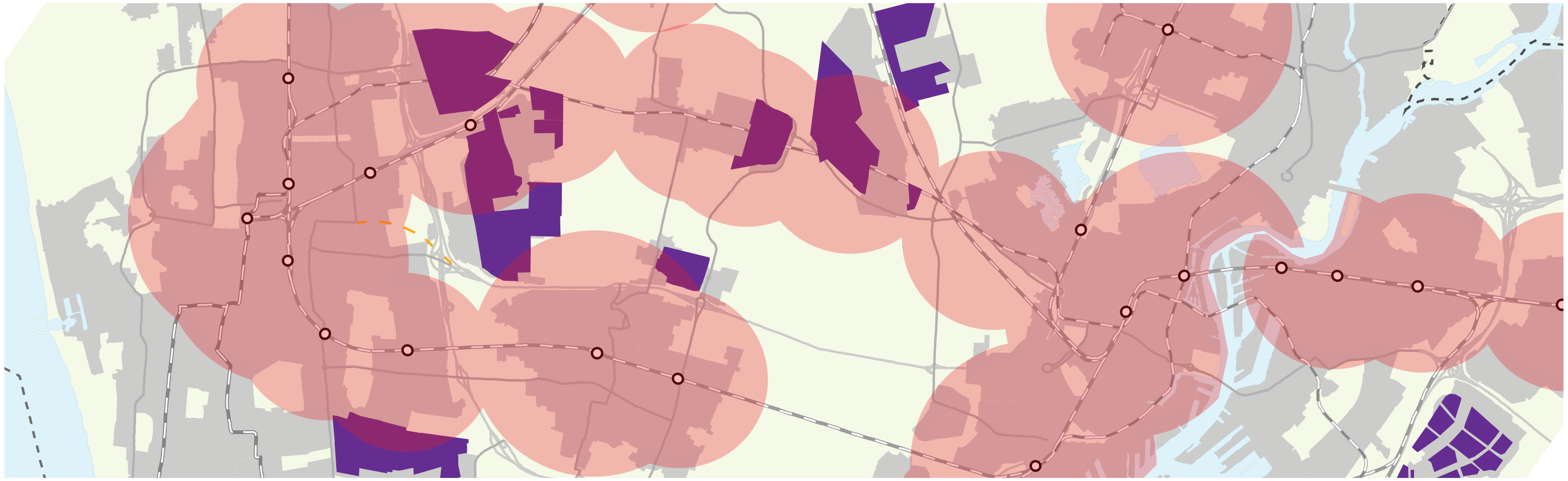
URBAN CYCLING = ~~HOT~~ HOD

A Study of the Relationship Between Urban Planning and the Hybrid Bicycle-Train System in Dutch Planning Practice



Erik Tetteroo

Thesis Master City Developer (MCD 10)
June 2015

Urban Cycling = HOD

A Study of The Relationship Between Urban Planning
and the Hybrid Bicycle-Train System in Dutch Planning Practice.

Erik Tetteroo

Thesis Master City Developer (MCD 10)
Erasmus University Rotterdam &
Delft, University of Technology
June 2015

Colofon

Urban Cycling = HOD

A Study of the Relationship Between Urban Planning and the Hybrid Bicycle-Train System in Dutch Planning Practice.

Thesis for Master City Developer (MCD 10)
Erasmus University Rotterdam &
Delft,Technical University

Erik Tetteroo
June 2015
tetteroo@appm.nl

management consultants

'Imagine if we could invent something that cut road and rail crowding, cut noise, cut pollution and ill-health – something that improved life for everyone, quite quickly, without the cost and disruption of new roads and railways. Well, we invented it 200 years ago: the bicycle.

As well as the admirable Lycra-wearers, and the enviable east Londoners on their fixed-gear bikes, I want more of the kind of cyclists you see in Holland, going at a leisurely pace on often clunky steeds. I will do all this by creating a variety of routes for the variety of cyclists I seek.'

Boris Johnson, Mayor of London
(Greater London Authority, 2013)

Prologue

At the start of the course Master City Developer we were asked to present a personal introduction. Of course I opted for a picture of myself on a bicycle, in strenuous exercise on the way to the top of Alpe d'Huez. I love cycling and posses three and a half bike: a lightweight Italian racing bike, a solid German MTB, a Dutch city bike and at home we share an old wreck to ride to the station. I declared my love for the bike, but I'm not (as the Germans say) 'Radverruckt', and this love should not predominate nor blur my professional view. I'm realistic about its limitations. For my job, I drive about 30,000 kilometer a year in a Volvo and can only rarely bicycle to the office. For visiting the colleges in Rotterdam and Delft I've alternated car and multimodal bicycle-train trips, and bicycled just a few times.

Cycling is not just a hobby. During the MCD study, I became also more concerned with the role that cycling plays in the city from a professional viewpoint. I was allowed to give several workshops and presentations for the Dutch Cycling Embassy about promoting cycling in foreign cities. One of the nice things about working abroad, is that you appreciate our own situation in the Netherlands even better. Most Dutch cities offer beautiful cycling facilities. Cycling in the Netherlands is so common sense that it's easily taken for granted, but the attribution to the economics of our cities is huge. When I had to choose a topic for my thesis, it was clear to me that it had to do with cycling. My interest is not so much the more technical part of infrastructure, but a more integral approach on bicycle-inclusive mobility and city development. It led to this thesis on the relationship between urban planning and the hybrid bicycle train system. It formed for me an exploration of the concept of Hybrid Oriented Development.

With this thesis, I'll end an interesting and challenging study on city development at the universities of Rotterdam and Delft. But I also hope it is the start of something new. I believe that the concept of Hybrid Oriented Development is worthwhile to be applied on a larger scale. It can encourage more sustainable concepts for economic and spatial development. I really hope that HOD will contribute to a better balance in facilitating the growth of cities and establishing a high quality of life.

Summary

Main Question and Subquestion

For most cities it is a contemporary challenge how to deal with the increasing urbanization and as a result the pressure on accessibility. Working towards sustainable mobility and enabling economic development makes demands on how this accessibility is shaped, and needs to be addressed urgently. One possible response is the combined use of the bicycle and train. This hybrid bicycle-train system (HBT) is sustainable, and combines speed and longer reach with door to door accessibility.

Now some questions arise how this 'new' hybrid modality is affected by planning. The reciprocal relationship between the HBT system and integrated planning, which consists of infrastructure and spatial planning systems, was explored in this thesis. The main question posed is:

To what extent can the use of a hybrid bicycle train (HBT) system in a Dutch metropolitan region be stimulated through integrated planning? The answer to the main question will be informed by an exploration of eight subquestions. The case of the Metropolitan Region Rotterdam The Hague (MRDH) was studied, with a focus on some typical station areas and commuter trips.

Analytical Framework

The hybrid bicycle train system (HBT) is a form of multimodal mobility, and can be seen as a combination of unimodal cycling and rail transit. Cycling can be included at the access or the egress trip, or at both ends of the transit. This hybrid form is here regarded as a separate modality that is best used for travel between different cores of cities because of the longer reach of the system, combined with a fast door-to-door acces.

HBT can be percieved as a meeting by the best of both worlds. The combination of two quite different modalities, cycling and train, can be very effective. They complement each other nicely. The speed and the long reach of the train and the door-to-door accessibility of the bicycle provide an efficient new modality, that has increased its modal share in the larger cities in the recent years. Concluding on the factors that can be influenced by planning to stimulate the

use of the HBT system, we can distinguish five factors:

- Frequency of rail service
- Bicycle infrastructure design
- Bicycle facilities near stations
- Proximity
- Density

Mobility has a large effect on spatial development. Land use is influenced by the way accessibility is provided, which leads to different choices between transport modes and thus to new infrastructure and so on. I distinguish spatial development concepts that are based upon different modalities. The car that built sprawled America, and public transport that formed the driver for TOD concepts. Following these, I see opportunities for a Hybrid Oriented Development (HOD) that is based upon the HBT system.
An efficiently functioning HBT system implies that the density should certainly be high within walking distance of the train station, and moderate to high within cycling distance. I assume that optimum HOD locations have a density of 35-50 dwellings per hectare in the first shell around a station, on a walkable distance of about 500 m. And in the second shell, that aims at cycling and thus has a radius of 2 to 3 km., the preferred density is 20-35 dwellings per hectare.

HBT and Integrated Planning in the MRDH

The reach of the HBT system is regarded as to what extent the system is available to residents, and to which areas it extends. The reach can thus be visualized by the surface, or by the number of inhabitants. The proposition that density leads to closer proximity is true when we look at the average distances to stations. All the smaller, less urbanized municipalities fail in the reach to HBT system. We can also distinguish a large difference in the densities between the suburb stations and the intercity station. The density around the suburb stations is mostly between 20 to 25 dwellings per ha, while the density around intercity stations, that all are positioned in the larger cities, is almost doubled.
The reach of HBT system in the MRDH region is not divided equal on MRDH. Approximately halve the surface of MRDH is not well covered for the HBT system. That includes the municipality Westland, and parts of The Hague and Zoetermeer.
The reach is not only limited by an area that it covers, but also by the number of people to which it is easily available. The number can be estimated on the basis of the results obtained in the focus stations, and the map that is drawn. While the total MRDH area is only about half covered by the defined reach, the population density is in general spread nicely around the stations. That makes that about 1.6 million of the 2.2 million inhabitants are within the prefered reach. Together that means that approximately 73 percent of the total population of MRDH is placed in a position to make a good choice for the HBT system, or for another means of transport. The ratio between the surface and the number of inhabitants that it covers, shows that the reach of the HBT system is efficient in MRDH.

If we look more into detail at the differences between the walking and cycling catchment area, it is remarkable that density is lower in the first shell than in the larger second shell. This is due to the space that is occupied by rail and major roads in the direct vicinity of the station. It is reinforced by security zones and environmental zones prohibiting housing.

Planning system
The Netherlands has a strong reputation on their restrictive spatial planning and its open proces for developing spatial policy. But it seems that the cooperation between the governmental layers is not always as fluent as we may think, and that especially the balancing of interests between spatial and infrastructural goals or concepts is difficult to achieve.
All governmental layers are involved in planning for bicycle-inclusive urban areas. But although, or maybe because all these actors are involved, there is no strong ownership of the multimodal displacement chain. No one is really responsible for the whole.

This leaves the question how and where (more) integrated planning in the MRDH region can stimulate the use of the HBT system? It seems that already some steps are taken and that the conditions for the use of HBT system are improved in the last decade. The succes of the system, with an increasing number of users, is also its weakness if we look at the transport factor. Trains are fully occupied during rush hour, and finding a free place to park your bike is really a difficult task. Investments should be made to increase the frequency of the number of trains, and to provide more bicycle parking places in the direct vicinity of the platforms. The difficulty is that these investments and the expected revenues are not always in the same hands.

This is more or less the same if we look at the spatial planning. To intensify the density and improve proximity a more restricted regime is needed. The more expensive lands near stations and in inner cities should be developed. This could be optimized by a better cooperation between the governmental layers, and by a more holistic view on the finance and the planning of burn areas that are designed and suited to stimulate the HBT system.

The main question of this thesis is to what extend can the use of a hybrid bicycle train system be stimulated through integrated urban planning? The above-mentioned insight in the limited succes of an integrated approach already provides a part of the answer.
All governmental layers should think more from the interest of the user, than from their own limitations. A more location specific approach, in which finance and planning of infrastructure are brought together with a stricter regime on urban planning. The revenues on the one side should benefit deficits on another plane, even if that is the responsibility of another layer of government. This could be optimized by a better cooperation between the governmental layers, and by a more holistic view on the finance and the planning of burn areas that are designed and suited to stimulate the HBT system. The polycentric structure of the MRDH proves a good basis to further implement the HOD concept, in which the hybride bicycle train forms the backbone.

Recommendations

Based upon the case of MRDH, that can be seen as an exemplary case because of the level of cycling facilities, rail network and urban planning system, I come to the following recommendations.

- Focus on the larger catchment area: in the slightly wider area around a station, that is still on an easy to cycle distance, are better opportunities to allow compaction at a lower cost.
- The more people cycle to the station, the more bikes need to be stalled. To provide in the latent demand for bicycle parking, keep on investing in well designed (underground) parkings. Built it and they come….
- Raise a HOD fund for integrated finance. From this fund additional budget comes available to allow developments in inconvenient locations that fit the policy to build sustainable accessible locations.

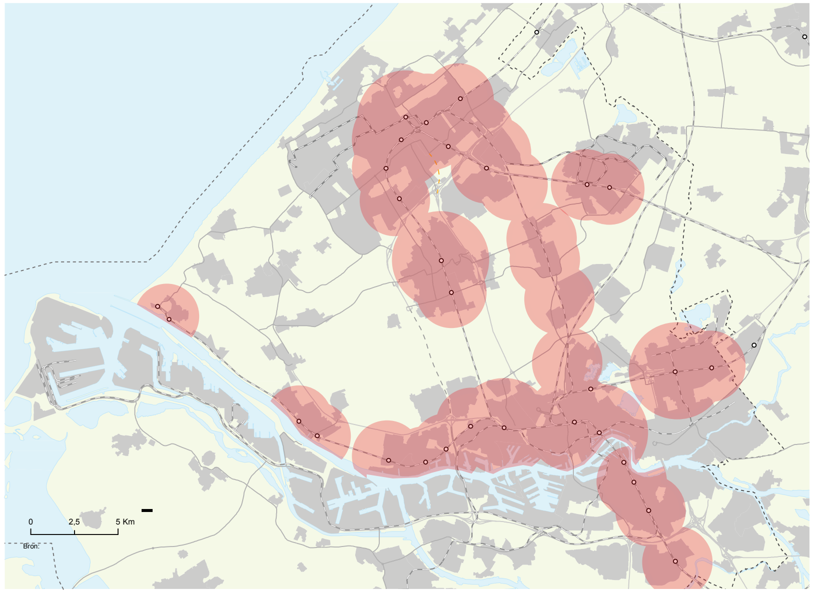


Table of Contents

Chapter 1 Introduction

The Dutch government has linked its ambitions for the economic development of the country on the relationship between infrastructure and spatial planning. The ambition is focused on a competitive, accessible, livable and safe Netherlands (SVIR, 2012). In addition, it is a challenge how to deal with the increasing urbanization and as a result the pressure on the accessibility of cities. Working towards sustainable mobility and enabling urbanization makes demands on how this accessibility is shaped, and needs to be addressed urgently. One possible response is the combined use of the bicycle and train. This hybrid bicycle-train system 'can serve a much greater variety of trip types compared to stand-alone use of either the bicycle or train' (Kager, 2015; p.1). Since the government is committed to a powerful approach that put the user first and connects spatial development and infrastructure, it is interesting to study the relationship between the bicycle-train system and the development of an urbanizing region.

1.1 Ongoing Urbanization Asks for Sustainable Transport

The world's population already exceeds 7.2 billion, and the majority lives in an urban region. This trend of urbanization still continues now that virtually all countries of the world are becoming increasingly urbanized. In the more developed countries, comprising Europe, North-America, Japan and Australia/New Zealand, even more than three quarters of its population houses in cities [1] (United Nations, 2013;). And in the Netherlands, 82 percent of the nearly 17 million inhabitants prefer the urban environments over the rural countryside. The four major cities have grown exceptionally strong in recent years and they are expected to continue to grow significantly in the future (Planbureau voor de Leefomgeving, 2013). This trend of urbanization affects the welfare of people: more people, more trade and more economic activity. Cities provide chances for people. But it also means more demand for mobility in densely populated cities, which causes congestion and air pollution. To ensure the quality of life and the viability and attractiveness of cities, it is necessary to have good alternatives for polluting car use. It is time for sustainable transport that encourages economic development and contributes to the quality of life.

1 http://esa.un.org/unpd/wup/Wallcharts/urban-rural-areas.pdf

There are several alternatives for car use: walking, cycling, scooters, motorcycles and public transport. Walking is most sustainable, but has a very limited reach due to the low speed. Scooters cause a lot of air pollution, especially by the very high concentrations of particulate matter emitted[2]. Motorcycling is done by relatively few people, and requires a specific license. The number of casualties is relatively high among motorcyclists[3]. According to the ADEME environmental calculator, cycling consumes only a third of the energy consumption compared to walking. And traveling by train is up to 5 times better than by car, and still 3 times better dan electric cars[4]. The hybrid combination of the bicycle and train is thus pretty sustainable.

Both modes have their different characteristics, and their share in the modal split (the percentage of travelers using a particular type of transportation or number of trips using said type) differs greatly from city to city. In many ways, bicycle and train can be seen as opposite transport modes: in speed, reach, distance, comfort, feel/freedom, etc. Yet their highly complementary characteristics form the basis to regard the bicycle-train combination as a distinctive system, and as a modality on its own. Recent studies (Kager et al, 2015) show the possibilities of the hybrid transport system:

"The bicycle is often understood as a disjointed 'feeder' mode that provides access to public transport. We argue that combined use of the bicycle and public transport should be understood in a broader perspective, especially where bicycles link to higher speed and higher capacity public transport, such as the train. Cycling and public transport can have a symbiotic relationship forming a hybrid, distinct transport mode, which should be reflected in transport planning. The bicycle is as a versatile way to soften the rigid nature of public transport and thus accommodate diverse individual travel needs and situations. Public transport can be seen as a means to dramatically extend cycling's spatial reach. We combine a system perspective with conceptual analysis to explore how, why and when this reconsideration is important." (Kager et al, 2015; p.1)

2 www.nature.com
3 http://www.swov.nl/rapport/Factsheets/NL/Factsheet_Mobiliteit.pdf
4 www.ademe.fr;https://en.wikipedia.org/wiki/Sustainable_transport#Sustainable_transport_toolbox

The assumption that public transport is not only a sustainable transport mode, but it may also be a cause to steer spatial development around the main stations was promoted by the 'New Urbanism' movement. In their charter[5] New Urbanism advocates urbanization aimed at transit (Cervero et al. 2002). The concept of Transit Oriented Development (TOD) is widely spread in recent years, and can be defined as:

"A compact, mixed-use community, centered around a transit station that, by design, invites residents, workers, and shoppers to drive their cars less and ride mass transit more. The transit village extends roughly a quarter mile from a transit station, a distance that can be covered in about 5 minutes by foot. The centerpiece of the transit village is the transit station itself and the civic and public spaces that surround it." (Bernick & Cervero 1997, p. 5)

Thus TOD is based on the concentration of spatial developments around nodes for public transport. It can contribute to the economic rise of cities, and to more sustainable development on well accessible locations that are less dependent on the car.

In recent years, most (European) metropoles have put more and more focus on cycling as an efficient alternative for car use. Transport for London claims to allocate £913 million of the city's budget to improve cycle networks in the next ten years. Paris launched an ambitious bikeshare program called 'Velib'[6] and Berlin even aimed at doubling the modal share of cycling in 2025 (Greather London Authority 2013; During 2014). Not only because it is a sustainable transport mode that has a very good score on reducing noise and air pollution and reducing the use of vanishing fossile fuels. The urban cyclist requires less space on the road as well for parking, and he or she contributes to a positive image of the city. As Pucher and Buehler (2008, p. 2) argue, "cycling is economical, costing far less than both the private car and public transport, both in direct user costs and public infrastructure costs. Because it is affordable by virtually everyone, cycling is among the most equitable of all transport modes. In short, it is hard to beat cycling when it comes to environmental, social and economic sustainability."

5 http://www.cnu.org/charter

6 www.velib.paris

Despite this new attention to cycling, little is known about the effect it has on new urban development. Will it improve the accessibility of dense areas? Does it change the planning of urban amenities, and does it invite to new building designs based on cycling?

A spatial development concept based upon bicycle use is a rarely recognized phenomenon. Some bicycle advocates like Stephen Fleming (2011) use the concept to promote bike-friendly buildings as the 8-house in Copenhagen, and some architecture in Portland is assumed to be influenced by a concept of Bicycle Oriented Development (BOD). But BOD is hardly seen as a concept for city development.

Now some questions arise how this combined bicycle-train system, the hybrid modality, is affected by urban planning. How is the use of hybrid bicycle train system (HBT) influenced by elements as density and proximity, which, in turn, are steered by planning decisions? Does HBT improve accessibility, can it thus play a role in the economic growth of a region, and in what urban geography is it (most) effective? As the concept of HBT system is rather new, its influence on urban planning has not yet been thoroughly studied. Not all of these questions can be answered in the restricted time frame for a thesis study, so I have to make choices on what to investigate more in depth. Nevertheless, this thesis generally aims to improve our insight in the relationships between urban planning and the emerging trend of bicycle-inclusive mobility in an urbanizing region.

1.2 Relevance

Relevance for Urban Development

This study should lead to recommendations for politicians and policy makers, entrepreneurs in bicycle-inclusive mobility, for real estate developers and especially urban planners and city developers involved in a metropolitan region or urban environment. By contributing more knowledge about the possibilities of urban development that contributes to a sustainable mobility principle, I hope to inspire planners and developers to act and to create more plans in this way. By creating an environment where the use of train and bicycle is more obvious, it can encourage residents to make more frequent use of it. For residents it provides more choices in their mode of transport, and above all a pleasant and clean living environment.

Scientific Relevance

In recent years, much has been written about the relationship between mobility and urban development. Most literature is about sustainable transport, and is aimed at the contribution to mobility or health (e.g. Bertolini 1999, Heinen et al. 2010, Maat et al. 2005). Also a lot can be found upon the (technical) design of bicycle infrastructure[7]. And the knowledge institute VerDuS is working on a study of the sustainable accessibility in the Randstad, including a research program on cycling[8]. But the field of the relation between urban planning and HBT is still rarely a focus of scientific inquiry. This study addresses this gap, and aims to contribute to recent research initiatives that explore the potential impacts of the bicycle-train system on urban planning and development. These initiatives are not limited to The Netherlands, but take place throughout Europe.[9]

The demand for more research in this field was also expressed by Kager et al. (2015), as they expressed a recommendation for further research on the relation with urban planning (p.11): …..“Reciprocal effects to land-use, in particular urbanisation. We have limited our system analysis of the bicycle-train system to the transport supply side. An external aspect, which distinguishes the system from car-based mobility, is its reciprocal and positive relationship with urban density and urban proximity. This is mainly because 1) bicycles have a rather limited radius and speed; 2) high-speed, high-capacity transit is only viable for transport corridors offering enough ‘mass’, thus favoring corridors to and from urban areas; and 3) conversely, the performance of the car system generally is negatively affected and/or restricted in areas with high urban density (but more competitive in low density, low proximity areas). These reciprocal relationships need to be further explored.“

With this study, I want to attribute to fill the gap in the knowledge on the relation between hybrid cycling-train modality and city development. I also hope to influence others and encourage them to write about planning from the viewpoint of bicycle-inclusive mobility, as I assume that a lot more research and study will be needed.

7 www.crow.nl
8 http://dbr.verdus.nl
9 http://ec.europa.eu/programmes/horizon2020/en/area/transport

1.3 Research Question

What concerns me in this study is to examine the relationship between the bicycle-train system and the development of an urbanizing region. The two most important research aims are to better understand:

I. the reciprocal relationship between HBT and urban planning
II. the relationship between the infrastructure and spatial planning system.

The relationship between infrastructure planning and spatial planning has been my great interest. In this paper I use the term integrated planning which primarily concerns the interaction between these two elements of urban planning. I want to contribute to scientific knowledge on the relation between urban planning and bicycle-inclusive mobility. This knowledge can be particularly relevant both for politicians and policymakers, and for developers. This is because we can assume that the increased use of a hybrid bicycle-train system is beneficial for the quality of life in cities, if only for the reduction of air pollution. The belief that the adaption to a more sustainable mobility concept is beneficial for its inhabitants in terms of reducing pollution, improving livability and enhancing accessibility is followed by an increasing number of cities, all over the world. Many of them are developing and promoting cycling and transit services in their policies (Pucher et al. 2011, 2012; Buehler and Pucher 2012; Harms et al. 2014; Carstensen and Ebert 2012; Loo and Comtois 2015; Kager 2015). The modal shift from car (and bus) to bicycle inside urban areas also has large social cost benefits. Van Ommeren (2013) calculated effects on traffic safety, noise pollution, emissions, grants and excises, life years gained, labour productivity and reducing congestion. A shift from car to bicycle of one person yields society about €0,41 per kilometer.

This brings me to the normative standpoint taken up in this thesis. Based on the cited literature above, I assume that improving the circumstances by which the use of HBT is stimulated is worth pursuing in urban planning and development.

I have chosen the Metropolitan Region Rotterdam The Hague (MRDH) as my empirical field of research. MRDH is a new partnership, established to strengthen the position as a metropolis and in its policy strongly focused on accessibility[10]. It is also interesting because it is a polycentric region, which provides an incentive for research on different levels of scale: the region as a whole, the different cities and the districts. MRDH has a modal share of cycling that is generally in line with the national average (26%), but with some great varieties[11]. As The Netherlands are internationally known as the worlds leading cycling nation[12], for its dense and well developed rail network and also for its urban planning system (Hajer, 2000), the case of MRDH can be regarded as a 'best practice' or, in methodological terms, as an exemplary case. Hence, I argue that research on this case is expected to provide insights and recommendations that are relevant on a more general scale.

Related to the statements above, the main question of this thesis is:
To what extent can the use of a hybrid bicycle train (HBT) system in a Dutch metropolitan region be stimulated through integrated planning?

The answer to the main question will be informed by an exploration of the following subquestions:
Theoretical Questions
1. What factors stimulate bicycle and train use in city regions?
2. What factors stimulate or hamper the use of a hybrid bicycle-train (HBT) system?
3. How do these factors relate to the economic functioning and accessibility of city regions?
4. Which of these factors can be influenced by the Dutch urban planning system?

10 www.mrdh.nl
11 www.fietsberaad.nl
12 http://www.ecf.com/ecf-cycling-barometer/

Empirical Questions
1. What is the reach of the hybrid bicycle-train (HBT) system in the MRDH region?
2. To what extent is this system attended to in MRDH urban planning practice?
3. What are the roles and responsibilities of key actors in planning and delivering HBT-related areas in the MRDH region?
4. How and where can integrated planning in the MRDH region stimulate the use of the HBT system?

The answers to the first four questions will be based on a literature review. The last four questions will be answered by performing a case study. The answers to the first set of subquestions will be presented in chapter 2 and 3. Sub question 4 is not only informed by literature, but also has an empirical component. This will be explained in chapter 4, followed by the principles for the analytical framework. The empirical part of this thesis can be found in chapter 5 and 6.

1.4 Methodology

The research underlying this thesis is qualitative and exploratory, and is particularly based on a literature study, expert interviews, and on a study of documents about the planning and development of the MRDH region. In addition, some quantitative analyses have been used to gain insight in elements as density, proximity and travel times in the MRDH region.

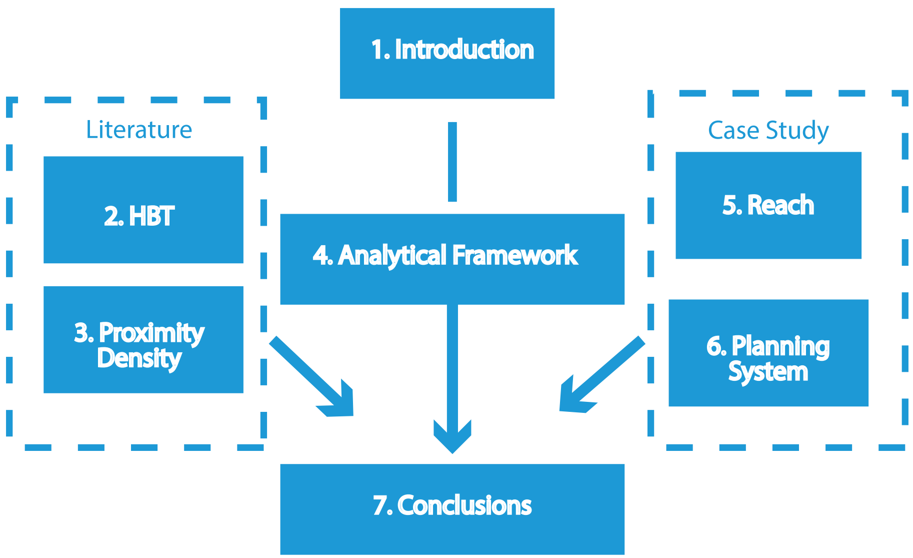
Data was gathered by starting with a literature review and exploratory interviews, with experts on urbanization and policy makers on mobility and urban planning. Further literature review followed to explore the most important theories on metropolisation, accessibility and the relation between transportation and land use. It is remarkable that, though there is a lot of knowledge and expertise about cycling in the Netherlands, most literature is from abroad. So, I studied a lot of American articles about transportation and development. Because the spatial development and modal split in Dutch and US city regions differs a lot, the results of the American studies can only be partly translated to our situation. However, some important insights can nevertheless be transferred to the Dutch situation.

For insight into the current situation in The Netherlands, I used data from existing studies and from research institutes as CBS and KiM. In addition, I have interviewed government actors, private actors and stakeholders to test assumptions about the impact of the bicycle-train system in urban planning, the focus in private development and to determine future application.
Because of the qualitative nature of the research I opted for keeping semi-structured interviews, which allowed me more flexibility to respond to the research situation and the information of the respondents (Baarda, 1996). In order to ensure that all issues could actually be addressed I prepared a short questionnaire and used it as a guide for the interview. The questionnaire and the list of interview partners are included in Appendix II.

The data collected through this process were transcribed and coded in order to identify patterns, in order to draw conclusions and to develop some recommendations. This was not a lineair process but it followed a few cycles. I did not plan all interviews in one week, but kept some intervals between them. So there was room for additional literature review and to reflect on insights from previous interviews. A second series of more in-depth questions was used at the final stage of the study.

1.5 Structure of the Report

The structure follows the methodology described above. Chapter 2 and 3 present the theoretical background. This part starts with a viewpoint on the types and characteristics of bicycle-inclusive mobility, and which factors influence bicycle and train use. This is followed by a review on how these influential factors for mode choice have an effect on economic functioning of cities.
Chapter 4 can be seen as the tipping point between the theoretical and the empirical study. It will provide insight into the relation between mobility and urban development, into the concept of Transport Oriented Development and how that may equally evolve into a new concept of Hybrid Oriented Development. Also, it provides insight into what influencing factors for HBT mode choice can be influenced by the Dutch planning system, which brings us to the components of the analytical framework.
This is followed by the case study. First I will give some backgrounds on the MRDH. Chapter 5 is further used to determinate the 'reach' of the HBT, and chapter 6 describes the urban planning processes that take place to encourage (or hamper) the use of HBT. This leads to the conclusions in chapter 7 in which the insight form the literature review and the case study are brought together in order to answer the main question and subquestions. Based on the normative standpoint explained above, the conclusions are followed by recommendations for policymakers and developers as well as for further research.
Finally, I give a brief reflection on the process of writing the thesis and following the MCD course.



Literature Review

Figure 2.1 Modal share regarding to trips (left) en distance (right) in the Netherlands (source KiM, 2013)

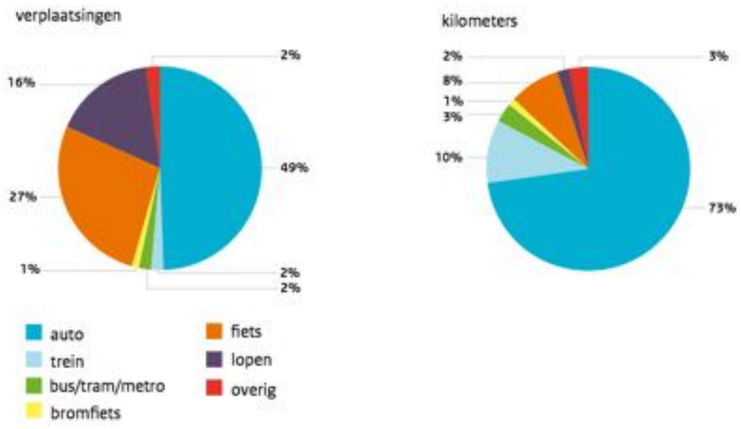
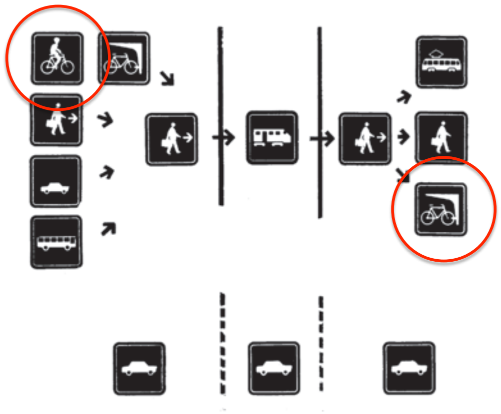


Figure 2.2 Bicycle as choice in pretransport and postransport for train travel, compared to other modes of travel.



Chapter 2 Hybrid Bicycle Train System

2.1 Intro

According to Kager et al. (2014) the bicycle-train system can be regarded as a separate modality, next to car, public transport and (stand alone) cycling. This chapter aims to give insight into the working of a hybrid bicycle-train (HBT) system. First, I will discuss the differences between unimodal bicycle trips and multimodal (bicycle-inclusive) trips, and distinguish the elements of a bicycle-train trip. Hence, I will translate the elements of the bicycle-train system into their spatial components, such as bicycle infra, station areas and catchment areas. Then I discuss the factors that influence (unimodal) cycling and (unimodal) train trips.

This leads to an overview of factors that stimulate (or hamper) the use of the bicycle-train system. In sum, this chapter answers the following subquestions: What factors stimulate bicycle and train use in city regions? And what factors stimulate or hamper the use of a hybrid bike-train (HBT) system? This is elaborated in several sections according to different themes.

2.2 Bicycle-Inclusive Mobility

In modern western societies, people have different choices to reach their destination. Walking, cycling, public transport and car use are most commonly used for commuting and recreational trips. An unimodal trip happens if only a single mode is used. When two or more different modes are used for a single trip between which the traveller has to make a transfer, we can speak of multimodal mobility (Van Nes, 2002).

I will use the term 'bicycle-inclusive mobility' as a broader and more general approach on various types of transport in which cycling is involved. We can distinguish cycling between unimodal and multimodal bicycle-inclusive mobility:

A. unimodal cycling: cycling as single means of transport;

B. multimodal bicycle-inclusive mobility: cycling as part of bicycle-train or bicycle-car trips.

A. Unimodal Cycling

Private, unimodal cycling can be seen as the standard for cycling in The Netherlands. Nearly all Dutchmen own a bicycle. The total number of bicycles is even higher than the number of inhabitants, with an average of 1.1 bicycle per person[1]. In most cases, the bicycle is used as the single means of transport for a door-to-door trip.

The distance traveled for commuting in unimodal cycling trips is relatively short, compared to other modes of transport as train and car use. It is widely agreed that a single fare distance of 7.5 km is the maximum most commuters will travel by bicycle. For distances up to 2.5 km, the bicycle claims about 50% of all trips, but for distances over 15 km not more than 3% cycles. Although the majority of bicycle trips are over relatively short distances, an increase apparent in the displacement distances on the relationship 'region / outside regions. (KiM 2013; www.fietsberaad.nl). The popularity of the bicycle on short distances can be explained by the reduced travel time. The bicycle is faster than the car and public transport on inner city trips up to 5 km (Olde Kalter, 2007). The recent emergence of e-bikes allows for improving the speeds and distances.

B. Multimodal Bicycle-inclusive Mobility

When cycling is part of a multimodal trip, the most common combination is with public transport, especially the train (60% of all multimodal trips). In fewer cases cycling is combined with car use (17%; Van Nes 2002). Mainly for recreational trips, as people bring their own bikes on a bicycle carrier, and partly in order to acces a city center by 'Park and Ride'.

Multimodal trips combine the advantages and characteristics of different transport modes. Cars and trains are much faster on longer distances, but less convenient in inner cities where cycling is faster. About 21% of all car kilometers is inside urban areas, but that part takes 39% of its travel time (PbL 2014). Public transport is limited to dedicated lines and simply can't stop always near your destination, so an additional transport mode is necessary.

