Nieuwe lessen over de potentie van Fiets en OV

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Samenvatting

Het combineren van fiets en openbaar vervoer is een duurzame oplossing voor de (mobiliteits)uitdagingen in zowel stedelijke gebieden als daarbuiten. Er is een revival van de fiets gaande en ook hoogwaardig openbaar vervoer rukt op. De keten van fiets mét openbaar vervoer combineert de voordelen van beide systemen: De fiets zorgt voor fijnmazige ontsluitingen van herkomst en bestemmingen, is milieuvriendelijk en stimuleert een gezonde leefstijl. Voor wat betreft OV neemt de kwaliteit de laatste jaren sterk toe door de introductie van hoogwaardig OV (HOV): snelle, frequente en betrouwbare bus- tram- en metrolijnen met een hoog comfortniveau. Voorbeelden zijn R-Net, Randstadrail en Q-Link. De halteafstanden van deze systemen zijn relatief hoog, waardoor de fiets een belangrijke rol speelt in de gebiedsontsluiting.
Om het succes van de fiets en OV verder uit te bouwen is kennis nodig over hoe de mobilist zich nu en in de toekomst beweegt: Wat zijn de succesfactoren, welke voorwaarden spelen een rol en waarom worden bepaalde keuzes gemaakt, bijvoorbeeld. Dit paper laat de resultaten zien van vier TU Delft onderzoeken op dit gebied. Belangrijkste, nieuwe inzichten zijn bijvoorbeeld dat het invloedsgebied van HOV haltes tot 4x groter is ten opzichte van "gewoon" OV. Verder blijkt dat treinreizigers bereid zijn ca. 6 min. extra te fietsen naar een station waar ze een directe trein kunnen nemen naar hun bestemming (in plaats van met een overstap). Tot slot blijkt dat de huidige groep fiets-OV'ers in te delen is in 7 groepen, waarvan de middle-aged male professionals de grootste zijn en de gepensioneerden de kleinste. De resultaten zijn de basis voor verder onderzoek en toepassing om te komen tot een optimaal Fiets-OV netwerk.

1. Introductie

Het combineren van fiets en openbaar vervoer is een duurzame oplossing voor (mobiliteitsgerelateerde) uitdagingen in zowel stedelijke gebieden als daarbuiten. Er is een revival van de fiets gaande en ook hoogwaardig openbaar vervoer rukt op. De keten van fiets mét openbaar vervoer combineert de voordelen van beide systemen: De fiets zorgt voor fijnmazige ontsluitingen van herkomst en bestemmingen, is milieuvriendelijk en stimuleert een gezonde leefstijl. Voor wat betreft OV neemt de kwaliteit de laatste jaren sterk toe door de introductie van hoogwaardig OV (HOV): snelle, frequente en betrouwbare bus- tram- en metrolijnen met een hoog comfortniveau. Voorbeelden zijn R-Net, Randstadrail en Q-Link. De halteafstanden van deze systemen zijn relatief hoog, waardoor de fiets een belangrijke rol speelt in de gebiedsontsluiting.

Om de combinatie van fiets en OV verder te stimuleren is een belangrijke eerste stap om te begrijpen hoe en waarom de huidige OV+fietser zich beweegt. Deze inzichten en kennis helpen om de besluitvorming en planning rond Fiets en OV te verbeteren. Denk daarbij aan aanleg, beheer en onderhoud en infrastructuur; maar ook aan exploitatie van bijvoorbeeld fietsenstallingen of het optimaliseren van een openbaar vervoernetwerk.

2. Fiets en OV: recente inzichten

Ondanks dat we als Nederland een rijke fietscultuur hebben, is de beschikbare kennis over bijv. fietsgebruik pas recent sterk aan het toenemen. Hetzelfde geldt ook voor kennis over de combinatie van fiets en OV. In 2017 zijn er verschillende onderzoeken over dit onderwerp gereedgekomen, waarvan de samenvatting hieronder worden gegeven. Deze onderzoeken zijn uitgevoerd door TU Delft, i.s.m. resp. Goudappel Coffeng, Witteveen en Bos, Stadsregio Amsterdam en het Ministerie van Infrastructuur en Milieu. De onderwerpen zijn:

- **Kenmerken huidige Fiets-OV gebruik(er):** Understanding the trip and user characteristics of the transit-bicycle mode (Shelat et al., 2017)
- **Invloedsfactoren of fiets-trein gebruik:** Why cycle to the railway station? A station scanner based on factors that influence bicycle-rail use (Leferink 2017);
- **Impact van kwaliteit OV op fietsgebruik**: Assessing Integration of Bus Networks with Non-Motorised Access and Egress Modalities (Brand et al., 2017);
- **Stationskeuzegedrag van fietsers**: Influencing station choice of cyclists: An innovative solution to reduce bicycle parking pressure at railway stations (Van Mill et al., 2017).

