number of times they switched between a virtual environment i.e. the screen of their smartphone and the physical environment. Additional information regarding the arrival can be found in appendix 7.

Insights

Several take-away's can be made from the departure observations. Almost all travellers who opted to take a shared modality were below the estimated age of 30 with the vast majority being male. The average time between entering the parking area and driving away on a shared modality is about one minute in total. Furthermore, at least half of the participants had to suddenly stop walking altogether in order to safely check information about their shared moped on their smartphone. About one third had to stop an extra time with some up to four times in total. For an average of three and a half times did travellers switch between a virtual environment and the physical environment, with some up to 13 times. The actual number is likely higher as this is excluding possible environment switches outside the frame of the camera.

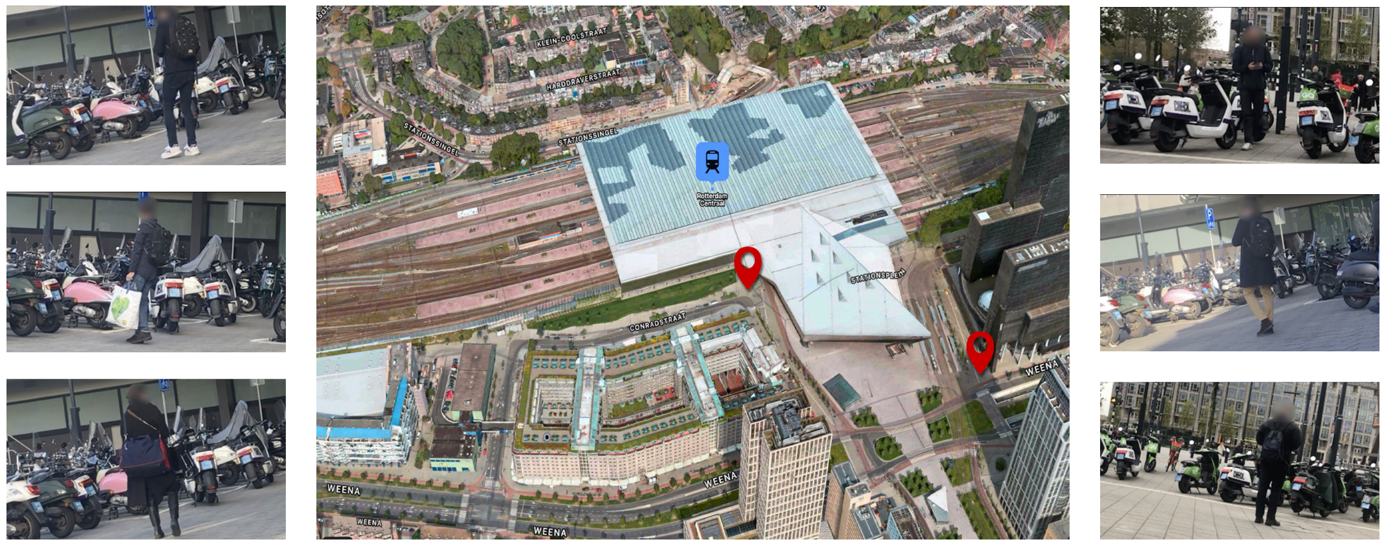


Figure 14 - Shared moped unlocking observations

An abstracted interaction overview for both arrival and interaction can be found in figure 15. Four phases can be identified for departure: (1) preparation, (2) hunt, (3) claim ownership, and (4) ride. The smartphone is taken out during the preparation phase as it is the only way of unlocking the shared modality. Most travellers suddenly stopped walking as they were presented with, apparently, too much information requiring their full cognitive capacity. The information includes remembering the number plate, memorising the relative location of the moped to the traveller's location, activating the light or claxon to identify which moped is the correct one etc. Continuing walking while performing these tasks would not be very safe as full attention is required. All the aforementioned steps are repeated when the moped is not yet located during the hunting phase. These actions increase cognitive load especially combined with the repeated switching between the virtual space of the smartphone and the real physical environment. Ownership is claimed during the third phase making the user feels some level of responsibility. This is reflected by a quick inspection if everything is in working condition and the cleaning of the saddle. Hesitant behaviour is displayed during the initial pull-up 'jerk' upon making sure the moped is ready to go. Only by then, does the actual trip commence.

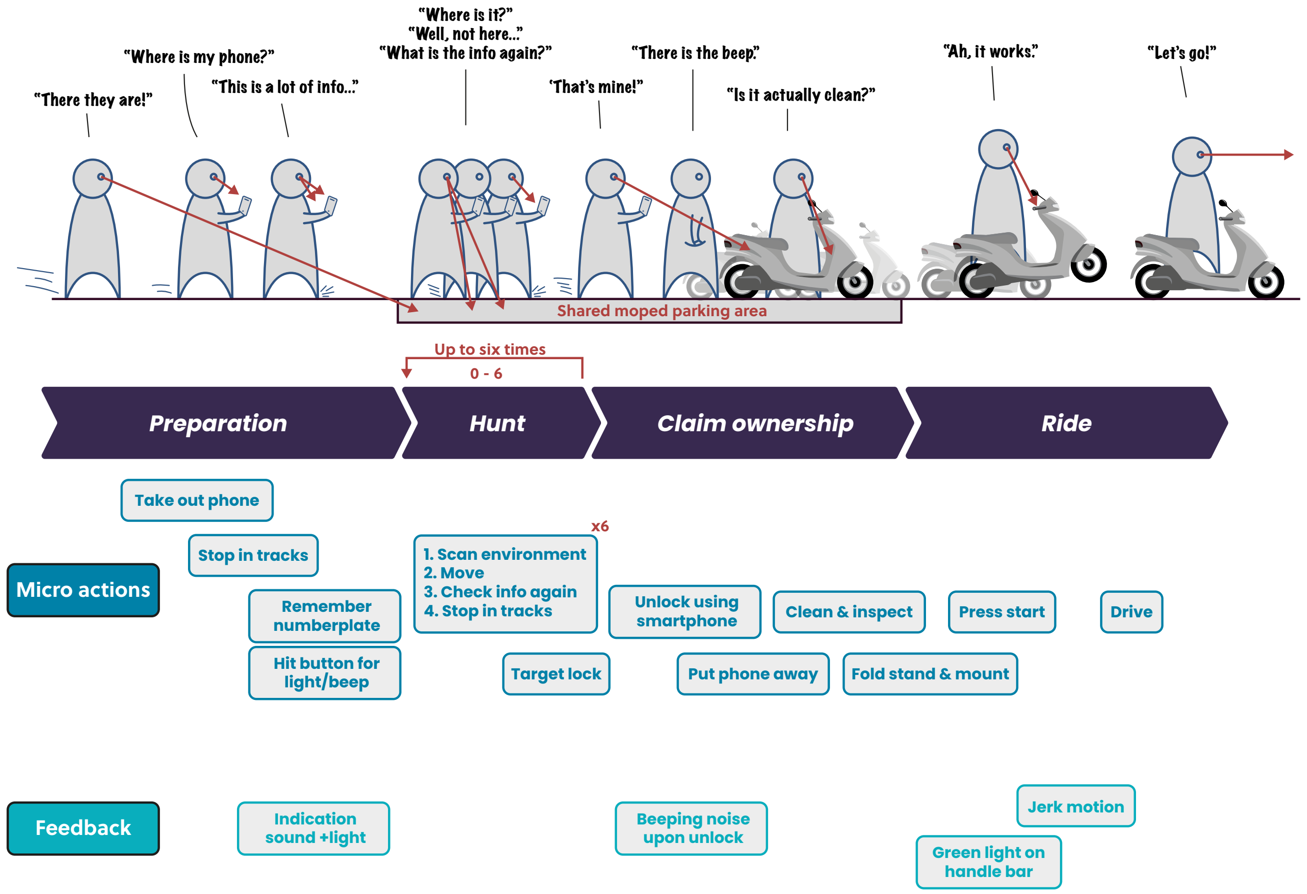


Figure 15 - Abstracted overview of unlocking shared mopeds

4.5 Complete travel observation

4.5.1 Setup and tools used

A full travel observation is performed both to get a good grasp on every step taken throughout the journey and to confirm aspects of previous research. A single, entire trip was recorded using a small camera mounted on a harness which was strapped to the chest of a male in his twenties. His task was to travel to his destination with the only requirement being that he must contain both a shared modality and a public transportation modality. All decisions were left in the hands of the participant in order to observe a natural travel experience. The observer occasionally asked a question about why certain actions were performed or what the participant was feeling like at a particular moment.

4.5.2 Insights

Slow versus fast travel

The observed participant has repeatedly expressed that he is more interested in what he calls slow travel instead of fast travel i.e. the most efficient. Somehow the participant has set a goal over the years to mitigate stress. As was pointed out, the participant would rather remain seated in a single tram, rather than take the combination of train and train which is 10 minutes faster. He specifically mentions his ability to 'zone-out' when an extra modality transfer is removed from his journey, yielding a more positive travel experience.

'The tram takes 10 minutes longer; slow travelling, that's nice.'

Only when fast travel is required does the participant opt for the most efficient combination of modalities, however, this does come at a cost. If a transfer is required, this lowers his level of certainty as there are now more actions to perform, each of which now could go wrong. Had the participant remained seated in the tram, not only would the ride be more comfortable, but the participant would also have higher levels of certainty of actually arriving at the destination as a transfer might be delayed. This would result in a sulky and grumpy state of mind.

Law of least effort

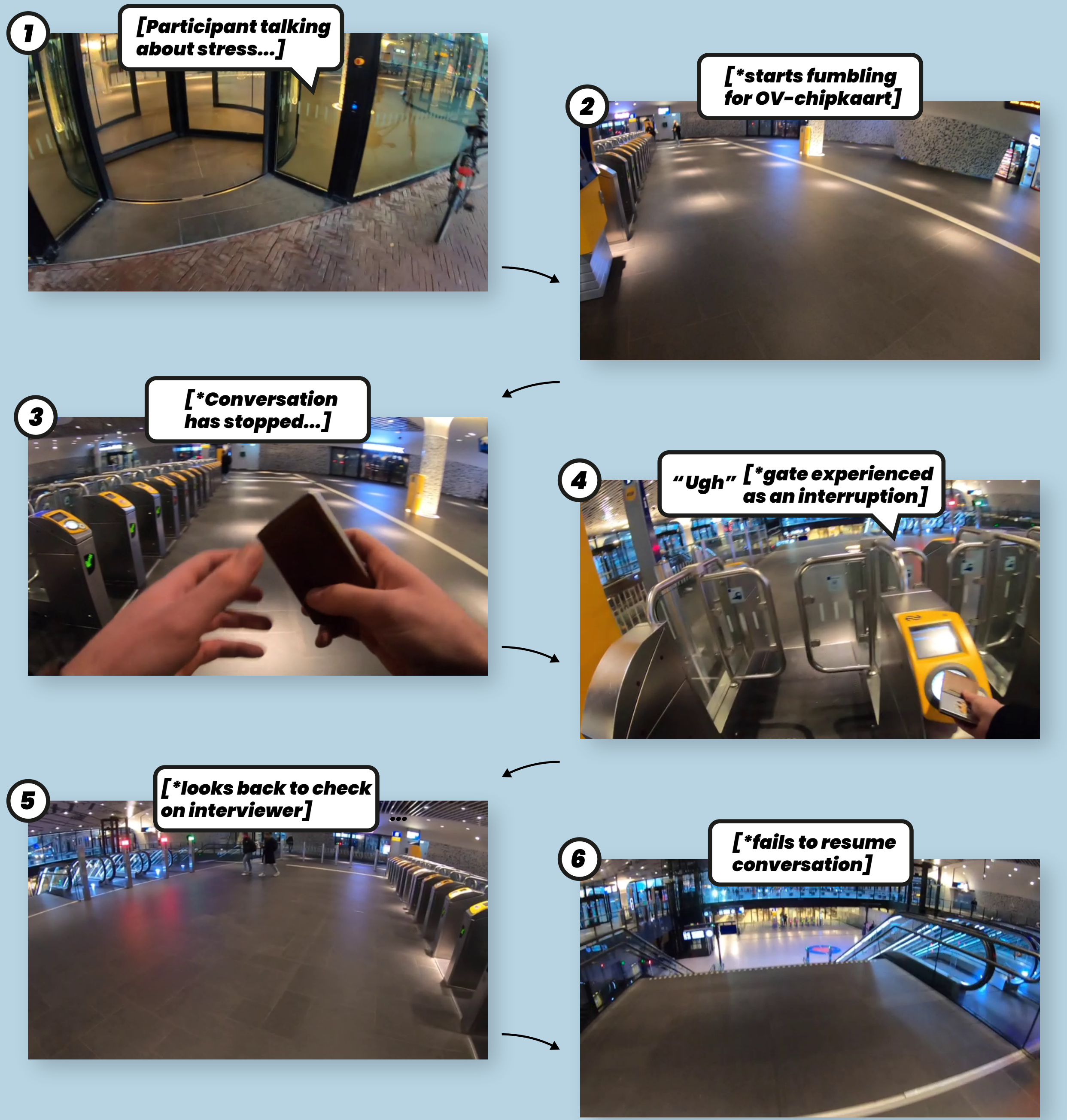
Unless the participant is in a hurry, gambling getting grumpy by opting for the more efficient transfer, the law of least effort is paramount. Upon walking to the station, the participant passed a shared moped of which he already had the application installed. He chose not to take it for various reasons. The first is a short rant about the cumbersome process of unlocking the sharable moped and the second is the fact that you always have to park some distance away from the station. Apparently, both add effort to the journey compared to just keeping walking a bit longer.

'Taking your phone out, unlocking it, find the app, open it, select the thing, unlock, put the phone back in your pocket… You could have walked a substantial distance by now.'

Figure 16 - A shared moped was passed but not taken

Because the participant mentioned the fact that the moped has to be parked some distance from the station, the question was raised if there is a difference in taking the shared moped the first mile compared to the last mile. The participant pointed out that a shared modality is mostly used during the last mile when he can park more conveniently at the final destination's doorstep.

Check-in



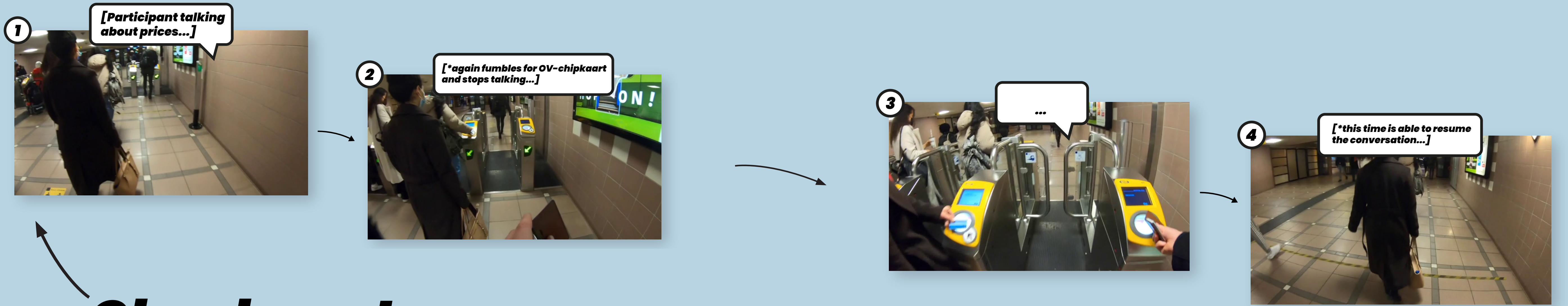
'What was I saying…'

An interesting set of actions and non-actions ensued upon approaching the check-in gate at the train station. The participant was commenting on the concept of slow travel, but stopped the conversation because apparently fumbling for the OV-chipkaart and presenting it to the gate is subconscious quite an effortful task. It did not end there. The participant made a not too loud noise of frustration as there is always a small delay in presenting the card and the gate opening, indicating that some level of friction is experienced. After having gone through the gate, the participant clearly looks back to see if the observant has passed the obstacle. The observant strangely enough, as he is the one who is well-aware of non-seamless aspects of travel journeys, made a confirming noise to indicate that he has rejoined the party, providing a queue to resume the conversation. Unfortunately, the conversation did not resume as the attention was turned to the DRIS-screens. The same set of actions can be observed during the check-out process. Consecutive screenshots of the above-mentioned check-in and out process including performed actions can be found in figure 17.

Time equals money

The participant would only use the shared moped if he is in a hurry, when there is absolutely no alternative available, or in case of an emergency. The most important reason is that you pay per minute—or per second as the participant puts it. It is a race against the clock implying a not so relaxed trip. This is in stark contrast to public transportation where a traveller pays per zone travelled. The customary route that is usually taken could not be taken due to roadwork resulting in the participant screaming out loud 'No, this is a dead-end. There goes my money!'. This induced significant stress levels. After arriving and ending the trip, the attention was instantly directed to the duration and price of the trip.

'What's the damage? €3,50. More expensive than taking the tram, and now I'm cold.'



Check-out

Figure 17 - Screenshots of the full travel observation

Chapter 5

Journey Mapping

This chapter consolidates all previous research, observations, and interview insights into a single traveller's journey. This traveller's journey acts as the starting point of the design phase. Subsequently, an analogy is provided to illustrate why the travel journey must be improved.

5.1 Consolidation of research, interviews & observations

Deconstruction is a valuable preparatory activity before starting the design phase. It enables a designer to playfully engage the problem space without any preconceived ideas [82]. For this project, a door-to-door journey using both a shared and public means of transportation is deconstructed into each specific section including all the traveller's interaction activities and experiences. The deconstructed journey is built up from several pieces of research, some of which were found during the literature review and some are conducted specifically for this project. The included research is van Kuijk's OV-chipkaart usability research [83], Groot Obbink's OV-chipkaart interaction observation [84], Puglia's shared modality interaction observation, Puglia's full travel observation using a point of view camera, and Puglia's semi-structured interviews using sensitising booklets [85]. The research is displayed on the timeline wherever they provided information. In the end, this deconstruction provides an overview of the entire journey. By deconstructing the entire journey, problem area's and their impact can be identified. A scoped-down problem space will be selected where a new design can provide the best improvements.

From the next page onwards, you will be following a fictitious character called Emma. She will leave her home and will travel to a different city where she is going to give a presentation to a client. During her trip, she will use various modes of transportation. The experiences, thoughts, and interaction activities are displayed in addition to a short explanatory paragraph. It is important to note that the trip is a distilled, average journey based on literature, research, interviews, and observations, and may differ from actual scenario's, however they are illustrative of the general context.

Figure 18 - Emma's journey explanation

5.2 Deconstruction

Tag along with Emma

Today, Emma has to give an important presentation to her company's client in Rotterdam. Whilst eating breakfast, she is looking up the quickest way to get to her destination. She uses the 9292 application on her phone to look up information and sees that the trams aren't going due to an accident. She is now running late and must get going. Out of necessity, she intends to include the faster and more expensive shared transportation for which she has to pay herself. She knows that the 9292 application does not show shared modalities, but she will figure it out later. Emma leaves the house.

Emma is walking to the train station as it is relatively close by. Besides, she likes to have a bit of morning exercise, but above all, does not want to get stressed being stuck parking her bicycle when she has a train to catch. While walking, she passes a shared moped. She knows she is in a bit of a hurry and already has the application installed on her phone, but she decides to keep walking anyway. By the time she would have finally gone through the cumbersome unlocking process of the shared moped, she would have almost been at the train station. 'Might as well keep walking...', she thinks. As Emma turns the corner and sees the train station, she gets a call from her colleague: 'Hey Emma, I want to go over some final details before the presentation.'

While in a conversation with her colleague, Emma enters the train station. She identifies the check-in gates in the distance and starts fumbling for her OV-chipkaart. 'Left pocket? Oh, no, it is right here!', she thinks as she is trying to listen to valuable information over the phone. She holds her card against the reader, sees that she is currently checked in with her business travel plan, and passes through the gate. 'I'm sorry, what was that last thing you said about the meeting? I was a bit distracted.', she says to her colleague while trying to store the OV-chipkaart again.

Emma is finally on the train and has found a window seat. Even though it is a relatively short train ride, she uses this time to relax a bit before arriving at the client. She puts her headphones on and starts listening to music. Near the end of the train ride, she suddenly remembers that she still has not checked whether a shared modality is available. She pauses the music and quickly opens one of the applications on her phone. None available. She opens, now a little bit tenser, a different application. A couple are still available. Emma's train will arrive in 4 minutes, so why not just start the reservation timer now? Music is not resumed and tick-tock goes the clock as the timer is counting down. Impatiently with her phone in her hands is she waiting on the doors of the train to open.

Emma leaves the train. She checks again if she booked her moped on the north or the south side of the station on her phone. While approaching the check-out gate, again, she starts fumbling for her OV-chipkaart. With a phone in her left hand to check in later, and the OV-chipkaart in her right hand to check out now, does she pass through the train station gate. Upon leaving the station, Emma is trying to figure out using the surrounding buildings where she is in relation to the booked moped. Going back and forth between her screen and the environment, Emma sees the parking area a little bit down the road.

Emma approaches the shared moped parking area with the phone still in her hand. As she is getting close, she glances at the screen once again. There is actually quite a bit of information that needs her direct attention causing Emma to stop in her tracks. Whilst standing still, she now has to remember the location of the moped, her own location, the brand of the moped, and its number plate. Emma shuffles around trying to find her booked moped, but she can’t find it. She stops, and grudgingly looks at the screen again for the information. She proceeds to shuffle around. ‘That’s mine!’ does she almost say out loud. She approaches the moped and claims ownership by unlocking it, putting her phone away, and checking if it is in good working condition. Because from this point onwards she is paying, Emma quickly presses start and gives a little bit of gas causing her to jerk forward. It is working and finally her trip commences.

Emma is enjoying herself on her moped. Nimbly does she move through traffic in Rotterdam, letting her forget that she is making up time. Wind in her hair, the sun is shining, Emma feels in control of her journey. That is until she has to stop at a red light. It is a busy crossroads, so it takes a little while for her to get going again. ‘This red light is costing me money!’, she thinks while contemplating jumping the light. As it finally turns green, does she revert back to being in the flow.

Emma swiftly arrives at the building of her client and parks the shared moped on the sidewalk. As she is eager to go inside, she checks out whilst walking away from her still booked moped. The application is struggling to update her location on the map. 'Any time now...', she thinks as she is already slowly walking towards the office. Finally, Emma is able to check out. While walking, she takes a quick glance to see if the lights flashed indicating the moped is checked out. She is now in the lobby and puts her phone away. Emma is actually a bit early. She approaches the front lobby to let the client know she has arrived. 'Now, I finally have my moment to relax.', she thinks as she is sitting down in the lobby.

5.3 Understanding the problem space

Emma's journey looks and sounds like a normal travel experience. In fact, you, the reader, might even have experienced a similar journey yourself. Yes, there were a couple of obstacles but they did not seem to pose such a major inconvenience. So what's the big deal? After all, Emma did get to her destination on time. The main issue is the accumulation of myriad small-scale decisions, actions, thoughts, and interactions. On the surface they seem insignificant, however, once the combined accumulation of obstacles, both mentally and physically, are removed, does a traveller understand the total price paid. To illustrate this point, the analogy of cruise control in a car is used. Image going on a skiing trip to the south of France from the Netherlands by car. Yes, you can get there in a car without cruise control. Yes, this does mean that the driver needs to hold the accelerator, and yes, the driver must glance once in a while at the dashboard to check the speed, but the destination will be reached eventually. Those actions of holding the accelerator pedal and glancing at the dash themselves are no big issue if seen as a single action. However, for the 1000+ kilometre journey, those actions accumulate to a constant balance between finding the optimum pedal pressure exerted by the foot and the feedback of the speedometer. You can imagine a driver experiencing cruise control for the first time would never want to go back to driving such a primitive car without cruise control. Chapter 6.3 will provide a detailed explanation of which aspects of Emma's journey are tackled in this project and how a new design is going to provide seamless travel.

Chapter 6

Synthesis

This chapter defines the opportunity gap and indicates where the untapped potential lies. The design brief is reformulated and the solution space is scoped. Fundamental design drivers are formulated in which the first research question is answered. A design vision is formulated and the reimagined interaction scenario is described.

6.1 Defining opportunity gap

6.1.1 Detachment

By synthesising the research, interviews and insights, it became clear that there exists an opportunity gap between the shared mobility providers and the organisational bodies. From the bottom-up, shared mobility providers indicate clear needs of being seen like public transportation, that they are willing to accept a unified check-in and out method, and above all, to be treated like a welcoming addition to the mobility sector instead of being seen as a threat. Mobility providers simply want to provide the best possible travel experience to their customers and understand that the traveller does not care about what application they have on their phone, what colour their modality is, or what brand name is on it. It is only, and has always been, about getting the traveller from A to B in the best possible way. Integrating the services offered by the mobility providers into MaaS applications or similar types of platforms is not a goal at the moment. There has been a proliferation of these services, likely adding more trouble than they are trying to take away. Mobility providers are waiting to see which platform becomes 'the one'. They are simply waiting on some party to take the initiative.

From the top-down, the organisational bodies express a clear desire to facilitate a better integrated form of mobility between public and shared transportation. It has been difficult as regulatory decisions are made per municipality with which naturally geographical restrictions are entailed. Consequently, the expansion of mobility providers is inhibited because they need to adapt to the wishes and demands of every single municipality. Therefore, a clear desire exists to streamline the policies, however, the organisational bodies up in the regulatory hierarchy e.g. provinces, OV-authorities, and national government, do not currently know what their role could be and as a result, have not taken the lead. Furthermore, the municipality desires the geographical demarcation of shared mobility services to increase from city-wide to regional-wide coverage, and finally, to unify the sector as a whole.

This opportunity gap could provide well-structured and organised integration of all forms of mobility, however, the two entities somehow just do not coalesce while they are saying the exact same things (see figure 19). The challenge lies in developing a clear strategy to make sure that the desires of both stakeholders are fulfilled and that the potential of integration is maximised. As the mobility expert has so well-summarised the challenge: 'Maas is not a technical problem, but an organisational problem.'

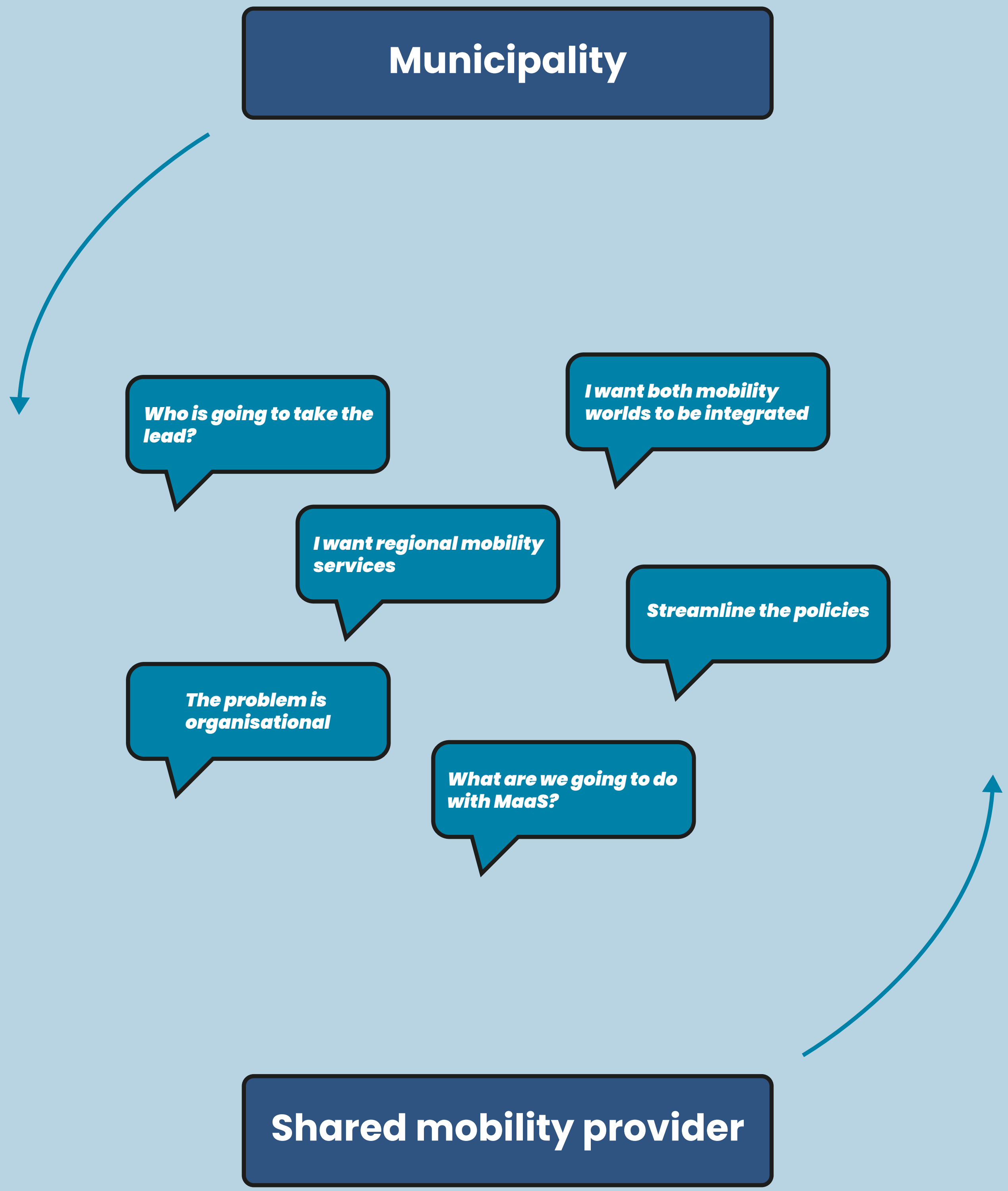


Figure 19 - Misalignment between the municipality and the shared mobility provider

6.1.2 Untapped potential

In the end, it is the traveller who must benefit from strategic changes on an organisational level. This implies that there exists a dependant relationship: a well-orchestrated organisational structure integrating all forms of mobility is a precondition for fulfilling the unarticulated needs of the travellers. From the interviews, it can be concluded that the travellers expressed manifold needs. These include the discarding of the smartphone application (or at the very least requiring a single application instead of many) and simplifying and streamlining the check-in and out process for both the public and shared transportation sector which reduces stress levels and removes the spill-over effect. Other needs are reducing the costs of shared modalities, changing the ticketing system, and improving the social perception overall. Travelling using shared modalities is mostly done in case of an emergency, indicating that spontaneous use is non-existent. The use of shared modalities proves to hold significant untapped potential as all travellers point out that when they are actually moving, they are experiencing a higher level of autonomy, freedom, and flexibility. They are enjoying themselves as it is a pleasant and exciting experience in addition to feeling more in control of their journey. Only when the integration of the public and shared mobility sector is realised, can this untapped potential be unleashed, fulfilling the needs of the travellers.