Van Nes (2002) argues that though multimodal mobility only represents 3% of all trips in the Netherlands, this does not imply that multimodal mobility is unimportant. Multimodal travel does have substantial shares in certain market segments. As 15 % of Dutch trips longer than 30 kilometres are multimodal, and 20% of trips to and from the four main cities in the Netherlands are mul-

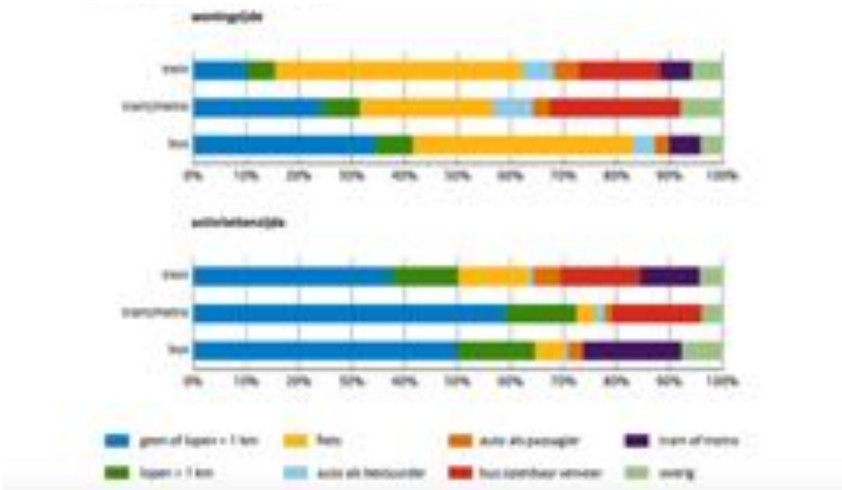
1 www.fietsberaad.nl

timodal. The combination of cycling and public transport is thus an important phenomenon for access to city centers. In the last three years, the number of kilometers traveled by the combined use of the bicycle-train system had an increase of 20-25% by inhabitants of the larger cities of The Netherlands (OViN 2014, www.fietsberaad.nl).

Hybrid Bicycle Train System

The favorite multimodal journey is the combination of bicycle and train. Kager et al. (2015) regard the combination of bicycle and train as a system that even can be considered as a separate modality, next to car, public transport and unimodal cycling. They perceive a bicycle-train trip as a multimodal trip that include a bicycle trip segment either before or after the transit trip segment, or on both sides. There is an important difference between the acces and the egress trip to the station. Almost 45 percent of all trips on the 'home side' (up to about 3 to 4 kilometer) is done by bicycle, against only 11 percent on the 'destination side'. This is mainly due to the fact that less bicycles are available on the egress side. Apparently most people won't buy a second bike for their egress trips. (KiM, mobiliteitsbeeld 2014).

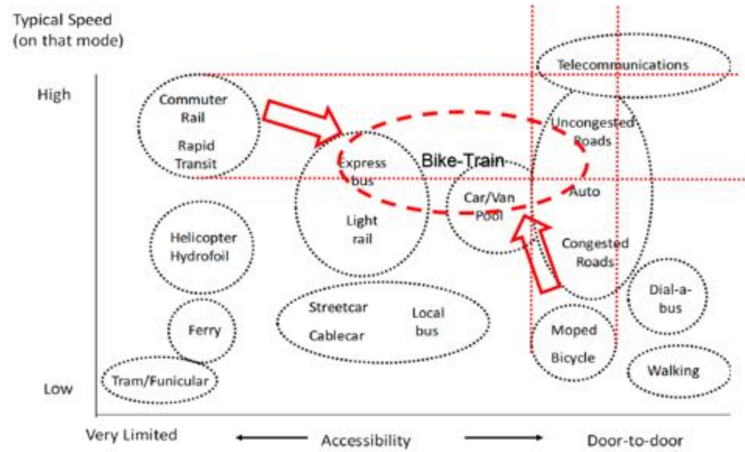
Figure 2.3 Modal shift in pretransport and posttransport, to access station (above) and egress station (below). Source: OVIN 2013.



The combination of cycling and transit seems so successful because these modalities are complementary in their performance. When the transfer is organized well, cycling offers a substantial increase in door-to-door accessibility compared to train trips. 'From a conceptual point of view, the bike adds a fine-grained spatial distribution of origins and destinations that the train system alone can never achieve and at a limited expense in terms of overall speed. Likewise, trains offer a substantial increase in speed compared to the bicycle at limited expense in terms of accessibility: this substantially adds to the spatial reach of the bicycle system. The resulting synergy of high speed (and thus spatial reach) of the train with the door-to-door accessibility of the bicycle give the system unique characteristics, making it competitive with the characteristics of personal motorized transport' (Kager et al, 2015; p.3).

We can relate the effectiveness of the bicycle-train system to other modalities on the dimensions of travel speed and accessibility, in this figure below. It shows that the combination offers a high score on as well average speed as on door to door accessibility.

Figure 2.4 Bicycle-train system compared to other modes on speed and door-to-door accessibility (based on Meyer and Miller 2013)



2.3 Spatial Translation of the Bicycle-Train System

The elements of the multimodal bicycle-train trip can be regarded from the view of a system. Within the tradition of system analysis, a system is defined as 'a group of interdependent and interrelated components that form a complex and unified whole intended to serve some purpose through the performance of its interacting parts' [Meyer and Miller 2013, p. 3]. This different elements of the trip can be shown in this system (adapted from Kager et al 2015).

Mode	Supply components
	(O = origin, D = destination; implicit walk trips for transfers)
Bicycle (stand-alone)	O→Bicycle park→Bicycle infra→Bicycle park→D
Transit (stand-alone)	O→Access stop→Transit services, facilities and change locations→Egress stop→D
Bicycle- Transit	O→(Bicycle park→Bicycle infra→Bicycle park)*→Access stop→Transit services, facilities and change locations→Egress stop→(Bicycle park→Bicycle infra→Bicycle park)*→D

Table 2.5 Supply components of bicycle, transit and bicycle-transit transport mode.

In understanding the bicycle-train trips, there are three trip segments and two transfers that can be distinguished:

1. 'access travel' between the origin (O) and the 'access station';
2. 'main travel' between the access station and the egress station;
3. 'egress travel' between the egress station and the final destination (D);
4. and in between the transfer from bicycle to train on the acces station and on the egress station.

The journey parts 1 and 3 are done by bicycle, and journey part 2 is done by train. The transfer in between is needed to stall a bike and to acces the platform. For a better understanding of the relation between urban planning and bicycle-inclusive mobility, I distinguish for each segment a dedicated spatial area. I categorise this on the basis of a regular daily (morning) commuting trip.

1. Acces travel > Residential catchment area
   This area is the 'feeder' for the system. The range of the catchment area is limited by the time people are willing to travel (cycle) to the station. If we include the possibility for trip chaining, e.g. bringing kids to school or shopping on the way back, the proximity of services as schools, nurseries and shops must be included as a favorable factor. The potential number of travelers is also influenced by the density in the neighborhoods.
2. Main travel > Regional train network
   Railway tracks are not flexible and can not be easily adapted to changes in land use. New stations can still be built if the need arises. The location of the railway network in the region is decisive for this part of the range.
3. Egress travel > Business catchment area
   This is the area that should attract work force. The range of the catchment area is limited by the time people are willing to travel (walk or cycle) from the station. The proximity of jobs from the egress station is a decisive variable, that can also be influenced by the density of building in the (office) district.
4. Transfer between bicycle and train > Station area
   For a smooth and quick transfer from bicycle to the platforms, the number and the location of the bicycle parking is important. The design of the station and surrounding public space are the main elements on this part of the trip.

2.4 Factors Influencing the Use of Hybrid Bicycle-Train System

As the bicycle-train system is a relatively new phenomenon, there is not much known about the factors that influence the use of this new kind of modality. To understand the factors that are involved, we must discuss and combine the factors that influence cycling and the factors that influence train use. Hence I will integrate the factors that influence the combined bicycle-train system by focussing on the concepts of density and proximity, and finally I want to indicate how the integration of the various and sometimes contradictory components lead to a successful system.

2.4.1 Categories of Influencing Factors on Modal Choice

Factors Influencing Cycling

In recent literature there are many factors found on the question that influences cycling. Heinen (2011) studied the motives for cycling or not among commuters. In her research bicycle commuters are defined as commuters who cycle the entire distance from home to work, so multimodal (bicycle-train) trips were not included. Cycling for utilitarian purposes, including commuting, is likely to be influenced by different determinants than those that influence other forms of cycling, such as cycling for leisure or for sporting purposes (Heinen, 2011).
Heinen categorized the factors influencing cycling for utilitarian purposes as follows:

- The built environment: urban form, infrastructure and facilities at work;
- The natural environment: landscape, hilliness, weather and climate;
- Socio-economic characteristics: socio-economic and household characteristics;
- Psychological factors: attitudes, norms and habits.

Rietveld & Daniel (2004) use a slight different classification, as they distinguish 'physical features', 'population & individual features' and 'efforts in implementing bicycle-friendly policies'. Ewing & Cervero (2010) try to list all influencing factors with a D. The original 'three Ds' coined by Cervero and Kockelman (1997), are density, diversity, and design, followed later by destination accessibility and distance to transit (Ewing & Cervero, 2001; Ewing et al., 2009). Ewing and Cervero (2010) finally add more D's to the sequence, as they speak of demand management, including parking supply and cost, and demographics, while not part of the built environment. The use of all these terms starting with a 'D' forms a nice alliteration, but seems a bit far-fetched and some factors show overlap.

Factors Influencing Train Use

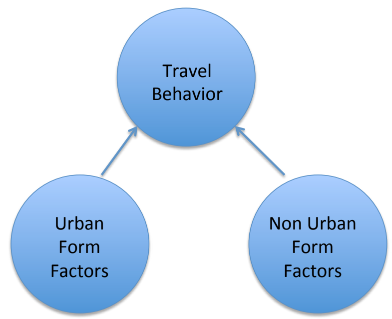
The factors that influence rail use are often studied in relation to multimodal trips, as trains lack the possibility of door-to-door accessibility. In order to facilitate multimodal mobility, it is therefore important that the entire multimodal trip is of high quality (Rietveld, 2003; Van Twuijver and Kramer, 2003), expressed in terms of the accessibility of the node, the quality of the node itself, and the quality of the journey from the node to the destination to. Also mobility management and constraints play a role such as having baggage, or the time of travel.
According to Brons, the propensity to use rail can be considered as a factor of three elements:

- The level and quality of the rail service provided;
- The level and quality of the access to the rail service and;
- The characteristics of the area and population served. (Brons et al, 2009).

Bos mentions similar elements: the accessibility of the station area, the quality of the station area, the quality of the rail service and personal and contextual characteristics (Bos, 2005; www.transumofootprint.nl). The Dutch railway company considers different elements on the performance of their service in a customer satisfaction survey, as punctuality, cleanliness, travel info, social security, seat availability, and customer service of the staff.

To associate the various categories on urban development, it is useful to make a subdivision urban factors. Frank and Pivo (1994) produce this simple conceptual model on discussing travel behavior. They distinguish urban form factors and non urban form factors that affect travel behavior.

Figure 2.6 Relationship between travel behavior and factors that affect it. Source: Frank and Pivo (1994)



As non-urban form factors we can consider the above mentioned socio-economic and psychological factors (Heinen, 2011; Rietveld and Daniel; 2004, Bos, 2005), demand management or mobility management (Cervero 2010; Rietveld 2003) and the quality of the rail service (Bos, 2005; Brons 2009).

The other urban form factors will be discussed by the main characteristics, as density, proximity, distance and diversity, and urban design and infrastructure design. And they can be related to the spatial segments of the hybrid bicycle train system: the both catchment areas at origin and destination, the station area, and the regional network.
The importance of the different factors varies by country and even by region or city. An example of this is found in the study by Feenstra (1993), in which he compares the Dutch cities of Groningen and Maastricht. Differences in modal split between both cities are mainly explained by the socio-economic factors: "there is only a slight effect of differences in urban planning on the variation in the use of the bicycle in Maastricht. This implies that the effect of other factors (for example socio-cultural background) is relatively great. The absolute difference in bicycle use will have to be sought there. With regard to urban planning, it can be concluded that bicycle traffic in Maastricht, also due to the division of the town by the River Meuse, will have more disadvantages from barriers. The detour factor is higher in Maastricht than in Groningen. Furthermore, in Maastricht the car needs to make relatively fewer detours than the bicycle." (Feenstra, 1993)

2.4.2 Non Urban Form Factors

Socio-economic and Psychological Factors
The population structure of a neighborhood has an effect on bicycle use. There are differences perceptible between young and old, men and women and between groups as students or migrants and natives. The effects of the latter group are particularly noticeable if there is strong segregation (KiM 2013). In university towns, bicycle use is relatively high, due to the larger number of resident students who often have no car. The introduction of the free public transport card has increased the share of public transport, but traditionally cities like Delft and Groningen have a high proportion of bicycle use. By contrast have neighborhoods with a high proportion of migrants a low share of bicycle use. 'Cultural tradition—possibly related to ethnicity—appears to play a role. This aspect should probably be interpreted more in terms of choice-set formation than generalised costs: cycling seems to be a travel alternative that has only a low probability of being included in the choice set of immigrants with a different cultural background.' (Rietveld & Daniel, 2004).
Also Heinen (2011) argues that cyclist are influenced by (regional) culture in their mode choice, as it affects their subjective norms, and their perceptions of the social norms in their social surrounding community. She mentions especially the visible cycling culture on and around a university campus. 'In addition to individual attitudes, perceptions of other cyclists – and of the cycling "culture" in a community – are also important. (…) The visibility of a cycling culture therefore might stimulate or prevent a person from bicycle commuting' (Heinen, 2011; p. 124).

Another aspect that has to be mentioned is 'residential self-selection'. Households with a predisposition toward a certain type of travel may choose to locate in a neighbourhood enabling the pursuit of the preferred type of travel (Steiner, 1994). An avid? train traveler loves to live close to the station, and (another extreme) an owner of a number of old-timers would rather prefer a country house with large garage. Bothe, Maat & Van Wee (2009) conclude that spatial planners should to take the effects of residential self-selection into account if they aim to encourage more sustainable travel behaviour. 'When constructing new neighbourhoods or modifying existing neighbourhoods, spatial planners could provide households that have sustainable travel-related attitudes with houses that combine their housing, neighbourhood and travel preferences. What is more, households that evaluate less sustainable travel modes slightly more favourably than more sustainable ones may be induced into more sustainable travel behaviour by building houses that fulfil their housing and neighbourhood preferences, and that facilitate the use of more sustainable travel modes' (Bothe et al., 2009; p. 354).

Bicycle and train score very differently on psychological factors. The bicycle is a highly individualized transport mode, allowing freedom of departure time, route choice, ultimate destination or intermediate stop locations, choice in vehicle type or its adaptation, speed, a feeling to be 'in control' and choosing one's own way of travelling. Car use is in many ways linked to the same kind of emotions, but trains as a collective system score low on these aspects. During a HBT trip a traveler might experience contradictory feelings as joy and aversion (Harms et al., 2014).

Demand Management or Mobility Managent
Demand management, or better mobility management consists of several policy measures to actively encourage sustainable transport or to discourage car use. Next to physical or spatial changes, they can vary from legal policies (e.g. prohibiting car traffic in city centers, parking control, decreasing speed limits), economic policies (taxation of cars and fuel, road or congestion pricing, kilometer charging, decreasing costs for public transport) and information and education measures (individualized marketing, public information campaigns) (Gärling & Schuitema, 2007).
Rietveld & Daniel (2004; p15) also points out that it is not only by promoting and shaping the best conditions for cycling or public transport, but also by reducing the attractiveness of car use: 'Concerning policy variables, significant parameters mainly concern variables associated with the improvement of the competitiveness of the bicycle vis-a-vis the car.' Different measures in mobility management largely influences mode choice. We can distinguish push and pull factors in local policies.

An example of a pull factor is an active price-setting policy of car-parking costs. In general the costs are much higher in dense inner cities than in suburban areas, which works to reduce the number of cars or the time people park their car. In this sense it stimulates other modes of transport (public transport, cycling) to enter the city centers. On the push factor side can be mentioned reducing the number of stops or hindrances per bicycle trip, and of achieving a gain of time in comparison with the same trip done by car. 'This combination of push and pull policies is a rather general result found in transportation research, and it also appears to apply to bicycle use'. (Rietveld & Daniel, 2004) This result implies that there are essentially two ways of encouraging bicycle use: (1) improving the attractiveness of a mode by reducing its generalized costs; and (2) making competing modes more expensive. As in all local policies, the extent to which this is applied in local (bicycle)policies differs per municipality and per political preference. Restrictive (parking) policy on final destinations have a large influence on train use, especially in the city centers (Rietveld, 2003).

The Level and Quality of The Rail Service
The level and quality of the rail service seems to be a continuous topic of discussion in The Netherlands (source). The perceived notion of the quality will form a reason for many people to state their in modal choice. But the measured quality of service provides some insights in the realized use of rail.
Increasing the frequency of service will reduce travel time when including waiting time to the service. If (in an average Dutch postcode) the frequency of public transport services to the station would increase from two to three services per hour (current average is 1.98) an additional 6357 trips per year can be expected, which constitutes an increase in 5.18%; not a minor increase in rail use.
A increased number of stations and higher frequencies lead to more train use. A larger number of stations, however, has in turn adverse effects on the travel time, as it causes more frequently stops on a route. The difference in travel time compared to other modalities such as car is for many travelers yet another important criterion for whether or not to opt for the train.
Technical innovations can also have a positive effect on train use, as they increase comfort. The introduction of WiFi in trains offer more possibilities to combine work and travel (Harms et al., 2014).

The Level And Quality Of The Access To The Rail Service
As part of the access to the rail service we can look at the facilities in and around stations. The presence of shops or kiosks is nice if travelers still want to buy something for their journey. And for the HBT system the presence of parking for bikes is mainly important. The number of parking places must match de-

mands. And the location counts, as the distance from the parking to the platform must not be perceived as too long.
The availability of bicycles especially on the arrival station is a concern. Two reasons are generally cited for the relatively low bicycle use in the onward journey: the availability of a bicycle and secure parking facilities. You could use your own bicycle of course, but that means buying one and getting it to the station at the other end. To continue the journey rental bikes are very favorable.

2.4.3 Urban Form Factors

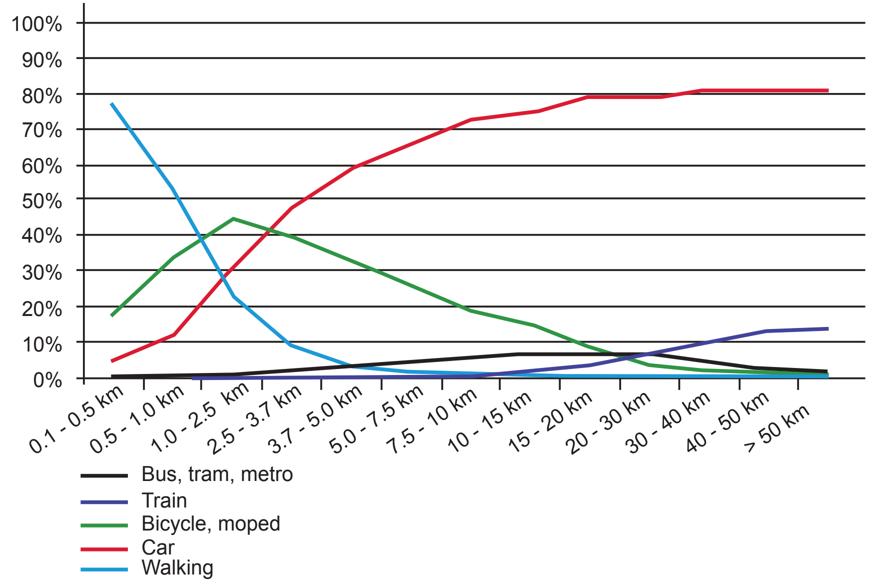
Both urban density and proximity form important factors to stimulate the bicycle use in the access and egress trips. Other aspects that will be discussed below are diversity and urban design and infrastructure design.

Proximity

The proximity to nearby jobs is one of the main reasons for people to choose their place of residence. The number of jobs that can be reached within 30-45 minutes has a greater influence on the price of housing in the Randstad than the characteristics of the neighborhood in which it is located (Boomen, 2012; Marlet, 2013). Also the proximity to urban amenities form an important motive (Glaeser, 2001). The distance people have to travel to reach their destinations determines often their choice of modality. As cycling and walking are considered a slow modes of transport with a limited range, it proves very useful to have all demanded destinations nearby and within reach.

Travel distance, and thus the proximity to jobs and services, form a key determinant of cycling in the urban form factors. "This determinant [distance} is more important for the bike (…) than for other means of transport, since an increase in distance not only means an increase in travel time, but also a (non-linear) increase in effort. Often cycling behavior is determined with a maximum displacement distance, up to 7.5 kilometers. Greater travel distance generally leads to a lower bike share and a lower cycle frequency movements"(Heinen, 2014). Though this distance of 7.5 kilometer is generally accepted as the standard in the last decades, it's changing in recent years because of the rise of the e-bike

Figure 2.7 Modal split according to distances. Bicycle (green line) scores good on shorter distances, train (dark blue) better on larger distances. (source Fietsberaad), 2009)



that enlarges regular daily distances with at least 30% to 50%[2]. The average bicycle trip on a non-electric bike is 3.6 km, while it almost doubles on the e-bike with 6.3 km (KiM, 2014). Of all bicycle trips about 12 percent is done by e-bike (KiM, 2014).

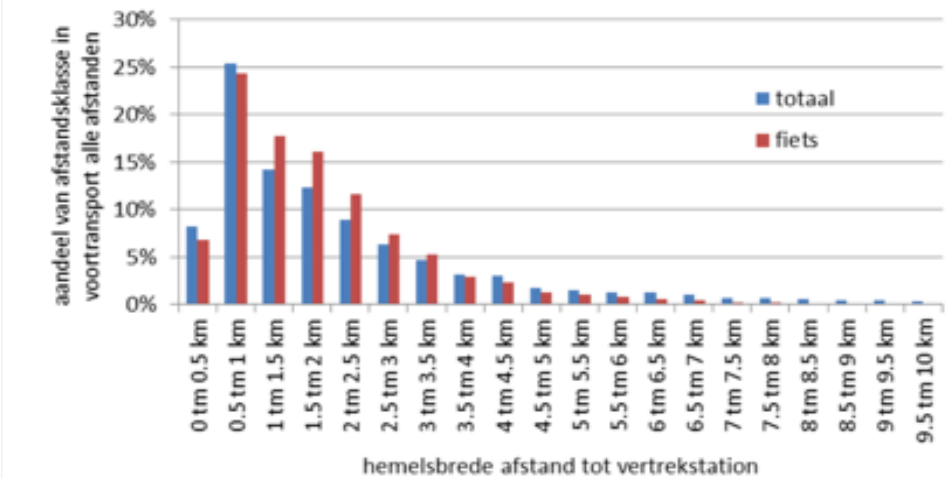
On the longer distances, car and train become more favorable travel modes. If we look at all trips in The Netherlands, car use is dominant. In the more dense metropolitan regions there's an increase on train use. The combination of bicycle and train becomes most popular in larger cities. For these multimodal trips, the distance to (from) transfer locations is the most important factor in access (egress) mode choice and probably the ultimate disincentive in the use of public transport. Access and egress determine, importantly, the availability (or the catchment area) of public transport (Bovy et al., 1991; Murray, 2001;

2 www.fietsberaad.nl

Ortu´zar and Willumsen, 2002). An increase in access and egress (time and/or distance) is associated with a decrease in the use of public transport (Cervero, 2001; O'Sullivan and Morrall, 1996). Should access and egress exceed an absolute maximum threshold, users will not use the public transport system. Should the access and egress trip components be acceptable, users may use the system, however; much will depend on the convenience of the system. (Krygsman et al, 2004).

Ewing and Cervero (2010) introduce two different types of distances, with Destination accessibility and Distance to transit. 'Destination accessibility measures ease of access to trip attractions. In some studies, regional accessibility is simply distance to the central business district. In others, it is the number of jobs or other attractions reachable within a given travel time, which tends to be highest at central locations and lowest at peripheral ones.' In the setting of the Randstad, with its polycentric spatial design, the destination accessibility can vary more and leads to complex patterns. Distance to transit is 'usually measured as an average of the shortest street routes from the residences or workplaces in an area to the nearest rail station or bus stop.
Alternatively, it may be measured as transit route density, distance between transit stops, or the number of stations per unit area.' (Ewing & Cervero 2010).
The distance to transit is important for multimodal (bicycle-train) trips, as it is an indicator for the ease for cyclist to reach a (light) rail station. The distance to a bus stop is less relevant as access trips to busses are mostly done walking. I'll use the distance to transit for the multimodal trips to the regular and lightrail systems.
In derogation from the 'general destination accessibility', is the widely acceptable distance for reaching a transit much shorter. This is obvious because the 'distance to transit' is part of a larger multimodal trip, and cycling can only be a part of the total travel time. According to market research by the Dutch railway company, most of the regular train customers live close to the station and cycle up to 3 km. The preferably distance for cycling is 1 to 2 km, and the percentage of cyclist drops faster after 4 km. (NS-MOA 2011).

The proximity to stations is a positive factor in The Netherlands. According to the PBL (2012) 54% of all residents live within a very reasonable distance from a station. This is calculated as follows: less than 1,000 meters to a metro or light rail stop, less than 2000 meters to trainstation and 3000 meters to an IC (intercity) station.



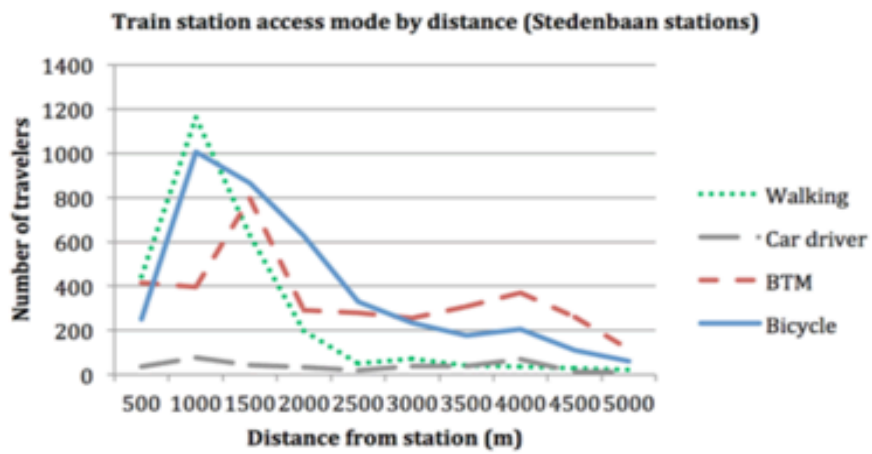


Figure 2.8 Modal share of cycling to train stations per distance, and figure 2.9 Train station acces mode by distance, cycling (NS MOA, 2011)

Diversity
Diversity measures pertain to the number of different land uses in a given area and the degree to which they are represented in land area, floor area, or employment. Entropy measures of diversity, wherein low values indicate single-use environments and higher values more varied land uses, are widely used in travel studies. Jobs-to-housing or jobs-to-population ratios are less frequently used.' (Ewing and Cervero, 2010). This concept of diversity is closely related to proximity.
Thus mixing function ensures that the average distance between the origin and location of activity is smaller, and thus may lead to a higher bicycle use or walking (from an egress station). The presence of convenience stores, offices, fast-food restaurants, hospitals and multifamily housing in a neighborhood has a positive effect on cycling (Heinen 2010, Moudon et al., 2005). Increasing car use in the post war period just led to widespread functions. Glaeser (2009, p.59): "Urban productivity and amenities are particularly sensitive to changes in transportation technology. Since cities ultimately exist to provide proximity either to other people or to fixed attributes of cities, we should expect changes in transport technology to have a strong impact on the demand for that proximity. Historically, cities grew because people wanted access to the great transport cost advantages created by access to waterways. In the 20th century, the car remade urban America."
Diversity is thus linked to proximity, and the more diverse functions and facilities are within close reach, the better for cycling. Not just for (unimodal) commuting trips, but especially for trip chaining it is beneficial and advantageous to have several different functions such as work, school and shopping together in the neighborhood.

Density
The definition and concept of density is already discussed in chapter 2. The relation between higher densities and sustainable transport as cycling is proved by the smaller distance that occur in a dense and compact city. On the other hand, public transport needs higher densities to have enough potential of travelers. High densities have a reinforcing effect: the more people, the greater the potential of travelers. And more travelers lead to an improvement in the operation of the train, which makes higher frequency possible. This leads again to a higher quality of the service.

Higher density means that more functions may be included in a smaller space, and thus the distance to the facility is smaller. Parkin et al. (2008) indeed found that higher densities are associated with a greater share of cycling in all movements. While on the other hand, lower densities in a region lead to decreased modal share on cycling. The planning decision to build satellite towns and facilitate living in suburbs (and thus creating lower densities) actually leads to more car use. 'Urban sprawl and car use have consistently reinforced each other' (Maat, 2005).

Rietveld and Daniel (2004) observed a a quadratic trend in density of urban areas (figure.): 'The use of the bicycle is low in low density areas, as in such areas there might be fewer opportunities to make short trips. Then it reaches a maximum in medium density areas, and falls again, as might be expected, in high density areas, where public transport is well provided so that it is a competitor to the bicycle.'

The study by Rietveld & Daniel proves that density and modal share of cycling are not simply correlated, but there is some optimum in density. If the density is low, like in sprawled areas, it encourages car use, caused by the larger (destination) distances. In the higher dense areas public transport is mostly better provided, and the modal share of cycling then drops in favor of bus, tram and metro (BTM).

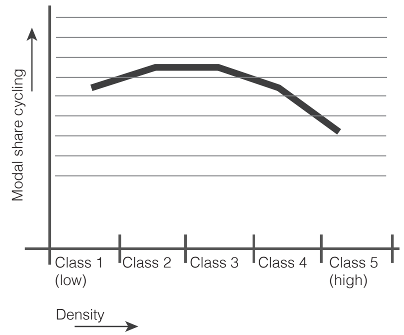
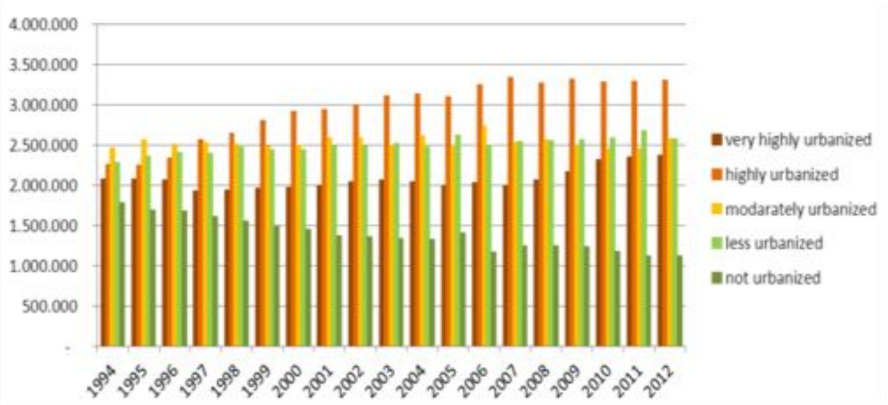


Figure 2.10 Relation on density and modal share cycling (Rietveld & Daniel, 2004)

Figure 2.11 Modal share of cycling in recent years compared to density (source CBS/OViN, 2011)



This view by Rietveld is somewhat contradicted by the more recent research of Harms et al. (2014) and the 'Mobiliteitsbeeld (KiM, 2014). Their analysis of the use of bicycles in recent yeras to the degree of urbanization indicates indeed that people in rural areas cycle significantly less than people in urban areas. But the differences between the other urbanization categories are small. In general, the categorie 2 'highly urbanized' scores best, but it depends on motive for travel. Both studies distinguish some differences to move motive. Cycling to work is even most popular in very highly urbanized areas, and again least in rural areas. For cycling to school, however, the opposite is true. (Harms et al., 2014; KiM, 2014).

In studying the impacts of land-use on travel behaviour, Frank and Pivo found a non-linear relationship with an inflection point for density around 13 persons per acre. This translates into roughly 32 persons per hectare, which is very similar to the intermediate density category (Frank and Pivo,1994). A cost-effective rail network requires high densities. Increasing urban densities will place public transit on firmer financial footing. Cervero (2011) suggests that light-rail systems need around 30 people per gross acre (roughly 73 inhabitants per hectare) around stations and heavy rail systems need 50 percent higher densities than this to place them in the top one-quarter of cost-effective rail investments (in the U.S). If we translate that to the categories of urban density, it seems that the preferable density for rail network is density class 1; highly urbanized (more than 2500 adresses per km2). We can also translate these figures to the average housing density. If we assume a average housing occupancy of 2,1 in the Netherlands (CBS, 2014) it means an urban density of 52 dwellings per hectare for rail, and 35 dwellings per hectare for lightrail (based on a walking distance to the station).
Vereniging Deltametropool (2014) also made a classification of types of locations to the desired mode of transport. They distinguish car targeted areas and public transport oriented areas, and 20 dwellings per hectare and 50 dwellings per hectare. This can also be related to metropolitan, urban or rural residential environments, respectively with densities of greater than 80 to less than 20 dwellings per hectare.
The preferred density for the catchment areas around HBT stations should be thus greater than 20 dwellings per hectare, in order to give preference to bicycle instead of car, and go up to 50 to the core around the station. To maximize the number of potential train travelers inside the catchment area in this hybrid form, seems a density of between 35 and 50 dwellings per hectare most ideal.

Urban Design and Bicycle Infrastructure Design
Design is a broad concept and can be distinguished into the higher scale level of urban design and the lower level of (quality of the) bicycle infrastructure.
Urban design includes street network characteristics within an area. Street networks vary from dense urban grids of highly interconnected, straight streets to sparse suburban networks of curving streets forming loops and lollipops. Measures include average block size, proportion of fourway intersections, and number of intersections per square kilometer (Ewing & Cervero 2010). Also the number of bridges to cross rivers and canals is an important measurement, especially in an aquatic environment as Netherlands.
The density of a street pattern influences travel times by a better choice of direct

routes. In a closer grid the average distance between origin and destination is smaller, and in more radial networks cyclist can take shortcuts. An intricate network is favorable for enabling cycling (Moudon, 2005).
Finally, the more technical design of the (cycle)infrastructure is an important determinant. The number of cycle lanes, the position of lanes or separate cyclepaths, adjacent car parking, etc. encourage people to go cycling. This preference seems due to a sense of safety (Stinson, 2003). Also the design of intersections and roundabouts, and the quality of the road surface (tarmac instead of pavers) affect the comfort of cycling. For traffic engineering, the CROW institute (Dutch knowledge institute in the field of infrastructure) has developed a set of criteria and requirements for cycle infrastructure. These requirements are: Cohesion, Directness, Attractiveness, Traffic safety and Comfort [3] (Bendiks & Degros, 2013).

2.5 Influencing Factors for the Segments of HBT

As mentioned above, trains and bicycles show opposite tendencies on other dimensions of modal performance. Yet this leads to further potential synergies, as we look on the aspects of distance/proximity and density. The transport quality aspects for trains tend to increase with distance travelled, for example on effective speed, value for money (or effort), comfort, reliability, practical availability and potential for productive time use. For cycling, the opposite holds true; its qualities tend to decrease as distance increase.
Trains are better suited for concentrated densities of trip origins and destinations, whereas bicycles benefit from a more equal distribution of trip origins and destinations. (Harms et al., 2014).
If we place the influence of the urban form factors on the different segments of the bicycle train systems, we can predict the following assumptions for urban planning:
1. Access or residential catchment area
As a 'feeder' for the system, this area should contain enough potential travelers. People have to live in the proximity of a railway station to choose for the hybrid bicycle train system, and the more dense Dutch situation most people do.

3 www.crow.nl

The range of the catchment area depends on the quality of the provided rail, and will vary between 1 to 5 kilometer for cyclists. The proximity of services as schools, nurseries and shops must be included in this range to ensure trip chaining. The preferred density of the area can be distinguished for both the walking and the cycling distance. The optimum in the first shell (walking distance) should be between 35 - 50 dw/ha, and for the second shell (cycling distance) between 20 and 35 dwellings per hectare (Frank and Pivo, 1994; Cervero, 2011).

2. Regional train network
The regional rail network must provide fast access to the different cores in the surroundings. To improve the speed of the train travel, less stops are preferable. High frequencies reduce the waiting time for the next train.

3. Egress or business catchment area
As the 'destination' side, the proximity of jobs from the egress station is a decisive variable. A high density and mixed use are preferable, as most people will walk from the egress station to their destination. If walking is the preferred mode, distances up to 500 meter are best.

4. Station area
For a smooth and quick transfer from bicycle to the platforms, the number and the location of the bicycle parking is important. The design of the station and surrounding public space are the main elements on this part of the trip.

2.6 Conclusion

In this chapter, I have looked for answers to the first two subquestions of this thesis: What factors stimulate bicycle and train use in city regions? And what factors stimulate or hamper the use of a hybrid bicycle-train (HBT) system? To answer these questions, I described the components of this specific hybrid mobility system.