2.1 Kenmerken huidige Fiets-OV gebruik(er): Understanding the trip and user characteristics of the transit-bicycle mode

Although the synergy of bicycle and transit has been recognised and several efforts towards better integration of these modes have been made, a scientific understanding of the users and trips of this mode is clearly lacking (Shelat et al., 2017). The common, ultimate goal of all stakeholders here is to increase the share of the sustainable bicycle + transit mode by shifting travellers away from the use of private cars. And, in order to achieve this, it is important to understand the current use of this mode to maintain and increase its share by encouraging likely users to divert to this mode. The factors affecting the use of this combined mode can be divided into four parts: 1) policies, 2) infrastructural facilities, 3) user characteristics and 4) travel characteristics. While infrastructural facilities and policies regarding the integration of bicycle and transit have been discussed extensively few studies consider the actual trips conducted or those who make the trips.

Understanding which trips and users the bicycle + transit mode is suitable for enables policy makers to make relevant decisions regarding the infrastructure and service investments to be made in order to increase its modal share. Such decisions could be regarding the type of service required, for example: "Where should we focus efforts on improving feeder transit reliability?"; or regarding the priority of investments, for example: "If Delft University of Technology and the University of Groningen both expand their student intake where should we improve services to support the bicycle + transit mode?". Further marketing decisions such as: "Towards whom should we campaign the bicycle + transit mode?" or "How to best attract travellers to the bicycle + transit mode?" will also benefit from this study.

Therefore this study is not only motivated by the gap in scientific literature regarding this topic but also by the existing need to answer the above questions, and more, in order to increase this combined mode's share and thus enable more sustainable transportation.

This study focuses on analysing the user and trip characteristics of the bicycle + transit mode with the aim of producing a clear picture of its current usage so that it can be used by policy makers to formulate policies encouraging its use. The Netherlands has a rich content of mobility related data enabling such a research. Specifically, this study will use the OViN (Onderzoek Verplaatsingen in Nederland), a national mobility survey database from the past six years (2010-2015) as input for all analyses.

In general, it is seen that bicycles are the most preferred mode for users within smaller distances: from approximately 1 to 1.5 kilometres. At the opposite, trains are largely used to travel distances larger than 10 kilometres. Less clear, however, is the distance travelled by other transit (3-40 kilometres), this also makes sense since the category of bus, tram, metro is quite diverse within itself.

Besides distances, travel time is an important indicator of connectivity. The decay curves of walking and cycling are nearly similar. However, due to the higher speed, cyclists can cover a larger distance within the same acceptable time. Further on, it can be seen that the same counts when walking and cycling are used as access and egress modes for transit, thus indicating a larger catchment area for cyclists in comparison with walkers.

In terms of socio-economic variables, car and train are more used by higher income users. This is likely since the daily urban system of higher income users is larger than the one of their lower income counterparts. Since higher incomes travel more by train, and have a wish to travel further, they are more likely to be bicycle and train users. Bus, tram and metro, at the other hand are more used by lower income classes.

Transit users are more willing to travel larger distances towards train stations than towards bus, tram and metro stations: 3.8 versus 1.5 kilometre respectively. The same applies for egress distances but with smaller distances travelled, namely 2.7 versus 0.7 kilometres respectively. These mentioned distances counts for travellers of transit in general, thus also with either access or egress modes different than a bicycle. Based on these numbers, it can be seen that travellers are either reluctant to combine cycling with bus/tram/metro or do not have the facilities to do so.

In comparison with main modes, the access distance is larger when the distance travelled by main mode is larger too. Although this is true for both train and bus, tram, metro travels, the increase rate is higher for bus, tram and metro than train. A positive relation is also found between the frequency of transit use and the use of the bicycle as an access mode. This is mainly due to the fact that the bicycle and transit mode is often used for work, business and education purposes which are likely to be activities done more than once a week.

The bicycle and transit mode is multimodal by its nature. This multimodal characteristic already implies that the distance travelled by bicycle and transit is longer than average. The average distance travelled by bicycle and transit is about 41 kilometres. The distance is likely to be larger when transit also has a feeder function, however, this is not the most common trip combination. Often the bicycle is used as an access mode, followed by transit and walking as an egress mode. 82.8% of the transit within these trips is 'train', whereas the remaining 17.2% consist of bus, tram or metro as the main mode. The majority of trips is used to go to work or education, starting home (or going home in the opposite direction). The trip objectives already imply that most trips are made multiple times per week (89% of the users) and mostly on weekdays during morning rush hours.

The people making the bicycle and transit trips are equally represented by males and females. This equality, however, does not count of the level of education: higher educated people use the bicycle and transit mode more than lower educated people. This is understandable since it is already proven that the bicycle and transit mode is an ideal mode to travel longer distances and higher educated, working people are more likely to travel further to work than their lower educated counterparts.

The OViN-data set is used to determine the bicycle and transit users by defining clusters with a Latent Cluster Analysis. Seven mutually exclusive groups have been defined. Based on the properties of the clusters, each cluster is given a title defining the prototypical user represented by that cluster. It should be noted that this label is a subjective, average group definition and does not imply that all bicycle and transit users belonging to a cluster have the properties of the label. Regarding the reliability of the results all clusters have >100 observed users except for 'Pensioners' who have 80 members, which is also the smallest group within the total pool of bicycle and transit users. The group sizes are displayed in Figure 1.