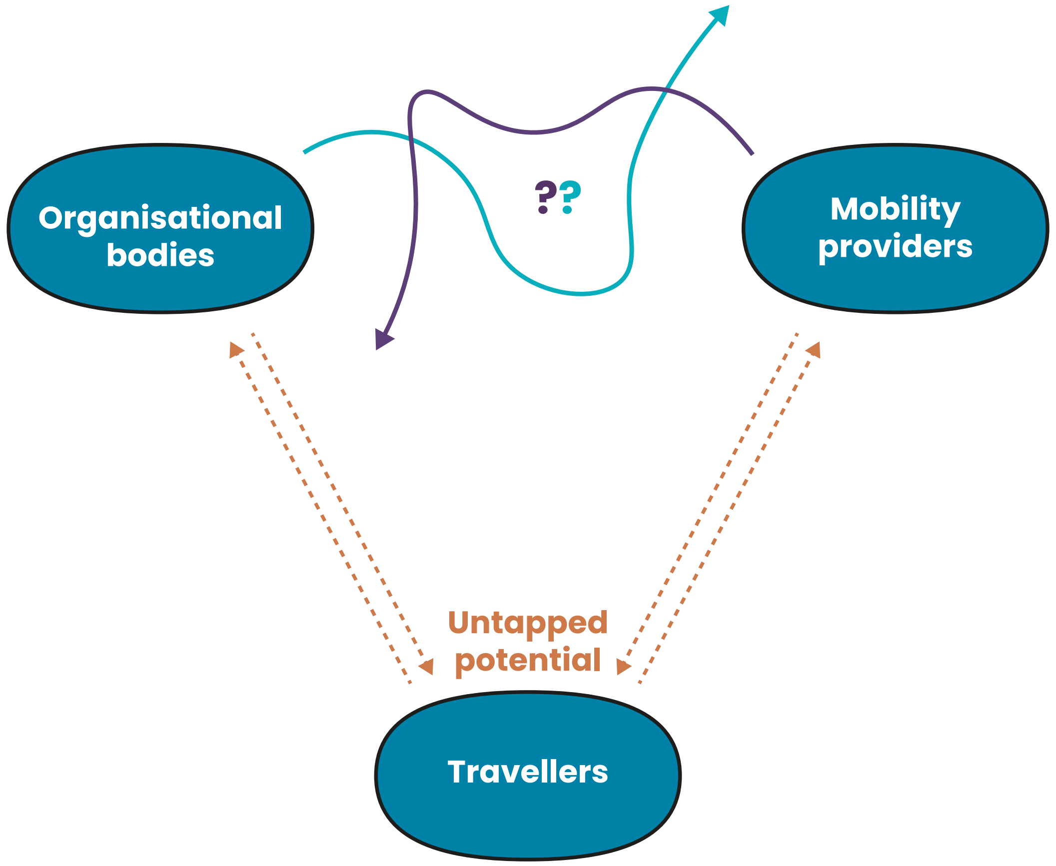


Figure 20 - Untapped potential for the traveller

6.2 Design brief

It is important to synthesise all research and gathered insights into a single design brief which clearly identifies the problem at hand. This redefined design brief concisely formulates the problem statement, the design challenge (what should be designed, for whom, where, when, how and why), and what benefits ultimately could be achieved. This design brief reflects on and is an update to the initial assignment and provides a reframed scope of the project which acts as a starting point of the design phase.

Problem statement

The discovery and synthesis phase have provided clear insights into the actual problem as set out by the initial design brief. True seamless travel is dependent on the level of integration of organisational bodies and the shared and public mobility providers. This is a strategic challenge which must first be addressed and acts as a precondition to providing the traveller with a truly seamless travel experience.

The problem statement is formulated as follows:
"How can we bring two worlds of public and shared mobility together as one to stimulate and facilitate increased usage of both types of transportation, ultimately delivering a more seamless experience to the traveller?"

Design statement

The design statement is derived from the problem statement and is defined as follows:

To develop a new organisational structure by integrating shared and public transportation providers (**WHAT**) in the coming decade (**WHEN**) and designing a complementary travel product concept (**HOW**) which will provide travellers (**WHO**) everywhere in The Netherland (**WHERE**) a carefree, effortless, and true seamless mobility experience (**WHY**).

This design statement is a deconstruction of the problem statement into specific design components based on the WWWWWH method [86].

Envisioned benefits

The outcomes of implementing a new strategic organisational structure are twofold: (1) bring value to the relationship between travellers and the organisational bodies, and (2) bring value to the relationship between travellers and the modality providers. Several benefits can be achieved from the relationship between the traveller and the organisational bodies. These include the fact that there now is a single point of contact, a single entity to retrieve information, the possibility to provide a streamlined check-in and out method for all forms of transportation, a nation-wide service coverage, and, since it falls under (semi-)governmental control, a subsidised and streamlined tariff systems.

In turn, these outcomes will provide benefits for the relationship between the traveller and the mobility providers. There will be increased use of shared transportation in combination with public transportation in general in addition to increased spontaneous use. Furthermore, it will be economically more viable, it will substantially be more accessible, there will be a streamlined door-to-door travel experience reducing stress, and there will be more freedom of choice, increased flexibility, and level of control.

6.3 Defining the scope

As can be concluded from the problem statement in chapter 6.2, the future interaction is dependent on a facilitating future organisational structure. Naturally, this report would like to reimagine the entire journey in conjunction with a proposed design strategy, however, one must realise such a deliverable is a result far beyond the breadth of a graduation thesis. Therefore it is opted to scope down to a specific portion of the traveller's journey. Scoping does come with limitations such as the fact that optimising constituent elements of the whole might not actually increase the overall experience as there must be proper regard for other elements throughout the journey. On the contrary, scoping down does allow the vision to be more detailed and tangible, delivering a better understanding of what could be seen as seamless mobility design.

Upon reviewing all the gathered insights, interviews, observations, research, and the deconstructed journey of Emma (see chapter 5.2), it can be concluded that purely the check-in interaction with any type of modality provides an opportunity with the best potential impact to improve the travel experience overall. This is regarding both checking in using a OV-chipkaart and checking in using an application on a smartphone. Checking in not only in itself can be seen as both a physical and mental obstacle, but checking-in also has several elements, especially cognitive and emotional, flowing over into other portions of the journey which can be mitigated. Since the inevitable act of checking in is shared by both types of transportation i.e. public and shared, it also provides an opportunity to try to bring the two separate mobility worlds interaction-wise closer. More specifically, as there are quite a few types of modalities currently operating in both the public and shared mobility sectors, is it a good idea to limit the project to one modality per mobility sector. Naturally, lessons can be drawn and applied to like-type services. The train station gates at the station and the electric sharable scooter are selected for both the public and shared mobility sector respectively.

Concluding, the scope is the following. On a strategic level, a facilitative high-level organisational structure will be developed which will be accompanied by a check-in product concept on the product level. Both these scopes are tightly intertwined, though are on both ends of the design challenge. The strategic and product concept scopes can be seen as the ends of the problem space from which future design only has to close the gap.

6.4 Envisioning

6.4.1 Design drivers

Seamless underpinning

It would not come as the surprise that seamlessness itself is a main design driver for this project. It does however pose the question of what exactly constitutes a ‘seamless’ mobility experience as set out by the main research question? This thesis has gone into great depths as to what it could mean specifically for the mobility sector, culminating in the following paragraph. This paragraph approaches the term and provides an explanation of what constitutes seamless mobility:

Truly seamless mobility can only be attained when seamlessness itself is not consciously perceived: upon the realisation of being in a seamless experience, does it fail to exercise its duty. It is a purely cognitive concept in which actions are without intent and decisions are based solely on heuristics. Therefore, travellers must not attempt to consciously interact with a seamless journey if they want to experience her operations undisturbed.

User-centred design

There are two perspectives one can take when trying to add value to the mobility chain. The first is from a purely human-machine interaction-based perspective. Interaction with and gaining access to modalities requires a series of unavoidable acts. Since the series of acts are inevitable, logically, optimising them improves the process in some form or another by specifically adding value to each of the acts such as efficiency. The approach here is confined by merely the interaction between the user and the machine without proper regard for non-utilitarian values: motivating values of personal importance. In contrast, when switching to a purely personal value perspective, the human-machine interaction can only be perceived as a nuisance. Having a deep, personal conversation with a travel companion, thinking through an amazing spontaneous idea which just came to you, intensely listening to a new album, or trying to comprehend a particular provoking conclusion from a podcast are all surely more meaningful, personal, and self-actualising values worth retaining without the interruption of the inevitable act? Designing for these personal motivations is undeniably and indisputably more important than optimising for utilitarian values of the human-machine interaction. Concluding, a hierarchy of values exists, and seamless travel requires optimisation only at the top of the value pyramid: motivated values of personal importance.

Non-obtrusiveness

Interactions invariably induce cognitive strain. From the performed research, interviews and observations during this project, on the surface, it seems like to most amount of cognitive strain is generated by seemingly simple and typical interactions throughout a traveller’s journey. Superficially, these typical interactions ought to be removed to improve the travel experience, however careful consideration is due as a single interaction should not be seen as an entity in itself, but as a constituent of the whole. It is also imperative to establish that some interactions, although inducing cognitive strain, might have a positive effect on the traveller and must be preserved. The utopian scenario with the doctrine of ‘no interaction is the best interaction’ is not desirable, however, it must be approached as close as possible. Obtrusive and negatively influencing interactions must be removed, and necessary interactions must remain, albeit in a non-obtrusive fashion. It is imperative to state that the removal of most interactions does not mean that the traveller should not be able to intervene. If absolutely necessary, the possibility to intervene must remain, giving the traveller a feeling of certainty as they remain in control of their actions.

6.4.2 Sub-design drivers

Non-digital design

One of the sub-drivers is designing for inclusivity. Transportation is used by everyone and must remain available to all. Smartphones are therefore not a preferred solution as not everyone is in the possession of one. In addition, smartphones are a source of distraction and require a user to switch between physical and digital interfaces generating stress, negatively influencing the user [87]. Furthermore, by designing solutions with the smartphone as a central piece of technology, essentially the design is subjugated to a dependent relationship to the maker of the smartphone and the technologies present on any particular device [88]. Not to mention the fact that when the battery runs out, the design is rendered useless. On a final and more personal note, a smartphone application as a single solution is the easy way out. The design-mantra of ‘there is an app for everything’ is not something I wish to deliver. It must be said that it does not mean that a smartphone or an application is fully disregarded. It could still serve a supportive role for example.

Privacy by design

An intricate relation exists between on the one hand the advantages of superb convenience, and on the other hand, surrendering an individual’s right to privacy with their behaviour and purchases to be used in different applications or even being sold. In the case of the Amazon Go case study, in effect, the customer is paying for their subjugation of data which is not desirable. Legislative pieces such as the General Data Protection Regulation are there for a reason: both to protect an individual’s privacy and to set up a framework for companies collecting the data. Privacy remains a strong pillar in this project.

Allow spontaneous travel

One of the most interesting findings in the literature research is the fact that travellers are behaviourally inert and prefer the status quo. Habits dominate behavioural outcomes in stable contexts. When travellers are accustomed to their habitual travelling behaviour, they are not inclined to change their behaviour if no external triggers exist. As a sub-driver, the design must allow spontaneous travel in order to change the status quo. To let the traveller try and experience various modality options not previously imagined before.

6.4.3 Formulating design vision

A vision is an expression of the desired future, it is the strategic reference point for actionable innovations [89], and above all, it is the direction of the solution design sparking creative processes. The following vision is conceived as a result of the extensive exploration of the term seamless, the case study, the research, observations, interviews, and design drivers:

"Those who don't look at the sky can say I spy with my little eye."

The vision can best be explained by two splitting it into two parts: (1) Those who don't look at the sky, and (2) can say I spy with my little eye.

Those who don't look at the sky

Looking at the sky metaphorically means to be in a holistic sensation of total involvement and focus on whatever is of personal importance to yourself at that particular moment in time. A traveller must remain 'looking at the sky' for the totality of their travel and must not be interrupted. Not whilst sitting in or on a modality, not during any check-in or out process, not even during a transfer between modalities. The goal is to remain in the metaphorical state of 'looking at the sky', drifting to the destination without even knowing it.

I spy with my little eye

I spy with my little eye implies that those travellers who are not looking at the sky, must still be in total control of their trip. When a traveller directs their attention away from the 'sky' to the trip itself, do they need to be able to see what brand of modality they are using, what their current balance is, where they can receive additional information if required, what their check-in status is, or maybe abort the trip altogether.

6.5 Proposed interaction idea

Even though checking in using an OV-chipkaart was not a pain point large enough worth mentioning by the interviewed participants, it certainly is a place where seamless travel is greatly reduced. It is both a physical obstacle as a traveller is permanently denied access to the station unless a valid OV-chipkaart is presented and it is a mental obstacle as it initiates prospective memory.

Checking in to a shared modality using an application on a smartphone requires substantially more interaction steps compared to checking in using the OV-chipkaart and undoubtedly results in an even larger physical and mental obstacle. It is physically an obstacle for the same reason that the gate at the station is permanently closed: a traveller is permanently denied access to a shared modality unless a valid account on a smartphone initiates the trip which requires substantial cognitive effort resulting in an even larger mental obstacle. All in all, for both mobility worlds, a seamless check-in experience is close to non-existent.

The proposed and reimagined interaction is essentially the inverse of the current situation revolving around the idea of a wireless digital handshake. Wherein the old scenario the traveller must physically present a modality-specific identifier to a permanently closed barrier i.e. gate or moped, a traveller now carries a small modality non-specific token which can be detected by a gate at the train station or by a parked shared modality if it is in close proximity. Check-in gates at the train station are now permanently open and subsequently will only close when a valid token is not detected i.e. the digital handshake cannot be made. The same goes for checking in on a shared modality. Shared modalities are permanently unlocked and turned on and will, for example, cut the power, apply the brakes, or sounds an alarm when a valid token is not detected i.e. the digital handshake cannot be made.

To illustrate the new check-in interaction, tables 2 and 3 provide an overview of the reimagined check-in section of Emma's journey for both the public and shared transportation modalities. Both new interaction scenarios will be explained separately below including benefits that the traveller is now able to experience. Thereafter, integrated and overlapping aspects are explained.

Table 2 - New public transportation check in scenario

OLD	NEW
While in a conversation with her colleague, Emma enters the train station. She identifies the check-in gates in the distance and starts fumbling for her OV-chipkaart. ‘Left pocket? Oh, no, it is right here!’, she thinks as she is trying to listen to valuable information over the phone. She holds her card against the reader, sees that she is currently checked-in with her business travel plan, and passes through the gate. ‘I’m sorry, what was that last thing you said about the meeting? I was a bit distracted.’, she says to her colleague while trying to store the OV-chipkaart again.	Upon entering the train station, Emma is carefully listening to valuable information given by her colleague. She identifies the NS check-in gates in the distance and heads in that direction. Emma passes through the gates. ‘That is some interesting stuff!’, she says to her colleague continuing the conversation.

Table 3 - New public transportation check in scenario

OLD	NEW
Emma approaches the shared moped parking area with the phone still in her hand. As she is getting close, she glances at the screen once again. There is actually quite a bit of information that needs here direct attention causing Emma to stop in her tracks. Whilst standing still, she now has to remember the location of the moped, her own location, the brand of the moped, and its numberplate. Emma shuffles around trying to find her booked moped, but she can’t find it. She stops, grudgingly looks at the screen again for information. She proceeds shuffling around. ‘That’s mine!’ does she almost say out loud. She approaches the moped and claims ownership by unlocking it, putting her phone away, and checking if it is in good working condition. Because from this point onwards she is paying, Emma quickly presses start and gives a little bit of gas causing her to jerk forward. It is working and finally does her trip commence.	Emma is still listening to music as she approaches the shared moped parking. She spots a shared moped, puts her earphones in her pocket, hops on, and drives away.

The aforementioned benefits of the two optimised scenarios are considered individually, although there is more than meets the eye. Since there is only a single token used to check in to both forms of travel, both modalities could be considered technologically integrated. They now share the same characteristics and require the same interaction from the traveller streamlining the experience. The technological integration is mirrored in the mind of the traveller as mental integration. Due to the facilitative nature of a new organisational structure, there is now a single point of contact. A single entity where information can be retrieved. Perceptually, the two worlds of mobility are merged as modalities aren’t seen as separate, adding even more value than the benefits of the optimised scenarios combined. The optimised whole is greater than the sum of the optimised parts.

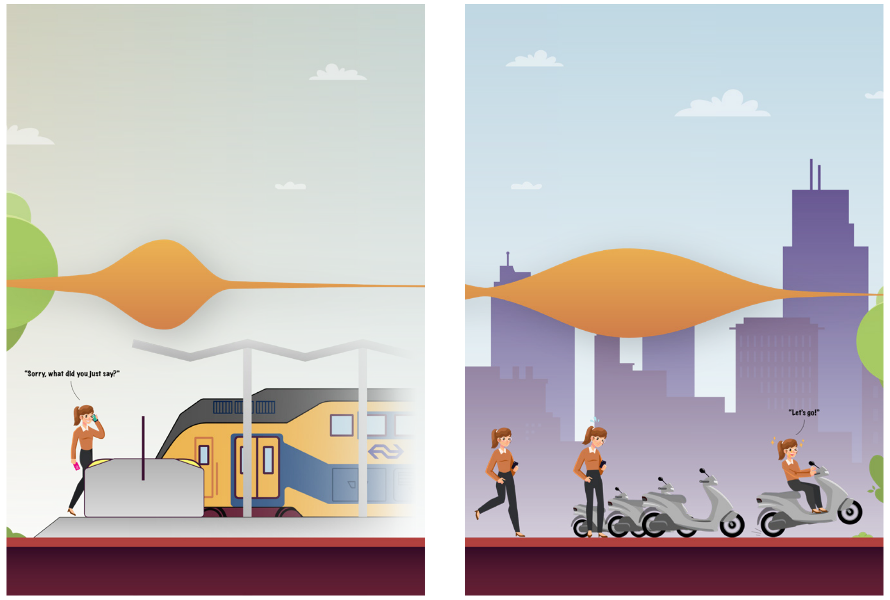


Figure 21 - Scoped section to redesign

Chapter 7

Technology exploration

This chapter conducts a technology deep dive to discover what technologies are necessary to realise the reimagined technology scenario. The wireless technology combination of Ultra-Wideband and Passive Keyless Entry and Start is selected.

7.1 Current technology

7.1.1 Current technology public transportation

The operation of the OV-chipkaart is based on a distributed offline system in which the credit is kept on the card itself. The OV-chipkaart uses a standard EMV communication scheme to communicate to the card reader. The technical equipment used by the carriers meets the specifications as drawn up by Translink and is certified as such to ensure interoperability between carriers. It is the responsibility of the individual carriers to provide the public transportation posts and gates. Card readers can be connected to online systems of carriers, but their operation is not directly dependent on this connection; data may be sent periodically or only when a modality is parked at the carrier's parking where data is sent at the end of the day. The data regarding journeys made are sent to the back office of the relevant carrier. This data is then forwarded to Translink, which on that basis ensures the distribution and payment of the public transport balance to the relevant carriers [90].

Five levels are recognised in the OV chip card system:

- Level 0: The OV chip card itself
- Level 1: The public transport card readers ('poles', 'gates') at the stations
- Level 2: The local public transport computer that controls the public transport card readers
- Level 3: The back offices of the various carriers
- Level 4: Translink's back office

7.1.2 Current technology shared modalities

Shared mobility services rely on a combination of GPS and cellular connectivity to track whichever vehicle is being rented, charging users by the minute, and immobilising the device wherever it is left at the end of its trip [91]. A smartphone app is the prevalent method of finding, reserving, unlocking, and locking the modality itself, and providing an interface for the traveller to get in contact with the operator. The modalities are connected to a vehicle sharing software suite which is usually not developed and operated in-house by the shared modality provider itself but is outsourced to an external software developer. Companies such as Wundermobility [92], WeGo [93], M-Tribes [94], Zemtu [95], and ATOM [96] have ready-to-go software, with some boasting a launch time of fewer than 20 days. This implies little innovation potential for the shared modality provider from a software perspective as they do not develop the software in-house but rely on the willingness of the software provider to innovate. In turn, this also implies that the wish of a shared modality provider to integrate their service to a particular MaaS platform is greatly inhibited since it is fully up to the software developer if they want to spend time and resources updating their services for integration.

7.2 Future technology innovation space

7.2.1 Future technology OV-chipcard

For the most part, the system will remain the same, although some changes are necessary to introduce the new Account Based Ticketing scheme proposed by OV-Pay. Minor hardware and software updates are necessary locally in the card readers. Several carriers participating in pilots are already equipped with these new improved card readers. Over the coming years, technicians will update every card reader by hand, all 60.000 of them. It is important to note that these changes are only minor improvements; radical new technologies will not be introduced. Updating every card reader to work with Account Based Ticketing will cost an estimated 100 million EUROS, meaning that the next generation of (wireless) card readers will be years from now [97].

The new OV-chipkaart, and other forms of identification in the Account Based Ticketing scheme, will work using EMV technologies. The program director of OV-Pay explains [98]: "The back office registers a tap-in and a tap-out per trip. At night, the back office calculates the price of all those journeys, adds them together and applies any discount percentages. That price is then charged to the cardholder's bank. The money is transferred by the issuer to the acquiring bank of Translink. If necessary, Translink splits the payment and pays out to the carriers involved. It is actually a deferred debit card payment. Compared to a regular debit card payment, the big change for cardholders is that they have to check out with the same card at the end of their journey."

7.2.2 Future technology shared modalities

There is not much innovation room left for the 'traditional' way of interacting with a shared modality. Shared modality providers are bound between the alignment of capabilities and willingness of software providers and the technologies currently in their fleet. Incremental improvements will still take place, however radical technological changes and improvements are not happening any time soon.

7.3 Technology scouting

The proposed and reimagined interaction scenario as explained in chapter 6.5 requires novel wireless technologies. Setting clear technical requirements is an essential step in the system development process. These technical requirements describe the technical aspects and issues that one must address for the interaction to work as intended. As the product is still on a conceptual level, these technical requirements should not be treated as binary requirements with them being met or not, but more as general targets which must be included and optimised. The main technical requirements are listed below. All technical requirements can be found in appendix 8.

7.3.1 Technical requirements

Accessibility

» Costs for the traveller
- The personal device in the reimagined concept should not be reserved for only those who can afford substantial extra costs but must be an economically viable alternative for everyone in the Netherlands. A ballpark cost estimation for the traveller should not be substantially different to that of the costs of the current OV-chipkaart.

Data quality

» Privacy
- To securely communicate between the personal device and the device mounted on a shared moped or at a terminal, full-duplex, cryptographically secure communication is required. Simply blasting your personal information omni-directionally is highly subject to hacking, misuse, and fraud. Not to mention the legal implications regarding the GDPR, or its directive code 95/46/EG [99].

Performance

» Accurate positioning
- Accurate positioning is imperative for the design to properly work. The user in the reimagined scenario must have a high degree of trust that the correct individual is checked in. Imagine a scenario where two people are stepping on an OV-fiets and exit the station cycling next to each other. As a cyclist, you are now the legal ‘owner’ of that particular bicycle, and you want to be sure that user A is checked in to bicycle A, and user B is checked in to bicycle B. Therefore, at least, sub-30-centimetre accuracy is required.

» Battery life
- The product concept is a hands-off system. Something the user should forget and would never have to worry about. Only if it is forgotten does the concept produce the most value for the user. This means that the device carried by the user should last for multiple years, and therefore require ultra-low power consumption.

Size

» Physical size personal device
- The technologies that will be used must be able to be carried by a traveller in a non-obtrusive manner. The device should be so small that one would not mind carrying it with them until the battery runs out after many years.

7.3.2 Technology comparisons

The future interaction scenario accompanied by a personal product relies fundamentally on a reliable and accurate wireless technology. It is essential to align the value drivers with smart choices about emerging technologies. Scouting for new technologies is one of the key activities to do this [100]. Below are several emerging technologies in addition to common and widely used technologies, all including their advantages and disadvantages. Thereafter, the most promising technology contender is selected.

BLE AoD

Bluetooth is developed and managed by the Bluetooth Special Interest Group (SIG) and is a ubiquitous communication technology found in most devices. As of 2009, Bluetooth ships approximately 920 million units annually [101]. By 2017, 3.6 billion Bluetooth devices were shipping annually and shipments were expected to continue increasing at about 12% a year [102]. There exist many standards for Personal Area Network (or in short PAN) communication. One of the most widely used is Bluetooth’s sibling Bluetooth Low Energy (or in short BLE). It is supported by most operating systems and personal digital devices. It allows the transfer of small data packets whilst consuming little energy [103]. One major drawback of using BLE in this particular concept is the fact that BLE uses Received Signal Strength Indicator (or in short RSSI) to estimate distances between the two devices. This method of distance-guessing is subject to substantial interference resulting in inaccurate readings and is therefore not suited for the application [104].

There does however exists a new standard of BLE which is called Angle of Departure (or in short AoD). BLE AoD enables people and things to determine their location within a building using multiple BLE beacons. Bluetooth describes it as ‘Indoor GPS’ as it operates in a similar way to an outdoor global positioning system. Their explanation is the following. In the AoD method, the transmitting device, such as a fixed locator in an Indoor Positioning System (IPS) solution, uses multiple antennas arranged in an array to transmit a special signal. The receiving device has a single antenna. As the signals from the transmitting device cross its antenna, the receiving device collects data that enables it to calculate signal direction [105]. Bluetooth is widely used in current devices and future standards will likely be implemented on millions of devices. The new standard could be a viable proximity solution for wireless checking-in as SIG boasts centimetre-level accuracy [106]. A full BLE AoD setup requires a 3x3m array of antennae [107].

NFC

Near Field Communication (or in short NFC) is a subset of RFID and has many upsides [108]. For most applications it is a passively powered technology i.e. it does not require a built-in power source as it relies on wireless energy transfer given by inductive coupling. Usually, an active reader (such as a payment terminal) produces energy using induction coils. These subsequently are captured by an NFC Tag and power the onboard integrated circuit (or in short IC). The NFC Tag IC shorts its own current thereby damping the carrier wave current, allowing communication between the reader and the tag. This system communicates in two directions using specific cryptographic standards. The one major downside, although this is mostly seen as a security feature, is the range in which NFC operates. Typically ranges are between 5-10cm [109].

GNSS

Global Navigation Satellite System (or in short GNSS) is a set of satellites providing global autonomous geo-spatial positioning. Various GNSSs are in operation today: GPS (United States), GLONASS (Russia), BDS (China), and Galileo (European Union). Satellite navigation and positioning was originally motivated for military purposes. Today it is found in many public and private applications across numerous market segments such as science, transport, and agriculture [110]. There are several disadvantages when using a GNSS system. First, it is a power-hungry application. A smartphone typically would not last a day with full GPS connectivity. If a new connection needs to be established, it takes up to half a minute to receive the first signal [111]. Another disadvantage is that GNSS signals do not penetrate walls or solid structures [112]. Indoor positioning will either not work or will be prone to large errors. The accuracy of GPS typically is around a couple of metres with new hardware modifications being able to bring it down to roughly one meter [113].

5G

5G is the fifth generation technology standard for broadband cellular networks. The global roll-out to 5G is well underway, with the number of connections to the next-generation network set to reach 1.34 billion in 2022, and more than 3.6 billion 5G connections worldwide by 2025, according to a market analysis [114]. The 3rd Generation Partnership Project (3GPP) is an umbrella term for several standards organisations which develop protocols for mobile telecommunications, including 5G [115]. 3GPP R16 (the current release of 5G at the time of writing this project) requires 5G to be able to provide positioning accuracy of 3m at 80% in indoor areas and 10m at 80% in outdoor areas for commercial equipment. 3GPP R17 is working on continuous enhancement of 5G positioning capabilities. In March 2021, 3GPP officially approved a new version which aims to increase the positioning accuracy to 0.5m at 90% or higher, and the battery endurance of positioning terminals to months or even years [116].

PKES

Passive Keyless Entry and Start Systems (or in short PKES) was introduced at the turn of the century. It allowed car owners to unlock and start their car by simply having their key-fob in their pocket. Typically, the car probes the key-fob using low-frequency pulses at 120 to 135KHz. These low-frequency probes are designed for short-range communication, ranging from a few centimetres in passive mode to a couple of meters in active mode. If a key-fob detects such a low-frequency probe it wakes up and starts its IC. Subsequently at a higher frequency, between 315 and 433MHZ, a challenge-response protocol is started using rolling codes. If the challenge is correct, the car unlocks and can be started. A low frequency is only used to communicate from the car to the key as such operation requires a large amount of energy. PKES has been prone to hacking using relay attacks over the years and is only suited for a pre-defined pair of both the car and the key [117]. However, there are major upsides. For the user, it provides a radically new and convenient experience. The experience would be classified as almost fully seamless since there are still physical obstacles in place such as the car door itself, the need to press an ignition button, and in some cases having to put the key-fob in a special place in a car for it to start. Modern car keys using the PKES protocol are small in size and provide a long-lasting battery life of approximately two to three years using a 3V CR2032 coin-cell type battery [118].

