MASTER

Towards a sustainable transport system in Amsterdam South East

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Towards a sustainable transport system in Amsterdam South East

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Graduation Project

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Towards a sustainable transport system in Amsterdam South East

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Preface

This report is written as a graduate thesis in conclusion of my master Architecture, Building and Planning at the University of Technology in Eindhoven. Within this study, I preoccupied myself into the field of Urban Design and Planning.

This graduation project started with the subject infrastructures and new developments in the Amsterdam Metropolitan area. Fascinated by the idea of changing mobility and implement new transport solutions in Amsterdam South East, this graduation project found a focus.

During the writing of this thesis, a lot of people have helped me. I would like to thank my supervisors Aloys Borgers, Ad de Bont and Johan van Zoest. They were willing to share their knowledge and give feedback when needed. Special thanks to Roy, who supported me and kept be motivated in difficult times. Finally, I would like to thank all the other people who I spoke to and who motivated me during my graduation project.

For now, I hope you will find my thesis useful. Enjoy reading it.

Charlotte van den Bosch

Eindhoven, augustus 2015
Summary

Infrastructures are vital elements in urban developments. Accessibility of a neighbourhood, city district or centre contributes to the liveability of the urban area. Also the way people move around affects the health and well-being of the inhabitants. This study is concentrated on slow transport infrastructure in the south eastern part of Amsterdam.

With regard to the infrastructural developments in the Amsterdam South East which affects the infrastructures, two topics are very important. Firstly, the original plan for the area was designed to create a green and safe living environment with motorized traffic separated completely from slow traffic (pedestrians and bicyclists). In the mean time, part of the area has been reconstructed, including the transportation infrastructure. This raises the question whether main locations in and around the area are well accessible by the inhabitants of the area.

Second, one of the increasing health problems is obesity. One of the causes is the fact that people exercise far too little. Stimulating slow transport modes may contribute to reducing the problem.

Therefore, the research question is: How can the existing transportation infrastructure in the study area be adapted in order to improve the accessibility of main facilities and stimulate more sustainable and healthy transportation choice behaviour of the inhabitants? Infrastructure forms the backbone of a city, because it holds everything together: transport systems, residential areas, business districts, and all types of facilities. The study area for this project is located southeast of the ring road A10 in Amsterdam, namely the villages Duivendrecht and Diemen and the city district Amsterdam South East. The suburb Bijlmermeer grew from an isolated satellite of a core city into a national hotspot with the Amsterdam Arena area.

A promising way to stimulate physical activity is to promote the choice for active modes of transport like walking and cycling. Travelling by bicycle brings a number of benefits: it can lead to reductions in air pollution and traffic jams, and increases people’s physical activity levels.

Five levels of walking needs are feasibility (mobility, time, responsibility), accessibility (activities, connectivity between uses, infrastructure), safety (people present, types of land-uses), comfort (traffic calming features, pedestrian walkway), pleasurability (varied streetscape, liveliness, presence of other people).

Riding a bike has many advantages over driving a car. A bike can be stored easier than a car, a bike is cleaner, has a positive effect on the health of the user and reduces environmental and noise pollution. A bicycle friendly network needs cohesion, immediacy, attractiveness (pleasureability), safety and comfort.

Accessibility reflects “the extent to which the land-use transport system enables (groups of) individuals or goods to reach activities of destinations by means of a (combination of) transport(s)”. 
The 2013 OVIN (Onderzoek Verplaatsing in Nederland) data shows that nearly 40% of the transportation in the study area is made by car. 36% of the people use the train, metro or bus, 11% use a bicycle as transportation mode and nearly 11% walked. The main destinations outside the study area are the inner city of Amsterdam (Damrak and area around Rembrandplein), the Zuid-as (business district), Nellestein (Gaaserdam), Almere, Purmerend-zuid and Hoofddorp. Although the bicycle infrastructure covers the area, there are still some missing links and improvements needed to reduce travel time and lower the distances.

The electric bike is an emerging vehicle type within the context of sustainable transport. With speed limits of 25 to 30 km/u an e-bike is faster than a regular bike. A solution would be to create specific e-bike routes and adapt the ordinary bicycle path. Multiple lanes would be ideal: a fast lane for e-bikes and a slow lane meant for standard bikes.

Three interventions at three scale level have been worked out to give an idea how to use the design criteria. The first intervention is an e-bike route which connects Amsterdam South East with the inner city of Amsterdam. The second intervention is a bicycle route to station Bijlmer Arena and the third intervention is a walking route in the southeastern side of the Bijlmermeer.
1. Introduction

Infrastructures are vital elements in urban developments. With examples of early infrastructures for water supply and waste removal dating back more than 5000 years BC, it was during the industrial revolution that cities started developing infrastructures we are familiar with nowadays. Without supply infrastructures (freshwater, electricity, natural gas), hygienic infrastructure (waste and wastewater removal), communication infrastructure (telephone, internet), traffic infrastructure for transportation of humans and goods, and water management infrastructure (protection from flooding, rainwater management, water storage) a city cannot survive these days.

The future use of infrastructures largely depends on demographic, societal, and climatic developments. Trends nowadays are not only individualisation and increasing scarcity of energy, raw materials, fresh air, food and water, but also climate changes, risks, ongoing digitization and increasing health problems as obesity. Infrastructures are all over the world. However, this study will concentrate on slow transport infrastructure in the south eastern part of Amsterdam.

1.1 Background, need and study area

Accessibility of a neighbourhood, city district or centre contributes to the liveability of the urban area. Also the way people move around affects the health and well-being of the inhabitants. To upgrade the infrastructure to a more sustainable and healthy level, accessibility of important destinations by foot and bike should be investigated and improved if necessary.

Study area

The areas Duivendrecht, Diemen and Amsterdam South East form the study area for this research (Fig.1). It is located enclosed by the A10 ring road and highways A2, A9 and A1. The area mainly belongs to the municipality of Amsterdam, but some parts belong to the municipalities of Diemen and Duivendrecht. The total population of Amsterdam South East amounts to approximately 84.030 in 2015 (Gemeente Amsterdam, 2015).
1.2 Statement of the Problem
With regard to the infrastructural developments in the study area, two topics are very important.
1) The original plan for the area was designed to create a green and safe living environment with motorized traffic separated completely from slow traffic (pedestrians and bicyclists). In the mean time, part of the area has been reconstructed, including the transportation infrastructure. This raises the question whether main locations in and around the area are well accessible by the inhabitants of the area.
2) One of the increasing health problems is obesity. One of the causes is the fact that people exercise far too little. Stimulating slow transport modes may contribute to reducing the problem.

1.3 Purpose of the Study
The purpose of this study is to improve the transportation infrastructure in Amsterdam South East, Diemen and Duivendrecht, to improve accessibility and stimulate more healthy transportation behaviour by the residents who live in the neighbourhoods.
In order to improve the accessibility of main facilities (schools, shops, offices) in the study area the existing transportation infrastructure will be analysed. The accessibility of the main facilities will be assessed. By using the data from the Onderzoek Verplaatsing in Nederland (OViN) more insight is given in the transportation behaviour of the residents of the study area. By discovering how the transportation infrastructure is used by the residents of the study area, improvements in the transportation network may be implemented. The aim is that the citizens in this area will be encouraged to choose a more sustainable and efficient transportation mode. A good example of such a transportation mode is the e-bike. The e-bike enlarges the range and shortens the travel time to the city centre of Amsterdam during peak hours.
As a result of this research, transportation infrastructure in this area can be adapted in order to improve accessibility of the main facilities and stimulate more sustainable and healthy transportation behaviour.
Fig.1 Location of Amsterdam South East, Diemen and Duivendrecht in the Amsterdam Metropolitan Region.
1.4 Research Questions
To investigate whether the transport infrastructure in the study area can be improved, the following main question has to be answered.

How can the existing transportation infrastructure in the study area be adapted in order to improve the accessibility of main facilities and stimulate more sustainable and healthy transportation choice behaviour of the inhabitants?

To give a well-founded answer to this question, first these six sub-questions have to be answered:

• How is the transportation infrastructure organized?
• How is the transportation infrastructure used by the residents of the study area?
• Are the most important facilities and land uses well accessible by means of appropriate transportation modes? If not, how can the accessibility be improved?
• How can the existing infrastructure be adapted in order to facilitate the use of the e-bike?
• How can inhabitants be encouraged to use more sustainable and healthy transportation modes?
• How can the future infrastructure be adapted in order to improve accessibility in general and to stimulate more sustainable and healthy transportation behaviour?

1.5 Structure of the thesis
In order to find the answers to the research questions, this thesis is divided in 5 chapters. Chapter two is dedicated to the urban development of the study area. Chapter three focuses on the literature concerning transport mode choice behaviour and accessibility. With the results of this general literature review in mind, in chapter 4 the accessibility analysis of main services in Amsterdam South East, Duivendrecht and Diemen will be executed in the transportation network. Then, chapter 5 describes and explains the vision about encouraging slow transport modes, interventions and the strategy. Lastly chapter 6 answers the research question and gives some recommendations.
Fig. 2 Noord-Holland in 1848 (Grote Historische Provincie Atlas, 1992).
2. Amsterdam South East

The graduation studio “Infrastructures and New Developments in Amsterdam Metropolitan Region” investigated the different kind of infrastructures and developments in Amsterdam, the capital city of the Netherlands.

Ideally, a city will have an extensive and functional infrastructure. Developed over centuries or even millennia, it forms the backbone of a city. It holds everything together: road networks, transport systems, universities, political institutions, hospitals, theatres, galleries and organisations for all kinds of activities, department stores and small specialty shops, parks, public squares and sport facilities. Infrastructure is a city’s circulatory system (Smart, 2014).

The first section of this chapter will address research related to the history of the development infrastructure in the Randstad and the Bijlmermeer. The second part will focus on the current situation of the study area.

2.1 Short overview of development of infrastructure in Amsterdam South East 1600-1950

This section offers a historical overview of the development of infrastructure around Diemen and Duivendrecht.

Development of water infrastructure
1627 the Bijlmermeer is debilitated with the Ringsloot ditch and later New Ringsloot ditch.
1638 construction of the Muidertrekvaart
1640 construction of the Weespertrekvaart and Ringsloot after reclamation of the Diemermeer.
1798 foundation of bureau for the Waterstaat (flood prevention).

National road network
1811 Rijkswegen net admitted, under Napoleon, in the road network of the French empire.
1817 Installation of the municipality of Bijlmermeer
1825-1850 In this period, almost the entire national road network (500km) was paved (Fig. 2 and Fig.3).
Public transport introduction of train and tram

1843 Opening of the Rhijnspoorweg from Amsterdam to Utrecht (Fig.4).
1846 Municipality of the Bijlmermeer was annexed by the municipality of Weesperkarspel.
1874 Opening of the Oosterspoorweg, railroad from Amsterdam to Weesp - Naarden-Bussem and Hilversum.
1881 Opening of the Gooische Stoomtram from Weesperpoortstation in Amsterdam to Diemerbrug Muiden, Muiderberg, Naarden, Laren and Hilversum.
1920-1930 Construction of the Rijksweg 1 to Muiden, broadening needed of the Muiderstraatweg and Hartveldseweg.
1950 Rijksweg A2 opened, taking over the function of the Rijksstraatweg located in Duivendrecht.
1966 the municipality of Amsterdam annexed part of the ground of the municipality Weesperkarspel.
1971 Train station the Bijlmer along railway Amsterdam-Utrecht (Rhijnspoorweg).
1972 Opening of the traffic junctions Diemen en knooppunt Diemen 2x2 lanes + Muiderslot 2x2 lanes.
1976 Opening of trainstation Amsterdam Bijlmer. 4 tracks with cross-platform between train and metro.
1977 Opening metro line 53 between Weesperplein and Gaasperplas and metro line 54 between Weesperplein and Holendrecht.
1985 Traffic junction Duivendrecht opened.
1990 Extension of tram line 9 via the Hartveldseweg to Diemen(Sniep).
1993 Opening of metro- and train station Duivendrecht.
1993 Opening of metro- and trainstation Diemen-Zuid.
1996 Opening of GVB maintenance depot Diemen at the Provincialeweg 2-4.
2006 Opening trainstation Amsterdam Bijlmer ArenA and the Utrechtboog by Duivendrecht in use.
2008 Extension of the highway A6 from traffic junction Muiderberg to Holendrecht finally collapsed because of political resistance.