The hybrid bicycle train system (HBT) is a form of multimodal mobility, and can be seen as a combination of unimodal cycling and rail transit. Cycling

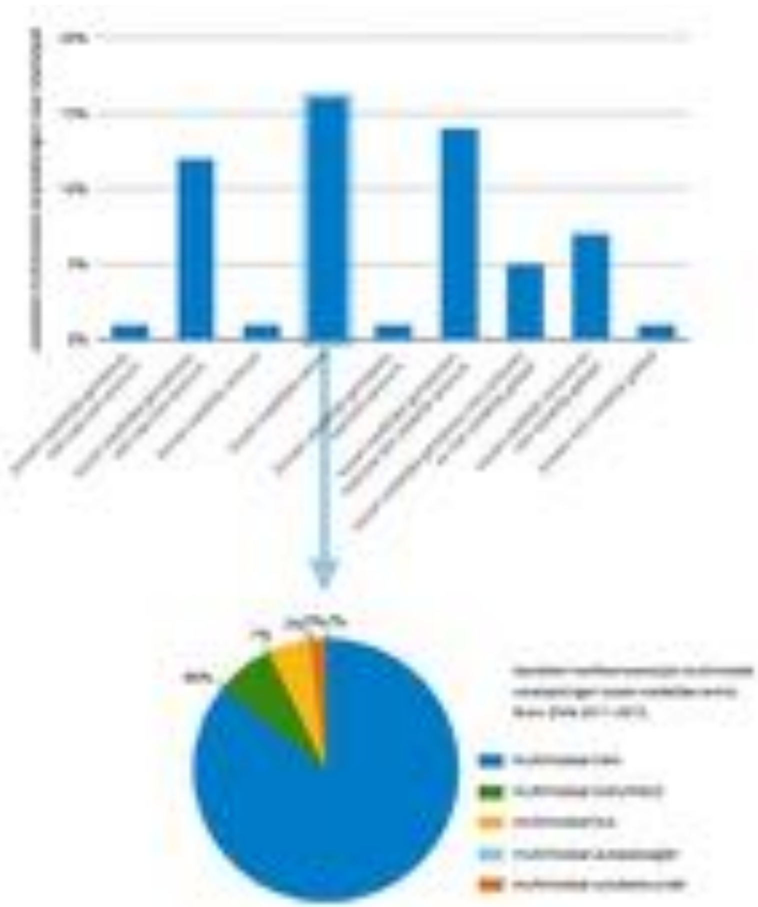


Figure 2.12 Share multimodal trips for relationship type (above) and share principal mode of transport multimodal travel within urban centers. Multimodal trips occur mainly between different cores of city centre (KiM, Mobiliteitsbeeld 2014)

can be included at the access or the egress trip, or at both ends of the transit. This hybrid form is regarded as a separate modality, that is best used for travel between different cores of cities because of the longer reach of the system, combined with a fast door-to-door acces.

The success of bicycle use depends on many factors. I will distinguish these factors for bicycle use in hardware (the built environment and the natural environment) and software (socio-economic characteristics and psychological factors) (Heinen, 2011). All the factors are of interest; you cannot expect many people to cycle if there is no proper infrastructure available. But if it is there, and the cycling culture is missing, there is also not much cycling. The importance of the various factors varies by country and have different effect on trip length or frequency. For example, trip frequencies are more influenced by socio-economic characteristics, and trip lengths are primarily a function of the built environment (Krizek, 2012).

On the side of the hardware I follow in outline the classification of Cervero, with the alliterative D's: distance, density, diversity and design (Cervero & Kockelman, 1997; Ewing & Cervero, 2001) though the use of all terms starting with a 'D' seems a bit far-fetched, and some factors show overlap. Distance can be regarded as the key determinant for bicycle use, as an increase in distance is directly linked to travel time as well as effort. And distance - either directly to destination or to a train station - is in turn affected by the concepts of density and proximity.
I consider density and proximity as key factors for bicycle use in city regions.
To quantify density I use the most recent studies by Harms et al (2014) and KiM (2014) and I reject the earlier assumption of Rietveld (2004). This means that higher densities lead to more bicycle use, and the optimal conditions for bicycle use can be found in highly to very highly urbanized areas.

The proximity factor is dependent on the choice for unimodal or multimodal trips. If the destination is within 7.5 kilometers, this is considered a good distance for cycling unimodal. In combination with train, the proximity to a train

station should preferably not exceed 3 kilometer.
The factors influencing train use are described by Brons et al (2009) by the level and quality of both the rail service provided, and of the access to the rail service, and by the characteristics of the area and population served. Similar to bicycle use, higher densities are favorable for train use. Especially in the immediate vicinity, where many people come on foot to the station. A higher density results in more passengers and more travelers lead to a more favorable operation.This can also improve the quality of the service. And a higher frequency attract more travelers, especially by the shorter waiting times and shorter total travel time.

The succes of the hybrid bicycle train system can be seen as a meeting of the best of both worlds: the combination of two quite different modalities, cycling and train, seems to be very effective. They complement each other nicely. The speed and the long reach of the train and the door-to-door accessibility of the bicycle provide a successful new modality, that has increased its modal share in the larger cities in the recent years.

In order to offer a credible alternative to the car, travel time and cost are important factors. The choice of the traveler may be affected by mobility management. Besides the influence of the spatial factors, policies may be deployed by influencing travel time and costs. This policy can be set not only by promoting and shaping the best conditions for cycling or public transport, but also by reducing the attractiveness of car use: 'Concerning policy variables, significant parameters mainly concern variables associated with the improvement of the competitiveness of the bicycle (or train) vis-a-vis the car.' (Rietveld and Daniel, 2004). Different measures in mobility management largely influences mode choice. Examples of push factors are reducing the number of stops or hindrances per bicycle trip, and examples of pull factors are an active price setting policy of parking costs, especially in dense inner cities.

Chapter 3 Proximity, Density and Their Effect on Economic Functioning of Cities

3.1 Intro

In the previous chapter, I have discussed the features of an HBT system and the main factors for the use of this modality combination. This revealed that the concepts of density and proximity as key. In this chapter I will discuss the concepts of urban density and proximity in relation to the economy and accessibility of cities. What are widely accepted definitions of these two factors? And what factors, in turn, influence urban density and proximity? And to what extent does higher density lead to more sustainable mobilty in cities? I will discuss the role of these concepts in the economic functioning of cities according to the visions on the attractiveness of the city (Glaeser, 2001/2011; Marlet, 2009) and metropolitan development (Meijers, 2012; Van den Berg, 2005). And I describe the relationship of urban density and proximity with distance and accessibility according to the so-called Brever Law, and the views of Boomen (2012) and Ewing & Cervero (2010). The focus of this chapter is, in order to provide this thesis an integrated approach on city development, more on economic factors. That is why I used here mostly economic geographic studies. In sum, this chapter will answer the third sub question: how do these key factors - that influence HBT mode choice - relate to the economic functioning and accessibility of city regions?

3.2 Definitions on Urban Density and Proximity

Kager (2015) argues that the bicycle-train system has a reciprocal and positive relationship with urban density and urban proximity. In the previous chapter it was confirmed that higher density and closer proximity has a positive effect on the mode choice for the bicycle-train system. To obtain a better understanding of density and proximity, I will start with the definitions of these concepts.

Ewing & Cervero (2010) use this basic definition of density: 'Density is always measured as the variable of interest per unit of area. The area can be gross or net, and the variable of interest can be population, dwelling units, employment, building floor area, or something else. Population and employment are sometimes summed to compute an overall activity density per areal unit.'

In The Netherlands, the most common measure for urbanity is based on density: the so called 'omgevingsadressendichtheid' (OAD) or neighborhood address density, by the national statistics agency CBS (Marlet, 2009). Neighborhood address density is defined as the number of addresses within a circle with a radius of one kilometer around an address, divided by the area of the circle. The classifications of urbanization are numerical values of the average neighborhood address density for separate areas categorized into five groups or classes. The class boundaries of the various categories of urbanity are applied from 1992 and are selected so that all classes contain approximately the same number of residents. Area address density is expressed in addresses per km2. The CBS distinguishes five classes of density[1]:

- very highly urbanised: 2500 or more addresses per km2
- highly urbanised: 1500-2500 addresses per km2
- moderately urbanised: 1000-1500 addresses per km2
- less urbanised: 500-1000 addresses per km2
- not urbanised; less than 500 addresses per km2

Urban proximity is related to distance, as it forms the space between where people live and goods and services that they want to use (Cervero & Lee, 2007; Talen, 2014). In urban planning and design, the best approach to proximity is to select a set of urban facilities or places to which access is important, and then evaluate distances throughout the neighborhood to those facilities or places. In this sense, proximity is mostly calculated as the distance to nearby jobs, or services as shops or train stations.

If we refer density and proximity to the topic of this thesis, the bike-train system, the definitions must refer to the daily use for commuting and thus can best be based upon the places where people live and the places where they work. This can be expressed in number of inhabitants and in jobs, or in (the combined) number of addresses. Density is the number of addresses per square km; or the number of people or jobs per km2. Proximity is the distance (in km or in travel time) to nearby jobs or services.

1 www.cbs.nl

3.3 Agglomeration Benefits By Increased Density And Proximity

Proximity can be regarded as the key succes factor for cities: Glaeser (2009, p.59): "… cities ultimately exist to provide proximity either to other people or to fixed attributes of cities..". Glaeser follows the vision of Jacobs (1969) that most innovations are made in cities, due to the easier flow of ideas, as 'geographical proximity facilitates transmission of ideas, we should expect knowledge spillovers to be particularly important in cities' (Glaeser, 1992; p.3).

Proximity offers economic benefits and contributes largely to accessibility, also according to the PBL: 'the increased proximity of urban functions by concentration and density serves different purposes, such as agglomeration advantages for businesses, shorter distances, reduced pollution from traffic, improving the support for urban facilities, revitalization of public space, providing open nature and energy efficiency.' (PBL, 2014; p. 22).

In the first sentence, it is already mentioned that proximity is related to density. A higher density ensures greater population size, allowing more facilities at a shorter distance may become available.

Ongoing urbanization comes along with increasing densities, and cities and metropolitan regions aim to profit from its larger scale. Edward Glaeser (2011) is convinced of the benefits of the city which he calls "the greatest invention of mankind". He proves that the city makes us smarter, richer, more sustainable and healthier and happier. In his book with the evocative title 'Triumph of the city' Glaeser (2011) points out that the love for the city comes from the many amenities it has to offer for its inhabitants. People are looking for jobs, for entertainment, amusement, or even for a partner. The best chance to be successful is in the city. The accessibility to urban amenities (theatre, cinema, restaurants, etc) seems even more important for their choice of living than the proximity of jobs. Citizens of a Consumer City also prefer to access those urban amenities more by walking or cycling, while they accept longer (car)trips for commuting to their jobs (Glaeser, 2001).

The agglomeration benefits of cities and regions lead to an increase of economic value, and growth of the regional gross product. The bigger the city, the greater the benefits (Melo et al., 2009; Meijers, 2012). The concentration of facilities in a certain region, due to good accessibility and proximity, offer economies of scale that are known as Marshallian externalities. Rosenthal & Strange (2004) give five advantages of these economies of scale:

- Input sharing, a wider choice of suppliers.
- Labor market pooling, a wider choice of workers and of jobs.
- Knowledge spillovers, allowing workers to learn from each other, and increase productivity.
- Consumption, main amenities, 'the bright lights of the city'.
- Home market effects, concentration of demand, more customers, wider choice of products.

Marlet (2009) also adds two disadvantages, or diseconomies of scale:

- Congestion forces, as high land prices, housing prices and traffic congestion.
- Disamenities, as environmental pollution (noise and air pollution), and criminality.

Through improved access and alignment of urban regions more benefits of the economies of scale can be achieved. But the choice of the transport mode can also contribute more to the above mentioned disabilities. Congestion and pollution are mainly due to car use in dense areas. Glaeser et al. (2001) mention also crime as a disadvantage of the city. Agglomeration effects naturally determine the extent to which urban density is attractive, but the benefits of the density overcome in the (Consumer) city: the future of the city depends on the demand for density.

In the last decades, the rise of modern communication technology has changed the entire business world so fast and put forward the question why proximity still matters in networks. It seems less important where you work, if you have the whole world under reach at your desktop by email, Skype and other fast data transfer. Van den Berg et al. (2005) gives several reasons why the place is yet so important, and why the possibility to meet others is essential. Firstly, they mention that face-to-face contact appears to be very important as sources of information and in the exchange of tacit knowledge. The possibility of such contacts is enhanced by spatial proximity. And secondly they argue that cooperation between actors requires mutual trust, which is even more important in joint (innovation) projects, when sensitive and valuable information is exchanged.

The model for the foundation of a knowledge economy described by Van den Berg et al. (2005) consists of seven factors: knowledge base, economic base, quality of life, accessibility, urban diversity, urban scale and social equity. Those factors form the base to flourish the activities in the knowledge economy. It is interesting to examine whether there are more links between aspects of the knowledge economy and the factors involved in cycling. Surely accessibility can be brought into relation with cycling as a means of transport, as cycling is faster in city centers than car use and because an increase on modal shift toward cycling reduces congestion, and thus improves accessibility for other road users. But also 'Quality of life' and 'Urban diversity' and even 'Social equity' can be linked to cycling. As stated in the introduction, quality of life is partly related to the absence or reduction of noise and air pollution. Cycling and train use contribute to a better living environment (Pucher et al. 2011, 2012; Buehler and Pucher 2008). Urban diversity asks for a mix of functions and is related to increase in bicycle use by Ewing & Cervero (2001). And social equity is linked to cycling by several authors, as cycling is a relative cheap and common transport mode. Burton (2001) links high densities to different aspects of social equity and to public transport use and cycling. Not only the wealthy and rich city dwellers, but all consumer citizen might profit from higher densities (Glaeser, 2001). Cycling can be considered as part of the progressive and prosperous cities, where knowledge is shared.

3.4 Proximity and Travel Time

For me, educated as an urban planner, distances were always measured in physical distance, expressed in kilometers. But for traffic engineers, distance is displayed in time and expressed in minutes to define travel time. And it is clear that time is a more useful measure than distance because individuals consider how much time they want to spend to travel for a particular job each day, as also on choosing a recreational trip. Hence, travel time is a very relevant factor for the individual user. In order to achieve short travel times individuals generally prefer transport modes with high speeds, though also costs and comfort are relevant.

The rise of motorized transport in the last century has made physical distances much smaller. People daily spend between one and one and a half hours using transport systems, and that travel time remained about the same time. So instead of reducing their travel time, most people used the increased average speed to travel longer distances. This rule on continuity of daily time spend on commuting is known as the Brever law (Hupkes 1982). Brever is a Dutch abbreviation for 'Wet op Behoud Van Reistijd', meaning 'law on continuity of travel time'. The faster transport modes gave commuters the opportunity to live on larger distances from their work, and opened the possibility for planners to develop new residential areas far outside town centers.

With the same Brever law in mind, one can argue the other way around, and choose for a slower mode of transport and live closer to your beloved destinations. Cities with higher densities, and with a wider spread on jobs, services and other leisure and nightlife can offer people all they long for within the same window of travel time. The proximity of a rich variety of services and consumer goods is a first critical urban amenity. The cities of the future will either be car cities with decentralized employment, in an American concept, or sustainable transport (walking/cycling/public transport) cities with extremely high levels of density, in a more European model (Glaeser, 2011). The trend in recent Dutch spatial planning is to pursue more compact cities, though there are still advocates for development of low density housing in the green.

3.5 Density, Proximity and Sustainable Transport

Encouraging higher densities by aiming at compact cities can be seen as a strategy towards more sustainable transport. Echeniqie (2012) distinguishes three alternative spatial designs for urban regions; compaction (brownfields), planned expansion and dispersal (sprawl). Compaction increases the intensity of urban

areas in order to reduce vehicle travel and increase social diversity and urban vitality. Dispersal diminishes the intensity of urban land use to reduce the costs of living and production and reflects the demand for affordable space and less crowding. Expansion by planned peripheral development and new settlements attempts to deliver the advantages of the preceding options and minimize their disadvantages by developing communities that are not crammed and protecting the open landscape. Compaction has the most positive effect on creating shorter distances between services and on increasing density.
In fact, this strategy for compaction has two possible effects that helps for more sustainable mobility. On the one hand, the shorter distances will reduce the total amount of kilometrages that people have to travel to reach their work or recreational destinations. So even if people prefer driving a car, compaction can have a positive effect on the use of fossil fuels. On the other hand, as argued above and in line with the Brever law, people could choose to change for a slower and more sustainable type of modality as cycling or public transport as long as their travel time remains the same.

Higher density means that more functions may be included in a smaller space, and thus the distance to the facility is smaller. Parkin et al. (2008) indeed found that higher densities are associated with a greater share of cycling in all movements. The planning decision to build satellite towns and facilitate living in suburbs (and thus creating lower densities) actually leads to more car use. 'Urban sprawl and car use have consistently reinforced each other' (Maat, 2005).

3.6 Density, Proximity and Metropolisation

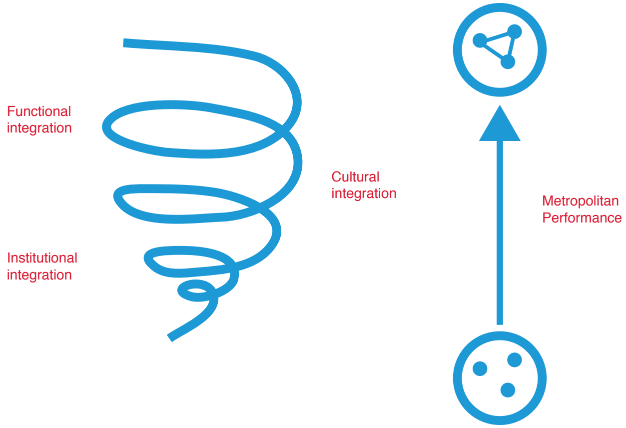
The metropolis can be defined as "an area consisting of an urban core with a high population density and high levels of employment, with a surrounding area that is socio-economically connected to the urban core. A metropolitan region often covers an area larger than a metropolis because many small places that are not directly connected to the urban area may also be part of the metropolitan region" (Ministry of Transport, 2012; p. 129). When, like in the case of MRDH, there is not one but two (or more) major cities, we speak of a polycentric area.

Polycentric metropolitan areas can be defined as collections of well-developed and administratively and politically independent cities in close proximity and with good infrastructural connections. These definitions indicate that those cities should collaborate well and aim at one daily urban system, the area around or between the cities, in which daily commuting occurs. Strengthening of the daily urban system can contribute to the competitiveness of the region, by increasing the labor market pool. In order to achieve this wider daily urban system, good links between the cities either physically or via networks are necessary (Meijers et al., 2012).

Extensive regional cooperation is on the rise in Europe, where we see a concentration of research-intensive industries and knowledge-intensive services on metropolitan regions and major urban agglomerations. Hall and Pain (2006; p. 3) conclude: "It is no exaggeration to say that this is the emerging urban form at the start of the 21st century." The metropolitan regions like Rhine-Ruhr, Flemish Diamond and Randstad are increasingly important for the European economy. Next to the former emphasis on global networks of large metropolitan cities (like London, Paris, New York), nowadays there is more and more interest in the relationships between smaller and more short distanced cities, the polycentric metropolitan areas. Huisman (2013) describes in the context of a trip to the Ruhr as well the international competition between cities and urban regions as a 'glocalisation game'. Essential conditions in this new international urban competition are world wide connectivity and 'quality of place': "an attractive living and working basis, durable, compact, complete, comfortable, accessible and safe. This 'global village' is one of the main factors of urban competitiveness" (Huisman, 2013: p.2-3).

The aim of shaping metropolitan regions is also to profit from its larger scale. As mentioned before, Glaeser (2011) is convinced of the benefits of the city. Agglomeration benefits lead to an increase of economic value, and growth of the regional gross product. The bigger the city, the greater the benefits (Melo et al., 2009; Meijers, 2012). But how does it work in a polycentric area?
Metropolisation in its best form can be seen as an upward spiral of increasing

Figure 3.1 Scheme of Metropolitan performance and integration in a polycentric region (Meijers, 2012)



and mutually reinforcing, functional, cultural and political context, in order to improve the coherence of the region and to increasing labor productivity per capita. In this knowledge era, the availability of service centers and a highly educated labor pool are important factors for economic development and innovation. The current internationally oriented economic development requires a relevant concentration of services. These services are in The Netherlands not yet available in one center, but spread over various larger towns in the Randstad. The cooperation in metropolitan regions is part of a strategy to become a more important player in the European market. By improving the functional, institutional and cultural integration, the metropolitan performance will increase. This requires the possibility of spreading knowledge, for which accessibility and proximity are influencing factors (Sassen, 2001; Meijers et al., 2014).
This phenomenon is also known as 'borrowed size': a concept that according to Meijers is 'essential to understand urban patterns and dynamics in North-West Europe. A place borrows size when it hosts more urban functions than its own size could normally support. A borrowed size for one place means that other places face an "agglomeration shadow" because they host fewer urban functions than they would normally support.' The size of a place seems to determine why one place borrows size while the other faces an agglomeration shadow. The largest places in their functional urban area are better able to exploit their own mass, and the smaller places function as a satellite that offer work force for the larger places. Forty years after the introduction of the concept by Alonso (1973) the policy idea is that several small towns together (polycentricity) can contribute more to agglomeration benefits and especially to international competitiveness than one large city. Connectivity forms the key factor for borrowed size. Within this concept of borrowed size, cities must not be seen so much as places, but much more as foci of networks and flows of people, companies, talent, information and social contacts. These networks also require infrastructures that connect locations in cities themselves, and that connect local networks with local and (inter)national networks (Boomen & Venhoeven 2012). HBT systems can ensure such connections, with the finely meshed nature of the bicycle as mode for the inner cities and the long stretch train for the interregional connections.

3.7 Conclusion

In this chapter I aimed at answering the question how key factors that influence HBT mode choice relate to the economic functioning and accessibility of city regions. In the second chapter, I had concluded that the concepts of density and proximity are the key factors for HBT use in city regions. So, I started to deepen our understanding of these two factors in this chapter.

Urban density can be seen as the number of adresses per square km; or the number of people or jobs per km2. Proximity is the distance (in km or in travel time) to nearby jobs or services. The adresses density is more general, and when for example we are focussing on the access station, the number of inhabitants will be more important. Density and proximity are closely related to each other. Cities with higher densities will offer smaller distances between services and jobs. A higher density is also expected to bring closer proximity. The effect of density and proximity is also beneficial for reducing travel distances, thus enabling less milage and alternative, more sustainable choice of transport. In this sense it is fair to assume that a higher density, realized in compact cities, contributes to sustainable mobility (Glaeser, 2011).

Density and proximity are seen as drivers for economic prosperity for cities. They offer better labor market pools. Agglomeration benefits lead to an increase of economic value, and growth of the regional gross product. On the other hand, a negative effect of high densities can be the agglomeration disamenities such as congestion and (noise and air) pollution (Marlet 2009, Glaeser 2011, Van den Berg, 2005). For increased economic performance of a polycentric region, it forms a challenge to increase accessibility and still avoid congestion. Offering and facilitating alternative transport modes can contribute to reduce congestion.

Connectivity is particularly important in polycentric metropolitan regions, as the Dutch 'Randstad', in which the different cities share (i.e. borrow) the elements they do not obtain theirselves. (Meijers, 2012). Within this concept of borrowed size, cities utilize each other's strengths to enhance their economic performance. To facilitate the underlying networks, infrastructure is required that connects locations in cities themselves, and that connects local networks with local and (inter)national networks (Boomen & Venhoeven 2012). With the combination of the finely meshed nature of the bicycle as mode for the inner cities and the long stretch train for the interregional connections, HBT systems can help to increase the accessibility and hence the network strength of metropolitan regions

Chapter 4 Urban Planning an Mobility Oriented Development

4.1 Intro

I started this study because of my interest in cycling and its role in urban development, and because I am curious about the reciprocal relationship between HBT and urban planning. Hence, the relationship between the infrastructure and spatial planning system plays a major role. I focus on the Dutch situation, because The Netherlands is widely considered a model country in the field of cycling. Therefore, I will also also explore the relationship between the planning and the use of HBT in this context. In this chapter, I consider the Dutch planning system to find how the factors that influence the use of HBT system, described in chapter 2 and 3, can be influenced by planning activities. Hence, I will answer the subquestion how urban density and proximity may be influenced by the Dutch urban planning system. The answer to this subquestion is partly informed by theory, and partly by empirical facts from the Dutch situation. That makes this chapter a tilting point between the literature review and the empirical study.
In this chapter, I will first consider the relationship between land use and transport according to the LUTC Theory of Hansen. Next, I discuss the concept of Transit Oriented Development and then try to translate this concept to a Hybrid Oriented Development, that is, urban development driven by the bicycle-train system. Finally I will describe the relevant aspects of urban planning and infrastructure planning, in order to sort out to what extent density and proximity may be influenced by the (Dutch) planning system. I will conclude this chapter with the analytical framework for the empirical study.

4.2 Relation Between Land Use And Transport

In 1959, Walter Hansen published a small but important article on the relation between accessibility and activities, arguing that accessibility is defined as the potential of opportunities for interaction (Hansen, 1959). He showed that places with good accessibility had a higher chance of being developed, and at a higher density, than remote locations. In chapter 2 I already described the benefits of higher densities for the economy of cities. Hansen studied the increase of the population in seventy residential areas and related that with the access to jobs. Thus the relationship was found between the number of jobs that you can reach from a particular place, and the popularity of the place. Already in that time, it encouraged the cooperation between urban planners and traffic engineers, on trip and location decisions for transport and land use planning. Today, a good balance between spatial planning and traffic is seen as a prerequisite for sustainable mobility (Wegener, 2004).

Hansen modeled his research into a simple, self-reinforcing cycle of accessibility and activities, which is later extended by Wegener (2004). The cycle shows the (positive) effect of changes in transportation systems on land use. Improving the traffic system causes places to become better accessible. This increased accessibility says nothing about mobility per se, but only about the opportunity to travel from one place to another. Property developers see highly accessible places as opportunities. They change the land-use by building houses, offices, shops, gyms, or cafes. This leads to activities: people live and work there, go shopping, sport and drinking. Because all the activities are tied to a place, people have to move from one place to another, which give incentives to change the traffic system….and thus completes the cycle (Boomen, 2012). As a result, it may again be necessary to enhance the traffic system, or to change the mode of transport.

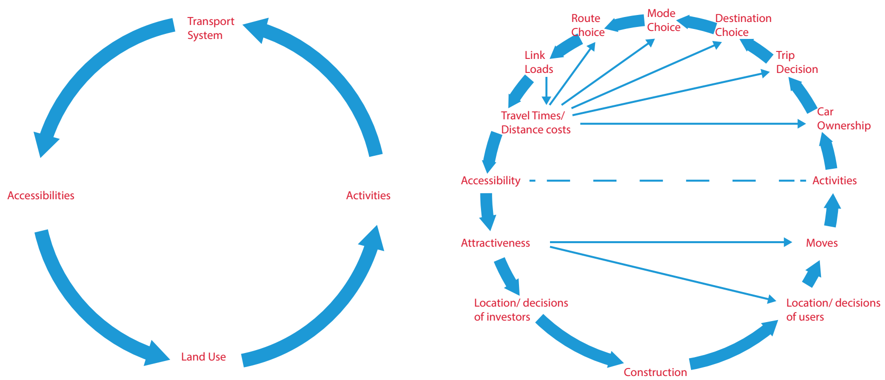


Figure 4.1 Land Use Transportation Cycle
Left Hansen (1959) and right the adaption by Wegener (2004)

The transport land use cycle (see figure 4.1) is an effective way to show the interaction between mobility and development. It is not really quantitative, but the relationships are clear. There were many succeeding studies based upon Hansen's model that showed that several factors are involved on each part of the circle. Wegener (1995) has combined this research to an adapted version of the land use transport cycle. As Wegener recognizes many more mutual relationships between the factors, the patterns turn out to be more complex. Also direct influence between environment and accessibility aspects play a role. The circle transforms to a multilayer diagram, and what 'used to be called land-use transportation (LT) models is increasingly being termed land-use transportation environment (LTE) models' (Wegener, 1995).

In short: accessibility is the combination of speed (the choice of transport system) and proximity (the activities that take place nearby). The LUT cycle is very useful yet simple scheme, but lacks for instance the human factor. In a broader connotation, accessibility is not just a feature of a transportation node (`how many destinations, within what time-frame, and with how much ease can an area be reached?'), but also of a place of activities (`how many, and how diverse are the activities that can be performed in an area?'). A third important component of accessibility is the user, or the question `by whom?'. In this wider connotation an accessible area is thus one where many, different people can come, but also one where many, different people can do many different things: it is an accessible node, but also an accessible place (Bertolini, 1999; Boomen, 2012).

4.3 Transit Oriented Development

As mentioned in the section on the Dutch history in spatial planning, the post war period was dominated by increasing car use and the spatial development that followed in the Modernist movement can be typed as Car oriented Development (COD). The typical characteristics of COD are mono-functional building neighborhoods, leading to larger distances, spread of functions and sprawl.
Stimulating hub development is currently very popular in many countries in the spirit of sustainable mobility. Though it was not appointed as the dominate strategy in The Netherlands, it was encouraged by the choice for the 'second generation' key projects in the 1990's, and in the reports on spatial planning (Nota Ruimte, 2004) and on mobility (Nota Mobiliteit, 2004). The state appointed then the central station areas of the six major cities as a focus point for new development, in order to support the competitiveness of those cities, and to contribute to the Structurevison Randstad 2040[1] (; Bertolini, 2009).

Transit Oriented Development (TOD) is a concept where infrastructure and spatial planning in both planning, financing and operation are integrated. The public transport system is seen as the backbone and driving force of urban development. TOD creates a regional network of high quality public transport surrounded by concentrated living environments, characterized by higher building densities, human scale, mixed use and an attractive public space. But often TOD is restricted to non-residential buildings close to a public transport stop center. This concept started in America, with the focus to create a type of community development integrated into a walkable neighborhood and located within a short distance of quality public transportation. In this sense, it should make car use redundant [2] (Cervero et al. 2002; Stedenbaanplus 2013).

To establish a genuine Transit Oriented Community (TOC) the development of real estate must be followed by extensively use of the transport system by the users of the area. Janssen-Jansen and Mulders (2013) are critical in terms of the feasibility of TOD's. Developments do not always run smoothly, sometimes because there's literally limited space around the station for real estate development. But sometimes also because demand trends are different than assumed, as consumers long for different types of housing. The mostly supply-driven ambitions fail, ignoring the fact that demand is not just to create. They can be considered as TafD strategies: Transit aiming for Development (Janssen-Jansen and Mulders, 2013).

In the American definition of TOD the walkability of the neighborhood is stressed. For instance, Cervero describe TOD as "a compact, mixed-use com-

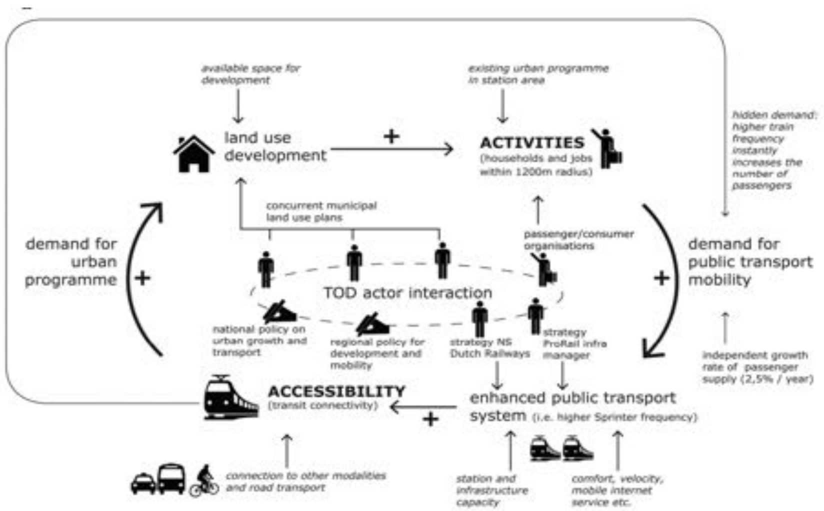
1 www.collegevanrijksadviseurs.nl
2 www.Reconnectingamerica.com

munity, centered around a transit station that, by design, invites residents, workers, and shoppers to drive their cars less and ride mass transit more. The transit village extends roughly a quarter mile from a transit station, a distance that can be covered in about 5 minutes by foot. The centerpiece of the transit village is the transit station itself and the civic and public spaces that surround it." (Cervero et.al., 2002, p.5).

TOD requires high densities around the stations. The catchment area is literary limited and is supposed to have a radius of about 1/4 mile (circa 400 meter), or 5 minutes walking. This means that all services, housing, offices and other functions must be concentrated on a small plot of land. (TOD) neighborhoods often 'consist of a center with a public transit station, surrounded by high-density development with gradually lower-density development spreading outward from the center.' (Holmes & van Hemert, 2008).
http://deltametropool.nl
The implementation of TOD struggles in many cases with the lack of with development within the catchment area. The required higher density leads to greater demand for land, and thus to higher land prices, which hamper the development of certain functions such as housing. The first shell around a station is often used for offices. Housing development is further limited by safety zones near the tracks. In addition, the room for parking space (for park and ride) claims too much space around the station.

The association Deltametropool provided an interesting insight in the aspects that are involved in planning of TOD concepts. In the scheme (figure 4.2) they combined the Land Use Transport Cycle with the elements that can stimulate TOD. It shows the necessary interaction between the governmental and semi-private parties. An increasing demand for urban programme, leads to more land use development close to the station areas, and hence to an increase of activities by consumer. This again leads to an increased demand for public transport mobility, which must be provided by the railway companies in cooperation with the national government.

Figure 4.2 LUTC and TOD concept, actors and planningproces (source deltametropool.nl)



In the scheme can be distinguished:

- municipalities > land use development & local infrastructure
- consumer > activities
- railway company > enhanced public transport system (higher frequency)
- national government > policy on urban growth and transport
- regional government > regional connections

Similar elements that can be influenced by planning are also expected in case of a development concept based upon the HBT system, which we consider in the next section.

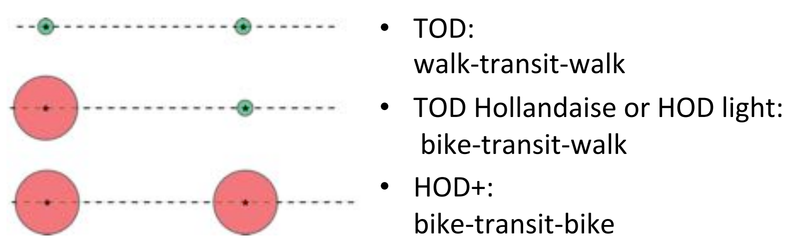
4.5 From TOD to HOD? Hybrid Oriented Development

The debate on TOD, and the difficulties on the implementation of new spatial concepts come with different viewpoints and discussion. Bertolini encourages a public debate on TOD, to attain a greater understanding of the concept and a nuanced and shared picture of what it means. He also adds in an interview that those concepts can have a more hybrid character: 'In a country [The Netherlands] where so many people cycle, residential areas just a few kilometers from a node can also be seen as TOD. (…) I think hub development not only helps to improve sustainability and accessibility, but it is also demanded by the market and the people themselves. Many people choose a car-independent life, a life where you can do everything on foot, by bicycle and by public transport. Especially in the big cities. And there are many more people who want a lifestyle that you live within cycling distance of the station: a TOD Dutch style !' [3]
It's interesting to see that Bertolini broadens the concept of TOD with a very large catchment area into more remote residential districts. This concept fits perfect into the idea of the Hybrid Bicycle-Train system.
This form could thus be identified as a hybrid form of TOD, which I will describe as 'HOD': Hybrid (multimodal bicycle and train) Oriented Development.

As mentioned before, over 45% of all train passengers arrive on their bike to the station. Research by the marketing bureau of the Dutch Railway company (NS-MOA) shows that the distance they travel at the access route is preferably up to 2 or 3 km, depending on the station. It can enlarges the radius of the catchment area for rail transport, if we focus on bicycle access to stations.
When also on the egress trips more people could use a bicycle, it become a challenge to enlarge as well the reach for the Transit Oriented Community on the other part of the commuting trip. Calculated from a train station, a much wider range of jobs can be reached by bike in the same travel time. The question is whether this enlargement of the catchment area can also lead to a higher real estate value. This concept requires the availability of bicycles also on the egress station.

3 www.gebiedsontwikkeling.nu

Figure 4.3 A diagram of three spatial planning concepts, all based on combination of the modalities train and walking and/or cycling. According to the author: TOD, TOD Hollandiase or HOD light, and HOD concept.