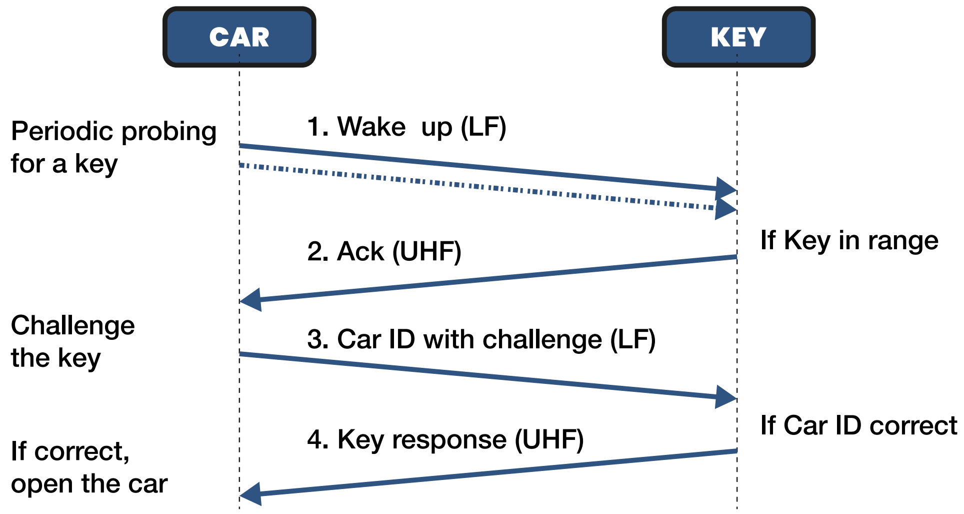


Figure 22 - PKES prototcol

Ultra-wideband

Conventional radio transmissions, such as the technologies mentioned above, transmit information by varying the power level, frequency, and phase of a sinusoidal wave. UWB takes a different approach by transmitting information at specific and very short time intervals across a wide bandwidth (generally more than 500MHz)—hence the name. This enables pulse-position and time modulation unleashing the capability of measuring distances using Time Difference of Arrival (or in short TDoA). UWB is able to measure distances with great accuracy since the technology does not succumb to multi-path propagation as some frequencies have a clear line-of-sight trajectory. UWB can measure distances and locations to an accuracy of sub-10 centimetre in both a peer-to-peer situation and triangulation scheme [119]. UWB operates on the noise floor of traditional narrowband wireless applications and is therefore able to coexist with little to no interference [120]. Regulation in the Netherlands limits the transmission power to -41.3 dBm/MHz EIRP (Effective Isotropic Radiated Power) effectively curtailing the range of UWB to about 10 meters [121], [122]. Theoretically, UWB is capable of transmitting data up to 200 meters. In addition, UWB consumes very little power. A sensor using UWB powered by a single coin-cell battery pulsing once every second is expected to last multiple years, although small and practical applications will see battery life of around one year [123], [124], [125]. UWB technology has been around for several years in industrial applications, however, it has not seen widespread adoption in consumer electronics due to slow progress in UWB standards development (the IEEE 802.15.3a task group was dissolved after reaching an impasse), the cost of initial implementation, and the fact that performance was significantly lower than initially expected [126], [127]. In 2018 the standard was re-opened in the form of 802.15.4z to add further security to the physical layer as UWB is expected to be used as a secure transaction wireless technology by the automotive and mobile industries [128]. Nowadays, there has been a slow increase in the adoption of UWB. Several big-brand smartphone manufacturers have been implementing the chips over recent years and the National Football League in the United States has been embedding UWB tags in the shoulder pads of the players to track their location during a game [129], [130]. With any novel technology, naturally, prices will fall the more units are produced. At the moment, UWB chips cost a little less than $10 per piece [131].

7.4 Technology selection

Let us take each of the aforementioned wireless technologies and determine if they stack up against the technical requirements. As mentioned before, solely using BLE will not work as distances are measured using RSSI. This method of distance-guessing is subject to lots of interference resulting in inaccurate readings and is therefore not suited for the application. Imagine a scenario wherein two individuals both want to check in to a moped which are placed next to each other. From the moment an individual is checked-in, that person is legally responsible for both the moped, in addition to being liable when an unfortunate accident occurs. A high degree of certainty is required which BLE on its own cannot provide. BLE AoD is able to provide the necessary accuracy by using multiple beacons to locate the token. At a train station, this will not be a problem since there is plenty of room for multiple beacons, however, a single shared modality on the street does not have this luxury since it does not provide adequate distance between multiple beacons. Therefore BLE AoD is also not a suitable technology. While NFC checks all the boxes, unfortunately, it is limited to a very small operating range. This is usually seen as a security benefit, however, the range limitation is too small for the purposes of the proposed idea. GNSS has several limitations: it is not very accurate positioning-wise, it is power-hungry, and must be paired with another wireless technology to talk to a check-in beacon since generally GNSS data is only used for positioning and not for duplex communication. Similar to GNSS, 3GPP R17 of the 5G network is not accurate enough. The future release of 3GPP R18 scheduled to be released in the fourth quarter of 2023 will have the required accuracy [132], however, solely using 5G implies that a device must continuously update and communicate the absolute device location because the proposed interaction is passive and fully hands-off. Updating and communicating a traveller's location every second of every day has major privacy implications. From the perspective of a designer's responsibility to ensure the full privacy of the travellers, 5G, including future releases, are not suited nor acceptable.

Table 4 - Overview technologies

	BLE (AOD)	NFC	GNSS	5G	PKES	UWB
Battery	Couple of years	n.a	Couple of days to weeks	Months	Couple of years	Around one year
Range	<70m	<10cm	~5m	3-10m	~2m	<10cm
Accuracy	~1m	<10cm	~5m	3-10m	~2m	<10cm
Cost	$	$	$$	$	$	$$
Data rate	High	Low	n.a.	High	Low	High

Based on the technical requirements, the selected technology is a combination of PKES and UWB. A combination of these two technologies holds the most potential for a secure and accurate digital handshake. In essence, PKES and UWB fill in each others shortcomings. The token works in two modes: (1) a passive listening mode and (2) an active positioning mode.

Passive listening mode

In the passive listening mode, only the PKES chip is active. Similar to a modern car, the token is merely listening for a low-frequency wake-up probe emitted by a beacon. Only when the traveller is in the near vicinity of a modality or gate and depending on the signal strength emitted by these beacons, does the PKES protocol trigger the UWB IC to turn on. In the passive listening mode, UWB is at all times fully turned off, yielding several benefits. Battery life is significantly extended since PKES draws substantially less current and there is no constant pinging of location data, increasing user privacy and digital security.

Active positioning mode

Only when a traveller is in the near vicinity of a particular beacon, and only after the PKES protocol initiates the UWB IC to wake up, does a digital handshake occur. This could be either at, for example, a station where multiple beacons are used for accurate triangulation positioning, or near a shared modality where a single beacon purely measures the distance to the traveller. The accurate sub-10-centimetre TDoA positioning allows a beacon to determine with a high degree of certainty that the traveller has passed through a particular gate or is the correct individual currently boarding a shared modality. As long as the UWB signal is in range, the traveller continuously updates their position relative to a beacon or array of beacons. Due to the limitation of the transmission power set up by law for UWB, the signal is effectively curtailed to about 10 meters. This implies that once the UWB connection is lost, UWB turns off, and PKES starts listening again for a new low-frequency wake-up probe. A modality is able to determine upon losing the UWB connection whether a user is checked-out. Once checked out, a beacon on a modality starts periodically transmitting low-frequency probes to determine if the next traveller is trying to check in.

Turning attention back to the technology requirements, the combination of PKES and UWB fulfils all demands compared fairly well compared to all the other technology contenders. The only drawback is affordability for the traveller at the moment. UWB is only recently gaining popularity in the consumer electronics market. Novel technologies not widely adapted come with an increased price tag. Currently, a single UWB chip is just below $10, which by the laws of mass of mass production will substantially come down, and once widely adopted, it would not be a far-reaching estimate to say that UWB chips will be comparable to, for example, BLE chips price-wise. The same reasoning goes for a cost-effective implementation for modality providers, although this would be less of a problem. As far as privacy and security, PKES allows UWB to remain turned off at all times, limiting positioning data transmission to only when absolutely required. Furthermore, UWB is a full-duplex, high-speed wireless protocol which allows for high-quality cryptographic standards. The selected technology combination, interoperability-wise, is able to be implemented in all forms of modality and can be used as an identifier in the Account Based Ticketing scheme scheduled to launch in the first quarter of 2023. The size of a token using the selected technologies will not be any larger than a modern car key fob. It is also scalable since UWB is gradually being implemented in more and more devices. All in all, the combination of PKES combined with UWB is selected as the two main technologies in the wireless token.

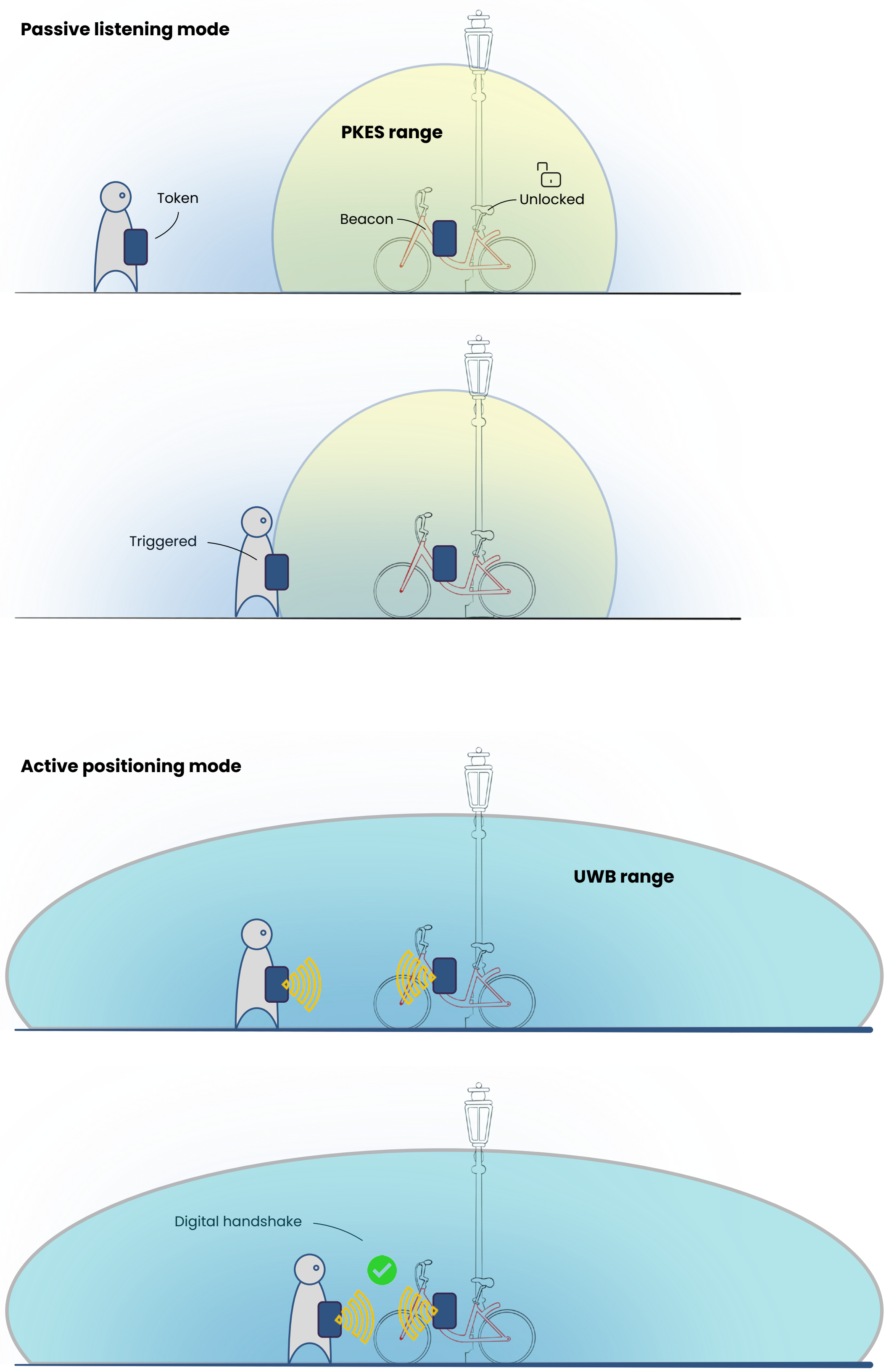


Figure 23 - Interplay between PKES and UWB

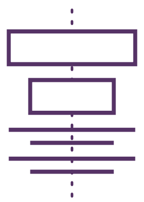
Chapter 8

Strategic intervention

This chapter proposes a strategic blueprint based on four different strategic design goals. Nine strategic interventions are formulated to move towards a fully integrated mobility system. Finally, the strategic blueprint is validated by a mobility expert.

8.1 Strategic design goals

Several strategic design goals can now be derived from the problem statement: “How can we bring two worlds of public and shared mobility together as one to stimulate and facilitate increased usage of both types of transportation, ultimately delivering a more seamless experience to the traveller?”

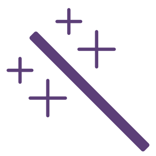


Design goal 1: Align

Design an organisational structure that aligns and integrates public transportation and shared transportation in such a way that the untapped potential is maximised.

Design goal 2: Stimulate

Design a mutually defined vision which stimulates a positive perception and healthy atmosphere between mobility providers and the municipalities.



Design goal 3: Improve

Systemically design the new organisational structure in such a way that the alignment of mobility worlds maximally improves the travel experience for the traveller.

Design goal 4: Demonstrate

Design a true seamless mobility concept which demonstrates the benefits and advantages of the proposed future interaction scenario.

8.1.1 Strategy blueprint

Figure 24 shows an overview of the strategy blueprint. In total there are nine strategic interventions, seven of which make up the pyramid. They are validated by a mobility expert from which the feedback can be read in chapter 8.3. Below is a summarised list of the strategic interventions after which each intervention is discussed in detail concerning the design goals:

1 Not just a name
This intervention calls for a perception change by all stakeholders to see the mobility sector not as two separate worlds but as one.

2 Home sweet home
This intervention aims at housing all types of mobility, that is both collective and personal, under a single shared roof. Personal mobility will be made private-public and will be organised similarly to collective mobility. It too will follow the three main levels: regional, national, and international.

3 It takes three
This intervention proposes to move towards a concession based system organised from a centralised regulatory body for both collective and personal mobility. Three mobility authorities are introduced: the national mobility authority, the regional collective mobility authority and the regional personal mobility authority.

4 Cupido
This intervention is a facilitating entity that is a personal point of contact for the wishes, demands and complaints of the municipality. Cupido also fulfils the role of a matchmaker to ensure that the various modalities fit in the city in the best possible way.

5 Alom
Alom is the central transaction broker tasked with processing all check-in data and status of both collective and personal modalities, and redistributing profits back to the provider.

6 Technology toolkit
Additionally, Alom is tasked with designing the technology toolkit consisting of a beacon, token, and the digital infrastructure allowing for the introduction of a universal check-in method.

7 Truly seamless mobility concept
The truly seamless mobility concept ultimately delivers a remarkably comfortable and care-free travel experience which is now possible if the aforementioned strategic interventions are implemented.

8 Tackling awareness
A conceptual marketing campaign is devised targeting the relevant stakeholders as the proposed strategy will require full acceptance of all the stakeholders.

9 Vision champion
The vision champion is able to transcend all layers in the mobility hierarchy to attain support for the future vision through securing the commitment of people across organisations.

8.2 Nine strategic interventions

8.2.1 Not just a name

On the surface, introducing a new naming scheme as the first design intervention might seem superfluous or excessive, however, it is an essential and imperative aspect of the proposed strategy. Currently, the two worlds of shared mobility and public transportation are seen as completely separate. This is due to the difference in the way in which travellers need to check in (smartphone applications versus OV-chipkaart), the different types of organisations running the services (young versus old, privatised versus semi-public, and non-subsidised versus subsidised), a different tariff system (time-based versus zone-based), and the different types of vehicles (one traveller per modality versus many travellers per modality). All these different aspects shape the perception of the traveller, subsequently reinforcing the mobility dichotomy.

Perception is the organisation, identification, and interpretation of information to represent and understand the presented information or environment [133]. Although the perception is a largely cognitive and psychological process, how one perceives objects and systems affects one's behaviour. It is logical to have different responses to different objects and systems, something undesirable when unifying mobility. Integrating the mobility worlds, therefore, is not possible when the two subsystems are seen as separate. Before integration is possible, the perception of the subsystems must first be aligned. This requires systems thinking as it takes such underlying complexities into account. Contrary to linear thinking, systems thinking is a critical way of viewing systems holistically and thus allows for a paradigmatic shift such as the mental integration of the two types of mobility.

Human interaction with the world occurs at four levels. The first is the events level where humans become immediately aware of changes in their direct surroundings. The second is the patterns level where multiple event-level changes are linked together, providing the interpreter with more meaningful lessons. The third level is that of the systemic structures in which it is critically understood exactly how observed patterns lead to outcomes. Finally, the fourth level is the mental models level. Mental models reflect the beliefs, values and assumptions that individuals personally hold, and they underlie our reasons for doing things the way we do. However, despite their critical importance, mental models generally remain obscure limiting our collective understanding of issues and hence impeding meaningful communications and the development of common vision and action [134].

Mobility integration in itself is certainly an event-level change as it is directly noticeable as an immediate change in the traveller's surroundings. The change can, by all means, be a forced introduction, though naturally, acceptance will thereby be low. Approaching the integration of the two worlds of mobility on only the event layer, as is in my humble opinion usually the case when reading about the introduction of MaaS, would lead to duck-taping behaviour as only symptoms of the underlying challenge are

Figure 24 - (left page) Overview of the seamless mobility strategy

surfacing. About 25% of corporations and more than 50% of government agencies plan and manage purely on event-level thinking [135]. To smooth the transition, one must precede by first satisfying the most fundamental layer: the mental model.

Therefore a new naming scheme is proposed as the one currently in use is counterintuitive. Why is shared transportation called shared since only one person is able to ride at a time? Is a train, bus or tram by this reasoning then not shared? The more apt naming scheme would be collective mobility and personal mobility for public transportation and shared transportation respectively. These will reside under the same denominator of public mobility. This idea is not new and has been coined before [136]:

'The call was to see whether the current system of Public Transportation can be expanded into a system of Public Mobility. With the underlying thoughts: better for travellers and more efficient from a government perspective. Taken together, such a system could be a sustainable and full alternative for our, still mainly car-bound, society.'

Benefits

From this point onwards in the report, the mobility subsystems will be referenced using the new naming scheme. In the end, the proposed design intervention will achieve the following outcome: it provides a new starting point and, if executed well, a new mental model. Subsequently, this will reshape the perception delivering a converged mindset pointing to the same ideal; seeing the two families of mobility not as separate, but as one.

Table 5 - Benefits 'Not just a name'

	ALIGN	STIMULATE	IMPROVE	DEMONSTRATE
Positive perception municipality	✓	✓		
Positive perception traveller	✓		✓	
Converged mindset	✓	✓		

8.2.2 Home sweet home

Personal mobility services currently do not suffer from teething issues anymore, nor are they limited in any way by technological innovations. It is therefore high time that the next step is taken: to house all types of mobility, that is both collective and personal, under a single shared roof. Personal mobility will be made public and will be organised similarly to collective mobility. It too will follow the three main levels: regional, national, and international. On all three of these levels, different companies can offer their services. Noteworthy is that international personal mobility arises as a new opportunity, but falls outside of the scope of this report.

Benefits

There exist several reasons for bringing the personal mobility services under the same roof together with the collective mobility services. The first is that in a single stroke the personal mobility services would be 12% cheaper as they currently fall under the higher 21% taxation rate [137]. Second, government interference in free-market economies, markets in which personal mobility providers operate nowadays, should be strictly limited for obvious reasons. Consequently, if personal mobility is housed under the same roof as collective mobility, it would give (local) governments the possibility to grant and distribute subsidies. This could be especially beneficial for, for example, hard to reach places in a municipality where a bus or tram route would not work, but introducing a small fleet of subsidised free-floating bicycles would solve the mobility demands. Third, since the combined system now offers a more personalised and flexible selection of transportation services, it now holds a more competitive position to owning private mobility; something which is on the radar of many municipalities since they are keen to move towards car-free city centres. In turn, cheaper, widespread subsidised services, and a more competitive position to private mobility will result in increased use of both the collective and personal mobility services. Finally, because both mobility worlds reside under the same roof, a nationwide standardised tariff system can be implemented, streamlining the payment structure.

Table 6 - Benefits 'Home sweet home'

	ALIGN	STIMULATE	IMPROVE	DEMONSTRATE
Cheaper			✓	
Allows for subsidies	✓			
Better competition to private		✓		
Increased use	✓	✓		
Nation wide tarif system	✓			

8.2.3 It takes three

Today, personal mobility is regulated by means of the APV, usually formulated per municipality. Since The Netherlands consists of more than 300 municipalities, streamlining the policies across all of them is not feasible. As a result, personal mobility providers have to adapt to different policies per municipality in which they operate. This inhibits expansion of the service being offered and gives off, unwanted or not, signs of being seen as unwelcome toward the personal mobility service providers. This is certainly regrettable given the desire to offer personal mobility on a regional scale. Right now, communication between municipalities regarding policies is done on an informal basis. It would be most convenient to streamline the policies, especially when it comes to cross-municipality usage of personal mobility.

Therefore it is proposed to move from permits towards a concession based system organised from a centralised regulatory body for both collective and personal mobility. A collection of three mobility authorities are introduced: the national mobility authority, the regional collective mobility authority and the regional personal mobility authority. The regional collective mobility authority is merely a new name for what is currently known as an 'OV-authority'. This decentralised government's purview remains the same: they still decide on, subsidise, and grant concessions to the collective mobility providers in their regions based on their own regional policies. What is new, is the addition of the regional personal mobility authority. Similar to its sibling, the regional personal mobility authority is concerned with the same aspects, however in this case it is specific to only personal mobility providers. The two decentralised authorities together make up the regional mobility authority.

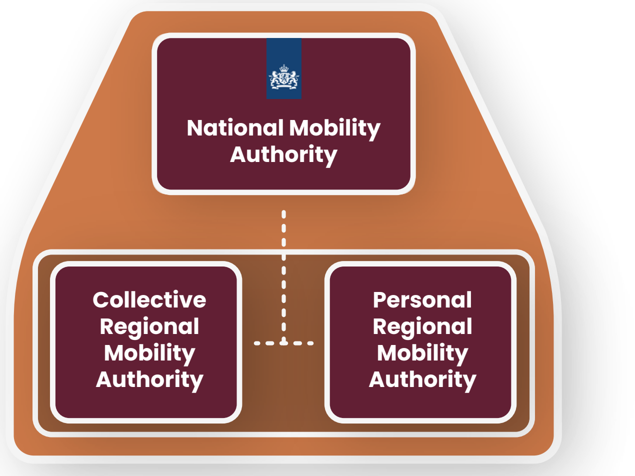


Figure 25 - Overview of mobility authorities

Benefits

Several reasons exist for organising the system in this particular fashion. The first is that it not only alleviates substantial efforts from municipalities who now need not develop multi-municipality coordinated policies next to monitoring compliance therewith (which can now be done by the regional authorities), but also alleviates efforts of personal mobility providers as they must follow standardised regional regulations. Second, the bundling of efforts, experiences and management by the collective and personal regional authorities is able to provide highly flexible, adaptable and personalised forms of mobility throughout the region—spanning wider than just the borders of the municipality. The travel experience will greatly be improved since there aren't a half dozen services offered; only a single carefully selected service per modality type (e.g. moped, scooter, bicycle etc.). Ultimately, if all regional mobility authorities opt to grant concessions to personal mobility services, nationwide coverage can be achieved.

An example is given to illustrate what this would look like practically. For instance, the four-wheeler Greenwheels and the two-wheeler OV-fiets could hold the concession for the national personal mobility services. NS would be the collective counterpart. Regionally, for example in the MRDH, the moped service Felyx and the electrified bicycle service Bondi could hold the concession for regional personal mobility services. RET and HTM would be the collective counterpart for metro and tram respectively.

Table 7 - Benefits 'It takes three'

	ALIGN	STIMULATE	IMPROVE	DEMONSTRATE
Alleviates municipalities		✓		
Standardised regulations for providers	✓	✓		
Standardised forms of modalities	✓		✓	
Unification of eperience			✓	✓
Nation wide coverage	✓			

8.2.4 Cupido

Responsibilities are now separated. The regional authorities are responsible for subsidising the collective mobility providers, personal mobility providers, and are responsible for the associated tendering and granting of concessions. The municipalities are solely responsible for environmental aspects and spatial planning.

Personal mobility is evidently more dynamic and complex compared to collective mobility, taking a larger toll on the streets of a municipality. Where, for example, a regular bus regarding spatial planning does not take up much space, hardly ever stands still, and only requires a static, relatively easy-to-maintain bus stop, personal mobilities can stand still for longer periods of time, be parked annoyingly, or where it suddenly becomes very busy in a short time, they can accumulate and pile up. These problems can be irritable for residents, shop owners, and pedestrians, but can also have a negative impact on more general topics such as the image of the city or the character of the streets. It is therefore important that policymakers in the municipality enjoy a sufficient sphere of influence in addition to ensuring that disputes are resolved quickly the moment they occur.

Benefits

That is why the portal Cupido is introduced. This is a facilitating entity that is a personal point of contact for the municipality's wishes, demands, and complaints. In a similar fashion to the vision champion, Cupido also fulfils the role of a matchmaker to ensure that the various modalities fit in the city in the best possible way.

Table 8 - Benefits 'Cupido'

	ALIGN	STIMULATE	IMPROVE	DEMONSTRATE
Easy implementation		✓		
Quick and personal contact		✓		
Extra influence to the municipality		✓		

8.2.5 Alom: central digital infrastructure

In 2023, Account Based Ticketing will replace the current ticketing scheme. The transaction is not executed locally anymore but instead is done on a central server in a virtual account where all the relevant information and travel products are stored. The potential of switching to Account Based Ticketing can be maximised by assigning a driver's license to such a virtual account of the traveller. This results in a theoretical full access to all forms of mobility since they now belong to the same family under an integrated organisational structure. This could be achieved by developing a joint check-in method. This is now practically possible because it can be included in the concession policies that are centrally arranged. After all, all forms of mobility must adhere to these agreements. Thusly, all travellers will gain access to every form of mobility throughout the country using a single virtual account via Account Based Ticketing to which a driver's license is linked and based on a single additional regulatory requirement. In such a train of thought, MaaS will be a naturally occurring result, not derived from a tunnel-visioned starting point.

All data transmitted by the collective and personal mobility providers must be centrally managed. Therefore the entity Alom is introduced. Alom is the central transaction broker tasked with processing check-in data and status of modalities and redistributing profits back to the provider. Additionally, Alom is tasked with designing the universal check-in method which will be discussed later. OV-Pay remains in force and only applies to the current collective mobility providers. On the side of the personal mobility providers, the smartphone applications still remain an alternative way of checking in. If travellers for some reason wish not to use the universal check-in method, they are free to use these alternative methods.

Benefits

The introduction of Alom and the underlying digital infrastructure accompanied by a universal check-in method brings many benefits to the table. The first is that the current developments towards the introduction of Account Based Ticketing in 2023 will go unhampered and can be implemented as it was originally designed. Second, it generates rich and valuable movement data because all transactions from all forms of mobility are now being processed by a single entity. This valuable data can provide a dynamic demand-driven supply of modalities on the street with minimal inconvenience. Furthermore, the traveller will see many benefits as well. Alom is now a single point of information retrieval, a single point of customer service, and a single point of payment. Additionally, because travellers now have the possibility to use all modes of transport, they can enjoy improved freedom of choice. Not only freedom of choice is improved, but also the ease of use since they share a universal check-in method, streamlining the experience.

Travellers are behaviourally inert and prefer the status quo. Currently, extensive use of personal mobility is still not widespread since there are many hurdles to overcome before someone actually is able to use a personal mobility service. The traveller has to install a smartphone application, must go through the cumbersome registration process, is required to fill in payment information, and must repeat this for many different services. Once that is all done, before starting a ride, the traveller has to take out the smartphone, search for the application, unlock the modality etc. One of the major advantages of the introduction of Alom is that it encourages spontaneous behaviour. One virtual account gives access to all forms of mobility, enticing the traveller to try them out without having to go through an extensive registration process every single time. Spontaneous use expands the user base, ultimately crossing the tipping point between niche appeal and mass (self-sustained) adoption. Increased use is the result.

Table 9 - Benefits 'Alom: central digital infrastructure'

	ALIGN	STIMULATE	IMPROVE	DEMONSTRATE
Current infrastructure untouched		✓		
Richer movement data		✓		
Single point of information			✓	
Single point of contact			✓	
Single payment service			✓	
Increased freedom of choice			✓	
Unification of interaction			✓	✓
Spontaneous use		✓	✓	
Increased use	✓	✓	✓	

Alom

8.2.6 Technology toolkit

The second main task by Alom is the development of the technology toolkit consisting of a token (which is named Copilot), a beacon, and a standardised digital infrastructure. These three components are developed in-house by Alom and are essential to the introduction of a universal check-in method. By developing the technology in-house, the concept is not dependent on third party devices ensuring operational stability. For example, by designing a solution with the smartphone as a central piece of technology, essentially the design is subjugated to a dependent relationship between the maker of the smartphone and the technologies present on any particular device. Not to mention the fact that when the battery runs out, the design is rendered useless.