2010-2016 duplication of the amount of trains along the railway Schiphol-Amsterdam-Almere-Lelystad.
2011-2026 Project Schiphol-Amsterdam-Almere A1/A6/A9, 63km road widening.
2015-2020 Construction of the Gaasperdammertunnel with 3km park on top (size 2x Vondelpark).

Fig.4 a) 1849-1859 and b) 1888-1905
Fig. 5 Infrastructure still visible in the landscape.
2.2 History, development of infrastructure in Amsterdam South East

Fig. 5 shows the waterstreams, railway and roads which is still visible in the landscape. The city of Amsterdam expanded and the landscape changed a lot after 1966 when Amsterdam added the Bijlmermeerpolder to her territory on a provisional basis. Therefore, a new administrative body was set up that kept all the financial arrangements for the new residential quarters to be erected separate from the municipal administration of the capital (Van der Velde, 1968). By far the largest and also the most controversial housing estate in Amsterdam was De Bijlmer, located in a polder of the same name. It was designed for 110,000 inhabitants, with no less than 450 hectares of space reserved for recreation. G.S. Nassuth, a student assistant of Van Eesteren in Delft, led the design team of the municipal planning board. The area could be reached by highways and elevated roads connected to parking garages; these gave direct access to the interior streets in the high-rise apartment buildings (De Boer & Lambert, 1987). Its most characteristic feature was the large, honeycomb-like high-rise apartments. The buildings spread across the countryside like a huge “megastructure”. Equally striking, and at the time a novelty in the Netherlands, was the separation of different traffic flows: pedestrians, cyclist, and automobile drivers. A brand new metro line was constructed to connect the Bijlmer to the inner city. The Bijlmer was celebrated as the first Dutch neighbourhood for the motor age (Wagenaar, 2011).

Helleman and Wassenberg (2003) argued that over the years, the Bijlmermeer has been a shining example of the high expectations and ideas of CIAM-planning, the disappointment, problems and stigma of numerous improvement trails and nowadays of a radical redesign and integrated approach are discussed in their paper. The purpose of their study was to describe and analyse developments in the Bijlmermeer and to place them within an international and historical context. The aim of the paper is to show how negative developments strengthened each other and that the early improvements were not sufficient. Nowadays, drastic renewal has taken place, with overall promising results, although there are still problems. The paper shows that the present policy in the Bijlmermeer goes further than possibly any other measure in the world. As a consequence, there is only a marginal future left for high-rises in the Bijlmermeer. Connecting the area to the region, an integrative approach, no fear of radical solutions, financial support and the participation of inhabitants are conditions for a successfully renewal (Helleman & Wassenberg, 2004). The study took place in the Bijlmermeer, a high-rise estate located in the south-east extension of Amsterdam. It was built in response to the enormous housing shortage in the Netherlands as a whole and Amsterdam in particular, to create “a modern city were the people of today can find the residential environment of tomorrow”, as the information folder announced in 1968. Between 1968 and 1975, 13,000 dwellings in 31 very large blocks (300-500 dwellings each) were built, each 10 storeys high and 200-300 meters long.
All of the ideas of Le Corbusier and the CIAM on modern living were applied: separation of functions (living, working, recreation), a great deal of space between the apartment blocks, large-scale park-like landscapes, parking garages and raised main roads (three meters above ground level). Contrary to the long-term process of individualisation of home life, the Bijlmermeer Plan emphasised collectivity (Mentzel, 1990). The designers imagined that the new social spaces would compensate for the limitations of high-rise living. Covered walks linking buildings would be lined with shops and recreate the feel of traditional streets. Using communal facilities would encourage neighbourliness and collective life (Blair & Hulsbergen, 1993). The dwellings themselves were, and in some respects still are, of high quality: large floor space, luxurious sanitary facilities, central heating and its own storeroom. Most of the dwellings are in the social rented sector, though definitely not in its least expensive segments. The aim of the planners was to attract households with children and a middle-incomes, because the city of Amsterdam already had enough dwellings for low income groups.

In the first years, living in the Bijlmermeer meant living far away from the rest of the world, hardly connected by public transport and far away from shops, work and leisure. However, since the mid 1980s, various facilities have been opened close by: a metro line to the city centre, a new stadium for the Ajax football club, large cinemas and theatres. This whole area is called the ‘Amsterdam ArenA’. One of the most expensive office areas in the Netherlands was built just opposite the railway station Bijlmer Arena. All these positive developments nearby have helped to rebuild the image of the Bijlmermeer, providing demand for extra housing and creating a lot of jobs at all levels. In fact, the location of the Bijlmermeer has changed from an isolated ‘satellite of a core city’ into a national hotspot, the ‘core of a network city’ (Kloos, 1997). Approaches used to improve the Bijlmermeer over the last 30 years can be divided in several phases: upgrading the environment, improving the management, fighting crime and safety, setting up participation projects and formulating integral approaches. The last phase has resulted in large scale demolition of the high rise building blocks.

In 1999, after the first years of renewal, a broad evaluation took place (Ouwehand, 1999). The question arose whether the physical renewal should be intensified, whether more high-rise dwellings should be demolished, renovated, sold or refurbished.

In 2001 a large questionnaire was conducted in the areas to be renewed researching which physical renewal measures residents supported (Helleman and Wassenberg, 2001). The response rate was extremely high (77%), with more than 3500 households participating, 79% of whom were born outside the Netherlands and representing 81 different nationalities. At present, about 40% of the population comes from Surinam and the Netherlands Antilles, another 40% from other countries, particularly West Africa, and only 20% has Dutch Roots. Almost 70% of the inhabitants agree that it is ‘a good idea’ to demolish one or more of the remaining
### Table 1 Opinion about the physical renewal per measure in 1995, 1999 and 2001 (in percent)

<table>
<thead>
<tr>
<th></th>
<th>Survey 1995 (1500 dwellings, respons 55%)</th>
<th>Survey 1999 (800 dwellings, respons 63%)</th>
<th>Survey 2001 (4900 dwellings, response 77%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>good idea</td>
<td>bad idea</td>
<td>good idea</td>
</tr>
<tr>
<td>Renovation of dwellings</td>
<td>62</td>
<td>21</td>
<td>73</td>
</tr>
<tr>
<td>Sale of dwellings</td>
<td>38</td>
<td>25</td>
<td>53</td>
</tr>
<tr>
<td>Demolition of high-rise blocks in general</td>
<td>65</td>
<td>25</td>
<td>63-74^b</td>
</tr>
<tr>
<td>Demolition of a part of high-rise blocks</td>
<td>43</td>
<td>20</td>
<td>37</td>
</tr>
<tr>
<td>After demolition single-family dwellings</td>
<td>78</td>
<td>9</td>
<td>81</td>
</tr>
<tr>
<td>After demolition low-rise flats</td>
<td>65</td>
<td>12</td>
<td>63</td>
</tr>
</tbody>
</table>

Source: Helleman & Wassenberg, 2001

^a^category 'no opinion/don't know' is left out of consideration

^b^63% wanted to demolish both buildings, 11% one of the two buildings

### Table 2 Physical renewal in numbers

<table>
<thead>
<tr>
<th></th>
<th>1990</th>
<th>demolition</th>
<th>new construction</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-rise</td>
<td>12.500 (100%)</td>
<td>6.550</td>
<td>0</td>
<td>5.950 (44%)</td>
</tr>
<tr>
<td>Low-rise apartments</td>
<td>0 (0%)</td>
<td>0</td>
<td>4.600</td>
<td>4.600 (34%)</td>
</tr>
<tr>
<td>Single-family dwellings</td>
<td>0 (0%)</td>
<td>0</td>
<td>2.850</td>
<td>2.850 (21%)</td>
</tr>
<tr>
<td>Total</td>
<td>12.500 (100%)</td>
<td>6.550</td>
<td>7.450</td>
<td>13.400 (100%)</td>
</tr>
</tbody>
</table>

Source: Projectbureau Vernieuwing Bijlmermeer, 2002
high-rise blocks. A comparison of the 2001 survey with two similar earlier surveys in the Bijlmermeer confirms this view. In 1995 a survey was carried out among inhabitants of three blocks in the F-Neighbourhood (one of the first renewal projects) and in 1999 a similar, but smaller survey was carried out in two buildings (Grunder and Grubbehoeve). Although the surveys did not involve the same respondents, it is possible to recognize a pattern (Table 1). A growing number of people dislike renovation and support demolition and new building. The 2001 survey supports this conclusion. After the renewal of the Bijlmermeer is finished, more than half of the original high-rise blocks have disappeared and have been replaced by low-rise apartments and single family dwellings (Table 2).

Helleman and Wassenberg show the situation in the Bijlmermeer in 1992 and the expected results in 2010 based on the renewal plan. In Fig.6 the current situation in 2015 is added. In 2003 the renewal approach for the Bijlmermeer aims to demolish over half of the original high-rise blocks and to relinquish the original ideas underlying the original plan. Positive elements as the extensive bicycle network, green spaces and water streams are still present. Inhabitants choose the measures and the new houses are being built, at moderate prices, for them. History has proven here that neither maintenance, nor social-economic measures, nor participation, nor physical measures alone are sufficient to solve the large problems which occurred in the Bijlmer during the 70s and 80s.

The transport infrastructure in the Bijlmermeer was based on the car. To connect the Bijlmer with the inner city two metrolines have been built. Station Bijlmer opened in 1971 with a stop along the railway Amsterdam- Utrecht (Rhijnspoorweg). In 1976 the new station Amsterdam Bijlmer opened with 4 railway tracks, 2 for the train and in the middle 2 for the metro. Amsterdam Bijlmer was nothing more than just a station where trains and metro’s stopped during 30 years. This changed when new facilities near the Bijlmer station, such as office buildings, schools, houses, shops and large scale facilities like the new football stadium for Ajax, the Amsterdam ArenA, mega cinema Pathé, the Heineken Music Hall and the Woonmall opened (Bouwwereld, 2008). These new facilities gave reason to upgrade the Bijlmer station to a new public transport node with cross-platform-transit between train and metro (Fig.7). At ground level different bus lines stop and a bicycle parking is located. At December 10, 2006 with the start of the 2007 rail service, the station name changed to Amsterdam Bijlmer Arena.
Fig. 6 Bijlmermeer 1992 and 2010 (Wassenberg et al. (2013) and Bijlmermeer 2015.

Fig. 7 The renewed station Amsterdam Bijlmer Arnea (Schouten, 2008)
2.3 The Bijlmermeer area in 2015

The renewal of the Bijlmermeer, started in the 90s, has not been finished yet. Projects in preparation are new residential housing in the E-Buurt, World of Food in garage Develstein (opening planned in July 2015), expansion of the Spinozacampus with student housing, Kleiburg 2nd phase and new buildings around the Bijlmer Sportcenter (Projectbureau Vernieuwing Bijlmermeer, 2015). Below the results of the renewal in Amsterdam South East (Fig.8).

Near the ArenA Poort the Bijlmerdreef is still there as originally planned. The dreef was raised 3 meters above ground level in the 60s. The new residential building blocks Fénice was built along the high dreef similar to the block in 1973. Under the dreef the parking garage P23 is situated, used by employees of surrounding office buildings and by shoppers who visit the Amsterdamse Poort. The underpasses under the Bijlmerdreef have been enlarged, enlightened and some have been decorated with art.
Two parts of the Daalwijk flat, an original high-rise flat in the D-neighbourhood, are still there. The other honeycomb like high-rise buildings have been demolished. A part of Daalwijk is rebuilt into student housing. The other apartments are renovated and office space was created at ground level. Het Klaverblad, a building with a school and owner occupied apartments, is built next to the flat (Fig.9). Due to the economical crisis, some building projects are delayed. New initiatives have resulted in provisional student housing for the next 15 years, called the Spinoza campus. The students and school provide liveliness in the area. The greenfield is used for sports activities, strolling around and playing.
Uniform building blocks have been transformed into low-rise housing. The Flats Frissenstein and Fleerde have been preserved and renovated into owner-occupied houses (Fig.10). At ground level of the Frissenstein flat the units got a terrace by the water. Low rise houses faced to squares with green and playgrounds are located around the flats.