Theoretically, we can distinguish three similar types of TOD/HOD concepts:

- TOD, with walkable catchment areas on both ends of the train trip;
- TOD Hollandaise or HOD light, the Dutch style TOD by Bertolini, with a larger catchment area (cycling distances) on the access station and a smaller walkable catchment area on the egress station;
- HOD 'full', with a larger catchment area based on cycling distances on both ends of the train trip.

The effect on planning by the bicycle-train system appears to have much in common with Transit Oriented Development. The (regional) train network is again a base for the development of office and housing locations. This means that the quality of the rail network is involved, and more specific the frequency of the number of trains. And as most people will arrive by bicycle at the station, there are two important factors involved that can be affected by planning: the bicycle infrastructure design to reach the station, and the bicycle facilities (both parking and rental services) near the station.
Compared to TOD the important difference is that the catchment area by bicycle use is much larger than the catchment area by foot. This might offer more flexibility and different approaches on proximity and density. It could also provide the possibility to develop more different and distinctive living environments, on a larger distance to the station and thus outside the most expensive

and difficult to develop areas. Still, the concepts of density and proximity are important factors that can be influenced by planning.

4.6 Governance, Spatial Planning and Infrastructure Planning

To understand to what extent the bicycle-train system is identified and influenced in urban planning, two different elements can be examined. First the co-operation of the different government layers and their joint approach in legislation, policies and investments. Next to that how different viewpoints from infra vs spatial planning can be identified: how can both disciplines work together and integrate vision, budget and strategy?

4.6.1 Instruments of Dutch Planning

The Dutch planning system rejoices a very positive reputation in the international academic planning literature (Hajer and Zonneveld, 1999). The succes of this system might be understood as a function of the complicated organizational format of the Dutch system in which much effort is put into inner-governmental coordination of spatially relevant policies. Dutch spatial planning is mostly consider as a decentralized system. We can distinguish three tiers that make spatial plans, but only local plans are generally binding. The superior (provincial, national) levels can intervene, but only if their interests are at stake (Ministry of infrastructure and environment, 2014).

The Planning law (Wet ruimtelijke ordening, 2008) provided a clear distinction between policy and implementation. On all tiers of planning structural visions ('structuurvisies') are drafted and each governmental level must make it's interests known beforehand.

4.6.2 Responsibilities for the Three Governmental Tiers

The Dutch planning system is based on coöperation of the different governmental tiers. There is a continuous consultation process between national government and regional/local authorities, in which national and regionals aims are considered.

The national government is responsible for national road, rail and waterway network, and for energy infrastructure. This means that the level and the quality of the rail service, such as the frequency of the number of trains, is determined at the national level. The main network is managed by ProRail, a state company. The implementation of the various rail services is in the hands of semi-private parties. Nearly all stations are owned and operated by NS Stations, a subsidiary of the Dutch railway company NS. The national policy is described in a strategy document, which is not a law. The Structural vision Infrastructure and Space (Structuurvisie SVIR, 2012) consist of an Integral framework of mobility and spatial policies at a national level, as a basis for existing and new national policies on spatial and infrastructure planning. It is mend to carry over to lower levels of government through separate legislation, and supported by instruments for financing.

The provinces are responsible for the construction and maintenance of regional roads, including regional bike paths. This includes bicycle highways and local infrastructure that has great significance for the region. Neither national government nor province play a major part in urban development, except for some specific key projects that will be supported with financial incentives.

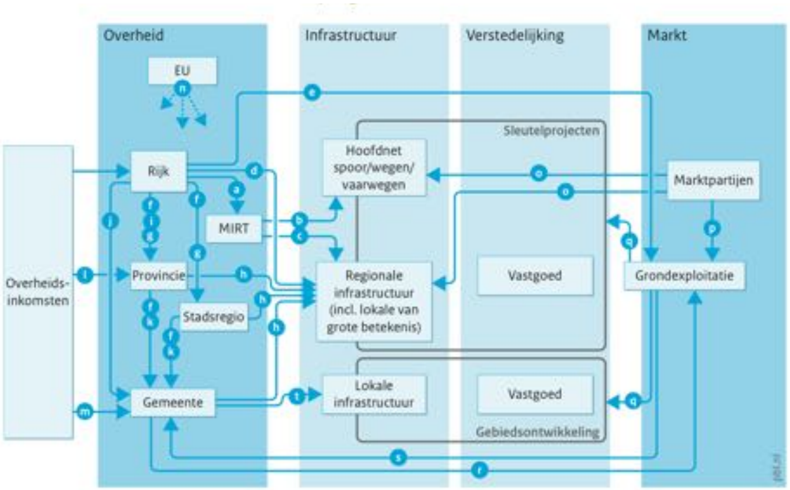
The responsibility for city development is primarily put by the municipalities. The local government proposes land use plans and may contribute to land development. Real estate will be developed by private actors as developers and semi-private housing associations, and must meet the requirements of the land use, that also contains provisions on building height and density. Municipalities do control power about what can be build on specific locations.

The construction and maintenance of local roads is also done by the municipalities. This surely includes the local bicycle infrastructure. Municipalities have much discretionary power in the construction of bicycle paths, but rely largely on the guidelines of the CROW.

4.6.3 Funding for Infrastructure and Urbanization

The flow of funds needed for the realization of infrastructure and urbanization can be presented in this scheme (figure 4.4). In the center are the two columns to which the money is spent: infrastructure and urbanization. The black lines suggest the integrated approach on these projects, for example some city development. On the sides of the scheme are the parties offering the investment,

Figure 4.4 Diagram of tools and flows of funds in Dutch spatial and infrastructure planning (PbL, 2014).



the governments on the left and private parties on the right. The two main elements by which finances are controlled stand in between: MIRT and land development.

Funding by the National Government

The consultations between the three governmental tiers, and with other stakeholders, must lead to an integrated and supported policy in the MIRT program, the Multi-annual Program for Infrastructure, Spatial Planning and Transport. The MIRT consist decisions about infrastructure and spatial projects or investments, based on regional agenda and accessibility indicator for all modalities, though the modalities walking and cycling are not yet included. In the next MIRT, that will follow this autumn, a chapter upon cycling will be included. In the period 2013-2028 approx. € 90 billion for new infrastructure, management and maintenance is invested. The MIRT program also offers the opportunity to contribute to spatial projects, but in practice there is no money available for the R of 'ruimte' or space.

The national government is also funding provinces and municipalities by specific funds. These are general allowances from the national government to the provinces, with a large degree of freedom of expenditure but the height is linked to certain tasks that local governments have to perform. Specific flows are allocated for infrastructure through the BDU to provinces and metropolitan regions, and that can only be spent on traffic and transport. The bulk of this is spent on the operation of public transportation, including light rail. Local authorities in the Netherlands have very limited own tax revenues.

The finance of new infrastructure, that is necessary to unlock new housing districts, should theoretically come from the proceeds of land development, brought together by the private parties. In recent years, however, due to the economic crisis, proceeds from the land development offered no budget for investments in infrastructure. The municipal government often contributed to get the land development profitable. Infrastructure investments remain thus outside the land development and arrive directly at the expense of the municipality.

4.6.4 Coordination Between Infrastructure and Spatial Planning

On national level a strong cooperation between spatial and infrastructure is suggested. In the SVIR (2012) competitiveness and accessibilities are main goals. The Ministry of Infrastructure and Environment states that the demand for mobility continues to grow until 2040. This growth is concentrated most strongly in areas where mobility problems already occur. The challenge for the mobility policy is to facilitate the growth of mobility where the user is positioned central. An integral link between mobility and spatial growth and development is to improve the coherence between different modes, for example, by multimodality (Ministry of Infrastructure and the Environmental eu, 2012, p.22). The government's ambition is that by 2040 travelers can choose for an optimal multimodal system by 'a good connection of the various mobility networks via multi-modal nodes (for passengers and goods) and a good coordination of infrastructure and spatial development'(p .25). This ambition will be realized by a collaboration of the national government with local authorities, market players and knowledge institutes. Although the accessibility of the Netherlands forms the basis of the structural operations, the vision or the emphasis on the reduction of CO2 and reducing the use of fossil fuels is clear. This can be considered as a transition to more sustainable mobility. The government strives to include an increase in train frequencies between major urban regions in the Netherlands. Although it is not directly named, it appears that the rationale for the SVIR focuses on increasing the use of public transport, cycling and walking and to encourage means of transport.

Although the Ministry claims that the best traffic and transport policy is spatial policy, and by that seems very content about its ability to bringing together different interests, others doubt whether the alignment between spatial and infrastructural planning is moderate and whether the aims for compact building stays in place. Hajer and Zonneveld (2000) argue that the planning process is less successful and there are differences in approach to processes and projects, by financing, organizational principles and programming. I want to illustrate this with two examples, in which other departments play a role in the spatial planning.

As a a result of a reform in Dutch policy in recent years and a shake up of national housing policy, the State leaves more room for the market, which means that there is less of a guarantee that new housing projects will be realized at locations (and densities!) that are favoured by the planning agency. Developers seem to prefer realizing new housing projects on cheaper and more remote greenfield than by redevelopment of brownfield that has the proximity of existing infrastructure. The Ministry of Agriculture made policies on developing rural landscapes brought the possibility to finance restructuring high quality 'green' environments by realizing 'red' housing projects. This 'red for green' policy was a direct challenge to the official planning concept of the compact city and the restrictive building policy for the open spaces surrounding the urban regions.

Another example of interference with the official locational policy was shown by the Ministry of Economic Affairs. In the paper 'Space for Economic Activity' (1994) the ministry claimed for additional space for economic activity, and suggesting a conceptual spatial strategy, rather than just in terms of plain demand led accommodation. This institutional turn to an active spatial-economic strategy was subsequently reinforced by the idea of a corridor-oriented development of economic activity. With the motorway infrastructure as the basis for the development of new business parks and distribution activities, it ran against the commitments of the official locational policy, which is aiming at a concentration of labour intensive economic activities in the direct vicinity of nodes in the public transport system (Hajer and Zonneveld, 2000).

These examples show that the coordination between spatial planning and infrastructure planning, when aiming at economic development and growth, is difficult to achieve. And not only the differences in (politcal) goals, but also the various tools, terms, culture and forms of financing make it difficult to arrive at an overall consideration.

Where in the development of planning policy a broad balance is struck and a consultation is held between the tiers on more or less equal basis, financing of infrastructure follows a strong top-down relationship. There is a contradiction in the financial flows and planning. Infrastructure funds work top down from state to municpality, while land development and revenues are created from the base of mar-

	Spatial planning	Infrastructure approach
Organisational principles	plan-based; area-oriented; prioritisation of claims; communication-oriented	project-based; infrastructure-oriented; fitting-in facilities (adapting areas); investment-oriented
Organisational structure	comprehensiveness as aim; decentralised orientation	sectoral goals; economical dominance; central orientation
Core programme/ paradigm	substantive orientation; spatial quality as a goal	strengthening economic structure; spatial quality as establishment factor
Policy legitimacy	balanced procedures; involvement by participation; carefulness takes time	instrumental; duration decision; involvement aimed at creating support; process 'not dynamic'
Policy effectiveness	primarily persuasion and negotiation; communication and concept formulation	primarily by distribution of resources; financial instruments; project-based intervention

Figure 4.5 Distinct differences between the characteristics of spatial planning and infrastructure approach (Hajer and Zonneveld, 2000)

ket initiatives and at local level. Exchanges between these two processes is limited. Municipalities have little own financial resources to build new infrastructure. They depend on the BDU budgets from the national government. But the BDU may only be used for the construction of asphalt or rails; a consideration to use the funds for a contribution in deficits housing development in unfavorable locations is not possible. This view is topical in recent years, as market conditions are that poor that developers are not able to realize feasible plans on specific locations.

4.7 Concluding Remarks and Analytical Framework

In the previous chapters, I have described the characteristics of HBT, and the factors that stimulate bicycle or train use in city regions. That brought me to the factors that stimulate or hamper HBT, density and proximity (chapter 2), and how these factors relate to the economic functioning of city regions (chapter 3). In this chapter, I set out to answer the question which of these factors can be influenced by the (Dutch) planning system?

The Transport Land Use Cycle of Hansen (1959) shows that mobility has a large effect on spatial development. Land use is influenced by the way accessibility is provided, that leads to different choice of transport modes and thus to new infrastructure and so on. This strong relationship between mobility and urban planning form the basis for this study.
Taking this LUTC into account, I distinguish different mobility based spatial concepts: COD, TOD and HOD. Research shows that these spatial concepts differ in characteristics as density and proximity.

Completion Of The Analytical Framework

In the empirical study I will focus on the possibilities offered by an HOD concept based on a hybrid bicycle-train (HBT) system. In order to find out to what extent the use of a hybrid bicycle train (HBT) system can be stimulated through integrated planning in a Dutch metropolitan region, the Metropolitan Region Rotterdam The Hague will be studied.

Table 4.6 Overview of characteristics COD, TOD and HOD

type/ characteristics	aimed/preferred travel mode	preferred proximity	preferred density	diversity and function mix
Car Oriented Development - COD	car	near highway junction	low to medium < 20 dw/ha	monofunctional
Transit Oriented Development - TOD	public transport	< 500m to station	high 50 dw/ha	multifunctional
Hybrid (bicycle-train) Oriented Development - HOD	hybrid bicycle train	< 3 km to station or light rail stop	medium to high 35 - 50 dw/ha (w) 20 - 35 dw/ha (c)	multifunctional

Chapter 2 described the factors that stimulate bicycle and train use in city regions, and what factors stimulate or hamper the use of a hybrid bicycle-train (HBT) system. Clearly, socio-economic and psychological factors play an important role in mode choice for commuters. Individual preferences of commuters can certainly influence mode choice, but they are not an element of planning. The government can steer in influencing mode choice by mobility management. But also mobility management is not an element of (urban) planning, but a transport policy instrument as was discussed in chapter 3. As part of the research question, I made this distinction in order to focus only on the factors that can be influenced by planning.
It showed that the concepts of urban density and proximity are both key factors to stimulate the HBT system. Proximity of jobs, shops and other services contributes to shorter distances which are favorable for cycling, and high density is favorable for train use as it provides a higher potential of travelers, as well for cycling as it showed that in higher urbanized areas people cycle more often. The HBT system is also stimulated by the quality of the rail service, wherein in particular, the frequency of the number of trains plays a major role. Also the

number and the quality of the bicycle facilities around and at stations affect the use of the HBT system. And last but not least, the quality of the bicycle infrastructure is an indispensable factor.
Concluding on the factors that can be influenced by planning to stimulate the use of the HBT system, we can distinguish 5 factors:

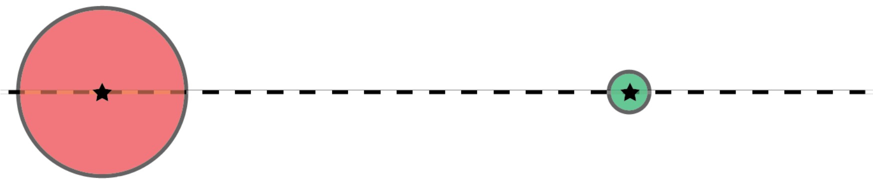
- Quality (frequency) of rail service
- Bicycle infrastructure design
- Bicycle facilities near stations
- Proximity
- Density

I will use these insights in the influencing factors to outline a model of the ideal HOD environment, and hence will test the characteristics of this model to examine whether MRDH provides space and gives priority to HOD in its planning system.

We can distinguish different spatial segments for the hybrid bicycle train system, and each segment has its specific urban form factors that influence the use of the system. The proximity to (railway or lightrail) stations is a necessary condition. The preferred cycling distance from residence to the station should not exceed 5 kilometer, but is preferrably less than 2 kilometer for a slow train station in the suburbs, and less than 3 kilometer for a better connected intercity station.
The density of the business catchment area should be higher, as in most cases people has to walk instead of cycle to their final destination. This walking distance should preferable not exceed 500 meters, and the density would be best in class 1 (highly urbanized) to ensure the proximity to jobs or other services.
An efficiently functioning HBT system implies that the density should certainly be high within walking distance of the train station, and moderate to high within cycling distance. However, urban densities can also be too high for an HBT system to function properly, because local public transport will be used more to the detriment of cycling in the pretransport. Higher densities can also lead to more urban disamenities and less attractive living environments. This is why I assume that optimum HOD locations have a density of 35-50 dwellings per hectare in the first shell around a station, on a walkable distance of about 500 m. And in the second shell, that aims at cycling and thus has a radius of 2 to 3 km, the preferred density is 20-35 dwellings per hectare. Locations with lower densities than 20 dwellings per ha. are more car-oriented. Locations with a higher density than 50 dwellings per ha. will focus more on public transport and walking.

For the quality of the rail service, I will focus on the frequency of the number of trains. An increase in frequency leads to an increase of the number of train passengers. The same counts for the cycling facilities around the stations, as there seems to be a hidden demand: more bicycle parking places lead to more passengers that arrive by bike. On the egress station I will also examine the availability of rental bikes.

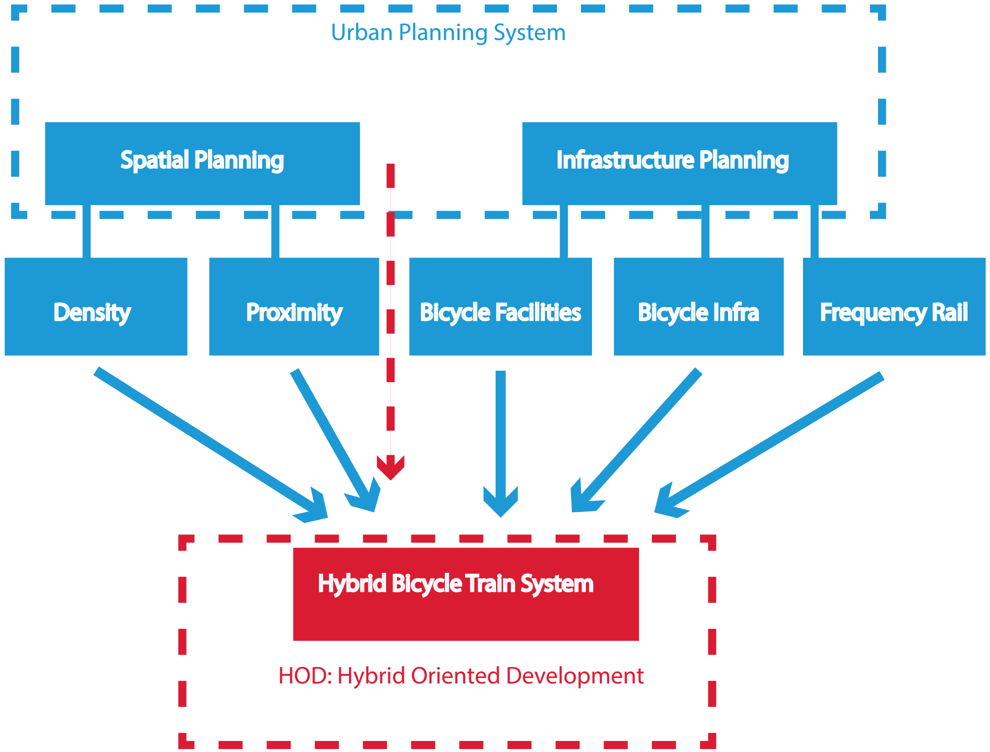
Figure 4.7 Diagram of the catchment areas for walking and cycling.
The range to a station could be classified in different shells, that are related to walking cq. cycling distance:
first shell; expected mode is walking; distance up to 500 m; preferred density 35-50 dw/ha
second shell; prefered mode is cycling; distance up to 2-3 km; preferred density 20-35 dw/ha.



The infrastructure design is not quantitatively assessed. There are no reliable methods available, which can be carried out within the limited time. The evaluation of the infra takes place by means of a qualitative point of view, based on the structure of routes to the station.

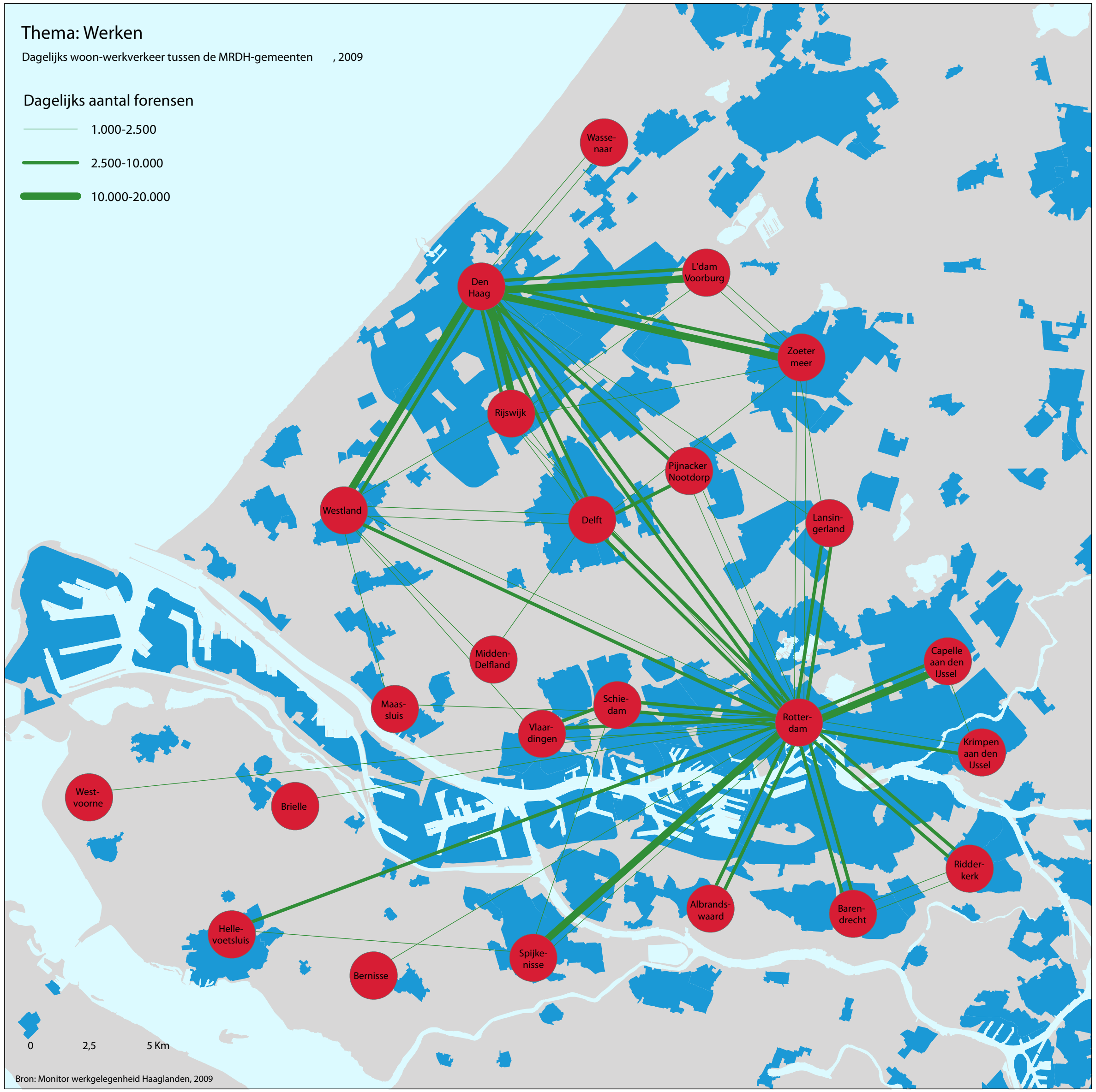
In the conceptual model (figure 4.8) is expressed that integrated urban planning consists of spatial and infrastructure planning. The influencing factors for the use of the HBT system are density and proximity, as part of spatial planning, and bucycle facilities, bicycle infra design and the frequency of rail, as part of infrastructure planning. The HBT system is an essential element of the concept of Hybrid Oriented Design.

Figure 4.8 Conceptual model



Case Study

Figure 5.1 Commuting patterns in The Hague and Rotterdam (source MRDH 2013)



Chapter 5 Spatial Analysis of the HBT in MRDH

5.1 About MRDH

I have chosen the Metropolitan Region Rotterdam The Hague (MRDH) in the west of The Netherlands as the case for the empirical study. The Netherlands form an exemplary case in the world of bicycle-oriented mobility because of the relative maturity of its bicycle-train connections. The region MRDH, in turn, is well-known for its progress into a combined metropolitan region and the renewal of railway lines and new housing projects. MRDH is a polycentric region, with different centers located in close proximity. Characteristic for a polycentric metropolitan region is the existence of strong functional relationships between the cores, and close relations between the residential areas in the region and the economic heart of this region (Grünfeld, 2010). The presence of various living and work areas, and the importance of mobility make a polycentric region an interesting field of research. The modal share of cycling is generally in line with the national average of 26%. An important issue is the transformed railway line into a lightrail (Randstadrail) that forms a central point for new (vinex) housing projects.

The Metropolitan Region is recently formed by a (voluntary) cooperation between 23 municipalities. Iconic are the largest seaport in Europe, the so-called mainport Rotterdam, and the seat of national government and international organizations in The Hague. Zoetermeer and Delft are two other larger cities in the region with more than 100.000 inhabitants. The greenhouse industry in the Westland forms one of the main 'greenports' of the Netherlands. The total area of the region covers 990 km2 and is home to about 2.2 million people. It is considered a very dense area, with 2.250 people per square km, and it includes the most densely populated municipality of the Netherlands, The Hague (6.117 inhabitants/km^2).

The administrative structure of the Metropolitan Region is formed by the two city regions 'Haaglanden' and 'Stadsregio Rotterdam', which are soon to be merged into a new entity: the Metropoolregio Rotterdam Den Haag (MRDH). MRDH is yet a voluntary cooperation but, depending on future legislation, will transform into a independent administrative and political entity. The administrative formation was more or less randomly formed by changing opinions in the First Cabinet Balkenende. The abolition of the city regions allowed for a new covenant, and is seen by policymakers as "a window of opportunity. The cooperation between the two city regions is already good, and can easily be enhanced with a common agenda and organization structure."

Metropolitan Region Rotterdam The Hague aims to increase the economic power of the region and to put the region as a strong player in international spotlights. The strategy developed jointly by the municipalities has three strands. 'The first strand is to exploit the potential of being a single daily urban system by improving internal connectivity. The second is to make better use of, and invest in the knowledge and innovation potential of the region. The third strand is to improve the exploitation of the services and amenities offered in the region' (Meijers 2014).

For the above purposes, one of the first acts of MRDH was the formation of the Transport Authority. The cooperation within one organization responsible for transport issues should facilitate and enhance the accessibility by working on a larger scale than before; with less cost, more investment in mobility. This ambition for the metropolitan region has been described in the Strategische Bereikbaarheidsagenda or 'Strategic Agenda Accessibility' (MRDH, 2013).

The ambition of the Transport Authority is that the economic cores in MRDH are easy to reach and within an acceptable time of up to 45 minutes, by a better matching of the metropolitan region's road network, public transport system and the cycle network (MRDH, 2013). The travel time of 45 minutes (single fare) is by policymakers regarded as "an acceptable travel time for most commuters".

The average travel time and distance for commuting in South Holland are about 29 minutes and about 17 km (single fare). If we compare that to the general Dutch average, it is slightly longer in time though shorter in distance. This difference can be explained by the stronger congestion in this area (KiM, 2013). The choice for 45 minutes as maximum is thus somewhat questionable, because

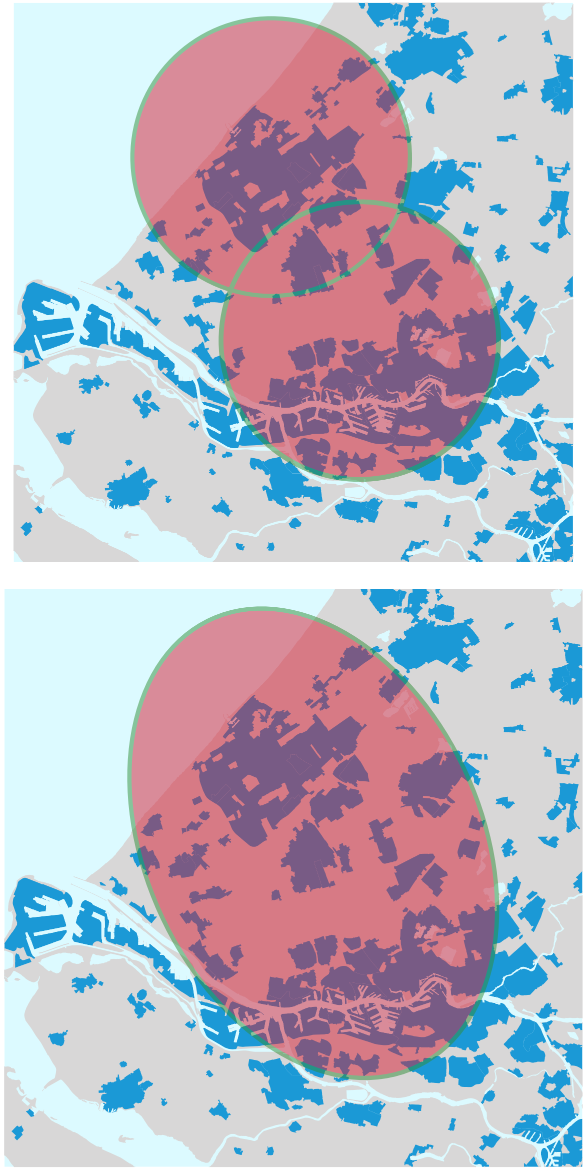


Figure 5.2
The two Daily Urban Systems in the current situation (above), and the proposed merge of the Daily Urban System in MRDH (below). (adjusted by the author, source: MRDH, 2013)

it substantially exceeds the average travel time. Nevertheless, I will consider the travel time of 45 minutes as a given for this research, and will use it to judge the reach of the HBT.

Mode Choice
The 2.2 million inhabitants of the MRDH travel about 42 billion kilometres each year (KiM, 2013). They prefer to travel by car, and the majority of their trips is within the region. Only 11% of all trips has a destination outside the region, while about 51% of all trips is characterized as intra-accessibility. Both Rotterdam and The Hague count for about 12% of the trips that stay within the city. Furthermore, it seems the Hague is slightly more attractive than Rotterdam for people from outside MRDH (11 and 7% of the mileage). And as for The Hague there are strong relationships with the commuters from the nearby satellite towns as Zoetermeer and Leidschendam-Voorburg, the commuters traveling to Rotterdam arrive mainly from Schiedam and Capelle aan den IJssel. The bicycle is used on 22% of all trips, which is about the halve of the car use but far more than the share for train (3%) and local public transport (6%). But the distance traveled by train is much larger with 5.6 billion km than on two wheels: 2.4 billion km per year. (KIM 2013 ; MRDH, 2013).

5.2 Methodology and Research

This chapter aims to gain more insight into the HBT and planning systems in the MRDH region. I will answer the empirical question on the reach of the hybrid bicycle-train (HBT) system in the MRDH region..With 'reach' I mean to what extent the system is available to residents, and to which areas it extends. Here, I focus primarily on the proximity of rail stations. I also want to consider whether there are differences in density between the areas that fit within the reach of the HBT system and those that do not fit within that reach. From all municipalities, I will then select a few station environments based on their role as a major origin point or destination in the region.

In the second section, we delve into the selected station environments. The focus is here to explore whether the density of the different shells around a station is adjusted to the expected access mode of transport, either on foot or by bike. I have formulated several appropriate densities from the literature. Also I will distinguish other relevant aspects, such as proximity to other services and the availability of bicycle parking spaces. This part must give a revealed picture of whether the urban planning system in MRDH has, deliberately or not, attended to the HBT system. This concerns spatial planning system as well as the infrastructure planning system.

For the case study, I consider some stations on the railways and light rail connection between Rotterdam and The Hague. The parts of the light rail in both city centers are considered equal to metro or tram modalities, because of the many stops and relatively low speeds reached there. To gain insight into the (housing) developments of the last few years I involve both existing urban areas as greenfield locations (Vinex) in the study.

The main factors in planning to measure the structure of the city are density and proximity. To determine the density I used the area address density (Omgevingsadressendichtheid; OAD). This is a view of the degree of concentration of human activities (housing, work, shops, school, entertainment, etc.) in an urban area (CBS, 2014). The OAD involves the number of addresses per square kilometer. CBS used the OAD to determine the degree of urbanization of a certain area (grid square, neighborhood, district, municipality).

In addition to the OAD, the population density and the housing density are used to describe the density at the different locations. The latter is calculated by dividing the number of dwellings by the area of the neighborhood. The OAD, population density and average housing density per research location are shown in separate tables per municipality and per station area.

For the first shell, the walking catchment area, I used for practical reasons 4 blocks of 500x500 m. The accepted distance for walking differs in literature studies from 400 m (American TOD) to 800 m. With this blocks the average distance is about 600 m.

For the second shell, the cycling catchment area, the distance varies per station type. For lightrail and suburb train stations the distance is set on 2 km, and for intercity stations I used 3 km.

Proximity is also determined on the basis of data by CBS, and on data by Lisa for the economic activities. The proximity to translations and to different other services was first collected on a municipal level. The average distance of 5 km is used to select those municipalities that are generally in reach for the HBT system (Kager, 2015).

The second selection was made based on the ratio between the number of jobs and the workforce. Municipalities with a much larger number of workers than jobs are considered the access stations, and municipalities with a surplus of jobs are considered egress stations.

5.3 Reach of HBT in MRDH

Table 5.3 gives an overview of all 23 municipalities in MRDH, the proximity to train stations and other services, the population and housing density and the degree of urbanization. I will discuss this data on different topics.

The MRDH region is a dense and well accessible area. The axis Rotterdam-Delft-The Hague is already framed by major infrastructure to handle the heavy traffic movements. The 'old' railway line, which is currently being improved with a tunnel through Delft, has recently been joined with a younger brother in public transport: the introduction of RandstadRail. This is a new light rail connection that integrates the metro and tramway systems of Rotterdam and The Hague. In addition, the motorists that are now facing strong congestion on the highway A13 look forward on the completion of the missing link of 7 km of highway A4 between Delft and Schiedam. The construction of this highway section started in 2012, and the new road is expected to be opened in 2015. And for unimodal cycling, the main measures are improving cycle highways between The Hague, Delft and Rotterdam, and the accessibility of

Municpalities MRDH density & proximity

Municipality	distance to station (km, average)	distance to intercity station	distance to primary school	distance to nursery	distance to supermarket	degree of urbanization (class 1-5)	OAD (#adress/km2)	# Inhabitants	Population density (#inhabitants/ km2)	Surface	# houses	Average housing density (#houses/ha)	number of jobs (x/ 1000)	modal share cycling - all trips	modal share cycling - short distances
Albrandswaard	8,7	8,7	0,7	0,7	0,9	4	980	25070	1150	2376	10167	4,3	718	20%	30%
Barendrecht	4,2	10,9	0,7	0,6	1,2	2	1581	47375	2380	2173	18867	8,7	930	16%	27%
Bernisse	16,5	10,6	0,6	1,6	1,1	5	423	12365	216	6846	5524	0,8	NA	22%	38%
Brielle	11,5	24,3	0,9	1,7	0,9	4	839	16310	591	3114	7678	2,5	NA	16%	24%
Capelle aan den IJssel	3,2	27,4	0,6	0,6	0,7	2	2262	66175	4655	1540	30728	20,0	1066	19%	29%
Delft	1,6	9,1	0,5	0,4	0,5	1	3403	100045	4381	2406	49199	20,4	957	26%	39%
Den Haag	2,9	4,2	0,4	0,4	0,5	1	4755	508940	6216	9811	251374	25,6	1024	18%	25%
Hellevoetsluis	16,8	31,5	0,7	0,7	0,7	2	1547	38950	1235	4627	17298	3,7	418	18%	29%
Krimpen aan den IJssel	7,4	11,5	0,6	0,6	0,7	2	1812	28825	3754	895	12322	13,8	555	17%	24%
Lansingerland	6,8	10,1	0,8	1	1,0	3	1202	57120	1053	5637	22523	4,0	746	22%	31%
Leidschendam-Voorburg	2,2	4,5	0,6	0,6	0,8	1	2813	73355	2245	3562	36383	10,2	524	19%	27%
Maassluis	2,1	17,3	0,6	0,6	0,7	2	1945	32080	3778	1012	14846	14,7	418	21%	31%
Midden-Delfland	3,4	12,6	0,7	0,6	0,8	3	1223	18455	390	4938	7578	1,5	NA	31%	42%
Pijnacker-Nootdorp	4,2	9,8	0,8	0,6	1,1	3	1382	51070	1367	3862	19721	5,1	473	28%	39%
Ridderkerk	5,4	11,4	0,7	0,5	0,7	2	1703	45250	1909	2526	20747	8,2	795	19%	29%
Rijswijk	1,9	4,3	0,6	0,5	0,5	1	3152	47635	3390	1449	25101	17,3	1263	18%	26%
Rotterdam	2,9	6,1	0,5	0,5	0,5	1	3909	618355	2960	32416	311324	9,6	1154	14%	23%
Schiedam	2,2	7	0,4	0,5	0,5	1	3270	76450	4247	1986	36581	18,4	803	19%	28%
Sliedrecht	1,7	9,9	0,6	0,9	0,7	2	1569	24525	1911	1401	10598	7,6	NA	22%	33%
Spijkenisse	13,8	19,4	0,6	0,8	0,7	2	2216	72560	2780	3027	33465	11,1	NA	18%	28%
Vlaardingen	2,1	10,4	0,5	0,6	0,6	1	2826	70980	3002	2669	34927	13,1	614	22%	31%
Wassenaar	4,4	7,1	0,7	0,8	1,3	3	1433	25675	504	6237	12192	2,0	604	17%	22%
Westland	6,6	12,4	0,6	0,7	0,9	3	1341	103240	1298	9058	42339	4,7	1057	26%	36%
Zoetermeer	3,3	13,9	0,6	0,5	0,9	2	2512	123560	3578	3705	55050	14,9	716	18%	27%

Figure 5.3 Municipalities in MRDH, density and proximity (source CBS)

public transport hubs including facilities like bike storage. These adjacent systems provide the (three) main choices for commuters on their transport mode.