The token is in the possession of the traveller who uses it to check-in and out to a particular modality, while the beacon is permanently installed on the modalities themselves. The beacon is designed in such a way that a new collective or personal mobility provider is able to implement the technology in a plug-and-play fashion. The personal mobility service only has to include a predetermined screen to display the necessary travel information. The digital infrastructure glues the concepts together and takes care of everything digital. The back-end is engineered in such a way that third party software companies are able to tap into the system and retrieve the minimum necessary information to provide their own travel planning services.

Although not directly contributable to the objectives of this project, additional advantages are still relevant to mention because of the achieved benefits. With the introduction of the technology toolkit, stations or busy collective and personal modality parking spaces now produce rich crowd heat maps which can be used to decrease crowding and increase traveller throughput. Another is being able to perform a more detailed check to ensure if a driver's license is legitimate since it has to be uploaded to just a single account. Yet another example is that a conductor in a train does not need to check everyone's ticket or OV-chipkaart, but can simply see if someone is correctly checked in or not as the Copilot can be triangulated where multiple beacons are present. More benefits likely exist.

Table 10 - Benefits 'Technology toolkit'

	ALIGN	STIMULATE	IMPROVE	DEMONSTRATE
Easy installation		✓		
Standardisation of technology	✓	✓	✓	
Enables universal check in			✓	✓

8.2.7 Truly seamless mobility concept

The proposed and reimagined interaction is essentially the inverse of the current situation revolving around the idea of a wireless digital handshake. Wherein the old scenario the traveller must physically present a modality-specific identifier to a permanently closed barrier i.e. gate or moped, a traveller now carries a small non-specific modality token which can be detected by a gate at the train station or by a parked shared modality if it is in close proximity. Check-in gates at the train station are now permanently open and subsequently will only close when a valid token is not detected i.e. the digital handshake cannot be made. The same goes for checking in on a personal modality. Personal modalities are permanently unlocked and turned on and will, for example, cut the power, apply the brakes, or sounds an alarm when a valid token is not detected i.e. the digital handshake cannot be made.

This inverse interaction scenario is able to remove many interruptions and obstacles eliminating stressful occurrences throughout the journey. This true seamless mobility concept ultimately delivers a remarkably comfortable and care-free travel experience which is only possible if the aforementioned strategic interventions are implemented. The concept embodiment is extensively investigated and explained in chapter 9.

Table 11 - Benefits 'Truly seamless mobility concept'

	ALIGN	STIMULATE	IMPROVE	DEMONSTRATE
Reduced stress			✓	✓
Seamless travelling			✓	✓
Mental integration for traveller	✓		✓	✓
Increased spontaneous use		✓	✓	
Increased use		✓		

8.2.8 Tackling awareness question

The proposed strategy will require the full acceptance of all the stakeholders. Even though it is backed-up by myriad advantages for all involved stakeholders, it would not be unwise to raise awareness far in advance to ease the implementation. Therefore a conceptual promotional campaign is devised to target the relevant stakeholders. The following are only examples of promotional concepts. These are only to provide a tangible idea of the message that is meant to be conveyed.

Towards the municipalities:

1 Municipality mobility awards:
The first is towards the municipalities themselves who might be benevolent or hesitant in accepting these new forms of mobility. This campaign is to inspire municipalities to fully embrace the newcomers to the mobility family and to give de mobility providers maximum room to show their potential. The idea of the municipality mobility awards instigates competitive behaviour. After all, who does not want to provide the best possible mobility?

Towards the mobility providers:

2 We ride as one:
The character of the personal mobility providers will change dramatically. This is welcomed by some, yet might not be by others. This campaign is to reassure that it is in everyone's best interest, that they are in good hands, and welcomed by everyone else.

Towards the travellers:

3 One Copilot to rule them all
Whether they are young or old, male or female, whether one uses it for work or leisure, in the end, all types of travellers must enjoy these design interventions. To enjoy the benefits, the travellers must start using it in the first place. Currently, the user group is relatively small and exists of mostly men in the age cohort of under 35 [138]. To expand the user base, and promote the new mobility system in general, a promotional campaign targeting the travellers is devised.

Figure 26 - Campaigns

8.2.9 Vision champion: Eye of Horus

A vision champion is what is currently missing in the search for the ongoing efforts of introducing MaaS or MaaS-like platforms. A vision champion is a group of creative people who take charge of communicating the vision, are those individuals who embody the key values and ideas contained in the vision, and are able to ‘walk the talk’. Effective champions are distinguished by three behaviours: conveying confidence and enthusiasm about the innovation; enlisting the support and involvement of key stakeholders; and persisting in the face of adversity. Effective champions build support for the innovation by astutely analysing key stakeholders’ interests and tailoring their selling strategies to be maximally persuasive, and by tying the innovation to positive organisational outcomes such as profitability, enhanced reputation, or strategic advantage [139].

Even though the vision champion is located at the tip of the pyramid, this does not mean that it is where decision powers are centralised—the opposite is quite the case. Within symbolism, the tip of a pyramid is generally seen as the most sacred part of the structure and holds references to the eye of providence. It symbolises a mythical figure carefully representing values such as good luck, protection and fortune. The vision champion is symbolically speaking analogous to the eye of providence. Without any legislative power, the vision champion is able to transcend all layers in the mobility hierarchy attaining support for the future vision by securing the commitment of people throughout organisations. When all stakeholders are more than willing to pitch in and help realise a vision, and will do whatever it takes to achieve that goal, the vision is securely supported [140].

Figure 27 - Eye of Horus on the one dollar bill

The vision champion is comprised of those individuals who are willing and able to transition the vision from theory into practice. Likely members of the vision champion will be the ministry, some of the largest collective and personal mobility providers, members of the Seamless Personal Mobility Lab, and a small number of senior designers with a track record of championing visions. Their tasks are communication aimed at reducing individuals’ natural resistance when they perceive that change is being imposed upon them, cultivating a greater sense of community, trust, respect and shared values in the interest of getting the job done, and enticing the public by demonstrating the vision in the form of a pop-up store or a pilot which properly communicates the imagined new values.

8.3 Validation

8.3.1 Objective

A validation session with a mobility expert from the MaaS-Lab (KNV) was organised to review the result of the Strategic Product Design master. The MaaS-Lab is a partnership of parties from the private sector that are involved in the development of Mobility as a Service in the Netherlands. The goal is to create the right preconditions for healthy and optimal MaaS services in the Netherlands. The strategic interventions were presented during a one-hour video call with the goal to see if certain elements are overlooked, where improvements might be possible, or if some elements outright would not be implementable.

8.3.2 Feedback

Legislative limitations:

The mobility expert quickly jumped to limitations regarding legislation and policies. While the mobility expert agrees on most points, some are at this point simply not possible due to current legislation. In the end, a conclusion was jointly formulated in the form of a paradox: improved positions of mobility providers would be desirable, though unfortunately not legally possible, but the legislator has not changed the law, because they do not know how it would turn out. A freer leeway in the law is desirable so that the market is able to mature.

Tariffs are more difficult than previously thought

Although this thesis has briefly discussed the integration of tariffs, they are a more difficult issue than previously estimated. Payment in itself is not the bottleneck, but it is the pricing. This is because it is ultimately up to the parties to reach an agreement. The strategy still lays a good foundation for reaching such a tariff agreement, but it is difficult to say exactly how that will play out.

MaaS concession

Originally, the idea was tendering a MaaS concession for what is now called Alom. This party winning the concession would then be responsible for developing the technology toolkit, processing the transactions, and distributing profits back to the providers. During the conversation with the mobility expert, the suggestion was made that a large foreign technology company will simply ‘purchase’ the concession when the tendering for a new concession is initiated. Because of this insight, it was decided to develop a self-organised entity which resulted in Alom.

Collective transportation as competition

One of the goals of this thesis is to shape a healthy atmosphere between the stakeholders. To do this as effectively as possible, various stakeholders were interviewed. The mobility expert indicated that there are also hesitancies among the collective transportation companies. They were not interviewed for this thesis and could have provided additional insights. Because of the breadth of the project, it has been decided to disregard these parties for now.

Confirmation

During the conversation, several undiscussed aspects of the project were implicitly confirmed. For example, the management and standards organisation Alom was described without it having been explicitly mentioned and it could be deduced from various comments that a perception change is indeed necessary because it was said that one world of mobility will take a bite out of the other’s user base (while it should be seen as a holistic whole). In the end, nothing in the strategy was identified as being totally impossible to implement.

Chapter 9

Concept development

This chapter focuses on the development of a family of mobility products now made possible by the strategy blueprint. Through a series of design sprints, it is understood how future travellers react to a seamless scenario, ultimately arriving at final design choices.

9.1 Structure design sprints

The concept development phase is split up into nine short design sprints. The goals of each design sprints is summarised below.

The interaction prototyping test makes use of a low-fidelity prototype of a scooter, train station gate, and a token to mimic the proposed interaction scenario. The test is conducted in a Wizard of Oz fashion: the interviewer is able to remotely control the setup while the participant believes that it is 'working'. The goal of this test is to see how the participants react to a non-seamless, a seamless, and a seamless scenario including possible indicator. Results lay the foundation for the remaining design sprints.

After the interaction prototyping sprint, there will be a technology toolkit concretisation intermezzo. It is imperative to understand the physical constrains the design has to consider. The appropriate UWB and PKES chips are selected and physical dimensions are given.

The next design sprints are the physical form of both the train station gate, the scooter and the token. While the emphasis is on the token, it would be remiss to leave the conceptual designs of the gate and the scooter untouched. These design sprints deliver a hint of what a gate and a scooter could look like in the near future.

Contrary to the gate and the scooter, the emphasis lies on the token. Therefore, it will undergo multiple design sprints. The first is, just like the previous sprint, the physical form sprint. Design requirements are formulated and the final shape is determined.

Before continuing to the remaining sprints of the token, it is important to develop the branding of the organisational body of Alom since it is the back-bone of the existence of the travel product. A logo, the name, and the name of the token are formulated.

The final sprint is the refinement and accessories sprints. The main goals is to understand the production costs and how the token can be sold to travellers. In the end, it is chosen to opt for a servitisation strategy in which the token is sold on a subscription basis of just 99 cents per month. Accessories are also designed in tangent with the reasoning behind opting for a servitisation strategy.

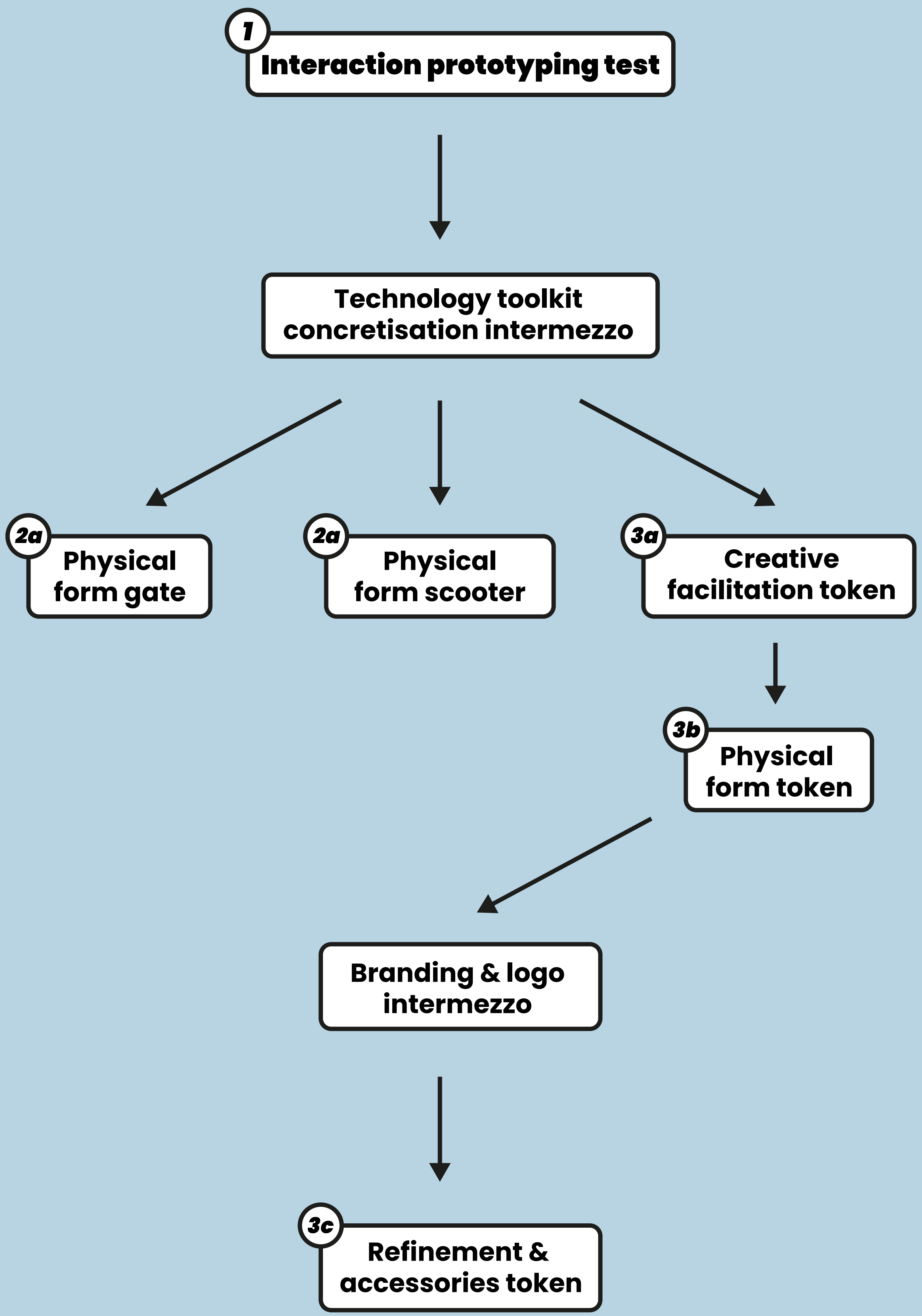


Figure 28 - Structure design sprints

9.2 Sprint 1: interaction prototyping

9.2.1 Objective

An early-stage, low-fidelity prototype intends to simulate a real-life environment and quickly test how people, in this case travellers, will experience future interactions based on the idea presented in this report. Plentiful interaction prototyping tests in the early stages of development facilitate quick learning cycles during concept development, ultimately providing interesting insights and final design requirements [141].

The assumption made in the design drivers chapter about the doctrine of 'no interaction is the best interaction' is fundamental to investigate in the interaction prototyping study. The current hypothesis is the more interactions are removed from a particular interaction, the less there is a cognitive burden on the individual. This is only logical since there are fewer actions to undertake by a traveller, and because there is an insignificant toll on the capacity of the brain. There comes a point however that when all forms of interaction are removed, the traveller may start to feel unease. It would not come as a surprise when upon the removal of all forms of interaction, levels of uncertainty or control will precipitously increase, thereby undoing the intentions desired by seamlifying in the first place. It is vital to define the minimum interaction requirements necessary as expressed by the participants performing the interaction prototyping test. Thereafter, the optimal balance can be found (see figure 29).

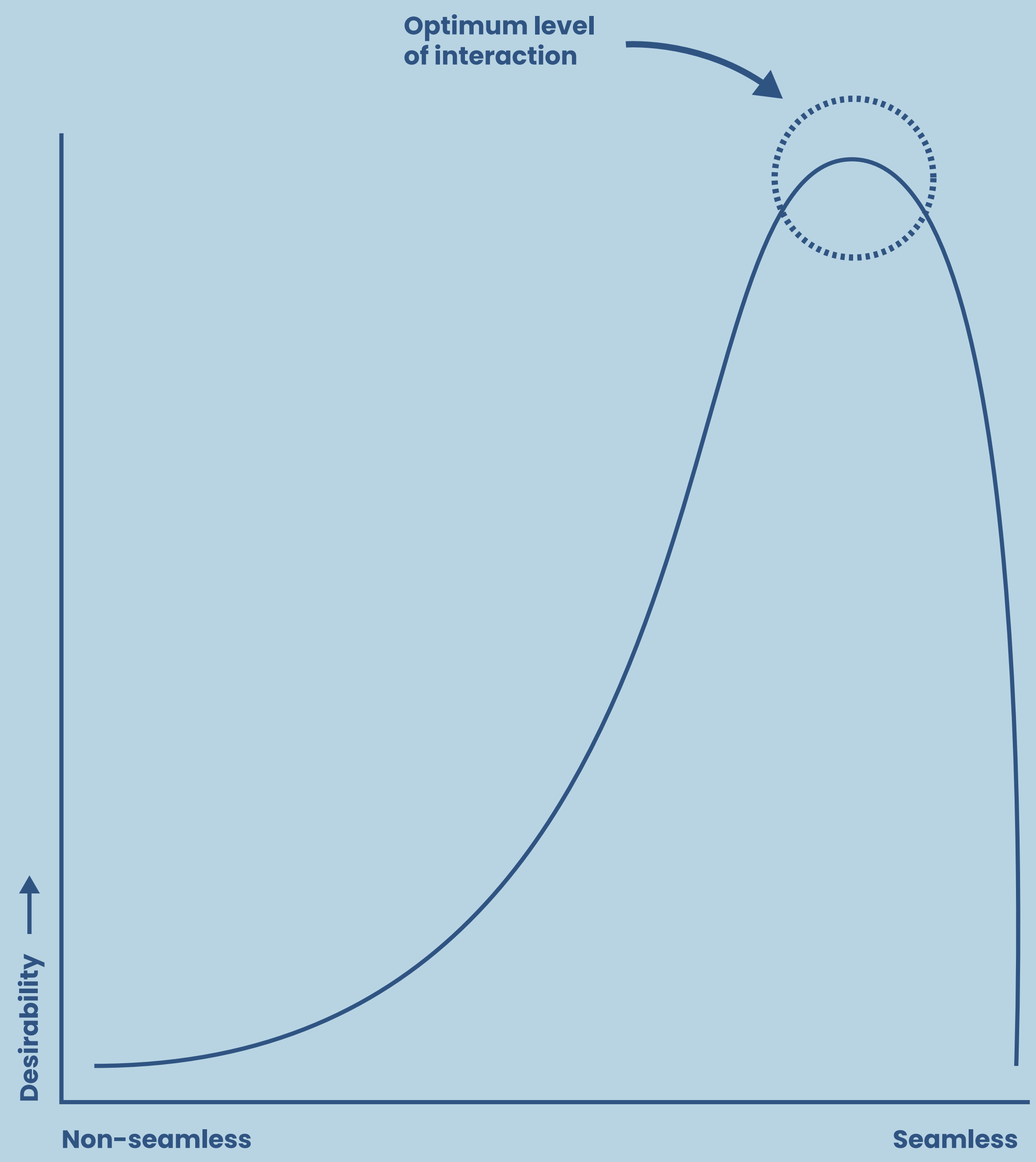


Figure 29 - Hypothesis desirability in relation to the degree of seamlessness

9.2.2 Test scenarios

The defined scope concludes that purely the check-in interaction with both types of mobility sectors provides an opportunity for the best potential to improve the travel experience overall. In order to integrate, align, and develop a meaningful seamless check-in experience for both worlds of mobility, that is collective and personal transportation, both a train station gate and a modality prototype must be fully functionally operational. Therefore a train station gate and an electrified scooter are built. For the prototyping test on both forms of mobility, three scenarios are imagined for the participant to experience: (1) non-seamless, (2) fully seamless, and (3) seamless with additional indicators. The non-seamless and seamless scenarios will be switched in the order of questioning for every new test subject. This is done to mitigate anchoring effects and biases resulting from the test structure in which the non-seamless scenario always precedes the seamless scenario. Each scenario includes a practice round, a baseline experience round, and a cognitive load round. A cognitive load is introduced to better understand where difficulties lie and what scenario is better. The cognitive load is counting down from 5000 in steps of 7. This is done to mimic a real-life scenario in which a participant may have to interrupt a conversation upon presenting an OV-chipkaart to the card reader or taking out a phone to unlock a personal moped. The entire test structure can be found in appendix 9.

Non-seamless

The non-seamless interaction consists of a setup in which the prototype mimics the current way of checking in. For the train station gate, this means that the participant must present an OV-chipkaart (or any other beforehand specified card) at the gate for it to open. Upon presenting the card, just like in the current real-life situation, a beep will sound, a green light will be displayed, and the gate will open. After a fixed amount of time, the gate will close again. For the shared modality, the participant must take out their phone and mimic the steps which are usually undertaken to unlock a shared modality: taking out a smartphone, opening an app, zooming in on a location, tapping modality, unlocking etc. The participant will call out 'unlocked' upon which the interviewer will unlock the scooter wirelessly from a distance. In turn, the scooter will produce an unlock beep and turn on the display light. The participant must first press a button to start the motor in order to drive away. All these steps for both setups imitate real-life interactions and are based on the observations made earlier in this report.

Fully seamless

In the fully seamless interaction scenario, the participants are first given a keychain with some electronics, imitating the wireless token. The fully seamless scenario removes all steps of interaction. This means that the gate is always open, and the scooter is always unlocked. Sounds, lights, everything else is turned off. If the participant however gives back the token and tries to repeat the interaction, the observer is able to wirelessly shut the gate and turn off the scooter.

Seamless with additional indicators

In the partial seamless interaction scenario, the user must carry the wireless token only in this case there are extra indicators for the user to determine whether or not they are checked in. For the gate, this includes introducing a beep, a simple light, or an adaptive light (increasing light determined by the distance from the gate), and for the scooter, this includes introducing a beep, a light, or a username on the display. The wireless token itself also includes an indicator light. Throughout the test, several combinations of indicators are turned on. This is done to understand the level of trust, certainty and control the participants have to determine if they are checked in correctly and to determine whether such additional indicators are required in the first place.

9.2.3 Test setup

Seven participants were interviewed totalling a little over four hours of video material. Of those seven participants, two were female and five were male. Four have never used a shared modality before but all have seen someone else go through the process of unlocking a personal modality. All participants felt that the prototyping test setup felt fully representative interaction-wise except for the unlocking process of the scooter being faster than usual—which in turn will provide better insights as the prototyping setup is an ideal representative scenario. During the observations as discussed in chapter 4.4, it became clear that the current user group of personal modalities is both under thirty years of age and is predominantly male. The seven participants are therefore a representative group of individuals. Finally, it was made sure that all participants did not have any design-related expertise.

Figure 30 - Interaction prototyping token worn by participants

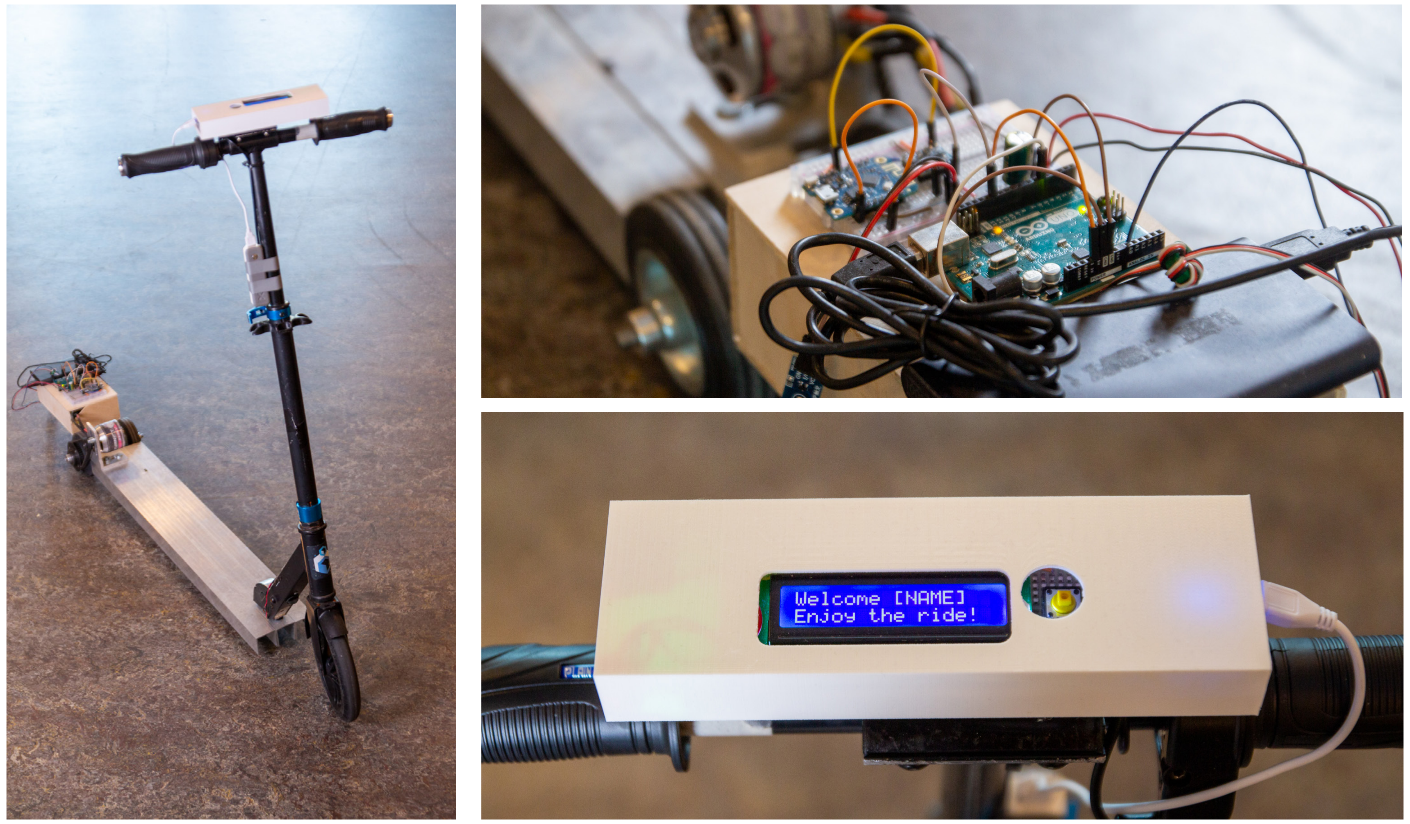


Figure 31 - Interaction prototype scooter

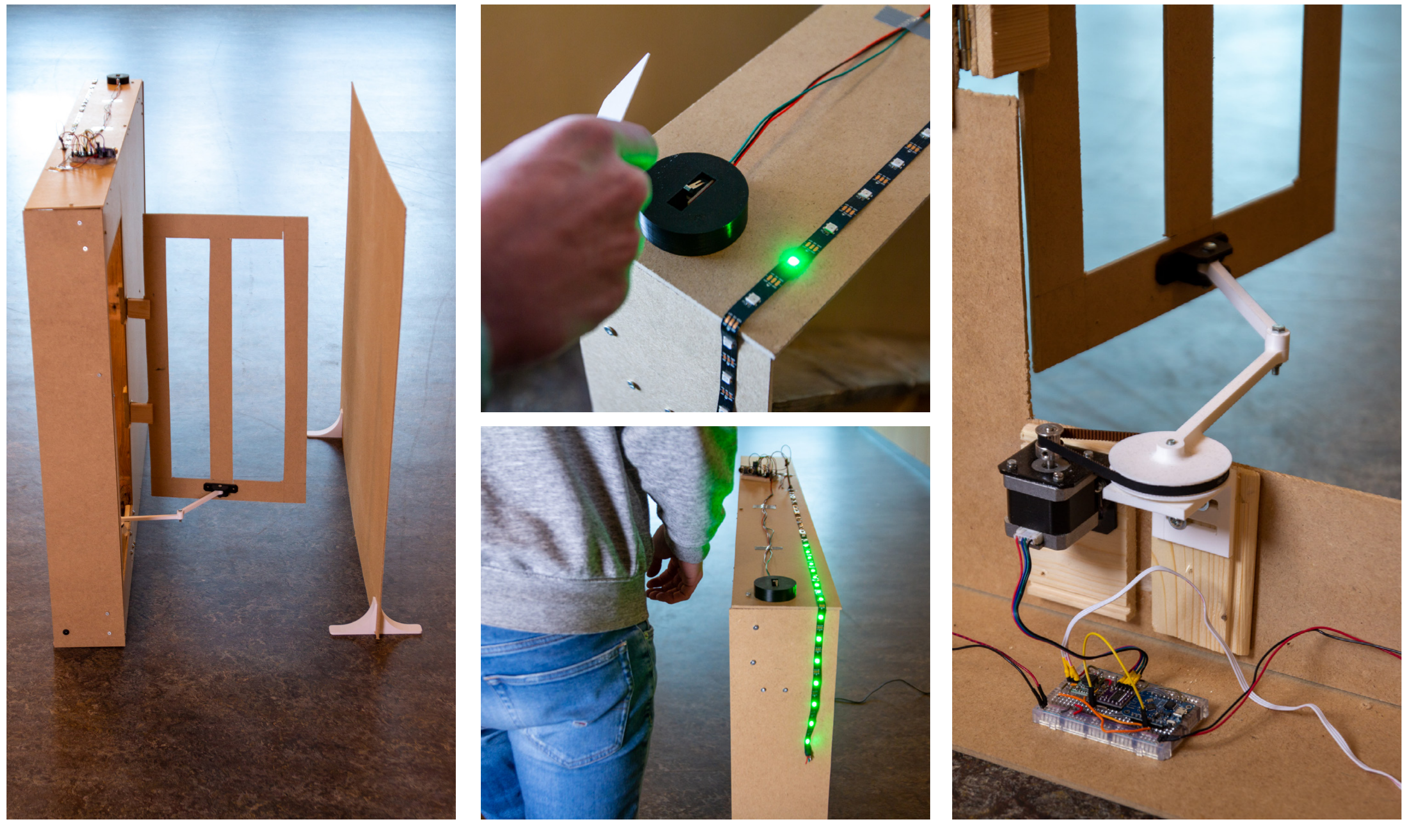


Figure 32 - Interaction prototype gate

9.2.4 Results

The results of the interaction prototyping test will be discussed in the following order: (1) general insights of the seamless versus the non-seamless scenario, (2) the static indicator versus the personal indicator (discussed per modality type), and (3) the token indicator. Subsequently, extra insights and design decisions are discussed before continuing to the second design sprint.