Fig.11 Along the Karspeldreef: Kraaiennest (left) and Kameleon (New shoppingcentre) (Beeldbank Amsterdam, Moorden & PVB, 2012) (Megavolt, 2012)

The old picture left (Fig.11) shows the original traffic transportation structure. The metro crosses the Karspeldreef and at ground level was space for cyclists and pedestrians. The Karspeldreef has been lowered to ground level and shops of the Kameleon shopping centre are now faced to the street, resulting in a lively street. The renewed metro station Kraaiennest is transparent and well organized. No dark spaces or cluttered hallways anymore.

Fig.12 Gooioord with old shoppingcentre Ganzenhoef (Beeldbank Amsterdam, Moorden & PVB, 2012) (Megavolt, 2012)
Every Honeycomb flat was accompanied by a parking garage. From the dreef the residents drove into the garage, parked their car and walked by footbridge to the flat or used a staircase to go the street. Shopping centre Ganzenhoef was located under the Bijlmerdreef and the parking platform of Gooioord. The Bijlmerdreef has been lowered to ground level and a new shopping centre Ganzepoort has been built on the other side of the Bijlmerdreef. The parking garage (Fig.12) is unrecognisable because the upper platforms have been removed. The public space and entrées to the flat are now well accessible.

Fig.13 High-rise buildings have made place for smallscale appartement blocks facing the Kromwijkdreef (Beeldbank Amsterdam, Moorden & PVB,2012) (Right: Megavolt,2012)

On the south side of the Karspeldreef in the K-neighbourhood 4 honeycomb flats have been replaced by small neighbourhoods of low-rise apartment blocks (Fig.13). Cars are mostly parked on the street. It is green and there is space for children to play. In the neighbourhood Karspelhof an adventure playground has been opened. The main facilities, such as a shopping centre and metro station, are located within walking distance.
2.4 Study area
In Amsterdam the A10 highway is the ring road around the city of Amsterdam. It has a length of 32 km and five other highways connect to the A10. These are the highway A8 at traffic node Coenplein (north), A5 at traffic node Coenplein (south), A4 at traffic node De Nieuwe Meer, A2 at traffic node Amstel and A1 at traffic node Watergraafsmeer. The ring road forms a spatial barrier but is needed to organise the traffic flows and keep car traffic out of the city centre.
The construction of this ring road started in 1962 with the Coentunnel and was finished in 1990 with the completion of another tunnel beneath the river IJ, the Zeeburgertunnel.
The district southeast of the A10 with the village Duivendrecht, Diemen and city district Amsterdam South East belongs to the three different municipalities Diemen, Ouder-Amstel and Amsterdam (Fig.14). What makes this district interesting is that different municipalities with different plans (also spatial plans) and still different identities come together in this district and this district has, with regard to infrastructures, some problems.
Duivendrecht (municipality Ouder-Amstel), is a small village with almost 5000 inhabitants (gemeente Ouder-Amstel, 2015) and is located between Amsterdam East (neighbourhood Overamstel), Amsterdam-Southeast (neighbourhood Venserpolder) and Diemen.
Train and metro station Duivendrecht and metro station Van der Madeweg are the main public transportation hubs.

Diemen is the name of the town and the municipality. It has just over 26,000 inhabitants. Diemen is divided in 3 parts: Diemen Zuid, Diemen Centrum, and Diemen Noord. The business locations are located along the Weesperdertrekvaart: Verrijn Stuart, Bergwijkpark and Stammerdijk. Near the Amsterdam Rijnkanaal are the recreation areas the Diemerpolder, Diemerbos and Diemer Vijfhoek. The Bergwijkpark in Diemen will be changed radically because many buildings in the outdated business district are unoccupied. These office buildings no longer meet the current requirements. A part of the area has been turned into a student campus. The rest of the business district will be redeveloped into the residential area Holland Park. The masterplan was designed by Sjoerd Soeters.

In Amsterdam South East live more than 84,000 people (Gemeente Amsterdam, 2015).
The area consists of the following districts:
- Amstel III/ Bullewijk (Offices/ business district with the Amsterdam Arena and Academic Medical Centre (AMC))
- Bijlmer; with neighbourhoods Bijlmer-Centrum, D-buurt, F-buurt, H-buurt, E-buurt, G-buurt, K-buurt.
- Gaasperdam; with the neighbourhoods Holendrecht, Nellestein, Reigerbos and Gein
- Venserpolder
- Driemond (village)
On the south side of the district the construction of the Gaasperdammertunnel has started. A park will be built on the top of the A9 highway between the rail track Amsterdam-Utrecht and the Gaasp river. Currently the A9 crosses city district Amsterdam South East; the Gaasperdammertunnel will connect both parts of the district and the tunnel will reduce the road traffic noise. Thus, the quality of life for local residents will be improved.

2.5 Conclusion
Infrastructure forms the backbone of a city, because it holds everything together: transport systems, residential areas, business districts, and all types of facilities. This project will focus especially on infrastructure in Amsterdam South East. In the 1960’s, the municipality of Amsterdam realized 20 high-rise honeycomb flats with 10 storeys in the Bijlmermeer polder. The suburb Bijlmermeer grew from an isolated satellite of a core city into a national hotspot with the Amsterdam Arena area. The transport infrastructure in the Bijlmermeer was based on the car. To connect the Bijlmer with the inner city two metro lines were built. Around the train station Bijlmer Arena office buildings, schools, houses, shops and large scale facilities like the new football stadium the Amsterdam Arena, mega cinema Pathe, the Heineken Music hall, the Woonmall and the music Dome have been developed. The renewal of the Bijlmermeer started in the 90s and has not been finished yet. The most high-rise honeycomb flats have been demolished and replaced by low-rise building blocks.

The study area for this project is located southeast of the ring road A10 in Amsterdam, namely the village Duivendrecht, Diemen and city district Amsterdam South East. This area belongs to three different municipalities.

Fig.14 Study area: Diemen, Duivendrecht and Amsterdam South East.
3. Literature review

The literature review will address four areas of research related to the accessibility and transportation choice behaviour. The first section will address research related to sustainable transport and new mobility solutions will be introduced. The second section will focus on research studies about transport mode choice behaviour related to health. The third section will discuss research related to accessibility. Finally, the last section will focus on design criteria for bicycle and pedestrian routes.

3.1 Sustainable transport and new mobility solutions.

In the journal Verkeerskunde Timmermans (2015) mentioned that if the car will develop to automotive driving a greater service, profit and deployment may be reached. More people can make use of the car. Nowadays shared cars initiatives show already results. A car is 95% of the time unused. If, for example in a neighbourhood more people use the same car less parking space is needed. An automotive car is able to serve the society better and is safer because of the new technologies built in the car. In Helsinki is the new policy to reduce the use of the private car. The municipality has introduced a transport pass with which residents have access to a range of transportation options like public transport, shared cars and bicycles, ferries and an on-call minibus. Other types of technological innovation, and in particular apps and the internet, make it possible to use different transport modes without owning the transport mode itself. The renewal in the Helsinki plan is the different use of smartphones and integrated payment system (Metz, 2014). Now the car reinvents itself, the interest of many young potential buyers declines to possess one (KiM, 2014).

Nobina, the largest passenger transport company in Scandinavia, ordered 15 hybrid Exqui.Citys that will be used to carry passengers in Malmö and the Skane region in Sweden (Fig.15). Van Hool Belgium is the first manufacturer to be awarded a contract for this kind of vehicle in Scandinavia. Sometimes referred to as a “tram-bus” because of its appearance, the hybrid “Exqui.City design Malmö” is an electrically driven, 24-metre-long, bi-articulated vehicle. Its electricity will be produced by a generator connected to a Euro6 biogas engine. Van Hool has previously been awarded contracts to supply 92 similar models of the Exqui.City in Metz (France), Barcelona (Spain), Parma (Italy) and Geneva (Switzerland), among other places (Van Hool, 2012).

A pilot with fifteen fully electric public transport buses has started in the region Brabant by VDL. Project VIBe-Bus (Vehicle for Innovation Bus) is a spin-off to introduce fully electric systems in the public transport sector. By the end of 2015 VDL Citea Electric buses will be used to transport passengers in the east of Brabant (BOM, 2015). Electric buses will have no CO\textsubscript{2} and noise emission and are therefore more environmentally friendly. Only the radius of action is smaller compared to fossil fuel buses. Heliox, a high tech company
in power electronics located in Best (Noord-Brabant, NL) developed an ultra-fast charging system for electric city buses and is implementing them in the V1Be buses, Fig. 16. Complex in the public transportation sector are the different parties and interests: drivers, passengers, principals, transport companies, traffic management centres and maintenance teams. These parties have to work together as a team. This will lead to more sustainable transport and new mobility solutions.

Van Wee et al. (2012) discussed the potential for transforming conventional car-based travel into electric mobility. To reduce the environmental burden of urban road traffic, researchers and policy-makers have focused on reducing car use in urban areas, and improving public transport. Their paper concludes that electric vehicles could bring substantial benefits to the environment and energy consumption, but the long-term environmental benefits largely depend on the size of potential rebound effects, the life-cycle effects with respect to energy, the differences between electric cars and their competitors. Secondly, the paper shows that policies to encourage the use of electric cars should be adaptive. Privileges in central urban areas could be useful. However in the long run, driving and parking electric vehicles should be limited for reasons of liveability (Van Wee et al, 2012).

An electric bicycle, also know as an e-bike, is a bicycle with an integrated electric motor which can be used for propulsion. There are a great variety of e-bikes available worldwide, from e-bikes that only have a small motor to assist the

Fig.15 A new mobility solution, the hybrid tram-bus (Van Hool, 2012)

Fig.16 Fast charging system for electric buses (BOM,2015).
3.2 Transport mode choice behaviour related to health
In the suburbs of Amsterdam South and Amsterdam New West are several problems which cause health problems: unhealthy food, obesity, diabetes, and alcohol abuse. Obesity is the cholera of the 21th century. 2300 children are dangerously overweighted in Amsterdam. Amsterdam Aanpak Gezond Gewicht is a campaign which has a goal that every child in Amsterdam has a healthy weight. The key is to stimulate physical activity by younger children. A promising way to stimulate physical activity is to promote the choice for active modes of transport (walking and cycling). Over the past years, several interventions and policies have been implemented to stimulate this mode shift. However, information concerning the effectiveness of these interventions and policies is still limited.

The aim of the study of Scheepers et al. (2014) was to systematically review the effectiveness of interventions designed to stimulate a shift from car use to cycling or walking and to obtain insight into the intervention tools that have been used to promote and/or implement these interventions. They systematically reviewed studies that have investigated the effects of interventions that aim to stimulate mode shift from passive to active transport.

Five databases (Medline, Embase, SciSearch, Social SciSearch, PsychInfo) were searched and articles published in English, Dutch, German, Danish, Norwegian and Swedish were included. Only studies that focussed on mode shift from car use towards active transport (walking or cycling)
in a general adult population, which were published in peer-reviewed journals and which investigated effectiveness were included. Intervention tools used were categorized by using the model of Hoogerwerf & Herweijer, as either legal, economic (subsidy, reward system, penalty), communicative (written materials, behavioural tools) and physical tools (providing bicycles, providing better bicycle facilities at work, adjustment of the environment). The search strategy resulted in 2106 records. After exclusions 19 publications were eligible for data extraction.

Interventions were categorised in work-place-based, architectural and urbanistic adjustments, population-wide, and bicycle-renting systems interventions. Nearly all studies (except three) showed positive effects concerning mode shift from car use to active transport. However, information about the statistical significance of these results was often lacking.