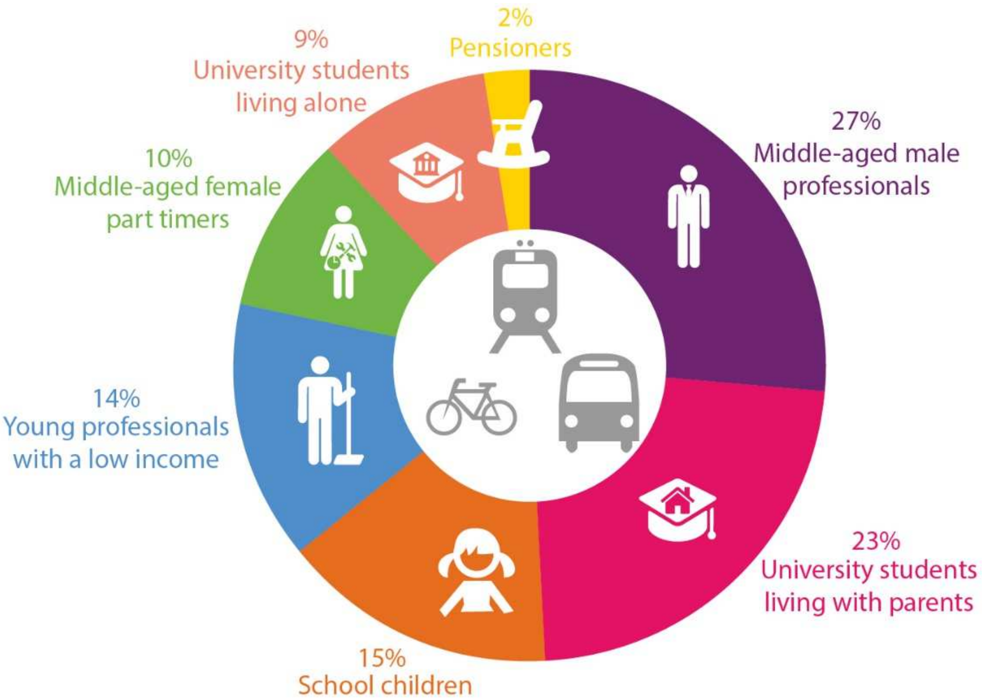

Figure 1: Seven identified clusters of bicycle and transit users as a result from the LCCA.

More than a quarter of the bicycle and transit mode users belong to the group of Middle-aged, male professionals. Most of the members of this group are middle-aged (35-64 years) working men, highly educated and from high income households.

2.2 Invloedsfactoren of fiets-trein gebruik: Why cycle to the railway station? A station scanner based on factors that influence bicycle-rail use

This study looks into an upcoming, sustainable multimodality: the combination of bicycle and train ("bicycle-rail"), and considers both bike-and-ride (BaR) and bike-on-board (BoB) journeys (Leferink 2017. Bicycle-rail combines the advantages of speed and accessibility of the train with the flexibility and (particularly in an urban context) reliability of the bicycle. Together they can form a competitive mode of transportation. When well-integrated, the benefits are evident for various parties: train operating companies see an increase in their catchment area, governments have less congested and more attractive cities, and travellers can choose a cheaper, faster and/or healthier alternative.

The advantages in theory are evident. However, bicycle-rail use is limited in worldwide practice. In the European Union on average four percent of rail users arrive or depart from the station by bicycle (BiTiBi, 2016). There is an exception: in the Netherlands on average 42% of the home-bound train journeys start or end with a bike ride (KiM, 2014). With increasing numbers of general bicycle and rail use worldwide, the number of bicycle-rail rides may be expected to rise too. This increase in demand requires more and better supply of bicycle-rail services. Vice versa: better bicycle-rail services can stimulate or unlock demand further and lead to a modal shift away from the car in particular. There are various design guides to help tailor services, and audit instruments that consider (potential) bicycle-rail use. However, there is no tool that combines relative potential

bicycle-rail use estimates on station level with interactive and attractive user-interfaces for strategic design and decision making. The framework for a Station Scanner is developed based on the research findings.
Scotland is selected to test the Station Scanner and illustrate the current roles and collaborations of relevant stakeholders to improve bicycle-rail use. Scotland has a particular receptive context for increasing bicycle-rail use: the government has high ambitions for general bicycle use, and current train operator ScotRail Abellio is implementing a "Cycle Innovation Plan". Additionally, the large variation in land-use, from very remote to highly urbanised, makes Scotland an excellent place to test the Station Scanner.
A combination of methods is chosen to answer the research questions. First of all, an extensive literature review is undertaken based on a selection of academic literature. From this review a selection of potentially influential factors is made and summarised to define their respective relations to bicycle-rail. These factors are discussed with two experts. Next, this knowledge is translated into the framework for a strategic analysis tool: the "Station Scanner". It is created in an iterative creative design process, parallel to testing the idea in data software and collecting input from Dutch and Scottish practitioners. The study then focuses on Scotland. A combination of desk research on (policy) documents and semi-structured and open interviewing techniques is used for this explorative research. Semi-structured interviews are undertaken with twelve representatives of eight parties identified as most influential on various relevant scale levels (local, regional, national), all involved with integrated transport in general or improving bicycle-rail in particular. Additional interviews with Dutch and Scottish transport specialists ensure an objective analysis of the context in which the various stakeholders work. These findings combined give an impressionistic analysis organised by theme.