The proximity of a station is a necessary condition for the HBT system. According to Kager (2015) the distance to a train station should preferably not exceed 5 km. The distance of 7,5 km is also often mentioned but as part of a multimodal trip, the time spent in the access trip seems to long. I used the 5 km distance to a train station as a determining criterion. Table 5.3 shows which municipalities may or may not meet this criterion.
It seems that traveling by train is most easy for the people in Delft, as they live mostly in the vicinity of a station. The average distance is only 1,6 km, while for the people in Bernisse and Hellevoetsluis the nearest station is at more than 16 km. The proximity to stations is related to density: all municipalities in class 1 of urbanization degree have a station within 5 km. Also other services as shops and nurseries are in closer range as the density increases.
Most of the municipalities of MRDH have a train station nearby. I have made an exception for Lansingerland. The table shows the nearby stations and the CBS index does not include the lightrail stops. But the Randstadrail line can be regarded as high class rail on the part between Rotterdam and The Hague, where the average speed is high and the connection to the central stations of both major cities also provide good access to the rest of the Dutch rail network. With this premise, I come to 16 of the 23 municipalities with a trains station within acceptable cycling distance for a multimodal trip. And because these are the most densely populated and largest municipalities, this includes the bulk of the total population of MRDH. I consider 85% as the potential for HBT.

This also means that roughly 15% of the population is not connected to the HBT system. For some of them, as in Spijkenisse, the metro network can play a role in the access trips to the train. For others that live in more remote regions, such as Bernisse and Brielle, the system is not available. Extension of the rail network to the sparsely populated areas is not very likely, due to the high costs and the unfavourable operation. Remarkable is the situation in Westland, that is also outside the reach of HBT. This municipality houses over 100,000 inhabitants but they are divided over more smaller communities. Westland is an important economic center as one of the Greenports.

Municipality	distance to station (km, average)	# Inhabitants
Delft	1,6	100045
Sliedrecht	1,7	24525
Rijswijk	1,9	47635
Maassluis	2,1	32080
Vlaardingen	2,1	70980
Leidschendam-Voorburg	2,2	73355
Schiedam	2,2	76450
Den Haag	2,9	508940
Rotterdam	2,9	618355
Capelle aan den IJssel	3,2	66175
Zoetermeer	3,3	123560
Midden-Delfland	3,4	18455
Barendrecht	4,2	47375
Pijnacker-Nootdorp	4,2	51070
Wassenaar	4,4	25675
Ridderkerk	5,4	45250
Westland	6,6	103240
Lansingerland *	6,8	57120
Krimpen aan den IJssel	7,4	28825
Albrandswaard	8,7	25070
Brielle	11,5	16310
Spijkenisse	13,8	72560
Bernisse	16,5	12365
Hellevoetsluis	16,8	38950
subtotal < proximity station	85,0%	1941795
subtotal > proximity station	15,0%	342570
total inhabitants	100,0%	2284365

Figure 5.4 Proximity to train stations. Municpalities of MRDH that fit into the 5 km average distance to a train station (green) and those that do not fit into this criterion (red). Exception for Lansingerland (orange) because of the lightrail station. (source CBS).

If we look at the relation between density and proximity, the table shows that all municipalities within close range to a train station are categorized in the most dense class. An exception applies to some suburbs of Rotterdam. Spijkenisse and Krimpen aan den IJssel have a high density but no station on average short distance. This can possibly be explained by the extensive subway network which was built at those suburbs, which offered a reasonable alternative to the train.
If we look at the other indicators for proximity, as the distance the shops or schools, we have the same relationship with density. The higher the density, the

closer the proximity.
The relationship between the modal share for cycling with density is rather less clear and distinctive in this scheme.

Origin and destination
The next step is to identify the difference between the 'origin' and 'destination' stations, which I will examine as focus stations in this empirical study. The origin stations are within municipalities where the number of jobs is lower compared to the number of employees. It is expected that stations in these municipality play a role as 'feeder' for the HBT system. And on the other hand, I will identify the municipalities that offer the most jobs and can be regarded as the main destinations or business catchment area. This distinction is important, as the bicycle use is very different in pre-transport and post-transport. According to NSMOA the modal split is 45% in pre-transport, as most people use their own bike from home to the origin station. And it is about 10-15% in post-transport, where less people have a second bike at his disposal, or rent a bike. Especially the OV-fiets (Public Transport Bike), a product from the Dutch railway company, is getting immensely popular but it only provides a small number of egress trips. Because of this difference in pre- and post transport, it is assumed that most office districts are closely to stations and that housing is also located on greater distances.
This selection is made based on the ratio between the number of jobs and the workforce (figure 5.5).

	Municipality	number of jobs (x/1000)	distance to station (km, average)	degree of urbanization (class 1-5)	OAD (#adress/km2)	# Inhabitants	modal share cycling - all trips	modal share cycling - short distances
	Den Haag	1024	2,9	1	4755	508940	18%	25%
	Leidschendam-Voorburg	524	2,2	1	2813	73355	19%	27%
	Pijnacker-Nootdorp	473	4,2	3	1382	51070	28%	39%
	Rijswijk	1263	1,9	1	3152	47635	18%	26%
	Rotterdam	1154	2,9	1	3909	618355	14%	23%
	Westland	1057	6,6	3	1341	103240	26%	36%
	Zoetermeer	716	3,3	2	2512	123560	18%	27%

Figure 5.5 Ratio between the number of jobs and the workforce (source CBS)

Rijswijk has the best ratio, and that is mostly due to the business district Plaspoelpolder. This district is a typical car based highway location, as it was largely developed in the sixties and seventies. Originally focused on industry, later gradually shifted to offices and small and medium-sized enterprises. Shell and the European Patent Office are among the first generation of businesses in the area. Later on, many other local, regional and international companies and institutions added. With 15,000 employees and nearly 400 companies the Plaspoelpolder offers a lot of jobs for the region. The central location in the Randstad and direct acces to the highway A4 are still a brand identifier for the business district. The distance to the nearest train station is between 700 meter and 2,5 km, which makes it less attractive to walk to the station.
The Hague and Rotterdam have also a high ratio between workers and workplaces, as was expected since these are the central cities of their regions. The majority of the jobs in MRDH is concentrated in the two major cities Rotterdam (374.000) and The Hague (265.000).
The location of Rotterdam at the Rhine-Meuse-Delta, created the perfect conditions to become world largest harbor from the 1960's and remained that until 2002. The harbor area stretches over 40 km, from the historic city centre to the new Maasvlakte 2 reclaiming land from the North Sea. With still the largest port of Europe, it is clear that 'transport and logistics' is one of the main sectors in the economy of the Rotterdam area. Also 'manufacturing' and 'business services' and increasingly 'utilities' score above average [1] [2] (Mun. Rotterdam, 2013).
The Hague has housed the seat of government already from the Middle Ages and more recently lots of international organizations. With the presence of world famous institutions like the International Criminal Court and the Yugoslav Tribunal, The Hague presents itself as a city of peace, justice and security. Besides the government the city is also home to a sizeable corporate service industry, including Shell's international headquarters.

Westland is almost even, and as argued before this is a specific business area. The green port function is important but attracts mainly workforce from the own region, and also form (the western part) of The Hague. Flora Holland, the larg-

1 www.mrdh.nl
2 http://www.zuid-holland.nl/monitorruimte

est auction of its kind in the world, is based in the municipality of Westland.

Most other municipalities offer less jobs and will be regarded as the feeders for HBT system, as they house the most of the workforce. From these municipalities I choose three, to study their role as 'origin' stations:

- Zoetermeer, a satellite town for The Hague, and located on the railway to Utrecht. Zoetermeer has expanded quickly in the seventies, but the part at the south side of the railway and highway was only developed in the nineties. The first study area is Zoetermeer (rail station).
- Leidschendam-Voorburg, a suburb near The Hague, has a light rail station on the former 'Hofpleinlijn' and is an older town. It has only half as much jobs as employees. The second study area is Leidschendam-V (lightrail stop)
- Pijnacker-Nootdorp, another smaller town, had large housing development for the Vinex, and is also located on the lightrail that was specifically transformed to serve for the new Vinex housing. The third study area will be Pijnacker-Zuid (new vinex housing in south, lightrail stop).

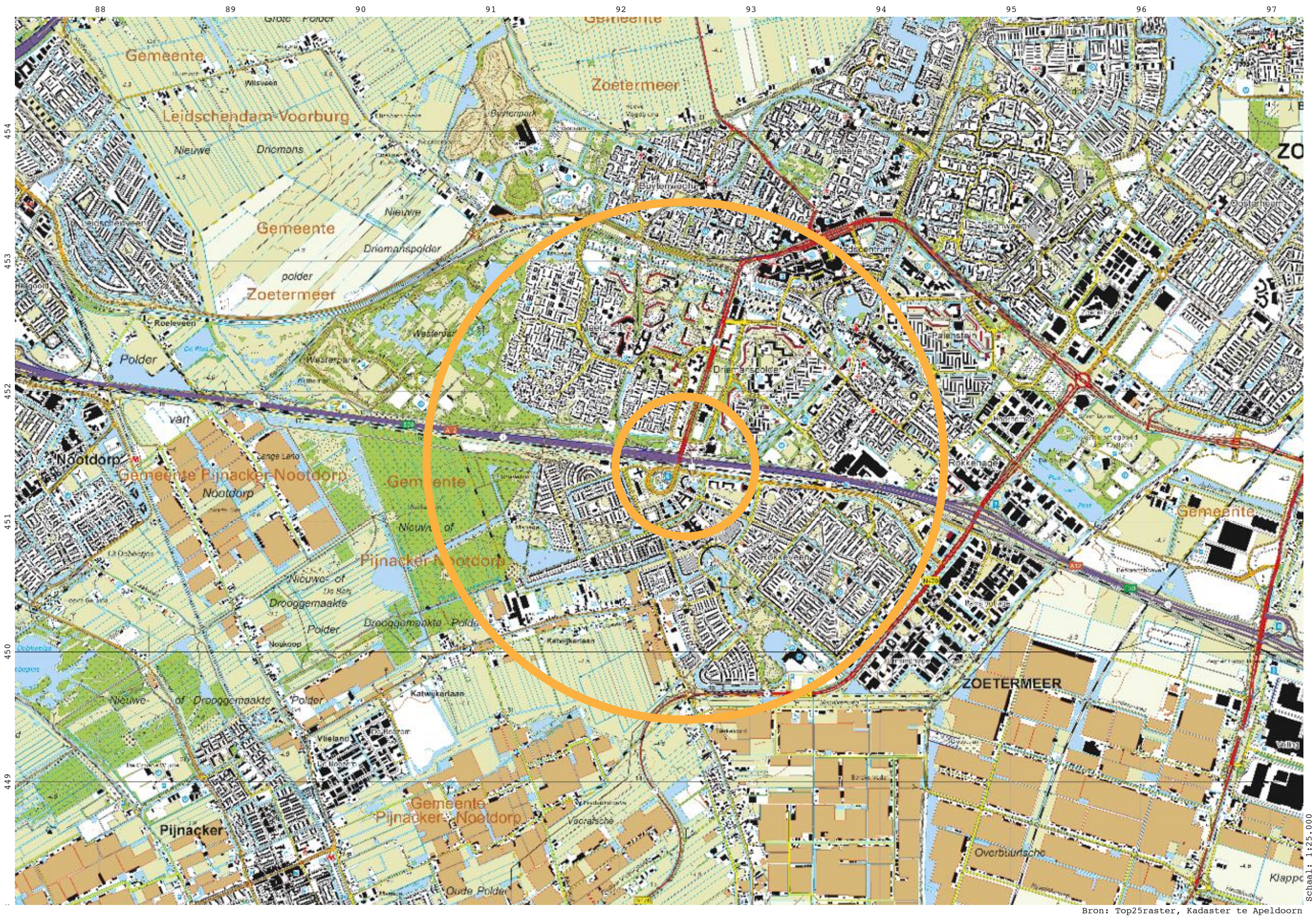
As the destination stations I choose the central stations of The Hague and Rotterdam. As described above, these main cities are attractive for the commuters from their both regions. But surely they also provide a workforce that will travel to other destinations, so I can also regards these stations as versatile. Next to their function as business district, I will also study the function as origin station and the relation with the housing density around the station.

For each station, I will study two shells around it with a radius based on either walking or cycling. Based on the literature, I choose the radius of about 500 meter as the walking distance. And for cycling, it depends on the connectivity of the station: 2 kilometer is the chosen cycling distance to lightrail and suburb stations that offer slow trains, and 3 kilometer is the preferred maximum cycling distance to an intercity station.

For each shell, I will identify the population and housing density, and the OAD, with data from CBS and Lisa. I will compare that to the preferred density for optimum HOD locations, with a density of 35-50 dwellings per hectare in the first shell around a station (walkable distance of about 500 m.) and 20-35 dwellings per hectare in the second shell (cycling distance 2 to 3 km). And surely I will compare if there are differences between the walking and cycling shells. Next I will regard the distance to shops and schools, within the catchment area, as these are important factors for trip chaining.
And finally I will study the spatial reach for the whole region, by positioning the radius of all stations over a map with the current situation, and the recent vinex housing development and finally for new housing and office development as planned (Nieuwe kaart van Nederland, Studie Deltametropool).

Zoetermeer

Station/neighborhood	OAD (#adress/ km2)	# Inhabitants	#houses	Population density (#inhabitants/km2)	Average housing density (#houses/ ha)	# shops at or near station	average housing occupancy	Total surface (ha)
TS Zoetermeer walking distance	2539	2660	1290	2660	13	None	2,1	
TS Zoetermeer cycling distance	2665	46575	21260	5680	25,9		2,2	820



Left above: density in the first (walking) shell and the second (cycling) shell around the station.
Above: position in the region.
Left: Topography of the station area with the catchment areas for walking and cycling.

5.3.1 Focus station Zoetermeer

Zoetermeer has two train stations and several light rail stops. The light rail network was developed in the seventies as a rail network, during the period of strong growth of the city as a satellite of The Hague. Because of the many stops and the indirect routes, the lightrail has a lower quality like a tram network. For the case I choose the main train station, that is located near the highway A12 between The Hague and Utrecht.

5.3.2 Density

Due to its location along the highway A12 and a major access road, a large part of the immediate vicinity of the station area is undeveloped. This is reinforced by the security zones and environmental zones, so housing near the station is not possible. This is confirmed by the figures.

The average housing density in the walking catchment area is only 13 dw/ha, which is far lower than the preferred density for HOD. In the wider cycling catchment area the density is twice as high, and it fits in the range for the preferred densities of 20 - 35 dwellings per hectare. It is an average housing density for Vinex suburbs.
The OAD is almost even for both catchment areas, which indicates that there must be also other functions and activities than housing near the station. In fact, the first shell around the station contains several office buildings.

5.3.3 Proximity

At the station only a small kiosk is available for some snacks and coffee. The distance to services as shops and schools is between 0,5 and 1 km, on both sides of the station.

5.3.4 Frequency

Every fifteen minutes a train leaves from this station. The station of The Hague CS is nearby and can be reached within 12 minutes. But the travel time to Rotterdam is 40 minutes by train, while the distance as the crow flies is only 2 kilometer longer.

proximity			quality rail network			bicycle facilities	
distance to shops	distance to school	# jobs within 15 minutes	frequency	travel time to The Hague	travel time to Rotterdam	# bicycle parkings	bicycle rental
0,5-1	0,5-1	106000	4	12	40	950	none

5.3.5 Bicycle facilities

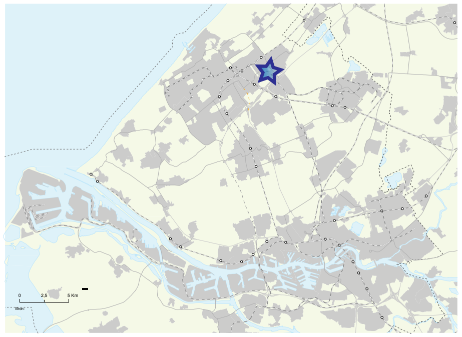
There are sufficient bicycle parking places at both entrances, but they are quite far away from the platform. The distance to the stairs is reasonable, but to reach the platforms one has to walk about 50 to 100 m over the bridge that stretches over the highway and the major road.
There are no OV-fiets or other bike rental services at this station.

5.3.6 Bicycle infrastructure

The quality of the local bicycle network in Zoetermeer is average according to Dutch standards. Most of the bicycle routes are constructed as separate lanes. Many of them have been carried out with tiles instead of asphalt. A peculiarity is that the cycle route to the station is included in the bridge across the highway, and the entrance to this elevated cycle path should be taken with an moving staircase.

Leidschendam Voorburg density

Station/neighborhood	OAD (#adress/ km2)	# Inhabitants	#houses	Population density (#inhabitants/km2)	Average housing density (#houses/ ha)
LRS LeidschendamV walking distance	2110	4929	2045	4929	20
LRS LeidschendamV cycling distance	2470	29165	13205	4829	21,9



Left above: density in the first (walking) shell and the second (cycling) shell around the station.
Above: position in the region.
Left: Topography of the station area with the catchment areas for walking and cycling.

5.4.1 Focus station Leidschendam-Voorburg

This light rail station is situated right on the former municipal border of Leidschendam and Voorburg. Since the merger, the border is gone, but the station is still called for the two municipalities. The lightrail system is in the nineties converted from the old track to the Hofplein in Rotterdam, because of the construction of the Vinex neighborhoods, and is name d Randstadrail. Two transport companies are active in this line: HTM and RET. They drive with different material, so separate platforms with different heights are built. The lines go both to Rotterdam, The Hague and Zoetermeer

5.4.2 Density

The density around this station is just above the 20 dwelling/ha. There is no other heavy infrastructure near the track, and the houses are built fairly close to the railway line. The density suits this part of the suburb, where relatively higher incomes live and most of the houses have gardens with lots of space. On the south side is a channel which formed a barrier traditionally for residential development. On the other side of the water is also less development, a rail yard and even pastures. Within cycling range are also some offices, the largest part of which is vacant.

5.4.3 Proximity

There are no services at the station. As the immediate vicinity is just a residential area, the distance to shops and schools is between 0,5 and 1 km, but schools are at closer distance.
The number of jobs that can be reached within fifteen minutes by public transport is quite poor.

5.4.4 Frequency

The advantage of the lightrail system is that it provides a high frequency. Every five minutes a train leaves the station, which causes very short waiting times. The Hague CS is nearby and is reached in 8 minutes. It takes half an hour to reach Rotterdam CS, so that leaves little and distance to reach your destination within the required 45 minutes,

proximity			quality rail network			bicycle facilities	
distance to shops	distance to school	# jobs within 15 minutes	frequency	travel time to The Hague	travel time to Rotterdam	# bicycle parkings	bicycle rental
0,5-1	0,5	15000	12	8	30	451	none

5.4.5 Bicycle facilities

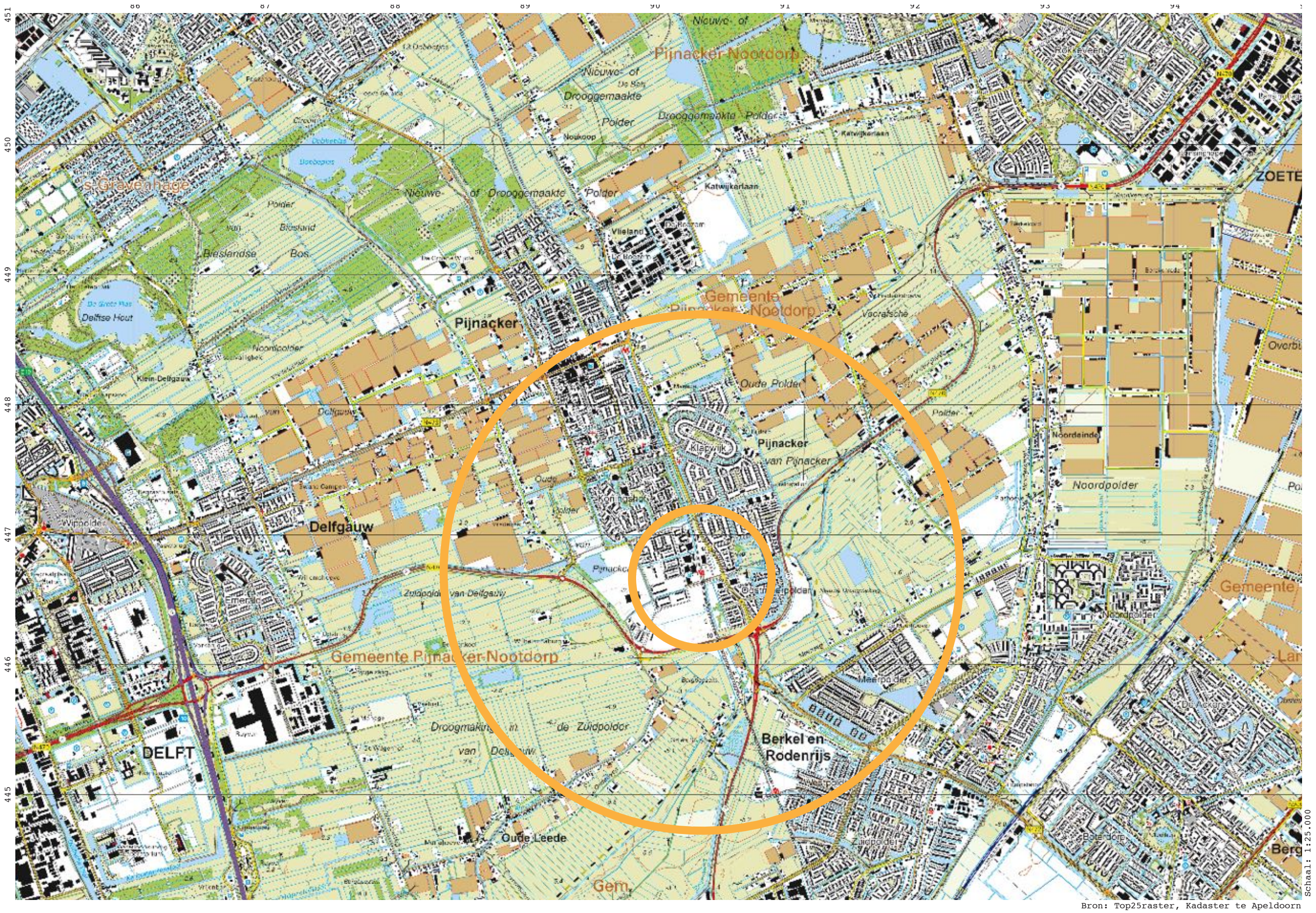
The 451 bicycle parkings are all situated pretty close to the stairs to the platforms, but their number is too low to meet the high demand for parkings. OV-fiets or other bike rental services are not available here.

5.4.6 Bicycle infrastructure

The station is easy to reach by bicycle. The cycle paths run under the station and both sides have branched out a dense network. The quality is in the embodiment with tiling reasonable.

Pijnacker Zuid

Station/neighborhood	OAD (#adress/ km2)	# Inhabitants	#houses	Population density (#inhabitants/km2)	Average housing density (#houses/ ha)	average housing occupancy
LRS Pijnacker Zuid walking distance	2539	2660	1290	2660	13	2,6
LRS Pijnacker Zuid Cycling Distance	1387	17015	6570	4599	17,8	2,6



Left above: density in the first (walking) shell and the second (cycling) shell around the station.
Above: position in the region.
Left: Topography of the station area with the catchment areas for walking and cycling.

5.5.1 Focus station Pijnacker-Zuid

Pijnacker Zuid is another station at the former 'Hofplein'line, that was converted to a lightrail track during the construction of the Vinex housing. The neighborhood Pijnacker Zuid is itself a Vinex housing district. It is situated at the south side of the small village of Pijnacker, and is designed as a traditional example of a greenfield development.

5.5.2 Density
The density around this station does not reach the 20 dwelling/ha. Though it was designed as a standard Vinex housing district that should aim at 30 dwellings/ha, it seems that number was not effected here. One of the reasons can be that there is a large parking place for cars situated in front of the station, which limits the building capacity in the first shell. And within the second shell, which is a 2 km distance determined factor, the housing district is so small that also uncultivated field and pastures are within the radius.

5.5.3 Proximity
There are no services at the station. The district is build with a focus on younger families, which is supported with sufficient schools on short distance. Nearby is only a temporary supermarket and to visit other shopping the residents have to drive a little further to around 2 km to the old town.
The number of jobs that can be reached within fifteen minutes by public transport is very poor.

5.5.4 Frequency
The frequency is quite high with a train every ten minutes. The station Pijnacker Zuid is right at the middel of Rotterdam and The Hague, so the trip to either central station takes 16 minutes.

proximity			quality rail network			bicycle facilities	
distance to shops	distance to school	# jobs within 15 minutes	frequency	travel time to The Hague	travel time to Rotterdam	# bicycle parkings	bicycle rental
2	0,5	5000	6	16	16	600	none

5.5.5 Bicycle facilities
There is plenty of bicycle parkings with about 600 paces. As mentioned before, there is also a large car park. That may decrease the demand for bicycle parking, but the effect has not been studied. OV-fiets or other bike rental services are not available here.

5.5.6 Bicycle infrastructure
The bicycle infrastructure is all very new, as the district is just constructed. The cycle paths run at street level along the station. The construction is performed in a rather high quality.

Station/neighborhood	OAD (#adress/km2)	# Inhabitants	#houses	Population density (#inhabitants/km2)	Average housing density (#houses/ha)	average housing occupancy
TS Den Haag centraal walking distance	2539	2660	1290	2660	13	1,6
TS Den Haag centraal cycling distance	5371	172160	89605	8222	42,8	2,6

Den Haag

Left above: density in the first (walking) shell and the second (cycling) shell around the station.
Above: position in the region.
Left: Topography of the station area with the catchment areas for walking and cycling.

5.6.1 Focus station The Hague Central

The Hague features five stations, of which even three are intercity stations. The Hague Central Station is a headend, and opens to the city center of the capital of the Province South Holland. The station area is labeled by the government as a key project, and the station itself is currently undergoing a major renovation.

5.6.2 Density

The Hague is the most dense city of the Netherlands, but if we look at the density in the first shell around the station that seems untrue. The housing density is very low with 13 dwellings/ha and the OAD is about the same as in the suburbs. This could be explained by the typical structure and the many unbuilt areas in the neighborhood. First, the station itself is large with a lot of parallel tracks to accommodate the trains to all the platforms. In front of the station is a large square, which borders on a park as part of the Hague forest. Hague forest is a protected area that may not be built. it also accommodates the 'Malieveld', a large open area where demonstrations and events are held.

The urban density is much higher if we look at the second shell, with more than 40 dwellings/ha and a twice as high OAD as in the first shell. Directly at the west side of the station a dense office district is located that houses several departments of the national government, and the city hall. And directly adjacent is the main shopping area of the region located.

5.6.3 Proximity

A supermarket, several shop, restaurant and other services are present at this large intercity station. And just adjacent to the station are hotels and more restaurants. Schools are pretty close. The proximity of jobs is very favorable, as we are here in the center of The Hague's business district.

5.6.4 Frequency

The frequency is very high. Trains leave from here to the directions of Amsterdam, Utrecht, Rotterdam and further, with several international destinations although there is no direct High Speed Train connection. Also the two companies for Randstadrail visit the station with lines to Zoetermeer and Rotterdam.

proximity			quality rail network			bicycle facilities	
distance to shops	distance to school	# jobs within 15 minutes	frequency	travel time to The Hague	travel time to Rotterdam	# bicycle parkings	bicycle rental
0	0,5-1	270000	20	-	24	7000	OV fiets

5.6.5 Bicycle facilities

There are several bicycle parkings around the station, and even a good accessible one in a basement right under the entrance to the platforms. Another somewhat larger bicycle 'flat' is built at the side entrance on a larger walking distance. The total number of places (about 7000) is not sufficient for the large demand. The municipality has proposed plans for a larger underground parking in front of the station, under the square, with about 4000 extra places.

5.6.6 Bicycle infrastructure

The municipal bicycle plan have resulted in recent years in a renewal of a large part of all bicycle lanes and paths in The Hague, following the demands for high quality and direct routes. The realization of star routes is a good example of this increased attention to better cycle facilities. The star routes are of high quality, fast and comfortable with a tarmac layer. And the star route network is related to urban planning: "the development of star routes is based on an integral approach. Where these routes run by new development sites, the establishment of high quality cycle routes becomes part of the area development." (The Hague, 2011; p.87-88)

The cycle routes towards the station are of high level. They consist of separate bicycle lanes through the Hague forest, but also complete streets in the historic city center. There is simply not enough space to provide separate lanes, but the intensity of car traffic is reduced which makes cycling safe and comfortable.

Rotterdam

Station/neighborhood	OAD (#adress/ km2)	# Inhabitants	#houses	Population density (#inhabitants/km2)	Average housing density (#houses/ ha)	average housing occupancy
TS Rotterdam walking distance	7121	9135	4805	9135	48	1,9
TS Rotterdam cycling distance	4879	119940	66200	7195	39,7	1,9

Left above: density in the first (walking) shell and the second (cycling) shell around the station.
Above: position in the region.
Left: Topography of the station area with the catchment areas for walking and cycling.

5.7.1 Focus station Rotterdam Central

Rotterdam is the largest city in the MRDH. It is well known for its large harbor, and the city is developed on both banks of the river Meuse. The harbor activities are more and more developed towards the seaside, which allowed room for new development in the former harbor areas in the center. Rotterdam has 7 railway stations, and they provide connections to all major cities in The Netherlands as well as international destinations. The HST line stops at Rotterdam CS and has a direct connection to airport Schiphol, Germany and France.

5.7.2 Density

The density near the station is very high with nearly 50 dwellings/ha and an OAD of over 7000 dresses per km2. The station area is, just like The Hague, a key project for the national government and it can be regarded as a good example of TOD. Rotterdam is the city with the most high-rise buildings in the city center in The Netherlands, and many towers are build just near the station. It forms the Central Business District that flourishes by the recent increased attention for the station area. The distinction between north and south side of the station is remarkable. The south side of the station is mainly an office district, while at the north side mainly residential areas can be found.

5.7.3 Proximity

The renewed station has a wide choice of facilities: supermarket, shops, restaurant and other services are all available. And also facilities are present in the near vicinity of the station. Schools are mainly situated at the north side at closer distance, as that is the more residential area. The proximity of jobs is guaranteed as you enter Rotterdam Central Business District right when you leave the station.

5.7.4 Frequency

The frequency is very high. Trains leave from here to the directions of Amsterdam, Utrecht, The Hague and further. The High Speed Train connection brings you in twenty minutes to the Airport Schiphol. The Randstadrail lightrail connection to The Hague stops also at the station, and goes further into the city center as a metro line.

proximity			quality rail network			bicycle facilities	
distance to shops	distance to school	# jobs within 15 minutes	frequency	travel time to The Hague	travel time to Rotterdam	# bicycle parkings	bicycle rental
0	0,5-1	160000	20	24	-	8100	OV fiets

5.7.5 Bicycle facilities

During the renewal of the station a large underground bicycle parking is build. It provides in 5.190 places, of which 1.400 are guarded. There is a small bicycle repair service, and rental services with OV-fiets.

5.7.6 Bicycle infrastructure

In a somewhat similar way as The hague did, Rotterdam has improved it's cycle network in the last years in order to encourage more sustainable mobility. Yet in Rotterdam less harsh measures against car use in the city center were implemented, and the acces to the city center by car is still quite easy. According to policymakers that is partly due to political choices ("alderman for transport stressed on high speed on through roads") and partly due to the post war street pattern that was designed after the demolition of the centre ("Mr. H. helped car use a hand" with an ironic reference to the bombing of Rotterdam).

The ambitions for improving the cycle network in the city are presented in the Actieplan Rotterdam Fietst ('Action Plan Rotterdam Ride!', Rotterdam, 2007). One of the goals is to make the bicycle network more effective. The distance between the regional routes was 1 to 1.5 kilometers, and this is particularly inside the city ring regarded as a rough set-up. Thus the urban cycle network is redesigned much denser, with a mesh size of 1 kilometer to 500 meters. This means that on average, 250 to 500 meters, all the inhabitants of Rotterdam urban cycle path at their disposal.

This is also present in the station area, where cyclist have to deal with lots of crossings with cars, and a lack of radial shortcuts. With the reconstruction of the public space around the station, improvements are intended to make cycling to the station more convenient.

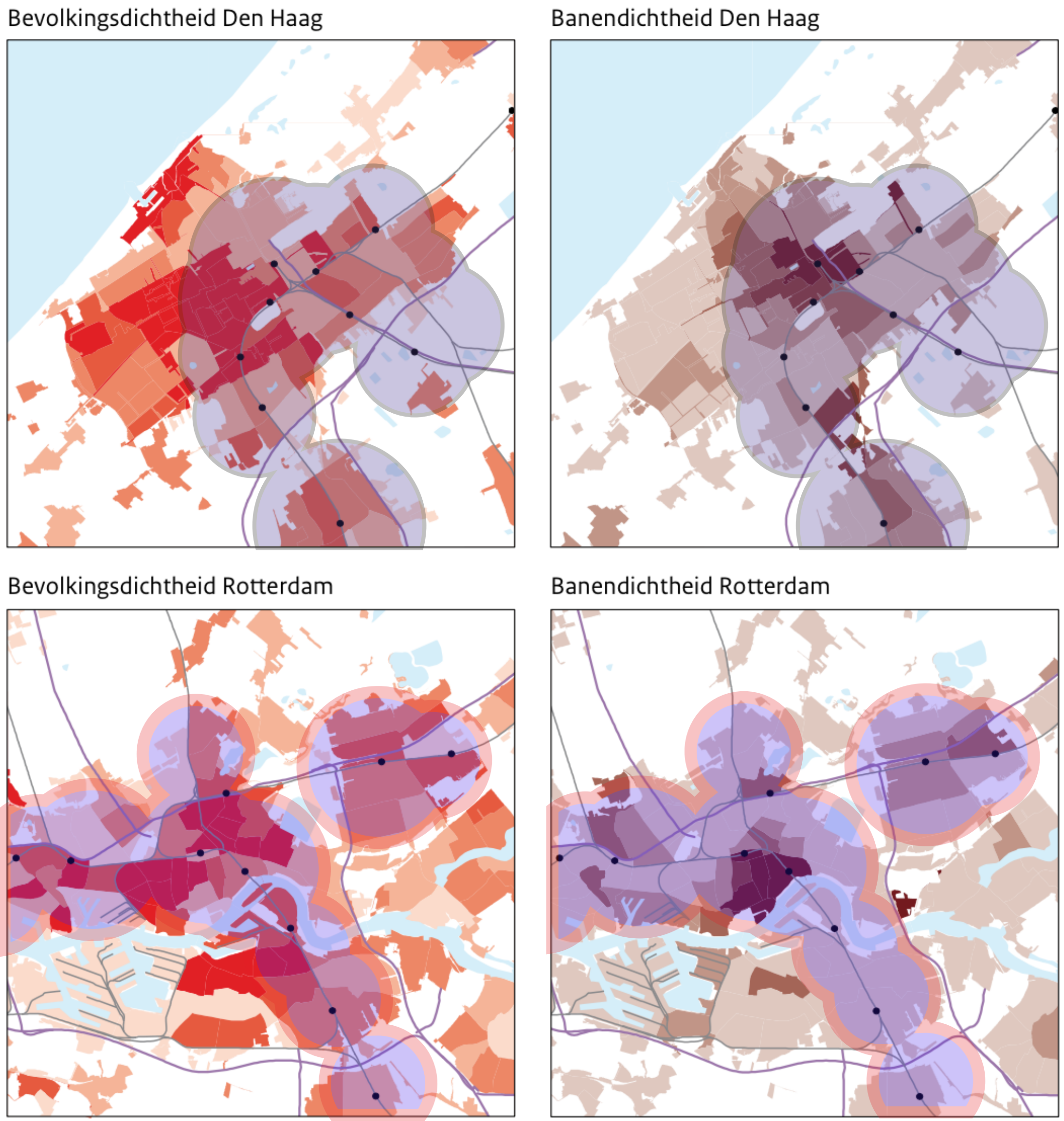


Figure 5.6 Comparison of density on jobs and population in Rotterdam and The Hague. (source: Lisa)

Above: The Hague population (left) and jobs (right).
The density on jobs is pretty much centered around the Hague's central station, as we can see in the figure on the right side. The darker colors illustrate the higher density on jobs. Also the big blank spot of the Hague forest is easily distinguished. But the population density shows another pattern. This is partly concentrated near the stations, but also runs far to the west and to the coast with high densities in Scheveningen.
The excentric position of the railway lines in relation to the city center makes the proximity to the stations less preferable to the north-east part of The Hague.