Non-seamless versus seamless scenario

One insight became abundantly clear from both the observation and from the remarks of the participants comparing the non-seamless to the seamless scenario: the former is unanimously and unequivocally recognised as the favoured interaction scenario. During the cognitive load task in the non-seamless scenario, participants were experiencing high levels of stress, tensions, and annoyances, and experienced difficulties in interacting with the test setup. One participant mentioned jokingly that he was trying to enjoy his vacation indicating that the cognitive load while trying to check in was everything but a simple task. Performing the juxtaposed seamless scenario right after the non-seamless scenario instantly prompted a participant to describe the removal of all interactions as a 'walk in the park'.

Non-seamless: 'I'm trying to enjoy my vacation!'

Seamless: 'Walk in the park.'

This is good news for the project, but all is not rosy in learning about the behaviour and remarks of the participants. Several concerns were identified during the test. The first is that participants experienced more difficulties during the cognitive load task in the non-seamless scenario whilst trying to unlock the scooter compared to opening the gate. Most participants described opening the gate, even during the cognitive load, as not too much of an interruption compared to the scooter. Using the gate almost daily produces muscle memory, easing the process into an accustomed procedure. This indicates that the introduction of a seamless scenario will mostly benefit unlocking the less familiar personal modality. Still, interactions during cognitive load task in the non-seamless scenario are not without hick-ups. Participants could not present the card while counting down and only presented their card during a pause or after finishing a subtraction. These observations are in line with the sudden ceasing of a conversation just before presenting the card as discussed in the full travel observation in chapter 4.5. Though to a lesser degree, a seamless interaction will improve the check-in experience at the gate. Furthermore, most participants pointed out that a seamless system without any form of feedback would be undesirable. Finally, one of the goals of this project is to integrate the two mobility worlds and provide a streamlined experience. Participants pointed out during the seamless scenario that because they are now able to check in using a single device, in this case, the UWB+PKES token, they feel that the two worlds of mobility as they currently exist are better connected and integrated.

'With this thing [token], it does feel more connected. Now I have a kind of all-ride card. A super ski so to speak.'

Several participants expressed some doubt about a continuously open gate without any form of feedback during the seamless scenario. They questioned if it would be safe for children or the fact that they might have to swerve unexpectedly. The responses were mixed with some pointing out that a non-closing gate without feedback during check-in is not sufficient information to determine that the system is working. The state of being checked in on the scooter results in physical movement, whereas the state of being checked in using the gate produces an inverted actuation—the gate is not moving. The gate opening upon approach could very well produce a logical stimulus for a traveller to determine that they are checked in. Unfortunately, a closed gate is visually a strong anti-seamless cue, something which is not desirable. Then again, some participants pointed out that because nothing happens, they would interpret the system as working. It would not be hard to imagine travellers getting used to the always-open gate after just a couple of interactions.

'Basically, it's a bit of getting used to that you just know that the gate will close if you don't have it.'

Indicators during the seamless scenario

Let us first discuss the non-personal indicators on the gate and the scooter. Participants sometimes interpreted the buzzer as if they did something wrong or as a warning that the system is malfunctioning. This reasoning is not unintelligible and poses the question of whether some form of feedback in a fully seamless system is always negative? One participant said out loud 'What is happening?' upon hearing the beep while walking through the gate. Another participant mentioned that the beep was interpreted as the scooter not being able to find the token and therefore giving three beeps. Finally, a participant exclaimed that they were going through a metal-detection gate at the airport as if the participant was carrying something prohibited. Little imagination is required to also make the supermarket conveyer belt metaphor—experiences not desirable by any stretch of the imagination. Mixed reactions were associated with the light on the gate. Even though participants expressed that some form of feedback is preferred to determine their check-in status as the gate itself is not moving, they continuously kept an eye on the light, indicating that it still is a small visual distraction. Better yet, a small light might induce a spontaneous endogenous interruption at a later stage in the travel journey because the traveller has unconsciously seen the light and therefore might not be sure, questioning whether it lit up in the first place. This type of interruption is currently present at stations where check-in poles instead of gates are present. A light on the scooter was seen as somewhat positive as it gave travellers certainty that the modality is turned on, something quite useful as an indication in traffic regarding safety.

Gate: 'I feel like passing through a metal detector.'

Scooter: 'The beep does distract a little bit.'

The personal indicator at the gate resulted in more positive responses compared to the non-personal variant discussed above. Participants describe the personal adaptive light as less obtrusive, a better balance, and even as 'it feels like a breeze'. Some did not see the added value of an adaptive light compared to a single light or it being off. The aforementioned observations concerning the non-personal light can likewise be made for the personal light as it remains a visual (latent) distraction. As far as the personal light and text on the scooter, all participants were overwhelmingly positive as it increased the feeling of the device belonging to the traveller which in turn increases the feeling of certainty and trust—especially in a crowded parking spot with multiple tokens in the vicinity. Participants questioned who would be checked into which scooter. Some did question privacy concerns, however, all mentioned that it would be a matter of getting used to.

Token indicator

The indicator light on the UWB + PKES token was the last form of feedback discussed during the test. In conclusion, it was welcomed as a valuable addition. The indicator light on the token gave participants extra levels of certainty as they could verify being checked in anywhere. This could especially be useful the first couple of times using the token lowering the threshold of gaining trust in the system. Checking the token was correctly identified as an interruption by participants, though participants also mentioned that they would ignore the token—and the other indicators—after having used the system a couple of times. One interesting remark is that having an indicator on the token flips the interpretation of the system; now a personal device knows about the modalities instead of the modalities knowing about the token. The former is concerning privacy psychologically superior.

'If you use it 5 times a day, you will trust it at some point.'

Extra insights

The interaction prototyping test was quite extensive which resulted in extra insights. The interaction with the scooter felt less familiar not only because the participants do not have as much experience compared to the muscle-memory-like interaction with the gate, but also because the companies operating the shared modality service are mostly new entrants to the market. These companies have not had the time to build a meaningful relationship with customers, resulting in lower levels of trust. In addition, because the interaction is in the seamless scenario mostly hands-off, participants mentioned that the responsibility of being correctly checked in is transferred to the operator. Finally, it was observed that using an electrified personal modality generates smiles! All participants enjoyed the ride with some not wanting to stop. This joy is something which currently is not experienced by the vast majority of travellers as they do not have immediate access to all current shared modality services.

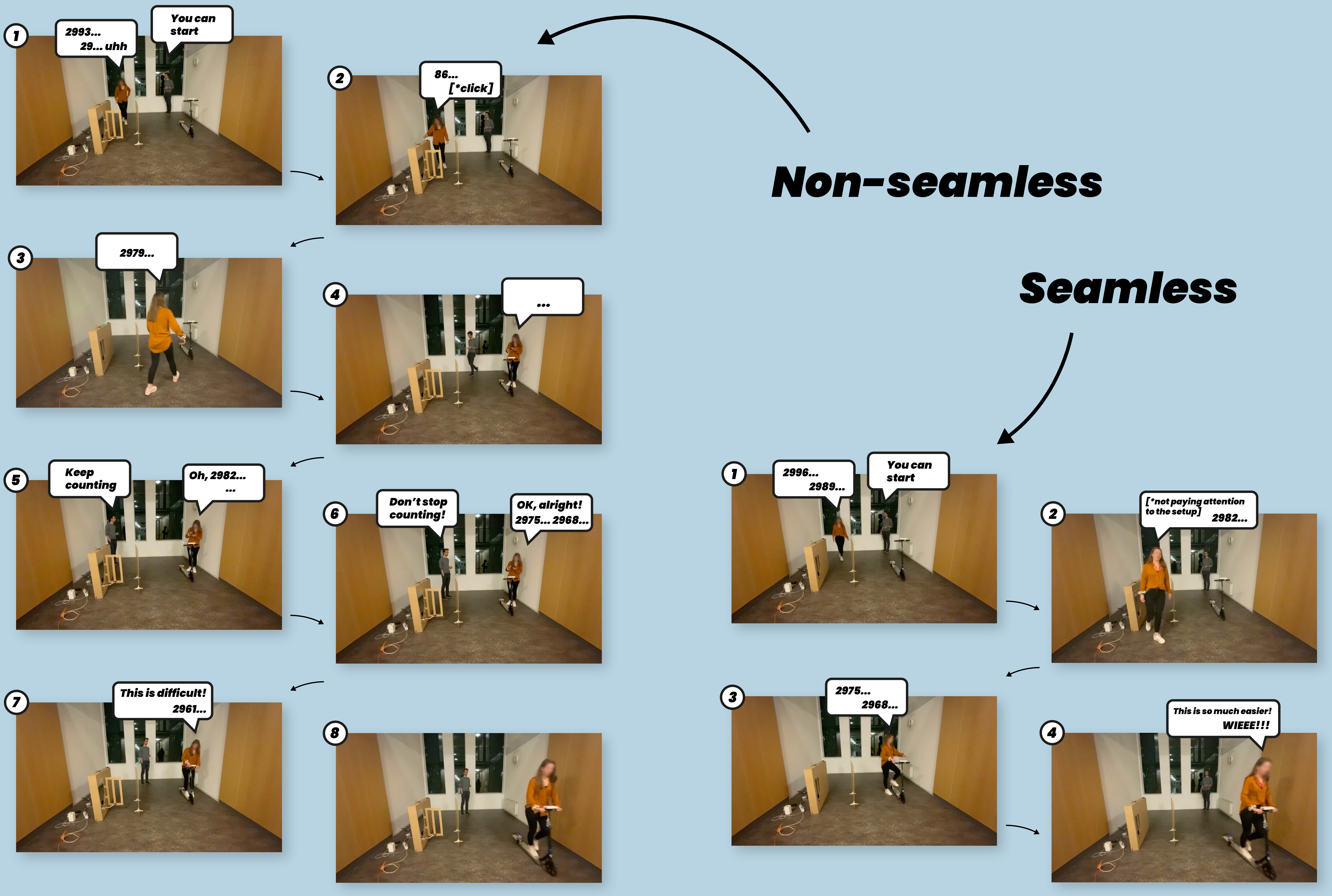


Figure 33 - Participant reaction non-seamless versus seamless

9.2.5 Conclusions design sprint 1

Coupling back to the hypothesis

The hypothesis made earlier in this chapter could be approached as a form of type-1-type-2 error. From the interaction prototyping test, it became clear that the optimum as highlighted in the graph is a highly personal aspect. One cannot possibly satisfy everyone's individual preferred interaction scenario without it having a negative effect on the preferred interaction of the other. As a designer, a realisation is present that a portion of the travellers will not be fully satisfied. Arguably, the negative sentiment of those not willing to adopt the proposed interaction scenario diminishes over time as people will get used to the system, but for those who for whatever reason still feel left out, legacy options such as printed tickets and the regular OV-chipkaart should still be compatible. With this reasoning in mind it is opted to design the system, not to the non-seamless end hypothesised peak where more people will likely adopt the interaction scenario as it will become more familiar, but more to the seamless end including legacy support.

Decisions

Figure 34 gives an overview of what was tested and what is preferred. A red cross is not favoured, a green tick is favoured, and an orange dash means there were mixed results. As discussed above, mixed results will be interpreted as not favoured or which should be made invisible as much as possible.

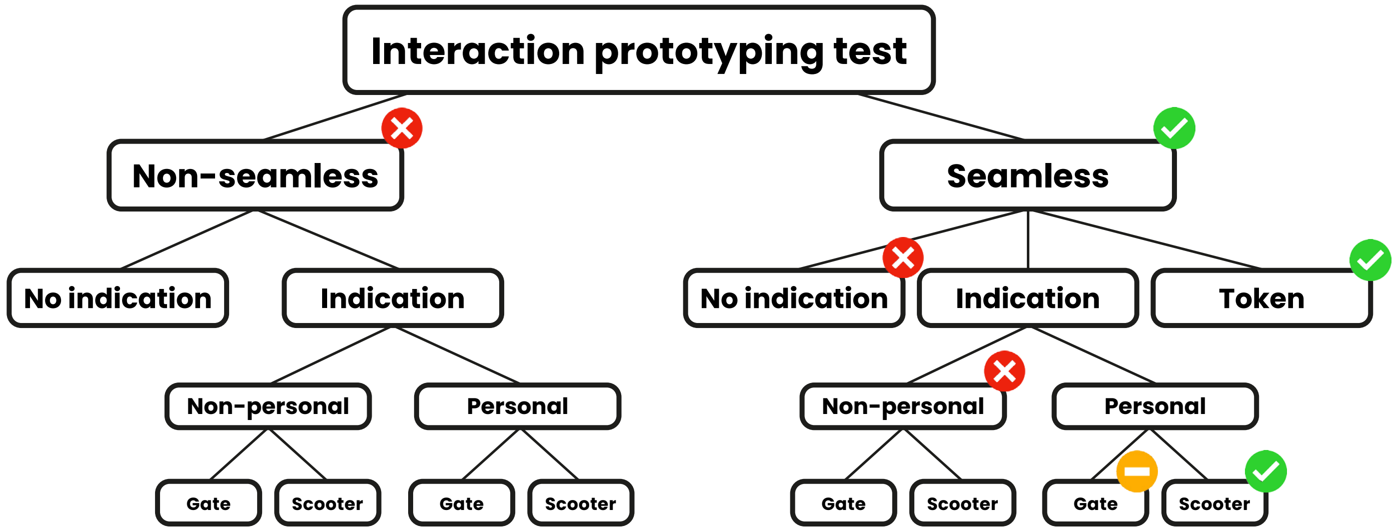


Figure 34 - Result overview of interaction prototyping sprint

Some concrete decisions can be made from the results of the prototyping interaction test. These decisions are listed below including a short explanation as to why.

1 No short beeps or quick lights anywhere
- Too much of an interruption
- Interpreted as something negative since the system is without interactions
- Upon hearing the check-in beep at the scooter, lower level of control on how to turn it off
- If partially observed it induces endogenous interruptions later in the journey

2 Do include the personalisation indicator on the scooter
- People feel that it is more 'yours'
- Higher feelings of trust that you are paying and not someone else

3 Do include an almost hidden personalisation indicator on the gate
- It provides a clue that the gate is turned 'on'
- Must provide a subtle indication for those who wish to determine if they are checked-in
- Must be completely hidden for those who would like to remain undisturbed

4 Do include light on token
- Lowers the threshold to get used to the system
- The possibility to check enhances confidence
- Even though it is still an interruption, it increases trust
- Different types of modalities feel more connected and integrated

5 Do include an application as a supportive feature
- Same reasoning as the previous point
- Ability to add user customisable notifications if desired

Conclusion design sprint 1

Sprint one is concluded. The decisions and insights provide a good understanding of where the three separate concepts are heading. To summarise: less change is required on the personal mobility side whereby only the addition of a personal indicator suffices, the gate is on the other hand a different story requiring more drastic changes. The token is welcomed as a valuable addition with just a simple LED indicator and provides psychological integration of the mobility worlds.

9.3 Technology toolkit concretisation intermezzo

Whereas the first design sprint was specifically focused on traveller behaviour concerning the gate, scooter, and token in multiple scenarios including various indicators, the second design sprint will concentrate on the physical embodiment of both the gate and the scooter. The third design sprint will be reserved for the token. One has to understand which specific components are to be implemented and what their specific requirements are. Questions such as ‘What is the size of the components?’, ‘What are the power requirements?’, ‘Do certain components require a specific place in the product?’, ‘What are the requirements regarding material properties of the case?’ must first be answered before even an attempt is made to start the physical form design sprint.

The strategy as discussed in chapter 8 proposes Alom to develop a so-called technology package. The package includes a beacon, a token, and the accompanying digital infrastructure with the purpose for mobility providers to quickly implement the technology following a plug-and-play philosophy. These items of the technology package are fundamental for the concept. Therefore a more concrete understanding of these components including limitations are important to define. To do so, reference chips both PKES and UWB technologies will be selected based on already implemented analogous applications. For PKES, the TMS37F128 [142] chip is selected as it is currently used in a PKES enabled car. For UWB, the Qorvo DWM3000 is selected since it is specifically designed and developed for automotive applications [143]. The TMS37F128 and the Qorvo DWM3000 use the TSSOP-DBT and the QFN40 package respectively. They are just under seven by ten millilitres in size for the former [144], and five by five for the latter [145]. Even accounting for some space for a standard CR2032 coin-cell battery in the case of the token or power input in the case of the beacon, space allocation for the antenna, and factoring in the PCB and other small components, the overall size of the PKES + UWB device would not be much larger than a standard car key-fob. Specifically determining the actual size would be too intensive of a task requiring specific electrical engineering knowledge. Ballpark dimensions are sufficient. In addition to dimensions, the device must be enclosed in a housing which does not produce a Faraday cage and the chips require low voltages, typically in the range of a CR2032 coin-cell.

The technology package which is developed by Alom consists of three distinct elements: (1) the token, (2) the beacon, and (3) the digital infrastructure.

1. **Token**
   The token is a personal device carried by travellers at all times. It is developed and produced in-house. When a consumer purchases a token, they are immediately able to use all connected modalities from the mobility providers.

2. **Beacon**
   The beacon is the device handling the check-in status of travellers. It is developed and produced in-house and permanently installed on a modality. It is designed in such a way that the mobility providers are able to quickly implement the beacon in a plug-and-play fashion, instantly enlarging the user base.

3. **Digital infrastructure**
   The digital infrastructure is the back-end software solution tying the token and the beacon together. The infrastructure must be designed in such a way that mobility providers are able to simply tap into the system while preserving their own method of checking in and out

This chapter provides a clearer explanation of the three components of the technology package as proposed in chapter 8.2.6. With the possibilities and limitations in mind is it time to proceed to the second design sprint.

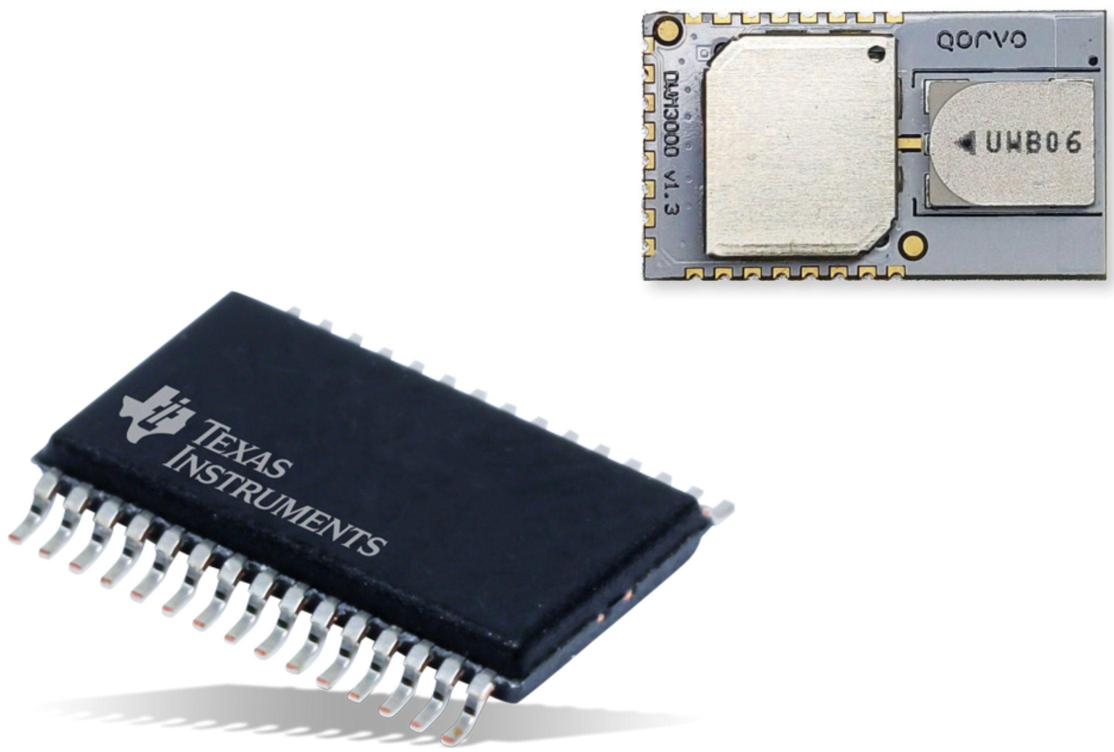


Figure 35 - PKES (left) and UWB (right) chips

9.4 Sprint 2a: physical form gate

9.4.1 Objective

The emphasis of concept development will be on the token, not the gate (nor the scooter for that matter). It would be remiss if the physical embodiment of the gate would go untouched as it does provide a more holistic and tangible picture of the family of products. One must not regard the physical embodiment of the gate as something final or as directly implementable, but more along the lines of giving a hint of what it could be. Ultimately in the utopian scenario, the gate would not even exist as travellers are located by the token and checked in upon entering a collective modality i.e. train, tram bus etc. This embodiment design sprint will only provide a product which would function as a transitionary, or placeholder, part of the system. With all that being said, some argumentation is given for design decisions, however, they are not as extensive nor well-substantiated compared to a project where the design of the gate would be central.

9.4.2 Chosen concept

In total, four concepts were designed. Figure 36 shows the selected concept. The remaining concepts can be found in appendix 10. The selected concept is mostly based on the current gate although the design is altered to be better suited for seamless interaction. Several design changes are introduced with the first being it for the most part made out of (plexi-)glass giving it a transparent, open and invisible character. There is still a gate present, however, it is seamlessly integrated as only a very small hinge is required. The aluminium frame on the bottom acts as an invisible hinge which is seamlessly tucked away when closed. In addition, in line with the vision and the results of the interaction prototyping test, an adaptive LED strip is located near the feat of the traveller. It is green when everything is working as intended and will turn slightly brighter at the location of the traveller. If the traveller is not carrying a token, it will first become orange indicating no digital handshake can be made. If an individual is trying to fare-dodge, the LED strip will turn red and the gate will subsequently close. A legacy check-in method can be presented inside the closed portion of the gate.

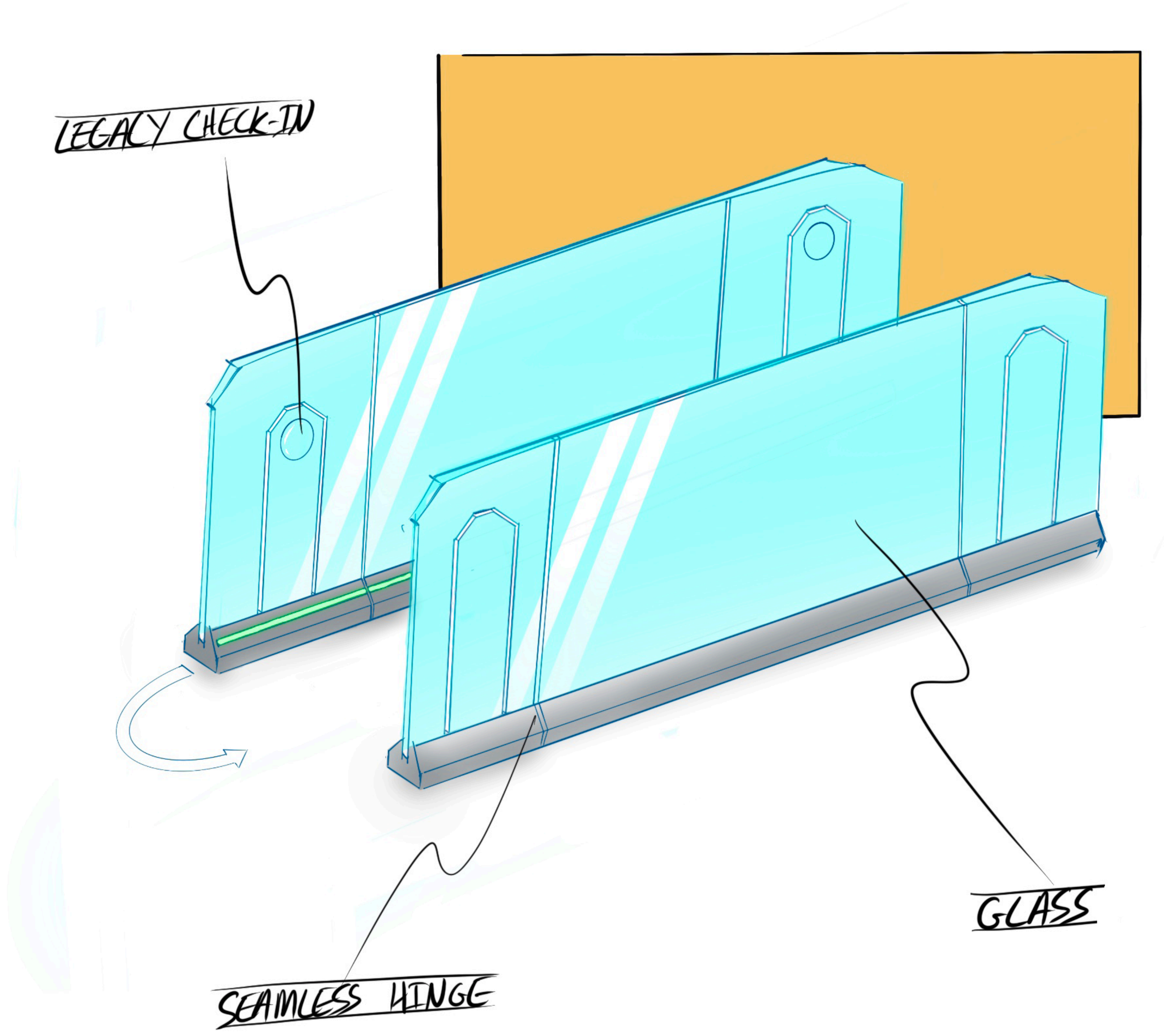


Figure 36 - Sketched seamless gate

9.5 Sprint 2b: physical form scooter

9.5.1 Objective

Similarly to the argumentation given in the second design sprint of the gate, the emphasis of concept development will be on the token, not the scooter. Again, it would be remiss if the physical embodiment of the scooter would go untouched. Even more pressing compared to the previous sprint, a scooter does not leave too much room for major design changes as the modalities themselves are heavily regulated by law and international standards regarding their physical form. In addition, the design of the personal modality itself is naturally chosen by the mobility provider themselves. Therefore only small additions can be made to the interaction with personal modalities. Luckily, small additions may only be required as concluded by interviews with participants in the first design sprint. Then again, with all that being said, some argumentation is given for design decisions, however, they are not as extensive nor well-substantiated compared to a project where the design of the scooter would be central.

9.5.2 Chosen concept

Only a single concept is chosen for the scooter. It is loosely based on a modern car media centre where a smartphone is able to take over the user interface upon connecting it with a cable. On the scooter, there will be a predetermined small screen capable of displaying basic information—as can now be required by the concession. If a Copilot is detected in the vicinity, the Alom digital infrastructure takes over control of the modality itself and the user interface. It can immediately, without traveller interaction, be used in the reimagined seamless scenario. If no Copilot is detected in the vicinity, the scooter can be unlocked using conventional methods already in place by the service provider operating the modality.

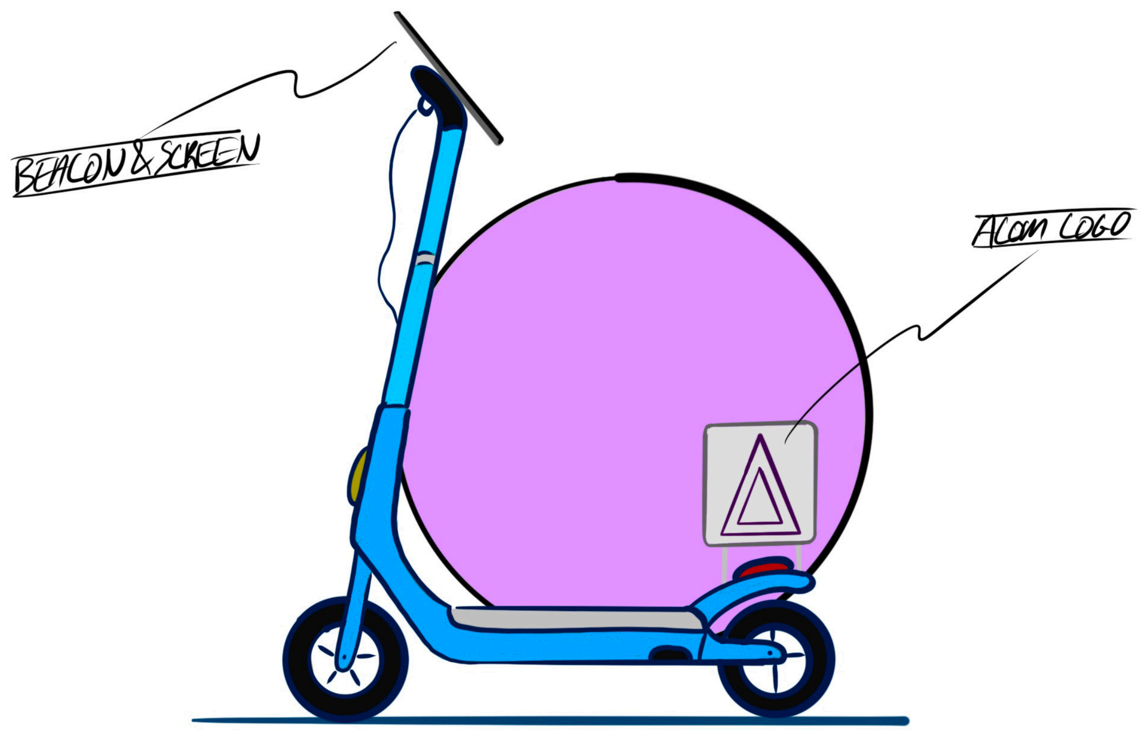


Figure 37 - Sketched seamless scooter

9.6 Sprint 3a: creative facilitation session Copilot

The token is the centrepiece of the technology package requiring careful design considerations and is therefore subject to multiple design sprints. Whereas the gate and the scooter were based on a short, single design sprint, the embodiment token design sprint will include a creative facilitation session, an embodiment sprint, and a refinement session.