Good bicycle-rail integration entails three aspects according to the literature: physical and network integration, an integrated ticket system and high quality information system. Practical guidelines mention services such as bicycle parking, public bicycles (e.g. London's Santander bikes), collaborations of bicycle-rail organisations, integrated payment systems (e.g. the Dutch OV chip card), positive communication and safe cycling infrastructure. Positive communication to raise awareness can be expected to be particularly important in 7 places where people are unfamiliar with this mode. Also among higher-level stakeholders and researchers, there is limited knowledge on how to best facilitate the growing or even unlock the potential demand.

Different stations and train services appear to attract different types and levels of bicycle-rail use. A literature review of Dutch and English academic publications yielded nearly forty factors to capture such variations. The most influential factors according to the review are the first/last mile distance (people will cycle up to five km), current bicycle and rail use, competition of other modes, safe and high-quality bicycle routes to the station, share of commuters among railway passengers and number of rainy days. The influential factors can be grouped in the three categories context, rail journey and first/last mile journey to align with the trip chain components.

The literature review made clear that there is variation between both countries and socio-demographic groups in how much they value these different factors. Where income or gender may highly correlate with bicycle(-rail) use in one place, it is insignificant elsewhere. As bicycle-rail literature is limited and considering these large variations, more than a generic overview cannot be given. However, it may be assumed that a combination of the factors can give a first indication of the potential for bicycle-rail use at station level.

To move from academic findings to a practical tool, the conceptual framework for a “Station Scanner” is developed. Existing bicycle-rail guides and analytical tools from different countries are studied to build upon and ensure a unique tool. The scanner enables its user to combine data of a (large) group of stations and provide a quick-scan of their relative bicycle-rail potential. This potential is based on scores of ten clusters derived from the factor overview. The first five clusters are more adjustable: bicycle use, bicycle infrastructure, rail use, competition BTM and competition car, the last five are established and harder to influence: land-use with potential, population with potential, trains with potential, climate and trip length/hills.
The scanner outcomes are shown on interactive dashboards that give the user a birds-eye view of all stations within a chosen boundary - e.g. a country. This can help in the first steps of the design and decision phase to decide where to focus improvements of bicycle-rail use. To ensure an objective view, we suggest a scanner should be designed and built by an independent party. The main two elements are a database and dashboard, with five steps required to design and create the scanner. They are shown in Figure 2 below.

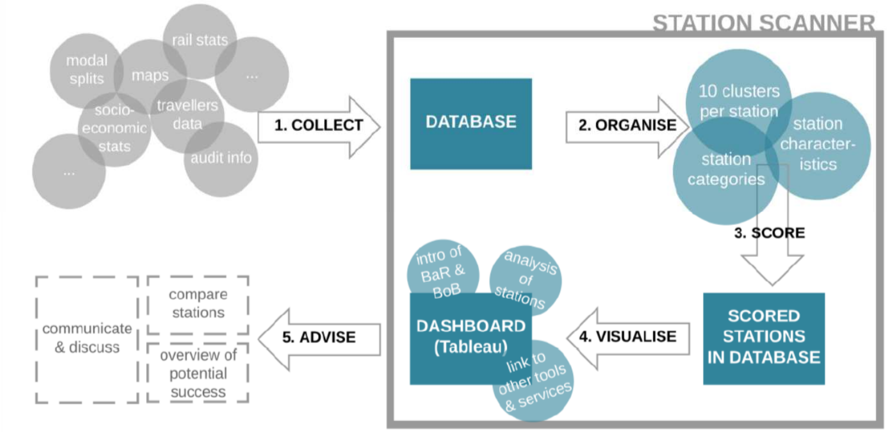

Figure 2: Elements of the Station Scanner framework 8

The framework has been tested by designing and creating a prototype for Scotland. The Station Scanner can roughly indicate the potential for bicycle-rail use on a station level. To unlock the potential for bicycle-rail, action is required from various stakeholders. To illustrate what current practice may look like, the Scottish stakeholders’ (in)formal objectives, tools and relations are mapped. On a national level already eight parties can be identified as being able to influence bicycle-rail. When including regional and local authorities this number increases quickly. The stakeholder’s level and the (trip chain) locations of (in)formal influence varies.
A number of opportunities are identified in Scotland where improvements for bicycle-rail are or can be realised. Examples include the renewal of the ten-yearly ScotRail franchise agreement, station development projects or the moment when new funding from public

parties comes available. Generally, attempts from any party to step out of the typical pragmatic paradigm and think beyond the party's formal boundaries and collaborate strategically are an excellent opportunity. This is important everywhere: integration requires collaboration. Who exactly collaborates and how financial, legislative and organisational powers are organised will differ from country to country. For bicycle-rail levels to take off in any place including Scotland, a shared vision among the stakeholders is vital.