Below: Rotterdampopulation (left) and jobs (right).
The density on jobs is mostly concentrated in the city center, and well accessible from the stations. Also population density is framed within the city ring, but some parts at the south bank are more distant situated from railway stations.
The railway lines are positioned through the middle of the city center.

5.8 Spatial Analysis of the Bicycle Train System in MRDH

The reach of the bicycle-train system will be studied by a spatial analysis of the whole MRDH region, focussing on the accessibility of the main economic centers. The ambition by MRDH to have all those key economic centers accessible within 45 minutes is a starting point. This means that from origin to destination, all steps of the multimodal trip must be performed within 45 minutes. The elements are presented in this scheme:

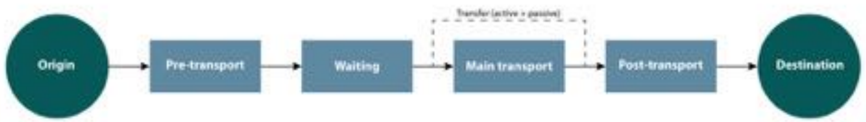


Figure 5.7 Diagram of elements of HBT system

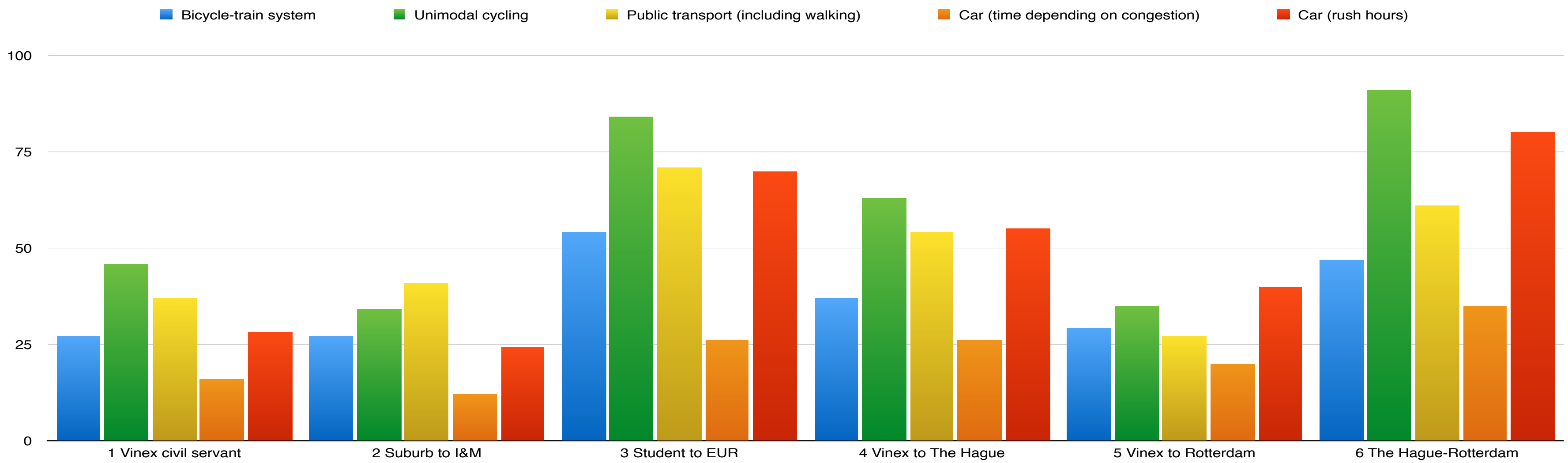
To determine the travel time per trip I will use this scheme to examine different journeys that could be taken from and towards the selected focus stations. Of course there are many different trips possible, with numerous choices for the origin as well as the destination. I identified some typical trips from residential districts to the main economic cores in MRDH. For each trip I selected a starting point (home) at an average distance of the focus station, and also a destination within predicted cycling distance of the egress station. To experience the situation I myself travelled each trip. I calculated the total travel time when using the HBT system by summing the individual components including waiting and transfer time, and it is listed in the column travel time. I have also compared it to the travel by unimodal cycling, public transport and car.

The scheme (figure 5.8, next page) shows that the majority of trips can be completed within about half an hour, but a few trips are critical with respect to the requested travel time of 45 minutes. This concerns the trips on the longer distance between The Hague and Rotterdam. The component 'train travel time' takes about 24 minutes by intercity train up to 30 minutes by light rail. If we include the waiting time and transfer time (parking bicycle, walking to platform), then there is little time left for cycling in pre- and/or post transport.
The trips that do fit well within the required traveling time are those between the suburbs and the nearest main core, either to The Hague or to Rotterdam. If we compare it with the overview of the most common journeys in the current situation (figure 5.xxx) it suits well. The calculated travel times even give space to bridge a greater distance, since there is a margin of about 15 minutes. Both on the access station as the egress station is the space to increase the catchment area slightly. If we count with a speed of 18 kilometers per hour over the distance can still be stretched by over 4 kilometers. The catchment area can be increased to 3 to 5 kilometers, but only in those cases with short train trips or with destinations in very close proximity to a station.
If we take into account that the ambition of MRDH is to have all economic cores accessible within 45 minutes, the preferred catchment areas of 2 kilometer for suburb stations and 3 kilometer for intercity stations seems quite right for most trips.
In the last four columns I have compared the travel time by different modes of transport. It shows that for these distances HBT system is faster than unimodal cycling or public transport. Outside rush hours the car is definitely the fastest way to travel. But the travel time by car can vary widely depending on the congestion on the road network. This causes that the travel time by car at certain times of the day may take another ten to twenty minutes more than traveling with HBT system.

Figure 5.8 scheme with travel times within HBT system, and compared to unimodal cycling, public transport and car use (source: Google Maps, GoAbout.nl).

Travel time

Trip	Origin	Pre-transport	Waitingtime	Main transport			Post-transport	Destination	Total travel time per modality					
Elements	**Home**	**Acces cycling trip**	**Incl. parking bicycle, walking to platform**	**Access station**	**Train travel time**	**Egress station**	**Egress cycling trip**	**Office or other destination**	**Bicycle-train system**	**Unimodal cycling**	**Public transport (including walking)**	**Car (time depending on congestion)**	**Car (rush hours)**	
1 Vinex civil servant	Hazelaarzoom Zoetermeer	4	7	Zoetermeer	12	The Hague CS	4	Ministerie Financiën, Korte Voorhout Den Haag	27	46	37	16	28	
2 Suburb to I&M	Delftsekade Leidschendam	5	2	Leidschenda mVoorburg	8	The Hague CS	12	Min. I&M, Plesmanweg Den Haag	27	34	41	12	24	
3 Student to EUR	Delftsekade Leidschendam	5	2	Leidschenda mVoorburg	30	Rotterdam CS	17	EUR, Burg. Oudlaan Rotterdam	54	84	71	26	70	
4 Vinex to The Hague	Rietsingel Pijnacker	3	3	Pijnacker Zuid	16	The Hague CS	15	Int. Crime tribunal, Churchillplein Den Haag	37	63	54	26	55	
5 Vinex to Rotterdam	Rietsingel Pijnacker	3	3	Pijnacker Zuid	16	Rotterdam CS	7	WTC, Beursplein Rotterdam	29	35	27	20	40	
6 The Hague-Rotterdam	Van Speijkstraat Den Haag	11	5	The Hague CS	24	Rotterdam CS	7	WTC, Beursplein Rotterdam	47	91	61	35	80	



5.9 Conclusions

This chapter described some backgrounds to the case Metropolitan Region Rotterdam The Hague. It was aimed at answering the subquestion: what is the reach of HBT system in the MRDH region? With reach is ment to what extent the HBT system is available to residents, and to which area it extends. As a determining factor for the reach I followed the ambition of the transport authority, which has indicated that all major economic centers in the region should be reachable within 45 minutes travel time.

The proximity to a train or high quality lightrail station is a necessary condition for access to the HBT system. 16 of the 23 municipalities in MDRH have a station within an average distance of of 5 km. These are all the more densely populated municipalities, and they count for 85% of all inhabitants.

If we take a closer look at the selected station areas, there is a large distinction between the suburb stations and the intercity station. The density around the suburb stations is mostly between 20 to 25 dwellings per ha, which is classified highly urbanized. The density in the first shell (of about 600 m.) is lower than in the larger second shell. This is due to the space that is occupied by rail and major roads in the direct vicinity of the station, and reinforced by security zones and environmental zones prohibiting housing. The very highly urbanized areas can be found near the intercity stations in Rotterdam and The Hague. with over 40 dwellings per ha. and also a higher OAD (average number of addresses per sq. km), indicating a higher density on jobs.

Not only the proximity to jobs is lower in the suburbs, but also other services as shops or schools can be found on a slightly larger distance. The suburbs stations itself offer almost no amenities, while the intercity train stations have plenty of shops and coffee bars.

The quality of the rail network is served better at the intercity stations than at the suburb station. The frequency is much higher and the connectivity to lots of (inter)national destinations is much better.

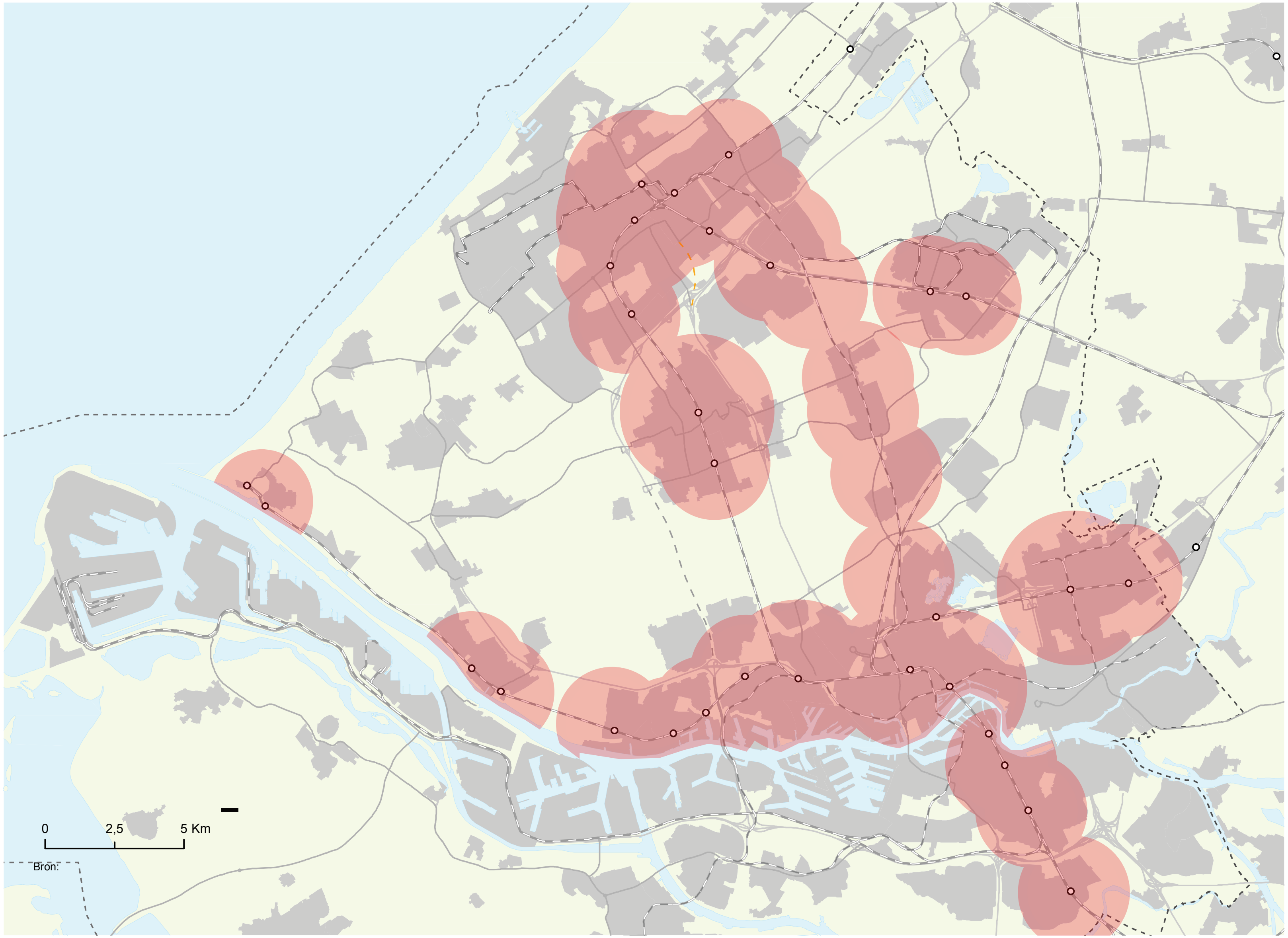
Finally also the bicycle facilities are far more extensive on the intercity train stations than on the suburb stations. The suburb station do not obtain rental bicycles. The number of bicycle parkings is also lower, but that is in line with the number of passengers. All station seems to offer to little parking for the ever increasing demand.

These differences in density, proximity, bicycle facilities and quality of rail network do all justify the choice for the wider catchment area for intercity stations than for suburb station. The catchment areas were chosen on 2 and 3 kilometers respectively. This suggests that the HBT system extends to an area with a 2 km radius around the suburb or high quality lightrail stations, and a 3 km radius around the intercity stations. But that radius might be somewhat flexible if we check on the travel time on some typical trips.

The ambition of the Transport Authority of MRDH - that all economic cores are easy to reach within 45 minutes - seems to fail if we look at the average travel times for some typical trips in the region. This concerns the trips on the longer distance between The Hague and Rotterdam, on which the longer 'train travel time' of 24 - 30 minutes leave little time for cycling in pre- and/or post transport. The trips that do fit well within the required traveling time are those between the suburbs and the nearest main core, either to The Hague or to Rotterdam. The calculated travel times even give space to bridge a greater distance. The catchment area can be increased to 3 to 5 kilometers, but only in those cases with short train trips or with destinations in very close proximity to a station. The hybrid system has by its structure in different bicycle and train components many variations in travel time. This means that there is a dynamic or elasticity in the determination of the catchment areas. What for one destination yields to still attractive cycling distances to an access station, can for another more distant destination have the effect that the bike ride in the pre-transport is already too large. For example, the cycling trip to the Erasmus University takes about 17 minutes from Rotterdam CS. A preceding train trip of 24 minutes remains almost no cycle time to reach the access station, and the the 45-minute limit is only feasible to people that life within 1 kilometer from the access station. But, if the University was housed in the direct vicinity of the egress station, the catchment area on the access station can even be stretched to 5 kilometer.

If we take into account that the ambition of MRDH is to have all economic cores accessible within 45 minutes, the preferred catchment areas of 2 kilometer

Figure 5.9The reach of HBT system in the MRDH region



for suburb stations and 3 kilometer for intercity stations seems quite right for most trips.

The reach of HBT system in the MRDH region is presented in this figure (5.9). It shows that the HBT system stretches around the different stations in MRDH with a radius based on the connectivity (suburb station or intercity station) of 2 to 3 km for the access trips, and with some elasticity at the egress side. The radius is at least the smaller radius of 600 m around the stations, but can be enlarged to another 2 or 3 km if only shorter train trips are examined, given the same travel time.
In both cases it means that the area that is reached with the HBT system is limited to the cities that include a train station, and that larger areas in Westland and southwest of Rotterdam are out of reach. Between many major cities, some blank spots also remain. This gives structure to the landscape with alternation of dense housing and open scenic and green values.
The reach is not only limited by an area that it covers, but also by the number of people to which it is easily available. The exact number is not easy to calculate because not for all station areas the density and the number of persons living were determined. It can only be estimated on the basis of the results obtained in the focus stations, and the map that is drawn. The total MRDH area is only about half covered by the defined reach, but the population density is in general spread nicely around the stations. That makes that about 1.6 million of the 2.2 million inhabitants are within the prefered reach. Together, that means that approximately 73 percent of the total population of MRDH is placed in a position to make a good choice for the HBT system or for another means of transport, particularly the car.

Chapter 6 Infrastructure and Spatial Planning in MRDH

6.1 Intro

Now that we gained insight into the reach of the HBT system in the MRDH region in chapter 5, this chapter aims to provide more insight into the relation between the HBT system and the planning system in the MRDH region. This will answer the sub-questions:
To what extent is this system attended to in MRDH urban planning practice?
What are the roles and responsibilities of public and private actors in planning for bicycle-inclusive urban areas in the MRDH region; and, how and where can (more) integrated planning in the MRDH region stimulate the use of the HBT system?

The chapter will first deal with an overview of the public actors that are involved in planning in MRDH. Then I will discuss recent policy documents on planning on different levels of government. In this study, the system HBT is considered as a separate modality as indicated by Kager (2015). In the Dutch planning practice, however, the HBT system is not (always) approached as a whole although in recent years multimodal travel has enjoyed increased attention. But because HBT as a system does not occur in most policy documents, I examine those factors that stimulate HBT and who individually are reflected in planning policy. Hence I will focus on density and proximity, that can for example be identified by policies on compaction, and on influencing the frequency of trains, and the construction and operation of bicycle parkings and other bicycle facilities. I will conclude this chapter by examining recent and future development projects, such as the Vinex housing projects and plans published in the New Map of The Netherlands.

6.2 Actors Involved in Urban Planning

The administrative structure of the Metropolitan Region is formed by a recent merge of the two city regions ‘Haaglanden’ and ‘Stadsregio Rotterdam’ into a new entity. MRDH is yet a voluntary cooperation but, depending on future legislation, might transform to an own administrative and political entity. According to policymakers, “The cooperation between the two city regions was already good, and can easily be enhanced with a common agenda and organization structure.”
But for now only the Transport Authority of MRDH has a formal responsibility. On economic and spatial domain the responsibility still lies with the 23 individual municipalities.
The highest decision-making body within the MRDH, that formally only deals with transport issues, is the general management, consisting of:

- 23 members appointed by the municipalities,
- the mayors of Rotterdam and The Hague,
- the traffic and transport portfolio holders of the municipalities of Rotterdam and The Hague.

At a higher level, we can distinguish between the Province of South-Holland and the national Government. As mentioned in chapter 4, the state has an important role in financing major infrastructural challenges and channeling tax money for the operation of public transport and other infrastructure.

Next to these formal governmental layers, semi-public and interest groups are active. Particularly to be mentioned are Zuidvleugel and specifically Stedenbaan. They form voluntary cooperations between regional and local public actors. And as (semi)public and private actors we can identify housing associations and several real estate developers to influence planning.
The MRDH is meant to show more vigor but success will also depend on the arrangement of the different partners, and the coordination between their policies on spatial and infrastructure planning. As described in chapter 4, the Dutch planning system is based on cooperation of the different governmental tiers and each tier has specific tools. To identify roles and responsibilities, let us first look at the different tools that are available to influence planning related to the HBT system. The relevant factors are density, proximity, the quality of rail network, bicycle facilities at stations and bicycle infrastructure.
Density and proximity are regulated by land use plans, which are determined by the individual municipalities. Guidance on regional level is given by the Province of South Holland and state, both with structure visions. Coordination between municipalities takes place through mutual contact and at the level of the metropolitan region of MRDH. But the adopted plans are eventually binding,

although they only indicate what is allowed, and no obligation to build. Here comes the influence of the developer on the agenda, because he determines, based on market demand to whether or not build at the by the municipality desired location. Driven by market demand or by own land ownership, sometimes municipalities decide to allow development at greenfields.
The rail network in the MRDH region consists of two types: the national rail network and regional light rail network. The national government manages the concession for the national network and their exploitation is owned by NS. The regional network is the responsibility of the transport authority of MRDH, and the operation is in the hands of the two major local transport companies: RET and HTM.
If we look at the bicycle infrastructure, all governmental tiers have some involvement though most of the responsibility lies with the municipalities as they plan and realize the cycle paths. The transport authority and the national government subsidize certain parts in specific programs, such as the program Beter Benutten ('better utilization') which is designed to reduce traffic congestion. The province of South Holland has its own bicycle plan and realizes several bicycle highways.
Finally, the bicycle facilities at the stations form a nice example of cooperation between the public and semi-public actors. NS (Dutch Railway company) fully manages the concept OV-fiets, the specific bicycle rental system. However, the bicycle parking spaces come under the shared responsibility of all actors.

This last example brings us to a frequent complaint about multimodal system or the 'displacement chain', that no one takes the responsibility. Although government policy is user-centered, and users are passing judgment on the basis of the whole chain, in practice the chain is owned by no one. The linking of the different modalities always means involvement of many different actors, each with their own interests and ambitions. To combine those interests appears in practice very difficult. If we look at a smaller suburb station, we see that the municipality is often responsible for the public space, ProRail for the infrastructure and the railway station, NS railway company for train service, the transport authority for the connecting buses and stops, sometimes a private operator for the bicycle rental, but none of the links between them. The quality of the total chain suffers.

Stedenbaan was created specifically to pay more attention to the displacement chain. It is formed as a cooperation of the public actors, including the railway company, to improve their cooperation and set to exploit the potential of multi-modal transport higher on the political agenda. The partners in Stedenbaan aim at a future in which many people live, work and play around easily accessible multimodal HOV nodes. They have made agreements on an integrated approach to stimulate spatial development:

- Of the until 2020 planned housing, 60 to 80% should be built within the catchment area of Stedenbaan, and 25,000 to 40,000 near the Stedenbaan stations.
- New offices to concentrate near the Stedenbaan stations.
- Improve the services around stations and stops to accommodate multimodal traveling (parking, bicycle parking, travel, safety, comfort).
- Ensure adequate rail infrastructure to allow more trains.

But Stedenbaan but has no formal powers, and can not define any law or regulation. The success of the organization is due to the stimulation of the other actors and keeping the debate alive. Stedenbaan publishes several reports on TOD, organizes exchange of knowledge between scientists and experts from public transport and spatial development and provides room for debate in so-called alliance calls. These alliance calls are ment to bring public and private actors together to bridge the gap between their (financial, institutional or market) possibilities. Successful alliance calls were held around the stations of The Hague Laan van NOI and Delft Zuid. One of the results mentioned by the Stedenbaan program manager is an agreement on improving the bicycle route to the Delft Zuid station. The bicycle connection between the station and the university is now cluttered, socially insecure and unattractive, as it runs along the busy main road. By providing better lighting, signage, upgrading of bicycle paths and pruning green, the routes will become faster, safer and more attractive. With its own bicycle bridge over the Schie, it will significantly shorten the bike ride.

6.3 Planning Policies on Different Tiers

The construction of large-scale infrastructure is nowadays hardly discussed. The first railway between Rotterdam and The Hague was allready built in the 19th century, and most highways in the middle of the 20th century. The construction of the missing section of the A4 between Rijswijk and Vlaardingen is a notable recent addition. If we look back at the spatial planning in the MRDH region, we can distinguish the influence of the infrastructure that was mostly implemented by national government, as well as the tension between infrastructure planning and spatial development.

6.3.1 National Guidance on Planning

Though The Netherlands has a long history of intervention in the development of urban form by spatial planners, and spatial planning has a significant role in mobility planning of (local) authorities, the different characteristics as mentioned in chapter 4 by Hajer and Zonneveld (2000) are recognizable in the planning history in MRDH. the organizational structure differs as most infrastructure is planned top-down, with the national government in the lead, while most spatial development has a stronger decentralised orientation. The management at national level for the spatial development of the Randstad was in previous decades much stronger.

Spatial planning followed more or less the infrastructure. The First Report on spatial planning in 1960 presented a growth model for Randstad, based on the existing ring of individual towns around a green, open central area: the Green Heart. The urban concept was complemented by a dense network of motorways; in those days, from car use was expected nothing than good (Ministry of Transport, 2004). The Green Heart concept formed the basis for the polycentric model, and this was reinforced in the 1970's and 1980's, by a policy of 'concentrated decentralisation'. The national government designated the development of growth centres and prohibited the growth of small rural settlements (Schwanen, 2004). The Third Report on spatial planning also pointed out the development of satellite towns like Zoetermeer and Capelle a/d IJssel. These new towns mostly functioned as a residential area, solely for housing and accessible by car and public transport. The main business areas remained in the larger cities like Rotterdam and The Hague. The development of office buildings and other business areas stayed poor in these New Towns, so most people had to commute each day for at least 10 km (one way) to the central cities. Train and metro lines were realized to provide in transport.
Cycling was not mentioned as a fully fledged modality, although the seventies have been the stage for activist groups who stood up for better bicycle facilities, as in those the numbers cycling was far from safe. Protest movements like 'Stop Kindermoord' (Stop Child Murder) showed its discontent on the increasing number of accidents and casualties. Helped by societal support, and influenced by the oil crisis that led to 'car-free sundays' and the awareness that car use had to change, politics gave way to a more bicycle-friendly design of public space (a.o. Goeverden & Godefrooij, 2010). The revival the bicycle led to the official National Bicycling Master Plan (Netherlands Ministry of Transport, 1999) in which cycling is promoted as a one of the 'spearheads to get commuters out of the car'. It also proposes various strategies to achieve this goal, such as better design, more and better parking facilities, more safety and better coordination with public transport modes. The execution is mainly deposited to the local level: "Bicycle traffic needs local actors - primarily municipalities but also companies - to a large extent." The central government provided the funding for special projects. From 1990 to 2006 the Ministry of Transport contributed an average of €60 million per year to various cycling projects, including €25 million per year specifically for bike parking at train stations. In addition, the Dutch Central Government provides €1.8 billion a year for provinces to spend on transport projects, including cycling facilities. (Pucher, 2008)

The increased focus on the environment was also basis for the Fourth Report for Spatial Planning (1988) and the later Vinex program (1994). The policy aimed at the contribution of spatial planning to reduce the environmental impact. The most important relationship was sought in reducing the need for mobility, by focussing on the urban concept of compaction. Space for new homes and businesses had to be found inside the existing cities or on the outskirts of these cities, and should include good public transport. Location policy pointed out that on the highway sites only companies with many goods and little public movements could settle. (Ministry of Housing, Spatial Planning and the Environment 1990).

In 2004, two new reports followed, respectively on spatial development (Nota Ruimte, 2004) and on mobility (Nota Mobiliteit, 2004). These reports followed another shift in policy on mobility: no longer reducing mobility was a goal, but enabling mobility for better economic performance. Improving the mobility was needed for better accessibility of the economically important regions. This could (again) be achieved by bundling around existing infrastructure, and also by the realization of high building densities around transport hubs (TOD's). But it's no longer a goal to reduce the modal share of car use. The word 'fiets' (bicycle) can only be found 10 times in the report on spatial development, and then mostly in relation to recreational routes, and hence there's only a small reference to multimodal (bicycle-train) mobility. In the report on mobility it is slightly elaborated by stressing the importance of further knowledge acquisition and distribution, and with the 'space for the bike' program for more bike shelters around train stations. "Innovations can promote bicycle use, there are opportunities in the field of automated parking facilities, travel information systems and tackling bicycle theft, also innovative transport concepts which the bicycle plays a role. Innovation is the responsibility of local governments, the state and the market" (Ministry of Transport, Public Works and Water Management, 2004)

6.3.2 Instruments to Boost Train Travel

The renewed attention from the state for rail as a sustainable means of transport, and as an alternative to the car, followed by the use of different instruments. With the program 'space for the bike', the value of the bicycle has been recognized in the pre-transport, and with the 'Programma Hoogfrequent Spoor' (PHF) was aimed at improving the quality of the rail network by increasing the frequency of the number of trains.

Bicycle Parkings

In April 1998, the Ministry of Transport, published the conditions to be met by bicycle parking facilities in its brochure 'Met de fiets naar de trein' (Cycling to the train). For example, each station must provide sufficient facilities for both regular and occasional travellers to park their bicycles in a guarded or unguarded bicycle park. The criteria also concern walking distances to the station entrance (maximum 200 metres for guarded and 50 metres for unguarded bicycle parks), the distance between two bicycle racks, social safety and tackling vandalism and theft.

This was followed by a joint approach of the bicycle parkings. In the Space for the Bicycle project, the Ministry is working together with municipalities and with the Dutch Railway company for realization and management of bicycle parking facilities and exploitation of guarded parks. In total, the bicycle parking facilities at all 380 railway stations will be modernised, at a rate of 50 a year.

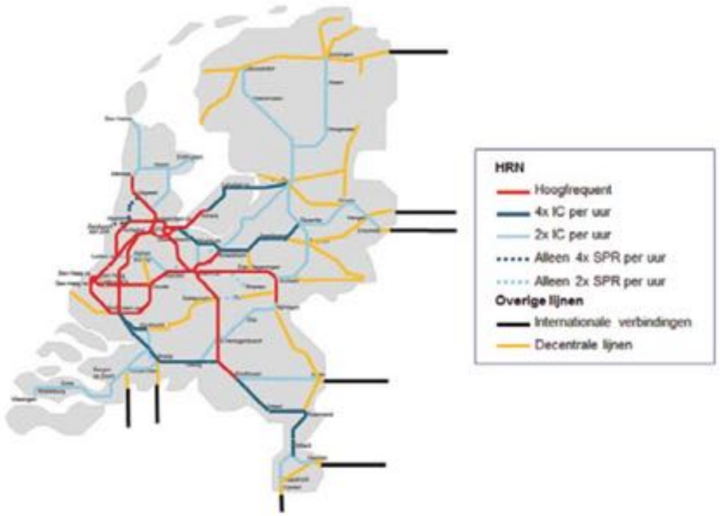
The finance of the construction of new bicycle parkings is a joint approach. 50% of the costs are paid by the national government, which has set aside €168 million until 2020. The other half is collected by the other authorities: Province South Holland, the former city regions or the new transport authority, and municipalities. Part of the program is also dealing with orphan bicycles. Many old and neglected bikes are left behind at stations, and occupy precious. The orphan bicycles are retrieved after a warning period and taken to a depot.

In The Hague, the plans are included in the Multi-Year Program Bicycle 2015-2018. New parkings are planned at the Central Station, with an underground bicycle parking for 10.000 bikes, at station HS for 2.500 bikes and at station Laan van NOI another 1.000 places. This is combined with a refurbishment of the station area. Plans will be elaborated in consultation with the Railway company and the Cycling Association.

Higher Frequency

Another impuls is given by the Programma Hoogfrequent Spoor (PHF), also a cooperation between the national government and the railway company. It is aimed at increasing the capacity of the rail network, both for passenger and freight. The general goal is set at a train at least every ten minutes. But for the

Figure 6.1 Programma Hoogfrequent Spoor (Source NS)



track between The Hague and Rotterdam the ambition is higher. The timetable now provides 7 intercity and 4 slowtrains per hour, but this should increase to 8 intercity and 6 in the timetable for 2028.

This operation also requires adjustments to some tracks. The coordination between infrastructure planning and spatial planning is also here present, as can be explained by the example of Delft. To expand the number of tracks the government proposed a new viaduct through the city, next to the existing one that was already a thorn in the side for the inhabitants.

The municipality succeeded after long negotiations in the construction of a tunnel so that all tracks are placed underground. On the vacant land, new developments take place. The revenues of the housing development is used to cover the higher costs. Meanwhile, the tunnel is finished, the financial return appears due to recent disappointing market situation too low to cover all municipal costs. And the formal decision to build the extra tracks is not yet taken at the ministry. The integration of planning is also limited, but the yield is a beautiful new station with good bicycle facilities.

6.3.3 Regional Planning

The Province of South Holland sets a policy on spatial planning in the MRDH, in several consecutive structure visions. It's policy in the last decade (Provincial reports 2003, 2010, 2014) is coherent with the national guidelines: a shifting towards more focus on accessibility to encourage economic development, and with a mobility policy aimed at car and public transport.

Transit Oriented Development (TOD, as the predecessor of my new concept of HOD) is promoted in 2003: "A node is a place with a high function value and high transport function value. The transport value is determined by the number of connections (public transport and car use) to that node. The function value is determined by the concentration of improving mobility functions. Each node has a characteristic scale, a characteristic function and transport value, often a thematic approach and a number of site-specific potentials and obstacles. In the ideal node, transport value and function value are in balance. That is, the scale of the features on a node is facilitated in terms of accessibility in a matching manner. A large number of nodes is also eligible for housing. The condition is that the residential program is realized, at a density of at least 60 dwellings per hectare. Housing on the nodes contributes to the development of the site as an integral part of the city." (Regional Plan Province of South-Holland, 2003).

The provincial focus on the bicycle for commuting is very limited, but it increased through the years. Not only in quantity - I counted the verb 'cycle' only 10 times in the 2003 version, and 25 times in the 2010 version - but also in quality and in terms of use. First, most attention was paid to improve the public transport system. "The province is strongly committed to supporting policies to promote public transport" (2003). And the bicycle was only mentioned as part of the multimodal mobility chain: "The main road structure, the road network and urban road network as a whole must function better. It is also necessary to improve cross linking the different networks (car, public transport, waterways and bike) for door to door transport. This chain mobility is the starting point for South Holland." (2010). But in regional perspective, cycling is mostly considered to have a recreational function. The realization of new cycle routes is part of the section on urban-rural connections, for recreational use and in

Figure 6.2 Scheme of the roles and responsibilities of the governmental tiers on the different influencing factors for HBT.
Bottom-up approach for the factors density, proximity and bicycle infra, for which the municipality is responsible.
Top-down for the frequency on rail, as the national government provides the concession. In dotted blue: the concession for light rail is provided by the Transport Authority of MRDH.
The responsibility for bicycle facilities is shared by national and local government, together with Dutch railway company.

combination with long distance walks.

The same trend occurs in the relation with the dedicated bicycle policy documents. Under the obvious name 'Programma Fiets' ('Bicycle Program') the provincial goals and implementation are described. In the 2008 version, investments are mentioned for 110 kilometer of cycle paths and 3000 bicycle parking places, especially near train stations. Yet the relation with the spatial and economic implications does not seem very clear at that moment, but it is expressed stronger in the Programma Ruimte ('Program Space', 2014) with a clear link to the 'Implementation Program Bicycle (2012) in which is included that between 2012 and 2016 forty urban-rural cycling links will be tackled. On these cycling projects the spatial quality has been emphasized. "They should well be fitted into the landscape, and provide good connections to the urban cycle network." The implementation also asks for more cycle highways, to upgrade the cycle network, from core to core. The highways are mentioned as "necessary to facilitate the bicycle as an alternative mode of transport". A policymaker indicate that bicycle use is increasingly linked to spatial policy, and that investment will be used to improve accessibility by bicycle commuters.

6.3.4 Cyling Policies on Local Level

Increased attention for cycling in local policy documents

The local governments are responsible for planning, constructing and funding bicycle facilities and plans. Also cycling training (school exams and special programs for immigrants), safety and promotional campaigns are performed by municipalities, even if they are funded by higher levels. Political focus on bicycle policies has increased significantly in recent years. All municipalities have included more attention to cycling in their policy programs, as they recognize the positive effect on accessibility in the modal shift from car to bicycle. Depending on the political flavor, the measures to promote cycling are followed by harsh or softer measures to reduce car use.

The Hague has implemented a new Traffic Circulation Plan as part of its new vision on mobility. The aim in the 'Haagse Nota Mobiliteit' (local report on mobility, The Hague 2011) is to focus on sustainable mobility in a healthy city. "The Hague wants to grow and become more attractive as a city in which it's pleasant to live, work and enjoy life. A forward looking vision of traffic and transport therefore is necessary". To achieve this, public transport and cycling should be stimulated and car use should be combined, organized and integrated. The new Traffic Circulation Plan provided a city ring and reduced car use through the city center. In addition to that, the cycle route network was improved by realizing missing links in the network and implementing star cycleroutes. The Traffic Circulation Plan encountered much resistance in the introduction, but the results are very positive. Car traffic in the city is strongly reduced, and the quality of life has improved by more liveliness and less air pollution.