9.6.1 Objective

The purpose of the creative facilitation session is fourfold: (1) to combat any arisen or dormant tunnel visions which likely developed over the past months, (2) to get an outsider's perspective indicating missed opportunities or unseen solution spaces, (3) to maximise the creative input as the session will invariably produce crazy ideas making room for novel solutions, and (4) to spark me as a designer in these final stages of the project.

The session itself lasted a little under two hours in which five participants partook. The session started with a short introduction about the contents of my project, the goal of the session, and for those who had never participated in such a creative session, what is expected from the participants (e.g. 'yes, buts…' are not allowed). The creative facilitation session started with the opening question 'How might you get people to carry something permanently?' after which several techniques and methods were executed. Several concepts were presented at the very end by the participants themselves. I took on the role of the facilitator. This implies that, as a facilitator, I am there only to provide support and keep the energy high. Giving input, swaying people into possible design directions, or writing anything on post-its is strictly forbidden.

9.6.2 Results

Two concepts presented by the participants at the very end of the session proved to hold valuable insights. The concepts are named 'integrated card set' and 'mag-check' and will be discussed below.

Integrated card set

Some participants were pondering the question of why the government issues multiple identification cards. Since it all comes from the same entity, that is the central government, why would one not want a driver's license, boating license, identification card, passport, public transportation card etc. integrated into a single card instead of carrying multiple cards around? The participants envisioned a new card which would combine the aforementioned cards into a single card including the technological possibilities presented in this report.

Mag-check

Other participants were more focussed on the way in which travellers are able to carry the token itself. No specific interest was directed to the shape of the token itself, but more towards the interchangeability using magnets. The participants imagined a built-in magnet which would snap to pieces of clothing, backpack straps, phone cases etc. where another magnet is present. This concept is mainly derived from a modularity underpinning which makes the token adapt to the user, instead of having the user adapt to the token

Session in general

General conclusions may also be drawn from the creative facilitation session. The first is the vast number of solutions as to where to carry the token. Everyone contributed many different ideas and listening to the conversations during the break and the end of the session, it can be concluded that there is no single location which is ultimately the best place to put the token. What was particularly interesting is that, considering the question was phrased openly, and the fact that the facilitator was not allowed to intervene nor steer the session, most solutions were more directed toward where the token should be hidden, carried or put, instead of aspects such as overall shape, material choice, and general ergonomics. This could indicate that the participants were not interested in the shape itself. Cognitive ergonomics, such as remembering to grab the token or trying not to lose it, were apparently much more valuable than, for example, specifying the roundness or the material of the token. In the end, the session was not only fun, which was also pointed out by the participants, but it initiated the creative process for the final design sprint.

Figure 38 - Creative facilitation sessions

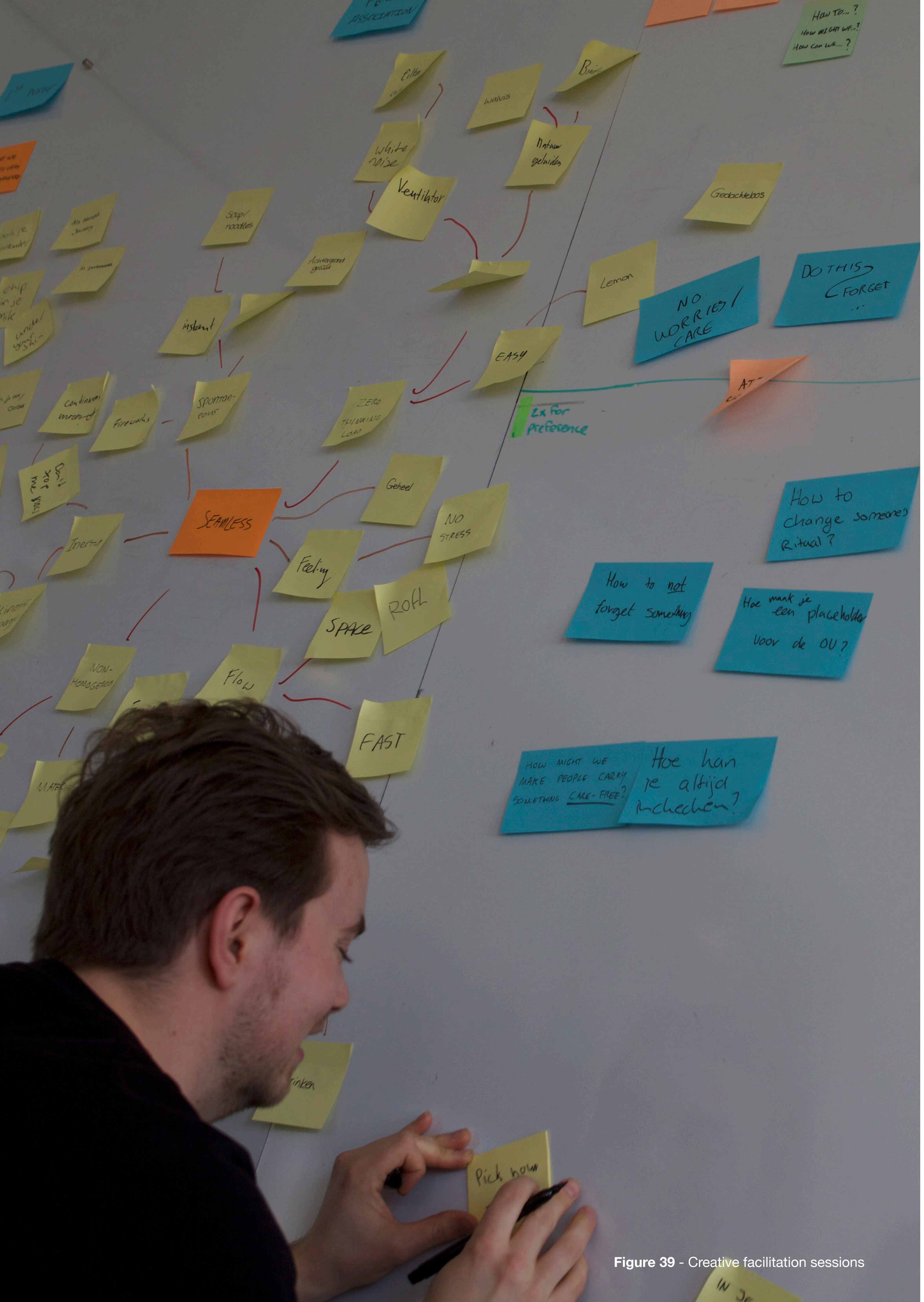


Figure 39 - Creative facilitation sessions

9.7 Sprint 3b: physical form Copilot

9.7.1 Objective

The following design sprint focuses purely on the physical form of the token itself. Design requirements are formulated which must be in line with the technical design requirements as formulated in chapter 7.3. Several concepts are prototyped, considered, and evaluated by users, ultimately resulting in a final physical form.

9.7.2 Design requirements

A checklist will be used to design and assess aspects of the final product. The purpose of the checklist is to make sure vital product aspects are not overlooked. It includes 24 categories of which 12 will be untouched for the scope of this project. The remaining categories will be discussed in appendix 11 from which design requirements are formulated below. In addition to formulating design requirements, Pugh's checklist helps to find currently unconcerned aspects of the product [146]. It is worth mentioning that formulating a list of requirements and wishes is usually done for products ready to be produced and are not intended for conceptual products. The token lives somewhere in between these states of being conceptual and production-ready meaning that requirements and wishes will be concretised to the degree that it still is relevant.

Requirements:

- The token includes a small LED to signal the check-in status of the traveller.
- The token must adhere to the IP65 water and moisture resistance rating.
- The life of service is ten years at a minimum.
- A CR2032 battery must be housed inside the token
- A single CR2032 battery must be able to power the token for a minimum of one year.
- The CR2032 battery must be user-replaceable.
- The system must be operationally reliable 99,99% of the time.
- The token should not cause discomfort to the user at any time.
- The material of the housing must not create a Faraday cage.

Wishes:

- The price must be as low as possible.
- The token must be produced as quickly as possible.
- The product must be as small as possible.
- The product must be as light as possible.
- The design of the product should be in-line with the core principles of the token's function as much as possible.
- The physical form of the token must be as versatile as possible for travellers to carry it in a way they see fit.

To investigate:

- Physical shape
- Battery status must be notified to the user in some way or another.
- The way in which the battery is replaced is currently ambiguous.
- The inclusion of a redundant check-in method e.g. a legacy OV-chipkaart.

9.7.3 Investigating physical shape

Several possible shapes are 3D printed. An overview of all the shapes is given in figure 40. The printed shapes are actual shapes which could house all the electronics. They are a (1) credit card (only this design includes the redundant OV-chipkaart), (2) a smaller credit card, (3) an elongated and stretched card, (4) a flat circle, (5) a double PCB-layered design, (6) a cylinder with all the components stacked, and (7) a rectangular shaped design similar to design six.

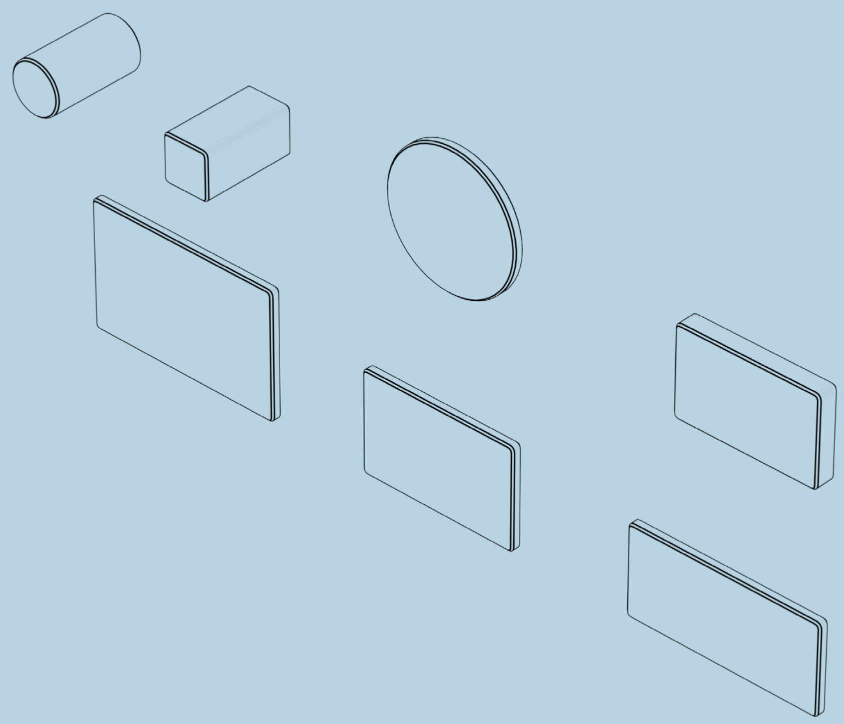


Figure 40 - Possible physical shapes

One thing became instantly clear after having printed all the shapes. Even though they are volumetrically similar, a thicker design instantly feels bulkier. A slim design not only feels smaller and lighter, but also aesthetically matches the core design characteristics.

In addition to the bulkiness effect, something more magical happened. The moment the credit-card design was picked up, it somehow just felt right. It made sense, and for the life of it, I couldn't figure it out. It felt like I had access to stuff, and was able to do things with it. It dawned on me that my brain made several heuristics in that particular moment of picking it up for the first time. Subconscious associations such as checking into a hotel room, paying for items in a shop, showing an ID to enter a club, and gaining access to public transportation were instantly connected to a rather simplistic white 3D printed shape. As was discussed in the very opening of this report (see chapter 2.1), the goal is to remain in a system-1 brain state which is based on heuristics, associative memory and effortless reasoning. The credit-card shape is aligned with these principles and it would not be wise to deviate from mentally ingrained associations which people have taken without much thought for, sometimes, decades. The elongated shape was less aligned, and the circle felt to some degree almost 'alien'.

Before the decision is made to pin the design to a credit-card shaped token, it was first validated. All designs were put on a tale which was pontifically placed in the faculty with a sign next to it saying 'Help me out here…'. Four questions were asked in total: (1) Which of these shapes gives you the feeling that you have access to modalities?, (2) Which of these shapes would you prefer to carry with you?, (3) Where would you carry it?, and (4) Why? Participants had to note down their answers on a sticky note. In addition to a half dozen informal conversations with students, it was confirmed that the prevailing opinion was that indeed a credit-card shaped design just 'felt rig

Figure 41 - Evaluation physical shape

Next in line to tackle is the redundancy conundrum. It surely adds more functionality to the card, yet is it desirable? The advantage of the extra functionality must be weighted against the lost advantages provided by the other contenders. First and foremost, the added functionality will be used sporadically since the token is designed to be almost 100% operationally reliable. In addition, the back-end of the public transportation system is transitioning to the Account Based Ticketing scheme (as discussed in chapter 2.3) which will allow a smartphone or bank card to essentially function as a backup. Furthermore, more components in a design result logically in higher development and production costs. Thusly, if the extra redundancy functionality is removed, the design can be smaller as it does not have to carry a standardised antenna coil and is cheaper as multiple components are not needed anymore. Finally, doesn't including a redundant check-in method scream anti-seamlessness? Carrying something with backup implies that the backup might be needed at some point and therefore the traveller is subconsciously reminded during checking in that the backup might have to be used. The choice is made to further develop the token as a smaller sized credit-card.

In the same train of thought regarding the battery indicator, indicating a low battery prompts the user with latent thoughts about it running low. A small speaker that starts beeping, such as when a smoke alarm is running low, could be seen as a constant interruption. Having the battery indicated on the modality itself elicits privacy concerns as pointed out during the interaction prototyping tests. Therefore is it chosen that the Account Based Ticketing scheme is leveraged: the battery status is included in the transaction while checking in to a modality. When the battery in the token is running low, the traveller will be notified via their account e.g. email, smartphone notification, or text message.

The battery is housed in a small tray housed inside the token. It is held in place by simple snap-fits: a common assembly method used to hold two pieces of plastic together. The user is able to replace the battery by removing the tray and simply sliding it back in upon which the token will have power for at least another year.

For the time being, figure 42 shows a conceptual representation of the design. Several aesthetically elements are added such as curvature continuous fillets, chamfered edges, transparent surfaces hinting at the invisibility of seamless design, and branding placeholders.

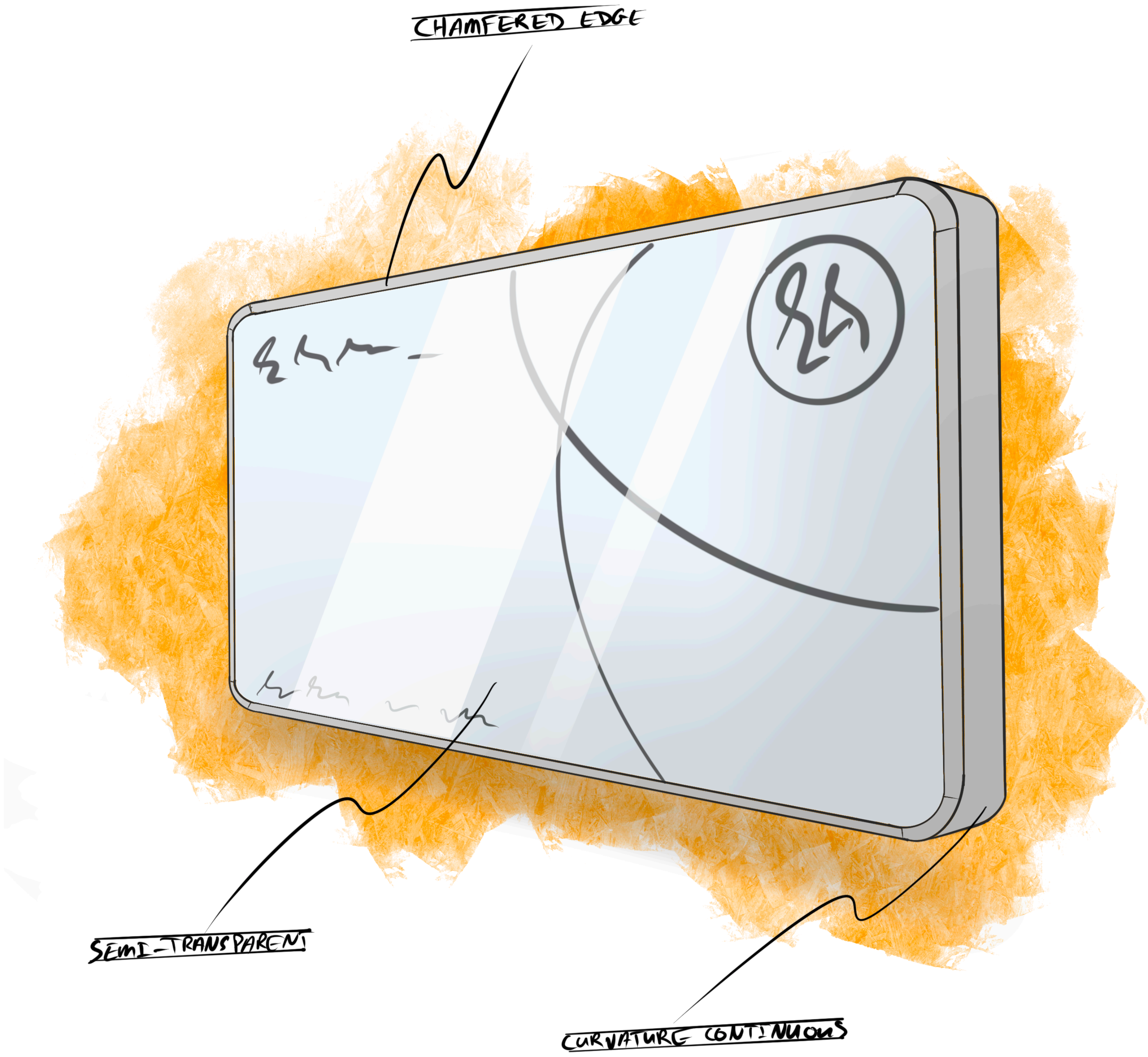


Figure 42 - Sketched token design

9.8 Logo & branding intermezzo

9.8.1 Objective

The objective of this design sprint intermezzo is to formulate the names of certain elements of the strategy and to develop the branding of the concepts. The naming and branding have already been implemented in the strategy chapters, however, they were only designed at the very end of the project. Reasons for doing so were to not get emotionally attached to a design early on in the project thereby not getting entangled in the concept of killing your darlings, but also to make sure that ill-informed and illogical reasoning steps were not masqueraded by vivid colour schemes and fancy vector illustrations, only to find out in a later stage that nothing made sense. The objective of the proposed branding in this report is to make all outcomes relatable and tangible. The branding will function as a visual glue hinting at the overall design atmosphere of what might be possible.

9.8.2 Brand design

The concept of branding stretches far beyond just a logo and a name developed by marketers representing a company. Beverland gives a more nuanced definition: ‘An intangible, symbolic marketplace resource, imbued with meaning by stakeholders and the broader context in which it is embedded that enables users to project their identity goal(s) to one or more audiences.’ Branding enables users to identify themselves with a particular brand, it provides values such as confidence, emotional resonance, and trust, and it gives meaning through a wide array of associations, characteristics, personalities, and above all, a brand represents promises to the users.

Three elements together form the branding scheme: (1) the logo of the digital infrastructure, (2) the name of the digital infrastructure, and (3) the name of the technology package.

Logo

An automotive-style badge consisting of two triangles representing both worlds of mobility being integrated. A custom gradient profile from Tyrian purple to ultraviolet is overlayed on top of the logo hinting at a subset of the core design principle of invisibility.

Name

Alom is derived from the translated Dutch shorthand meaning all-encompassing. It means ‘everywhere, in all places’. No matter where the traveller might find oneself, there is always a way home. The triangle depicts a playful interplay between the logo and the name.

Alom

COPILOT

Token

The technology package consisting of the digital infrastructure, the beacon and the token is named Copilot for self-explanatory reasons.

9.9 Sprint 3c: refinement & accessories Copilot

9.9.1 Objective

The objective of the final design sprint is to determine the production cost of the Copilot and what pricing scheme is used to sell it to a traveller. In addition, the traveller must carry the token at all times without it being obtrusive. Several solutions are designed concerning how a traveller might carry the Copilot.

Costs

Figure 43 shows an exploded view of the copilot. The production cost of each component is estimated. Seven components are included in the cost estimation: (1) the body of the Copilot which is made of ABS plastic, (2) two covers which are made of a transparent version of PC plastic, (3) the battery holder which is made of the same material as the body, (4) two glue strips, (5) a PCB including assembly steps and costs of various small SMD components, (6) the UWB chip, and (7) the PKES chip. The body, both covers, and battery holder are injection molded parts. The costs are estimated using an online tool and are split up into the cost of the required material, the production costs themselves, and the tooling costs for the moulds [147]. The glue strips are imported at a fixed price [148], the PCB is estimated using a cost estimator of a large PCB manufacturer [149], and the UWB and PKES chips are produced at a fixed rate via an online retailer [150], [151]. The final product price per Copilot is 12,96 EUROS. This number is estimated to be significantly lower since the novel UWB and the PKES chips combined are 82% of the production cost and will decrease in price both in the future and in higher quantities.

Servitisation

Still, a production cost of almost 13 EUROS, and a likely asking price of around 25 to 30 EUROS, is significantly higher than the current OV-chipkaart's purchasing price of 7,50 EUROS. Even with all the advantages gained upon carrying the Copilot, it would not be hard to imagine future travellers paying such an amount. This problem can be solved by implementing a servitisation business strategy. Servitisation is the innovation of an organisation's capabilities and processes to shift from selling products to selling integrated products and services that deliver value in use. The product and service combination of Copilot lends itself greatly to delivering it as a pay-per-month service. This would mean that the Copilot can be sold for 0,99 EURO per month on a 24-month subscription basis.

Table 12 - Copilot cost estimation

	QUANTITY	PRICE	TOTAL PRICE
Body (ABS): material	1	8.990	8.990
Body (ABS): production	1	12.015	12.015
Body (ABS): tooling	1	20.312	20.312
Top Cover (PC): material	2	2.401	4.802
Top Cover (PC): production	2	4.030	8.060
Top Cover (PC): tooling	1	8.324	8.324
Battery holder (ABS): material	1	1.807	1.807
Battery holder: (ABS) production	1	9.707	9.707
Battery holder (ABS): tooling	1	21.220	21.221
Glue strip	200.000	0,15	30.000
PCB	1	92.336	92.336
UWB	100.000	5,75	575.000
PKES	100.000	4,32	432.000
Sum			1.224.574
Risk factor of 15%			1,15
Sum after risk factor			1.408260
Exhange rate $ to €			0,92
Sum after exchange rate			1.295.599
Quantity			100.000
Price per Copilot			€12,96

€0,99

Copilot subscription (24 months)

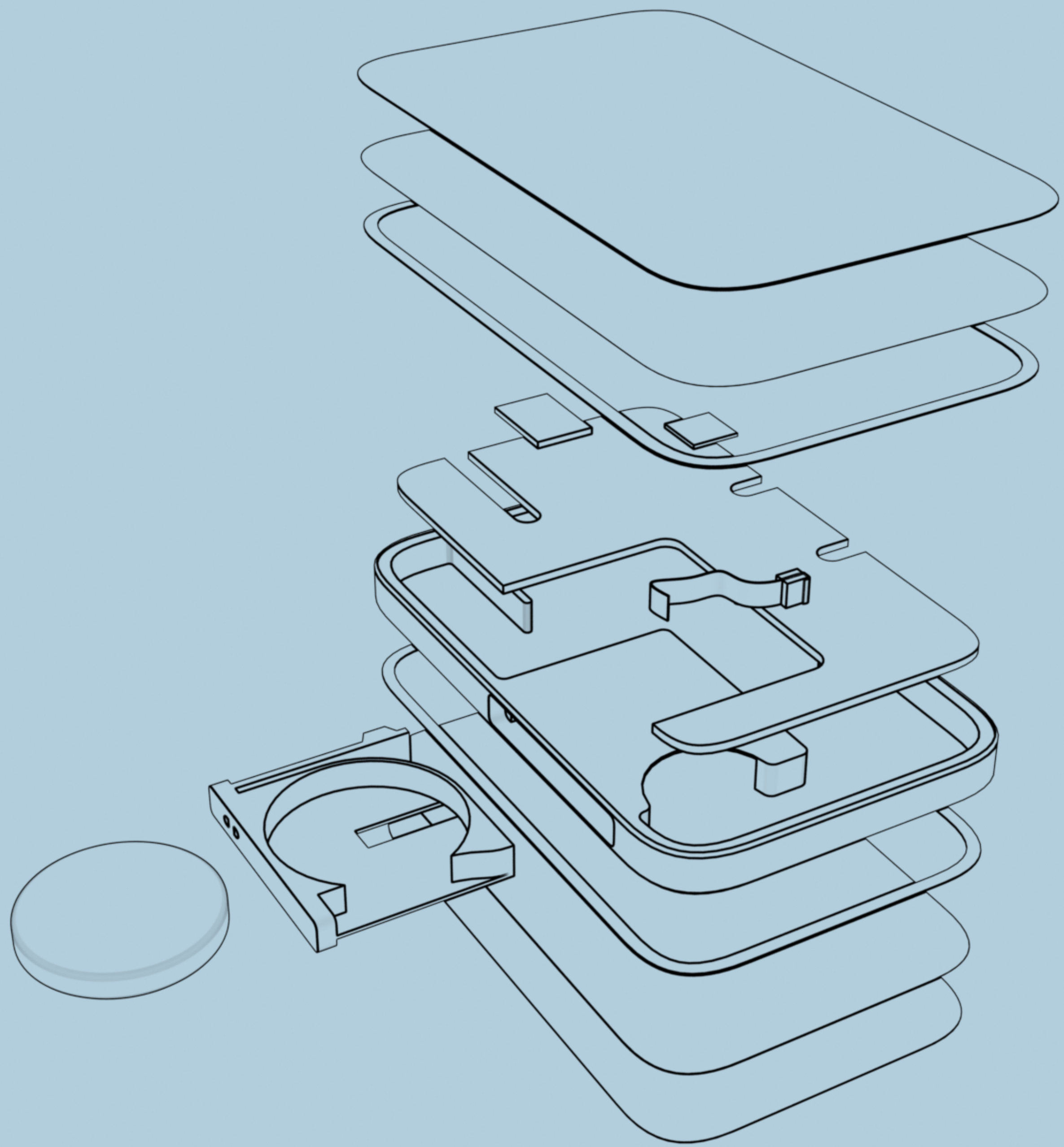


Figure 43 - Exploded view token

Accessories

It was determined that the physical shape of the Copilot should be able to adapt to the wishes of the traveller instead of the traveller having to adapt to the physical form of the token. To make up for the lost profit margins, an accessories line is designed in combination with the Copilot. These accessories not only have higher profit margins, but they also provide flexible options for the traveller to store the Copilot where they see fit.

Figure 44 - Leather sleeve and phone case accessories

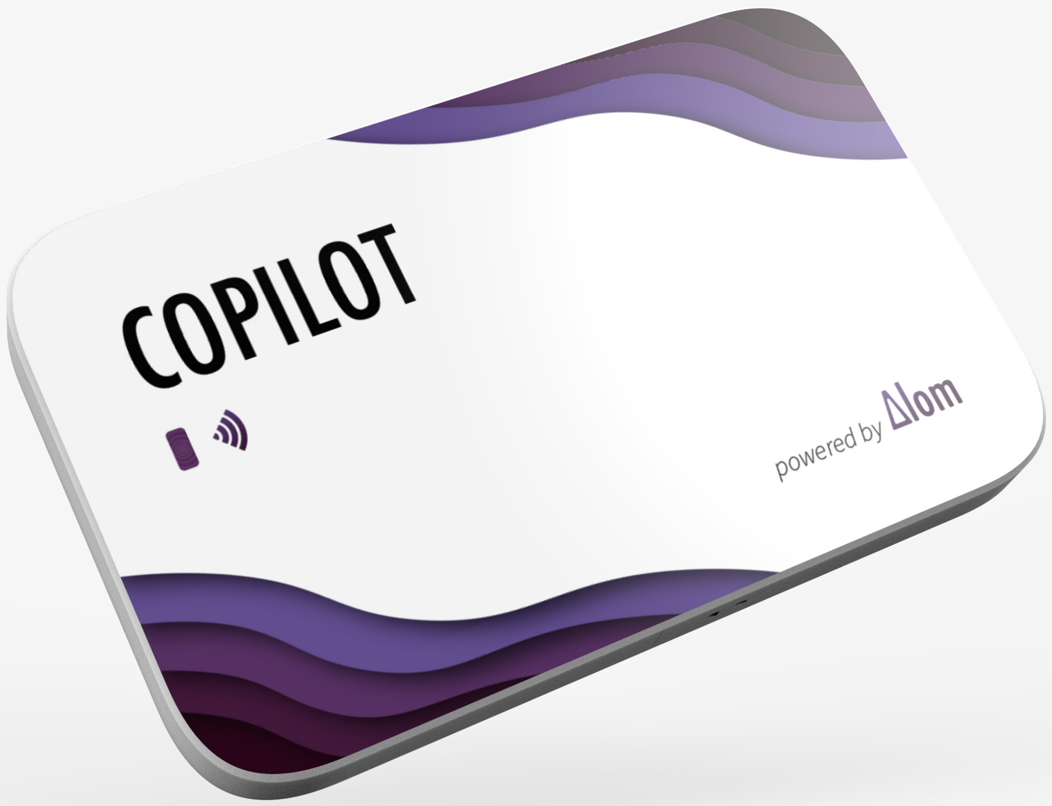
Chapter 10

Showcase & demonstrator

The main goal of this chapter is to showcase the family of mobility products and to build a functional prototype. The showcase is intended to make the solutions more tangible and relatable, and the functional prototype is for attendees at the final presentation to experience the reimagined seamless travel scenario.