This research presented helps to bridge the gap between theoretic knowledge and everyday practice of improving bicycle-rail use. The formulated main question can be divided into two components:
1. What (in)direct factors influence the combined use of bicycle and train?
2. How can these findings be applied to advice (Scottish) stakeholders to improve the bicycle-rail combination?

The first component builds from the idea that bicycle-rail use will increase, as it becomes an attractive option in an individual user's choice set. Besides various bicycle-rail services that can influence bicycle-rail use directly, a literature review found that many other factors can influence the (potential) demand for bicycle-rail use. A total of 39 factors is found in the literature. Their overlap and weights are expected to differ from place to place. Similarly, we may assume that different situations and stations require different strategies and services to ensure the demand is facilitated. These findings answer the first part of the main question.

The framework for the Station Scanner is a direct answer to the second component of the main question of this research. The scanner introduces the concept of bicycle-rail and enables its user to gain a bird's-eye view on the relative bicycle-rail potential of a set of stations, by scoring each station on ten clusters derived from the literature review.

The prototype scanner and explorative stakeholder analysis in Scotland provide a proof of concept and recommendations for the scanner's framework and illustrate day-to-day practice in improving bicycle-rail. Some of these findings apply to other countries as well: project-based and pragmatic working appears to be the norm but windows of opportunity include working beyond formal boundaries, ambitious formal agreements, funding availability for sustainable or active travel and development of strategy plans.

This study is part of a growing body of research undertaken on bicycle-rail travel. Nevertheless, change can only happen through action. It depends on influential stakeholders to make a difference and actively stimulate a better integration of bicycle-rail. Only then bicycle-rail can grow to its full potential.

2.3 Impact van kwaliteit OV op fietsgebruik: Assessing Integration of Bus Networks with Non-Motorised Access and Egress Modalities

Demand for transportation is subject to change influenced by technological, spatial, societal and demographic aspects. The political environment, together with financial and spatial constraints limit the possibilities to address transport issues arising from growing demand through the construction of new infrastructure. Upgrading of existing services and improving integration over the entire trip chain are two options that can address these transport issues. However, there is a lack of (scientific) insights in the influence of service upgrades on the performance of the bus system, and a lack of (scientific) knowledge into the characteristics of the transport system that influence transport network integration (Brand et al., 2017). Hence, to be able to assess and improve integration in bus networks, insight is needed in:

- The differences in performance and effects between conventional and high quality bus services
- The causes and effects of network integration in Bus-NMT transport systems;
- The assessment of the performance of the entire transport chain as the result of transport network integration, considering the interaction of the transport network with its environment.

To be able to develop an assessment framework, insight is needed in the different concepts of integration and the elements and characteristics of the transport system. In this research, integration is described as the combination of individual elements (links) of the transport chain, from a travellers' origin to its destination, thus combining different transport networks in one system, with the aim to positively influence effects of the transport system. This combination entails the integration of the different links through improvement of mode specific characteristics that influence integration, taking into account the environment of the entire system.

The 'system' mentioned in the description of integration, needs to be explained in more detail. A system can be described as 'a collection of elements that is discernible within the total reality'. The outcomes of the system, or 'emergence' is 'the principle that whole entities (groups of elements) display characteristics that are not only meaningful when they are assigned to the whole and cannot be reduced to the individual elements'. In this research, the integrated transport system consists of:

A. The Transport Chain

Which is the entire trip from origin (O) through the access node (AN) and egress node (EN), using the bus link, to the destination (D).

B. The Spatial and Demographic Elements

Which are the elements from the environment of the system, that influence the system, and as such are drivers of the system that determine the outcomes (effects).

C. The Effects of the Integrated Transport System

Which is the 'outcome' of the system, the effects of the system on travellers (e.g. total travel time) and society (e.g. emissions), which presents the way the integrated transport system influences the environment.

These different elements and their characteristics are the building blocks of the assessment framework.

Based on the literature research into transport network integration and the different elements of the integrated transport system, three different prerequisites have been identified that need to be captured in an assessment framework. These prerequisites (considerations) are:

- The influence of network specific characteristics on transport network integration;

Implies that the framework should be able to identify and assess different characteristics of the system elements, and should be able to determine the influence of these characteristics on network integration.

- The influence of the integrated transport system on (societal) effects;

Implies that the framework should be able to determine the effects of a system, and should be able to determine the influence of network integration on these effects.

- The assessment and comparison of different systems in terms of characteristics and effects.

Implies that the framework should allow for the comparison and improvement of different bus systems.