One of the behavioural intervention tools used in the included studies was mass media campaigns. All interventions using mass media campaigns, except for one, were showing positive results on mode shift. Mass media campaigns are useful in increasing awareness and knowledge about the campaign, and are of importance in supporting other intervention tools (Kahn et al., 2002). Four of the included studies (Alcott and DeCindis, 1991; Brockman and Fox, 2011; Meland, 1995; Wen et al., 2005) using a communicative tool also used a reward (incentives) or penalty system. Incentives used were a healthy breakfast/lunch (Wen et al., 2005) and the opportunity to win prizes when participating in the intervention (Alcott and DeCindis, 1991). Two studies contained a penalty system by increasing parking charges (Brockman and Fox, 2011) or having to pay a toll fee when entering the city centre (Meland, 1995). Three of the four studies showed a positive effect on mode shift. Only the introduction of the Trondheim Toll Ring did not show effect on mode shift. In this study the introduction of the Toll Ring caused a shift in the timing of the car trips instead of mode shift. Since this Toll Ring has been designed to raise revenue for the ‘Trondheim package’, it can be argued that this intervention was not designed effectively for stimulating mode shift. Another two studies did not show any positive effect on mode shift. The development of a neighbourhood trail was the only intervention with a negative effect on mode shift. In this study, there was only an environmental adjustment and no promotional activities concerning the use of this trail were implemented. Though as a result of the trail a loop of 2.5 miles was created, adequate signposting was missing, which possibly limited the trail’s effectiveness. The included studies support the notion that a combination of different intervention tools is more effective than using only one tool. More than half of the included interventions used a combination of several intervention tools. However, in the vast majority of these studies the intervention tools all focus on the same area, for instance, health promotion or an environmental adjustment. Interventions were implemented with, for example, the aim to increase physical activity levels, reduce air pollution or improve accessibility of a neighbourhood. Only one intervention focussed on multiple aims by using both behavioural intervention tools and an environmental adjustment.
The research showed that shifting transportation modes not only influences the level of physical activity, but also has beneficial health effects due to decreased air pollution emissions (De Hartog et al., 2010), greenhouse emissions (Lindsay et al., 2011) and noise levels (Van Kempen et al., 2010). The effect of mode shift on road safety is claimed to be an improvement by Jacobsen (2003), but other authors showed that this effect depends on age and gender (Stipdonk and Reurings, 2012). Because of this diversity in (beneficial) effects on health and environmental quality, collaboration between the health, transport, spatial planning and environmental sector and thus a more intersectorial approach would be beneficial in developing (cost-efficient) interventions stimulating active transport.

Heinen et al. (2013) researched the effect of work-related factors on the bicycle commute mode choice in the Netherlands. Travelling by bicycle to work brings a number of benefits: it can lead to reductions in air pollution and traffic jams, and increases people’s physical activity levels. The work-related factors influence whether an individual decides to cycle to work, and whether an individual cycles to work every day. The Dutch Government acknowledges the importance of cycling and bicycle-related policies, and encourages commuting to work by bike, for example by offering tax benefits when employees purchase a bicycle. Attitudes towards cycling change when people change their mode of transport. Gatersleben and Appleton (2007) identified a negative shift in new cyclists’ perceptions related to fitness, fun, being outside, and convenience. However, these individuals developed a more positive perception of cycling’s flexibility and traffic safety.

Heinen et al. (2013) conducted an Internet survey in April and May 2008 in 4 Dutch municipalities, gathering data from over 4,000 respondents. The results suggest that the following factors increase the likelihood of being a commuter cyclist: having a positive attitude towards cycling; colleagues’ expectations that an individual will cycle to work; presence of bicycle storage inside; having access to clothes changing facilities; and needing a bicycle during office hours. The presence of facilities for other transport modes, an increase in the commute distance, a free public transport pass or car parking provided by the employer, reduces the chance that an individual will cycle. These results indicate that an individual’s working situation affects the commuting cycling behaviour. The findings also indicate that (partly) different variables influence an individual’s decision to cycle to work, and their decision to cycle every day.

The turbulent growth of car traffic and the effects on the accessibility and impact on the environment have been debated for years. Both policy makers and academics debated in recent years about the question how the built environment influences travel behaviour of the inhabitants. In short, do people who live in a city with all facilities close by, travel less than people who live in a suburb or settlement far from shops and theatres?
Maat (2009) investigated the role of the environment in the way people organize their daily activities and travel patterns, the role of the job site and how partners deal with decisions regarding car ownership and car use. The findings indicate that the built environment influences travel behaviour of individuals and households in a complex manner. As urbanisation progresses, the use of the car in urban areas somewhat declines. Still the effects are small. Less car travel is partly offset by other developments. Higher densities bring shorter distances and more chain trips, which cut travel time, but the freed-up time is spent on extra activities that are within reach. Similarly, people who work in a more compact environment use alternative modes of transport to get to work, but this may be because their partner has a greater need of the car. One important lesson is that behavioural mechanisms are never simple; they invariably elicit compensation. Hence, there is no point in forcing households into compact residential environments that they do not want – it is better to invest time and energy in people who prefer a cycle-friendly environment or a location with easy access to efficient public transport (Handy, 2005; Snellen et al., 2001).

In the past few decades Dutch spatial planning policy has focused on concentration at the level of urban regions, while simultaneously encouraging densities and mixed-use development. More recently, attention has shifted to an even higher spatial scale: the polycentric network city. The study by Maat (2009) (and others, e.g. Schwanen et al., 2004) revealed, however, that the greatest influence of the built environment is on mode choice. This is particularly evident on the micro scale. It would therefore be interesting to see whether more advanced neighbourhood designs, in terms of mode shifts, can be developed (as advocated by Marshall, 2005).

More attention also needs to be paid to the work location. The literature offers very little empirical research on the influence of the spatial structure of the work location or other destinations. The study of Maat (2009) shows that the work location does exert an influence, even though to a lesser extent than the residential location. It may be concluded that the Dutch government’s policy to encourage worker-intensive businesses to settle at more compact locations and to improve accessibility to public transport is promising, although expectations should not be too high. The density of many low-density industry parks may be increased and new business sites may be better connected to public transport networks.

Finally, most policies concentrate on necessary activities, such as living and commuting. Yet, these activities are such an integral part of people’s lives that they adapt these to their personal preferences, which are often expressed in low-density neighbourhoods and commuting by car. Government policy that neglects these preferences will inevitably encounter resistance. Other factors that put pressure on the mobility system, and might be good candidates for targeted policies, include leisure travel (around 50 percent of all travel) and the excessive availability and use of company cars. Other initiatives that might assist the management
of the adverse effects of car use include pricing policies to level off congestion in peak hours and technological improvements, such as electric mobility, which may sever the link between car travel and environmental damage.

Although other policies may be more effective in the short term, urban sprawl needs to be prevented as this has long lasted impacts. Further concentration and densification do not reduce the need to travel as people tend to spend the benefits of shorter distances on satisfying their latent travel demand, but they do help to reduce car use. The challenge facing planners is to design cities and neighbourhoods that make it easier for people to drive less and are attractive to live in at the same time.

The Dutch policy may focus more on the benefits of the urban network in the Randstad. Therefore less focus on the accessibility in neighbourhoods and distance reduction, but more on the accessibility of the nodes in the transportation network and mode shift. Profits can be achieved by modal shift from passive to active transport and a more efficient public transport. Furthermore, more attractive built environments around stations help to let people travel more by feet or bicycle (Molster & Schuit, 2009).

3.3 Accessibility

Definition of accessibility

Accessibility becomes more and more essential in land-use and transport decisions, thus having significant economic, social and environmental implications (Geurs & Ritsema van Eck, 2001). Jointly with positive externalities such as investments or a favourable policy environment, accessibility influences the organisation and the dynamics of regions and, consequently, the location of activities and individuals (Bavoux et al., 2005).

Accessibility is a frequently-used concept but there is no consensus about its definition and formulation. It is a common term experienced by diverse individuals (i.e. characterised by different needs, abilities and opportunities) at any place and moment of the day, which results in considerable variation in components included in the measure, and in how it is formulated. Accessibility is commonly defined as the ease with which activities can be reached from a certain place and with a certain system of transport (Van den Bulcke et al., 2009).

Accessibility is determined by the spatial distribution of potential destinations, the ease of reaching each destination, as well as the magnitude, quality and character of the activities found there. Geurs and Ritsema van Eck (2001) formulated a very complete definition of the concept: according to them, accessibility reflects “the extent to which the land-use transport system enables (groups of) individuals or goods to reach activities or destinations by means of a (combination of) transport mode(s)”. The concept
of accessibility is determined by four interdependent components: a transport component (transport system), a land-use component (the magnitude, quality and characteristics of activities found at each destination), a temporal component (availability of activities) and an individual component (needs, abilities and opportunities of individuals).

Fig. 17 shows the relationships between these components and accessibility (as defined above), and relationships between the components themselves: here, the land-use component (distribution of activities) is an important factor in determining travel demand (transport component) and may also introduce time restrictions (temporal component) and influence people’s opportunities (individual component) (Geurs & van Wee, 2004).

Table 3 Perspectives on accessibility and components (Geurs & van Wee, 2004).

<table>
<thead>
<tr>
<th>Measure</th>
<th>Component</th>
<th>Land-use component</th>
<th>Temporal component</th>
<th>Individual component</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Infrastructure-based</strong></td>
<td><strong>Transport component</strong></td>
<td>Travelling speed; vehicle-hours lost in congestion</td>
<td>Peak-hour period; 24h period</td>
<td>Trip-based stratification, e.g. home-to-work business</td>
</tr>
<tr>
<td>Location-based measures</td>
<td>Travelling time and or costs between locations of activities</td>
<td>Amount and spatial distribution of the demand for and/or supply of opportunities</td>
<td>Travel time and costs may differ, e.g. between hours of the day, between days of the week, or seasons</td>
<td>Stratification of the population (e.g. by income, educational level)</td>
</tr>
<tr>
<td>Person-based measures</td>
<td>Travel time between locations of activities</td>
<td>Amount and spatial distribution of supplied opportunities</td>
<td>Temporal constrains for activities and time available for activities</td>
<td>Accessibility is analysed at individual level</td>
</tr>
<tr>
<td>Utility-based measures</td>
<td>Travel costs between locations of activities</td>
<td>Amount and spatial distribution of supplied opportunities</td>
<td>Travel time and costs may differ, e.g. between hours of the day, between days of the week, or seasons</td>
<td>Utility is derived at the individual or homogeneous population group level</td>
</tr>
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</table>

Measurement of accessibility.
Following the definition of accessibility of Geurs and Ritsema van Eck (2001), an accessibility measure should ideally take all components and elements within these components into account. In practice, applied accessibility measures focus on one or more components of accessibility, depending on the perspective taken.

Four basic perspectives on measuring accessibility can be identified (Table 3).

1. Infrastructure-based measures analyse the observed or simulated performance of the transport infrastructure. Typical are the level of congestion or the average speed on the road network. Such measures provide comprehensible information about the service level of transport infrastructure and are easy to operationalise (e.g. the necessary data are
Fig. 17 Relationships between components of accessibility (Geurs & Van Wee, 2004)
often readily available and measures are easy to understand by planners, policy makers or researchers), but they do not include a land-use component (e.g. they are not sensitive to changes in the spatial distribution of activities) and they are not able to treat temporal constraints as well as individual characteristics (Geurs and Ritsema van Eck, 2001; Geurs and van Wee, 2004).

2. Activity-based measures analyse accessibility at locations on a macro-level, i.e. the range of available activities with respect to their distribution in space and time. Also more complex measures include capacity restrictions of supplied activity characteristics to include competition effects (e.g. competition for job vacancies or hospital beds; see e.g. van Wee et al., 2001).

3. Person-based measures (also called space-time accessibility measures), analyse accessibility at the individual level (i.e. on a micro-level) and assume that “accessibility applies to a particular individual at a particular time and place” (Helling, 1998). This type of measure is founded in the space-time geography of Hägerstrand (1970) that measures limitations on an individual’s freedom of action in the environment, i.e. the location and duration of mandatory activities, the time budgets for flexible activities and travel speed allowed by the transport system.