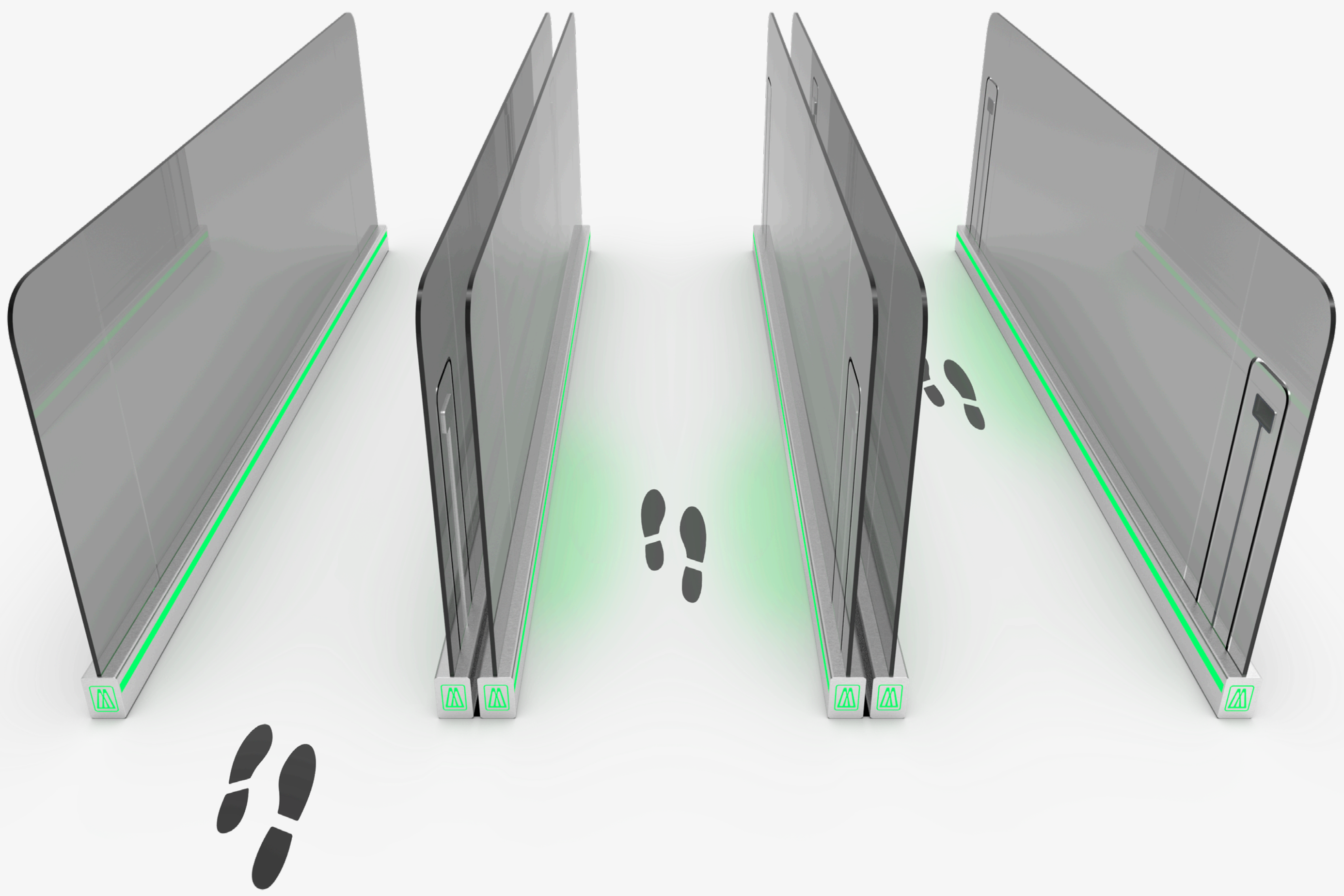
Copilot

The copilot is a small token enabling a truly seamless travel experience. Fully hands-off, Copilot wirelessly and automatically checks in the traveller regardless of the type of modality.

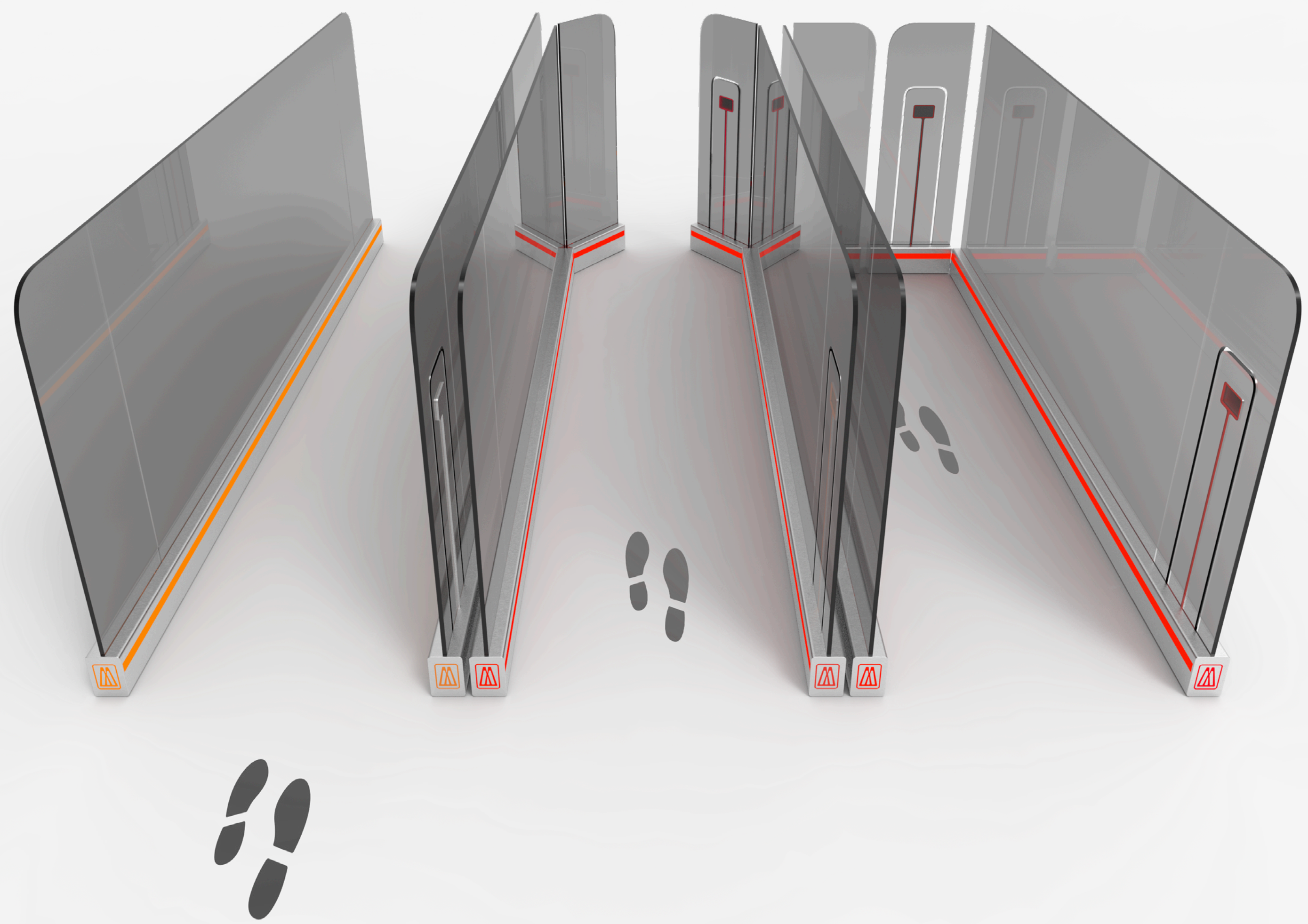


Seamless gate

A truly seamless check-in experience if a traveller is carrying a Copilot. The green light will follow the traveller unobtrusively through the gate.



If a Copilot is not detected, the light will first turn orange and the traveller is asked to check in using a legacy option. If the traveller is trying to fare-dodge, the gate will close.



Seamless scooter

A truly seamless check-in experience if a traveller is carrying a Copilot. The scooter by brand 'X' automatically greets the traveller if a Copilot is detected. Check in will occur the moment the scooter is moving. The scooter will not move if no Copilot is detected and the traveller is asked to check in using legacy options.

10.3.1 Demonstrator prototypes

One of the main goals set out by this project was to fundamentally understand what exactly constitutes as seamlessness within the mobility context. Even though this report has tried to formulate a complete definition, the term is only closely approximated. It remains difficult to comprehend the meaning of the term, especially for the reader who has not continuously pondered and racked their brain for one hundred days. It is best to be able to experience the reimagined interaction scenario so that travellers can make up their own minds. Therefore, a functional prototype is created for attendees at the thesis defence to experience the reimagined seamless travel scenario for themselves.

Based on the showcase designs, a Copilot, gate, and scooter are built. When an attendee wears Copilot around their neck using the attached keycord, they are able to 'check in' to both the gate and the scooter. If the attendee is not wearing Copilot, the gate will turn red and close and the scooter will not turn on.

There are some limitations to the setup likely decreasing the seamlessness of the experience. Since programming a UWB chip is out of scope for this project as it requires a very specific skillset, RSSI is used as a substitute technology. Based on the signal strength between the Copilot and the gate or scooter, the distance can be estimated. When something or someone is in between the line of sight of the two nodes, the accuracy drops drastically rendering the data unusable. In addition, the update rate is not as fast, introducing a couple of seconds of delay, nor is the size of the token anywhere near the actual physical dimensions.

Understandably, the reader of this report likely has not been present at the thesis defence and therefore has not experienced the seamless demonstrator prototype. The following photographs are best treated as an injunction to your imagination.

10.3.2 Token demonstrator

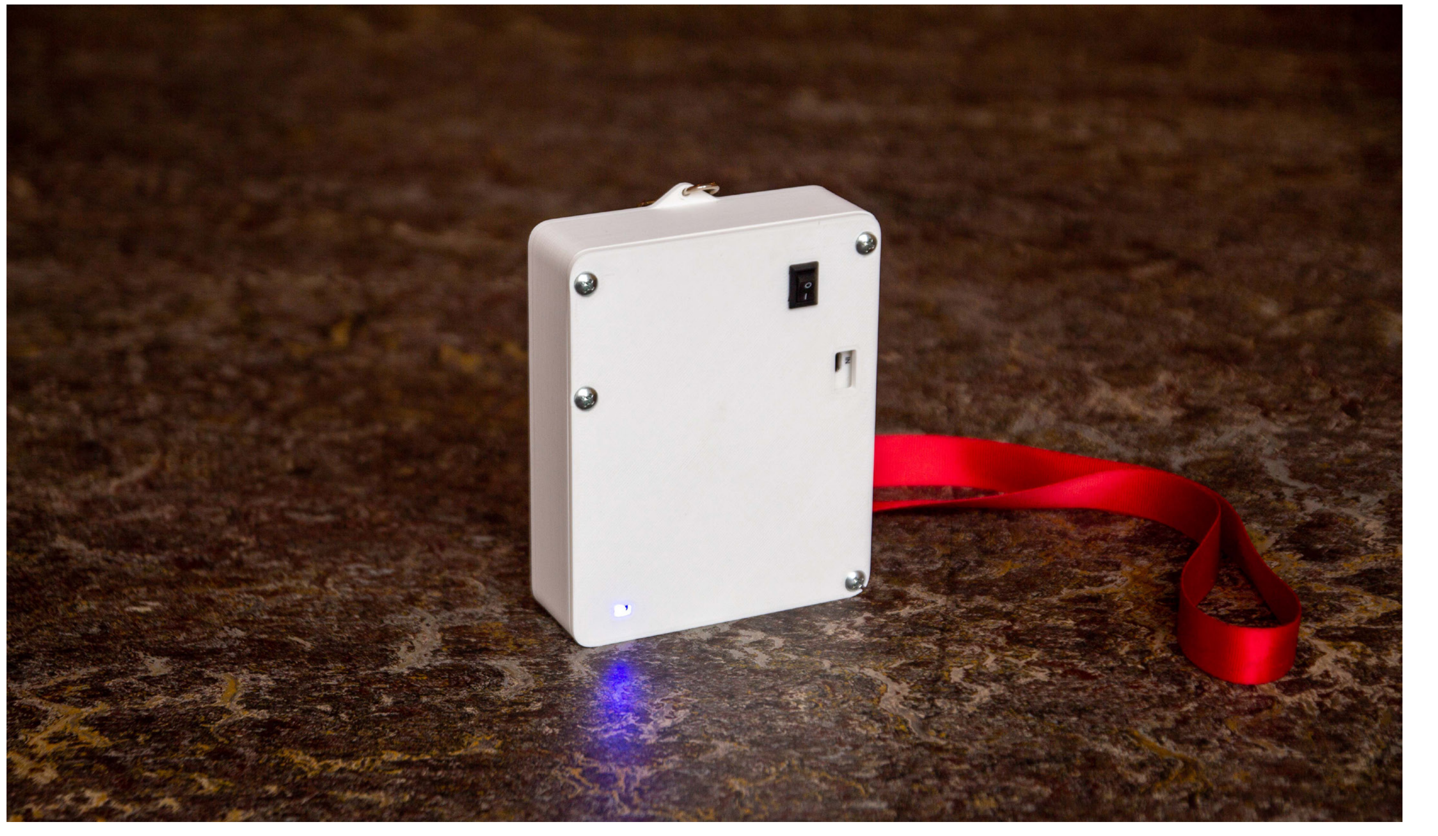


Figure 45 - Demonstrator Copilot

10.3.3 Gate demonstrator

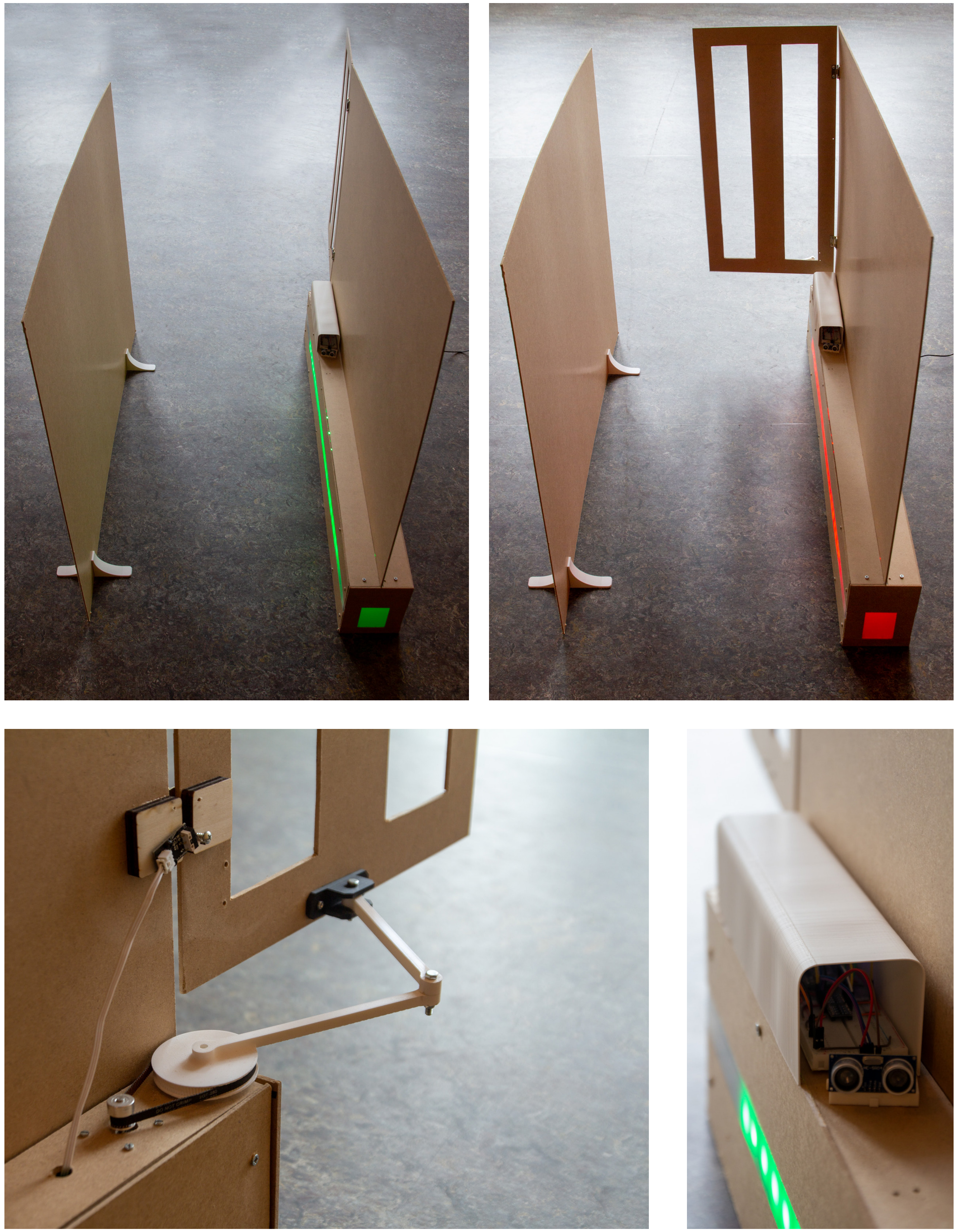


Figure 46 - Demonstrator gate

10.3.4 Scooter demonstrator

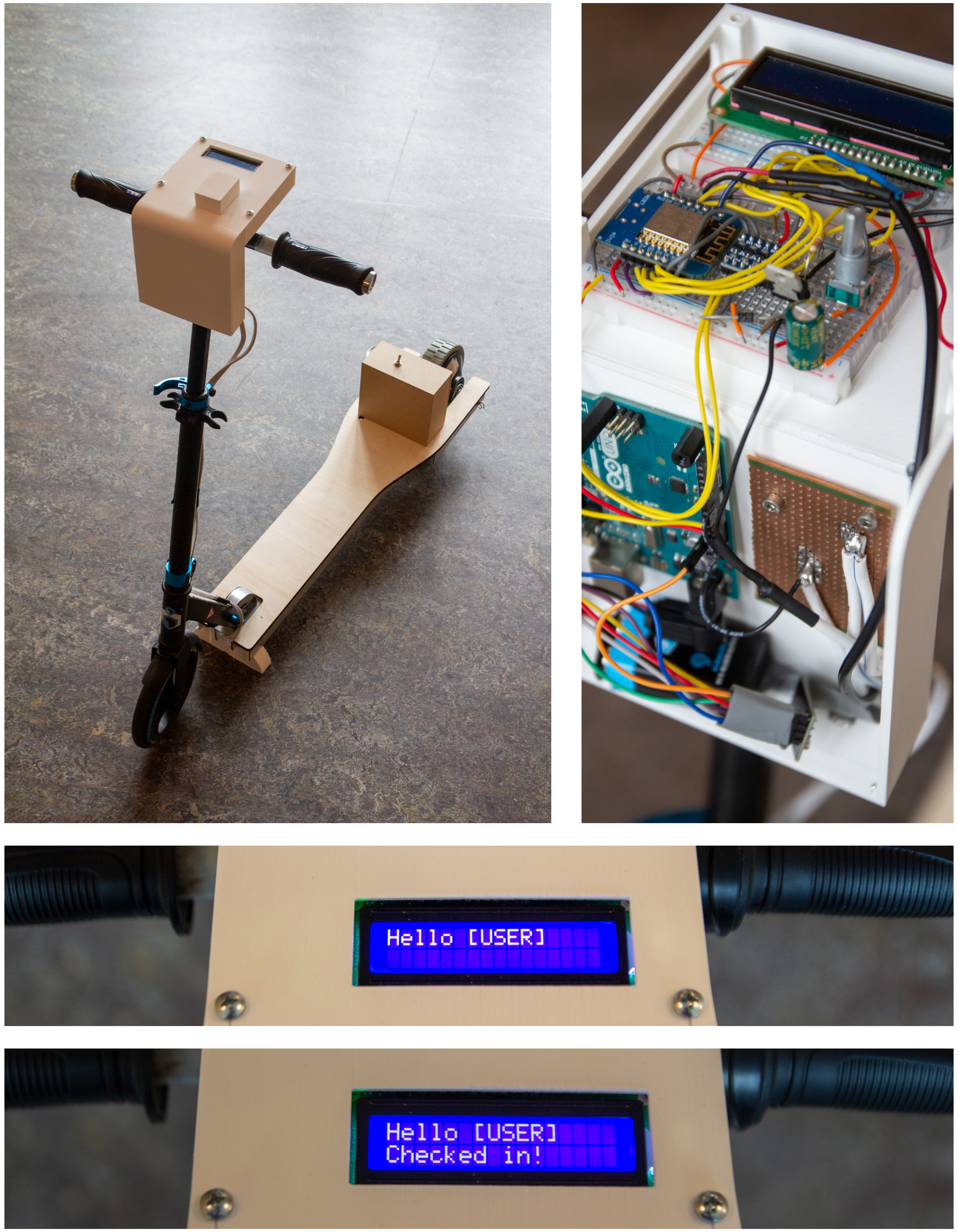


Figure 47 - Demonstrator scooter

Chapter 11

Conclusion

In this chapter, the discussion, recommendations and limitations are discussed. Finally, this thesis comes to an end with a personal reflection by the author.

11.1 Discussion, limitations & recommendations

As the author, I'm well aware of the fact that my knowledge only scratches the surface of all the dynamic and complex forces in the mobility sector. Better yet, at this point, I strongly believe that there is no individual able to self-declare themselves as an expert covering the entire sector and as such, given the comprehensiveness of it all, I think it's impossible for an individual to create any kind of well-working system on their own. Thereby, it would only be an act of arrogance of this thesis to dictate a new organisational structure and simply call it a day. This thesis tries to integrate a dynamic and complex mobility world with another dynamic and complex mobility world. Any concrete changes to these complex organisational structures undoubtedly will result in manifold unintended consequences. Therefore, even though the sphere of influence of this report is limited, the insights and conclusions in this thesis are still able to provide suggestions and recommendations to those currently making decisions.

Feasibility

All aspects of this project are carefully addressed to make sure that the reimagined interaction is not only theoretically possible, but also practically. Modalities can adopt the new interaction scenario, the selected technologies are already starting to gain traction in devices, and aspects of the organisational structure have a proven track record. What has not been included in the feasibility is the rate at which legislation can be changed and the time it would take to develop the proposed products. This could take years, yet all is possible today.

Desirability

From the perspective of the traveller, one aspect became abundantly clear during the interaction prototyping tests. Every participant unambiguously preferred the seamless scenario significantly more than the non-seamless scenario. In addition, the proposed strategy tackles various desires expressed by the traveller such as the removal of smartphone applications, the mental integration of the two types of mobility, and making, for example, the services cheaper. From the perspective of the municipality and the personal mobility provider, the strategy achieves goals expressed by both parties and minimises concerns.

Viability

The new strategy and complementary travel product provide the travel experience of the future. Solutions proposed by this thesis are designed with the long-term at the foundation with one major aspect being designing for spontaneous use. Travellers are behaviourally inert and prefer the status quo. Copilot allows for these travellers to try out new forms of transportation that they otherwise would not even have considered for a second. Now only possible due to the strategic interventions, spontaneous use ultimately expands the user base of public mobility and promises widespread adoption.

11.1.1 Limitations

It might be objected that the number of interviewed participants only fits this particular case and therefore lacks general validity. Where the observations and interaction prototyping had sufficient data with which to work, interviews were conducted with a single municipality and personal mobility service provider. Even though they are located in the same city, policies, opinions, and strategic decisions might vary compared to others. The same reasoning can be applied to validating with a single mobility expert.

During the validation session, the mobility expert indicated that there also exist hesitancies among the collective transport companies when trying to integrate both mobility worlds. They were not interviewed for this thesis and could have provided additional insights. Because of the breadth of the project, it has been decided to disregard these parties for now.

Legislation is a vital aspect of introducing the proposed strategy blueprint. For the purposes of this design thesis, legislation and policies are only briefly discussed and therefore may cause bottlenecks during the development and introduction of the proposed solutions.

Finally, only two small sections of the journey are reimagined: checking in at a train station gate and a personal modality. From the research in trying to understand what exactly constitutes seamless mobility, it is concluded that optimising constituents off the whole, does not imply that the whole itself is optimised. The scope of this thesis did not allow the entire travel journey to be reimagined. Therefore careful consideration is due upon implementing an optimised portion of the entire journey.

11.1.2 Recommendation

If you, the reader, see advantages and benefits for the traveller and the sector as a whole, and if you work in the field of mobility, I have one major recommendation to give: construct a vision champion. It is the very bedrock of bringing any design presented in this report to life. Without it, all stakeholders will dwell, waiting on someone else to act first. In turn, this means that travellers will not experience the untapped potentials of a truly seamless mobility journey for years to come; the stakeholder for whom this thesis is all about.

A second major recommendation is to invest in a working setup actually using PKES and UWB technologies. Even though this thesis has gone into great depth in defining what seamlessness means in the mobility sector, the term itself remains difficult to comprehend. The easiest way to fully understand what true seamless mobility means, is best to experience it yourself. In line with understanding it yourself, it would be wise to let the traveller experience what is yet to come, ultimately generating hype and setting future expectations.

Finally, one must not regard solutions of this thesis as something final or as directly implementable, but more along the lines of giving a hint of what it could be. They could also function as an outsider's perspective, challenging biases and possible tunnel visions which may have arisen over time. As Shunryu Suzuki puts it so eloquently: in the beginner's mind, there are many possibilities, in the expert's there are few.

11.2 Conclusion

This thesis presents both a strategic blueprint to integrate the two separated mobility worlds and a reimagined interaction scenario made possible by a complementary travel product. Currently, the two worlds of collective and personal mobility are seen as completely separate. This is due to the difference in the way in which travellers need to check in (smartphone applications versus OV-chipkaart), the different types of organisations running the services (young versus old, privatised versus semi-public, and non-subsidised versus subsidised), a different tariff system (time-based versus zone-based), and the different types of vehicles (one traveller per modality versus many travellers per modality). All these different aspects shape the perception of the traveller, subsequently reinforcing the mobility dichotomy.

At the very beginning of the project, the original research question was formulated as 'What exactly constitutes seamless travel?'. An attempt was made by exploring seemingly unrelated fields in order to get an outsider's perspective of what seamlessness could implicate in the mobility sector. In addition, an analogous application was benchmarked and non-seamless aspects throughout the journey are identified by means of various methods, observations and tests. The question concerning what constitutes seamlessness is answered as a design driver. The short paragraph does not cover the full concept and meaning, it only approaches it. Seamlessness must be experienced and only then can it be fully understood. For this reason alone, a fully functional demonstrator prototype is built. It does not use the selected technologies as dictated by this thesis, but it uses a proxy which is able to mimic the reimagined interaction within the confines of the demonstrator.

The sub-question 'How to incorporate seamless travel in the Dutch mobility sector?' quickly focussed on the dichotomy of the mobility worlds and how to integrate them both. This led to a reformulated design statement To develop a new organisational structure by integrating shared and public transportation providers (WHAT) in the coming decade (WHEN) and designing a complementary travel product concept (HOW) which will provide travellers (WHO) everywhere in The Netherland (WHERE) a carefree, effortless, and true seamless mobility experience (WHY).

Through a combination of interviewing and observing stakeholders, journey mapping techniques, a technology deep dive, desk and literature research, and design sprints, in the end, nine strategic interventions are proposed and a showcase is made displaying the new family of travel products.

11.3 Personal reflection

One aspect of my future life as an Industrial Design Engineer is certain: I am never able to travel without thinking about seamlessness again. Paradoxically, if you ever unconsciously experienced some difficulties in presenting an OV-chipkaart, for the rest of my life I will from this point onwards experience those same difficulties, but now consciously, and including questioning myself relentlessly why it has not been fixed yet, or if my solutions would solve it.

For the same reasons I will never travel as I did about half a year ago, I am never able to see the interior of a car as if it was designed by that particular brand, or go to a festival and not look at all the truss structures and cable management, or look at a soap dispenser like a normal person would. Seeing the world through the Industrial Design Engineer's lens brings both frustrations and joy: frustrations since I am able to see problem spaces desperately needing a solution that someone else would never even think about, but also joy as I am now capable of doing something about it.

Over the course of my student life, my friends have coined the term 'TMT'. It is an abbreviation for 'too much Tim'. The abbreviation describes the way in which I work rather accurately. Upon hearing about it, my family has adopted the term and to this day, they still uses it extensively. As a result, I decided to embrace it as well. To illustrate the term, I will give two examples: (1) 'In charge of the sweet potatoes, laboriously pushes them through a fine sieve because it 'enhances the texture...' and (2) 'Has trouble waking up, builds Siri-enabled smart curtains…'. The question begs: is there something in this report which would constitute a TMT? I will leave that up to the reader to decide.

Looking toward the future, this project could be one of the last projects in which I am able to apply both my masters. I highly enjoyed thinking on a strategic level and building on a product level throughout this project, but it is likely that such a position in the job market is hard to find. It is therefore my ambition to complement the expertise of one master applied in a job, by projects in my spare time by the other.

Again, a word of appreciation is given to both my chair and mentor, but also to those who helped me in some way or another during the project.

Figure 48 - Building the frame of the scooter

References

1 Veeneman, W. W., Van Kuijk, J. I., & Hiemstra-van Mastrigt, S. (2020). Dreaming of the travelers' experience in 2040: Exploring governance strategies and their consequences for personal mobility systems. In Towards User-Centric Transport in Europe 2 (pp. 225-239). Springer, Cham.

2 M. Maartens, Handboek reizigersinvloed: Wat Je moet weten om het regionale openbaar vervoer Te Verbeteren. Amersfoort: Uitgave van Rover, 2017.

3 Cohen, A., & Shaheen, S. (2018). Planning for shared mobility.

4 "Seamless: Meaning & definition for UK English," Lexico Dictionaries | English. [Online]. Available: https://www.lexico.com/definition/seamless.