To be able to address these considerations, the framework that has been developed consist of three individual parts that are influenced by one another, being:

- Bus Line Performance Assessment;

Which involves the assessment of the different system elements and their characteristics of different (types of) bus services, including a comparison between different bus lines.

- System Effect Assessment.

Which involves the assessment of the effects of the (optimised) integration of the individual systems, including a comparison between bus lines.

- Integration Assessment,

Which involves the assessment of the manifestation of integration in transport networks and the related integration effects.

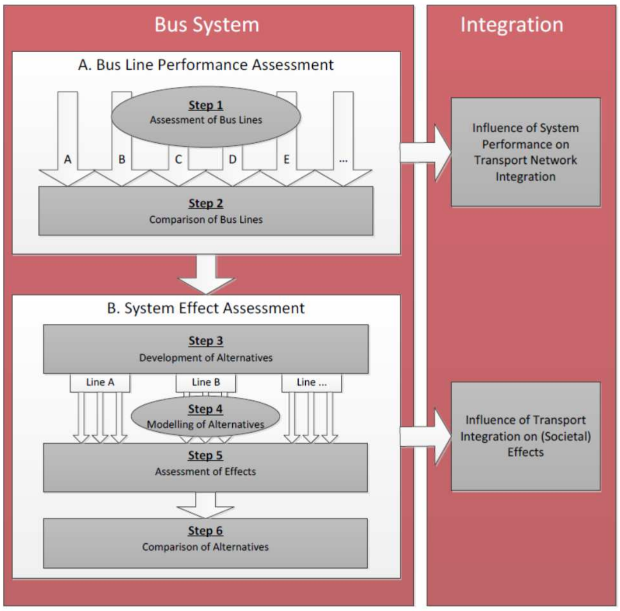

Figure 3: The Assessment Framework

The considerations, the building blocks (elements and their characteristics) and the three different parts of the assessment framework lead to the framework that is presented in Figure 3. The case study has been carried out for the concession area Amstelland-Meerlanden of Stadsregio Amsterdam. Each step of the framework represents a different step in assessment.

Step 1: Assessment of Bus Lines

The first step involves the assessment of individual bus lines. The different bus lines are assessed on elements and characteristics, and are compared using a scorecard in step 2. General survey outcomes give a chance to give a general overview of system performance of the 10 assessed bus lines. The break-down of use of access and egress modalities for the bus lines is most important. This break down emphasises the need for more detailed knowledge in the use of access and egress modalities for bus networks. The bicycle is an important modality on the access side, whereas its share on the egress side is much smaller. This can be explained by the fact that on the access side of a trip, people often have more modalities at their disposal, and thus have a larger choice of modalities. On the egress side, these modalities are often not or less available. Furthermore, walking is more important on the egress side, suggesting distances on this side of the trip are often shorter, hence allowing for walking. These outcomes stress the importance of the bicycle on the access side, where for bus systems, walking and cycling are very often considered as one modality. Hence, the high use of the bus on both the access and egress side suggest that other bus services are important as feeder services to faster or last-mile bus services. Opportunities might exist on the egress side of the trip (last-mile) if these distances are short, for instance through the supply of cycle-hire facilities, thus aiming for competition between bus and bike for short last-mile distance.

Step 2: Comparison of Bus Lines

The bus system (lines) are compared in three different ways: by bus type, by bus line, and by stop.

The bus type comparison compares Comfortnet (conventional bus system) with R-Net (high quality bus-system). Striking is that for R-Net, the share of the bike, both for access and egress trips, is much higher than the share in Comfortnet lines (25% versus 11% access, and 10% versus 5% egress). One explanation could be that people accept longer trips for R-Net services due to the positive performance differences between R-Net and Comfortnet (e.g. higher speeds, higher frequencies). The accepted distances for access and egress for walking and cycling have been assessed in more detail. For R-Net, distances are often higher than for Comfortnet, with the exception of the bicycle use on the egress side.

Step 3: Development of Optimisation Alternatives

The previous steps have shown that two characteristics contribute to an increase in integration. For two bus lines in Amstelland-Meerlanden, one Comfortnet line and one R-Net line, alternatives are developed to determine the influence of the identified characteristics (integration) on the effects of the systems. For the Comfortnet line, six alternatives are considered (base alternative, frequency increase, speed increase, decrease in stop density, speed and frequency, and finally speed, frequency and stop distances). For the R-Net line, three alternatives have been generated (the base alternative, the express service alternative (skipping stops) and the tunnel alternative (allowing for a higher service speed)).

Step 4: Modelling of Alternatives
The different alternatives are modelled and assessed using a traffic model. The traffic model used is the transit model VENOM, the regional model of Stadsregio Amsterdam. Venom is used for two main purposes: the assignment of traffic to the network, and the generation of transit costs (skims). The model has first been validated for use. By comparing the number of passengers (Qlik data of March 2015) with the modelled number of passengers, the model is validated based on outcomes. By comparing the usage of bus stops (GOVI data) with the usage of bus stops in the model, the behaviour of the model is validated.