4. Utility-based measures, analysing the economic benefits (e.g. consumer surplus) that people derive from access to the spatially distributed activities. This approach estimates the accessibility at the individual level and accounts not only for users’ characteristics (e.g. income) but also for modal characteristics (e.g. travel costs; Geurs and Ritsema van Eck, 2001).

The five criteria which an accessibility measure should meet keeping all other conditions constant:

1. If the service level (travel time, costs, effort) of any transport mode in an area increases (decreases), accessibility should increase (decrease) to any activity in that area, or from any point within that area.

2. If the number of opportunities for an activity increases (decreases) anywhere, accessibility to that activity should increase (decrease) from any place.

3. If the demand for opportunities for an activity with certain capacity restrictions increases (decreases), accessibility to that activity should decrease (increase).

4. An increase of the number of opportunities for an activity at any location should not alter the accessibility to that activity for an individual (or groups of individuals) not able to participate in that activity given the time budget.

5. Improvements in one transport mode or an increase of the number of opportunities for an activity should not alter the accessibility to any individual (or groups of individuals) with insufficient abilities or capacities (e.g. drivers licence, education level) to use that mode or participate in that activity.

Geurs and van Wee (2004) conclude that the current practice of accessibility evaluation of land-use and transport strategies can be much improved by operationalising more advanced accessibility measures that are still relatively easy to interpret for researchers and policy makers, and can be computed with state-of-the practice data and/or land-use and transport models.
3.4 Criteria bicycle and pedestrian routes
In this section a review of literature is given with criteria for pedestrian and bicycle routes to encourage active transport behaviour.

The city life has changed; the industrial society’s essential city life has developed to the elective city life of a leisure and consumer society. City life was once a necessity and taken for granted, but today it is an option. The quality of a city space plays an important role in the activities people do. City space must be carefully designed to invite walking, cycling and staying, encouraging people to join in the common life of the city.

Figure 18 illustrates the dramatic changes in the character of city life during the 20th century. Necessary work-related activities dominated around 1900. The streets were crowded with people, most of whom have to use city space for their daily activities. The picture has changed appreciably by the year 2000. Necessary activities play only a limited role because the exchange of goods, news and transport has moved indoors. In contrast, optional recreational activities have grown exponentially. Where the city once provided a framework almost exclusively for work-related daily life, the city hummed with leisure- and consumer-related activities in 2000. Recreational activities set high standards for the quality of city space, and can be roughly divided into two categories: 1) passive staying activities such as stopping to watch city life from a stair step, a bench or a café, and 2) active, sporty activities like jogging and skating. The time line also shows when the car invasion hit the Netherlands in the mid-1950s. The pressure of car traffic and functional planning in the 1960s triggered a counter-reaction to reclaim city space. In the following 40 years this reaction was reinforced, and developed nationally and internationally in an ongoing process (Gehl et al, 2006).

Walking is the first and foremost type of transportation, a way to get around, but it also provides an informal and uncomplicated possibility for being present in the public environment (Gehl et al, 2006). One walks to do an errand, to see the surroundings, or just to walk. The act of walking is often a necessary act but can also merely be an excuse for being present – “I will just walk by.”

Common to all forms of foot traffic are a number of physically and physiologically determined demands on the physical environment. Walking demands space; it is necessary to be able to walk reasonably freely without being disturbed, without being pushed, and without having to manoeuvre too much. The problem here is to define the human level of tolerance for interferences encountered during walking so that spaces are sufficiently narrow and rich in experiences, yet still wide enough to allow room to manoeuvre.

Pedestrian traffic is quite sensitive to pavement and surface conditions. Cobblestones, sand, loose graven, and an uneven ground surface are in most cases unsuitable, especially for those who have walking difficulties. Adverse surface conditions can also have a negative influence on pedestrian travel in general. People avoid wet and slippery pavements, water, snow, and slush whenever possible. Those with walking problems are particularly inconvenienced under such circumstances.
Fig. 18 Development of city life from 1880 to 2005 (Gehl et al, 2006).
Walking is physically demanding, and there are narrow limits as to how far most people can or will walk. In a large number of surveys, the acceptable walking distance for most people in ordinary daily situations has been found to be around 400 to 500 meters. For children, old people, and disabled people, the acceptable walking distance is often considerably less.

Crucial to determining the acceptable distance in a given situation is not only the actual physical distance, but also to a great extent the experienced distance. A stretch of 500 meters viewed as a straight unprotected and dull path is experienced as very long and tiring, while the same length can be experienced as a very short distance if the route is perceived in stages. Acceptable walking distances thus are an interplay between the length of the street and the quality of the route, both with regard to protection and stimulation en route.

Walking routes
The fact that it is tiring to walk makes pedestrians naturally very conscious of their choice of routes. People reluctantly accept large deviations from the determined main direction, and if the goal is in sight, they tend to steer directly toward it.

Whenever people walk, they prefer direct routes and shortcuts. Only very great obstacles, like dangerous traffic, extensive barriers, and so on, seem to be able to interrupt this pattern.

The main rule for pedestrian traffic and differences in level, then, is that variations in level should be avoided whenever possible. If it becomes necessary to direct pedestrians up or down, then ramps, not stairs, should be used.

The important quality criteria for use of city space are mentioned by Gehl et al. (2006). The criteria are divided in protection, comfort and enjoyment (Fig.19).

Protection
Protection expresses the need to be kept safe from accident, insecurity and discomfort. Traffic is an important factor. Good city spaces provide such good traffic safety that we do not have to fear being run over or remain on constant alert, with children firmly in hand and so on. In short, good city spaces provide good conditions for pedestrian traffic.

Another criterion that falls under protection is crime prevention to ensure a genuine sense of security when we move around the city. Dark, deserted spaces and streets often promote a feeling of insecurity. For places to feel safe there have to be people around with things to do. This is best achieved by the presence of diverse functions: housing, offices, shops and restaurants, so that there are lights in the windows and people nearby at all times of night and day.

The third factor deals with protection against uncomfortable sensory experiences such as unpleasant smells, pollutions or adverse weather conditions (Gehl et al, 2006).
Comfort
Opportunities to participate in a variety of activities and experience the surroundings rest on how city space is designed to facilitate basic human activities under good conditions. Pedestrians need to move freely, as well as stand and sit where it feels good and natural (Gehl et al, 2006).

Enjoyment
Creating thoroughly enjoyable spaces is highly dependent on utilizing the qualities, attractions and special opportunities found in and around city spaces. It is vital to create city spaces on a human scale, with fine details, good materials and good street furniture. Good city space must also provide opportunities to enjoy the positive aspects of the local climate. Finally city space should offer good experiences, great views and interesting sensory impressions (Gehl et al, 2006).

Fig. 19 Key quality criteria (Gehl et al, 2006).
Alfonzo (2005) investigated the relationship between urban design, walkability, and sense of place and community. The article of Alfonzo offers a social-ecological model of walking that presents a dynamic, causal model of the decision-making process. Within the model a hierarchy of 5 levels of walking needs influences the walking decision-making process (Fig.20).

Many factors are believed to influence a person’s level of physical activity. The conceptual model outlined, using a social-ecological framework, posits that individual, group, regional, and physical environmental variables affect an individual’s choice to walk. The hierarchy of walking needs model posits that there are five levels of needs that are considered within the walking decision-making process. These needs progress from the most basic need, feasibility (related to personal limits), to higher-order needs (related to urban form) that include accessibility, safety, comfort, and pleasurability, respectively. Within this hierarchical structure, an individual would not typically consider a higher-order need in his or her decision to walk if a more basic need was not already satisfied (Alfonzo, 2005).

Individual-, group-, and regional-level attributes may all moderate the relationship between the hierarchy of walking needs and a person’s decision to walk. A person’s psychological health, expectations, motivations, and other psychological, cognitive, or emotional-level attributes may all affect the point on the hierarchy at which a person decides to walk. Similarly, attitudes toward driving or attachment to a car as the primary means of transportation may affect the number of levels that must be met for a person to decide to walk.

Five levels of walking needs by Alfonzo (2005), Fig. 20.

Feasibility
Feasibility refers to the practicality or viability of a walking trip, but is a walking trip feasible? For destination trips, feasibility factors may affect the choice between walking and other forms of transportation, taking in consideration mobility, time, or other responsibilities. Mobility factors may be affected by a person’s age, weight, or physical condition. Limited mobility may make a walking trip unfeasible. Similarly, limited time may limit feasibility and may ultimately affect a person’s decision to walk. Responsibility for children, elderly, or other commitments may also reduce feasibility.

Accessibility
Accessibility encompasses the pattern, quantity, quality, variety and proximity of activities present, as well as the connectivity between the uses (Handy, 1996). Accessibility factors may include the presence of sidewalks, paths, and trails of features that provide perceived paths on which to walk. Accessibility may also involve actual or perceived barriers to walking, including physical barriers such as an impenetrable land use, natural feature, or a psychological barrier to access. Accessibility may also include
the number of destinations available within a reasonable walking distance as well as the integration of various land uses within a specified area. Factors related to accessibility have been found to affect walking behaviour. For example, neighbourhood proximity to commercial areas and the presence of links between residential and commercial areas are associated with the frequency of non-work destination trips (Alfonzo, 2005).

Safety
If both feasibility and accessibility needs are met, then the person can begin to consider the next need – safety. Safety refers to whether a person feels safe from the threat of crime. A person’s level of safety may be affected by urban form, particular land uses, and the presence of certain groups or individuals.
Urban form features that may contribute to feelings of safety include graffiti, litter, abandoned or run-down buildings, and the presence or absence of threatening groups may also contribute to a person’s level of safety within his or her neighbourhood. The number of street lights, the presence of yard decoration, block watch signs, and private plantings have all been negatively related to fear of crime (Alfonzo, 2005).

Comfort
Once feasibility, accessibility, and safety needs have been met, a person may consider the next level of need – comfort. Comfort refers to a person’s level of ease, convenience, and contentment. A person’s satisfaction with comfort for walking may be affected by environmental qualities that either facilitate walking or remove factors that might make the walk distressing. Overall, the qualities that may affect comfort levels include urban form features that affect the relationship between the pedestrian and motorized traffic (e.g., traffic calming elements, speed limits, the width and length of streets, and the presence of buffers), the condition of the pedestrian walkway system (e.g., sidewalk widths and sidewalk maintenance), urban design elements intended to offer protection from unfavourable or extreme weather conditions (e.g., canopies and arcades), and features that provide amenities throughout a setting (e.g., street benches, drinking fountains, and other street furniture). Sidewalk comfort has also been linked to higher walking rates (Alfonzo, 2005).

Pleasurability
If the first four levels of the hierarchy are met, a person may consider an area’s pleasurability features in his or her decision to walk. Pleasurability refers to the level of appeal that a setting provides with respect to a person’s walking experience. Pleasurability is also related to how enjoyable and interesting an area is for walking (Alfonzo, 2005).

Diversity, complexity, liveliness, architectural coherence and scale, and aesthetic appeal may all affect a person’s level of satisfaction with pleasurability. Streetscapes, urban design features, architectural elements, and the activity level of a setting may enhance these qualities. Specifically, some factors that may make for a pleasurable environment include street trees, mixed uses, public spaces, other people, attractive or interesting architecture, historic or unique buildings, colour, and outdoor dining areas, among others.

The Hierarchy of Walking needs model, along with the overall social ecological model of walking, underscores the important fact that there is not one universal remedy to stimulate walking. A variety of individual, group, regional, and physical-environmental factors come into play. Therefore it is imperative that policy makers consider their settings and populations carefully and adopt a multilevel approach to program interventions aimed at increasing walking.
Walking routes criteria

Feasibility
• Mobility
• Time
• Responsibility

Accessibility
• The pattern, quantity, quality, variety and proximity of activities present
• Connectivity between uses
• Walking related infrastructure

Safety
• People present
• Types of land uses

Comfort
• Presence of traffic calming features
• Pedestrian walkway system and street network
• Urban design amenities

Pleasurability
• Presence of a varied streetscape
• Liveliness (activity level)
• Presence of other people
Criteria Bicycle routes
Riding a bike has many advantages over driving a car. A bike can be stored easier than a car, a bike is cheaper, has a positive effect on the user’s health and reduces environmental and noise pollution (Scheepers et al, 2014). The bike is very well suited for different kinds of movement purposes. Because of the increased use of bikes, congestion problems in cities decreased. Also a bike can be used perfectly in combination with public transport. Especially for students a bike is a solution when they do not want to be completely dependent on public transport and owning a car is not feasible.