5 "Colby College Digital Commons @ colby." [Online]. Available: https://digitalcommons.colby.edu/cgi/viewcontent.cgi?article=1022&context=ugrs.

6 "Seamless definition & meaning," Merriam-Webster. [Online]. Available: https://www.merriam-webster.com/dictionary/seamless.

7 Csikszentmihalyi, M. (1990). Flow. The Psychology of Optimal Experience. New York (HarperPerennial) 1990.

8 Jackson, S. A., & Csikszentmihalyi, M. (1999). Flow in sports. Human Kinetics.

9 J. Geirland, "Go with the flow," Wired, 01-Sep-1996. [Online]. Available: https://www.wired.com/1996/09/czik/.

10 Csikszentmihalyi, M. (2014). Applications of flow in human development and education (pp. 153-172). Dordrecht: Springer.

11 Weiser, M. Creating the invisible interface: (Invited talks) UIST '94, 1994.

12 Weiser, M. The Computer for the 21 Ubicomp Paper after Sci Am Editing, 1991

13 H. Ishii and B. Ullmer, "Tangible bits: towards seamless interfaces between people bits and atoms", SIGCHI Annual Conference on Human factors in computing systems (CHI), pp. 234-241, 1997.

14 A. Schmidt, "Implicit human computer interaction through context", Journal on Personal Technologies, vol. 4, no. 2–3, pp. 191-199, 2000.

15 H. Ahmed, "Natural harmony in Taoism— a cornerstone of Chinese society." [Online]. Available: https://thefinancialexpress.com.bd/views/natural-harmony-in-taoism-a-cornerstone-of-chinese-society-1516031957.

16 Elizabeth Pollard; Clifford Rosenberg; Robert Tignor (16 December 2014). Worlds Together, Worlds Apart: A History of the World - From the Beginnings of Humankind to the Present. W.W. Norton. p. 164. ISBN 978-0-393-91847-2.

17 Woodhead, Partridge, & Kawanmi, Linda, Christopher, & Hiroko (2016). Religions in the Modern World. New York: Routledge. p. 146. ISBN 978-0-415-85880-9.

18 E. Pollard, C. D. Rosenberg, R. L. Tignor, J. Adelman, S. Aron, P. Brown, B. A. Elman, S. Kotkin, X. Liu, S. L. Marchand, H. Pittman, G. Prakash, B. D. Shaw, and M. T.-W. Tsin, Worlds together, worlds apart. New York: W.W. Norton & Company, 2019.

19 Boehm-Davis, D. A., & Remington, R. (2009). Reducing the disruptive effects of interruption: A cognitive framework for analysing the costs and benefits of intervention strategies. Accident Analysis & Prevention, 41(5), 1124-1129.

20 Dismukes, R. K., Young, G. E., Sumwalt III, R. L., & Null, C. H. (1998, January). Cockpit interruptions and distractions: Effective management requires a careful balancing act. In CRM Industry Conference.

21 Latorella, K. A. (1998, October). Effects of modality on interrupted flight deck performance: Implications for data link. In Proceedings of the human factors and ergonomics society annual meeting (Vol. 42, No. 1, pp. 87-91). Sage CA: Los Angeles,

CA: Sage Publications.

22 Ferreira, E., Ferreira, D., Kim, S., Siirtola, P., Röning, J., Forlizzi, J. F., & Dey, A. K. (2014, December). Assessing real-time cognitive load based on psycho-physiological measures for younger and older adults. In 2014 IEEE Symposium on Computational Intelligence, Cognitive Algorithms, Mind, and Brain (CCMB) (pp. 39-48). IEEE.

23 Schwartz, B. (2012). Choice, freedom, and autonomy. In P. R. Shaver & M. Mikulincer (Eds.), Meaning, mortality, and choice: The social psychology of existential concerns (pp. 271–287). American Psychological

24 Iyengar, S. S., & Lepper, M. R. (2000). When choice is demotivating: Can one desire too much of a good thing? Journal of Personality and Social Psychology, 79(6), 995–1006.

25 Hazel Rose Markus, Barry Schwartz, Does Choice Mean Freedom and Well-Being?, Journal of Consumer Research, Volume 37, Issue 2, August 2010, Pages 344–355,

26 Heying, H., & Weinstein, B. (2021). A Hunter-gatherer's Guide to the 21st Century: Evolution and the Challenges of Modern Life. Penguin.

27 Morewedge, C. K., & Kahneman, D. (2010). Associative processes in intuitive judgment. Trends in cognitive sciences, 14(10), 435-440.

28 Daniel, K. (2017). Thinking, fast and slow.

29 "Introducing amazon go and the world's most advanced ... - youtube." [Online]. Available: https://www.youtube.com/watch?v=NrmMk1Myrxc.

30 Accenture, "5 reasons why Amazon Go has changed the convenience experience forever". [Online]. Available: https://www.accenture.com/us-en/blogs/accenture-energy/5-reasons-why-amazon-go-has-changed-the-convenience-experience-forever.

31 "Amazon go store implications for the traditional retail market." [Online]. Available: https://www.researchgate.net/profile/Josef_Baker-Brunnbauer/publication/349412426_Amazon_Go_Store_Implications_for_the_Traditional_Retail_Market/links/606601b5458515614d2b61ff/Amazon-Go-Store-Implications-for-the-Traditional-Retail-Market.pdf.

32 "Amazon go! cashierless retail analysis - Thomas Wuest Jr." [Online]. Available: http://thomaswuestjr.com/wp-content/uploads/CIS-420-Research-Paper-Mason-Wuest.pdf.

33 "Amazon GO's high-tech retail how excited are Americans about it?," Piplsay, 23-Sep-2021. [Online]. Available: https://piplsay.com/amazon-gos-high-tech-retail-how-excited-are-americans-about-it/.

34 "60% of global shoppers favour an amazon go-like experience, study finds," InternetRetailing. [Online]. Available: https://internetretailing.net/mobile-theme/mobile-theme/60-of-global-shoppers-favour-an-amazon-go-like-experience-study-finds-17925.

35 Davis, L. (2016, March 23). U.S. companies losing customers as consumers demand more human interaction, Accenture strategy study finds. Accenture. Retrieved February 25, 2017, from https://newsroom.accenture.com/news/us-companies-losing-customers-as-consumers-demand-more-human-interaction-accenture- strategy-study-finds.htm.

36 Huberman, J. (2021). Amazon Go, surveillance capitalism, and the ideology of convenience. Economic Anthropology, 8(2), 337-349.

37 Loose, W. (2010). The State of European Car-Sharing. Energy-efficient mobility through car-sharing, funded by the programme Intelligent Energy Europe.

38 Motta, G., Ferrara, A., Sacco, D., You, L., & Cugola, G. (2013). Integrated Mobility: A Research in Progress. Journal of Software Engineering and Applications, 6, 97-101. doi:10.4236/jsea.2013.63b021

39 Preston, J. (2012). Integration for Seamless Transport. Discussion Paper at the International Transport Forum (ITF).

40 Schade, W., Krail, M., & Kühn, A. (2014). New mobility concepts: myth or emerging reality? Paper presented at the 5th Transport Research Arena (TRA), Paris, France.

41 Smile mobility. (2015). Results of the smile pilot. Retrieved from smile-einfachmobil.at/pilotbetrieb_ en.html#dieergebnisse. Accessed on December 6th, 2017.

42 Durand, A., Harms, L., Hoogendoorn-Lanser, S., Zijlstra, T. (2018). Mobility-as-a-Service and changes in travel preferences and travel behaviour: A literature review.

43 Holmberg, P.-E., Collado, M., Sarasini, S., & Williander, M. (2016). Mobility as a Service-MaaS. Describing the framework (Final report MaaS framework). Göte- borg: Viktoria Swedish ICT.

44 "PDF hosted at the Radboud Repository of the Radboud University Nijmegen." [Online]. Available: https://repository.ubn.ru.nl/bitstream/handle/2066/174112/174112.pdf.

45 Sochor, J., Karlsson, I. C. M., & Strömberg, H. (2016). Trying out Mobility as a Service: Experiences from a field trial and implications for understanding demand. Transportation Research Record: Journal of the Transportation Research Board, 2542. doi:10.3141/2542-07

46 Spickermann, A., Grienitz, V., & von der Gracht, H. A. (2014). Heading towards a multimodal city of the future?: Multi-stakeholder scenarios for urban mobility. Technological Forecasting and Social Change, 89, 201-221. doi:10.1016/j.techfore.2013.08.036

47 Hensher, D. A. (2017). Future bus transport contracts under a mobility as a service (MaaS) regime in the digital age: Are they likely to change? Transportation Research Part A: Policy and Practice, 98, 86-96. doi:10.1016/j.tra.2017.02.006

48 Matyas, M., & Kamargianni, M. (2018). The potential of Mobility as a Service bundles as a mobility management tool. Transportation, Published online on August 6th 2018. doi:10.1007/s11116-018-9913-4

49 Matyas, M., & Kamargianni, M. (2018). The potential of Mobility as a Service bundles as a mobility management tool. Transportation, Published online on August 6th 2018. doi:10.1007/s11116-018-9913-4

50 Ratilainen, H. (2017). Exploring Consumer Preferences for MaaS Subscription Packages using a Stated Choice Experiment. Master Thesis, Delft University of Technology.

51 Aarts, H., Verplanken, B., & van Knippenberg, A. (1998). Predicting Behavior From Actions in the Past: Repeated Decision-Making or a Matter of Habit? Journal of Applied Social Psychology, 28(15), 1355-1374. doi:10.1111/j.1559-1816.1998.tb01681.x

52 Gardner, B. (2009). Modelling motivation and habit in stable travel mode contexts. Transportation Research Part F: Traffic Psychology and Behaviour, 12(1), 68-76. doi:10.1016/j.trf.2008.08.001

53 Gärling, T., & Axhausen, K. W. (2003). Introduction: habitual travel choice. Transportation, 30(1), 1-11. doi:10.1023/a:1021230223001

54 Gärling, T., Fujii, S., & Boe, O. (2001). Empirical tests of a model of determinants of script-based driving choice. Transportation Research Part F: Traffic Psychology and Behaviour, 4(2), 89-102. doi:10.1016/S1369-8478(01)00016-X

55 Verplanken, B., Aarts, H., & van Knippenberg, A. (1997). Habit, information acquisition, and the process of making travel mode choices. European Journal of Social Psychology, 27, 539-560. doi:10.1002/ (SICI)1099-0992(199709/10)27:53.0

56 Smith, G., Sochor, J., & Karlsson, I. M. (2018). Mobility as a Service: Development scenarios and implications for public transport. Research in Transportation Economics, 69, 592-599.

57 Alonso-González, M., Van Oort, N., Cats, O., & Hoogendoorn, S. (2017). Urban Demand Responsive Transport in the Mobility as a Service ecosystem: its role and potential market share. Paper presented at the International Conference Series on Competition and Ownership in Land Passenger Transport (Thredbo 15), Stockholm, Sweden.

58 Haahtela, T., & Viitamo, E. (2017). Searching for the potential of MaaS in commuting - comparison of survey and focus group methods and results. Paper presented at the 1st International Conference on Mobility-as-a-Service, Tampere, Finland.

59 "Mobility-as-a-service and changes in travel preferences and travel ..." [Online]. Available: https://www.researchgate.net/publication/330958677_Mobility-as-a-Service_and_changes_in_travel_preferences_and_travel_behaviour_a_literature_review

60 Smith, G., Sochor, J., & Karlsson, I. M. (2018). Mobility as a Service: Development scenarios and implications for public transport. Research in Transportation Economics, 69, 592-599.

61 Veeneman, W. W., Van Kuijk, J. I., & Hiemstra-van Mastrigt, S. (2020). Dreaming of the travelers' experience in 2040: Exploring governance strategies and their consequences for personal mobility systems. In Towards User-Centric Transport in Europe 2 (pp. 225-239). Springer, Cham.

62 "The rise of mobility as a service," Deloitte Review. [Online]. Available: https://www2.deloitte.com/content/dam/Deloitte/nl/Documents/consumer-business/deloitte-nl-cb-ths-rise-of-mobility-as-a-service.pdf.

63 "Visie ov Betalen - cooperatieovbedrijven.nl." [Online]. Available: https://cooperatieovbedrijven.nl/wp-content/uploads/2019/05/Visie-OV-Betalen.pdf. [Accessed: 12-May-2022].

64 Coöperatie Openbaar Vervoerbedrijven - Coöperatie OV Bedrijven. [Online]. Available: https://cooperatieovbedrijven.nl/.

65 "Waar is OVpay Beschikbaar?," Waar is OVpay beschikbaar? [Online]. Available: https://www.ovpay.nl/nl/proef. [Accessed: 12-May-2022].

66 Gelevert, H., Wiersema, H., Ensing, H., Huitema, G., & en Milieu, O. M. V. I. (2016). Uitkomsten van een quickscan naar technische ontwikkelingen in relatie tot enkelvoudig in-en uitchecken op het spoor (No. TNO 2016 R11146). TNO.

67 M. Maartens, Handboek reizigersinvloed: Wat Je moet weten om het regionale openbaar vervoer Te Verbeteren. Amersfoort: Uitgave van Rover, 2017.

68 M. van I. en Waterstaat, "Toekomst Openbaar Vervoer 2040," Openbaar vervoer (ov) | Rijksoverheid.nl, 07-Apr-2021. [Online]. Available: https://www.rijksoverheid.nl/onderwerpen/openbaar-vervoer/betere-verbindingen-openbaar-vervoer/ov-in-de-toekomst.

69 Minister of Transport. (1979, May 7). Tarievenplan openbaar vervoer. Letter number 2 addressed to the Dutch House of Representatives, dossier 15572, session 1978-1979.

70 D. M. Slütter, "Wat Moeten we met De Chinese Deelfietsen?," Fietsersbond, 03-Nov-2017. [Online]. Available: https://www.fietsersbond.nl/nieuws/moeten-we-chinese-deelfietsen/.

71 "Kansen voor Deelfiets en Deelscooter in Zuid-holland," Fietsberaad. [Online]. Available: https://fietsberaad.nl/kennisbank/ontwerperscafe-fietsrotonde-op-philosofenallee-zwo?aliaspath=%2Fkennisbank%2Fkansen-voor-deelfiets-en-deelscooter-in-zuid-holla.

72 DPG Media Privacy Gate. [Online]. Available: https://www.ad.nl/leiden/mysterie-waarom-heb-je-in-leiden-geen-deelscooters-a0bb00ce/.

73 "Regulering deelmobiliteit fiets Den Haag," 2019. [Online]. Available: https://denhaag.raadsinformatie.nl/document/8314808/1/RIS304140_Bijlage_1_Nota.

74 DeMaio, Paul (2009). "Bike-sharing: History, Impacts, Models of Provision, and Future". Journal of Public Transportation. 12 (4, 2009): 41–56. doi:10.5038/2375-0901.12.4.3

75 Published by L. Ceci and O. 19, "Number of apps installed by U.S. users 2019," Statista, 19-Oct-2021. [Online]. Available: https://www.statista.com/statistics/267309/number-of-apps-on-mobile-phones/.

76 [Online]. Available: https://gaiyo.com/?lang=en.

77 "Tier Gaat samenwerking aan met Grootste Maas-app gaiyo," Innovactory, 27-Oct-2021. [Online]. Available: https://innovactory.com/tier-gaat-samenwerking-aan-met-grootste-maas-app-gaiyo/?lang=nl.

78 Gaiyo Whatsapp Service Inquiry, 2022.

79 Sanders, L., & Stappers, P. J. (2013). Convivial Toolbox: Generative Research for the Front End of Design. Laurence King Publishing.

80 Robson, C. (2011). Real world research (Vol. 3). Chichester: Wiley.

81 Hanington, B., & Martin, B. (2012). Universal methods of design: 100 ways to research complex problems, develop innovative ideas, and design effective solutions. Rockport Publishers.

82 P. Hekkert, Vision in product design: A guidebook for innovators. Amsterdam: BIS, 2014.

83 Joppien, J., Niermeijer, G., Niks, T., & Kuijk, J. (2013). Exploring new possibilities for user-centred e-ticketing. University of Technology.

84 Groot Obbink, L. T. (2016). Opening the closed: Design of a user-centered closed payment border.

85 Puglia, M.T. (2022). Seamless mobility: a strategic intervention integrating public & shared mobility using a complementary travel product. Delft University of Technology.

86 Van Boeijen, A., Daalhuizen, J., van der Schoor, R., & Zijlstra, J. (2014). Delft design guide: Design strategies and methods.

87 Ferreira, E., Ferreira, D., Kim, S., Siirtola, P., Röning, J., Forlizzi, J. F., & Dey, A. K. (2014, December). Assessing real-time cognitive load based on psycho-physiological measures for younger and older adults. In 2014 IEEE Symposium on Computational Intelligence, Cognitive Algorithms, Mind, and Brain (CCMB) (pp. 39-48). IEEE.

88 "Mobility-as-a-service and changes in travel preferences and travel ..." [Online]. Available: https://www.researchgate.net/publication/330958677_Mobility-as-a-Service_and_changes_in_travel_preferences_and_travel_behaviour_a_literature_review.

89 L. Simonse, Design roadmapping. Amsterdam, Niederlande: BIS Publishers, 2017.

90 Gelevert, H., Wiersema, H., Ensing, H., Huitema, G., & en Milieu, O. M. V. I. (2016). Uitkomsten van een quickscan naar technische ontwikkelingen in relatie tot enkelvoudig in-en uitchecken op het spoor (No. TNO 2016 R11146). TNO.

91 https://www.ala.org/tools/future/trends/micromobility

92 "Vehicle sharing software and sharing-ready vehicles: Wunder mobility," Vehicle sharing software and sharing-ready vehicles | Wunder Mobility. [Online]. Available: https://www.wundermobility.com/.

93 "Discover our solution for shared mobility," WeGo Carsharing, 08-May-2022. [Online]. Available: https://wegocarsharing.com/en/technology/.

94 "Vehicle sharing software with white-label apps: car sharing, Scooter

Sharing, bike sharing," Vehicle Sharing Software With White-Label Apps | - Car Sharing, Scooter Sharing, Bike Sharing. [Online]. Available: https://www.motiontools.com/vehicle-sharing-software.

95 "Professional carsharing software," Zemtu. [Online]. Available: https://www.zemtu.com/.

96 "Technology for shared mobility," ATOM. [Online]. Available: https://atommobility.com/.

97 "OVPro-Webinar: 'Nieuwe Betaalmiddelen in het ov' - webinargeek," webinar. [Online]. Available: https://ntp.webinargeek.com/webinar/replay/XT9pSlx8lXs/. [Accessed: 12-May-2022].

98 "EMV in transit: The Dutch OVpay Case," Connective Payments, 17-Dec-2021. [Online]. Available: https://www.connectivepayments.com/emv-in-transit-the-dutch-ovpay-case/.

99 "GDPR," General Data Protection Regulation (GDPR), 02-Sep-2019. [Online]. Available: https://gdpr-info.eu/.

100 L. Simonse, Design roadmapping. Amsterdam, Niederlande: BIS Publishers, 2017.

101 J. Happich, "Global shipments of Short Range Wireless ICS to exceed 2 billion units in 2010," EETimes, 24-Feb-2010. [Online]. Available: https://www.eetimes.com/global-shipments-of-short-range-wireless-ics-to-exceed-2-billion-units-in-2010/.

102 "Bluetooth® Technology Website." [Online]. Available: https://www.bluetooth.com/wp-content/uploads/2019/03/Bluetooth_Market_Update_2018.pdf.

103 Link-labs. (2015, October 28). A Bluetooth & ZigBee Comparison For IoT Applications. Link-Labs.Com. https://www.link-labs.com/blog/bluetooth-zigbee- comparison

104 Bluetooth. (2015, September 21). Proximity and RSSI. Bluetooth.Com. https://www.bluetooth.com/blog/ proximity-and-rssi/

105 https://www.bluetooth.com/learn-about-bluetooth/recent-enhancements/direction-finding/?utm_source=tw&utm_medium=social&utm_campaign=location-services&utm_term=social&utm_content=tw-dflandingpage21-org

106 "How aoa & AOD changedthe direction of bluetoothlocation services," Bluetooth® Technology Website, 26-Mar-2022. [Online]. Available: https://www.bluetooth.com/blog/new-aoa-aod-bluetooth-capabilities/.

107 "Bluetooth angle of arrival and angle of departure - silicon labs," Bluetooth Angle of Arrival and Angle of Departure - Silicon Labs, 17-Jan-2022. [Online]. Available: https://www.silabs.com/wireless/bluetooth/bluetooth-5-1. [Accessed: 12-May-2022].

108 Thrasher, J. (2013, October 11). RFID versus NFC: What's the difference between NFC and RFID? Retrieved November 30, 2020, from https://www. atlasrfidstore.com/rfid-insider/rfid-vs-nfc/

109 ISP/IEC. (2013). Information technology — Telecommunications and information exchange between systems — Near Field Communication — Interface and Protocol (NFCIP-1). Iso.Org. https://www. iso.org/standard/56692.html

110 "Applications," EU Agency for the Space Programme, 17-May-2021. [Online]. Available: https://www.euspa.europa.eu/european-space/galileo/applications.

111 S. Liao, "Why GPS-dependent apps deplete your smartphone battery," The Verge, 17-Aug-2018. [Online]. Available: https://www.theverge.com/2018/8/17/17630872/smartphone-battery-gps-location-services.

112 A. A. Ltd, "Advantages and disadvantages of Global Positioning System (GPS)," UK Essays, 31-Dec-2021. [Online]. Available: https://www.ukessays.com/essays/technology/global-positioning-system-gps-advantages-and-disadvantages.php.

113 "How to achieve 1-meter accuracy in Android," GPS World, 10-Oct-2018. [Online]. Available: https://www.gpsworld.com/how-to-achieve-1-meter-accuracy-in-android/.

114 "5G Progress Continues but Mobile Phone Supply Concerns Remain a Risk." [Online]. Available: https://www.ccsinsight.com/press/company-news/5g-progress-continues-but-mobile-phone-supply-concerns-remain-a-risk/.

115 "3GPP Scope and Objectives." [Online]. Available: https://www.3gpp.org/ftp/Inbox/2008_web_files/3GPP_Scopeando310807.pdf.

116 "5G open API-based positioning industry white paper - huawei." [Online]. Available: https://www-file.huawei.com/-/media/corporate/pdf/news/5g-positioning-open-api-industry-white-paper-en.pdf?la=en. [Accessed: 12-May-2022].

117 A. Francillon, "Relay attacks on passive keyless entry and start systems in modern cars." [Online]. Available: https://eprint.iacr.org/2010/332.pdf.

118 T. A. Vlad Samarin, "When does the key FOB Battery need replacing? :   testing autos," icon. [Online]. Available: https://www.testingautos.com/car_care/key-fob-battery.html. [Accessed: 12-May-2022].

119 "What's the difference between measuring location by UWB, Wi-Fi, and ..." [Online]. Available: https://www.electronicdesign.com/technologies/communications/article/21800581/whats-the-difference-between-measuring-location-by-uwb-wifi-and-bluetooth.

120 Inpixon, "Ultra-Wideband (UWB) Positioning & Sensor Technology," Inpixon. [Online]. Available: https://www.inpixon.com/technology/standards/ultra-wideband.

121 EETimes, "Wireless HD video: Raising the UWB Throughput Bar (again)," EETimes, 19-Feb-2008. [Online]. Available: https://www.eetimes.com/wireless-hd-video-raising-the-uwb-throughput-bar-again/.

122 "Application note: APR001 - decawave." [Online]. Available: https://www.decawave.com/sites/default/files/apr001_uwb_worldwide_regulations_summaryrev1.2.pdf.

123 "Technology," Decawave, 24-Apr-2019. [Online]. Available: https://www.decawave.com/technology1/.

124 "What is Ultra-Wideband (UWB)? here's everything you need to know," Bleesk. [Online]. Available: https://bleesk.com/uwb.html. [Accessed: 12-May-2022].

125 V. Savov, "How the NFL tracks everything on the field but the ball," The Verge, 28-Oct-2014. [Online]. Available: https://www.theverge.com/2014/10/28/7082683/nfl-real-time-motion-tracking-by-zebra-technologies.

126 "IEEE 802.15 Wpan High Rate Alternative Phy Task Group 3A (TG3A)," IEEE 802.15 TG3a. [Online]. Available: https://grouper.ieee.org/groups/802/15/pub/TG3a.html.

127 D. Takahashi, "Tzero technologies shuts down; that's the end of ultrawideband," VentureBeat, 13-Feb-2009. [Online]. Available: https://venturebeat.com/2009/02/12/tzero-technologies-shuts-down-thats-the-end-of-ultrawideband/.

128 "Technology," Decawave, 24-Apr-2019. [Online]. Available: https://www.decawave.com/technology1/.

129 Inpixon, "Ultra-Wideband (UWB) Positioning & Sensor Technology," Inpixon. [Online]. Available: https://www.inpixon.com/technology/standards/ultra-wideband.

130 V. Savov, "How the NFL tracks everything on the field but the ball," The Verge,

28-Oct-2014. [Online]. Available: https://www.theverge.com/2014/10/28/7082683/nfl-real-time-motion-tracking-by-zebra-technologies.

131 D. Pailthorpe, "New RTLS module to cut active UWB tag cost (RFID Journal)," Decawave, 29-Jul-2019. [Online]. Available: https://www.decawave.com/new-rtls-module-to-cut-active-uwb-tag-cost-rfid-journal/.

132 K. Flynn, "A global partnership," Release 18. [Online]. Available: https://www.3gpp.org/release18.

133 "Perception: Medical journals," IOMC. [Online]. Available: https://www.iomcworld.org/medical-journals/perception-39571.html.

134 "Systems thinking – language of complexity for scientists and managers." [Online]. Available: https://www.researchgate.net/publication/43468483_Systems_thinking_-_Language_of_complexity_for_scientists_and_managers.

135 Ackoff, R. (1999), Re-Creating the Corporation, Oxford University Press, Oxford.

136 J. van S. DOVA, "Van Openbaar Vervoer Naar publieke mobiliteit?," OV. [Online]. Available: https://www.ovmagazine.nl/blog/van-openbaar-vervoer-naar-publieke-mobiliteit. [Accessed: 12-May-2022].

137 Belastingdienst, "Vrijstellingen Van Btw," Naar de startpagina van de Belastingdienst, 16-Mar-2020. [Online]. Available: https://www.belastingdienst.nl/wps/wcm/connect/bldcontentnl/belastingdienst/zakelijk/btw/tarieven_en_vrijstellingen/vrijstellingen/vrijstellingen.

138 "Deeltweewielers in Rotterdam." [Online]. Available: https://www.rotterdam.nl/wonen-leven/deelvervoer/Jaarrapportage-deeltweewielers-Rotterdam-2020.pdf.

139 "That instructional designer? - jstor.org." [Online]. Available: https://www.jstor.org/stable/40324327?seq%3D1%23metadata_info_tab_contents.

140 L. Simonse, Design roadmapping. Amsterdam, Niederlande: BIS Publishers, 2017.

141 A. van Boeijen, J. Daalhuizen, and J. Zijlstra, Delft Design Guide: Perspectives, models, approaches, methods. Amsterdam, The Netherlands: BIS Publishers, 2020.

142 "TMS37F128 Controller Remote Access Identification device." [Online]. Available: https://datasheet.octopart.com/TMS37F128D3IDBTRG4-Texas-Instruments-datasheet-41218158.pdf.

143 Wouters, L., Marin, E., Ashur, T., Gierlichs, B., & Preneel, B. (2019). Fast, furious and insecure: passive keyless entry and start systems in modern supercars. IACR Transactions on Cryptographic Hardware and Embedded Systems (TCHES), 2019(3), 66-85. https://doi.org/10.13154/tches.v2019.i3.66-85

144 "DBT0038A." [Online]. Available: https://www.ti.com/lit/ml/mpds368a/mpds368a.pdf?ts=1652366833670&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FADS7960.

145 "Product Overview DW3000." [Online]. Available: https://nl.mouser.com/datasheet/2/412/Qorvo_DW3000-2934245.pdf.

146 Pugh, S., Total design; integrated methods for succesful product engineering. Wokingham: Addison Wesly, 1990, p. 48-64

147 "Cost estimator," Injection Molding Cost Estimator. [Online]. Available: https://www.custompartnet.com/estimate/injection-molding/.

148 "Waterproof Adhesive Glue Tape Sticker." [Online]. Available: https://www.alibaba.com/product-detail/Adhesive-Iphone-Screen-Waterproof-Adhesive-Glue_62315786592.html?spm=a2700.galleryofferlist.normal_offer.d_image.188a5f10tewPWm&s=p.

149 "Advanced PCB manufacturing cost calculator,get manufacturing price of HDI PCBS, high-frequency and thick-copper PCBS - pcbway," Custom PCB Prototype Manufacturer. [Online]. Available: https://www.pcbway.com/HighQualityOrderOnline.aspx.

150 "DWM3000 RF Zendontvanger," Zoekresultaten voor dwm3000 RF Zendontvanger - Mouser Nederland. [Online]. Available: https://nl.mouser.com/c/semiconductors/wireless-rf-integrated-circuits/rf-transceiver/?q=dwm3000.

151 TMS37F128 from Texas Instruments. [Online]. Available: https://www.electronics-datasheets.com/manufacturers/texas-instruments/parts/tms37f128.

Image Credits

https://www.ad.nl/den-haag/parkeervakken-moeten-chaos-van-deelscooters-voorkomen-op-scheveningen~ad00b97c/

https://edition.cnn.com/2018/12/12/tech/amazon-go-small-format/index.html

Campsite vector created by freepik - www.freepik.com

Electric scooter vector created by pch.vector - www.freepik.com

Cupid by Simon from NounProject.com

Business woman character vector created by pikisuperstar - www.freepik.com

Real estate business vector created by freepik - www.freepik.com

Town silhouette vector created by rawpixel.com - www.freepik.com

Commercial property vector created by freepik - www.freepik.com

Friendship by Teewara soontorn from NounProject.com