Step 5: Assessment of Effects
The different alternatives are modelled and compared. This comparison allows for the calculation of total travel times. These travel times will be used in a Cost-Benefit Analysis (CBA) in step 6 to compare the effects of the different alternatives. The assessment of effects has also shown that when the characteristics that influence integration are altered, the number of passengers increases.

Step 6: Comparison of Systems
The performance of the different alternatives, in terms of travel time and number of passengers, is done using a Cost-Benefit Analysis (CBA). This CBA allows to assess the alternatives on societal viability by taking into account both the costs of implementation of these alternatives (e.g. operational costs, implementation costs), as well as the benefits (travel time savings, increase in operational income through the increase in number of passengers). This analysis shows that for line 172, the frequency alternative and the speed alternative give a positive outcome. For line 300, both developed alternatives are positive, but the express service alternative has shown a tremendous increase in monetised benefits as compared to the base scenario.

2.4 Stationskeuzegedrag van fietsers: Influencing station choice of cyclists: An innovative solution to reduce bicycle parking pressure at railway stations

The rise of the bicycle in combination with the train has a backside. At more and more railway stations this leads to overcrowded bicycle parkings. The upswing of the bicycle is being seen as something good that should continue. However, extending capacity is not always possible within limited budgets and space, and therefore innovative solutions are necessary (Van Mill 2017). Influencing station choice in order to spread parking pressure is one of those innovations. This study researches this innovation on parking pressure. There has not been done much research yet into influencing station choice, nor into the process that takes places when a station choice is made. Research has been done into the valuation of time and costs of trip parts; this knowledge is useful, but it has not been studied yet within the context of station choice. To influence station choice, knowledge about the factors that play a role in that choice is required. To fill this knowledge gap and to see how station choice can be influenced this study is set up. This led to the main research question: On what factors do 'bicycle-train' travelers base their station choice

when accessing the railway network, how are those factors related and what are measures to influence this choice based on those factors?
This question has a fundamental part and a part that is focused on generating policy. The answering of the fundamental part was split up in several stages. Because the available knowledge on station choice was scarce, the factors that play a role in station choice had to be explored. This exploration was based on literature supplemented by the experience of bicycle users. No distinction in impact of the factors was made yet. Some factors had an overlap because they influenced each other completely or partly. Dependencies were mapped, leading to a pure list of factors that have influence on one of the trip parts: access part, station part and train part. Besides the factors that directly influence the trip parts there are also factors that influence the valuation of those direct factors. Those are the personal characteristics of the users and the context variables like weather and trip purpose. The factors are shown in Figure 4.

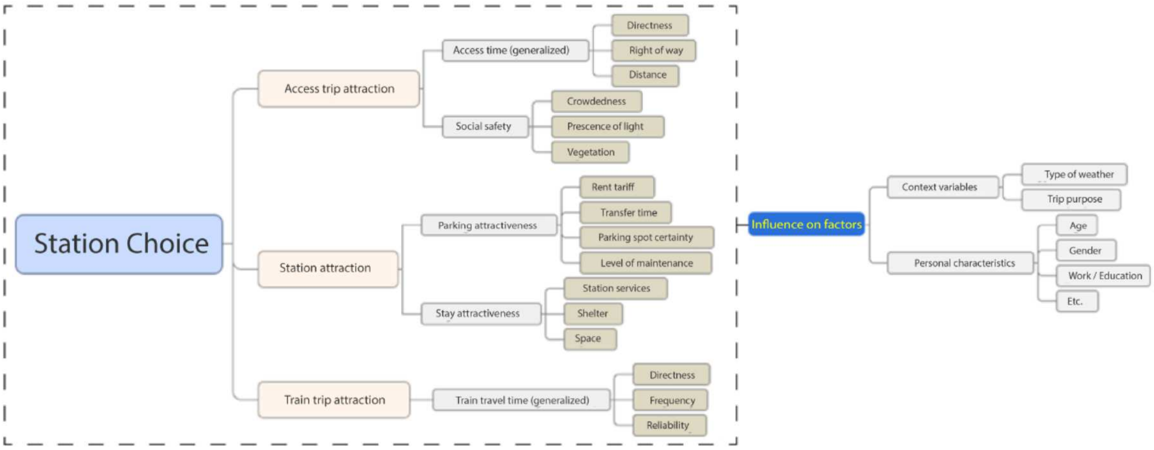

Figure 4: Factors that influence station choice

To acquire knowledge about how those factors relate, a stated preference experiment was set up. Stated preference has the benefit that an experiment can be created in the optimal way for the researched attributes. Every respondent makes his choices based on the same situation. The disadvantage is that respondents must emphasize with a situation that they are not familiar with. Nevertheless, stated preference best fits the goals of this study. There was a maximum number of five factors that could be included in the choice experiment, therefore a selection had to be made of the list of factors. In order to do this, 20 bicycle train users were asked to rank the factors. Out of this ranking the most influential factors were selected to be included in the choice experiment. It was important to include the strongest factors in the choice experiment because they provide the most information and it avoids dominant alternatives in the choice set. The factors were bicycle time, time to park and go to the platform, train time, parking price and transfer (in the train). The experiment was conducted by distributing a survey. This survey consisted of 3 parts. First the personal characteristics and habits of respondents were presented; the reason for this was to observe the impact of those characteristics on the factors. Then the choices were presented. Respondents had to choose between two stations that differed on the five factors. To each respondent 9 choices were presented. At the end, a few extra questions were asked to check how people interpreted the questions. The survey was distributed at stations and via social media. A total of 269 respondents completed the survey, of whom most were acquired through social media.