Bicycle friendly network needs (Sens, 2013)
1. Cohesion,
2. Immediacy,
   • Avoid loss of time.
3. Attractiveness (pleasureability),
4. Safety
   • Avoid conflicts with crossing traffic.
   • Separate vehicle types.
   • Avoid conflicts with oncoming traffic.
   • Reduce speed on conflict issues.
   • Provide recognition.
   • Provide uniform traffic situations.
5. Comfort
   • Avoid bends in the road.
   • Provide a level of surface.
   • Minimize slope disturbance.
   • Minimize weather nuisance.

Categorize the bicycle paths to their different function
• Non-local routes or a nationwide cycle network
  This network forms an enclosed network.
• The main routes which connect the most important destinations and facilities. These routes are used intensively and are an important part of the bicycle network in the city.
• Local routes which connect the neighbourhood facilities.

The bicycle is used to travel to locations to work, learn, recreate, shop or to go to/from public transport facilities. The road network can be divided into three categories (Fig.25).
• Flow roads are for a continuous, uninterrupted traffic flow with a relatively high speed. These roads are not suitable for cyclists. The cycle path should physically be separated from the roadway.
• Distributor roads are roads which have a function to flow and exchange. When a bike path is separated from the road section, it is suitable for cyclists.
• Residential roads are meant for providing access to home zones. These roads are suitable for cyclists.

For identification of the bicycle network, an integral style is devised (Fig.21-24). This style has to ensure that the network of bicycle paths gets known by more inhabitants. To make bicycling as comfortable and as nice as possible several devices can be added to increase bicycle comfort and bicycle environment. Next to this the municipality should be advised how to implement these criteria by reconstructing the network.
Fig. 21 Cycle street (Gemeente Hilversum, 2015)

Fig. 22 Bicycle path (Fietsersbond, 2015)

Fig. 23 Bicycle lane next to a road (Zonnigzeezicht, 2012)

Fig. 24 Bicycle lanes (Reindonk, 2015)
Fig. 25 Road categories (Sens, 2013)

<table>
<thead>
<tr>
<th>Road categories</th>
<th>Flow road</th>
<th>Distributor road</th>
<th>Residential road</th>
<th>Park etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed limit in Km/h</td>
<td>≥ 100</td>
<td>50</td>
<td>&gt; 50</td>
<td>30</td>
</tr>
<tr>
<td>Traffic intensity (mv/day)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of bicycle path</td>
<td>Not appropriate</td>
<td>Bicycle path</td>
<td>Parallel</td>
<td>Not appropriate</td>
</tr>
<tr>
<td>Bicycle lanes</td>
<td>1</td>
<td>2</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Minimum width bicycle lane in meters</td>
<td>2.00</td>
<td>2.40</td>
<td></td>
<td>1.60</td>
</tr>
</tbody>
</table>
3.5 Conclusion
As stated in this chapter, a promising way to stimulate physical activity is to promote the choice for active modes of transport like walking and cycling. Travelling by bicycle brings a number of benefits: it can lead to reductions in air pollution and traffic jams, and increases people’s physical activity levels.
To reduce the environmental burden of urban road traffic researchers and policy-makers have focused on reducing car use in urban areas, and improving public transport.
The challenge that is facing planners is to design cities and neighbourhoods that make it easier for people to drive less and are attractive to live in at the same time. Profits can be achieved by modal shift from passive to active transport and a more efficient public transport.
Accessibility reflects “the extent to which the land-use transport system enables (groups of) individuals or goods to reach activities of destinations by means of a (combination of) transport(s)”. Four basic perspectives on measuring accessibility can be identified: Infrastructure-based, activity-based, person-based and utility-based measures.
Walking is physically demanding, and there are narrow limits as to how far most people can or will walk. An acceptable walking distance for most people in ordinary daily situations has been found to be around 400 to 500 meters. The acceptable walking distances are an interplay between the length of the street and the quality of the route, both with regard to protection and to stimulation en route. Five levels of walking needs are feasibility (mobility, time, responsibility), accessibility (activities, connectivity between uses, infrastructure), safety (people present, types of land-uses), comfort (traffic calming features, pedestrian walkway), pleasurability (varied streetscape, liveliness, presence of other people).
Riding a bike has many advantages over driving a car. A bike can be stored easier than a car, a bike is cleaner, has a positive effect on the health of the user and reduces environmental and noise pollution.
4. Analysis

The purpose of this study is to improve the existing transportation infrastructure in Amsterdam South East, Diemen and Duivendrecht in order to improve the accessibility of main services and stimulate more sustainable transportation choice behaviour of the inhabitants, taking into consideration new transportation modes. In order to improve the accessibility of main services (schools, shops, offices) in the study area the existing transportation infrastructure will be analysed. In this chapter the approach of the accessibility analyses with help of OViN (Onderzoek Verplaatsing in Nederland) data will be explained. To perform the accessibility analyses the study area is mapped by means of a GIS: infrastructure for different transportation modes, residential neighbourhoods, facilities and land uses. The infrastructure is layered in pedestrian network, bicycle network, roads and railway tracks for train, and tram line.

4.1 Study Area

GIS is used to map the transportation network, to map the most important destinations in and around the study area and to assess the accessibility of these destinations (Fig.26). In the literature (Chapter 2) the definition of accessibility has been discussed (Geurs & Van Wee, 2004). Also important variables in the transportation mode choice behaviour, namely distance to nearest public transport stop (metro/bus/train) or destination, the travel time, travel costs, waiting times and number of transfers have been listed (Maat, 2009). This research will take into account the travel time, distance and mode of transport to measure the accessibility of the main facilities.

The main facilities in the study area are clustered in the different city districts. Three shopping centres are located in the Bijlmermeer: the Amsterdamse Poort, Kameleon (near metro station Kraaiennest), and Ganzenhoef. In Duivendrecht the supermarkets and other shops are located near the Dorpsplein, the Kruidenhof is located in Diemen Zuid, and the Diemerplein can be found in the centre of Diemen. Primary schools, high schools and higher education are spread in the area, see Fig. 27.

4.2 OVIN Data Analysis

The OVIN data (Onderzoek Verplaatsing in Nederland) is part of mobility research in the Netherlands. CBS has been investigating the mobility of inhabitants of the Netherlands since 1978. Between 1978 and 2004 the name of the research was Onderzoek Verplaatsingsgedrag (OVG). In 2004 the research became executed by Rijkswaterstaat, Dienst Verkeer en Scheepvaart. The name of the research changed into Mobility Research Nederland (MON). Since 2010 the mobility research is executed by CBS, now under the name OVIN. The OVIN data exists of respondents who write down their transport behaviour for one day. People are asked to keep track for that day where they are going to.
Fig. 26. Transportation infrastructure of the study area mapped by transCAD.
27. Facilities in the study area

- Supermarket
- Primary school
- Higher education
The participants also indicate which mode of transport (e.g. walking, cycling, car or train) they used, where the trip was going, the time of departure and arrival, and how far it was (the distance).

The OViN data includes the most used transport modes in the study area. After analysing the data a policy can be made to facilitate the mode shift to active transport. Different scenarios are possible. If the public transport is underused the accessibility to public transport hubs has to be improved. If the car is used for trips which could be easily done by bicycle, the bicycle routes have to be checked and revised.

The 2013 OViN dataset has the size of 135762 respondents with 159 variables in the Netherlands. After selecting the respondents with departure ZIP codes (Fig. 28) located in the study area of Diemen, Duivendrecht and Bijlmer (Amsterdam South East), the dataset is reduced to 539 respondents.

The most popular destinations will be mapped and tested on their accessibility. The walkability and bicycle routes around public transportation hubs and the main facilities will be investigated. The average distance of trips with a bicycle is 2.3 km, commuters cycle around 10km. The e-bike is an emerging vehicle and used more by commuters. The e-bike enlarges the radius and maximises the accessibility (Rose, 2011). The radius of an e-bike will be around 20km. The car has the greatest radius of these transportsations modes. The weather and traffic congestion influence the transport mode choice behaviour. At a rainy day more people will use their car or public transport. Different weather conditions and the influences on the transport choice behaviour are ignored in this research.

The main destinations in the study area where most services can be found are the areas Bijlmermeer, Bullewijck, Duivendrecht, Diemen Zuid, Diemen and Diemen Noord. In the daily urban system the most important trips are to the supermarket (AH, Lidl, Jumbo, Aldi), to a primary school, high school or higher education (UVA, HvA: Hogeschool van Amsterdam, ROC). The most important business districts are Bullewijck, Arena Boulevard, Overamstel, and Verijn Stuart. The nearest hospital is the Academic Medical Centre (AMC) Amsterdam. Inhabitants can visit the Bijlmer Park, Bijlmerweide, Amsterdamse Poort, Amsterdam Arena, Ziggo dome, Heineken Music Hall, cinema Pathé or sports clubs.
The OViN data shows the destinations of the inhabitants. The most visited destinations are mapped in figure 29. The most trips are made in the study area. On city scale the inner city of Amsterdam (Damrak and area around Rembrandplein), the Zuid-as (business district), Nellestein (Gaaserdam), Almere, Purmerend-zuid and Hoofddorp are the most chosen destinations. After analysing the data and the accessibility a policy can be made to facilitate the mode shift to active transport.

Transport mode choice behaviour of the inhabitants of Amsterdam South East is shown in Table 4. Most trips are done by car as either passenger or driver. The second mode of transport is public transport. The public transport is used by 36% of the inhabitants. This indicates adequate available services of the transport companies GVB, NS and R-Net. Notable is the use of the bicycle as transport mode; 10.8% choose the bicycle as transport mode.

More than 55% of those who own both a car and a bicycle choose the car as mode of transport. 92% of the households owns one or more bicycles and around 12% is in possession of an electric bicycle (Bosch, 2014).

15 users have chosen the car as transport mode when making short trips of 1 kilometer or less. 11 people have chosen to use the car when making trips with a length of 2 kilometers. Trips of 2km or less could easily be done by bicycle, but the user has chosen to take the car instead. This may be because of lacking accessibility and further investigation is needed to confirm this.

Furthermore, the results of the data analysis shows that public transport is used frequently and more attention has to be given to the bicycle users. Cycling is a sustainable mode of transport and is beneficial to the health of the bicyclist and the environment.

<table>
<thead>
<tr>
<th>Transport mode</th>
<th>percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>39.8</td>
</tr>
<tr>
<td>Driver</td>
<td>29.5</td>
</tr>
<tr>
<td>Passenger</td>
<td>10.3</td>
</tr>
<tr>
<td>Public Transport</td>
<td>36.1</td>
</tr>
<tr>
<td>Train</td>
<td>17.6</td>
</tr>
<tr>
<td>Bus/tram/metro</td>
<td>18.5</td>
</tr>
<tr>
<td>Bicycle</td>
<td>10.8</td>
</tr>
<tr>
<td>By feet</td>
<td>11</td>
</tr>
<tr>
<td>Other</td>
<td>2.3</td>
</tr>
</tbody>
</table>
Fig. 29 Main destinations around the study area (OVIN, 2013).
4.3 Accessibility analysis

Accessibility of main facilities will be measured with help of TransCAD. At neighbourhood level the facilities are supermarkets, primary schools, public transport stops. At greater scale the facilities are metro stations, train stations, shopping areas, leisure areas (e.g. ArenA boulevard, Bijlmerweide), secondary schools, and work locations Amstel III and Bullewijk.

The accessibility analyses will be performed for pedestrians with a distance of 400 metres, bicycles a distance of 2000 metres to a public transport stop or destination in the neighbourhood and 10-20km to work (commuters) or other destination by e-bike.