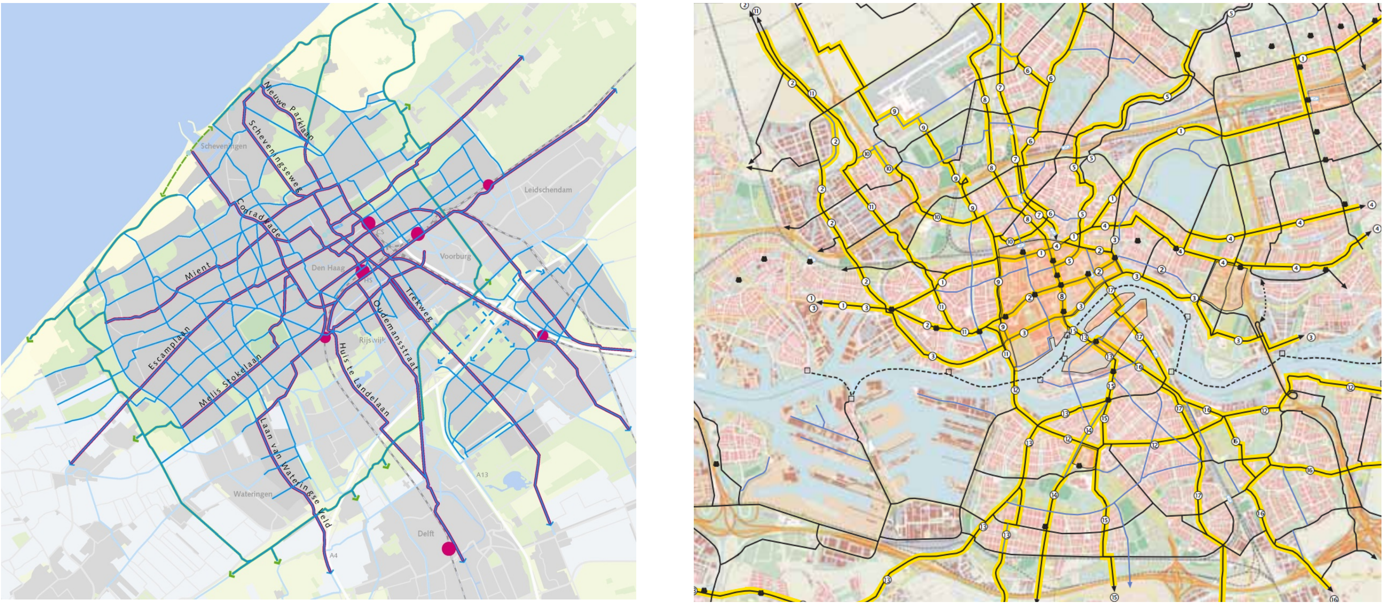
In a somewhat similar way Rotterdam has improved it's cycle network in the last years in order to encourage more sustainable mobility. Yet in Rotterdam less harsh measures against car use in the city center were implemented, and the acces to the city center by car is still quite easy. According to policymakers that is partly due to political choices ("alderman for transport stressed on high speed on through roads") and partly due to the post war street pattern that was designed after the demolition of the centre ("Mr. H. helped car use a hand" with an ironic reference to the bombing of Rotterdam).

The ambitions for improving the cycle network in the city are presented in the Actieplan Rotterdam Fietst ('Action Plan Rotterdam Ride!', Rotterdam, 2007). One of the goals is to make the bicycle network more effective. The distance between the regional routes was 1 to 1.5 kilometers, and this is particularly inside the city ring regarded as a rough set-up. Thus the urban cycle network is redesigned much denser, with a mesh size of 1 kilometer to 500 meters. This means that on average, 250 to 500 meters, all the inhabitants of Rotterdam urban cycle path at their disposal.

The cycling network provides also some 'long lines' in the city that will connect direct relationships. Some routes follow old urban ribbons like the 's Gravenweg or are linked to water, like the scenic routes along the Rotte and the Meuse.

There are some significant differences recognizable between Rotterdam and The Hague. The urban network in Rotterdam has the structure of a grid, which can

Figure 6.3 Cycle routes in The Hague (left) and Rotterdam (right), according to municipal cycling plans.
Source: The Hague 2015, Rotterdam 2014



be less direct than the star route network in The Hague. The density in The Hague is nearly twice as high as in Rotterdam, partly due to the river Meuse. The river divides the harbor city in a north and a south part, and it limits the number of direct connections as there are only four useful bridges. To make the network more refined at several points ferries are planned, but just one functions that is suited for bicycles.
Of the larger cities Delft, well known for its Technical University, scores best in the modal share for cycling. Partly due to the large number of students, but also by the historical urban structure and a sophisticated network of cycle paths. The historic center contains small paved roads along canals. Though there are surprisingly little separate cycle paths in the cities centre, that doesn't seem to affect the attractiveness for cycling. As most are one-way streets and by abundance of sufficient on street parking places it's not attractive for car use, and the small turns are problematic for large busses. The meshed and intricate network makes it most suitable for cycling.
The bicycle plans have resulted in recent years in a renewal of a large part of all bicycle lanes and paths, following the demands for high quality and direct routes. Priority is put to improve the bicycle routes to the city centers and to the stations. As railway lines form often a barrier, tunnels are needed to provide shortcuts, and they are realized at all new stations.

Availability of Bicycles

The large difference in the bicycle modal split between the access and the egress trip is mainly due to the lack of the availability of a bicycle at the egress station. In fact, there are three options to feature a bike: bikesharing, an own (second) bicycle at the egress station and bringing your own bicycle with you.
The last option is poorly supported. It is prohibited to carry your bicycle into the train during rush hours, and outside these hours the costs are high as you

pay €6 per day. In the lightrail the two transport companies have different policies: RET allows bicycles for free outside rush hours, and HTM allows them only in the evening and the weekend.
Apparently most people won't buy a second bike for the egress trips, or they regard the cost for a parking place (about €100 per year) too high. The Dutch railway company anticipated on this by introducing the OV-fiets ('PT-bike'). The OV-fiets is a blend between bikeshare and traditional bike rental, allowing for day-long rentals to encourage passengers to cycle to their destination. The rental rate is £3,15 per day. The use of the OV-fiets increased significantly in recent years, up to more than 1.2 million trips in 2012. This is almost 4 percent of the bicycle rides on the 'destination' side[1] (KiM 2013).
Market initiatives for a more generic bikesharing program in The Hague and Rotterdam are until now not supported by the local government. The initiators foresee good chances, as it provides local sustainable mobility and supports city marketing. It might also work as an addition to the OV-fiets as it should be available at every lightrail station, and throughout the city centre. The suggestion of a bikesharing system can count on greater appreciation among the interviewees. They especially value its contribution to accessibility, as part of the chain mobility, and suggest that it might help on to reduce the number of parked bicycles. But it will take more time to convince all policymakers, as the introduction of a bikesharing program is blocked by local government. The arguments against it were that it would cost too much, claims too much of the public space and it competes with the OV-fiets ('PT-bike').

6.4 Recent Spatial Development

To examine to what extent the HBT system is attended in urban planning practice we can dive deeper into recent major developments. I will focus on the Vinex housing program, planned from 1995 to 2010, and future plans as set out in the New Map of the Netherlands. Both can give an indication of how the different governmental layers cooperated in realizing housing and whether they took into account, consciously or not, the factors that stimulate HBT systems.

1 www.fietsberaad.nl

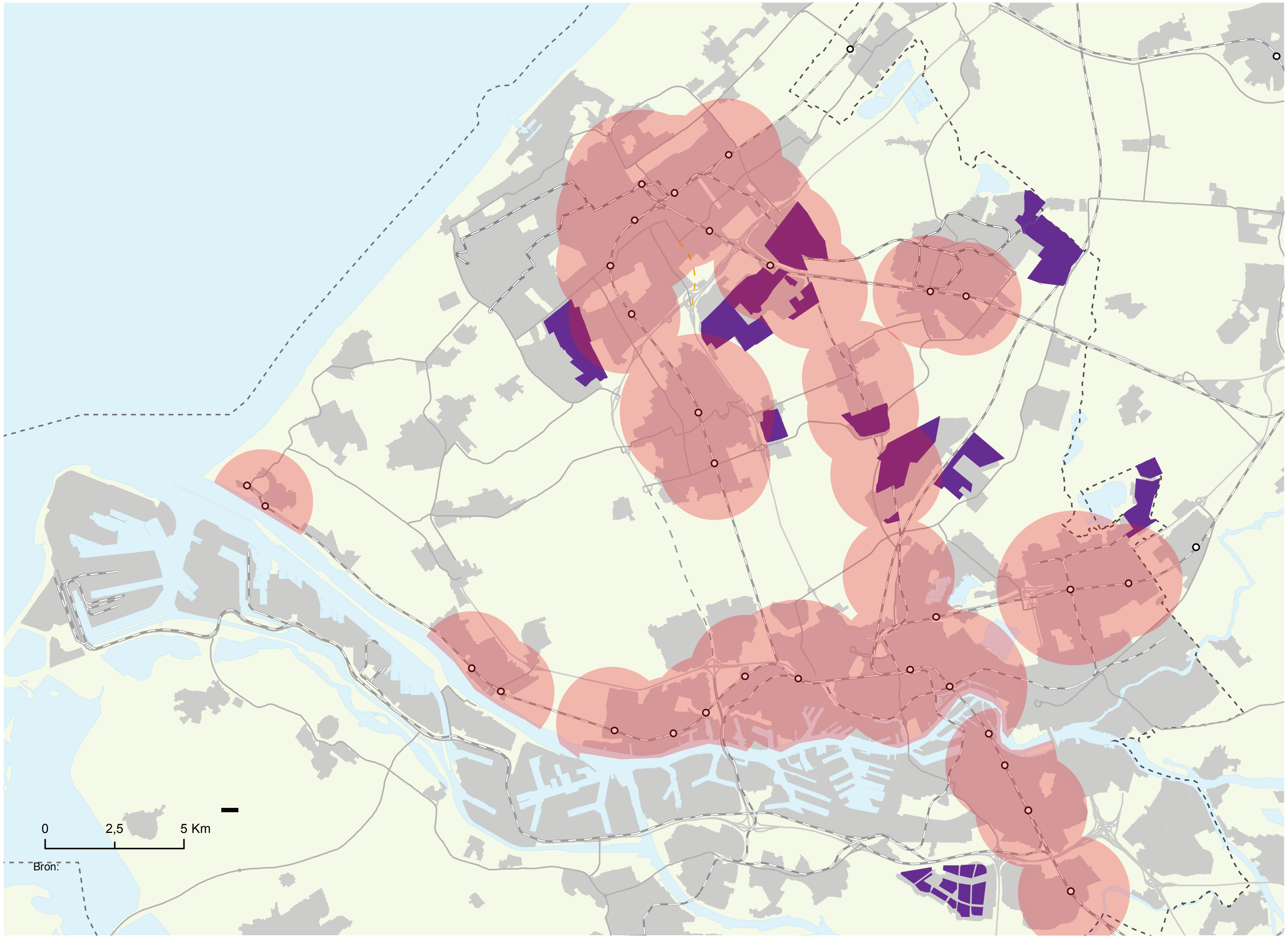
6.4.1 Vinex 1995-2010

Large housing developments in the last decades were based on the national policy of compaction, as described in the Fourth Report on Spatial Planning and its 'extra' follow up: 'Vinex'. The demand for new houses had to be fulfilled in or close to the existing cities, in order to reduce the need for additional mobility. A strict parking policy was implemented to support public transport and non-motorized modes of transport. The density should be high, related to other greenfield developments, with a minimum of 30 dwellings per hectare (Snellen, 2005). Those densities are not achieved in all new districts.

The Vinex report resulted in agreements with the city regions on the development of new districts. The main so called 'Vinex-disctricts' near The Hague were Leidschenveen, Ypenburg and Wateringse Veld, all built on the edge of the city but just outside the existing highways. In the whole 'Haaglanden' region seven Vinex-districts were built with a total amount of 42.000 dwellings, only 9.000 within urban borders. It was plannend in the period from 1995 to 2010 but parts are not yet finished. Also in the Rotterdam region building is almost done, with Carnisselande, Nesselande and 's-Gravenland as largest and nearest new districts. In Rotterdam inner city housing was plannend for 28.000 of the total 53.000 dwellings, so a much larger amount within reach of the existing infrastructure. (Stadsgewest Haaglanden, 1995; Stadsregio Rotterdam, 1995).
For the accessibility to the new residential areas the main focus was on high quality public transport. Extra investments were part of the agreements with the national government, that were budgeted at €1 billion in the region Rotterdam and €0.6 billion in the region The Hague.

According to policymakers, cycling policy has not played a real role in the developing of the new neighborhoods. For most of the Rotterdam locations, cycling was not an option because of the distance, and high quality public transport wasn't available in time. That favored car use for new residents. "The first inhabitants of the Vinex housing were dependent on car use and got used to it. That makes it hard to let them change their habits." New facilities and routes must be very attractive to compete with car use.

Figure 6.4 The reach for the HBT system (red) compared to the recent housing developments in the Vinex program (dark blue).



The Vinex policy was primarily focused on accessibility by public transport, which was also part of the convenants. It resulted in one new train station on the line The Hague Utrecht to serve parts of Ypenburg and Leidschenveen. But it also succeeded in the realization of the Randstadrail lightrail network between The Hague and Rotterdam, with new stations in Leidschenveen, Nootdorp, Pijnacker Zuid, Berkel Westpolder and Berkel Rodenrijs. The lightrail network was operated under a concession by respectively the City region Rotterdam and the city region The Hague, by different transport companies. The frequency of the lightrail is quite high, which made it a popular means of transport. The number of bicycle parkings near the stations is quite high and complies with the demand, but there are no other facilities such as bike rentals are available.
The other Vinex districts were connected by extended metro lines and trams. Also new roads were included in the network, to facilitate car use. In all the new residential districts safe cycle paths were provided (Stadsgewest Haaglanden, 1995; Stadsregio Rotterdam, 1995).
Not all Vinex districts are planned within the reach of the HBT system (figure 6.4). In particular, the new districts around Rotterdam and Zoetermeer are not well connected on a cycling distance to a train station.
When it comes to the proximity of basic services, the Vinex policy is not successful. The basic facilities for new housing residents by bike or on foot are not better accessible than elsewhere. In addition, on Vinex locations there is less mixed functions than on non-Vinex locations (Snellen et al. 2007).

6.4.2 Planned Developments

On the 'Nieuwe Kaart van Nederland'2, a digital map with future developments plans. In figure 6.xxx I have projected the new housing developments on the map with the reach for HBT system, as defined in chapter 5. All plans shown have a formal planning status, and are included in land use plans and structure visions. Some developments can be realized in the short term, others are still waiting for funding.
Most of the plans seem to fit into the projected reach for the HBT system. The majority of the developments are planned within the current urban area, and

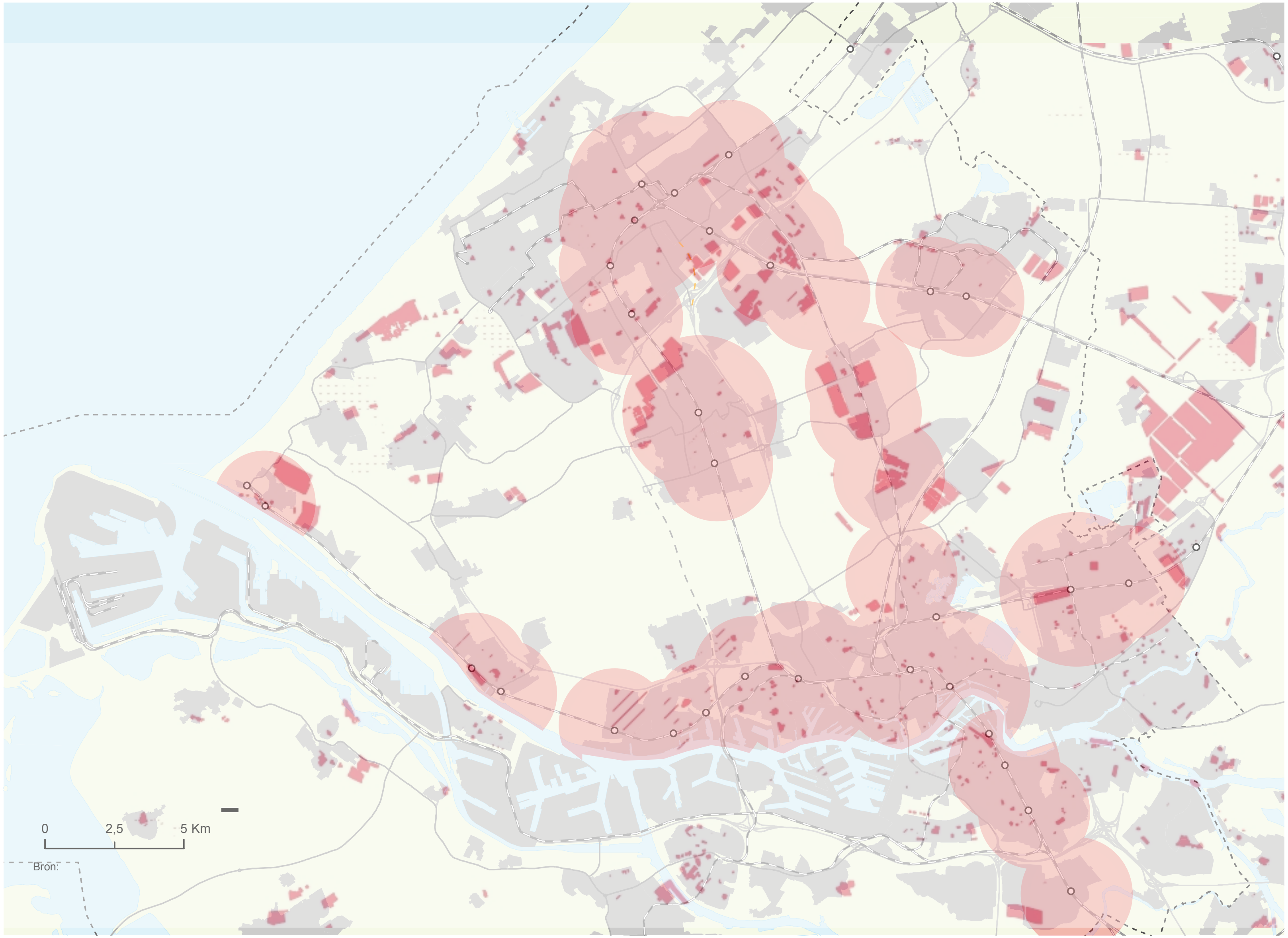
2 http://geoplaza.vu.nl/cms/

International Zone and distance to nearest train station

only a part is allowed on greenfields. As the reach of the HBT system covers a very large part of the current urban area, it is clear that these plans are within the preferred reach. Especially in Rotterdam it works out well. But as the urban area of The Hague is not everywhere within close proximity of the station, because of the somewhat eccentric position of the railway lines, some of the plans in the southwest inner city fail to the design reach. Most specific are the plans for Scheveningen (harbor) and the International Zone, that are regarded as key projects for the municipality. Both are located at more than 4 kilometer of the Central Station. The accessibility by car is fine, with easy access from the highway via the International Ring (N14). Scheveningen beach is located at less than 7 km from the city center. Already two 'starroutes' lead towards the beach, so cycling is an easy alternative for recreative travel for the own inhabitants. But as part of the HBT trip the distance is too long.

The concentration of functions in the International Zone is seen by policymakers as a good basis for further improvement of public transport, which is also necessary to cope with increased car mobility. Scheveningen and the International Zone are not part of the lightrail network, but accessed with a number of busses and trams. Policymakers regret that it is not wired in at the rapid transit system. "The connection from Rotterdam to the center of The Hague is well cared for at high speed and 'metro' quality, but after the Grote Marktstraat Randstadrail turns down as a slow tram. The extension of the lightrail line to

Figure 6.5 The reach for the HBT system (light red) compared to the recent planned developments in MRDH (dark red).



Scheveningen certainly would have been desirable.” The possibility to extend the lightrail is lost, when next year a new elevated stop of the RET line will be finished in the Central Station of The Hague.

Another more generic critical point is that in the last years more development has been exploited near the highway junctions than near multimodal nodes (PbL, 2015). In contract with the Stedenbaan program most new jobs are offered in the proximity of the highway. And the number of new housing developments near stations is also less than expected. There are several reasons mentioned by the interviewees: the environmental restrictions (safety zones) near stations, the restricted availability and higher costs of land near stations and the demand for other dwelling types with more space than can be provided in the denser areas. Another aspects is the land ownership by municipalities in these outskirts of the city. Most of these land was bought as a strategic basis, but it brings the municipality into a twisted responsibility. On the one hand the responsibility for good spatial planning, and on the other hand the responsibility for its own budgets where the costs of interest on non developed plots is problematic. Some interviewees point at another negative influence of infrastructure finance, that opposes spatial policy. In the debate on building inside or outside current urban area, the costs for the construction of new infrastructure are an important factor. Developers often prefer greenfield development because the land is cheaper, but as the demand for new housing is poor, the revenues are limited. When there is no financial space in the land plan for the costs of infrastructure, regional and local government support the development by financing the new infrastructure. This makes it more profitable to develop on subsidized greenfields than on the more complicated location near station or inner city. Also in the Vinex housing development, the costs for infrastructure where not brought up by the developers, but part of the convenants between the national government, the city region and the municipalities.

6.5 Conclusions

This chapter aimed to provide more insight into the relation between the HBT system and the planning system in the MRDH region, and answered the sub-questions: To what extent is this system attended to in MRDH urban planning practice? What are the roles and responsibilities of public and private actors in planning for bicycle-inclusive urban areas in the MRDH region; and, how and where can (more) integrated planning in the MRDH region stimulate the use of the HBT system?

The Netherlands have a strong reputation on their restrictive spatial planning and its open proces for developing spatial policy. Yet the cooperation between the tiers is not always as fluent as we may expect, and especially the balancing of interests between spatial and infrastructural goals or concepts is difficult to achieve.

Improving accessibility to increase the economic functioning of the region is the most important goal for planning in the MRDH region. The HBT system is not attended to as the prime modality to answer this demand, but the attention for multimodal transport has improved in the last ten years. This is expressed in as well spatial as infrastructure planning. On the spatial side, we can distinguish the efforts to develop the station areas of Rotterdam and The Hague. Both are appointed as key project by the national government, which indicates their importance for the Dutch economy. On the infrastructure side the program ‘Hoogfrequent Spoor’ for increasing the capacity and the frequency of rail can be mentioned, as well as the program ‘Space for the bike’ that must lead to an enormous increase of the number of bicycle parkings. All these programs are formed as a cooperation between the different governmental layers, and are ment to improve the ‘displacement chain’ and to stimulate people to use sustainable modes of travel. The follow up to increase the building of houses in the vicinity of stations is less successful. Little space leading to small plots, expensive land and many restrictions by safety and environmental zones. This is also due to the fact that building in the outskirts of the cities is made possible and sometimes even subsidized by building new infrastructure, and that some municipalities have their own financial interest in building there.

All governenmental layers are involved in planning for bicycle-inclusive urban areas. Most responsibilities are decentralized to local and regional government. The municipalities plan and deliver land use plan that are the binding plans to divide density and accommodate proximity. Also the realization of bicycle infrastructure is a municipal task. But the responsibility for the quality of rail is at two different, higher levels. The national government for the main rail network, and MRDH's transport authority for the lightrail network, provide the concessions to transport companies. The state and the region are also involved in the improvement of the bicycle facilities, by which they cooperate with the municipality and the railway company that ensure the implementation. But although, or maybe because all these actors are involved, there is no strong ownership of the multimodal displacement chain. No one is really responsible for the whole. Stedenbaan, an alliance of regional and local government bodies and rail transport operators, tries to fill this gap. They have formulated an integrated program for spatial development and high quality public transport in the region, and stimulate the public debate. In bringing actors together Stedenbaan booked some succes in improving bicycle-inclusive urban areas.
Private actors play no specific role in planning for bicycle-inclusive urban areas. They seem eager to invest in the vicinity of the two larger stations, but developments near other stations is not overwhelming. The example of Delft shows that the decreased demand for housing slows down development, especially when land development is somewhat more difficult and expensive than elsewhere.

Chapter 7 Conclusions and Recommendations

7.1 Intro

In this thesis, the reciprocal relationship between the hybrid bicycle train (HBT) system and integrated planning, which consists of infrastructure and spatial planning systems, was explored. The case of the Metropolitan Region Rotterdam The Hague was studied, with a focus on some typical station areas and commuter trips. The main question posed is to what extent the use of a hybrid bicycle train system in a Dutch metropolitan region can be stimulated through integrated planning? The answer provided in this chapter is based upon a literature review, interviews with experts, and a case study of the MRDH region, which have been elaborated in the preceding chapters of this thesis.

7.2 Analytical Framework

For sustainable mobility, the HBT system can be perceived as the best of both worlds. The combination of two quite different modalities, cycling and train, can be very effective in getting people out of their cars. They complement each other nicely: the speed and the long reach of the train and the door-to-door accessibility of the bicycle provide an efficient new modality, that is best used for travel between different cores of cities, e.g. in a polycentric region.

HBT has increased its modal share in the larger cities in the recent years. The factors that influence the use of the HBT system can be found by the weighted sum of those that affect cycling and rail use. In this thesis, the work of Heinen (2011), Rietveld and Daniel (2004) and Cervero et al. provide most insights on cycling. Frank and Pivo (1994), Brons (2009) and Rietveld (2003) helped to understand the drivers for rail use. In addition, I gained most insights into the planning process by the work of Hajer and Zonneveld (2000), Hansen (1959), and by policy documents of the Dutch Ministry of Infrastructure and the Environment. In order to be able to examine the case of MRDH I studied the factors that influence traveler's modal choices, and especially how these factors relate to planning.

In general, travel time and cost are important factors in order to offer a credible alternative to the car. These can be well affected by mobility management. For example, policies on parking costs are effective to influence the choice of the traveler. But the traveler also has its own mindset. Cultural aspects matter, which, like other more individual preferences, are hard to steer. When the costs and travel times of modalities are very competitive, it is clear that these can have a large impact on a modal choice in practice. But individual preferences and mobility management are no subject of urban planning, which is the focus of this study.

The concepts of urban density and proximity are factors that can be influenced by urban planning, and they prove important factors for bicycle and train use. The proximity to a railway station is a clear necessary condition for the HBT system: the (potential) cyclist has to live close to a station. Distance is regarded as the key determinant for bicycle use, as an increase in distance is directly linked to an increase in travel time as well as effort. And distance - either directly to a destination or to a train station - is strongly related to both the concepts of density and proximity.

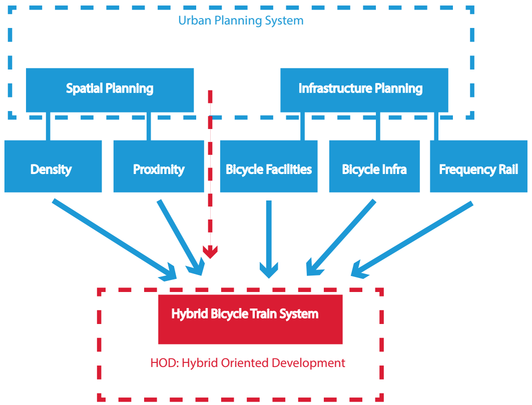
When we look at proximity, the type of station influences the choice of travellers: is it a small station for slow light-rail trains, or a large and well-connected high-speed train station? According to different sources, the proximity to a train station should not exceed 2 km for small stations and 3 km for larger stations in order to be an attractive HBT node. Urban density, in addition, is favourable for both cycling and train use, and thus certainly for the combined HBT system. Recent studies state that higher densities lead to more bicycle use, and the optimal conditions for bicycle use can be found in highly to very highly urbanized areas (Harms et al., 2014; KiM 2014). Non-urbanized areas show a strong decrease in bicycle use over the last ten years. Even stronger than with bicycle use, higher densities near stations are favourable for train use. This is particularly true in the immediate vicinity, where many people can come to the station on foot. A higher density results in more passengers, and more travellers lead to a more favourable operation. This can increase the frequency of the service, which is a third factor that influences the use of HBT system. A higher frequency will, in turn, attract more travellers, especially due to the shorter waiting times and

shorter total travel time.
Also, the number and the quality of the bicycle facilities around and at stations influence the use of the HBT system. Cyclists that arrive at a station are often in a hurry to catch their train, and desire to lose less time finding a vacant and safe parking place. The walk from the bicycle parking to the platform must also be short. On the egress station, the availability of rental bikes is an important factor.

Last but not least, the quality of the bicycle infrastructure is an indispensable factor. The favourite cycling network is finely meshed, attractive, consistent and coherent. It is interesting to note that these factors fit well with the design standards as formulated by the Dutch CROW, a technology platform for transport, infrastructure and public space supported by the government and businesses.

Concluding on the factors that can be influenced by planning to stimulate the use of the HBT system, we can distinguish five factors:

- Proximity
- Density
- Frequency of rail service
- Bicycle infrastructure design
- Bicycle facilities near stations



7.3 Mobility-oriented Spatial Concepts

The research was started because of my interest in the relationship between urban development and mobility. Both the way in which different modalities, such as HBT, influence the design of the city has been studied, as the extent to which spatial design affects modal choice. It showed that
mobility has a large effect on spatial development. Land use is influenced by the way accessibility is provided, which leads to different choices between transport modes and thus to new infrastructure and so on, as described in the Land Use Transport Cycle (LUTC) of Hansen (1959). Taking this LUTC into account, I have distinguished spatial development concepts that are based upon different modalities. The car that built sprawled America, and public transport that formed the driver for Transit Oriented Development (TOD) concepts. Following these, I identified several opportunities for a Hybrid Oriented Development (HOD) that is based upon the HBT system. I introduce the HOD light version or TOD Hollandaise, that consists of the successive modalities cycling-train-walking, and the 'full' HOD concept with cycling both in access and egress trip to the train station.

Research shows that car-oriented spatial concepts and TOD, and presumably as well HOD, differ in characteristics as density and proximity. If we look at the relation between these factors and the economic functioning of cities, we distinguish substantial effects. Cities with higher densities will offer smaller distances between services and jobs. Hence, a higher density is also expected to yield closer proximity. The effect of density and proximity is also beneficial for reducing travel distances, thus enabling less mileage and alternative, more sustainable choice of transport. In this sense it is believed that a higher density, realized in compact cities, contributes to sustainable mobility (Glaeser, 2011).

Density and proximity are also seen as drivers for economic prosperity for cities. They offer better labour market pools. Agglomeration benefits lead to an increase of economic value, and growth of the regional gross product (Melo et al., 2009; Glaeser, 2011; Rosenthal & Strange, 2004; Marlet, 2009). So next to the assumed sustainability benefits of the HBT system, a HOD concept that incorporates this modality - and therefore aims at higher densities and closer proximity - provides ever more advantages for city development.

In theory, an efficiently functioning HBT system implies that the density should certainly be high within walking distance of the train station, and moderate to high within cycling distance. Based on (Frank and Pivo (1994), Cervero (2011) and Deltametropool (2014), I assume that optimum HOD locations have a density of 35-50 dwellings per hectare in the first shell around a station, on a walkable distance of about 500 m. And in the second shell, that aims at cycling and thus has a radius of 2 to 3 km, the preferred density is 20-35 dwellings per hectare. Locations with lower densities are likely to be more car-oriented. In contrast, locations with a higher density will focus more on public transport and walking.

7.4 HBT and Integrated Planning in MRDH

The reach of the HBT system shows to what extent the system is available to residents, and to which areas it extends. The reach can thus be visualized on maps and quantified by the number of inhabitants. Based on the assumptions and proxies explained above, I used the case of MRDH to examine the reach of the HBT system in this part of the Netherlands, and also explored the question to what extent integrated planning actually stimulates the use of the HBT system in this region.

The proposition that density leads to closer proximity is true when we look at the average distances to stations in the region. Sixteen of the twenty-three municipalities in MDRH have a station within an average distance of 5 km. These are all the more densely populated municipalities. All the smaller, less urbanized municipalities fail in the reach to HBT system.
We can also distinguish a large difference in the densities between the suburb stations and the intercity station. The density around the suburb stations is mostly between 20 to 25 dwellings per ha, while the density around intercity stations, which all are positioned in the larger cities, is almost doubled.

The higher densities in the major MRDH cities leads to a higher potential of travellers, and has a reciprocal effect on the quality of rail service. The frequency is much higher and the connectivity to lots of (inter)national destinations is much better. The dense areas show also higher OAD (average number of addresses per sq. km), indicating a higher density of jobs.

Not only the proximity to jobs is lower in the suburbs, but also other services as shops or schools can be found on a slightly larger distance. The suburbs stations itself offer almost no amenities, while the intercity train stations have plenty of shops and coffee bars. Access to these services is important for a mobility chain.

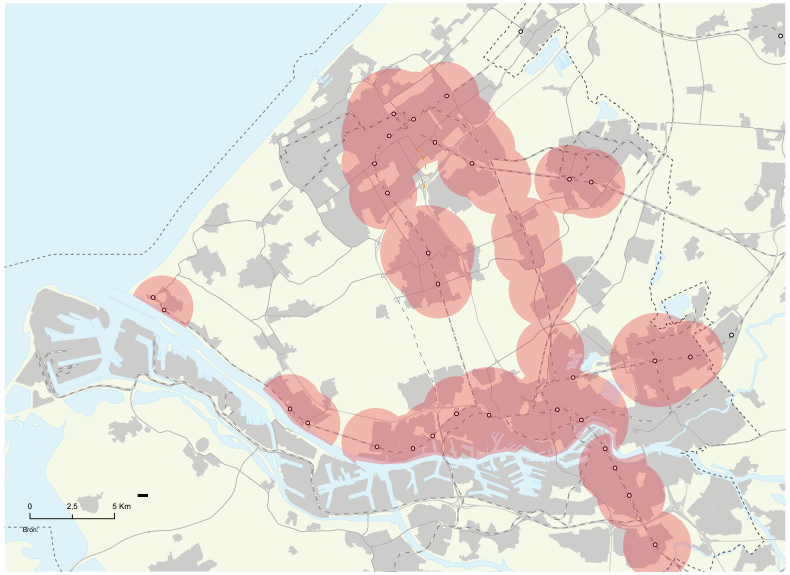
Finally, also the bicycle facilities are far more extensive on the intercity train stations than on the suburb stations. The suburb stations do not provide rental bicycles. The number of bicycle parkings is also lower, but that is generally in line with the lower number of passengers. Nearly all station offer too little parking places for the latent demand.

The above differences in density, proximity, bicycle facilities and quality of rail network do all justify the choice for the wider catchment area for intercity stations than for suburb station. The catchment areas were chosen on a 2 kilometer radius around the smaller (slow train or light-rail) stations respectively a 3 kilometer radius around the larger intercity stations.

The travel radius around a station must facilitate a traveller to reach a destination within the desired maximum travel time. The ambition by the Transport Authority of MRDH is that all economic cores are easy to reach within 45 minutes. For the trips that are mostly identified in the current agglomeration between the suburbs and the nearest main core, either to The Hague or to Rotterdam, the travel time fits well. It was not feasible for the trips on the longer distance between The Hague and Rotterdam. The component 'train travel time' takes about 30 minutes, which leaves little time for the transfer and cycling in pre- and/or post transport.

If we take into account that the ambition of the MRDH Transport Authority is to have all economic cores accessible within 45 minutes, the option is to realize all main destinations within closer proximity to stations. This suggests that either houses should be built in close proximity to the access station, or that offices should be built on short distance to the egress station. Or, alternatively, the travel time by rail must be reduced, for example by increasing the speed on the track. Another option could be to opt for longer acceptable travel times. If we accept that one hour is the maximum travel time, all examined trips in this study will fit.

The reach of HBT system in the MRDH region is not divided equal across the region. The red coloured surfaces indicate where people have well use of the system, and which areas are out of reach. Approximately half the surface of MRDH is not covered by the HBT system. That includes the whole municipality Westland, the northeast side of The Hague, the northern half of Zoetermeer and the smaller cities southwest of Rotterdam. The location of rail, somewhat eccentric from The Hague and the coast, makes the difference.



As explained above, the reach of the system is not only limited by the surface area that it covers, but also by the number of people to which it is easily available. The number can be estimated on the basis of the results obtained in the focus stations, and the map that is drawn. While the total MRDH area is only about half covered by the defined reach, the population density is in general spread nicely around the stations. That makes that about 1.6 million of the 2.2 million inhabitants are within the preferred reach of the HBT system. Together, that means that approximately 73 per cent of the total population of MRDH is placed in a position to make a good choice for the HBT system or for another means of transport, particularly the car.