To analyze the data a Multinomial Logit Model (MNL) was used. The outcomes of this model are the dependencies between the included factors.
The outcomes show what the strength of the factors is in the station choice process. Because a monetary factor was included (parking price) this can be used to calculate a value of time or willingness to pay. This made it possible to validate, since there is research available in that field. Furthermore, it is also an understandable way to show the impact of the factors on station choice. The values are shown below:

- Bike time: € 0.11 per minute
- Time to Park: € 0.08 per minute
- Train time: € 0.08 per minute
- Transfer: € 0.60 per transfer

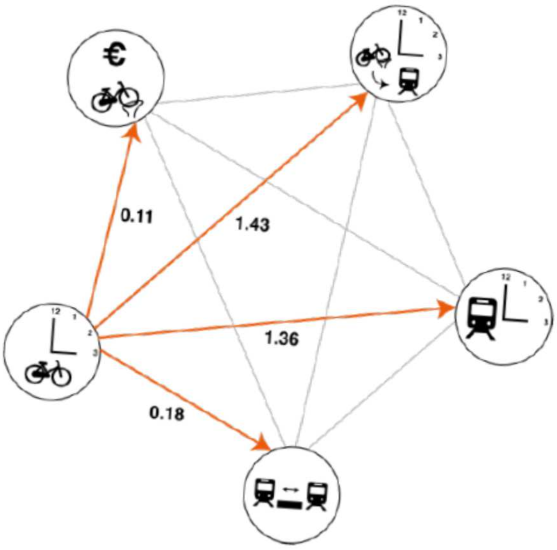

Figure 5: Bike time relating to other factors

Monetizing the factors is not the only way to interpret the outcomes; it is possible to use any unit to show the interdependencies. So, for example comparing bike time with the other components. Figure 5 shows that 1 minute of bike time is equal to €0,11 of parking costs, 1.4 minute of time to park, 1.4 minute of train time and one sixth of a transfer. This means that someone is willing to cycle an extra 6 minutes (e.g. to an intercity station) to avoid a transfer. This knowledge can be used to alter the attractiveness of a station. A different attractiveness results in a different station choice.
The analysis per personal characteristic and habit shows that the differences between age categories are quite high, while trip purpose and the number of trips per week has a much smaller effect on the outcomes. The outcomes were validated by comparing them to existing research about value of time and willingness to pay, and by showing the results to experts. This showed that the outcomes were in general valid.
To build further based on the lessons learnt in this thesis, a set of recommendations for further research is composed. It is advised to execute an experiment like this with a larger number of respondents and with more factors included. If a larger study is not possible the data of this study can be used for further analysis, for example on zip code level. In the preparation of this thesis it was discovered that there is some research available about the attractiveness of stations, this thesis adds an extra piece to that puzzle. It would be valuable to execute a meta-analysis to combine all research. It is also advised to explore all factors that play a role in station choice in an extensive empirical study. And as a last recommendation the measures that were found in this thesis were rated ‘quick and dirty’. It would be valuable to let a larger group of experts rate them.
This thesis shows that there is potential for influencing station choice. Several

recommendations for practice are given. The true potential can be examined by starting a pilot. It would be most logical to start implementing measures that have the lowest effort to implement and the highest impact. It is therefore advised to start with pricing measures. The other recommendations are to build new parking's as close as possible to the platforms (at stations where cyclists should be drawn to) and to start a discussion about redesigning the railway schedule, with more stops on secondary stations, because it has a lot of potential. With this two-stage study valuable insights on station choice fundamentals are gained and potential measures to influence station choice are presented. Influencing station choice can become an innovative solution for parking problems at railway stations.

3. Conclusies

Dit paper laat de resultaten zien van vier TU Delft onderzoeken op dit gebied. Belangrijkste, nieuwe inzichten zijn bijvoorbeeld dat het invloedsgebied van HOV haltes tot 4x groter is ten opzichte van "gewoon'' OV. Verder blijkt dat treinreizigers bereid zijn ca. 6 min. extra te fietsen naar een station waar ze een directe trein kunnen nemen naar hun bestemming (in plaats van met een overstap). Tot slot blijkt dat de huidige groep fiets-OV'ers in te delen is in 7 groepen, waarvan de middle-aged male professionals de grootste zijn en de gepensioneerden de kleinste. De resultaten zijn de basis voor verder onderzoek en toepassing om te komen tot een optimaal Fiets-OV netwerk.

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