At neighbourhood level the facilities will be checked whether they are reachable by feet (400m) and by bicycle (2km). The actual distance in meters and the shortest distance in meters on a map (bird’s eye distance) will be measured. The accessibility of greater distances (city level) will be measured by examining the travel distance by bicycle (10km), e-bike (20km) and public transport (bus/tram/metro/train) and will then be compared with the travel time by car. The introduction of the e-bike asks for a new policy and design rules of the public space. E-bikes go faster than conventional bikes. The e-bike is interesting for commuters in the metropolitan area, because in rush hour the commuter is often faster than by car. Therefore, the e-bike could be a feasible alternative to the car and public transport.

Figure 30 shows the service areas of the public transport hubs in and around Amsterdam South East by bicycle (2km) in purple and by feet (400m) in yellow around train stations. Around metro stations a bicycle distance of 1km is drawn. The organisation of the public transport is mapped in Fig. 31. The accessibility is not fully covered in the south east of the Bijlmer. In section 5.3 have been worked out an intervention to improve the accessibility in the south east of the Bijlmer. The Bijlmer park is located in the middle of the area. The next step is to look closer at the accessibility by bicycle and the walkability around the transport hubs Bijlmer Arena, Duivendrecht, Diemen and Diemen Zuid.
Fig. 31 Organization of public transport in Amsterdam South East (GVB, 2014).
Figure 32 shows the service area of train and metro stations in Amsterdam South East, Diemen and Duivendrecht. Figure 33 shows the most important destinations in and around Amsterdam South East, Diemen and Duivendrecht. The accessibility of the stations in the study area has been analysed, the results are shown in Fig. 34-37. The sphere of influence around stations is the area were people who work or live in will walk to the station. Designers and policy makers who use this approach assume an open space with equal distances, but in reality the area is smaller, due to buildings and other barriers, waiting time at traffic lights and walking speed (Molster & Schuit, 2012).
The service area of the shopping centres Amsterdamse Poort, de Kameleon, Ganzenhoef, Duivendrecht, Kruidenhof and Diemerplein in Diemen and the accessibility of these destinations is shown in Figure 38. To look closer to the surroundings of these destinations the accessibility, the position of the entrance, parking places and conflict points with other traffic by car, bicycle and feet have been checked.

Figure 39 shows the Amsterdamse Poort and the Arena Boulevard, Figure 40 shows the Kameleon near metrostation Kraaiennest, Figure 41 shows Dorpsplein in Duivendrecht and Figure 42 shows the Kruidenhof in Diemen Zuid and the Diemerplein in Diemen.
Fig. 34 Accessibility of station Duivendrecht.

Fig. 35 Accessibility of station Amsterdam Bijlmer Arena.
Fig. 36 Accessibility of station Diemen

Fig. 37 Accessibility of station Diemen Zuid.

Fig. 38 Service area of the shopping centres.

Fig. 39 Service area of the Amsterdamse Poort.
The shopping centre the Kameleon in Figure 40 does not serve the whole area. The residential area around the Kantershof in the K-neighbourhood is located outside the service area. The ‘s-Gravendijkdreef is a barrier and difficult to cross. By shorten the distances by feet and bicycle and improve the crossing with the ‘s-Gravendijkdreef the accessibility improve.

The dorpsplein in Duivendrecht and the Kruidenhof and Diemerplein in Diemen covers the area and serve the residents. Enough parking space around, the entry is easily accessible by feet and bicycle parking places are present.
Primary schools are spread equally over the study area. The schools are all accessible by bicycle, feet, public transport and car. Every school has a metro or train station within two kilometer.

Amsterdam South East is well accessible by public transport. Optimization of the public transport system is not needed, because the average use of the public transport in the study area is higher than in most other parts of Amsterdam (Gemeente Amsterdam, 2015). The bicycle is under used in Amsterdam South East. By improving the bicycle network and shorten the distances between destination more inhabitants will use the bicycle.

The bicycle structure has to be revised at some points. A few bottle necks in the bicycle network came forward during the accessibility analysis. The travel time could be improved by adapting the bicycle routes and at several points construct a new bicycle path to shorten the cycle distances (Fig. 44). In the neighbourhoods itself short cuts and attractive walking routes are necessary for the accessibility and liveability of the residential areas.
4.4 Conclusions
The 2013 OVIN data shows that nearly 40% of the transportation in the study area is made by car. 36% of the people use the train, metro or bus, 11% use a bicycle as transportation mode and nearly 11% walked. The main destinations outside the study area are the inner city of Amsterdam (Damrak and area around Rembrandplein), the Zuid-as (business district), Nellestein (Gaaserdam), Almere, Purmerend-zuid and Hoofddorp.
The accessibility and mixed functions around train station Bijlmer Arena is positive. The car infrastructure used to be dominant in the Bijlmer. With interventions such as lowering parts of the Bijlmerdreef, the ‘s-Gravendijkdreef and the Karspeldreef, first steps have been made to integrate the bicycle- and pedestrian network to the main routes in Amsterdam South East. Duivendrecht with its train station and 3 metro stations (Venserpolder, Duivendrecht and Van der Madeweg) is a well connected settlement in the metropolitan region Amsterdam. In Diemen the inner city of Amsterdam, the Zuid-As (business district) and Schiphol are easy to reach by public transport because of two train stations (Diemen and Diemen Zuid), 3 metro stations (Diemen Zuid, Verrijn Stuartweg and Venserpolder) and tram line 9 (which connects Diemen (Sniep) to Amsterdam central station).
Although the bicycle infrastructure covers the area, there are still some missing links and improvements needed to reduce travel time and lower the distances. The introduction of the e-bike asks for a new policy and design rules for the public space. E-bikes go faster than normal bikes. The e-bike is interesting for commuters in the metropolitan area. In rush hours the commuter is probably faster by e-bike than by car. However design rules by traffic planners and the government are missing. In the next chapter more attention is given to the implementation of the e-bike in the transport infrastructure.
5. Spatial Plan

In this section the results of the analyses will be translated in design criteria for pedestrian and bicycle routes. In addition, a strategy that shows how policymakers could integrate newer transport modes in their policy will be presented. Three interventions at three scale level are worked out to improve the transport infrastructure.

5.1 Vision
Sustainable transport is important to keep the city accessible and its inhabitants healthy. Furthermore, active transport has to be stimulated. A solid bicycle network with good connections between the neighbourhoods and main destinations is important. A threat is the increasing level of obesity, which is mostly the result of an unhealthy lifestyle. One of the keys to more physical exercise is active transport, such as transport by feet or bicycle. Active transportation helps to lower in cholesterol levels and the probability of being obese. Active transport can be a feasible way to add exercise into a daily routine, and building cities in order to support active transportation could be an effective policy intervention. In this way governments might be both able to improve the lives of their citizens and save money on healthcare expenditures (Schauder & Foley, 2015). In older parts of the city the bicycle and walking network has to be revised, in order to contribute to the accessibility and service level.

5.2 Design criteria for redeveloping bicycle and pedestrian routes
Criteria for bicycle and pedestrian should be used to revise the existing bicycle and pedestrian network and improve the routes. There are two key considerations: firstly, street user hierarchy should consider pedestrians first and private motor vehicles last. Secondly, street design should be inclusive, providing for all people regardless of age or ability (The Scottish government, 2010).

Pedestrians
There are a number of general principles which should be observed in the design of crossing places as follows:
- Consideration should be given to the raising of crossings, of whichever type to footway height where possible. Footway surfacing of contrasting colour should be used to demonstrate pedestrian priority and tactile paving should be used to indicate the change in condition to visually impaired pedestrians.

- Pedestrians refuges and kerb build-outs, used separately, or in combination, effectively narrow the carriageway and so reduce the crossing distance.

- Footbridges and subways should be avoided; they are usually unsuccessful and create hostile environments – the ground level should be prioritized for pedestrians.
- Pedestrian’s desire lines should be kept as straight as possible at side-street junctions. Small corner radii minimise the need for pedestrians to deviate from their desired line (Fig. 45) (The Scottish government, 2010).

Any footway should be fit for purpose, but should give primary importance to creating positive, attractive spaces. There is no maximum width for footways. In lightly-used streets (such as those with a purely residential function), the unobstructed width for pedestrians should generally be 1.5-2 m, however this can be varied to accommodate character and practical requirements. Additional width should be considered between the footway and a heavily used carriageway, or adjacent to gathering places, such as schools and shops (The Scottish government, 2010).

Green and outdoor furniture should be provided to stop along the route. In a neighbourhood setting, street trees provide shade, safety, greenery, storm mitigations, energy savings, fresh air and a haven for songbirds and squirrels. Trees visually screen utility poles and concrete sidewalks, and they help to quiet street noise. Trees can be planted in tree wells, between sidewalks and streets and in curb extensions and refuge islands (The Scottish government, 2010).

Fig. 45 the effect of corner radii on pedestrians (Devon city council, 2010).
In many communities, lighting is installed on very high poles in order to light the street for safety and visibility of motor vehicles. Pedestrian-scaled lighting illuminates sidewalks, bus stops, seating areas, paths and other walking and bicycling features (Fig.46).

Allocate way-finding signs to improve the orientation. Using travel time instead of travel distances accompanied by maps in orientation direction makes it easier to navigate (Fig.47).

Design criteria for bicycle routes

Cyclists are more likely to choose routes that enable them to keep moving. Routes that take cyclists away from their desire lines and require them to concede priority to side street traffic are less likely to be used. Designs should contain direct and barrier-free routes for cyclists.

The design of junctions affects the way motorists interact with cyclist. It is recommended that junctions are designed to promote slow motor-vehicle speeds. This may include short corner radii as well as vertical deflections (The Scottish government, 2010).
A solid bicycle network requires (Sens, 2013):

• Comfort: quality pavement, avoid loss time
• Safety: avoid conflicts with crossing traffic, separating bicycle types, reduce speed on conflict issues.
• Cohesion
• Distinction between fast and slow bicycle traffic.
• Provide recognition; introduction of wayfinding signs.

The different bicycle roads could be divided in three different categories. The first category involves non-local bicycle routes (part of the national bicycle network). The second relates to the main routes, which connect the most important destinations and facilities. These routes are used intensively and area an important part of the bicycle network in the city. The third refers to local routes, which connect the facilities of the neighbourhood. The different bicycle categories of Amsterdam South East can be found in Fig. 48.

E-Bike
The electric bike is an emerging vehicle type within the context of sustainable transport. With greater range and enhanced performance the e-bike as transport mode is becoming increasingly popular (Rose, 2011). Governments could employ a range of police instruments to respond to the opportunities and threats presented by these vehicles, but a policy and legalisation is still missing around this transport mode. In this part of the thesis some guidelines will be given how to improve the e-bike safely in the city.

An e-bike goes faster than a regular bike. Commuters have started using the e-bike as an alternative for the car since a few years. Commuters choose the car when they have to cycle for over 15km. However, an e-bike solves this problem: it is faster than a conventional bike, so the travel time decreases. In fact travelling by car is not necessarily faster.

An electric freeway between Almere and Amsterdam South East was opened in July 2013, which is a new connection from Amsterdam South East to the inner city and can be regarded as an asset for the bicycle network (Buitelaar, 2013).

One might wonder whether the e-bike actually belongs on the bicycle path. With speed limits of 25 to 30 km/h an e-bike is faster than a regular bike. A solution would be to create specific e-bike routes and adapt the ordinary bicycle path. Multiple lanes would be ideal: a fast lane for e-bikes and a slow lane meant for standard bikes. Furthermore, it is important to avoid conflicts with other users by giving priority to the bicycle lanes. Also, e-bikes should have a speed limit when used in the inner city, because it prevents accidents.
Fig. 48 Categorising bicycle routes in Amsterdam South East.
5.3 Interventions
In the analysis section it is concluded that interventions are needed to improve the transport infrastructure. Three interventions at three scale level are worked out to give an idea how to use the design criteria (Fig.49). The first intervention is an e-bike route which connects Amsterdam South East with the inner city of Amsterdam. The second intervention is a bicycle route to station Bijlmer Arena and the third intervention is a walking route in the southeastern side of the Bijlmermeer.