The ratio between the surface and the number of inhabitants that it covers, shows that the reach of the HBT system is efficient in MRDH. Density is spread in an advantageous manner, leading to proximity to stations. The sequence of stations often leads to overlap, forming two corridors of catchment areas along the railways. As the area for blank spots in between the catchment areas will be filled, it reduces the effect of an alternation of dense housing and open scenic and green values. The same effect occurs if the catchment areas would be much enlarged.

If we look more into detail at the differences between the walking and cycling catchment area, it is remarkable that density is lower in the first shell than in the larger second shell because a higher density would be desirable there. The concept of TOD, for example, is fully based upon a very high density in the direct vicinity, or more precisely, on a walking distance of the station. From the perspective of a HOD, this dependency on walking distances seems to be one of the weaknesses of TOD, because it fails to incorporate and consider the people travelling to and from the station by bike.

The fact that the density in the first shell around the station is less than in a second shell around it, is due to the space that is occupied by rail and major roads in the direct vicinity of the station. It is reinforced by security zones and environmental zones prohibiting housing, and presumably also by higher land prices due to scarcity. Most buildings nearby the station have an office function. This tendency might lead to more mono-functional station areas, with lower quality of life as it lacks liveliness in the evenings. A more mixed and diverse district could be established if functions could be spread over a larger area, fitting in the wider catchment area for cycling. Diversity in itself can also encourage cycling, as it was also regarded as a factor that stimulates more bicycle use.

If we compare these results of the above analyses with the two proposed variants of HOD concepts we can say that the TOD Hollandaise or HOD light concept fits best in the current situation. This concept is based on a larger catchment area with cycling distance to the origin side and a smaller, walkable one to the destination side.
The HOD full concept with enlarged catchment areas on both sides does not fit if we follow the ambitions of MRDH for the enlarged daily urban system. The travel times are not always feasible within 45 minutes. Furthermore factor is that at the destination side often no or not enough (rental)bicycles are available.

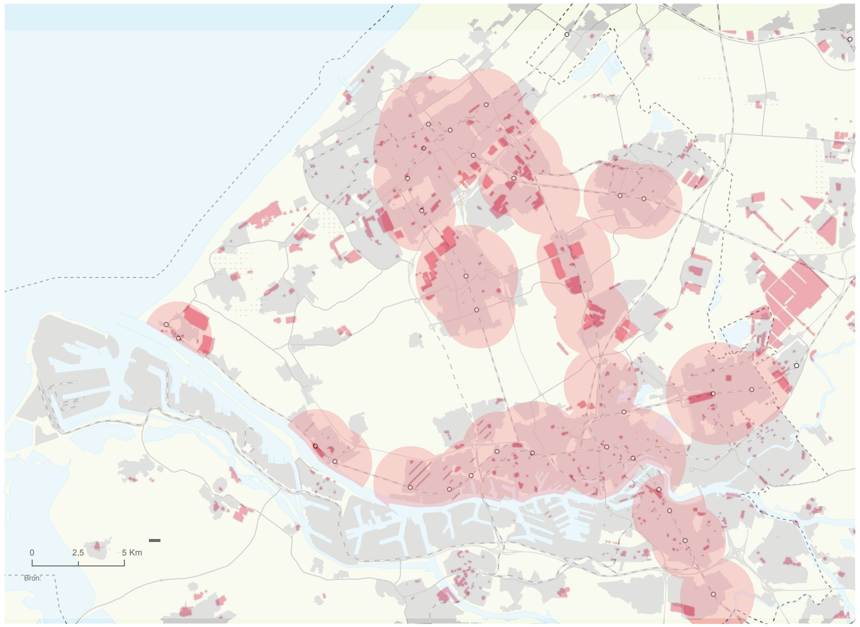
The Dutch Planning System
The Netherlands has a strong reputation on their restrictive spatial planning and its open process for developing spatial policy. But it seems that the cooperation between the governmental layers is not always as fluent as we may think, and that especially the balancing of interests between spatial and infrastructural goals or concepts is difficult to achieve.

The HOD concept, based upon the HBT system, is not identified yet in spatial planning. That does not mean there is no implicit attention for it. The increased focus for multimodal transport and nodes has led to the appointment of the station areas of Rotterdam and The Hague as key project by the national government. The development of these business districts has risen to high standards. But if we look at the rest of MRDH, there is relatively little built near the station areas, and more on a greater distance. The policy to develop in high densities around station exists on paper, but is poorly implemented. This is due to the fact that building in the outskirts of the cities is easier, with less safety zones restrictions, leaving larger plots to develop. It is also cheaper and sometimes even subsidized by government in financing new infrastructure, and that some municipalities have their own financial interest in building there. Spatial planning does not fully support the concepts of TOD or HOD.

More success is achieved at the infrastructure side. The attention to the combination of bicycle and train has improved in the last ten years. The program 'Hoogfrequent Spoor' for increasing the capacity and the frequency of rail can be mentioned, as well as the program 'Space for the bike' that must lead to an enormous increase of the number of bicycle parkings. On a municipal level, the increased political attention for cycling has led to an improvement of most cycle routes.

All governmental layers are involved in planning for bicycle-inclusive urban areas. Most responsibilities are decentralized to local and regional government, but I distinguish a difference in approach in processes and finance between spatial planning, the infrastructure planning for cycling and the infrastructure planning for rail.
The planning for rail planning may be considered as a top down approach. The state is responsible for the concession and the agreements with the railcompany. Specific in MRDH is that the transport authority of the region provides the concession for the lightrail. Municipalities can hardly influence the quality of rail.
Opposite to that the spatial planning has a bottom up approach. Developers provide initiatives, and municipalities plan and deliver land use plan that are the binding plans to divide density and accommodate proximity. Land development should contribute sufficient to reimburse the cost of local infrastructure, but this does not always match. Grants from other governments may be needed.

The planning and the realisation of the bicycle infrastructure is a municipal task, though finance is provided from national government by general funds as BDU, as municipalities have little own tax measures. And the planning of



bicycle facilities is most ambiguous because both the state, municipalities and railwaycompanies are involved in the financing, construction and management.

But although, or maybe because all these actors are involved, there is no strong ownership of the multimodal displacement chain. No one is really responsible for the whole.
Stedenbaan, an alliance of regional and local government bodies and rail transport operators, tries to fill this gap with a more holistic approach - but without formal authority. Yet their effort to nourish the debate and to support local initiatives proves very important for boosting the use of the HBT system, and provides the ability to implement the HOD concept.

This leaves the question how and where (more) integrated planning in the MRDH region can stimulate the use of the HBT system? It seems that already some steps are taken and that the conditions for the use of HBT system are improved in the last decade. The succes of the system, with an increasing number of users, is also its weakness if we look at the transport factor. Trains are fully occupied during rush hour, and finding a free place to park your bike is really a difficult task. Investments should be made to increase the frequency of the number of trains, and to provide more bicycle parking places in the direct vicinity of the platforms. The difficulty is that these investments and the expected revenues are not always in the same hands.

This is more or less the same if we look at the spatial planning. To intensify the density and improve proximity a more restricted regime is needed. The more expensive lands near stations and in inner cities should be developed. This could be optimized by a better cooperation between the governmental layers, and by a more holistic view on the finance and the planning of burn areas that are designed and suited to stimulate the HBT system.
The places where a higher density could be achieved are numerous. If we look on the map with the reach for the HBT system, many blank spots can be identified. The catchment area is often wider than the current urban boundaries of the suburbs as Pijnacker and Zoetermeer. Surely the preservation of the land-

scape must be adressed to as well. The same counts if we look at the Hague Forest near its CS. A very large plot of unbuilt land, on a perfect location, could easily house lots of inhabitants and offices. But the beauty of the park is clear, what justifies that it is not to be built.

The main question of this thesis is to what extend can the use of a hybrid bicycle train system be stimulated through integrated urban planning? The above-mentioned insight in the limited succes of an integrated approach already provides a part of the answer. HBT can be influenced by planning instruments density, proximity, bicycle infrastructure, bicycle parkings and the frequency of rail. The responsibilities for the tools to enhance these factors are assigned to different tiers. All governmental layers should think more from the interest of the user, than from their own limitations. A more location specific approach, in which finance and planning of infrastructure are brought together with a stricter regime on urban planning. The revenues on the one side should benefit deficits on another plane, even if that is the responsibility of another layer of government. This could be optimized by a better cooperation between the governmental layers, and by a more holistic view on the finance and the planning of burn areas that are designed and suited to stimulate the HBT system.
There are definitely more factors beyond urban planning that does effect mode choice, as mobility management and individual preferences. But the integrated approach on spatial and infrastructure planning is important to facilitate the commuter to choose for the HBT system. You can not expect an inveterate motorist to suddenly bicycle to the station, just as the cycle route will be improved or if only the frequency of trains is increased. It is a cliche, but a chain is indeed only as strong as its weakest link. Besides the infrastructure and the bicycle facilities, the spatial conditions must be set by focussing on higher densities in close proximity to stations. Bringing all these elements together requires more coordination between the governments. The polycentric structure of the MRDH proves a good basis to further implement the HOD concept, in which the hybride bicycle train forms the backbone.

7.4 Recommendations

Based upon the case of MRDH, that can be seen as an exemplary case because of the level of cycling facilities, rail network and urban planning system, I come to the following recommendations.

Recommendations for Policymakers and Politicians

Focus on the second shell
The HBT system is bound to high densities in the area, in order to ensure a sufficiently high potential to travellers. In practice, it turns out to be particularly difficult to achieve these high densities in the vicinity of the stations. Nuisance Zones, environmental demand and high land prices constrain development. But in a slightly wider area there are better opportunities to allow compaction. Focuses attention on that second shell, where at a lower cost more can be achieved.

Provide serious space for the bicycle
The more people cycle to the station, the more bikes need to be stalled. It is simple as that. But the enormous number of bicycles has become a major problem around train station. It damages public space if they are not parked neatly, and it discourages cyclists as they have to walk far to the platform and thus lose precious time. The ease with which the platform can be reached is crucial. Recent examples as the underground bicycle parking in Rotterdam (over 5,000 spots) show that good design can be worth a lot to travellers. Investing in such delights improves the quality of public space, and improves the traveller's well-being and travel time.

Raise a HOD fund for integrated finance
One of the problems in stimulating inner-city building, in the vicinity of stations, is that the land prices are higher than in the more remote locations. Also, often more measures are needed to meet the environmental requirements. To solve this kind of problem a HOD fund could be founded that is filled by the revenues of land development, BDU funds and grants. The regional authority

should manage the HOD fund and make additional budget available to allow developments in inconvenient locations that fit the policy to build sustainable accessible locations.

Recommendations for Further Research
One of the elements that could not be examined in this study, was the latent demand for better bicycle availability on egress stations. It was made clear that there is a large difference on the modal shift in access trips and egress trips, and that it could be explained by the unavailability of bicycles. In contradiction to most other countries, The Netherlands do not provide bikesharing systems. But it would be interesting to know if the introduction of such a system should lead to different travel patterns, and hence to new opportunities for urban development.

Another tendency that was not examined in this study but should be named, is the increase of the use of e-bikes. Not many e-bikes are currently used for an access trip to the station. But if sufficient and safe bicycle parking is provided, more people might use their e-bike prior to a train trip. And as the average trip length on an e-bike is about 1.5 times that of a normal bike within the same travel time, we can expect that the catchment areas can indeed be enlarged. But it the larger range of the e-bike also favours unimodal cycling, and in combination with more cycle highways between the cities, more regional destinations are accessible. Does this make the train superfluous for medium distances? And will it lead to other spatial concepts, based upon the e-bike as driver and the cycle highways as the potential locations for development? This effect should be studied in a case study.

And finally, this study was mostly about commuting and work related mobility. But people are traveling more and more for recreational purposes, and especially the bicycle is widely used for pleasure trips. As Glaeser (2011) stated, the preferences for city residents might be based more upon their recreational needs than on the proximity of jobs. The travel time by bicycle to certain recreational services seem to form an important factor for residents on their choice of living. A study based upon the effect that those location decisions for residents related to the bicycle use has, can provide useful information for business owners and policymakers.

Epiloque

For my fellow students it was no surprise that my thesis would be about urban cycling. Particularly in the last year I got more involved and interested in this topic, and discussed about it in between lectures. The study Master City Developer (MCD) does not include too much about the relation between mobility and spatial development in its curriculum, and the attention for the bicycle is none. Yet, due to this study, I have become much more active in the field of consultancy on bicycle use in cities, and it led to some nice workshops and presentations in European and American cities. MCD helped me in two objectives I had set at the start of the course: personal development and more focus on consulting in stead of projectmanagement.
Also in terms of content, I learned a lot in the two years of this study. Especially the major theories about the functioning of the city, and the integration of the different backgrounds have sharpened my vision on urban planning. The quality of the tutors and the involvement of the fellow students have certainly contributed to the value of the study. I really loved the various discussions we had on the wednesdays. Working on your thesis was some contrast. It took too long, and felt too lonely. I had to handle some big disappointments. Sometimes I compared the proces with a though mountainride. To finally reach the summit is very satisfactory!

I'm very grateful for the help of Tom Daamen, my supervisor on this thesis, and to Giuliano Mingardo who helped me previously. Many thanks to APPM, the finest company I know, for offering me this opportunity to develop myself. This study would not have been half as fun and challenging without my friends from the 'Bende van Venlo'. I am very pleased that we have experienced the MCD together.
And saved the best for last, big thanks to my family and friends for all the interest and encouragement. That helped me to persevere at the awkward moments. Olav, thanks for your support, and I'm looking forward to join more of your football games - and some bike rides. All this was not possible with the love of Neline My dearest, you were a great inspiration! I am aware that I have asked of you a lot of time, attention and patience. We really have some time to catch up together.

Appendix I References

- Albrechts, L. (2004). Strategic (spatial) planning reexamined. Environment and Planning B, 31, 743-758.
- Althuisius, J. (2014, januar 22). Superfiets (45 km) zaait verwarring. De Volkskrant, p. 3.
- Aultman-Hall, L., Hall, F. L., & Baetz, B. B. (1997). Analysis of bicycle commuter routes using geographic information systems: implications for bicycle planning. Transportation Research Record: Journal of the Transportation Research Board, 1578(1), 102-110.
- Baarda, D.B. & De Goede, M.P.M. & Teunissen, J. (2005). Basisboek Kwalitatief Onderzoek, Handleiding voor het opzetten en uitvoeren van kwalitatief onderzoek, tweede geheel herziene druk.
- Bendiks, S., Degros, A. (2013). Fietsinfrastructuur - Cycle infrastructure, nai010 uitgevers Rotterdam.
- Bertolini, L. (1999). Spatial development patterns and public transport: the application of an analytical model in the Netherlands. Planning Practice and Research, 14(2), 199-210.
- Bertolini, L., le Clercq, F., & Kapoen, L. (2005). Sustainable accessibility: a conceptual framework to integrate transport and land use plan-making. Two test-applications in the Netherlands and a reflection on the way forward. Transport policy, 12(3), 207-220.
- Bertolini, L. and Le Clercq, F. (2003) Urban development without more mobility by car? Lessons from Amsterdam, a multimodal urban region, in: Environment and Planning A, Vol 35, pp. 575-589, DOI: 10.1068/a3592
- Bertolini, L. (2012) Integrating Mobility and Urban Development Agendas: a Manifesto. In disP - The Planning Review, Vol. 188(1), pp. 16-26.
- Berg, L. van den, Pol, P., Winden, W. van en Woets, P. (2005), 'Research Framework' chapter 1, pp. 1-22, in: European cities in the knowledge economy. Ashgate.
- Bernick, M., & Cervero, R. (1997). Transit villages in the 21st century.
- Bohte, W., Maat, K., & van Wee, B. (2009). Measuring attitudes in research on residential self-selection and travel behaviour: A review of theories and empirical research. Transport reviews, 29(3), 325-357.
- Boomen, T. van den., & Venhoeven, T. (2012). De mobiele stad, nai010 uitgevers Rotterdam.
- Bos, R. (2014, april 8). BMW's eruit trappen op een e-bike. De Volkskrant, p. 15.
- Boussauw, K., Zwerts, E., & Witlox, F. (2009). Mobiel Vlaanderen. De sociale staat van Vlaanderen, 279-312.
- Broach, J., Dill, J., & Gliebe, J. (2012). Where do cyclists ride? A route choice model developed with revealed preference GPS data. Transportation Research Part A: Policy and Practice, 46(10), 1730-1740.
- Brons, M., Givoni, M., & Rietveld, P. (2009). Access to railway stations and its potential in increasing rail use. Transportation Research Part A: Policy and Practice, 43(2), 136-149.
- Burton, E. (2001, April). The compact city and social justice. In A paper presented to the Housing Studies Association Spring Conference, Housing, Environment and Sustain ability, University of York.
-
- Carstensen, T.A. and Ebert, A.-K. (2012) Cycling cultures in Northern Europe: from 'Golden Age' to 'Renaissance'. In: Parkin, J. (Ed.), Cycling and Sustainability, vol. 1. Emerald Group Publishing, Bingley, pp. 23–58
- Cavill, N., Kahlmeier, S., Rutter, H., Racioppi, F., & Oja, P. (2008). Economic analyses of transport infrastructure and policies including health effects related to cycling and walking: a systematic review. Transport policy, 15(5), 291-304.
- Cervero, R., & Duncan, M. (2003). Walking, bicycling, and urban landscapes: evidence from the San Francisco Bay Area. American journal of public health, 93(9), 1478-1483.
- Cervero, R., & Kockelman, K. (1997). Travel demand and the 3Ds: density, diversity, and design. Transportation Research Part D: Transport and Environment, 2(3), 199-219.
- Cervero, R., & Radisch, C. (1996). Travel choices in pedestrian versus automobile oriented neighborhoods. Transport Policy, 3(3), 127-141.
- Cervero, R., Ferrell, C., & Murphy, S. (2002). Transit-oriented development and joint development in the United States: A literature review. TCRP research results digest, (52).
- Corbin, J., & Strauss, A. (2007). Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory. SAGE.
- Clifton, K., Muhs C., Morrissey S., Morrissey T., Currans K., Ritter C. (2012) Consumer behaviour and travel mode choices.
- Christiaens, B. (2000) 'Fiets en auto om(ge)zet: een onderzoek naar de relatie van vervoerswijzekeuze fiets en auto op winkelomzetten in binnensteden', soab, Breda.
- Daamen, T., G. Wigmans en J. van Haaren (2011), 'De kwaliteiten van de stad', in: Real Estate Magazine, 14e Jaargang nummer 74, pp. 23-28.
- During, R. (2014, Februar 12). Welches Verkehrsmittel wird wichtiger für Berlin? Der Tagesspiegel, p. 17.
- Echenique, M. H., Hargreaves, A. J., Mitchell, G., & Namdeo, A. (2012). Growing cities sustainably: does urban form really matter?. Journal of the American Planning Association, 78(2), 121-137.
- Ewing, R., & Cervero, R. (2001). Travel and the built environment: a synthesis. Transportation Research Record: Journal of the Transportation Research Board, 1780(1), 87-114.
- Fleming, S. (2011). The bicycle oriented development (BOD): a new tool in urban resilience. AST Management, Newcastle.
- Fleming, S. (2012). Cycle Space. Architecture and Urban Design in the Age of the Bicycle. nai010 publishers Rotterdam.
- Gärling, T., & Schuitema, G. (2007). Travel demand management targeting reduced private car use: Effectiveness, public acceptability and political feasibility. Journal of Social Issues, 63(1), 139-153.
- Gehl, J. (2010). Cities for people. Washington's DC, USA: Island press.
- Glaeser, E. L., Kolko, J., & Saiz, A. (2001). Consumer city. Journal of economic geography, 1(1), 27-50.
- Glaeser, E. L. (2009). The death and life of cities. Making cities work–prospects and policies for Urban America, 22-62.

- Glaeser, E. (2011). Triumph of the city: How our greatest invention makes US richer, smarter, greener, healthier and happier. Pan Macmillan.
- Glaeser, E.L., Kahn, M.E., (2008). The greenness of cities: Carbon dioxide emissions and urban development, NBER Working Paper 14238
- Glaser, B. G., & Strauss, A. L. (2009). The discovery of grounded theory: Strategies for qualitative research. Transaction Publishers.
- Greather London Authority (2013). The mayor's vision for cycling in London – An Olympic Legacy for all Londoners. London.
- Groves, J. (2010). Bicycle weight and commuting time: randomised trial. BMJ, 341.
- Handy, S. L., & Xing, Y. (2011). Factors correlated with bicycle commuting: A study in six small US cities. International Journal of Sustainable Transportation, 5(2), 91-110.
- Hansen, W. G. (1959). How accessibility shapes land use. Journal of the American Institute of Planners, 25(2), 73-76.
- Healey, P. (2006). Urban complexity and spatial strategies: towards a relational planning for our times. Routledge.
- Heinen, E. (2011). Bicycle commuting. IOS Press, under the imprint Delft University Press.
- Heinen, E., van Wee, B., & Maat, K. (2010). Commuting by bicycle: an overview of the literature. Transport reviews, 30(1), 59-96.
- Hilbers, B. (2008). The influence of the spatial planning on bicycle use and health. Comparisons between Houten and Leidsche Rijn. University of Amsterdam.
- Huisman, J. (2013). 'Inspiratie door confrontatie op locatie: van 'Kohlenpott' naar Metropole Ruhr: Transformation von Masse zur Klasse'. Excursiegids MCD.
- Hull, A. (2010). Transport matters: Integrated approaches to planning city-regions. Routledge.
- Jacobs, J. (1961). The Death and Life of Great American Cities. New York: Modern Library.
- Janssen-Jansen, L., Smit, N. (2012). Visie versus vraag, over de TOD-maakbaarheidsutopie. In: Knooppuntontwikkeling in Nederland, Platform31.
- Jordan, P. (2013). In the city of bikes. The story of the Amsterdam cyclist. New York, USA: HarperCollins Publishers.
- Kager, R., Bertolini, L. & Te Brömmelstroet, M. (2015). The bicycle-train mode: Characterisation and reflections on an emerging transport system. Elsevier Editorial System(tm) for Transportation Research Part A: Policy and Practice Manuscript.
- Kennisinstituut voor Mobiliteit (2010). Infrastructuur en economische structuurversterking.
- Krygsman, S., Dijst, M., & Arentze, T. (2004). Multimodal public transport: an analysis of travel time elements and the interconnectivity ratio. Transport Policy, 11(3), 265-275.
- Loo, B. and Comtois, C. (2015) Sustainable Railway Futures. Issues and Challenges. Farnham: Ashgate
- Maat, K., van Wee, B., & Stead, D. (2005). Land use and travel behaviour: expected effects from the perspective of utility theory and activity-based theories. Environment and Planning B: Planning and Design, 32(1), 33-46.
- Maat, K. (2012) Slimme verstedelijking zorgt voor complex mobiliteitsgedrag. In Milieudossier, september 2012, p. 55-60
- Marlet, G. (2009). De aantrekkelijke stad. Moderne locatietheorieën en de aantrekkingskracht van Nederlandse steden. Nijmegen, The Netherlands: VOC uitgevers.
- Martens, K. (2004). The bicycle as a feedering mode: experiences from three European countries. Transportation Research Part D: Transport and Environment, 9(4), 281-294.
- Melo, P. C., Graham, D. J., & Noland, R. B. (2009). A meta-analysis of estimates of urban agglomeration economies. Regional science and urban Economics, 39(3), 332-342.
- Meijers, E., Hoogerbrugge, M., & Hollander, K. (2012). Metropoolvorming in de praktijk: metropolitane strategieën in Europa. In: Deltametropoolforum 2012, programmaboekje. vereniging Deltametropool, p. 38-39.
- Meijers, E., Hoogerbrugge, M., & Hollander, K. (2014). Twin cities in the process of metropolisation. Urban Research & Practice, 7(1), p. 35-55.
- Metropolitan region Rotterdam The Hague (2013) Strategische bereikbaarheidsagenda. Vervoersautoriteit Metropoolregio Rotterdam Den Haag.
- Metropolitan region Rotterdam The Hague (2013) Atlas Metropoolregio Rotterdam Den Haag.
- Meurs, H., & Haaijer, R. (2001). Spatial structure and mobility. Transportation Research Part D: Transport and Environment, 6(6), 429-446.
- Mingardo, G., Van Den Berg, L., & Van Haaren, J. (2009). Transport, environment and economy at urban level: The need for decoupling.
- Mingardo, G., & Van Meerkerk, J. (2012). Is parking supply related to turnover of shopping areas? The case of the Netherlands. Journal of Retailing and Consumer Services, 19(2), 195-201.
- Ministry of Housing, Spatial Planning & the Environment (1990), Vierde Nota over de Ruimtelijke Ordening Extra: op weg naar 2015, deel 1: Ontwerp Planologische Kernbeslissing. Den Haag: Ministry of Housing, Spatial Planning and the Environment.
- Ministry of Housing, Spatial Planning & the Environment, (2005). Evaluatie verstedelijking VINEX 1995-2005, Den Haag.
- Ministry of Transport, Public Works and Water Management, Directorate-general for Passenger Transport (1999). The Dutch Bicycle Master Plan, The Hague.
- Ministry of Transport, Public Works and Water Management (2004) Nota Mobiliteit
- Ministry of Transport, Public Works and Water Management, Directorate-general for Passenger Transport (2009). Cycling in the Netherlands, The Hague.
- Ministry of Transport, Public Works and Water Management (2012): Structuurvisie Infrastructuur en Ruimte, Nederland concurrerend, bereikbaar, leefbaar en veilig, The Hague.
- Ministry of Transport, Public Works and Water Management, Directorate-general for Water, Transport and Habitat (2014). Publieksrapportage Rijkswegennet, The Hague.
- Moudon, A. V., C. Lee, A.D. Cheadle, C.W. Collier, D. Johnson, T.L. Schmid and R.D. Weather (2005) Cycling and the built environment, a US perspective, Transportation Research Part D, 10, pp. 245-261.

- Municipality of The Hague (2010). Collegeprogramma Den Haag, 2010-2014, The Hague.
- Municipality of The Hague (2011) Haagse Nota Mobiliteit. Bewust kiezen, slim organiseren.
- Municipality of The Hague (2014). Vertrouwen op Haagse kracht. Collegeprogramma Den Haag, 2014-2018, The Hague.
- Municipality of Rotterdam (2013) Economische Verkenning Rotterdam 2013, afdeling Stadsontwikkeling, Rotterdam. Onderzoek en samenstelling Stadsontwikkeling Rotterdam
- Municipality of Rotterdam (2014) Op volle kracht! Collegeprogramma Rotterdam, 2014-2018, Rotterdam.
- Ommeren, C van., Lelieveld, M., Pater, M de., (2012). Social costs and benefits of investments in cycling.
- Orricks, P., Trapenberg Frick K., Ragland D., (2011). Why Do Building Owners Invest in Bicycle-Oriented Design? UCTC Policy Brief 2011-05, University of California, Berkeley.
- Parkin, J., M. Wardman and M. Page (2008) Estimation of the determinants of bicycle mode share for the journey to work using census data, Transportation, 35(1), pp. 93-109.
- Pettinga, A. (2013). Fietsen in de Deltametropool. In: Deltametropoolforum 2013, programmaboekje. vereniging Deltametropool.
- Pettinga, A. & Wilmink, A. (1986) Opstappen en doortrappen. Het Delfts fietspadenplan. In Verkeerskunde 37 (12), 566-574.
- Planbureau voor de leefomgeving, (2013). Regionale prognose 2013–2040; Vier grote gemeenten blijven sterke bevolkingstrekkers.
- Pucher, J., & Buehler, R. (2008). Making cycling irresistible: lessons from the Netherlands, Denmark and Germany. Transport Reviews, 28(4), 495-528.
- Pucher, J., Buehler, R., & Seinen, M. (2011). Bicycling renaissance in North America? An update and re-appraisal of cycling trends and policies. Transportation research part A: policy and practice, 45(6), 451-475.
- Rietveld, P. (2000). The accessibility of railway stations: the role of the bicycle in
- The Netherlands. Transportation Research Part D 5, 71-75.
- Rietveld, P. (2001). Biking and walking: the position of non-motorised transport modes in transport systems.
- Rosenthal, S. S., & Strange, W. C. (2004). Evidence on the nature and sources of agglomeration economies. Handbook of regional and urban economics, 4, 2119-2171.
- Saelens, B. E., Sallis, J. F., & Frank, L. D. (2003). Environmental correlates of walking and cycling: findings from the transportation, urban design, and planning literatures. Annals of behavioral medicine, 25(2), 80-91.
- Sanders, J.F.M., Van Nes, R., Van Lint, J.W.C., Wiggenraad, P.B.L. (2011), Dictaat Transport en Planning. TU Delft, Faculteit CiTG, oktober 2011.
- Schwanen, T., Dieleman, F. M., & Dijst, M. (2004). The impact of metropolitan structure on commute behavior in the Netherlands: a multilevel approach. Growth and Change, 35(3), 304-333.
- Schwanen, T., Dijst, M., & Dieleman, F. M. (2004). Policies for urban form and their impact on travel: the Netherlands experience. Urban studies, 41(3), 579-603.
- Snellen, D., Hilbers, H., & Hendriks, A. (2005). Nieuwbouw in beweging: een analyse van het ruimtelijk mobiliteitsbeleid van Vinex. NAi Uitgevers.
- Skinner I., Wu D., Schweizer C., Racioppi F., Tsutsumi R., (2014) Unlocking new opportunities, jobs in green and healthy transport. World Health Organization.
- Stadsgewest Haaglanden (1995). Vinex uitvoeringsconvenant Haaglanden.
- Stadsgewest Haaglanden (2014). Begroting Stadsgewest Haaglanden.
- Stadsregio Rotterdam (1995). Vinex uitvoeringsconvenant Stadsregio Rotterdam.
- Stadsregio Rotterdam (2014). Begroting Stadsregio Rotterdam.
- Stinson, M. A. and C. R. Bhat (2003) An analysis of commuter bicyclist route choice using stated preference survey, Transportation Research Board. Washington, D.C.
- Storper, M., Manville, M., (2006), 'Behaviour, 'Preferences and Cities: Urban Theory and Urban Resurgence'. In: Routledge Urban Studies, 43 (8), pp. 1247-1274, July 2006.
- Straatemeier, T. (2008). How to plan for regional accessibility?. Transport Policy, 15(2), 127-137.
- Tennekens, J. en A. Harbers (2012), 'De bevindingen', in: Grootschalige of kleinschalige verstedelijking, pp. 8-17. Uitgeverij PBL. Publicatie.
- Tennekens, J. en A. Harbers (2012), 'Geen Belgische maar Duitse toestanden'. In: Tijdschrift voor de Volkshuisvesting, juni 2012, pp. 19-22. Artikel.
- Tordoir, P.P. (2009), 'Contouren van een economisch ontwikkelingsplan voor Rotterdam Zuid en Deltapoort'. Essay.
- United Nations, Department of Economic and Social Affairs, Population Division (2013). World Population Prospects: The 2012 Revision, Highlights and Advance Tables. ESA/P/WP.228
- Vries, C. de. (2013). Verplaatsingen In Rotterdam, Stadsregio En Nederland, 2004-2011, Centrum voor Onderzoek en Statistiek (COS), 2e, verbeterde druk; oktober 2013. Afdeling Verkeer & Vervoer van het Cluster Stadsontwikkeling van de gemeente Rotterdam.
- Wegener, M. (2004). Overview of land-use transport models. Handbook of transport geography and spatial systems, 5, 127-146.
- Yin, R.K. (2003) Case study research - Design and methods. Thousand Oaks: Sage Publications.

Internet websites (accessed between November 2014 and July 2015)

- http://www.theguardian.com/cities/bike-blog/2014/mar/04/cycling-cities-search-bike-friendly-metropolis
- http://www.verkeerskunde.nl/integrale-artikelen/fietsgebruik-slim-stimuleren.16473.lynkx
- www.vinex-locaties.nl/Infocorner/wat_is_vinex.htm
- http://www.who.int/gho/urban_health/situation_trends/urban_population_growth_text/en/
- https://www.tfl.gov.uk/campaign/reinvesting-in-transport
- http://www.newurbanism.org/centerfortod.html
- http://www.tagesspiegel.de/berlin/verkehr/stadtentwicklung-berliner-sollen-aufs-fahrrad-umsteigen/2184292.html
- http://www.rotterdam.nl/Clusters/Stadsontwikkeling/Document%202013/Stadsinitiatief/Projectplannen/Projectplan_BikeShare.pdf
- http://www.dac.dk/en/dac-cities/sustainable-cities/all-cases/transport/vienna-bike-city-housing-project-stimulates-soft-mobility/
- http://www.neutelings-riedijk.com/
- http://www.rvo.nl/sites/default/files/2013/10/Special%20Elektrische%20tweewielers.pdf).
- www.bikesharingworld.com
- http://cycle-space.com/everyone-is-talking-about-bods/
- http://www.nytimes.com/2011/09/21/business/portland-ore-developments-cater-to-bicycle-riders.html?_r=3&pagewanted=all&
- http://www.planetizen.com/node/51496
- http://bikeshare.com/map/
- http://berkeley-crec.blogspot.nl/2010/11/bod-bicycle-oriented-development.html
- https://www.youtube.com/watch?v=-q-e9_KFcoY
- http://www.archdaily.com/83307/8-house-big/
- http://www.dac.dk/en/dac-cities/sustainable-cities/all-cases/transport/vienna-bike-city-housing-project-stimulates-soft-mobility/
- https://smartcity.wien.at/site/projekte/bauen-wohnen/bike-city/
- http://www.plaspoelpolder.nl/Over+de+Plaspoelpolder/default.aspx
- http://esa.un.org/unpd/wup/Wallcharts/urban-rural-areas.pdf
- www.velib.paris
- http://www.cnu.org/charter
- http://dbr.verdus.nl/
- http://www.fietsberaad.nl/?repository=Cijfers+over+fietsgebruik+per+gemeente

Appendix II Interviews

Interview partners

- Roel Bouwman, stadsregio Rotterdam, senior beleidsadviseur
- Bertus Postma, gemeente Rotterdam, senior beleidsadviseur
- Paul Gerretsen, Deltametropool, agent
- Gijs Overbeek, Provincie Zuid-Holland, programmamanager Fiets
- Theo Strijers, MRDH, programmamanager
- Klaas van Staalduine, Stedenbaan, beleidsadviseur
- Rico Zweers, De Mannen van Schuim, conceptontwikkelaar
- Paul van Munster, Stadkwadraat, planeconoom
- Bram Loggers, ASR, vastgoed ontwikkelaar
- Joost Beenker, Maastricht Bereikbaar, programmamanager
- Hidde van der Bijl, gemeente Den Haag, beleidsadviseur
- Frans Botma, gemeente Den Haag, beleidsadviseur
- Kees Miedema, NS, ketenmanager
- Rob van der Bijl, RVDB Urban Planning, adviseur
- Wim Serne, MRDH, senior beleidsadviseur
- Bert Zinn, Ministerie van Infrastructuur en Milieu, beleidsadviseur
- Stijn van der Walle, Stedenbaan, programmadirecteur

Questionary

- MRDH focust sterk op OV bereikbaarheid, klopt dit beeld?
- Belang van bereikbaarheid van de ‚eigen' metropoolregio; interne en intramobility
- Oprichting vervoersautoriteit gedreven door ov concessie en mirt gelden?
- Gezamenlijke agenda aanwezig of niet nodig?
- Aandacht voor aanleg nieuwe infra of beter benutten bestaand?
- Focus op hardware of op software?
- Waar nieuwe ontwikkelingen te faciliteren? Prioritering van de 45 toplocaties/MRDH
- Belang van sleutelprojecten dhcs en rdamcs
- New towns en vinex
- Leefbaarheid van steden en centra?
- Duurzaam imago geholpen met fietsbereikbaarheid?
- Aantrekkingskracht voor hoogopgeleiden en creatieve klasse vergroten door bod?
- Fietsbereikbaarheid:
- Verbeteren door fietssnelwegen en stimulering e-bikes? Met name gericht op satellietsteden?
- Verbeteren fietsfaciliteiten rond stations voor ‚last mile' probleem?
- Specifieke faciliteiten voor e-bikes en speed pedelecs in centra en kantoorgebieden?
- En faciliteiten verplichten in kantoorgebouwen en bij stedelijke uitgaangscentra?
- Verantwoordelijkheidsverdeling gemeenten en markt/aanbieder?
- Verantwoordelijkheidsverdeling gemeenten, provincie, rijk en regio?
- Omvang en planning van de fietsparkeervoorziening bij stations.