At city level, the bicycle connections from Amsterdam South East to the inner city of Amsterdam are now lacking. First, the routes are not clearly signposted and, second, the growing number of e-bikes and other electric vehicles create a problem: there is not enough space on the cycling paths at the moment. The new e-bike route is linked with the existing electric freeway from Almere to Amsterdam South East. By widening the bicycle path separate lanes for slow and fast traffic are created. The intervention shows the challenges in the urban area with the introduction of the e-bike. Higher speed means a longer braking distance and cornering speed. E-bikers have to reduce their speed when cycling in dense urban areas with heavy traffic.
Figure 51 shows the location of the intervention and Figure 52 shows the new e-bike route through the Amsterdamse Poort. The next impression is located between Venserpolder and Duivendrecht (Fig. 53-54). The bicycle path is widened and divided in four lanes for slow and fast traffic.
Fig. 53 E-bike route to city centre.

Fig. 54 Impression of the e-bike route between Venserpolder and Duivendrecht
The location of the interventions are shown in Figure 55. The H.J.E. Wenckebachweg in Figure 56 and Figure 57 is redeveloped as a cycle street. More space for cyclists and the cars can still reach their destinations accessible by the H.J.E. Wenckebachweg.
The location of the interventions are shown in Figure 58. After the H.J.E. Wenckebachweg the e-bike route will be split on both sides of the Spaklerweg. Between the railway and Amstel is too little space for a four lane bicycle path at one side. After the roundabout (Fig.59) the e-bike route follows the Amstelboulevard to the Weesperzijde.
Bicycle route to station Bijlmer Arena

Connections to transit nodes are present, but could be improved. For instance the accessibility of train station Bijlmer Arena for cyclists from the east of the Bijlmermeer could be improved. A shorter path is possible (Fig. 61), because now the cyclists to the station Bijlmer Arena are redirected along the Bijlmer Park and in front of the Amsterdamse Poort. The pedestrian area (orange) starts in front of the Amsterdamse Poort, so cyclists have to make a detour (yellow) along the south or north of the Amsterdamse Poort.
The new bicycle route (Fig.62) follows the Bijlmerdreef from station Bijlmer Arena to the Gooiseweg. To create space for the bicycle route, at a few places have been road narrowings applied. Near the t-junction with the Dolingadreef two lanes to turn left to the Dolingadreef are replaced by one. And after the t-junction the footpath is 10 meters wide, enough space left for the bicycle lane. This bicycle route improves the bicycle network and accessibility of the Arena boulevard and Bijlmerdreef by bicycle.
Bijlmer south east
The service level is low in the south eastern side of the Bijlmermeer. The pedestrian and bicycle routes to the shopping centre (called the Kameleon), primary school and playgrounds need attention. A new proposal on how to improve the accessibility in this neighbourhood is developed below.
In the Figure 63 the primary schools, playgrounds and the shopping centre are important destinations in the neighbourhood. Between the primary school and the shopping centre is a shorter path possible. An impression of the walking and bicycle route is given in Figure 64, Figure 65 and Figure 66.

Fig. 63 Concept connecting the playgrounds.

Fig. 64 Floor plan new walking route.
Fig. 65 Impression new walking and bicycle route along the Karspeldreef.

Fig. 66 Section walking route.
5.4 Strategy
Transport choice behaviour is difficult to change. People have their habits and changing these takes time. The strategy of planners and designers should be to adapt the environment such that individuals are stimulated to make more sustainable transport choices.

Providing a walkable and bicycle friendly network with well-accessible facilities in the neighbourhood and city district is important, because only then residents might choose to walk and cycle to their destination. The public transport network works as backbone of the transport infrastructure that is well accessible by feet and bicycle. The car infrastructure is subordinate to the public transport, bicycle and pedestrian network.

Sustainable and healthy transport choices start by educating people. Educating younger children at primary schools on how to cycle in the neighbourhood and teaching them the traffic rules is a start and helps to develop sustainable transport behaviour.

Lively streets are the key to attract people to go out and walk around. People will choose new transportation choices if they realise that a supermarket or station is just a few minutes by bicycle or that the primary school in the neighbourhood is reachable by a safe pedestrian or bicycle route.

To encourage commuting to work by bike the advantages of using an e-bike instead should be emphasised. The employer could stimulate this transport mode to compensate the employee. The radius is greater than for a conventional bike, and with an e-bike there are no parking problems near the office. Adapted bicycle routes for e-bikes to stimulate this transport behaviour can already be found in Amsterdam South East. With clear way-finding signs and no obstacles along the route, it is possible for cyclists to be in the city centre in 20 minutes. Healthier transport choices of inhabitants and more sustainable transport modes bring us closer to a sustainable future.

5.5 Conclusion
Sustainable transport is important to keep the city accessible and its inhabitants healthy. A threat is the increasing level of obesity, which is mostly the result of an unhealthy lifestyle. The key to more physical exercise is active transport, such as transport by feet or bicycle.

Criteria for bicycle and pedestrian routes can be used to revise the existing bicycle and pedestrian network and improve the routes. There are two key considerations: firstly, street user hierarchy should consider pedestrians first and private motor vehicles last. Secondly, street design should be inclusive, providing for all people regardless of age or ability.

A general principle in the design of intersections should be that pedestrian’s desire lines should be kept as straight as possible at side-street junctions. Any footway should be fit for purpose, but should give primary importance to creating positive, attractive spaces.
Cyclists are more likely to choose routes that enable them to keep moving. Designs should contain direct and barrier-free routes for cyclists. A solid bicycle network requires:

- Comfort: quality pavement, avoid loss time
- Safety: avoid conflicts with crossing traffic, separating bicycle types, reduce speed on conflict issues.
- Cohesion
- Distinction between fast and slow bicycle traffic.
- Recognition; introduction of way finding signs.

The electric bike is an emerging vehicle type within the context of sustainable transport. With greater range and enhanced performance the e-bike as transport mode is becoming increasingly popular. Commuters have started using the e-bike as an alternative for the car since a few years. With speed limits of 25 to 30 km/h an e-bike is faster than a regular bike. To increase the traffic safety and avoid conflict between slow and fast bicycle traffic a solution could be to create specific e-bike routes and adapt the ordinary bicycle path. Multiple lanes would be ideal: a fast lane for e-bikes and a slow lane meant for standard bikes.

Three interventions at three scale level have been worked out to give an idea how to use the design criteria. The first intervention is an e-bike route which connects Amsterdam South East with the inner city of Amsterdam. The second intervention is a bicycle route to station Bijlmer Arena and the third intervention is a walking route and bicycle connection in the southeastern side of the Bijlmermeer.

Providing a walkable and bicycle friendly network with well-accessible facilities in the neighbourhood and city district is important, because only then residents might choose to walk and cycle to their destination. Healthier transport choices of inhabitants and more sustainable transport modes bring us closer to a sustainable future.
6. Conclusions

This final chapter sketches a conclusion of the research that has been done and tries to answer the research question presented in chapter one. First a description of the problem and its solution will be given. Second, and explanation of what urban designers, planners and policy makers can learn from this graduation project will follow. Finally, recommendations for further research are given as well as a reflection on this thesis.

6.1 Conclusions

The starting point of this research is the study area Amsterdam South East. The original plan of Amsterdam South East was designed to create a green and safe living environment with motorized traffic separated completely from slow traffic (pedestrians and bicyclists). In the mean time, part of the area has been reconstructed, including the transportation infrastructure. This raised the question whether main locations in and around the area are well accessible to the inhabitants of the area.

A second issue relates to the increasing health problems, such as obesity. One of the causes of obesity is the fact that people exercise far too little. Stimulating slow transport modes may contribute to reducing this problem.

The organisation of the transport infrastructure has been investigated by mapping it by means of GIS. After analysing the infrastructural development of the area it can be concluded that the development of the Bijlmermeer in the 60s radically contrasted former city expansions in this area: motorized traffic became separated from slow traffic (pedestrians and bicyclists).

In order to decide which transportation mode needs to be optimised, mobility data of the residents who live in this area was analyzed. The results indicate the main transport mode choices and destinations. The main used transport mode in Amsterdam South East is the car, second is the public transport and third the bicycle. The bicycle is under used in this area compared to the other city districts of Amsterdam. A reason could be that the transport infrastructure facilitates the car more than the bicycle and walking. To locate the main facilities in the neighbourhoods and analysing the accessibility by bicycle and foot have given more insight in the service level of the transport infrastructure.

Although accessibility can be defined and measured in different ways, distance and directness of a route from origin to destination was used as the main principle to improve accessibility.

The literature review showed that shifting transportation modes not only influences the level of physical activity, but also has beneficial health effects due to decreased air pollution emissions (De Hartog et al., 2010), greenhouse emissions (Lindsay et al., 2011) and noise levels (Van Kempen et al., 2010).

Walking is physically demanding, and there are narrow limits as how far most people can or will walk. An acceptable
Walking distance for most people in ordinary daily situations has been found to be around 400 to 500 meters. The acceptable walking distances are an interplay between the length of the route and the quality of the route, both with regard to protection and to stimulation en route (Gehl et al, 2006).

Five levels of walking needs are feasibility (mobility, time, responsibility), accessibility (activities, connectivity between uses, infrastructure), safety (people present, types of land-uses), comfort (traffic calming features, pedestrian walkway), and pleasurability (varied streetscape, liveliness, presence of other people) (Alfonzo, 2005).

Cycle criteria are cohesion, immediacy (avoid loss of time), attractiveness, safety (avoid conflicts with crossing traffic, reduce speed on conflict issues), comfort (avoid bends in the road, provide a level of surface, minimize slope disturbance, minimize weather nuisance).

Stimulating slow transport modes could be done by restructuring the bicycle network: adapt it to the needs of the users and new transport modes (e.g. the e-bike), encouragement, education and enforcement are needed. Also, tackle the missing links in the bicycle network and integrate a way finding system for cyclists and pedestrians to show the shortest paths to important destinations in the area.

What can urban designers, planners and policy makers learn from this project? This research gives background information about transport mode choice behaviour related to health issues, the latest views on accessibility in scientific papers and an approach to measure accessibility.

The challenge facing planners is to design cities and neighbourhoods that make it easier for people to drive less and are attractive to live in at the same time. Further concentration and densification do not reduce the need to travel as people tend to spend the benefits of shorter distances on satisfying their latent travel demand, but they do help to reduce car use. Profits can be achieved by modal shift from passive to active transport and a more efficient public transport. It is important to focus on the accessibility of the nodes in the transportation network and mode shift.

A promising way to stimulate physical activity is to promote the choice for active modes of transport. The challenge facing planners is to design cities and neighbourhoods or adapt existing neighbourhoods to promote walking or cycling, so that people will choose to go by bike instead by car. In other words, show alternative transport modes and encourage active transport. Respond to new mobility trends by facilitating them in the built environment instead of waiting for the right time.

With the design guidelines in chapter 3 and 5 policy makers are able to evaluate the existing bicycle and pedestrian network if the connections meet the required standards. The interventions, which have been elaborated on in chapter
5, shows how the criteria could be implemented. The three interventions are examples of how to anticipate on the upcoming use of the e-bike and improve the accessibility in Amsterdam South East by renewing bicycle routes and extending the pedestrian network.

6.2 Recommendations
Mobility services such as Uber, Car2go and Snappcar are winning market share. More people use these services and society is changing into a sharing community. New mobility solutions in the near future like the self driving car and cooperative systems are coming. How could these systems be successfully implemented in the Netherlands?

Further implementation of fully electric public transport buses should be examined in the metropolitan region of Amsterdam. Implementing fully electric buses and adaptation of the urban area is needed. Furthermore the future of hybrid tram-bus has to be investigated. Could this new mobility solution replace the existing tram?

A start with the e-bike is made but further investigation to this new transport mode and the consequences in the urban area is needed. Design rules have to be established and regulations regarding this new vehicle are missing. The government has to change the law to regulate these bikes. Cooperation is important, exchange knowledge and learn from each other.
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